Department of
Environment &
Conservation

DWR-PAS-P-02-QAPP-102017
Quality Assurance Project Plan For 106 Monitoring

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1.) Effective Date: December 2021

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Document Revision History

(Detailed revision record for each document can be found in Appendix I)

Revision Number	Date	Brief Summary of Change
15	11/2021	General update of personnel changes and organizational charts. Updated MDL's and fishing sites. Revised SQSH desired endpoint and biology upload worksheet screenshots. Updated Mercury from optional to required for long term trend sites.
14	08/2020	General update of document storage, personnel changes and organizational charts. Updated information to new FY 20-21 such as fishing sites, monitoring graphs and monitoring budget. Specific updates such as updating name of 303 (d).
13	12/31/2019	Updated the section name from PAS to WPU. Update personnel changes. Clarify parameters in Table 8. Update sampling and assessment timelines to project into the future. No major changes.
12	10/2018	No major changes
11	02/28/2016	Updated personnel, organizational chart and revised monitoring priorities.
10	5/01/2015	Updated personnel, organizational chart, updated QM chart, methods, data transmittal, references, updated sampling priorities
9	5 /15/2014	Updated personnel, organizational chart, references, methods and data transmittal information.
8	2/13/2013	Updated personnel, updated references, updated parameter list and MDLs, updated TDH sample receiving policy and sample handling.
7	05/05/2011	Updated personnel and references, updated record holding time, updated MDLs,
6	2/05/2010	Updated personnel, updated reference tables and titles, updated data handling specifications for EPA, and updated MDLs.

Revision Number	Date	Brief Summary of Change
5	4/15/2009	Updated personnel, changed wording about Tiers, changed % duplicates, added periphyton to Ecoregion sampling, corrected TDH Lab methods and instrumentation, MDLs and holding times, and updated number of ecoregions.
4	4/15/2007	Updated personnel, projects, Section D, clarified wording, added equipment and supplies, revised performance criteria, and verification requirements.
3	2/15/2006	Clarified wording, updated personnel, reference documents, budget, lab specifications methods, and needed parameters
2	7/13/2005	Clarified wording, specified lab security, described QC procedures.
1	2/16/2005	No significant changes
0	12/30/2004	Initial QAPP

PART A

PROJECT MANAGEMENT

A1 QUALITY ASSURANCE PROJECT PLAN

TITLE AND APPROVAL SHEET

DOCUMENT TITLE	Quality Assurance Project Plan (QAPP) for 106 Monitoring (Volume I – 305(b) and 303(d) assessments, TMDL monitoring, and ecoregion reference monitoring)
ORGANIZATION TITLE	Tennessee Department of Environment and Conservation, Division of Water Resources
PREPARED BY	Tennessee Department of Environment and Conservation, Division of Water Resources Watershed Planning Unit
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DIVISION QAPP PROJECT MANAGER	Jennifer Dodd Environmental Program Director Division of Water Resources
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PLAN COVERAGE	General instructions for the collection of water quality data for 305(b) and 303(d) assessments, ecoregion reference monitoring, and TMDL development.

PEER REVIEW

As a part of the internal review process, the following individuals reviewed this document:

Barry Brawley
Jennifer Dodd
Paula Mitchell
Debbie Arnwine
Kim Laster
Daniel Lawrence
Craig Edwards
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TDEC QUALITY ASSURANCE PROJECT PLAN FOR 106 MONITORING REVISIONS AND ANNUAL REVIEW

1. This document shall be reviewed annually to reconfirm the suitability and effectiveness of the program components described in this document.

2. A report of the evaluation of effectiveness of this document shall be developed at the time of review and submitted to appropriate stakeholders. Peer reviews shall be conducted, if necessary and appropriate. It shall be reconfirmed that the document is suitable and effective. It shall include, if necessary, clarification of roles and responsibilities, response to problem areas and acknowledgement of successes. Progress toward meeting Tennessee Department of Environment and Conservation (TDEC) mission, program goals and objectives shall be documented. Plans shall be made for the upcoming cycle and communicated to appropriate stakeholders.

3. The record identified as “Revisions” shall be used to document all changes.

4. A copy of any document revisions made during the year shall be disseminated to all appropriate stakeholders. A report shall be made to the Deputy Commissioner of any changes that occur. Other stakeholders shall be notified, as appropriate and documented on the “Document Control” sheet. Revisions are in Appendix I.

TDEC QUALITY ASSURANCE PROJECT PLAN FOR 106 MONITORING EVALUATION INSTRUCTIONS

As this Quality Assurance Project Plan for 106 Monitoring is used, it will become apparent which changes or improvements are needed. Specific recommendations for improvements or changes are solicited as well as information concerning typographical or formatting errors. Please copy this page and complete all questions. Electronic versions of this are encouraged especially if comments are significant.

Your Name	______________________________
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Document Effective Date	______________________________
Section(s) and Page Number(s) to which your comments apply	______________________________
Comments	______________________________
	______________________________
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Send all comments, along with the following information, to the address below.

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A3 DISTRIBUTION LIST

Copies of this document were distributed to the following individuals in Tennessee Department of Environment and Conservation (TDEC) and Tennessee Department of Health (TDH) (Table 1). Additional copies were distributed to non-TDEC agencies and individuals upon request (including other state and federal agencies, consultants, universities, etc.). An updated list is maintained in the Watershed Planning Unit (WPU). The system for document control is described in the *Bureau of Environment Quality Management Plan*.

Copies of this document are also maintained on the department's website and the QMS library on a shared drive.

Table 1: QAPP Distribution List

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A4 PROJECT/TASK ORGANIZATION

A4.1 Project Purpose Based Upon Data Quality Objectives

The overall organizational structure of the project and accountability of participating parties are described in this section. This QAPP ensures reproducible and defensible water quality assessments for use in TMDL development, ATTAINS, EPA Approved List of Impaired and Threatened Waters, advisories, special studies associated with the Clean Water Act and provides representative reference data for criteria development and assessments.

A4.2 Roles and Responsibilities

The responsibility for water quality monitoring and assessment is shared among the Division of Water Resources (DWR), Watershed Planning Unit (WPU), and Environmental Field Offices (EFO) personnel. Fish tissue and limited sampling is contracted to the Department of Health Environmental Laboratories (TDH) with oversite by WPU.

- WPU develops and updates QAPP, QSSOPs and CALM and ensure procedures are followed by field staff and assessors
- WPU and EFO develop annual monitoring plan to identify monitoring stations, parameters and frequency to ensure objectives are met.
- EFO staff collect samples and record field observations.
- Surface water samples are analyzed by TDH and contract laboratories, who then report results to EFO and WPU staff.
- Biological samples are analyzed or subcontracted by TDH and EFO staff, who then report results to WPU.
- WPU staff and EFO staff jointly assess water quality results.
- WPU staff upload data to EPA WQX and assessment data to ATTAINS.

A4.2.1 Roles and Responsibilities.

Table 2 lists planning team members. Table 3 contains a summary of the roles and responsibilities of individuals and organizations participating in this project including principal data users, decision makers, trainers, purchasing staff, data management staff, records management staff, laboratory personnel, TDEC management, quality management program staff and others. Acronyms and definitions used by DWR are included in Appendix A. Organizational charts are included in Appendix B.

Table 2: List of Planning Team Members

Name	Organization	Person to Whom Reports	Telephone Number	E-Mail Address
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Table 3: Planning Team Members Roles and Responsibilities

Name	Project Role and Responsibility
Jennifer Dodd	Environmental Program Director
Paula Mitchell	Deputy Director – Central Office Operations
April Grippo	Deputy Director – Water Quality QA Project Plan Manager
Chris Rhodes	Deputy Director - Field Office Operations
Rich Cochran	Project planning Water quality standards Ecoregion reference management SOP development and training coordination Data QC Data management Record management Data analyses and assessment decision Report generation TMDL decisions and development Watershed planning documents Project planning GIS management
Jennifer Innes	Water quality monitoring and assessment
Brad Ulmer	Water quality monitoring and assessment
Conner Franklin	Water quality monitoring and assessment
Dane Cutshaw	Water quality monitoring and assessment
Michael Atchley	Water quality monitoring and assessment

Name	Project Role and Responsibility
Joellyn Brazile	Water quality monitoring and assessment
Timmy Jennette	Water quality monitoring and assessment
Bryan Epperson	Water quality monitoring and assessment
Marc Rumpler	TDH Environmental Lab Director/Laboratory QC
Barry Brawley	Quality Assurance Manager

A4.2.1.A Management Responsibilities

The education, training, and experience for staff with management and supervisory responsibility in the project are described as follows.

1. **Public Health (PH) Laboratory Director**

   Education and Experience: There is no formal job description for this classification. The job title is executive service and serves at the pleasure of the appointing authority of the department in which the position is located.

   Responsibilities: This position oversees all central laboratory operations at the TN State Public Health Laboratory and ensures the integrity of the referenced third-party laboratory services.

2. **TDEC Environmental Manager 3**

   Education and Experience: Graduation from an accredited college or university with a bachelor's degree in environmental science, biology, chemistry, geology, or other acceptable field and five years of full-time professional environmental program work including at least one-year supervisory experience.

   Responsibilities: These positions manage programs and environmental professional staff either in the Central Office or in Environmental Field Offices. The job responsibilities of these staff members are:

   - Through staff supervisory and management personnel, assigns, trains, supervises, and evaluates technical staff.
   - Managing environmental monitoring work.
   - Participating in establishing standards, laws, rules, regulations, and administrative policies and procedures.
   - Managing preparation and maintenance of records and reports.
   - Reviewing report findings.

3. **Public Health (PH) Laboratory division Director**

   Education and Experience: Possession of a doctorate in microbiology, biology, chemistry, or public health and laboratory practices from an accredited university and two years of responsible professional health laboratory experience and licensed as a Medical Laboratory Technologist by the TDH. This Executive Service position has additional qualifications as specified by the appointing authority.

   Responsibilities: This position manages all external and central environmental laboratory operations. The job responsibilities of this employee include:

- Managing internal, external, and other personal request for information, explaining laboratory results and related matters.
- Preparing, checking, and reviewing laboratory technical records and reports for accuracy and conformity.

4. TDEC Environmental Manager 4

Education and Experience: Graduation from an accredited college or university with a bachelor’s degree in environmental science, biology, chemistry, geology, engineering or other acceptable science related field. Seven years of full-time professional environmental program.

Responsibilities: These positions manage programs and environmental professional staff either in the Central Office or in Environmental Field Offices. The job responsibilities of these staff members are:

- Through staff supervisory and management personnel, assigns, trains, supervises, and evaluates technical staff.
- Managing environmental monitoring work.
- Participating in establishing standards, laws, rules, regulations, and administrative policies and procedures.
- Managing preparation and maintenance of records and reports.
- Reviewing report findings.

5. TDEC Environmental Manager 2

Education and Experience: Graduation from an accredited college or university with a bachelor's degree and four years of full-time professional environmental program, natural resource conservation work, increasingly responsible professional work, or full-time professional work that involved ensuring compliance, with radiation safety standards and/or regulations. Substitution of Education for Experience: Graduate coursework may be substituted for the required experience, on a year-for- year basis, to a maximum of two years (24 semester hours is equivalent to one year).

Responsibilities: These positions manage programs and environmental professional staff either in the Central Office or in Environmental Field Offices. The job responsibilities of these staff members are:

- Through staff supervisory and management personnel, assigns, trains, supervises, and evaluates technical staff.
- Managing environmental monitoring work.
- Participating in establishing standards, laws, rules, regulations, and administrative policies and procedures.
- Managing preparation and maintenance of records and reports.
- Reviewing report findings.

6. **Public Health (PH) Lab Consultant 2**

Minimum Qualifications:
Education and Experience: Graduation from an accredited college or university with a bachelor's degree in physical sciences (e.g. physics, chemistry), ecology, life sciences (e.g. biology, microbiology, health physics, biochemistry or biophysics), medical laboratory science, pre-medicine, or other acceptable science or successful completion of an accredited medical laboratory scientist program and one year of full-time professional work in the related field.

Responsibilities: These positions manage programs. The job responsibilities of these staff members are:

- An employee in this class provides routine laboratory consultant work of considerable difficulty with the smallest scope.
- Ensures quality control guidelines are being met.
- Prepares records and reports to meet division needs.

7. **TDEC Environmental Fellow**

   Education and Experience: There is no formal job description for this classification. The job title is executive service and serves at the pleasure of the appointing authority of the department in which the position is located. The qualifications for executive service positions are determined by the appointing authority.

   Responsibilities:
   These positions manage programs and environmental professional staff for the division.

8. **TDEC Environmental Program Director (Division Deputy Director)**

   Minimum Qualifications:
   There is no formal job description for this classification. The job title is executive service and serves at the pleasure of the appointing authority of the department in which the position is located. The qualifications for executive service positions are determined by the appointing authority.

   Responsibilities:
   These positions manage programs and environmental professional staff for the division.

9. **TDEC Environmental Program Administrator (Division Director)**

   Minimum Qualifications:
   There is no formal job description for this classification. The job title is executive service and serves at the pleasure of the appointing authority of the department in which the position is located. The qualifications for executive service positions are determined by the appointing authority.

Responsibilities:
These positions manage programs and environmental professional staff for the division.

10. **Public Health (PH) Lab Manager 2**

Minimum Qualifications:
Education and Experience: Graduation from an accredited college or university with a bachelor's degree in physical sciences (e.g. chemistry), ecology, life sciences (e.g. biology, microbiology, biochemistry or biophysics), medical laboratory science, pre-medicine, or other acceptable science, and two years of full-time professional work in the related field.

Responsibilities: These positions manage programs. The job responsibilities of these staff members are:

- Responsible for routine laboratory work of considerable difficulty.
- Monitors and controls reagents and consumables to ensure an adequate supply for testing needs.
- Performs day-to-day administrative tasks involving timekeeping, scheduling, ordering and management reports.

11. **Public Health (PH) Lab Manager 4**

Minimum Qualifications:
Education and Experience: Graduation from an accredited college or university with a bachelor's degree in physical sciences (e.g. chemistry), ecology, life sciences (e.g. biology, microbiology, biochemistry or biophysics), medical laboratory science, pre-medicine, or other acceptable science, and five years of full-time professional work in the related field, and experience equivalent to three years of full-time laboratory supervisory experience.

Responsibilities: These positions manage programs. The job responsibilities of these staff members are:

- Researches equipment specifications and methodologies to evaluate the usefulness and cost effectiveness.
- Analyzes, communicates and implements resolutions to various issues as they arise.
- Monitors the cost of and expenditures related to contracts and testing to ensure compliance with budgetary constraints.

12. TDEC- Director of Emergency Services

Minimum Qualifications:
There is no formal job description for this classification. The job title is executive service and serves at the pleasure of the appointing authority of the department in which the position is located. The qualifications for executive service positions are determined by the appointing authority.

A4.2.1.b Quality Assurance Responsibilities

See Section II of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017), the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018),* and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) for qualifications and responsibilities of quality assurance team.

The person responsible for maintaining the official, approved Quality Assurance Project Plan is the Deputy Director Paula Mitchell, TDEC, DWR.

A4.2.1.c Field Responsibilities

The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017), the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) provide qualifications and responsibilities of field personnel.

A4.2.1.d Laboratory Responsibilities

The TDH Environmental Laboratories performs or sub-contracts most of the chemical, bacteriological and biological analyses for DWR. Drinking water certified (or equivalent) contract laboratories throughout the state have been contracted to analyze *E. coli* samples due to the closing of the Jackson TDH environmental laboratories and to facilitate the 6 hour holding time requirement TDH labs continue to perform E. coli analyses in Knoxville and Nashville. The Chattanooga Environmental Field Office performs E. coli analysis in Chattanooga. Organic samples are contracted to third party laboratories. The education, training, and experience for laboratory staff are described below.

The *Environmental Organic SOPs* (TDH, 2002-2014) and the *Environmental Inorganic SOPs* (TDH, 2002-2020) outline qualifications and responsibilities for chemistry laboratory personnel. Microbiology laboratory personnel perform standardized microbiological laboratory tests. The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) provides qualifications and responsibilities for DWR and TDH biologists performing biological analyses.

The laboratories performing chemical analysis must maintain NELAC or ISO/IEC 17025 for surface waters and have drinking water certification or the equivalent for *E. coli* analysis.

A4.2.1.e Other Stakeholders

DWR requests data from other agencies to include in the division's assessment of surface waters of the state. (Table 4)

Table 4: Other Stakeholders

Agency	Physical Data	Biological Data	Chemical Data	Bact. Data
US Army Corp of Engineers (USACE)	X	X	X	
US Environmental Protection Agency	X	X	X	X
US Office of Surface Mining	X		X	
Tennessee Valley Authority (TVA)	X	X	X	X
US Geological Survey	X	X	X	X
Tennessee Wildlife Resources Agency (TWRA)	X	X		
Phase II MS4 permittees	X	X	X	X
NPDES permittees	X	X	X	X
Universities	X	X	X	X
Oak Ridge National Laboratory ORNL (DOE)	X	X	X	
USFS	X	X		
MS4 Permitees	X	X	X	X
National Park Service	X		X	X
Watershed groups	X			

A4.2.2 Organizational Chart

Organizational charts for the project are included in Appendix B. The charts show relationships and lines of communication among project participants.

A4.3 Key Resources

The primary data source is monitoring conducted by DWR personnel.

The TDH Environmental Laboratories analyzes inorganic chemical, bacteriological, and Semi-Quantitative Single Habitat (SQSH) biological samples. Organic analyses are contracted to third party certified laboratories thought the TDH lab. Drinking water certified (or equivalent) contract laboratories throughout the state have been contracted to analyze *E. coli* samples due to the closing of the Jackson TDH laboratories. Knoxville Department of Health Laboratory has continued performing *E. coli* for the KEFO. The Chattanooga EFO also performs E. coli analysis in their area. The primary data source, for reservoirs and large rivers are TVA, ORNL and USACE.

A4.4 Data Types (Table 5)

Table 5: Data Sources

Data Type	Intended Use
Computer Databases	
Waterlog	Storage and Management of Chemical and Biological data and documents. Public accessibility of data. Linked to online assessment map used to determine ecoregion, and watershed boundaries, antidegradation and assessment status.
File Net	Chemical and Bacteriological data/documents prior 2014 in transition of moving to File Net.
SharePoint	Storage of electronic workbooks, chemical and bacteriological data and reports post 2014.
EPA WQX	Upload chemical and biological data to meet EPA 106 grant requirements and public accessibility of data. Access data from other agencies after 2009.
ATTAINS	EPA Database used for cataloging assessments.

Data Type	Intended Use
Literature Files	
Consolidated Assessment and Listing Methodology (CALM) (Denton et al, 2021).	Used as guidance for assessment of waterbodies.
Rules of the TDEC, Chapter 0400-40-03, General Water Quality Criteria (TDEC-WQOG, 2019)	Used to determine appropriate water quality criteria.
Rules of the TDEC, Chapter 0400-40-04, Use Classifications for Surface Waters (TDEC-WQOG, 2019)	Use to identify assigned use designations.
DWR Surface Water Monitoring and Assessment Program Plan (TDEC, 2021)	Used to plan monitoring schedule including parameters, sample frequency and site locations.
Development of Regionally Based Interpretations of Tennessee's Narrative Nutrient Criterion (Denton et al, 2001)	Use as guidance for determining appropriate nutrient criteria.
QSSOP for Macroinvertebrate Stream Surveys (TDEC, 2017)	Use as guidance for protective habitat scores. Use to score biorecon and SQSH results. Currently under revision.
QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)	Use as guidance for collecting chemical and bacteriological samples.
QSSOP for Periphyton Sampling (TDEC, 2010)	Use as guidance for collecting periphyton samples. Currently under revision.
Historical Databases	
Legacy STORET	Access data from other agencies prior to 2009.
Paper (historic data) and Electronic Files (current)	Paper files are currently being scanned for electronic storage.
Watershed Files	Used to store biorecon taxa lists and field observations.
Ecoregion Files	Used to store reference condition information prior to 2017
Antidegradation Files	Used to store old antideg reviews.
Fish Tissue Files	Used to store old fish tissue field records.

A5 PROBLEM DEFINITION AND BACKGROUND

A5.1 Problem Definition

The purpose of the division's water quality monitoring program is to provide a measure of Tennessee's progress toward meeting the goals established in the Federal Clean Water Act and the Tennessee Water Quality Control Act. This is achieved by determining use-attainment status of surface waters of the State.

To accomplish this task, data are collected and interpreted in order to:

1. Assess the condition of the state's waters.
2. Identify problem areas with parameter values that violate Tennessee numerical or narrative water quality standards.
3. Identify causes and sources of water quality problems.
4. Document areas with potential human health threats from fish tissue contamination or elevated bacteria levels.
5. Establish trends in water quality.
6. Gauge compliance with NPDES permit limits (Table 6).
7. Document baseline conditions prior to a potential impact or as a reference stream for downstream uses or other sites within the same ecoregion and/or watershed.
8. Assess water quality improvements based on site remediation, implementation of Best Management Practices, and other restoration strategies (Table 6).
9. Identify proper water-use classification, including antidegradation policy implementation.
10. Identify natural reference conditions on an ecoregion basis for refinement of water quality standards.

Table 6 : Pollution Response Agencies

Problem	Agency	Solution
Point Source Pollution	DWR Permit and Enforcement Units	Tighten permit limits and enforce permit violations
Non-Point Source Pollution	Department of Agriculture	Grant assistance for voluntary cleanup and education
Waterbody Alteration	DWR Natural Resource Unit	Aquatic Resources Alteration Permit (ARAP), enforcement and implementation

To gauge Tennessee's progress toward meeting the goals of the *Federal Water Pollution Control Act* (U.S. Congress, 2000) and *Tennessee Water Quality Control Act* (TN Secretary of State, 2020), water quality data are compared to *Rules of the TDEC*, Chapter 0400-40-03, General Water Quality Criteria (TDEC-WQOG, 2019) and the Level IV ecoregional reference data set (Table 7).

5.2 Historical and Background Information

Tennessee first created a water pollution regulatory organization in 1927. In 1929, the Department's scope 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 completed study was 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 Quality Control Act of 1971 was passed. In 1972, the Federal Clean Water Act was passed. Tennessee revised the Water Quality Control Act in 1977 and began a statewide stream monitoring program. In 1985, the Division of Water Quality Control was divided into the Division of Water Pollution Control and the Division of Water Supply. In 2012 the Divisions of Water Pollution Control, Water Supply and Groundwater were combined to create the Division of Water Resources. DWR EFO and CO staff continue to monitor surface water for 305(b) and 303(d) assessments.

A5.2.1 Ecoregions

In 1995, the division began ecoregion delineation and reference stream monitoring. Tennessee has 31 Level IV ecological subregions in the state. Reference sites were selected to represent the best attainable conditions for all streams with similar characteristics. Reference conditions represent a set of expectations for physical habitat, general water quality and the health of the biological communities in the absence of human disturbance and pollution. Selection criteria for reference sites included minimal impairment and representativeness. Streams that did not flow across subregions were targeted to identify the distinctive characteristics of each subregion.

A5.2.2 Watersheds

In 1996, the division adopted a watershed approach that reorganized existing programs based on management and focused on place-based water quality management. This approach addresses all Tennessee surface waters including streams, rivers, lakes, reservoirs and wetlands. There are 54 USGS eight-digit hydrologic units (HUC) in the state that have been divided into five monitoring groups for assessment purposes. One group, consisting of between 9 and 16 watersheds, is monitored and assessed each year. This allows intense monitoring of a limited number of watersheds each year, with all watersheds monitored every five years.

A5.2.3 Total Maximum Daily Load (TMDL) Monitoring

A Total Maximum Daily Load (TMDL) is a study that (1) quantifies the amount of a pollutant in a stream, (2) identifies the sources of the pollutant, and (3) recommends the regulatory or other actions that may need to be taken in order for the stream to no longer be polluted. DWR WPU continues to work collaboratively with the EFOs to ensure that enough monitoring takes place to meet our TMDL obligations for EPA's Approved List of Impaired and Threatened Waters.

A5.2.4 Site Description

Monitoring sites are located throughout Tennessee's 54 watersheds. For specific information on planned sampling locations see the division's Surface Water Monitoring and Assessment Program Plan (TDEC, 2020). Maps of scheduled monitoring stations are found in Appendix C

A5.2.5 Past Data Collection Activities

Water quality data have been collected throughout the state since the late 1920's. Various approaches have been used to collect water quality information including fish population surveys, fish tissue analyses, bioassay testing, macroinvertebrate surveys, chlorophyll analyses, periphyton surveys, diurnal dissolved oxygen monitoring, habitat assessments, geomorphological surveys, as well as chemical and bacteriological monitoring. Historical water quality data prior to 2009 are in Legacy STORET. All other historic data and reports are stored in the DWR library, storage areas, and electronic files.

A5.2.6 Involved Parties, Resources

The Division of Water Resources has approximately 327 positions, 306 positions are filled. Approximately 70 personnel are assigned in whole or part to monitoring and assessment activities (including both technical and support staff). Water quality monitoring is funded by state appropriation and EPA funds.

Table 7: Project Decision Statements and Actions

Decision Statement	Action to Be Taken With Reason
Prioritize TMDL development and collect appropriate data.	Develop TMDL.
Identify natural reference conditions on an ecoregion basis for refinement of water quality standards. (Monitor Level IV ecoregional reference sites.)	Data used to refine Water Quality Criteria and ecoregional water quality expectations.
Monitor EPA Approved List of Impaired and Threatened Waters	Refine EPA Approved List of Impaired and Threatened Waters.
Assess the condition of the state's waters.	Compare monitoring results to *Rules of the TDEC*, Chapter 0400-40-03 General Water Quality Criteria (TDEC-WQOG 2019) and regional reference data to determine if waters are supporting of designated uses. Assign assessment in ATTAINS.
Identify problem areas with parameter values that violate Tennessee numerical or narrative water quality standards. Identify causes and sources of water quality problems.	Included in the EPA Approved List of Impaired and Threatened Waters.
Document areas with potential human health threats from fish tissue contamination or elevated bacteria levels.	Notify public of water contact or fish consumption advisory at waterbodies that pose a threat to human health.
Identify waterbody-use classification.	Assign use classification to all monitored waterbodies in the watershed group. Identify antidegradation status for waters where regulatory decisions are needed.

A6 PROJECT/TASK DESCRIPTION AND SCHEDULE

A6.1 Description of the Work Performed

The division maintains a statewide monitoring system consisting of approximately 8000 stations (Appendix C). In addition, new stations are created every year to increase the number of assessed streams. Streams are monitored following a five-year watershed cycle with approximately 20% of the watersheds monitored each year.

Approximately 539 stations will be monitored in FY 21-22 (Appendix C). Stations are sampled monthly, quarterly, bimonthly, semi-annually, or annually depending on the objectives of the project. Within each watershed cycle, monitoring stations are coordinated between the central office, the eight Environmental Field Offices (EFOs) and the Mining Unit

Prior to developing workplans, field staff fully coordinate with other monitoring agencies within the watershed to maximize resources and avoid duplication of efforts.

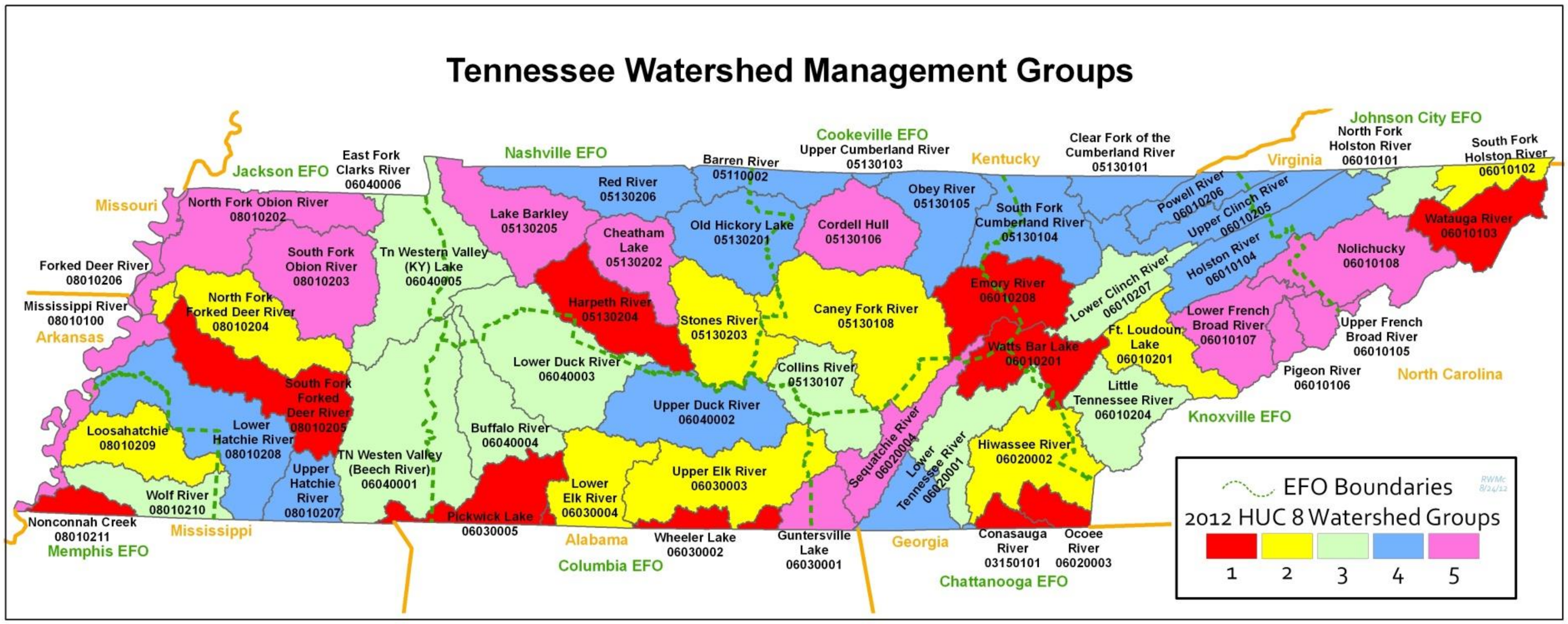

Figure 1: Watershed Groups

Table 8: Watershed Sampling Schedule with EFO Watershed Assignments

Group /Year	Watershed	HUC	EFO	Watershed	HUC	EFO
1 2022 2027 2032 2037 2042	Conasauga	03150101	CH	Ocoee	06020003	CH
	Harpeth	05130204	N	Pickwick Lake	06030005	CL, J
	Watauga	06010103	JC	Wheeler Lake	06030002	CL
	Upper TN (Watts Bar)	06010201	K, CH, CK	South Fork of the Forked Deer	08010205	J
	Emory	06010208	K, CK	Nonconnah	08010211	M
2 2023 2028 2033 2038 2043	Caney Fork	05130108	CK, CH, N	Upper Elk	06030003	CL
	Stones	05130203	N	Lower Elk	06030004	CL
	S. Fork Holston (u/s Boone Dam)	06010102	JC	North Fork Forked Deer	08010204	J
	Upper TN (Fort Loudoun)	06010201	K	Forked Deer	08010206	J
	Hiwassee	06020002	CH	Loosahatchie	08010209	M
3 2024 2029 2034 2039 2044	Collins	05130107	CK, CH, CL	TN Western Valley (Beech)	06040001	J
	N. Fork Holston	06010101	JC	Lower Duck	06040003	CL
	S. Fork Holston (d/s Boone Dam)	06010102	JC	Buffalo	06040004	CL, N
	Little Tennessee (Tellico)	06010204	K	TN Western Valley (KY Lake)	06040005	N, J
	Lower Clinch	06010207	K	Wolf	08010210	M
	Tennessee (Chickamauga)	06020001	CH	Clarks	06040006	J

Group /Year	Watershed	HUC	EFO	Watershed	HUC	EFO
4 2025 2030 2035 2040 2045	Barren	05110002	N	Holston	06010104	JC, K
	Clear Fork of the Cumber-land	05130101	K, MS	Upper Clinch	06010205	JC, K
	Upper Cum-berland	05130103	CK	Powell	06010206	JC, K
	South Fork Cumberland	05130104	K	Tennessee (Nick-ajack)	06020001	CH
	Obey	05130105	CK	Upper Duck	06040002	CL
	Cumberland (Old Hickory Lake)	05130201	N	Upper Hatchie	08010207	J, M
	Red	05130206	N	Lower Hatchie	08010208	J, M
5 2021 2026 2031 2036 2041	Lower Cum-berland (Cheatham)	05130202	N	Nolichucky	06010108	JC, K
	Lower Cum-berland (Lake Bar-kley)	05130205	N	Sequatchie	06020004	CH
	Upper Cum-berland (Cor-dell Hull)	05130106	CK, N	Guntersville	06030001	CH, CL
	Upper French Broad	06010105	K	Mississippi	08010100	M, J
	Pigeon	06010106	K	Obion	08010202	J
	Lower French Broad	06010107	K	Obion South Fork	08010203	J

After determining the watersheds to be monitored each year, monitoring resources are prioritized as follows:

Monitoring Priorities

1. **Antidegradation Monitoring:** Before the division can authorize degradation in Tennessee waterbodies, the appropriate category under the Antidegradation Policy must be determined. These categories are (1) Available or (2) Unavailable Parameters, (3) Exceptional Tennessee Waters, or (4) Outstanding National Resource Waters (ORNWs). ORNWs can only be established by promulgation by the Tennessee Board of Water Quality, Oil and Gas. The other three categories must be established by division field staff or permitting staff. Complicating matters further, waterbodies can be in more than one category at a time, due to the parameter-specific nature of categories 1 and 2 above.

   If a permit application requesting authorization to degrade water quality is for a stream without recent (within last five years unless conditions have changed) water quality data, unless the applicant is willing to provide the needed information in a timely manner, these surveys must be done by field office staff. Because the identification of antidegradation status must be determined prior to permit issuance, this work must be done on the highest priority basis.

   Streams are evaluated as needed in response to requests for new or expanded National Pollutant Discharge Elimination System (NPDES) and Aquatic Resource Alteration Permit (ARAP) permits, including ARAP water withdrawal applications. Streams are evaluated for antidegradation status based on a standardized evaluation process, which includes information on specialized recreation uses, scenic values, ecological consideration, biological integrity and water quality. Since permit requests generally cannot be anticipated, these evaluations are generally not included in the workplan. The number of antidegradation evaluations conducted by the state is steadily increasing as the process becomes more refined and standardized.

2. **Posted Streams**: When the department issues advisories due to elevated public health risks from excessive pathogen or contaminant levels in fish, it accepts a responsibility to monitor changes in those streams. In the case of fishing advisories, in conjunction with the monitoring cycle, field office staff should determine when tissue samples were last collected and if appropriate, notify the central office that the state lab should be contracted to sample in the upcoming watershed year, unless another agency like TWRA or TVA are willing to do the collections. This should be coordinated with the central office. During review of field office monitoring plans for the upcoming watershed year, central office may also discuss needed tissue sampling with the field office.

   For pathogen advisories, in conjunction with the monitoring cycle, monthly *E. coli* samples, plus a minimum of one geo mean sample (5 in 30) must be scheduled and accomplished. If another entity (such as an MS4 program) has already planned to collect samples, that effort can substitute for division sampling, if staff have confidence that the other entity can meet data quality objectives. However, field office staff must confirm that this sampling is taking place, remembering that the ultimate responsibility to ensure that sampling is done remains with the division.

   As fish tissue or pathogen results are received and reviewed, field office staff should communicate with the central office and vice versa if it appears that an advisory could possibly be lifted. Additionally, field office staff have the primary responsibility to ensure existing signs on posted waterbodies are inspected periodically (annually is preferred) and replaced if damaged or removed.

3. **Ecoregion Reference Streams, Ambient Monitoring Stations, and Southeastern Monitoring Network Trend Stations (SEMN):** Established ecoregion or headwater reference stations are monitored in conjunction with the watershed cycle. Each station is sampled quarterly for chemical quality and pathogens as well as in spring and fall for macroinvertebrates and habitat. Diatoms are sampled once during the growing season (April –

October). Both semi-quantitative and biorecon benthic samples are collected to provide data for continued refinement of both biocriteria and biorecon guidelines. If watershed screening efforts indicate a potential new reference site, more intensive reference stream monitoring protocols are used to determine potential inclusion in the reference database.

Ambient Monitoring Sites are the division's longest existing trend stations and any disruption in sampling over time reduces our ability to make comparisons. Regardless of monitoring cycle, all ambient stations must be sampled quarterly according to the set list of parameters established for this sampling effort.

Southeastern Monitoring Network Stations: Like ambient stations, SEMN stations within each field office area must be sampled according to the project plan and grant for this project, regardless of watershed cycle.

4. **EPA Approved List of Impaired and Threatened Water segments:** The EPA Approved List of Impaired and Threatened Waters is a compilation of the streams and lakes in Tennessee that are "water quality limited" and need additional pollution controls. Water quality limited streams are those that have one or more properties that violate water quality standards. They are considered impaired by pollution and not fully meeting designated uses.

   Like posted streams, by identifying these streams as not meeting water quality standards, the division accepts responsibility to develop control strategies and to continue monitoring in order to track progress towards restoration.

   The majority of impaired waters are monitored, at a minimum, every five years coinciding with the watershed cycle. A smaller subset of impaired waters, such as those known to be impacted by severe and ongoing habitat alterations (e.g. channelization or upstream impoundments) may be assessed using the Division's Evaluation Framework found in the CALM document.

Waters that do not support fish and aquatic life are sampled at least once for macroinvertebrates (semi-quantitative sample preferred), habitat and other physiochemical parameters and monthly for the listed pollutant(s). Streams with impacted recreational uses, such as those impaired due to pathogens are sampled monthly for *E. coli.* Another acceptable sampling strategy for *E. coli* is called the Horton Rule. In this approach, an initial geometric mean within the first quarter of the monitoring year is collected (5 samples within a 30-day period). If the results are well over the existing water quality criterion of 126 colony forming units, no additional sampling needs to be done to confirm continued impariment. If results meet the water quality criterion, staff will continue with monthly samples during the remainder of the monitoring cycle. If the geo mean is not substantially over the criterion, field staff may at their discretion continue monthly monitoring to evaluate if in the hope that additional samples will indicate that the criterion is met.

For parameters other than pathogens, resource limitations or data results may sometimes justify fewer sample collections. For example, there are cases where pollutants are at high enough levels that sampling frequency may be reduced while still providing a statistically sound basis for assessments. In other cases, monitoring may be appropriately bypassed during a monitoring cycle. (Chapter II, Section C).

When developing workplans prior to the next monitoring cycle, field office staff should coordinate with the Division of Remediation (DoR) to confirm that any Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites are being monitored by either DoR or the permittee. DoR should be specifically asked if the site continues to violate water quality standards. If not, sampling should be designed to document improvement and provide a rationale for delisting.

5. **Major Dischargers, Landfills and CAFOs:** During each monitoring cycle, the major dischargers should be identified. Stations should be established upstream and downstream at those waterbodies, if the facility does not currently have in-stream monitoring requirements built into their permit. The pollutant of concern and the effect it would have on the receiving stream may determine the location of the station. (Note: stations may not be required for dischargers into very large waterways such as the Mississippi River or large reservoirs.) Frequent collection (monthly recommended) of parameters should include those being discharged, plus a SQSH survey if the stream is wadeable. Stations associated with WWTPs or industries that discharge nutrients should include a SQSH, plus monthly nutrient monitoring.

   Streams below both active and inactive landfills are monitored for both macroinvertebrates and monthly chemicals as outlined in Table 9.

   Stations should also be established downstream of CAFOs with individual permits or others in which water quality based public complaints have been received. The emphasis should be on monitoring biointegrity (SQSH survey if the stream is wadeable or in a region in which SQBANK surveys can be done) and monthly nutrient and pathogen sampling.

6. **TMDL:** Waterbody monitoring is required to develop TMDLs. Monitoring for scheduled TMDLs in the watershed group is coordinated between the Watershed Planning Unit manager and the EFOs to meet objectives for each TMDL. The frequency and parameters monitored for TMDL monitoring depends on the specific TMDL. Detailed information about TMDLs can be found in the department's 106 Monitoring QAPP, (TDEC, 2020), and in the document *Monitoring to Support TMDL Development* (TDEC, 2001).

7. **Special Project Monitoring**: Occasionally, the division is given the opportunity to compete for special EPA grant resources for monitoring and other water quality research projects. If awarded, activities related to these grants become a high priority because the division is under contract

to achieve the milestone set out in the workplan. Federal funds might have to be returned if the division fails to meet project goals. Additionally, failure to meet grant obligations may result in a loss of competitiveness for future grant opportunities.

Normally, monitoring activities related to these projects is contracted out to the state lab. However, if problems arise, field offices might be called upon if the lab is unable to fulfill the commitment. Examples of historical special studies include sediment oxygen demand surveys, nutrient studies, ecoregion delineation, coalfield studies, air deposition surveys, reference stream monitoring, and various probabilistic monitoring designs. \

8. **Watershed Monitoring**: In addition to the previous priorities, each EFO should monitor additional stations to confirm continued support of designated uses and to increase the number of assessed waterbodies. Macroinvertebrate biorecons, habitat assessments, and field measurements of DO, specific conductance, pH and temperature are conducted at the majority of these sites. These priorities include:

    - Assessment of potential new reference stations in streams in relatively protected watersheds. Each year, existing reference streams are degraded by various impacts in their watersheds and must be replaced.

    - Previously assessed segments, particularly large ones, that would likely revert to Category 3 unassessed status. (Note that a single site per assessed segment is generally adequate if assessment was supporting and no changes are evident).

    - Sites below ARAP activities or extensive nonpoint source impacts in wadeable streams where biological impairment is suspected. Examples might be unpermitted activities, violations of permit conditions, failure to install or maintain BMPs, large-scale development, clusters of stormwater permits, or a dramatic increase in impervious surfaces.

- Unassessed reaches especially in third order or larger streams or in disturbed headwaters.

- Pre-restoration or BMP monitoring. This sampling would be to document improvements but is also be needed for antidegradation purposes and to confirm that the stream is a good candidate for such a project. This protects against the possibility that a good stream could be harmed by unnecessary restoration and evaluated the effectiveness of the restoration of the BMP approach. SQSH should be collected at these sites.

A6.1.1 Measurements Expected During Project

Table 9 provides the parameters list for each type of site sampling. The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) describes protocols for collection of benthic macroinvertebrate samples and habitat assessment. The *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* describes chemical and bacteriological sampling, field parameter readings, and flow measurement procedures.

1. **TMDL Measurements:** *Monitoring to Support TMDL Development* (TDEC, 2001) and Table 19 specify needed monitoring for TMDL development. Field parameters (DO, pH, Specific conductance, and temperature), and specific chemical and/or bacteriological samples are collected monthly during periods of concern.

2. **Ecoregion Reference Monitoring**: Ecoregion reference sites (including headwater reference streams) located in the watershed monitoring group are monitored on the watershed cycle. Biorecons and Semi-Quantitative Single Habitat samples are collected at ecoregion reference sites in the spring and fall. Chemical and bacteriological samples as well

as field parameter measurements are taken quarterly. Periphyton samples are collected annually during the growing season.

3. **EPA Approved List of Impaired and Threatened Waters Monitoring**: Minimally, all EPA Approved List of Impaired and Threatened Waters in the watershed group are monitored for the listed cause(s) and a biorecon (or SQSH) sample is collected. No macroinvertebrate sample is needed if the only impairment is pathogen or fish tissue contamination. If water quality improves and a waterbody becomes a candidate for removal from the EPA Approved List of Impaired and Threatened Waters a SQSH sample is collected instead of a biorecon sample.

4. **Long Term Trend Station Monitoring:** Minimally chemical parameters listed in Table 9 are collected quarterly at long term trend stations.

5. **Watershed Sites Monitoring**: Minimally, a biological sample (biorecon or SQSH), habitat assessment, and field parameters (DO, temp, pH, Specific conductance) are collected to determine if the waterbody fully supports fish and aquatic life. If a biorecon is collected and it scores in the ambiguous category, a Semi-Quantitative Single Habitat (SQSH) sample is collected, unless other data clarifies assessment. To assess recreational uses, monthly bacteriological samples are collected.

6. Landfills: Minimally a SQSH and chemical parameters listed in Table 9.

Table 9: Parameters for Surface Water Samples

Parameter	TMDLs				Ref. Sites ECO, FECO & SEMN	303(d)*	Long Term Trend Stations	Water-shed Sites	Landfills	Trip and Field Blanks
	Met-als†/pH	DO	Nutri-ents	Patho-gens						
Acidity, Total	X (pH)							O		
Alkalinity, Total	X (pH)				X	O	X	O		
Aluminum, Al	X†					O	X	O	X	O
Ammonia Nitrogen as N		X	X		X	O	X	O	X	O
Arsenic, As	X†				X	O	X	O	X	O
Cadmium, Cd	X†				X	O	X	O	X	O
Chloride					X		X		X	
Chromium, Cr	X†				X	O	X	O	X	O
$CBOD_5$		X				O		O		
Color, Apparent					X		X			
Color, True					X		X			
Conductivity (field)	X	X	X	X	X	X	X	X	X	
Copper, Cu	X†				X	O	X	O	X	O
Dissolved Oxygen (field)	X	X	X	X	X	X	X	X	X	
Diurnal DO		X	X							
E. Coli				X	O	O	X	O		
Flow	O	O	O	O	O, X SEMN	O	O	O		
Iron, Fe	X†				X	O	X	O	X	O
Lead, Pb	X†				X	O	X	O	X	O
Manganese, Mn	X†				X	O	X	O	X	O
Mercury, Hg	X†					O	X	O	X	O
Nickel, Ni	X†					O	X	O	X	O
Nitrogen NO_3 & NO_2		X	X		X	O	X	O	X	O
pH (field)	X	X	X	X	X	X	X	X	X	
Residue, Dissolved					X	O	X	O	X	
Residue, Settleable						O	O	O		
Residue, Suspended	X		X	X	X	O	X	O	X	
Residue, Total						O	X	O	X	
Selenium, Se	X				X	O	X	O	X	O
Sulfates					X(68a,69de), SEMN	O	X(68a,69de)	O		O
Temperature (field)	X	X	X	X	X	X	X	X	X	
Hardness ($CaCO_3$) by calculation	X				X	O	X	O	X	O
Total Kjeldahl Nitrogen		X	X		X	O	X	O	X	O
Total Organic Carbon	X		X		X	O	X	O		
Total Phosphorus (Total Phosphate)		X	X		X	O	X	O	X	O
Turbidity (field or lab)			X	X	X	O	X	O		
Zinc, Zn	X†				X	O	X	O	X	O

Parameter	TMDLs				Ref. Sites ECO, FECO & SEMN	303(d)*	Long Term Trend Stations	Water-shed Sites	Landfills	Trip and Field Blanks
	Met-als†/pH	DO	Nutri-ents	Patho-gens						
Biorecon					X			X (or SQSH)		
SQSH			X (or bi-orecon)		X	X (or bio-recon) un-less listed for patho-gens				
Habitat Assessment					X	X		X		
Chlorophyll *a* (Non-wadeable)		R	X			R for nu-trient in non-wadeable				
Periphyton (Wadeable)		R	X		X	R for nu-trients in wadeable				

Optional (O) – Collected if waterbody has been previously assessed as impacted by that substance or if there are known or probable sources of the substance. Collect a Field Blank every 10th time parameter is collected and a Trip Blank every 10th trip which includes specified parameter.

R – Recommended if time allows.
† – Sample for pollutant on EPA Approved List of Impaired and Threatened Waters.
* - Minimally parameters for which stream is EPA Approved List of Impaired and Threatened Waters must be sampled.

The following parameters are never requested unless there is specific reason to do so: **antimony, barium, beryllium, calcium, magnesium, potassium, silver, sodium, boron, silica, total coliform, fecal coliform, enterococcus, fecal strep, cyanide, ortho-phosphorus and $CBOD_5$**

Nitrogen (nitrate) and nitrogen (nitrite) should only be collected at waterbodies with designated use of drinking water unless other specific reason to do so.

QC samples (trip and field blank) are only collected for parameters requested at other sites in the same sample trip unless otherwise specified above to not sample.

A6.1.2 Special Personnel, Credentials and Training Requirements

The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) defines qualifications for personnel collecting macroinvertebrate biorecon or Semi-Quantitative Single Habitat samples. The *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* describes qualifications for personnel collecting chemical or bacteriological samples, flow and field parameters. The *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) describes qualifications for personnel collecting periphyton samples.

Management personnel involved in the assessment of waterbodies must meet the criteria in section A4.2.1 and have at least one-year experience in water quality assessment. The WPU personnel must have expertise in water quality assessments, quality assurance, ATTAINS, and Waterlog databases. Personnel involved in geo-indexing of water quality information have training in the use of Environmental Systems Research Institute (ESRI), ArcView software and ATTAINS. Table10 lists roles of key personnel.

A6.1.3 Regulatory Citation

Under the authority of *The Tennessee Water Quality Control Act of 1977* (Tennessee Secretary of State, 2020), 106 monitoring is conducted by DWR. Use designations are defined in *Rules of the TDEC* Chapter 0400-40-04, Use Classifications for Surface Waters (TDEC-WQOG 2019). Specific criteria are described in *Rules of the TDEC*, Chapter 0400-40-03, General Water Quality Criteria (TDEC-WQOG 2019). Required criteria for each parameter is in Table 14.

A6.1.4 Special Equipment Requirements

The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) lists equipment and supplies needed for collection of macroinvertebrate biorecon or Semi-Quantitative Single Habitat samples. The *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* lists the equipment needed to collect chemical or bacteriological samples. The *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) lists the equipment needed to collect periphyton samples. The equipment lists are located in Appendix G. The water quality assessment team uses laptop computers with ATTAINS and ArcView software in the water quality assessment process.

A6.1.5 Project Assessment Techniques

The Tennessee Division of Water Resources Surface Water Monitoring and Assessment Program Plan (TDEC, 2020) describes project assessment techniques.

A6.1.6 Required Project and Quality Records (including types of reports needed)

Section II of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017), of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* and of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) describe project and quality control record handling protocols. After data are compiled, they are used to produce the following paper and electronic records:

Records:

- Waterlog database
- ATTAINS
- SharePoint
- Laboratory report files
- Watershed files (historic)
- Ecoregion files (historic)

Reports:

- *2020 EPA Approved List of Impaired and Threatened Waters* (TDEC, 2020) – Submitted to EPA in April 2020
- *Tennessee Division of Water Resources Surface Water Monitoring and Assessment Program Plan* (TDEC, 2021)

- *Rules of the TDEC*, Chapter 0400-40-03, General Water Quality Criteria (TDEC-WQOG, 2019)
- *Rules of the TDEC* Chapter 0400-40-04, Use Classifications of Surface Waters (TDEC-WQOG, 2019)

Table 10: Primary Roles of Key Personnel*

Name	Job Title	Station	Role
N. Goodman	TDEC-ENV Scientist 1	CHEFO	Biological Analyses/ Field Sampler
A. Obershmidt	TDEC-ENV Manager 2	CHEFO	Field Office Coordinator
J. Innes	TDEC-ENV Manager 3	CHEFO	Field Office Manager
C. Walton	TDEC-ENV Scientist 3	CHEFO	Biological Analyses/ Field Sampler/ QC Officer
S. Puckett	TDEC–ENV Scientist 3	CKEFO	Field Sampler/Chem & Bio QC Officer/Field Office Co-ordinator
R. Rodriguez	TDEC-ENV Scientist 2	CKEFO	Field Sampler
B. Ulmer	TDEC-ENV Manager 3	CKEFO	Field Office Manager
C. Augustin	TDEC-ENV Manager 2	CLEFO	Field Office Coordinator
E. Gordon	TDEC-ENV Scientist 2	CLEFO	Biological Analyses/ Field Sampler
S. Glass	TDEC_ENV Manager 3	CLEFO	Field Office Manager
J. Dodd	TDEC-Water Resources Director	CO	QAPP Project Director
A. Grippo	TDEC-DWR Deputy Director	CO	QAPP Assistant Project Director
P. Mitchell	TDEC-DWR Deputy Director of Operations	CO	QAPP Assistant Project Director
N. Moore	TDEC-ENV Scientist 3	CO WPU	QA/Data Management
D. Arnwine	TDEC ENV Consultant 2	CO WPU	QA/ Project Coordinator/ Data Analyses
R. McGahen	TDEC-ENV Manager 3	CO WPU	Program Manager

Name	Job Title	Station	Role
R. Cochran	TDEC ENV Manager 4	CO WPU	TMDL Development; Geo-indexing, Program Supervisor
D. Borders	TDEC ENV Protection Specialist 3	CO WPU	TMDL Development
K. Laster	TDEC-ENV Consultant 2	CO-WPU	QA/Project Coordinator /Data Analyses
D. Hale	TDEC-ENV Scientist 3	JCEFO	Biological Analyses/ Field Sampler
B. Brown	TDEC-ENV Consultant 1	JCEFO	Biological Analyses/ Field Sampler/QC Officer
F. Coyler	TDEC-ENV Consultant 1	JCEFO	Chemical QC Officer/Field Sampler
T. Robinson	TDEC-ENV Manager 1	JCEFO	Field Office Coordinator/ Field Sampler
C. Rhodes	TDEC-ENV Program Director	JCEFO	Management Field Office Operations
D. Cutshaw	TDEC-ENV Manager 3	JCEFO	Field Office Manager
C. Franklin	TDEC-ENV Manager 3	JEFO	Field Office Manager
A. Fritz	TDEC-ENV Specialist 5	JEFO	Biological Analyses/ Field Sampler/ QC Officer
B. Smith	TDEC–ENV Consultant 1	JEFO	Biological Analyses. Field Sampler / QC Officer
G. Overstreet	TDEC-ENV Manager 2	JEFO	Field Office Coordinator
L. Yates	TDEC Biologist 3	KEFO	Biological Analyses/ Field Sampler
J. Burr	TDEC-ENV Program Fellow	KEFO	Management Field Office Operations
L. Everett	TDEC-ENV Specialist 5	KEFO	Biological Analyses/ Field Sampler/ QC Officer
M. Swanger	TDEC–ENV Scientist 3	KEFO	Field Sampler
C. Renfro	TDEC-ENV Scientist 3	KEFO	Field Sampler/QC Officer
J. Frazier	TDEC-ENV Scientist 3	KEFO	Field Sampler

Name	Job Title	Station	Role
M. Atchley	TDEC-ENV Manager 3	KEFO	Field Office Manager
D. Murray	TDEC-ENV Consultant 1	KEFO Mining Section	Biological Analyses/ Field Sampler/QC Officer
C. Pracheil	TDEC- ENV Scientist 2	KEFO Mining Section	Biological Analyses/ Field Sampler
B. Epperson	TDEC-ENV Manager 4	DWR-Mining Unit*	Program Manager
J. Brazile	TDEC-ENV Manager 3	MEFO	Field Office Manager
H. Smith	TDEC-ENV Manager 2	MEFO	Biological Analyses/ Field Sampler/QC officer/ Program Coordinator
G. McWhirter	TDEC-ENV Scientist 3	MEFO	Field Sampler/Biological Analyses
M. Murphy	TDEC-ENV Manager 2	NEFO	Field Office Coordinator
T. Jennette	TDEC-ENV Manager 3	NEFO	Field Office Manager
J. Worsham	TDEC –ENV Scientist 3	NEFO	Biological Analyses/Field Sampler
J. Fey	TDEC-ENV Consultant	NEFO	Field Sampler/QC Officer
K. Murphy	TDEC-ENV Scientist 2	NEFO	Biological Analysis/Field Sampler/QC Officer
B. Moore	PH Lab Consultant 2	NLAB	Quality Assurance
T. Smith	PH Lab Supervisor 2	TDH KLAB	Lab Manager, QA
C. Perry	PH Lab Scientist 3	TDH NLAB	Biological Analyses/ Field Sampler
K. Gaddes	PH Lab Scientist 2	TDH NLAB	Biological Analyses/ Field Sampler
M. Smith	PH Lab Scientist 2	TDH NLAB	Biological Analyses/ Field Sampler
P. Alicea	PH Lab Manager 2	TDH NLAB	Lab Manager

Name	Job Title	Station	Role
Vacant	PH Scientist 3	TDH NLAB	Analyses
A. Wilson	PH Scientist 4	TDH NLAB	Metals Analyses
D. Wade	PH Lab Scientist 1	TDH NLAB	Metals Analyses
S. Sawarkar	PH Lab Technician 2	TDH NLAB	Sample Processing
P. Leathers	PH Lab Manager 2	TDH NLAB	Lab Manager, Analyses
C. Edwards	PH Lab Manager 4	TDH NLAB	Lab Manager of Analyses, QA
M. Rumpler	PH Lab Division Director	TDH NLAB	Director Environmental Operations
K. Dunaway	PH Lab Scientist 2	TDH NLAB	Analyses

*All personnel will be asked to do additional tasks as needed.

A6.2 Project Timeline for Monitoring, Analyses, and Reports

Table 11 provides project monitoring timelines and deliverable due dates for chemical, bacteriological, and biological analyses results. Table 12 provides project data reduction and report generation timelines.

A6.3 Project Budget

Water quality monitoring is funded by state appropriation and EPA grant dollars. Approximately $2,384,035 was obligated for employee salaries and benefits in support of this program in the state in FY 2020-2021. Another $319,263 is required for travel, printing, utility, communication, maintenance, professional service, rent, insurance, vehicle and equipment expenses. Indirect charges are estimated at $458,656.

Table 11: Project Monitoring Schedule

Activity	Collection		Assessment Period	Sample Delivery	Reporting Date
Watershed Monitoring	**Start Date**	**End Date†**			
Group 1	July 2021 July 2026 July 2031 July 2036 July 2041	June 2022 June 2027 June 2032 June 2037 June 2042	Oct. '23-Feb. '24 Oct. '28-Feb. '29 Oct. '33-Feb. '34 Oct. '38-Feb. '39 Oct. '43-Feb. '44	*Chemical and bacteriological samples are delivered to TDH Environmental Laboratories within holding time* (Appendix D) **Macroinvertebrate SQSH samples are delivered to TDH Environmental Laboratories within 30 days of sampling (negotiated as needed).**	*Chemical and bacteriological data are due to WPU and the sampler in 25 days (negotiated if needed) **SQSH biological results are due December in year of watershed collection year (negotiated if needed). **Biorecon data due as soon as processed and appropriate QC has been completed.
Group 2	July 2017 July 2022 July 2027 July 2032 July 2037	June 2018 June 2023 June 2028 June 2033 June 2038	Oct. '19-Feb. '20 Oct. '24-Feb. '25 Oct. '29-Feb. '30 Oct. '34-Feb. '35 Oct. '39-Feb. '40		
Group 3	July2018 July 2023 July 2028 July 2033 July 2038	June 2019 June 2024 June 2029 June 2034 June 2039	Oct. '20-Feb. '21 Oct. '25-Feb. '26 Oct. '30-Feb. '31 Oct. '35-Feb. '36 Oct. '40-Feb. '41		
Group 4	July 2019 July 2024 July 2029 July 2034 July 2039	June 2020 June 2025 June 2030 June 2035 June 2040	Oct. '21-Feb. '22 Oct. '26-Feb. '27 Oct. '31-Feb. '32 Oct. '36-Feb. '37 Oct. '41-Feb. '42		
Group 5	July 2020 July 2025 July 2030 July 2035 July 2040	June 2021 June 2026 June 2031 June 2036 June 2041	Oct. '22-Feb. '23 Oct. '27-Feb. '28 Oct. '32-Feb. '33 Oct. '37-Feb. '38 Oct. '42-Feb. '43		

**QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* has additional information.

***QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) has specific information.

†The following fiscal year may be used to clarify ambiguous results or fill in data gaps.

Table 12: Project Data Reduction and Report Generation Schedule

Report Name	Report Recipient	Report Due Date
Integrated Reporting - 303(d), 305(b) Assessment Database Compatible Spreadsheet and Geo-referencing.	USEPA ATTAINS	April 1 even number years
303(d) Comment Responses	USEPA	One month after comment deadline
DWR WQ Branch Monitoring and Assessment Program Plan (CALM)	USEPA	October 1 odd numbered years
Water Quality Standards	USEPA WQCB TN Secretary of State	Annual status report on 12/31. Revision every 3 years
TMDL Development Prioritization.	USEPA	April 1
TMDL Development Schedule	USEPA	Final schedule for the current 2-year planning cycle 10/1
Final TMDL and Alternative Restoration Approach Submittals.	USEPA	As completed per the Development schedule
Nutrient Criteria Implementation Plan	USEPA	Annual progress report on 12/31. Revise plan and re-establish mutual agreement if needed
Joint Evaluation/Progress Report	USEPA	Annually 12/31
End-of-Year Review	USEPA	January

Report Name	Report Recipient	Report Due Date
Joint Evaluation/Progress Reports	USEPA	Annually 12/31
Monitoring Workplan	USEPA TDEC WPU TDEC EFO TDH Lab	Annually July 31
State Monitoring Strategy	USEPA TDEC WPU	Annually with Monitoring Workplan July 31
Monitoring Design	USEPA TDEC WPU	Annually with Monitoring Workplan July 31
Program Evaluation	USEPA	Annually 12/31
Strategy Implementation	USEPA	Annually 12/31
106 supplemental progress or final reports.	USEPA	Annually 12/31 and end of grant period
Quarterly Activity Reports	DWR Managers and Directors	End of each quarter
Performance Results Reports	TDEC WPU	End of each quarter
Annual Performance Report	USEPA	December 31
Quality Assurance Report	CO WPU	Every data batch
QSSOP for Chemical and Bacteriological Sampling of Surface Water	CO WPU DWR EFOs	Reviewed and revised if needed annually by July 1

Report Name	Report Recipient	Report Due Date
QSSOP for Macroinvertebrate Stream Surveys	CO WPU DWR EFOs	Revised with standards
QAPP for 106 Monitoring	EFOs USEPA CO WPU	Reviewed and revised if needed annually
QSSOP for Periphyton Stream Surveys	CO WPU DWR EFOs	Reviewed and revised if needed annually by July 1
WQX data upload	EPA WQX	Monthly (minimally by April 1 each year)

A7 QUALITY OBJECTIVES AND CRITERIA FOR DATA MEASUREMENT

A7.1 Data Quality Objectives

The experimental design and rationale for the division's statewide monitoring program are established in this section. All samples obtained for 106 assessments follow the protocols and quality control measures in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)*, the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010). All laboratory data obtained for 106 assessments follow the protocols and quality control measures in the *Environmental Inorganic SOPs* (TDH, 2002-2020) and the *Environmental Organic SOPs* (TDH, 2002-2014). The specific monitoring goals and type of data are described in section A6 of this document. The data are used to fulfill the objectives for each type of monitoring strategy.

A7.2 Steps Scheduled for Specific Watershed Data Quality Objective Process

Step 1 Define Problem – Allocate monitoring resources for TMDL development, ecoregion reference condition definition, and 305(b) and 303(d) watershed assessments.

Step 2 Identify Problem – Determine monitoring needs, allocate monitoring resources, and define sampling priorities to conduct water quality assessments and develop TMDLs.

a. Monitoring

1. A combination of the EPA Approved List of Impaired and Threatened Waters and available models are used to determine which TMDLs are needed in a watershed. EFO's and WPU determine which waterbodies require monitoring for TMDL development, determine sampling parameters and frequencies, and station locations.

2. Ecoregional reference sites are identified in the watershed monitoring group for the fiscal year by consulting Waterlog for active reference sites.
3. Waterbodies on the EPA Approved List of Impaired and Threatened Waters, within the watershed monitoring group, and the cause of impairment are identified.
4. Long term trend stations in EFO area of responsibility are identified.
5. Unassessed waterbodies in the watershed monitoring group for the fiscal year are identified in ATTAINS.
6. Assessed waterbodies of concern in the watershed monitoring group are identified in ATTAINS.

b. Assessment Process

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

1. Biological integrity, nutrient and habitat narrative guidance for wadeable streams were developed to define Fish and Aquatic Life use-support by establishing reasonable water quality expectations. These documents are referred to in the *Rules of the TDEC*, Chapter 0400-40-03, General Water Quality Criteria (TDEC-WQOG, 2019). Biological data are reviewed every 3 years and acceptable metric ranges are adjusted if necessary. In 2019, the division revised a 10-year plan to develop nutrient guidelines for large rivers, lakes and reservoirs (*Tennessee's Plan for Nutrient Criteria Development,* 2019).

2. Numeric criteria define physical and chemical conditions that are required to maintain designated uses. The ecoregion reference dataset has helped refine Dissolved Oxygen (Arnwine and Denton, 2003) criteria for fish and aquatic life use support in wadeable streams.

3 The reference database has helped develop numeric translators for narrative nutrient (Denton et al, 2001) and biological (Arnwine and Denton, 2001) criteria.

4. To make defensible assessments, data quality objectives are met. For some parameters, a minimum number of observations are required to assure confidence in the accuracy of the assessment.

5. 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.

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

7. Waterbodies 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.

8. Waterbodies on the EPA Approved List of Impaired and Threatened Waters are not removed from the list until enough environmental data provide a rationale for delisting.

9. Ecoregion reference sites are re-evaluated and statistically tested every three years. New sites are added whenever 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 other states are used to test suitability of reference sites or to augment the database. Currently the state is reviewing river, lake and reservoir data to target reference conditions in these systems.

10. Watershed groupings are reviewed and revised if needed to ensure staffing is available for adequate coverage. Large watersheds are split when needed.

11. The TDEC Commissioner is identified in the Tennessee Water Quality Control Act as having the authority to post bodies of water based on public health concerns. The Commissioner has delegated authority to the Deputy Director of the DWR. This authority is carried out with assistance from the TWRA and the TVA. Waterbodies that are posted with fish consumption advisories are also listed on the EPA Approved List of Impaired and Threatened Waters as not supporting recreation use.

    The list of waterbodies with advisories is posted on the TDEC web-site. This information is also provided by TWRA in their fishing regulations. Fish are posted by species with two types of consumption advisories. The no consumption advisory targets the general population. The precautionary advisory specifies children, pregnant women and nursing mothers should not consume the fish species named while all others should limit consumption to one meal per month.

c. Future Planning:

1. Waterbodies that need additional monitoring (unassessed and insufficient data) are identified.
2. Additional resources required to complete future monitoring goals are allocated as needed.

Step 3 Identify Needed Analytical Measurements and Sample Handling Requirements – Sampling information varies with sampling purpose. Table 9 lists the sampling parameters for TMDL, ecoregion, 303(d), long term trend stations, and watershed monitoring. Appendix D lists test containers, preservatives, detection limits, and holding times. The *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)*, the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) describe sample handling protocols.

Step 4 Study Boundaries – Fiscal watershed groups are illustrated in Figure 2, Table 8, and Appendix C.

Step 5 Decision Rules –

a. Monitoring:

The schedule for watershed monitoring (Appendix C) and resource allocation are determined using the following. Detailed information is provided in the DWR *Surface Water Monitoring and Assessment Program Plan* (TDEC, 2021).

1. The *Monitoring for TMDL Development* (WMS, 2001) and the WPU manager determine TMDL monitoring requirements for specific TMDLs.
2. Waterlog lists active ecoregion reference sites in each watershed group.
3. The EPA Approved List of Impaired and Threatened Waters identifies impaired waterbodies.
4. Waterlog identifies long term monitoring stations.
5. ATTAINS identifies all monitoring segments including assessed and unassessed waterbodies.
6. Waterlog identifies point source discharges, landfills, and exceptional Tennessee waters.

b. Assessment (Categorization of Use Support):

To determine the uses the waterbody supports, the water quality criteria are referenced. Monitored waters are compared to the most restrictive water quality standards to determine if they meet their designated uses. Generally, the most stringent criteria are recreational use and support of fish and aquatic life.

All major rivers, streams, reservoirs and lakes have been placed into georeferencing sections called waterbody segments. Each waterbody segment has a unique identification number referencing an eight-digit watershed hydrologic unit code (HUC), plus a reach number, and an identification segment.

All available water quality data, including information from DWR, other governmental agencies, universities, and private groups are considered. However, not all data meet state quality control standards and approved collection techniques. Assessments are completed using scientifically sound monitoring methodologies. After use support is determined, waterbodies are placed in one of the following five categories recommended by EPA:

Category 1 Waters are those waterbody segments, which have been monitored and meet water quality criteria. The biological integrity of Category 1 waters is comparable with reference streams in the same sub ecoregion and pathogen criteria are met. Previously these water-bodies were reported as fully supporting.

Category 2 Waters have only been monitored for some uses and have been assessed as fully supporting of those uses but have not been assessed for the other designated uses. Often these waterbodies have been assessed and are fully supporting of fish and aquatic life but have not been assessed for recreational use. In previous assessments, these waters were assessed as fully supporting.

Category 3 Waters have insufficient or outdated data and therefore have not been assessed. These waters are targeted for future monitoring. In previous assessments, these waterbodies were identified as not assessed.

Category 4 Waters are waterbodies that have been monitored and found to be impaired for one or more uses, but a TMDL is not required. These waters are included in the EPA Approved List of Impaired and Threatened Waters. Category 4 has been subdivided into three subcategories. Previously, these waters were reported as either partially or non-supporting.

Category 4a Impaired waters have had all necessary TMDLs approved by EPA.

Category 4b Impaired waters do not require TMDL development because other pollution control requirements required by local, state or federal authority are expected to address all water-quality pollutants (EPA, 2003).

Category 4c Waters are those in which the impacts are not caused by a pollutant (e.g. certain habitat 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 EPA Approved List of Impaired and Threatened Waters. The current EPA Approved List of Impaired and Threatened Waters may be viewed at http://tn.gov/environment/article/wr-wq-water-quality-reports-publications .

The division is increasing its reliance on biological assessments, which provide an accurate assessment of the general water quality and aquatic life use-support in a stream. However, biological assessments do not provide specific toxic pollutant or bacterial levels in waterbodies. The challenge in the coming years will be to combine biological assessments with chemical and bacteriological data.

c. Assessment Participants:

- Watershed Planning Unit manager and assessment staff
- Environmental Field Office Managers and Program or Unit Managers
- Environmental Field Office monitoring staff (environmental scientist and/or biologist)
- Watershed Planning Unit GIS personnel (geo-indexing)

In a joint effort, the WPU manager and EFO staff compare monitoring results to water quality standards and ecoregional reference data to determine if a waterbody supports its designated uses. The support (categorized use) status of each assessed waterbody is entered in ATTAINS. Watershed Planning personnel provide geo-indexing support to link the ATTAINS assessment to a Geographic Information Systems (GIS) map with National Hydrography Dataset (NHD).

In even numbered years, after the assessments are completed, the impaired waterbodies are compiled into the EPA Approved List of Impaired and Threatened Waters. This list is submitted to EPA for review and made available to the public on the division's website for comments. Public meetings are conducted to allow public comments on the EPA Approved List of Impaired and Threatened Waters. Written comments are also received.

d. Assessment Reports:

Assessment information is compiled biennially in two reports:

- EPA Approved List of Impaired and Threatened Waters of impaired waters in Tennessee
- ATTAINS

These reports are sent to EPA and made available to the public through public meetings and the website.

e. Future Planning:

- Review Waterlog and ATTAINS for data gaps and unresolved issues
- Evaluate data acceptability
- Consult with field office personnel and WPU
- Automate identification of numeric criteria violations in Waterlog data system
- Update Consolidated Assessment and Listing Method (CALM)
- Update monitoring SOP's

Step 6 Specify Limits on Decision Rules

Detailed information concerning method detection limits, analytical methods, and QC requirements are included in Section B. Specific limits on decision rules are listed in Table 13. Regulatory criteria for specific parameters (analytes) are found in Table 14.

Table 13: Limits on Decision Rules

Parameter	Parameter Range	Null Hypothesis	Tolerable Limit	Consequences of Decision Error	Corrective Action	Gray Region	Probability Value
Chemical	• *Rules of the TDEC*, Chapter 0400-40-03, General Water Quality Criteria (TDEC-WQOG, 2019) • *Development of Regionally based Interpretation of Tennessee's Narrative Nutrient Criterion* (Denton, Arnwine, and Wang, 2001) • *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)*	Waterbody does not exceed criteria or regional guidelines	90% of data points fall within criteria or guidelines	Placed on EPA Approved List of Impaired and Threatened Waters erroneously	Additional data are collected, and assessment revised. Waters removed from EPA Approved List of Impaired and Threatened Waters.	Macroinvertebrate data indicates FAL is supporting and chemical data exceed criteria.	FAL support decision based on macroinvertebrate results.
Bacteriological	• *Rules of the TDEC*, Chapter 0400-40-03, General Water Quality Criteria (TDEC-WQOG, 2019) • *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)*	Waterbody does not exceed criteria	Geomean and/or single criterion meet criteria	Placed on EPA Approved List of Impaired and Threatened Waters erroneously	Additional data are collected, and assessment revised. Waters removed from EPA Approved List of Impaired and Threatened Waters.	Geomean is acceptable, but single sample exceeds criteria due to rain.	Support decision is based on criteria.

Parameter	Parameter Range	Null Hypothesis	Tolerable Limit	Consequences of Decision Error	Corrective Action	Gray Region	Probability Value
Macroinvertebrate	• *Rules of the TDEC*, Chapter 0400-40-03, General Water Quality Criteria (TDEC-WQOG, 2019) • *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017)	Waterbody does not fall below regional guidelines	Index values meet or exceed regional guidelines	Placed on EPA Approved List of Impaired and Threatened Waters erroneously	Additional data are collected, and assessment revised. Waters removed from EPA Approved List of Impaired and Threatened Waters.	Biorecon scores ambiguous.	Support decision is based on field, habitat, or chemical data or is considered unassessed until SQSH is collected.
Habitat	• *Rules of the TDEC, Chapter 0400-40-03, General Water Quality Criteria (TDEC-WQOG, 2019)* • *QSSOP for Macroinvertebrate Stream Surveys (TDEC, 2017)*	Waterbody does not fall below regional guidelines	Habitat scores meet or exceed regional guidelines	Placed on EPA Approved List of Impaired and Threatened Waters erroneously	Additional data are collected, and assessment revised.	Macroinvertebrate sample scores fully supporting, and habitat assessment does not meet goals.	Support decision is based on macroinvertebrate sample.
Periphyton	• *QSSOP for Periphyton Stream Surveys (TDEC, 2010)*	Waterbody does not fall below regional guidelines	Habitat scores meet or exceed regional guidelines	Placed on EPA Approved List of Impaired and Threatened Waters erroneously	Additional data are collected, and assessment revised.	Periphyton sample scores fully supporting and habitat assessment does not meet goals.	Support decision is based on periphyton sample.

Table 14: Regulatory Criteria†

Parameter	Use	Criteria*	Citation
Alkalinity	FAL	Will not be detrimental to Fish and Aquatic Life (FAL)	*Rules of the TDEC*- Chapter 0400-40-03, General Water Quality Criteria (WQOG, 2019)
Aluminum, Al	FAL	Will not be detrimental to FAL	
Ammonia Nitrogen as N	FAL	Will not be detrimental to FAL	
Arsenic, As	FAL	FAL toxic substances criteria*	
	Domestic Water Supply	10 µg/L	
Cadmium, Cd	FAL	FAL toxic substances criteria*	
Chromium, Cr	FAL	FAL toxic substances criteria*	
CBOD	FAL	Will not be detrimental to FAL	
COD	FAL	Will not be detrimental to FAL	
Color, Apparent,	FAL	Will not materially affect FAL	
Color, True	FAL	Will not materially affect FAL	
Specific conductance (field)	FAL	Will not be detrimental to FAL	
Copper, Cu	FAL	FAL toxic substances criteria*	
Cyanide, Cy	FAL	FAL toxic substances criteria*	

Parameter	Use	Criteria*	Citation
Dissolved Oxygen (field)	FAL	• Shall not be less than 5.0 mg/L for all waters except in the following • Trout streams shall not be less than 6.0 mg/L • Naturally reproducing trout streams shall not be less than 8.0 mg/L • Ecoregion 66 not designated as naturally reproducing trout streams shall not be less than 7.0 mg/L • Sub ecoregion 73a shall not be less than a daily average of 5.0 mg/L with a minimum of 4.0 mg/L	
E. Coli	Recreation	• ≤ 126 CFU as geometric mean of 5 samples/30 days • Individual samples for reservoirs, State Scenic Rivers, Exceptional Waters or ONRW ≤ 487 CFU • All others individual samples ≤ 941 CFU	
Flow	FAL	Will be adequate to provide habitat for FAL	
Iron, Fe	FAL	Will not be detrimental to FAL	
Lead, Pb	FAL	FAL toxic substances criteria*	
	Domestic Water Supply	5 µg/L	
Manganese, Mn	FAL	Will not be detrimental to FAL	

Parameter	Use	Criteria*	Citation
Mercury, Hg	FAL	FAL toxic substances criteria*	
	Recreation	Organism criteria = 0.051 µg/L	
	Domestic Water Supply	2 µg/L	
Nickel, Ni	FAL	FAL toxic substances criteria*	
	Domestic Water Supply	100 µg/L	
Nitrogen NO_3 & NO_2	FAL	Per *Development of Regionally Based Interpretations of Tennessee's Narrative Nutrient Criterion* (Denton et al., 2001)	
pH	FAL	Per FAL pH criteria.	
Residue, Dissolved	FAL	Will not be detrimental to FAL	
Residue, Settleable	FAL	Will not be detrimental to FAL	
Residue, Suspended	FAL	Will not be detrimental to FAL	
Residue, Total	FAL	Will not be detrimental to FAL	
Selenium, Se	FAL	FAL toxic substances criteria*	
Sulfates	FAL	Will not be detrimental to FAL	
Temperature field	FAL	≤ 30.5°C w. > 2°C change/hour Trout waters ≤ 20°C	
Total Hardness	FAL	Will not be detrimental to FAL	
Total Kjeldahl Nitrogen	FAL	Will not be detrimental to FAL	
Total Organic Carbon	FAL	Will not be detrimental to FAL	
Total Phosphorus	FAL	Per *Development of Regionally Based Interpretations of Tennessee's Narrative Nutrient Criterion* (Denton et al., 2001)	

Parameter	Use	Criteria*	Citation
Turbidity	FAL	Will not materially affect FAL	
Zinc, Zn	FAL	FAL toxic substances criteria*	
Biorecon	FAL	Per *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017)	
SQSH	FAL	Per *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017)	
Habitat Assessment	FAL	Per *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017)	
Toxic Substances	Domestic Water Supply	Will not “affect the health and safety of man or animals or impair the safety of conventionally treated water supplies”. *	

*This is a criteria summary. For specific criteria see *Rules of the TDEC*, Chapter 0400-40-03, General Water Quality Criteria (TDEC WQOG, 2019).
†Method detection limits are included in Appendix D. QC requirements are in Table 37.

Step 7 Optimal Design for Obtaining Data

1. Develop a long-term state monitoring strategy
2. Identify monitoring objectives
3. Select a monitoring design
4. Identify core and supplemental water quality indicators
5. Develop quality management and quality assurance plans
6. Use accessible electronic data systems
7. Determine methodology for assessing attainment of water quality standards
8. Produce water quality reports
9. Conduct periodic review of monitoring program
10. Identify current and future resource needs

A7.3 Measurement of Performance Criteria for Monitoring and Analyses

The division's monitoring program is evaluated during each planning and assessment cycle to develop the most comprehensive and effective plan. The sampling and monitoring processes are discussed in section B1 of this document. The specific data quality objectives and performance criteria as discussed below are expressed in terms of data quality indicators. The principal indicators are precision and accuracy, bias, representativeness, completeness, comparability, and sensitivity. A summary of data quality objectives and performance criteria are presented in Table 15.

A7.3.1 Precision and Accuracy

Precision and accuracy of all data collected is of prime importance for surface water monitoring. All data collected will be compared with the associated method's precision and accuracy capabilities outlined in the *Environmental Inorganic SOPs* (TDH, 2002-2020), and the *Environmental Organic SOPs* (TDH, 2002-2014) by the state lab. Field duplicate samples are collected at 10% of the sample sites. Duplicate chemical analyses are run on at least 10% of the samples. A precision chart for QC samples must be constructed after 20 measurements of the parameter or analyte of interest. Duplicate analysis of a standard or set of standards must be used to determine precision. An accuracy chart for QC samples must be constructed from the average and standard deviation values after 20 measurements of the parameter or analyte of interest. The QC samples must have the same standard concentration. Corrective action must be taken when the QC check exceeds the acceptance limits. The issue should be reported and documented in a bound logbook or lab notebook. Data that does not meet precision and accuracy requirements will be handled according to procedures outlined in section D1 and D2 of this document.

A7.3.2 Bias

Monitoring analyses on a check standard or set of standards over time controls bias and variability. Laboratory control charts must be constructed from the average and standard deviation values for each standard concentration used for QC. A change in the measurement on the check standard or set of standards that is persistently outside the upper control limit indicates a positive measurement bias. A change in the measurement on the check standard or set of standards that is persistently outside the lower control limit indicates a negative measurement bias. Data determined to be biased will be handled according to procedures outlined in section D3 of this document.

A7.3.3 Representativeness

The statewide monitoring program attempts to collect data that are representative of the environmental conditions being monitored. The types of monitoring are outlined in section A6 of this document. Each type of monitoring requires its own unique set of guidelines for the type of sampling and parameters analyzed. The specific type of chemical, bacteriological, or biological sample to be collected varies with the sampling objectives. The sampling strategy for each type of monitoring is shown in Table 9 of section A6. The guidelines for collecting a representative water sample are described in Protocol A of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018).* The guidelines for collecting a representative macroinvertebrate sample are described in Protocols A, F, and G of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017). The guidelines for collecting a representative periphyton sample are described in Protocols C, D, F and G of the *QSSOP for Periphyton Stream Sampling* (TDEC, 2010).

A7.3.4 Comparability

Data comparability is dependent on standardization of monitoring objectives, sampling, analysis, and data reporting. This is ensured through a collaborative monitoring effort by DWR WPU, the EFOs, and TDH Laboratories. The monitoring objectives are included in the *DWR Surface Water Monitoring and*

Assessment Program Plan (TDEC, 2020). Standardized sampling procedures for Chemical and Bacteriological sample collection are outlined in Protocol A of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018).* Standardized sampling procedures for collecting a macroinvertebrate sample are described in Protocols A, F, and G of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017). Standardized sampling procedures for collecting a periphyton sample are described in Protocols C, D, F and G of the *QSSOP for Periphyton Stream Sampling* (TDEC, 2010). Quality control samples are collected at 10% of sampling events. This includes trip blanks, field blanks, duplicate samples, temperature blanks, and equipment field blanks, if applicable. Typically, equipment field blanks are not checked because DWR samples *in situ* whenever possible. All data collected are documented by the EFO responsible for collection and the laboratory responsible for the analyses and reported to DWR WPU. The data are systematically entered into the Waterlog database using standardized forms illustrated in Appendix E.

A7.3.5 Completeness

The statewide monitoring program uses a 5-year watershed cycle to meet the demands of the water quality program data requirements. The watershed groups monitored in the 5-year watershed cycle are outlined in section A6 of this document. There are standard data quality objectives for each type of monitoring performed during the cycle. The percentage of valid data points relative to the total possible data points is calculated to determine the completeness of the monitoring objectives. The completeness of sampling, documentation, and chain-of-custody is ensured by using the protocols described in the *QSSOP for Chemical and Bacteriological Sampling for Surface Water* (TDEC, 2018), in the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017), and in the *QSSOP for Periphyton Stream Sampling (*TDEC, 2010*)*, the *Environmental Laboratories Laboratory Quality Assurance Plan* (TDH, 2020), and the *Environmental Organic SOPs* (TDH, 2002-2014).

A7.3.6 Sensitivity

Method sensitivity is determined by field and laboratory performance. Several factors influence the attainable level of sensitivity of sampling, chemical, bacteriological, and biological methodology. Field personnel must demonstrate the ability to properly collect samples by using the protocols outlined in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2018), the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017), and in the *QSSOP for Periphyton Stream Sampling* (TDEC, 2010). Laboratory analysts must demonstrate the ability to measure analytes of interest at the minimum required detection limit of the method, the instrument detection limits, or at regulatory levels. The analytical methods and associated sensitivities are described in the Environmental Laboratories *Laboratory Quality Assurance Plan (TDH, 2020), and the Environmental Organic SOPs* (TDH, 2002-2014).

Table 15: Record of Performance Criteria.

Performance Criteria	Chemical and Bacteriological	Biological
Matrix	Surface water	Benthic macroinvertebrates, diatoms
Parameter	Table 9	Biorecon SQKICK SQBANK RPS MPS
Project Action Level	Rules of the TDEC, Chapter 0400-40-03, General Water Quality Criteria (TDEC-WQOG, 2019)	Rules of the TDEC, Chapter 0400-40-03, General Water Quality Criteria (TDEC-WQOG, 2019)
Sampling Procedure	QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)	QSSOP for Macroinvertebrate Stream Surveys (TDEC, 2017) QSSOP for Periphyton Stream Survey (TDEC, 2010)

Performance Criteria	Chemical and Bacteriological	Biological
Analytical Method/SOP	Environmental Inorganic SOPs (TDH, 2002-2020)*, Environmental Organic SOPs (TDH, 2002-2014)*, and 40CFR part 136, May 18, 2012	QSSOP for Macroinvertebrate Stream Surveys (TDEC, 2017) QSSOP for Periphyton Stream Survey (TDEC, 2010)
Precision and Accuracy	Field duplicate samples are collected at 10% of samples per QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018). Duplicate chemical analyses are run on at least 10% of the samples. Laboratory precision is addressed in Environmental Laboratories Laboratory Quality Assurance Plan (TDH, 2020), Environmental Organic SOPs (TDH, 2002-2014)*. Precision for bacteriological analyses is addressed 40CFR part 136, May 18, 2012	Duplicate macroinvertebrate samples are collected at 10% of sites per QSSOP for Macroinvertebrate Stream Surveys (TDEC, 2017) Duplicate diatom samples are collected at 10% of sites per QSSOP for Periphyton Stream Survey (TDEC, 2010)

Performance Criteria	Chemical and Bacteriological	Biological
Bias	To avoid field sampling bias all samples, trip field blanks, and duplicates are collected following QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018). Laboratory bias is addressed in Environmental Laboratories Laboratory Quality Assurance Plan (TDH, 2020), Environmental Organic SOPs (TDH, 2002-2014)* and 40CFR part 136, May 18, 2012.	Duplicate macroinvertebrate samples are collected at 10% of sites. Sorting efficiency and taxonomic verification are completed on 10% of all samples per QSSOP for Macroinvertebrate Stream Surveys (TDEC, 2017). Probabilistic monitoring results are compared to targeted monitoring results to check for bias in watershed assessment. Duplicate diatom samples are collected at 10% of sites. QSSOP for Periphyton Stream Survey (TDEC, 2010)
Representativeness	A representative water sample is achieved by following guidelines in Protocol A of QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018).	A representative macroinvertebrate sample is collected by following guidelines in Protocols A, F, and G of QSSOP for Macroinvertebrate Stream Surveys (TDEC, 2017). Standardized sampling procedures for collecting a diatom sample are described in Protocols C, D, F and G of the QSSOP for Periphyton Stream Sampling (TDEC, 2010).

Performance Criteria	Chemical and Bacteriological	Biological
Completeness	Sampling, documentation, and chain-of-custody protocols are described in QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018) and Environmental Laboratories Laboratory Quality Assurance Plan (TDH, 2020) and Environmental Organic SOPs (TDH, 2002-2014)*	Sampling, documentation, and chain-of-custody protocols are described in QSSOP for Macroinvertebrate Stream Surveys (TDEC, 2017). Sampling, documentation, and chain-of-custody protocols are described in the QSSOP for Periphyton Stream Sampling (TDEC 2010).
Comparability	Duplicate samples at 10% of sampling events per QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018), Environmental Laboratories Laboratory Quality Assurance Plan (TDH, 2020), Environmental Organic SOPs (TDH, 2002-2014), and 40CFR part 136, May 18, 2012	Duplicate samples at 10% of sampling events per QSSOP for Macroinvertebrate Stream Surveys (TDEC, 2017) Duplicate diatom samples are collected at 10% of sites per QSSOP for Periphyton Stream Survey (TDEC, 2010).

Performance Criteria	Chemical and Bacteriological	Biological
Sensitivity	QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018), Environmental Laboratories Laboratory Quality Assurance Plan (TDH, 2020), Environmental Organic SOPs (TDH, 2002-2014)*, and 40CFR part 136, May 18, 2012	QSSOP for Macroinvertebrate Stream Surveys (TDEC, 2017), QSSOP for Periphyton Stream Survey (TDEC, 2010).

*A complete list of TDH Environmental Laboratories Standard Operating Procedures is included in the references.

A8 Special Training Requirements/Certification

A8.1 Training

Specialized training requirements for this project are described in this section. This includes field sampling techniques, field analyses, laboratory analyses, assessments, and data validation. All specifically mandated training requirements are also summarized here. New staff members receive on the job training by working with experienced staff in as many different studies and sampling situations as possible. During this training period, the new employees are encouraged to perform all sample collection tasks under the supervision of an experienced staff member. Staff members have at least 6 months of field experience before selecting sampling sites, sampling alone or leading a team.

Unless prohibited by travel restrictions, statewide training is conducted at least once a year through workshops, seminars and/or field demonstrations in an effort to maintain consistency, repeatability and precision between field staff conducting surveys. This is also an opportunity for personnel to discuss problems encountered with the methodologies and to suggest SOP revisions prior to the annual SOP review.

Environmental Laboratory chemists are trained in accordance with the *Environmental Inorganic SOPs* (TDH, 2002-2020). Environmental Laboratory aquatic biologists are trained in accordance with the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010). Microbiologists are trained according to *Standard Methods for Examination of Water and Wastewater* (APHA, 2012).

The QC coordinator assures that staff members receive required training annually. Supervisors (and/or managers) assure each employee hired is qualified and properly trained. A record of who has been trained and the type of training will be kept in each EFO. The employee's supervisor and the Department of Human Resources maintain personnel records and documentation. New training requirements are communicated to EFO managers, QAPP manager, in-house QC officers, and other key personnel through email. WPU maintains records on statewide training.

- The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) lists specific qualifications and training for personnel collecting macroinvertebrate biorecon or Semi-Quantitative Single Habitat samples.

- The *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018),* describes qualifications and training for personnel collecting chemical or bacteriological samples.

- The *QSSOP for Periphyton Stream Survey* (TDEC, 2010) describes qualifications and training for personnel collecting periphyton samples.

- The *Environmental Inorganic SOPs* (TDH, 2002-2020) and the *Environmental Organic SOPs* (TDH, 2002-2014) provide information on analyses and data validation training requirements for laboratory personnel.

A8.2 Certifications and Credentials

Table 16 summarizes certifications and credentials required for staff members participating in this project and the timeline needed for obtaining them, if necessary. Certificates and other documentation are maintained in employee personnel files.

Table 16: Summary of Required Certifications and Credentials for Projects

Title	Requirement	Other Requirements
PH Lab Scientist 1	B.S. in physical sciences (e.g. chemistry), ecology, life sciences (e.g. biology, microbiology, biochemistry or biophysics), medical laboratory science, pre-medicine, or other acceptable science.	No Experience
PH Lab Scientist 2	B.S. in physical sciences (e.g. chemistry), ecology, life sciences (e.g. biology, microbiology, biochemistry or biophysics), medical laboratory science, pre-medicine, or other acceptable science.	Experience equivalent to one year of full-time professional work in the related field.
PH Lab Scientist 3	B.S. in physical sciences (e.g. chemistry), ecology, life sciences (e.g. biology, microbiology, biochemistry or biophysics), medical laboratory science, pre-medicine, or other acceptable science.	Experience equivalent to three years of full-time professional work in the related field.
PH Lab Scientist 4	B.S. in physical sciences (e.g. chemistry), ecology, life sciences (e.g. biology, microbiology, biochemistry or biophysics), medical laboratory science, pre-medicine, or other acceptable science.	Experience equivalent to five years of full-time professional work in the related field.

Table 16: Summary of Required Certifications and Credentials for Projects

Title	Requirement	Other Requirements
PH Lab Consultant 2	B.S. in physical sciences (e.g. chemistry), ecology, life sciences (e.g. biology, microbiology, biochemistry or biophysics), medical laboratory science, pre-medicine, or other acceptable science.	Have graduated from an accredited college or university with a bachelor's degree in chemistry, including at least 32 credit hours in the following areas: (1) general chemistry, (2) organic chemistry, (3) quantitative analysis, (4) instrumental analysis and (5) physical chemistry.
PH Lab Manager 1	B.S. in physical sciences (e.g. chemistry), ecology, life sciences (e.g. biology, microbiology, biochemistry or biophysics), medical laboratory science, pre-medicine, or other acceptable science.	Experience equivalent to one year of full-time professional work in the related field.
PH Lab Manager 2	B.S. in physical sciences (e.g. chemistry), ecology, life sciences (e.g. biology, microbiology, biochemistry or biophysics), medical laboratory science, pre-medicine, or other acceptable science.	Experience equivalent to two years of full-time professional work in the related field.

Table 16: Summary of Required Certifications and Credentials for Projects

Title	Requirement	Other Requirements
PH Lab Manager 4	B.S. in physical sciences (e.g. chemistry), ecology, life sciences (e.g. biology, microbiology, biochemistry or biophysics), medical laboratory science, pre-medicine, or other acceptable science.	Experience equivalent to five years of full-time professional work in the related field.
TDEC Environmental Manager	B.S. in environmental science, biology, chemistry, geology, engineering or another acceptable field.	Five years of full-time professional environmental program work, including at least two years of supervisory.
PH Lab Division Director		There is no formal job description for this classification. The job title is executive service and serves at the pleasure of the appointing authority of the department in which the position is located.
Lab Supervisor 2 (Certified)	Possession of a doctorate in microbiology, biology, chemistry, or public health and laboratory practices from an accredited university	Two years or responsible professional health laboratory experience and licensed as a Medical Laboratory Technologist by the TDH.

Table 16: Summary of Required Certifications and Credentials for Projects

Title	Requirement	Other Requirements
Lab Supervisor 3	Possession of a doctorate in microbiology, biology, chemistry, or public health and laboratory practices from an accredited university	For Executive Service positions – minimum qualifications, necessary special qualification, and examination method are determined by the appointing authority.
TDEC Deputy Director		There is no formal job description for this classification. The job title is executive service and serves at the pleasure of the appointing authority of the department in which the position is located.
TDEC DWR Director		There is no formal job description for this classification. The job title is executive service and serves at the pleasure of the appointing authority of the department in which the position is located.

Table 16: Summary of Required Certifications and Credentials for Projects

Title	Requirement	Other Requirements
TDEC Environmental Consultant 1	Graduation from an accredited college or university with a bachelor's degree in environmental science, biology, chemistry, geology, engineering or other acceptable science related field.	Three years of full-time professional environmental program.
TDEC Environmental Consultant 2	Graduation from an accredited college or university with a bachelor's degree in environmental science, biology, chemistry, geology, engineering or other acceptable science related field.	Five years of full-time professional environmental program.
TDEC Environmental Consultant 3	Graduation from an accredited college or university with a bachelor's degree in environmental science, biology, chemistry, geology, engineering or other acceptable science related field.	Five years of full-time professional environmental program.
TDEC Environmental Consultant 4	Graduation from an accredited college or university with a bachelor's degree in environmental science, biology, chemistry, geology, engineering or other acceptable science related field.	Seven years of full-time professional environmental program.

Table 16: Summary of Required Certifications and Credentials for Projects

Title	Requirement	Other Requirements
TDEC Environmental Fellow		There is no formal job description for this classification. The job title is executive service and serves at the pleasure of the appointing authority of the department in which the position is located.
TDEC Environmental Manager 2	Graduation from an accredited college or university with a bachelor's degree in environmental science, biology, chemistry, geology, engineering or other acceptable science related field.	Five years of full-time professional environmental program.
TDEC Environmental Manager 3	Graduation from an accredited college or university with a bachelor's degree in environmental science, biology, chemistry, geology, engineering or other acceptable science related field.	Five years of full-time professional environmental program.
TDEC Environmental Manager 4	Graduation from an accredited college or university with a bachelor's degree in environmental science, biology, chemistry, geology, engineering or other acceptable science related field.	Seven years of full-time professional environmental program.

Table 16: Summary of Required Certifications and Credentials for Projects

Title	Requirement	Other Requirements
TDEC Environmental Protection Specialist 3	Graduation from an accredited college or university with a bachelor's degree in engineering.	Three years of full-time professional environmental engineering work.
TDEC Environmental Scientist 1	Graduation from an accredited college or university with a bachelor's degree in environmental science, biology, chemistry, geology, engineering or other acceptable science related field.	
TDEC Environmental Scientist 2	Graduation from an accredited college or university with a bachelor's degree in environmental science, biology, chemistry, geology, engineering or other acceptable science related field.	One year of full-time professional environmental program.
TDEC Environmental Scientist 3	Graduation from an accredited college or university with a bachelor's degree in environmental science, biology, chemistry, geology, engineering or other acceptable science related field.	Three years of full-time professional environmental program.

A9 DOCUMENTATION AND RECORDS

A9.1 Field Documentation

Required field data sheets for chemical and bacteriological samples:

- Analysis Request and Chain of Custody Form
- Flow measurement sheet or field book (if flow is to be measured)
- Required field data sheets or field book

The *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* provides field documentation and chain of custody requirements for chemical or bacteriological sampling.

Required paper or electronic data sheets for macroinvertebrate samples:

- Habitat assessment data sheet
- Stream survey sheet
- Macroinvertebrate taxa lists (biorecon only)
- Biorecon field sheets (biorecon only)
- Site pictures
- Analysis Request and Chain of Custody Form (for samples sent to TDH Environmental Laboratories for analyses).

The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) provides complete instructions on field documentation and chain of custody requirements for macroinvertebrate surveys.

Required paper or electronic data sheets for diatom samples:

- Habitat assessment data sheet
- Rapid periphyton survey data sheet (required at Ecoregion reference sites and SEMN and recommended at waterbodies with suspected nutrient enrichment).

- Analysis Request and Chain of Custody Form

The *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) provides complete instructions on field documentation and chain of custody requirements for periphyton surveys.

A9.2 EFO Documentation

Required documentation and logs for EFOs:

- Flow meter calibration and maintenance logbook and manual
- Field water parameter meter calibration and maintenance logbook and manual
- Macroinvertebrate sample log
- Macroinvertebrate QC log (if analyzing biological samples in-house)
- Periphyton sample log and QC log
- Biologist Qualifications

A9.3 Laboratory Turnaround Time Requirements

Generally chemical and bacteriological analyses results are received from the TDH Environmental Laboratories within 25 days of receiving the sample. If results are not received in the expected time period, EFO staff or CO WPU staff contact the appropriate TDH Environmental Laboratories section manager. Chemical and bacteriological analyses results sheets are stored electronically and permanently in the DWR central office. Turnaround time for routine inorganic and organic samples is 25 business days after receipt of samples. For routine environmental microbiology samples, the turnaround time is 7 business days after receipt of samples. Turnaround times for antidegradation SQSH samples are 30 days, after receipt of the sample at the lab, and negotiated on a project-by-project basis for other samples. Biological analytical turnaround is adjusted according to specific project deadlines and are negotiated per agreements between TDEC and TDH. (If results are needed sooner than standard turnaround times, the priority date is recorded on the Analysis Request Forms.) Biological samples are maintained for at least five years.

Biological data and field sheets are stored electronically permanently in the DWR central office. Samples collected after July 2017 are stored in Waterlog.

A9.4 Laboratory Documentation

A9.4.a Chemical and Bacteriological Documentation

- Chemical and bacteriological analyses report
- Copy of sample chain of custody
- Copy of chain of custody for sample transfer
- Chemical and bacteriological sample receipt logs
- Chemical and bacteriological analyses QC logs

The TDH Environmental Laboratories produce a work order report using Microsoft Excel. This Excel file is an Electronic Deliverable Data (EDD) file in a WQX format that is uploaded into Waterlog. The work order report (chemical and bacteriological analyses report) contains sample identification and analytical results. The *Environmental Laboratories Laboratory Quality Assurance Plan* (TDH, 2020) and the *Environmental Inorganic Laboratory SOPs* (TDH, 2002-2020), and the *Environmental Organic Laboratory SOPs* (TDH, 2002-2014) provide required laboratory documentation. Table 17 lists required chemical and bacteriological analyses results documentation.

A9.4.b Macroinvertebrate and Periphyton Documentation

(reporting laboratory may be at field office)

- SQSH taxa list uploaded to Waterlog
- Biological Sample Request and Chain of Custody Form
- Biorecon taxa list uploaded to Waterlog
- Habitat assessment uploaded to Waterlog
- Stream survey sheet uploaded to Waterlog
- Sample log (Waterlog report)
- QC log (Waterlog report)
- Rapid Periphyton Survey Sheet uploaded to Waterlog (optional unless SEMN)
- Diatom taxa list uploaded to Waterlog
- Bioform uploaded to Waterlog

The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) and the *Biological Survey Electronic Guidance* (TDEC, 2017) provide detailed information about biological documentation. Table 17 lists required biological analyses results documentation.

Table 17: Data Reporting Packages

Biological Data Reporting Package	Chemical and Bacteriological Data Reporting Package
Taxa list uploaded to Waterlog by sampler (biorecons) or lab (SQSH and diatoms).	Analyses results in EDD format
Biometric Scores calculated by waterlog from taxa lists.	Reporting units in EDD format
Habitat assessment sheet (bioform) uploaded to Waterlog by sampler	Method in EDD format
Stream survey sheet (bioform) uploaded to Waterlog by sampler.	Detection limits
Rapid Periphyton Survey Sheet (bioform) uploaded to Waterlog by sampler.	Analysis Request and Chain of Custody Form
Analysis Request and Chain of Custody Form	Laboratory Sample Control Log and Manifest and Inter Laboratory Chain of Custody
Biorecon field sheet (biorecons only) bioform.	Physical water parameters uploaded to Waterlog by sampler

A9.5 Management and Quality Assurance

The *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)*, the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017), the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010), the *Environmental Laboratories*

Laboratory Quality Assurance Plan (TDH, 2020), *Standard Methods for Examination of Waters and Wastewater* (APHA, 2017) and 40 CFR136.7 2012, which requires twelve QC elements to be included in the laboratory's SOPs, provides quality assurance requirements.

A9.6 Audit Reports

- DWR historically audited EFOs periodically by the QAPP Manager or EFO Deputy Director. (A copy of the Historic EFO Audit report is in Appendix F.
- EPA audits TDH Environmental Laboratories every three years with a report submitted to the Commissioner of TDEC.

A9.7 Other Reports, Documents and Records

Following processing and quality control checks, chemical, bacteriological, biological, and habitat results are entered into the TDEC – DWR database maintained by WPU in Waterlog. Annually, WPU and EFO personnel compare results to water quality criteria and ecoregional reference data to determine use support for waterbodies monitored in that year. The agreed upon assessments are entered into ATTAINS.

Ultimately, the watershed monitoring, assessments, and data are submitted to EPA through ATTAINS. TMDL monitoring results are incorporated in the TMDL. Ecoregion reference monitoring is used to refine the *Rules of the TDEC*, Chapter 0400-40-04-3, General Water Quality Criteria (TDEC-WQOG, 2019) and for assessment purposes. The division uses feedback from EPA, other state and federal agencies, as well as the private sector, to improve and enhance the reporting process.

A9.8 Data Storage and Retention

Electronic records, including the current Waterlog database, are stored on the TDEC Central Office server, and are backed-up nightly on 22-cycle tape by STS personnel. Environmental Field Offices and the TDH Environmental Electronic (pdf) files are stored indefinitely on the DWR H: drive, an external hard drive and on SharePoint (Table 18). Bioforms are stored in Waterlog post July 1, 2017. Earlier field forms are stored on DQR shared drive or paper files. TDH Environmental Laboratories logs, instrument printouts, calibration records, and QC documents are stored at TDH Environmental Laboratories. All noncompliance sample analytical data are be stored for 5 years, and then destroyed. The lab has changed to a paperless or electronic (pdf) storage process. Whenever revisions are made to this QAPP, the QAPP Project Manager will send an electronic copy of the updates to the individuals identified in the distribution list in Section A3.

Table 18: Summary of Project Data Reports and Records

RECORD OR DATA TYPE*	ELECTRONIC	PAPER
Chemical and bacteriological analyses reports and field measurements	H: Lab files and external hard drive SharePoint STORET Legacy (up to 2009) STORET Modern (2009 to present) WQX Waterlog	
Chemical and bacteriological Analysis Request and Chain of Custody Form	H: Lab files, SharePoint and external hard drive	
Habitat assessment data	Waterlog	Some older data in watershed files will be scanned when staff time is available.

RECORD OR DATA TYPE*	ELECTRONIC	PAPER
Stream survey sheet	Waterlog H: files prior to 2017.	Some older data in watershed files will be scanned when staff time is available.
Macroinvertebrate assessment report	All semi-quantitative data and newer biorecon (post 2017) and all reference data are in Waterlog. H: lab biological files prior to 2017.	Some older data in watershed files will be scanned when staff time is available.
Biological Analysis Request and Chain of Custody Form	H: lab biological files	Some older data in watershed files will be scanned when staff time is available.
Macroinvertebrate and Diatom taxa lists	All semi-quantitative data as well as biorecon and diatoms post 2017 are in Waterlog. Bio-recons prior to 2017 are in pa-per files. Diatom taxa lists prior to 2017 are in EDAS or paper files	Some older data in watershed files will be scanned and taxa lists entered when staff time is available.
Rapid periphyton survey data sheet	Waterlog	Some older data in watershed files will be scanned and taxa lists entered when staff time is available.

RECORD OR DATA TYPE*	ELECTRONIC	PAPER
Field instrument calibration		EFO logbooks
Diurnal dissolved oxygen data	Excel spreadsheets on H drive and SharePoint. Will transfer to TNCON database if it becomes operational.	
TDH Environmental Laboratories instrument calibration		TDH Environmental Laboratories
Fish tissue data	Waterlog.	Some older data in fish files will be scanned when staff time is available.

PART B

MEASUREMENT AND DATA ACQUISITION

B1 SAMPLING PROCESS DESIGN (Monitoring Program Experimental Design)

The experimental design and rationale were established using the Data Quality Objective (DQO) Process as documented in Part A. The following sections describe implementation of design.

B1.1 Background and Design Monitoring Program Strategy

The division has a comprehensive monitoring program that serves its water quality management needs. Groundwater issues are managed by a different unit in the division and will be addressed in a separate document.

In 1996, WPC adopted a watershed approach that reorganized existing programs, based on management, and focused on place-based water quality management. This approach addresses all Tennessee surface waters including streams, rivers, lakes, reservoirs and wetlands. The primary goals of the watershed approach are:

- Improve water quality assessments
- Assure equitable distribution of pollutant limits for permitted dischargers
- Develop watershed water quality management strategies that integrate controls for point and non-point sources of pollution
- Increase public awareness of water quality issues and provide opportunities for public involvement

The 54 USGS eight-digit hydrologic unit codes (HUC) in Tennessee have been divided into five monitoring groups for assessment purposes. One group, consisting of between 9 and 16 watersheds, is monitored and assessed each year. This allows intense monitoring of a limited number of watersheds each year with all watersheds monitored every five years. Tennessee has completed three entire cycles.

The watershed cycle provides a logical progression from data collection and assessments to TMDL development and permit issuance. The watershed cycle coincides with the development of permits issued to industries, municipalities, mining and commercial entities. The key activities involved in each five-year cycle are:

1. **Planning and Data Collection** – Existing data and reports from appropriate federal and state agencies as well as private organizations are compiled and used to describe the quality of streams, rivers, lakes, reservoirs and wetlands.

2. **Monitoring** – Field data are collected for targeted waterbodies in the watershed. These data supplement existing data and are used for water quality assessment.

3. **Assessment** – Monitoring data are compared to existing water quality standards to determine if the waterbodies support designated uses.

4. **Wasteload Allocation/Total Maximum Daily Load (TMDL)** – Monitoring data are used to determine pollutant limits for treated effluent released into the watershed by permittees. Limits are set to assure that state water quality is protected. The TMDL program identifies continuing pollution problems in the state and then determines how to solve the problem. The Total Maximum Daily Load is calculated considering all sources of pollution for the stream segment and includes a margin of safety.

5. **Permits** – Issuance and expiration of all discharge permits are synchronized with watershed assessments. Tennessee has approximately 430 mining and 600 individual discharge permits under the federally delegated National Pollutant Discharge Elimination System (NPDES) program.

6. **Watershed Management Plans** – Watershed management plans are developed for each watershed. The plans include a general watershed description, water quality goals, major quality concerns and issues and watershed management strategies.

This approach considers all sources of water pollution including discharges from industries and municipalities and runoff from agriculture and urban areas. Another advantage is the coordination of local, state and federal agencies and the encouragement of public participation.

B1.2 Monitoring Objectives

The purpose of the division's water quality monitoring program is to provide a measure of Tennessee's progress toward meeting the goals established in the Federal Clean Water Act and the Tennessee Water Quality Control Act. To accomplish this task, data are collected and interpreted in order to:

1. Assess the condition of the state's waters.
2. Identify problem areas with parameter values that violate Tennessee numerical or narrative Water Quality Standards.
3. Identify causes and sources of water quality problems.
4. Document areas with potential human health threats due to fish tissue contamination or elevated bacteria levels.
5. Establish trends in water quality.
6. Gauge compliance with NPDES permit limits.
7. Document baseline waterbody conditions prior to a potential impact; provide a reference stream for downstream or other sites within the same ecoregion and/or watershed.
8. Assess water quality improvements based on site remediation, Best Management Practices (BMP), and other restoration strategies.
9. Identify proper waterbody-use classification, including Antidegradation Statement implementation.
10. Identify natural reference conditions on an ecoregion basis for refinement of water quality standards.

11. Identify and protect wetlands.

B1.3 Monitoring Design

Tennessee uses several methodologies in its waterbody monitoring design. The primary monitoring design is a five-year rotational cycle based on USGS eight-digit HUC units.

B1.3.a Watersheds

The watershed approach serves as an organizational framework for systematic assessment of Tennessee's water quality. Assessing the entire drainage area allows DWR to address water quality problems using an organized schedule and provides an in-depth study of each watershed, encouraging coordination among public and governmental organizations.

The watershed approach is a five-year cycle that has the following features:

- Commits to a monitoring strategy that results in an accurate assessment of water quality
- Synchronizes discharge permit issuance with the development of TMDLs
- Establishes TMDLs by integrating point and non-point source pollution
- Partners with other agencies to obtain the most current water quality and quantity data

To attain the watershed goals mentioned above, four major objectives must be met:

- Monitoring water quality intensively within each watershed at the appropriate time in the five-year watershed cycle
- Establishing TMDLs based on best available monitoring data and sound science
- Developing a watershed water quality management plan

- Attaining good representation from all local interests at public meetings and continuing a dialogue with local interest throughout the five-year cycle

Watersheds are organized by the 54 USGS eight-digit HUC codes found in Tennessee. The watersheds are addressed by groups on a five-year cycle coinciding with permit issuance and renewal. Each watershed group contains between 9 and 16 watersheds.

Six key activities occur during the cycle:

1. Planning. Existing data and reports from appropriate federal, state, and local agencies and citizen-based organizations are compiled and used to describe the quality of rivers and streams, and to determine monitoring priorities. Priority of streams to be sampled are listed in Section B.1.4 of this document.

2. Monitoring. Field data is collected by DWR staff for streams previously prioritized. These data supplement existing data and are used for water quality assessments.

3. Assessment. Monitoring data is used to determine if the streams support their designated uses based on stream classifications and water quality criteria. The assessment is used to create the EPA Approved List of Impaired and Threatened Waters and ATTAINS.

4. Wasteload Allocation/TMDL. Monitoring data is used to determine pollutant limits for permitted dischargers releasing wastewater to the watershed. Limits are set to ensure that state water quality is protective. TMDLs are studies that determine the point and nonpoint source contributions of a pollutant in the watershed.

5. Permits. Issuance and expiration of all discharge permits is synchronized to the five-year watershed cycle. Individual permits are issued by Tennessee under the National Pollutant Discharge Elimination System (NPDES).

6. Watershed Water Quality Management Plans. These watershed plans include a general watershed description, water quality assessment summary results, inventory of point and nonpoint sources, water quality concerns, federal, state, and local initiatives, and management strategies.

Figure 2: Graphic Representation of the Watershed Cycle

More details may be found on the DWR homepage ; https://www.tn.gov/environment/program-areas/wr-water-resources-home.html
The watershed management groups are shown in Figure 2. Monitoring activities are coordinated with TVA, DOE, TDA, TWRA, USGS, and USACE to avoid duplication of effort and increase watershed coverage.

B1.3.b Ecoregions

Tennessee relies heavily on ecoregions to serve as a geographical framework for establishing regional water quality expectations (Arnwine et al, 2000). Tennessee has 31 Level IV ecological subregions in the state (Figure 3). Selection criteria for reference sites included minimal impairment and representativeness. Streams that did not flow across subregions were targeted so the distinctive characteristics of each subregion could be identified.

Three hundred and fifty-three potential reference sites were evaluated as part of the ecoregion project. The reference sites were chosen to represent the best attainable conditions for all streams with similar characteristics in each subregion. Reference conditions represented a set of expectations for physical habitat, general water quality and the health of the biological communities in the absence of human disturbance and pollution.

Based on EPA recommendations, three reference streams per subregion were considered the minimum necessary for statistical validity. Only two streams could be found in smaller subregions. Seventy streams were targeted for intensive monitoring beginning in 1996. After analyses of the first year's data, it was determined that a minimum of five streams per subregion would be more appropriate. Where possible, additional reference streams were added. However, in smaller subregions or those with widespread human impact this was not possible. Forty-four reference streams were added to the study resulting in intensive monitoring at 114 sites beginning in the fall 1997. There were between two and eight reference streams targeted in each subregion.

All reference sites were monitored quarterly for three consecutive years. Since 1999, sites have been monitored as part of the five-year watershed cycle. New reference sites are added, as they are located during watershed monitoring, while some of those originally selected sites have been dropped due to increased disturbances or unsuitability. This reference database has been used to establish regional guidelines for wadeable streams.

In 2007, six additional subregions were added in ecoregions 66, 68, 69 and 73 resulting in 31 Level IV ecoregions in Tennessee. In addition, the names of four subregions have been revised (65e, 66d, 69d and 73a).

With the exception of 69e, the majority of new subregions are very small, or the streams originate in a different subregion. Therefore, it may not be necessary or even possible to find reference streams. Until such time as reference sites can be established these subregions will be treated as part of their original subregion and/or bioregion for assessment purposes.

B1.4 Scheduled Project Activities Including Measurement Activities

Monitoring Priorities

The division maintains a statewide monitoring system consisting of approximately 8000 stations. In addition, new stations are created every year to increase the number of assessed streams. Approximately 539 stations will be monitored in FY 20-21 (Figure 5 and Appendix C). Stations are sampled monthly, quarterly, bimonthly, semi-annually, or annually depending on the objectives of the project. Within each watershed cycle, the locations of monitoring stations are coordinated between the central office and staff in the eight Environmental Field Offices (EFOs) and the Mining Unit located across the state, based on the following priorities.

Prior to developing workplans, field staff should coordinate with other monitoring agencies within the watershed in order to maximize resources and avoid duplication of efforts.

1. **Antidegradation Monitoring**: Before the division can authorize degradation in Tennessee waterbodies, the appropriate category under the Antidegradation Policy must be determined. These categories are (1) Available or (2) Unavailable Parameters, (3) Exceptional Tennessee Waters, or (4) Outstanding National Resource Waters (ORNLs). ORNLs can only be established by promulgation by the Tennessee

Board of Water Quality, Oil and Gas. The other three categories must be established by division field or permitting staff. Complicating matters further, waterbodies can be in more than one category at a time, due to the parameter-specific nature of categories 1 and 2 above.

If a permit application requesting authorization to degrade water quality is for a stream without recent (within last five years unless conditions have changed) water quality data, unless the applicant is willing to provide the needed information in a timely manner, these surveys must be done by field office staff. Because the identification of antidegradation status must be determined prior to permit issuance, this work must be done on the highest priority basis.

Streams are evaluated as needed in response to requests for new or expanded National Pollutant Discharge Elimination System (NPDES) and Aquatic Resource Alteration Permit (ARAP) permits, including ARAP water withdrawal applications. Streams are evaluated for antidegradation status based on a standardized evaluation process, which includes information on specialized recreation uses, scenic values, ecological consideration, biological integrity and water quality. Since permit requests generally cannot be anticipated, these evaluations are generally not included in the workplan. The number of antidegradation evaluations conducted by the state is steadily increasing as the process becomes more refined and standardized.

2. **Posted Streams:** When the department issues advisories due to elevated public health risks from excessive pathogen or contaminant levels in fish, it accepts a responsibility to monitor changes in those streams. In the case of fishing advisories, in conjunction with the monitoring cycle, field office staff should determine when tissue samples were last collected and if appropriate, notify the central office that the state lab should be contracted to sample in the upcoming watershed year, unless another agency like TWRA or TVA are willing to do the collections. This should be coordinated with the central

office. During review of field office monitoring plans for the upcoming watershed year, central office may also discuss needed tissue sampling with the field office.

For pathogen advisories, in conjunction with the monitoring cycle, monthly *E. coli* samples, plus a minimum of one geo mean sample (5 samples in 30 days) must be scheduled and accomplished. If another entity (such as an MS4 program) has already planned to collect samples, that effort can substitute for division sampling, if staff have confidence that the other entity can meet data quality objectives. However, field office staff must confirm that this sampling is taking place, remembering that the ultimate responsibility to ensure that sampling is done remains with the division.

As fish tissue or pathogen results are received and reviewed, field office staff should communicate with the central office and vice versa if it appears that an advisory could possibly be lifted. Additionally, field office staff have the primary responsibility to ensure that existing signs on posted waterbodies are inspected periodically (annually is preferred) and replaced if damaged or removed.

3. **Ecoregion Reference Streams, Ambient Monitoring Stations, and Southeastern Monitoring Network Trend Stations (SEMN):** Established ecoregion or headwater reference stations are monitored in conjunction with the watershed cycle. Each station is sampled quarterly for chemical quality and pathogens as well as in spring and fall for macroinvertebrates and habitat. Periphyton is sampled once during the growing season (April – October). Both semi-quantitative and biorecon benthic samples are collected to provide data for both biocriteria and biorecon guidelines. If watershed screening efforts indicate a potential new reference site, more intensive reference stream monitoring protocols are used to determine potential inclusion in the reference database.

Ambient Monitoring Sites are the division's longest existing trend stations and any disruption in sampling over time reduces our ability to make comparisons. Regardless of monitoring cycle, all ambient stations must be sampled quarterly according to the set list of parameters established for this sampling effort.

Southeastern Monitoring Network Stations: Like ambient stations, SEMN stations within each field office area must be sampled according to the project plan and grant for this project, regardless of watershed cycle.

4. **EPA Approved List of Impaired and Threatened Waters segments:** The EPA Approved List of Impaired and Threatened Waters is a compilation of the streams and lakes in Tennessee that are "water quality limited" and need additional pollution controls. Water quality limited streams are those that have one or more properties that violate water quality standards. They are considered impaired by pollution and not fully meeting designated uses.

   Like posted streams, by identifying these streams as not meeting water quality standards, the division accepts responsibility to develop control strategies and to continue monitoring in order to track progress towards restoration.

   Impaired waters are monitored, at a minimum, every five years coinciding with the watershed cycle. Waters that do not support fish and aquatic life are sampled once for macroinvertebrates (semi-quantitative sample preferred) and monthly for the listed pollutant(s). Streams with impacted recreational uses, such as those impaired due to pathogens are sampled monthly for *E. coli.* Another acceptable sampling strategy for *E. coli* is called the Horton Rule. In this approach, an initial geometric mean within the first quarter is collected (5 samples within a 30-day period). If the results are well over the existing water quality criterion of 126 colony forming units, no additional sampling needs to be done. If results meet the water quality criterion, staff will continue with monthly samples during the remainder of the monitoring cycle. If the geomean is not substantially over the criterion, field staff may at their discretion continue monitoring in the hope that additional samples will indicate that the criterion is met.

For parameters other than pathogens, resource limitations or data results may sometimes justify fewer sample collections. For example, there are cases where pollutants are at high enough levels that sampling frequency may be reduced while still providing a statistically sound basis for assessments. In other cases, monitoring may be appropriately bypassed during a monitoring cycle. (Chapter II, Section C).

When developing workplans prior to the next monitoring cycle, field office staff should coordinate with the Division of Remediation (DoR) to confirm that any Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites are being monitored by either DoR or the permittee. DoR should be specifically asked if the site continues to violate water quality standards. If not, sampling should be designed to document improvement and provide a rationale for delisting.

5. **Sampling downstream of Major Dischargers and CAFO's:** During each monitoring cycle, the major dischargers should be identified. Stations should be established at those waterbodies, if the facility does not currently have in-stream monitoring requirements built into their permit. The pollutant of concern and the effect it would have on the receiving stream may determine the location of the station. (Note: stations may not be required for dischargers into very large waterways such as the Mississippi River or large reservoirs.) Frequent collection (monthly recommended) of parameters should

include those being discharged, plus a SQSH survey if the stream is wadeable. Stations downstream of STPs or industries that discharge nutrients should include a SQSH, plus monthly nutrient monitoring.

Stations should also be established downstream of CAFOs with individual permits or others in which water quality based public complaints have been received. The emphasis should be on monitoring biointegrity (SQSH survey if the stream is wadeable or in a region in which SQBANK surveys can be done) and monthly nutrient and pathogen sampling.

6. **TMDL:** Waterbody monitoring is required to develop TMDLs. Monitoring for scheduled TMDLs in the watershed group is coordinated between the Watershed Management Unit (WMU) manager and the EFOs to meet objectives for each TMDL. The frequency and parameters monitored for TMDL monitoring depends on the specific TMDL. Detailed information about TMDLs can be found in the department's 106 Monitoring QAPP, (TDEC, 2015), and in the document *Monitoring to Support TMDL Development* (TDEC, 2001).

7. **Special Project Monitoring:** Occasionally, the division is given the opportunity to compete for special EPA grant resources for monitoring and other water quality research projects. If awarded, activities related to these grants become a high priority because the division is under contract to achieve the milestone set out in the workplan. Federal funds might have to be returned if the division fails to meet project goals. Additionally, failure to meet grant obligations may result in a loss of competitiveness for future grant opportunities.

Normally, monitoring activities related to these projects is contracted out to the state lab. However, if problems arise, field offices might be called upon if the lab is unable to fulfill the commitment. Examples of historical special studies include sediment oxygen demand surveys, nutrient studies, ecoregion delineation, coalfield studies, air deposition surveys, reference stream monitoring, and various probabilistic monitoring designs.

8. **Watershed Monitoring:** In addition to the previous priorities, each EFO should monitor additional stations to confirm continued support of designated uses and to increase the number of assessed waterbodies. Macroinvertebrate biorecons, habitat assessments, and field measurements of DO, specific conductance, pH and temperature are conducted at the majority of these sites. These priorities include:

    - Previously assessed segments, particularly large ones, that would likely revert to Category 3 unassessed status. (Note that a single site per assessed segment is generally adequate if assessment was supporting and no changes are evident).
    - Sites below ARAP activities or extensive nonpoint source impacts in wadeable streams where biological impairment is suspected. Examples might be unpermitted activities, violations of permit conditions, failure to install or maintain BMPs, large-scale development, clusters of stormwater permits, or a dramatic increase in impervious surfaces.
    - Unassessed reaches especially in third order or larger streams or in disturbed headwaters.
    - Pre-restoration or BMP monitoring. In most cases this sampling would be to document improvements but might also be needed to confirm that the stream is a good candidate for such a project. This protects against the possibility that a good stream could be harmed by unnecessary restoration.

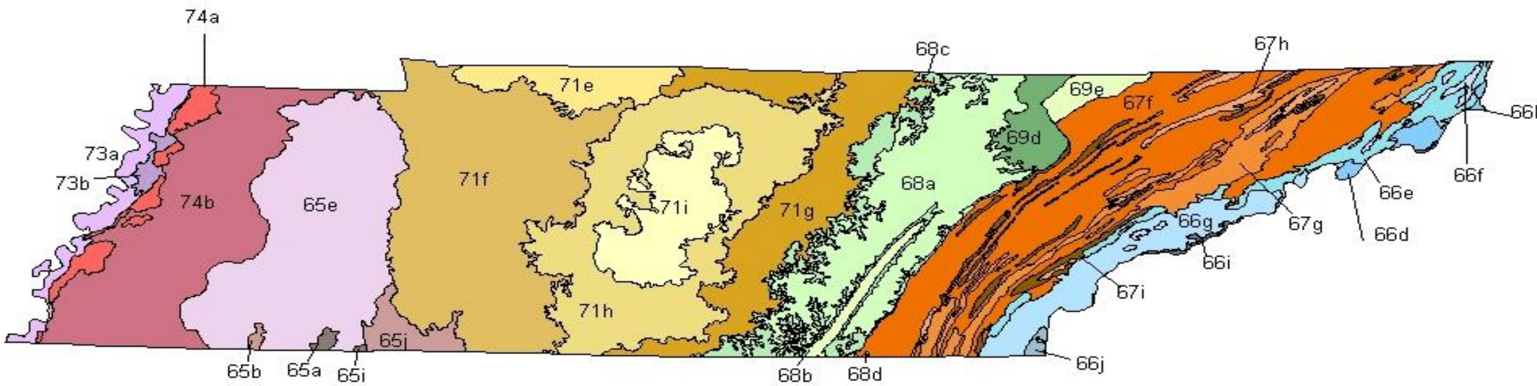

Figure 3: Level IV Ecoregions in Tennessee

65a Blackland Prairie	66k Amphibolite Mountains	69e Cumberland Mountain Thrust Block
65b Flatwoods/Alluvial Prairie Margins	67f Southern Limestone/Dolomite Valleys and Low Rolling Hills	71e Western Pennyroyal Karst
65e Northern Hilly Gulf Coastal Plain	67g Southern Shale Valleys	71f Western Highland Rim
65i Fall Line Hills	67h Southern Sandstone Ridges	71g Eastern Highland Rim
65j Transition Hills	67i Southern Dissected Ridges & Knobs	71h Outer Nashville Basin
66d Southern Crystaline Ridges and Mountains	68a Cumberland Plateau	71i Inner Nashville Basin
66e Southern Sedimentary Ridges	68b Sequatchie Valley	73a Northern Holocene Meander Belts
66f Limestone Valleys and Coves	68c Plateau Escarpment	73b Northern Pleistocene Valley Trains
66g Southern Metasedimentary Moun-tains	68d Southern Table Plateaus	74a Bluff Hills
66i High Mountains	69d Dissected Appalachian Plateau	74b Loess Plains
66j Broad Basins		

During development of the annual monitoring program plan, both Central Office and EFO staff provide input into monitoring needs.

- The monitoring program plan is reviewed to ensure all sampling and assessment priorities are addressed.
- The Attains is used to identify unassessed segments which are incorporated into the monitoring plan whenever possible.
- During plan development, Central Office and EFO staff coordinate location of monitoring stations and type of samples collected to ensure adequate information is provided for TMDLs targeted for completion during that cycle.
- The location of monitoring stations is coordinated with other state and federal agencies to eliminate duplication of effort.
- At the end of each monitoring cycle, the plan is reviewed to make sure monitoring needs were covered. Uncompleted sampling or data gaps are incorporated into the next years monitoring cycle or contracted to the TDH Environmental Laboratory Aquatic Biology Section for completion.

1. Antidegradation Monitoring –

Tennessee's water quality standards require the incorporation of the antidegradation policy into regulatory decisions (Chapter 0400-40-03-.06).

As one of the elements comprising Tennessee's water quality standards, the antidegradation statement has been contained in the criteria document since 1967. EPA has required the states, as a part of the standards process, to develop a policy and an implementation procedure for the antidegradation statement. "Additionally, the Tennessee Water Quality Standards shall not be construed as permitting the degradation of high-quality surface waters. Where the quality of Tennessee waters is better than the level necessary to support propagation of fish, shellfish, wildlife, and recreation in and on the water, that quality will be maintained and protected unless the state finds, after intergovernmental coordination and public participation, that lowering water quality is necessary to accommodate important economic or social development in the area in which the waters are located" (TDEC-WQCB, 2019).

A three-tiered antidegradation statement was incorporated into Tennessee's 1994 revisions. In the 1997 triennial review, the three tiers were more fully defined. A procedure for determining the proper tier of a stream was developed in 1998. The evaluation took into account specialized recreation, scenic considerations, ecology, biological integrity and water quality.

Tennessee further refined the antidegradation statement in 2004 specifying that alternatives analysis must take place before new or expanded discharges can be allowed in Tier I waters.

In 2006 the antidegradation statement was revised and the Tier designations were replaced by the following categories.

1. "Unavailable parameters 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."

2. "Available parameters 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."

3. Exceptional Tennessee Waters are waters in which no degradation will be allowed unless that change is justified as a result of

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.
* Streams with naturally reproducing trout.
* Waters with exceptional biological diversity as evidenced by a score of 40or 42 on the TMI (or a score of 28 or 30 in subregion 73a), provided that the sample is considered representative of overall stream conditions.
* Other waters with outstanding ecological, or recreational value as determined by the department.

1. Outstanding National Resource Waters (ONRW). These ETWs constitute an outstanding national resource due to their exceptional recreational or ecological significance. https://publications.tnsosfiles.com/rules/0400/0400-40/0400-40-03.20190911.pdf.

   A record of Exceptional Tennessee Waters and Outstanding National Resource Waters is maintained on the Waterlog database and is posted on TDEC's website at https://dataviewers.tdec.tn.gov/pls/enf_reports/f?p=9034:34304:4364479562473527 .

   This record is updated as new high-quality waters are identified.

2. **TMDL Development Monitoring** – The Watershed Unit works with the EFOs to determine monitoring necessary for upcoming TMDLs. The number and location of monitoring stations vary by drainage area and possible pollutant sources. The document *Monitoring to Support TMDL Development* (TDEC, 2001) and the WMS manager are consulted for specific monitoring needs. Table 19 lists typical monitoring required for TMDL development.

Table 19: Minimum TMDL Monitoring

TMDL	Matrix	Analyses	Field Parameters	Flow	Frequency	Number of Data Points
Metals	Water	Hardness (CaCO3) TSS TOC Metals†	pH Temperature Specific conductance DO	Optional	Monthly	Min. 12**
pH	Water	Acidity, Total Alkalinity, Total TSS Hardness (CaCO3) TOC	pH Temperature Specific conductance DO	Optional	Monthly	Min. 12**
DO	Water	$CBOD_5$ NH3 NO2NO3 TKN Phosphorous, Total	pH Temperature Specific conductance DO	Optional	Monthly (DO can be diurnal)	Min. 12**
			Diurnal DO		1-2 (Low Flow)	Min. 14 days

TMDL	Matrix	Analyses	Field Parameters	Flow	Frequency	Number of Data Points
Nutrients	Water	NH3 NO2NO3 TKN Phosphorous, Total TSS Turbidity TOC Diatoms	pH Specific conductance Temperature DO	Optional	Monthly	Min 12** (at least 1 high flow/ quarter) min. 4 high-flow
			Diurnal DO		1-2 (Low Flow)	Min. 14 days
Pathogens***	Water	*E. coli* TSS Turbidity	pH Temperature Specific conductance DO	Optional	Monthly	Min 12** (at least 1 high flow/ quarter) min. 4 high-flow

** Unless weather conditions prevent the minimum sampling points
†Total Metal(s) on the EPA Approved List of Impaired and Threatened Waters (Dissolved preferred for Ag, Cd, Cu and Pb)
***If candidate for de-listing (BMPS installed, CAFO moved etc.) sample for listing/delisting 5/30 days.
If station is ambient station, quarterly sampling is sufficient (all parameters).

3. **Ecoregional Reference Stream (ECO and FECO) Monitoring** – Reference stream monitoring is performed at the established ecoregion reference site in the appropriate watershed group. Reference streams are sampled every 5 years coinciding with the watershed cycle. If watershed screening indicates a potential new reference site, more intensive protocols are used to determine potential inclusion in the reference database. The division's program plan (TDEC, 2021) lists the ecoregion stations to be sampled for the current FY. Table 20 specifies ecoregion reference stream monitoring requirements.

Table 20: Ecoregion Reference Stream Monitoring Requirements

Annually**	Spring and Fall*	Quarterly Monitoring			
Diatom	**Benthic Macroinvertebrate**	**Water Field Parameter**	**Water Chemical Parameters**	**Water Bacteriological Parameters**	**Stream Flow**
MPS	Biorecon	DO	Alkalinity	*E. Coli* optional	Optional (required for SEMN)
RPS	SQSH	pH	Ammonia Nitrogen as N		
	Habitat Assessment	Temperature	Arsenic, As		
		Specific conductance	Cadmium, Cd		
			Chromium, Cr		
			Color, Apparent,		
			Color, True		
			Copper, Cu		
			Iron, Fe		
			Lead, Pb		
			Manganese, Mn		
			Nitrogen NO_3 & NO_2		
			Residue, Dissolved		
			Residue, Suspended		
			Selenium, Se		
			Sulfates (69d and 68a, SEMN only)		
			Total Hardness		
			Total Kjeldahl Nitrogen		
			Total Organic Carbon		
			Total Phosphorus		
			Turbidity		
			Zinc, Zn		

*Spring is January-June
Fall is July-December
** April-Oct

4. **Long Term Trend Station Monitoring –** At least quarterly, chemical and bacteriological samples are collected, and field water parameter measurements are taken at long term trend stations (Table 21). The division's program plan (TDEC, 2021) lists the long-term trend stations.

Table 21: Long Term Trend Monitoring Requirements

Field Water Parameters	**Chemical Parameters**	**Bacteriological Parameters**
Specific conductance	Alkalinity	*E. coli*
DO	Aluminum, Al	
pH	Ammonia	
Temperature	Arsenic, As	
	Cadmium, Cd	
	Chromium, Cr	
	Color, Apparent	
	Color, True	
	Copper, Cu	
	Iron, Fe	
	Lead, Pb	
	Manganese, Mn	
	Nickel, Ni	
	Nitrogen NO_3 & NO_2	
	Residue, Dissolved	
	Residue, Suspended	
	Residue, Total	
	Selenium, Se	
	Sulfates (68a & 69de)	
	Total Hardness	
	Total Kjeldahl Nitrogen	
	Total Organic Carbon	
	Total Phosphorus	
	Turbidity	
	Zinc, Zn	

5. Monitoring for EPA Approved List of Impaired and Threatened Waters

The EPA Approved List of Impaired and Threatened Water is a compilation of the streams and lakes in Tennessee that are "water quality limited" or are expected to exceed water quality standards in the next two years and need additional pollution controls. Water quality limited streams are those that have one or more properties that violate water quality standards. They are considered impaired by pollution and not fully meeting designated uses. Impaired waters are monitored, at a minimum, every five years coinciding with the watershed cycle. There are numerous reasons that this is good public policy:

1. Documentation of current conditions, which may change from year to year. This documentation can provide a rationale for "delisting" a stream from the EPA Approved Lists of Impaired and Threatened Waters or may just confirm the water's impairment status.

2. Sampling can provide data for pre or post TMDL evaluation. Data can be used for model calibration.

3. Surveys can document the need for enforcement actions.

4. Data can assist in the evaluation of the effectiveness of BMPs or help target BMP installation for maximum effectiveness.

5. Results over time can provide insight into historical water quality trends.

6. Conditions may represent a human health threat.

For these reasons, the monitoring of impaired waters is identified as a high priority for division field staff. The division's intended goal is to always collect new data on these waters unless there is a compelling reason for not doing so.

Waters that do not support fish and aquatic life are sampled once for macroinvertebrates (semi-quantitative sample preferred) and monthly for the listed pollutant(s). Streams with multiple listed segments are sampled monthly for the listed pollutant for each segment. Additional chemical parameters are collected if they are frequently associated with the listed parameters or if other pollutants are expected. (Hardness and TSS must always be collected in conjunction with metals.) Field parameters (minimally conductivity, pH, temp and DO) should always be included with any biological, chemical or pathogen monitoring (field parameters are required for ammonia). Ideally chemical parameters should be collected monthly although allowances are made for high levels of pollutant following the guidance in the QAPP (Table 22) for frequency of sampling. If a stream is being monitored monthly for other parameters, pathogen sampling should be included.

Ideally streams with impacted recreational uses, such as those impaired due to pathogens are sampled both geomean (five samples in 30 days) and monthly. If necessary, sample collections may be reduced by collecting a geomean within the first FY quarter (July-Sept). If the data confirms impairment, additional monitoring is not necessary. If the data are ambiguous or indicates improvement, monthly sampling should be conducted until a minimum of seven additional samples are collected. If the monthly data indicate improvement, additional monthly sampling and geomeans may be added in year 2.

Streams posted for water contact must be monitored at a minimum every five years. If another responsible party will be monitoring the stream, then the EFO does not need to sample the stream. The failure of another party to sample the stream places the burden back on the EFO to monitor the stream. THERE IS NO ACCEPTABLE REASON FOR FAILURE TO MONITOR A STREAM POSTED FOR WATER CONTACT.

Resource limitations or data results may sometimes justify fewer sample collections. For example, there are cases where pollutants are at high enough levels that sampling frequency may be reduced while still providing a statistically sound basis for assessments. In some other cases, monitoring may be appropriately bypassed during a monitoring cycle.

1. EPA approved list of impaired and threatened waters sites requiring no additional monitoring

All impaired streams in targeted watersheds must be accounted for in the program plan. If a field office is proposing to bypass monitoring of an impaired stream, an appropriate rationale must be provided and included in the program plan (Table 7). It is recommended that the EFO verify the condition of the stream at least every other cycle. Should an impaired stream be dry during two consecutive cycles, consideration should be given to requesting the stream be delisted based on low flow. Streams impacted by poor biology, habitat alterations, or siltation due to habitat alterations must still be monitored at least once (habitat assessment, plus SQSH or biorecon).

There are individual sites where conditions may justify retaining the impaired status of the stream without additional sampling during an assessment cycle. The reasons may include, but are not limited to, the following:

- Data have been collected by the division or another agency within the last five years and water quality is thought to be unchanged. If another division or agency has collected stream samples the EFO must follow up with that division or agency to retrieve the data and forward it to WPU.

- Another agency or a discharger has accepted responsibility for monitoring the stream and will provide the data to the division. During the planning process for each watershed cycle, field staff should recommend to the permitting unit those streams where it would be appropriate for monitoring to be performed by a discharger. Where permits are up for renewal, such conditions could be added.

- The stream is known to be dry or without flow during the majority of the year that sampling is being scheduled.

- Impounded streams impacted by flow alteration with no change in management of hydrology.

2. Impaired streams where additional sampling may be limited or discontinued

   There are individual sites where initial results may justify a discontinuation of sampling. The reasons are limited to the following:

   - Where emergency resource constraints may require that sampling be restricted after a monitoring cycle is initiated, but before it is completed. Discontinuation of monitoring on this basis must be approved in advance by the manager of the Watershed Planning Unit. Before requesting a halting of sampling in impaired streams, assistance from the TDH Aquatic Biology section should be considered. Such requests should be coordinated through the Watershed Planning Unit.

   - Initial stream sampling documents elevated levels of pollutants indicating, with appropriately high statistical confidence, that the applicable water quality criteria are still being violated. (Note – rain event sampling is inappropriate for this purpose.)

   The levels of pollutants that indicate continued water quality standards violations with statistical confidence are provided in Table 22. For example, if three samples are collected and all three values exceed the levels in the far-right hand column, then sampling for that parameter may be halted, as there is a very high probability that criteria would be exceeded in future sampling. If all three samples do not exceed the level provided in the table, then at least four more samples must be collected. If all seven samples exceed the levels in the middle column of the table, then sampling may cease. If all seven samples do not exceed the value in the table, then all sampling must be completed.

Important notes about this process:

- This process only applies to chemical parameters or bacteriological results. Streams impacted by poor biology, habitat alterations, or siltation due to habitat alterations must still be monitored at least once (habitat assessment, plus SQSH or biorecon), flow permitting.

- Rain event samples cannot be used to justify a reduction in sampling frequency.

- The division is not establishing new criteria with Table 22 and the numbers in the table should not be used independently to assess streams. These numbers, which are based on the actual criteria, simply indicated the statistical probability that the criteria have been exceeded by a dataset when the number of observations are considered.

- Where streams are impacted by multiple pollutants, all parameters must exceed the values in Table 22 before sampling can be halted.

Table 22: Minimum Sample Requirements for EPA Approved List of Impaired and Threatened Waters (Matrixes for all samples are water.)

Nutrient Sampling			
Ecoregions	**Nitrogen NO_3 & NO_2 (mg/L) †**		
	10 samples	7 samples	3 samples
73a	< 0.49	0.49 – 0.68	>0.68
74a, 65j, 68a	< 0.28	0.28 – 0.40	>0.40
74b	< 1.49	1.49 – 2.08	>2.08
65a, 65b, 65e, 65i	< 0.43	0.43 – 0.60	>0.60
71e	< 4.35	4.35 – 6.09	>6.09
71f	< 0.32	0.32 – 0.56	>0.56
71g, 71h, 71i	< 1.15	1.15 – 1.61	>1.61
68b	< 0.54	0.54 – 0.75	>0.75
69d	< 0.34	0.34 – 0.47	> 0.47
67f, 67g, 67h, 67i	< 1.53	1.53 – 2.14	>2.14
66d	< 0.63	0.63 – 0.88	>0.88
66e, 66f, 66g, 68c	<0.38	0.38 – 0.54	>0.54
Ecoregions	**Total Phosphate (as P) (mg/L) †**		
	10 samples	7 samples	3 samples
73a	<0.25	0.25 – 0.44	>0.44
74a	<0.12	0.12 – 0.21	>0.21
74b	<0.10	0.1 – 0.18	>0.18
65a, 65b, 65e, 65i, 65j, 71e, 68b, 67f, 67h, 67i	<0.04	0.04 – 0.07	>0.07
71f, 71g	<0.03	0.03 – 0.053	>0.053
71h.71i	<0.18	0.18 – 0.32	>0.32
68a, 68c, 69d, 66f	<0.02	0.02 – 0.035	>0.035
67g	<0.09	0.09 – 0.16	>0.16
66d, 66e, 66g	<0.01	0.01 – 0.018	>0.018

Pathogen Sampling			
Ecoregions	***E. coli*** **(cfu/100mL) †**		
	10 samples	7 samples	3 samples
Statewide	<941	941 – 1647	>1647
Metals Sampling			
Ecoregion	**Metals (ug/L) †**		
	10 samples	7 samples	3samples
Chromium (hexavalent)	<11	11 – 19.5	>19.5
Mercury	<0.77	0.77 – 1.35	>1.35
Aluminum	<338	338 – 592	>592
Iron	<1218	1218 – 2132	>2132
Manganese	<185	185 – 325	>325
Copper* 65e, 65j, 66d, 66e, 66g, 68a, 74b	<1.25	1.25 – 2.19	>2.19
Copper* 66f, 71f	<4.44	4.44 – 7.77	>7.77
Copper* 67f, 67h, 67i, 68b, 68c, 71g, 71h, 73a	<11.6	11.6 – 20.3	>20.3
Copper* 67g, 71e, 74a	<18.0	18.0 – 31.5	>31.5
Lead* 65e, 65j, 66d, 66e, 66g, 68a, 74b	<0.19	0.19 – 0.33	>0.33
Lead* 66f, 71f	<1.02	1.02 – 1.79	>1.79
Lead* 67f, 67h, 67i, 68b, 68c, 71g, 71h, 73a	<3.51	3.15 – 6.14	>6.14
Lead* 67g, 71e, 74a	<6.07	6.07 – 10.6	>10.6
Zinc* 65e, 65j, 66d, 66e, 66g, 68a, 74b	<16.8	16.8 – 29.4	>29.4
Zinc* 66f, 71f	<58.9	58.9 – 103	>103
Zinc* 67f, 67h, 67i, 68b, 68c, 71g, 71h, 73a	<153	153 – 268	>268
Zinc* 67g, 71e, 74a	<237	237 – 415	>415

Total Suspended Solids Sampling			
Ecoregions	**Total Suspended Solids (TSS) (mg/L) †**		
	10 samples	7 samples	3samples
65a, 67i, 73a	<64	64 – 112	>112
65e, 65i, 74b	<29	29 – 51	>51
65b, 67g, 68c, 71e, 71g, 71i, 74a	<13	13 – 23	>23
65j, 66d, 66e, 66f, 66g, 67f, 67h, 68a, 68b, 69d, 71f, 71h	<10	10 – 18	>18
Biological Monitoring†**			
Statewide			
SQSH (preferred) or biorecon	1 sample		
Habitat assessment	1 report		

† Field parameters are recorded when samples are collected.
*Dependent on Hardness
**Biological monitoring is not required if pathogens are the only contaminants listed.

6. **Monitoring for Watershed Screenings –** Once antidegradation, TMDL, ecoregion reference, 303(d), and long-term trend stations sampling conditions are completed, each EFO monitors as many additional stations as possible to increase the percentage of assessed waterbodies. Emphasis is placed on waterbody segments that have been previously assessed. Sampling locations are located near the mouth of each tributary if possible. Minimally, a biorecon sample is collected and a habitat assessment is completed. If impairment is observed, and time and priorities allow, additional sites are located upstream of the impaired water reach to define the impairment length. When waterbodies are assessed for recreational uses, bacteriological samples are collected. Table 23 details monitoring requirements for watershed screenings.

Table 23: Watershed Screening Monitoring Requirements

Desig-nated Use	Parameter	Matrix	Fre-quency	Minimum Number of Data Points
Fish and Aquatic Life	Biorecon (or SQSH)	Macroinverte-brate	1	1
	Habitat Assessment	Physical Habitat		
	Field Parameters	Water		
	Chemical Parame-ters for suspected sources * (optional)	Water	See table 21	See table 21
	Periphyton (op-tional)	Periphyton		
Recrea-tion	*E. coli*	Water	Monthly	10

*Table 9 lists recommended watershed screening parameters.

7. **Fish Tissue Monitoring –** Fish tissue samples are often the best way to document chronic low levels of persistent contaminants. In the mid-1980's, sites were selected that had shown significant problems in the past and would benefit from regularly scheduled monitoring. Other stations are periodically monitored to obtain baseline information. A list of established fish tissue stations appears in Table 24 along with fish sampled for special studies. Fish tissue monitoring is planned by a workgroup consisting of staff from DWR, DoR Oak Ridge, TVA, TWRA, and ORNL. The workgroup meets annually to discuss fish tissue monitoring needs for the following fiscal year. Data from these surveys help the division assess water quality and determine 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 field collections and analysis to the TDH Aquatic Biology Section. 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. Unless specified for special projects, only fillets (including belly flap) are analyzed. Table 25 includes parameters to be analyzed.

Table 24: 2021-2022 Fish Tissue Sampling Sites

STATION ID	WATER-BODY	LOCATION	PARAME-TER	TARGET SPE-CIES*	Agency
BRM36.0	Beech Reservoir	Forebay	Hg PCB, DDT	Catfish, Large-mouth Bass	TVA
CFORK28.0DB	Center Hill Reservoir	Near Dam	Hg+Se	Black Bass, Wall-eye, Crappie	TDH
FWATE005.2PU	Center Hill Reservoir	Downstream Peter Cave Branch	Hg+Se	Black Bass, Wall-eye, Crappie	TDH
CFORK058.9DB	Center Hill Reservoir	Hwy 70/Sligo Bridge	Hg+Se	Black Bass, Wall-eye, Crappie	TDH
CUMBE185.7DA	Cheatham Reservoir	Bordeaux Bridge Nash-ville	106 met-als/organics	LMB and catfish	TDH
CUMBE191.1DA	Cheatham Reservoir	Shelby Street Bridge Nash-ville	106 met-als/organics	LMB and catfish	TDH
HRM55.0	Cherokee Reservoir	Forebay	Hg and PCB	Catfish, Large-mouth Bass	TVA
HRM76.0	Cherokee Reservoir	Mid Reser-voir	Hg and PCB	Catfish, Large-mouth Bass	TVA
HWR8.5	Chickamauga Reservoir	Hwy 58	Hg and PCB	Catfish, Large-mouth Bass	TVA
TRM472.3	Chickamauga Reservoir	Forebay	Hg and PCB	Catfish, Large-mouth Bass	TVA
TRM518-529	Chickamauga Reservoir	Inflow	Hg and PCB	Catfish, Large-mouth Bass	TVA
TRM490.5	Chickamauga Reservoir	Mid reservoir	Hg and PCB	Catfish, Large-mouth Bass	TVA
TRM605.5	Fort Loudoun Reservoir	Forebay	Hg and PCB	Catfish, Large-mouth Bass	TVA
TRM652	Fort Loudoun Reservoir	Inflow	Hg and PCB	Catfish, Large-mouth Bass	TVA
TRM624.6	Fort Loudoun Reservoir	Mid reservoir	Hg and PCB	Catfish, Large-mouth Bass	TVA

STATION ID	WATER-BODY	LOCATION	PARAME-TER	TARGET SPE-CIES*	Agency
HiwasseeRM37.0	Hiwassee River	Patty Station Road	Hg and PCB	Catfish, Large-mouth Bass	TVA
HRM118.7	Holston River	Surgoinsville	Hg PCB, DDT	Catfish, Large-mouth Bass	TVA
LITTL008.9BT	Little River	Rockford (upstream Hwy 33)	106 Metals + Organics	Catfish	TDH/TDEC
MCKEL001.8SH	McKellar Lake	Entire lake	106 met-als/organ-ics,(dioxin on cats)	game/cat-fish/rough (buf-falo or carp)	TDHTDEC/TDH
MCKEL001.8SH	McKellar Lake	Entire lake	106 met-als/organ-ics,(dioxin on cats)	game/cat-fish/rough (buf-falo or carp)	TDEC/TDH
MISSI724.6SH	Mississippi River (not completed FY20-21 due to equipment failure)	Memphis South Plant	106 met-als/organ-ics,(dioxin on cats)	game/cat-fish/rough (buf-falo or carp)	TDEC/TDH
MISSI735.0SH	Mississippi River (not completed FY20-21 due to equipment failure)	Near I-40	106 met-als/organ-ics,(dioxin on cats)	game/cat-fish/rough (buf-falo or carp)	TDEC/TDH
MISSI754.0SH	Mississippi River (not completed FY20-21 due to equipment failure)	Meeman Shelby State Park	106 met-als/organ-ics,(dioxin on cats)	game/cat-fish/rough (buf-falo or carp)	TDEC/TDH
NONCO001.8SH	Nonconnah Creek	Rivergate Road	106 Metals + Organics	Catfish, Large-mouth Bass	TDH
NFHRM4.6	North Fork Holston River	Cloud Ford	Hg PCB, DDT	Catfish, Black Bass	TVA
ORM2.5	Ocoee River	Benton Pike	Hg and PCB	Catfish, Spotted Bass	TVA

STATION ID	WATER-BODY	LOCATION	PARAME-TER	TARGET SPE-CIES*	Agency
REELF00002LA	Reelfoot Lake (not completed FY20-21)	Lower Blue Basin at Rays Camp	106 metals and organics	Bass/Crappie	TDEC/TDHTDH
REELF00005OB	Reelfoot Lake (not completed FY20-21)	Upper Blue Basin Mouth of Walnut Log Ditch	106 metals and organics	Crappie	TDEC/TDHTDH
SFHR51.0	South Holston Reservoir	Forebay	Hg PCB, DDT	Catfish, Largemouth Bass	TVA
SFHR62.5	South Holston Reservoir	Mid reservoir	Hg PCB, DDT	Catfish, Largemouth Bass	TVA
LTRM1.0	Tellico Reservoir	Forebay	Hg and PCB	Catfish, Largemouth Bass	TVA
LTRM15.0	Tellico Reservoir	Mid reservoir	Hg and PCB	Catfish, Largemouth Bass	TVA
WRM45.5	Watauga Reservoir	Mid Reservoir	Hg PCB, DDT	Catfish, Largemouth Bass	TVA
WRM37.4	Watauga Reservoir	Forebay	Hg PCB, DDT	Catfish, Largemouth Bass	TVA
ELK170.0FR	Woods Reservoir	Near Dam	Organics	Catfish	TDH
ROLLI000.0FR	Woods Reservoir	Rollins Creek embayment	Organics	Catfish	TDH
BRADL000.0CE	Woods Reservoir	Bradley Creek Embayment	Organics	Catfish	TDH
BRUM000.0FR	Woods Reservoir	Brumalow Creek Embayment	Organics	Catfish	TDH

Table 25: Parameters for Fish Tissue Analysis

Weight (Pounds)		Chlordane, total		Selenium
Length (Inches)		CIS Chlordane		Zinc
Lipid Content (Per-cent)		Trans Chlor-dane		Methoxychlor
PCBs		CIS Nonachlor		Dioxins
Aldrin		Trans No-nachlor		Furans
Dieldrin		Alpha BHC		PFAS (limited)
DDT, total		Gamma BHC		
O, P – DDE		Hexachloroben-zene		
P, P – DDE		Arsenic		
O, P – DDD		Cadmium		
P, P – DDD		Chromium		
O, P – DDT		Copper		
P, P – DDT		Mercury		
Endrin		Lead		

* Fish Tissue results reported in mg/kg, wet weight except for dioxins which are reported in ng/kg. Metals are analyzed by Tennessee Department of Health (TDH), Laboratory Services and organics by contract laboratories.

B1.5 Laboratory Schedules

Chemical samples are shipped to the TDH Central Environmental Laboratory, bacteriological samples are delivered to designated private laboratories near the EFOs, within holding time (Appendix D) for processing and analyses. Samples from the Nashville EFO are delivered to the TDH Central Laboratory. SQSH and periphyton samples are delivered or shipped to the TDH Aquatic Biology Section.

TDH Environmental Laboratories and designated private laboratories accepts samples between 8 am and 4:30 pm Monday through Friday with the following exceptions:

- Bacteriological samples are not accepted on Fridays.
- 5-day BOD samples are not accepted on Mondays.
- 5-day CBOD samples are not accepted on Mondays.

The laboratory is contacted if samples cannot be delivered during normal business hours. The *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* provides TDH Environmental Laboratories contact information.

B1.6 Sampling Priority Schedule (Table 26)

Table 26: Project Activity Schedule

Project	Type of Monitor-ing	Sampling frequency	Matrices
Antidegradation	Biological*** (SQSH- for ETW, Habitat Assessment for any)	Once	Benthics Habitat
TMDL development monitoring	Chemical and/or bacteriological*	Monthly*	Water column
Ecoregion reference stream monitoring	Chemical and bacteriological**	Quarterly**	Water column
	Biological*** (Biorecon and SQSH)	Spring and Fall***	Benthics

Project	Type of Monitor-ing	Sampling frequency	Matrices
	Diatoms****	Annually between April and October.	Diatoms
303(d) monitoring†	Chemical and/or bacteriological**	Monthly and or 5 *E. coli*/ 30days (preferably both) (See Table 22)	Water column
	Biological***(SQSH or Biorecon) and/or diatoms.	Once (Not required if pathogens are the only impairment.)	Benthic macroinvertebrates and/or diatom
Ambient Monitoring (long term)	Chemical	Quarterly	Water Column
Watershed monitoring	Biological***(SQSH or Biorecon) and/or diatoms.	Once	Benthic macroinvertebrates and/or diatom
	Bacteriological**	Monthly and or 5 *E. coli*/ 30days (preferably both)	Water column
	Chemical**	Once (optional)	Water column
Fish tissue monitoring	Fish tissue	As needed	Fish tissue

*Consult *Monitoring to Support TMDL Development* (TDEC, 2001) for specifics.
**Consult the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* for specifics.
***Consult the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) for specifics.
****Consult the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) for specifics
†Consult the most recent EPA Approved List of Impaired and Threatened Waters.

B1.7 Rationale for the Sampling Design

The DWR water quality monitoring program measures Tennessee's progress toward meeting the goals established in the Federal Clean Water Act and the Tennessee Water Quality Control Act. Data are collected and interpreted in order to:

1. Assess the condition of the state's waters.
2. Identify stream segment/waterbodies with contamination that exceed Tennessee numerical or narrative water quality standards.
3. Identify causes and sources of water quality problems.
4. Document areas with potential human health threats due to fish tissue contamination or elevated bacteria levels.
5. Establish trends in water quality.
6. Document baseline stream conditions prior to a potential impact or identify a reference stream for downstream or other sites within the same ecoregion and/or watershed.
7. Measure water quality improvements resulting from site remediation, Best Management Practices, and other restoration strategies.
8. Identify proper waterbodies-use classification.
9. Evaluate waterbody tier for antidegradation implementation.
10. Identify natural reference conditions on an ecoregion basis for refinement of water quality standards.
11. Identify and protect wetlands.

B1.8 Parameter Selection

Table 9 lists analytes of interest for sampling objectives. Appendix D contains method detection limits, analytical method number, sample container requirements, sample preservation requirements, sample volume requirements and holding time information. QC requirements are listed in Section B5 and Table 36. The *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* provides additional chemical and bacteriological parameter selection information. The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) describes the method used to select the proper biological sampling approach.

B1.9 Procedures for Locating and Selecting Environmental Samples

Site selection is dependent on the study objectives. After determining the specific objectives of the study and clearly defining information needed, sampling sites are identified within specific waterbody reaches. Reconnaissance of the waterway is very important. Possible sources of pollution, access points, substrate types, flow characteristics, and other physical characteristics are considered in selecting the sampling sites. Although the number and location of sampling stations vary with each individual study, the following basic rules are applied:

1. For **watershed screenings**, sites are located near the mouth of each tributary if representative of the stream. If impairment is observed, the watershed is inspected to see if the impairment is consistent. Additional monitoring is not needed if the impairment is consistent. However, if the impairment originates in a particular area, additional monitoring, if time allows, will help pinpoint the extent of the impairment.

2. For monitoring **point source** pollution, stations are located both upstream and downstream (below the mixing zone) of the source of pollution. Unless the waterbody is extremely small or turbulent, an effluent discharge will usually flow parallel to the bank with limited lateral mixing for some distance. If complete mixing of the discharge does not occur

immediately, left bank, mid-channel and right bank stations may be established to determine the extent of possible impact.

Stations are established at various distances downstream from the discharge. Collection stations are spaced farther apart going downstream from the pollution source to determine the extent of the recovery zone.

3. All biological sampling stations under comparison during a study shall have similar habitat unless the object of the study is to determine the effects of habitat degradation.

4. For biological surveys, it shall be determined if the study site can be compared to biocriteria or biorecon guidelines derived from the ecoregion reference database. To compare to biocriteria, the watershed upstream of the test site must be:

   a. At least 80% within the specified bioregion
   b. The appropriate stream order (estimated using topographic maps) or drainage area (GIS)
   c. Samples shall be collected using the method designated for that bioregion (SQKICK or SQBANK) unless a biorecon is collected.

   If comparisons to biocriteria are inappropriate due to any of the above reasons, then an upstream or watershed reference site may be needed. Departure from protocols shall be explained in detail.

5. Sampling stations should be located in areas where the benthic community is not influenced by atypical conditions, such as those created by bridges or dams, unless judging the effects of atypical conditions is a component of the study objectives.

6. Sampling stations for macroinvertebrates shall be located within the same reach (200 meters or yards) where sampling for chemical and physical parameters will be located. If the macroinvertebrates are collected more than 200 meters from the chemical sampling, it is considered a

separate station and assigned a different station ID number, unless there are no tribs, dischargers or bank disturbance or other factors that would influence water quality.

The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) has additional information on selecting biological sampling locations and the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* for information on selecting chemical stations. The *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) has additional information on selecting periphyton sampling locations. A list of stations including type and frequency is included in the monitoring program plan for each fiscal year beginning in July.

Inaccessibility

If a planned sampling location becomes inaccessible due to flooding, closed roads, or other temporary setbacks, if possible, sampling is rescheduled during normal flow and the sampling location is accessible. If a site is permanently inaccessible, the sampling location is moved upstream or downstream to nearest accessible location if possible.

B1.10 Classification of Measurements as Critical or Noncritical

B1.10.a Biological Measurements

1. **Critical Biological –** Two biological monitoring types represent the primary biological indicators in Tennessee although diatoms are increasing in importance and may become critical when a regional index is developed this year. The state relies heavily on biological monitoring to assess fish and aquatic life use support.

   a. Semi-Quantitative Single Habitat samples are used for stream tier evaluations (Antidegradation policy), permit compliance and enforcement, and as reference stream monitoring to refine biocriteria guidelines. Additionally, ambiguous biorecon sample results can be resolved by use of SQSH results.

Biocriteria based on multi-metric indices composed of seven biometrics have been calculated and provide guidelines for each bioregion (Arnwine and Denton, 2001). The seven indices are:

- Taxa Richness
- EPT Richness
- EPT Density excluding *Cheumatopsyche* spp
- North Carolina Biotic Index
- Density of Oligochaetes and Chironomids
- Density of Clingers excluding *Cheumatopsyche* spp.
- Density of Nutrient Tolerant Taxa

b. Biorecon samples are used for watershed assessments for a screening tool where more definitive information is not necessary or where habitat is not appropriate for a SQSH. Biorecon sampling events have been completed at reference streams to refine guidelines. At test streams, multi-metric indexes comprised of three descriptive biometrics are calculated and compared to reference guidelines for the bioregion. The three biometrics are:

- Taxa Richness
- EPT Richness
- Intolerant Taxa Richness

2. Noncritical Biological

- Fish IBI
- Diatoms (recommended when nutrients are elevated)
- Chlorophyll *a*

B1.10.b Habitat/Physical Measurements

1. **Critical Habitat Measurements –** Habitat assessments using a process developed by Barbour et al. (1999) are conducted in conjunction with all biological monitoring and some chemical monitoring. Habitat guidelines based on reference conditions have been developed for wadeable streams in each ecoregion (Arnwine and Denton, 2001). The division has found these especially useful in assessing impairment due to riparian loss, erosion and sedimentation. The *QSSOP for Macroinvertebrate Steam Surveys* (TDEC, 2017) defines regional expectations for each of the parameters addressed in the assessment.

- Epifaunal Substrate/Available Cover
- Embeddedness
- Pool Substrate Characterization
- Velocity Depth Combinations
- Pool Variability
- Sediment Deposition
- Channel Alteration
- Frequency of Riffles or Bends
- Channel Sinuosity
- Bank Stability
- Bank Vegetative Protection
- Riparian Vegetative Zone Width
- Canopy Cover (Densiometer)

2. **Noncritical Physical/Habitat Measurements**

- Stream Profile
- Particle Count

B1.10.c Chemical/Toxicological Analyses

Chemical sampling is dependent on the monitoring needs (Table 27). The following samples and field measurements should be taken:

1. **TMDL:** Monitoring to support pollutant specific TMDL development depends on the TMDL type.

   a. **Metal TMDLs** (Preferred number of data points at each site is 12, some data points are obtained at low flow conditions).
      - Critical: Hardness as $CaCO_3$, TSS, TOC, Total Metal(s) on EPA Approved List of Impaired and Threatened Waters, Dissolved Metals preferred for Ag, Cd, Cu, Pb, pH, temperature, Specific conductance, and DO.

   b. **pH TMDL** (Preferred number of data points at each site is 12, some data points are obtained at low flow conditions).

      - Critical: Acidity, Alkalinity, Hardness as $CaCO_3$, TSS, TOC, pH, temperature, Specific conductance, and DO.

   c. **DO TMDLs** (Preferred number of data points at each site is 12, some data points are obtained at low flow conditions).
      - Critical: pH, temperature (water), Specific conductance, DO, diurnal DO, $CBOD_5$ and $CBOD_5$, Ammonia, Nitrogen NO_3 & NO_2, Total Phosphorus, Total Kjeldahl Nitrogen, and channel cross-section (transect profile, width, and depth).
      - Noncritical: Flow, Velocity (dye study), temperature (air), CBOD decay rate, reaeration rate, SOD, chlorophyll *a*, field notes (weather conditions, presence of algae, point source discharge, etc.).

d. **Nutrient TMDLs** (Preferred 12 monthly samples, minimum of four high-flow samples).
   - Critical: Ammonia, Nitrogen NO_3 & NO_2, Total Phosphorus, Total Kjeldahl Nitrogen, TSS, TOC, Turbidity, periphyton, chlorophyll *a*, pH, temperature, Specific conductance, DO, and Diurnal DO and project specific.
   - Noncritical: Weather conditions.

e. **Pathogen TMDLs** (Preferred 12 monthly samples, minimum of four high-flow samples)
   - Critical: *E. coli*, TSS, Turbidity, pH, temperature, Specific conductance, and DO
   - Noncritical: Weather conditions.

Table 27: Critical/Noncritical Activities for TMDL Development

MEASUREMENT TYPE	CRITICAL	NONCRITICAL
Metals TMDL		
Flow	X	
Water Field Parameters • pH • Temperature • Specific conductance • DO	 X X X X	
Chemical Parameters • Hardness, as $CaCO_3$ • TSS • TOC • Total Metal(s) on EPA Approved List of Impaired and Threatened Waters	 X X X X	
Dissolved Metals (Cd, Cu, Pb, Ag)	X (Preferred)	X
pH TMDL		
Flow	X	
Water Field Parameters • pH • Temperature • Specific conductance • DO	 X X X X	

MEASUREMENT TYPE	CRITICAL	NONCRITICAL
Chemical Parameters • Acidity, Total • Alkalinity, as $CaCO_3$ • TSS • Hardness ($CaCO_3$) • TOC	 X X X X X	
DO TMDL		
Water Field Parameters • DO • Temperature • Specific conductance • pH • Diurnal DO	 X X X X X (minimum 2-weeks during growing season)	
Velocity (Dye Study)		X
Channel Cross-section (transect profile)	X	
Air Temperature		X
Chemical Parameters • $CBOD_5$ & $CBOD_{ultimate}$ • NH_3 • NO_2/NO_3 • Total Phosphorus • TKN • CBOD decay rate • Reaeration rate • SOD • Chlorophyll *a*	 X X X X X	 X X X X
Nutrient TMDL		
Field Parameters • Temperature • Specific conductance • pH • DO • Diurnal DO	 X X X X X (minimum 2-weeks during growing season)	

MEASUREMENT TYPE	CRITICAL	NONCRITICAL
Chemical Parameters • NH_3 • $NO_2 + NO_3$ • Total Phosphorus • TKN • TSS • TOC • Turbidity • Periphyton density (wadeable) • Chlorophyll *a* (non-wadeable)	 X X X X X X X X X	
Pathogen TMDL		
Field Parameters • Temperature • Specific conductance • pH • DO • Flow	 X X X X	
Bacteriological Parameters • *E. coli*	 X	
Chemical Parameters • TSS • Turbidity	 X X	

2. **Ecoregion Reference Stream:** The same critical parameters are collected at all ecoregion reference sites (Table 28). Specific chemical and bacteriological analyses are found in Table 9.

Table 28: Critical/Noncritical Activities for Ecoregion Reference Monitoring

MEASUREMENT TYPE	CRITICAL	NONCRITICAL
Chemical	X (Table 9)	
Bacteriological		X
Field Parameters • Temperature • Specific conductance • pH • DO	 X X X X	
Biorecon	X	
SQSH	X	
Habitat Assessment	X	
Channel cross section		X
Particle count		X
Fish IBI		X
Diatoms	X	
Chlorophyll *a*		X

3. **EPA Approved List of Impaired and Threatened Waters:** Samples collected due to EPA Approved List of Impaired and Threatened Waters are analyzed, at a minimum, for the pollutant(s) (cause) on the EPA Approved Lists of Impaired and Threatened Waters. EPA Approved List of Impaired and Threatened Waters may be monitored for other parameters as needed (Table 29).

Table 29: Critical/Noncritical Activities for 303(d) Monitoring

MEASUREMENT TYPE	CRITICAL	NONCRITICAL
Chemical and/or bacteriological impairment cause on EPA Approved List of Impaired and Threatened Waters	X	
Other chemical and/or bacteriological parameters		X
SQSH *	X	
Habitat Assessment*	X	
Field Parameters • Temperature • Specific conductance • pH • DO	 X X X X	
Biorecon*		X
Diatoms		X

*Not required if pathogens are the only impairment.

4. **Long Term Trend Stations:** Samples from long term trend stations are minimally analyzed for the parameters listed in Table 9. Additional monitoring is not usually conducted at these long-term sites. Any other monitoring is considered supplemental. The program plan (TDEC, 2017) lists long term trend stations.

5. **Routine Watershed Screenings:** For routine watershed sampling, minimally, a biorecon sample is collected and field parameters (temperature, Specific conductance, pH, and DO) are measured to determine if waters support fish and aquatic life (Table 30). Bacteriological samples are collected to evaluate waters for recreational uses. Additional chemical monitoring may be conducted as needed. Table 9 lists recommended parameters.

Table 30: Critical/Noncritical Activities for Watershed Screening

MEASUREMENT TYPE	CRITICAL	NONCRITICAL
Biorecon	X*	
Field Parameters • Temperature • Specific conductance • pH • DO	 X X X X	
Habitat Assessment	X	
SQSH		X
Bacteriological	X	
Chemical	X (Table 9)	
Periphyton		X

*Collect SQSH macroinvertebrate sample if biorecon score is ambiguous.

B1.11 Sources of Variability

B1.11.a Chemical and Bacteriological Sample Variability

To check for variability in chemical and bacteriological samples, trip blanks, field blanks, equipment blanks, and duplicate quality control samples are collected at 10 percent of the sampling events. The *QSSOP for Chemical and Bacteriological Sampling of Surface Waters* (TDEC, 2018) provides sample collection quality control additional information. When discrepancies from analyses of the samples are found, both the collection team and laboratory are contacted to determine the source of the contamination. Once the source of contamination is located, corrective actions are taken to avoid repeating these errors in the future. The *Environmental Laboratories Laboratory Quality Assurance Plan* (TDH, 2020) has information regarding laboratory instrument blanks, analyses infrastructure, and corrective action procedures.

B1.11.b Biological Sample Variability

To check for variability in biological samples, duplicate biorecon, SQSH, or periphyton samples are collected at 10 percent of the sampling events. A second sampler collects duplicate biorecon samples and results are compared. If the samples generate differing results, the reasons for variability are determined and staff are retrained if necessary. In addition to collecting duplicate SQSH samples, 10 percent of processed samples are checked for sorting efficiency and taxonomic identification by a second experienced biologist. Section II of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) provides additional sample variability information and corrective action measures. The *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) provides additional sample variability information and corrective action measures.

B1.11.c Field Parameter Variability

Minimally, duplicate field parameter readings are taken at the first and last sites surveyed each day. If time allows, duplicate readings are also recorded at each site to check for variability. Calibrate DO probes each morning of use and at each site where necessary. Daily calibration is preferred for most defensible data, but when necessary conductivity and pH probes can be calibrated weekly with a drift check performed daily upon return. The drift check can be performed the next morning if time is a factor. The probes must be recalibrated when the drift check is out of the acceptable range, A drift check should be performed weekly for temperature. Pre-sampling calibration and post-sampling drift checks are also required to help ensure the field equipment is functioning correctly.

In the event measurements do not meet quality control guidelines, the field equipment is examined to determine the source of the problem and repaired or serviced as needed. Protocol J of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* or Protocol C of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) has specific quality assurance guidelines on field parameter meters. Protocol D of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) has specific quality assurance guidelines on field parameter meters.

B1.11.d Water Level Variability

In the event of flood or high-water episodes, sampler safety is of paramount importance. If sampling during a flood event cannot be avoided, it is noted on associated paperwork and remarks section of Chain of Custody that the sample was collected during a rain or flood event, so the results can be evaluated accordingly. Field staff should notify WPU, so data are flagged as a rain event in the comment field in the Waterlog.

Chemical and bacteriological samples are not collected if the stream only has water in isolated pools. Biological samples are not collected if the water level is extremely low or it appears the waterbody has not had continuous flow for at least 30 days.

B2 SAMPLING METHODS REQUIREMENTS

The objective of surface water sampling is to obtain a representative sample that does not deteriorate or become contaminated before it is analyzed. The proper sample collection, preservation techniques, and appropriate quality control measures must be followed to verify the accuracy and representativeness of sample analyses. This section describes the field procedures for collecting representative surface water samples.

B2.1 Sample Collection, Preparation, and Decontamination Procedures

Standard protocols have been established to meet the specific sampling requirements for the division's statewide monitoring program. Detailed procedures for chemical, bacteriological, and biological sample collection, preparation, and decontamination are in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* , the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010). The reference documents for the division's monitoring program are listed in Table 31. The information provided in this QAPP supplements the SOPs for surface water sampling.

Table 31: Document Use

DOCUMENT TITLE	DESCRIPTION OF PROJECT ACTIVITY WHERE DOCUMENT IS USED
QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)	• TMDL surveys • Reference stream monitoring • EPA Approved List of Impaired and Threatened Waters monitoring • Watershed/305(b) monitoring • Long Term Trend Stations
QSSOP for Macroinvertebrate Stream Surveys (TDEC, 2017)	• TMDL surveys • Reference stream monitoring • EPA Approved List of Impaired and Threatened Waters monitoring • Watershed/305(b) monitoring
QSSOP for Periphyton Stream Surveys (TDEC, 2010)	• TMDL surveys • Reference stream monitoring • EPA Approved List of Impaired and Threatened Waters monitoring • Watershed/305(b) monitoring
Monitoring to support TMDL development (TDEC, 2001)	• TMDL surveys

DOCUMENT TITLE	DESCRIPTION OF PROJECT ACTIVITY WHERE DOCUMENT IS USED
Rules of the TDEC, Chapter 0400-40-03, General Water Quality Criteria (TDEC-WQOG, 2019)	• TMDL surveys • Reference stream monitoring • EPA Approved List of Impaired and Threatened Waters monitoring • Watershed/305(b) monitoring
Rules of the TDEC, Chapter 0400-40-04, Use Classifications for Surface Waters (TDEC-WQOG, 2019)	• TMDL surveys • Reference stream monitoring • EPA Approved List of Impaired and Threatened Waters monitoring • Watershed/305(b) monitoring
Tennessee Division of Water Resources Surface Water Monitoring and Assessment Program Plan (TDEC, 2020)	• TMDL surveys • Reference stream monitoring • EPA Approved List of Impaired and Threatened Waters monitoring • Watershed/305(b) monitoring • Long Term Trend Stations
Final Version Year 2020 EPA Approved List of Impaired and Threatened Waters (TDEC, 2020)	• EPA Approved List of Impaired and Threatened Waters monitoring

B2.1.1 Sample Collection Procedures, Protocols, and Methods

- Chemical and bacteriological surface water samples are collected according to Protocols C through F in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018).*

- *In situ* field parameters are measured according to Protocol J in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018).*

- Continuous monitoring field parameters are measured according to Protocol K in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018).*

- Composite, homogenized, and split samples are collected according to the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018).*

- Flow is measured according to Protocol L in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018).*

- Biorecon macroinvertebrate samples are collected according to Protocol F in the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017).

- SQSH macroinvertebrate samples are collected according to Protocol G in the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017).

- Diatom samples are collected according to Protocols F and G in the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010)

- Fish tissue samples are collected according to the SOP *Fish Tissue Collection SOP No. Env-AqBio-SOP-512* (TDH, 2016).

Table 9 lists analytical requirements for different types of monitoring. Appendix D lists appropriate sample containers, preservatives volumes, and holding times for chemical and bacteriological surface water samples. The *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* provides additional information on sample collection and preservation.

B2.1.2 Sampling Equipment

Required equipment for chemical and bacteriological sampling are listed in Section I.H of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2018). Equipment needed for biological sample collections are listed in Section I.H of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010). A list of equipment is also found in Appendix G of this document. Equipment manual and logbooks kept in the EFOs list specific make, model, and serial numbers of sampling equipment.

B2.1.3 Support Facilities

Field water parameter meters and flow meters are calibrated at regional Environmental Field Offices. TDH Environmental Laboratories provide chemical, bacteriological, biological (SQSH), and periphyton laboratory analyses. Regional private laboratories analyze bacteriological samples for DWR also.

B2.1.4 Key Project Personnel (Table 32)

Table 32: Key Project Personnel

Name	Role
J. Dodd	QAPP Project Manager
C. Rhodes	Deputy Director of Field Offices
A. Grippo	Deputy Director
R. Cochran	WPU DWR Manager
P. Mitchell	Deputy Director of Operations
C. Franklin	JEFO DWR Manager
T. Jennette	NEFO DWR Manager
D. Cutshaw	JCEFO DWR Manager
J. Brazile	MEFO DWR Manager
S. Glass	CLEFO DWR Manager
J. Innes	CHEFO DWR Manager
B. Ulmer	CKEFO DWR Manager
M. Atchley	KEFO DWR Manager
B. Epperson	KSM DWR Manager

B2.1.5 Equipment Decontamination Procedures

When possible, all chemical and bacteriological samples are collected in the appropriate container. If an intermediate sampling device is used to collect a chemical sample, it shall be composed of Teflon® or High-Density Polyethylene. All reusable sampling equipment are cleaned according to Protocol E of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018).*

Bacteriological samples are collected directly into sterile sample containers. Subsurface bacteria samples may be collected in a sterile sampling container using a bottle holder connected to a long handle, rope or other sampling device that has minimal sample contamination. The *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* has additional information on bacteriological sampling procedures.

All nets used to collect macroinvertebrate samples are thoroughly rinsed to remove debris and clinging organisms after the sample is collected and before leaving the collection site. The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) provides additional biological sample handling information.

B2.1.6 Sample Containers, Preparation, and Holding Time Requirements

Information provided in this QAPP supplements standard operating procedures established for these tasks. Section I.H of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018),* lists equipment and supplies needed for chemical and bacteriological sampling, flow measurement, and field parameter readings. Section I.H of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) lists equipment and supplies needed for biological sampling and field parameter readings. Section I.H of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) lists equipment and supplies needed for biological sampling and field parameter readings.

Chemical and bacteriological sample containers obtained from the TDH Environmental Laboratories are certified-clean and pre-preserved. No additional preparation is needed. Appendix D lists sample containers, preservation requirements, and holding times for routine chemical and bacteriological samples. The *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018),* provides additional information on sampling equipment, preservation, and holding times. The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) provides information regarding macroinvertebrate sampling equipment and preservation. The *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) provides information regarding periphyton sampling equipment and preservation.

B2.3 System Failure and Corrective Action

B2.3.1 Sample Collection

a. If a sample cannot be collected as scheduled (flooding, dry, equipment failure, temporary inaccessibility, etc.) the EFO DWR manager or their designee is notified, and the sampling event is rescheduled as soon as possible. If the site has become permanently inaccessible, it is moved upstream or downstream to the nearest accessible location. WPU is notified of the new station ID and location.

b. If ecoregion reference sites have become degraded, WPU is notified. If statistical analyses conducted by WPU indicate the site no longer meets reference criteria, the site is removed from the reference list for future sampling. Existing data will be maintained. The EFO is notified and is requested to select a replacement site in the same ecoregion.

c. If field equipment results are outside the calibration range during post drift check, results are not uploaded. If equipment becomes inoperable in the field, routine watershed and ecoregion monitoring continues without taking field measurements and field parameters are flagged with IF (instrument failure). If monitoring is for TMDL or EPA Approved List of Impaired and Threatened Waters for DO, pH, temperature or mining, sampling is rescheduled when properly functioning equipment is available.

d. If, when collecting SQSH samples, fewer than 200 organisms are estimated, additional samples of the same habitat are collected and composited. The total number of sampling efforts is noted on the Sample Analysis Form as well as internal and external tags.

e. Rain events are flagged in the comment field in the Water Quality Database.

f. Additional issues are addressed in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018),* the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010).

B2.3.2 Laboratory Analyses

a. **Biological:** If fewer than 160 organisms are found in a SQSH sample, the sample results are flagged, and results are viewed with caution. The site is re-sampled if necessary, to obtain acceptable results. The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) has specific information regarding macroinvertebrate analyses.

b. **Chemical:** Any instrument that fails QC procedures shall not be used until the problem is corrected. Duplicate, laboratory fortified blank, laboratory fortified matrix, and method blanks that fail to meet goals are immediately reviewed for the source of error. Chemical analyses issues are addressed in the *Environmental Laboratories Laboratory Quality Assurance Plan* (TDH, 2020), and the *Environmental Organic SOPs* (TDH, 2002-2014). Bacteriological analyses issues are addressed in the *Standard Methods for the Examination of Water and Wastewater* (APHA, 2012).

If it is not possible to collect a sample, monitoring is rescheduled as soon as possible.

B2.4 QC Data Review

Results of field, trip, and equipment blanks are reviewed by WPU staff and the Quality Team Member (In-house QC officer in EFO) for potential contamination. If contamination is found in the blanks, the collection and laboratory staff are contacted to determine and correct the source of contamination. All samples collected that day by the same team are viewed with caution and excluded if outside of the existing data set.

Any analyses flagged by the TDH Environmental Laboratories are viewed with caution and excluded if outside of the existing data set. Samples collected during rain events are also flagged and viewed with caution. Historic data qualifiers are listed in Table 33. Data with these codes are located in EPA Legacy STORET. The current list of qualifiers are found in Appendix H and are from the EPA's WQX https://www.epa.gov/waterdata/water-quality-data-wqx.

Table 33: Historic Data Qualifiers Key

Qualifier	Description
U	Analyte requested but not detected.
J	Estimated value-result is between the method detection limit and the method quantitation limit.
B	Analyte in lab blanks as well as sample.
E	Analyte concentration exceeds the calibration range of instrument.
N	Uncertainty in result other than "J" flag
Q	Received out of holding time.
Z	Analyzed out of holding time.
V	TDH Environmental Laboratories or EFO verified result.
R	Sample collected during rain event.
X	Other flag used to determine results as needed.
C	Comment in comment field
L	Lab not able to verify results lab destroyed records
IF	Instrument failed in field
F	Samplers failed to collect field parameters

Qualifier	Description
H	Hit contamination in field blank, trip blank or equipment blank
NA	Not applicable
LE	Lab accident sample could not be analyzed

B2.5 Field Documentation

The *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018),* stipulates field documentation for chemical, bacteriological samples, and flow measurements. The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) stipulates documentation for macroinvertebrate surveys. The *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) stipulates documentation for periphyton surveys.

B2.6 Field Derived Waste

In most circumstances there is no field derived waste. If waste is generated, it is contained until it can be properly disposed.

B2.7 Health and Safety

The *Health and Safety Plan* (TDEC-BOE, 2016) is followed for all procedures. Section I.D of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)*, the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) provides additional health and safety warnings and cautions specific to water safety.

B3 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

B3.1 Chemical and Bacteriological Handling Procedures

After chemical and bacteriological samples are collected, labeled, placed in a clean cooler on ice, and a custody seal is attached to the cooler, they are delivered or shipped to the Nashville TDH Environmental Laboratories or one of the private laboratories that have been contracted to analyze TDEC samples. Laboratories conducting chemical analyses for 106 monitoring activities are NELAC (or equivalent) certified. Laboratories performing bacteriological analysis are drinking water (or equivalent) certified. Chemical samples are usually shipped directly to the laboratory. Bacteriological samples are delivered in a state vehicle directly to the local laboratory by the sampling team or delivered to a commercial delivery service, FedEx, for delivery to the Nashville TDH laboratory or contract lab. Chain of custody is completed each time a sample is transferred to another custodian.

"The use of custody seals may be waived if field investigators keep the samples in their custody as defined from the time of collection until the samples are delivered to the laboratory analyzing the samples." (*Ecological Assessment Standard Operating Procedures and Quality Assurance Manual.* USEPA Region 4, 2002).

Once samples are received in the laboratory, laboratory staff sign the chain of custody form and take custody of the samples. When delivering samples, the sampler should wait until the receiver has verified the sample request form is acceptable and legible before leaving the samples. Beginning January 1, 2013, the state lab plan is to reject samples where the sample request form is not legible. An attempt will be made to contact the sampler prior to discarding samples. If samples are transferred to another laboratory, Laboratory Sample Control Log and Manifest and Interlaboratory Chain of Custody are completed.

A temperature blank is included in each cooler. Sample arrival temperature is checked in temperature blank bottles, to ensure samples are 6^{o} C or less. This temperature is recorded on the Sample Analysis Form.

TDH Environmental Laboratories are secured facilities. Chemical samples are logged in and then stored in a central walk-in cooler until analyses. Bacteriological samples are processed immediately.

B3.2 Biological Sample Handling Procedure

After SQSH samples are collected, preserved, and labeled, they are delivered to the TDH Environmental Laboratory, Aquatic Biology Section for processing. After receipt in the laboratory, SQSH samples are logged in, assigned a unique log number, and stored in the sample holding area until processed. Following analyses, macroinvertebrate samples are stored in a secured area for at least five years. Aquatic Biology is housed in TDH Central Laboratory in Nashville, which is a secured facility.

Biorecon samples are field processed and voucher specimens are confirmed in EFO laboratories. Vouchers may also be delivered to the TDH Environmental Laboratory, Aquatic Biology Section for confirmation. The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) has additional information regarding biological sample handling procedures.

After diatom samples are collected, preserved, and labeled, they are shipped to the TDH Environmental Laboratory, Aquatic Biology Section for processing. The *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) has additional information regarding periphyton sample handling procedure. After receipt in the laboratory, periphyton samples are logged in, assigned a unique log number, and stored in the sample holding area until processed.

The electronic form is used to record field survey, habitat and biorecon field sheets. An EDD is automatically generated which is uploaded to Waterlog. The bioform is also uploaded to Waterlog. Chain of Custody/sample request forms are submitted to the state laboratory with the sample.

Examples of field sample labels, Analysis Request and Chain of Custody Forms, and custody logs are included in the *QSSOP for Chemical and Bacteriological*

Sampling of Surface Water (TDEC, 2018), the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010)

The TDH Environmental Laboratories provide laboratory sample, handling, transport, and logging information in *Environmental – Receiving Samples Standard Operating Procedure – 101* (TDH, 2020), *Environmental – Sample Log-in Standard Operating Procedure – 102* (TDH, 2020), and *Environmental Laboratories Laboratory Quality Assurance Plan* (TDH, 2020).

B3.3 Holding Times

Appendix D lists chemical and bacteriological sample holding times. Properly preserved biological samples have no specific holding time but do have required turn-around. Further information is provided in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)*, the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010).

B3.4 Chain of Custody

TDEC's Office of General Counsel requires the chain of custody to be complete for any sample that has the potential for use in court, review by the Water Quality Oil and Gas Board, or in state hearings. Therefore, all samples are potentially legal, and the integrity of the sample must be beyond question. The chain of custody form shall be completed in entirety and maintained in the project file.

The entire right column of TDH Environmental Laboratories' Chemical and Biological Analysis Request Form is TDEC's official chain of custody. The TDEC Office of General Counsel has approved these forms. A copy of the chain of custody form for chemical analyses is in Appendix I of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018).* A copy of the chain of custody form for biological analyses is in Appendix B of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017). A copy of the chain of custody form for periphyton analyses is in Appendix B of the *QSSOP for Periphyton Stream Surveys*

(TDEC, 2010). If using a TDEC contract laboratory a contract lab chain of custody form is completed.

The chain of custody follows the sample through collection, transfer, storage, analyses, quality assurance and disposal. Each person responsible for the sample signs, dates, and records the time when samples are transferred into their custody. Beginning January 1, 2013, the state lab plan is to reject samples where the sample request form is not legible. An attempt will be made to contact the sampler prior to discarding samples. The TDH Environmental Laboratories maintains a separate Sample Control Log and Manifest and Interlaboratory Chain of Custody for samples transferred between laboratories.

The *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* THE *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) provide additional information on chain of custody. An interlaboratory chain of custody is completed when chemical samples are removed from the walk-in cooler for analyses. The *Environmental – Receiving Samples Standard Operating Procedure – 101* (TDH, 2020), the *Environmental – Sample Shipping Standard Operating Procedure – 104* (TDH, 2020), and the *Environmental Laboratories Laboratory Quality Assurance Plan* (TDH, 2020) have additional sample transfer, handling, and analyses custody information.

B3.5 Sample Identification

The sampler identifies all chemical, bacteriological, and biological sample tags and associated field forms with the unique station identification number that has been assigned to the sample location. Protocol B in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018),* the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) describes the process for assigning station identification numbers.

Protocol H in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018),* provides additional information for completing and attaching external sample tag and labels for chemical and bacteriological samples. Protocols F and G in the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) provides information on internal and external tags for biological samples. Protocol G in the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) provides information on internal and external tags for periphyton samples.

TDH Environmental Laboratories assign unique log numbers to each chemical and biological sample upon receipt for sample tracking. The contract laboratories assign a unique log number to the bacteriological samples. Both the station ID number and log number follow all paperwork associated with the samples.

The *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018),* the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017), and the *Environmental – Receiving Samples Standard Operating Procedure – 101* (TDH, 2020) provide sample identification information. For macroinvertebrate samples processed in the EFO, a unique log number is assigned to each sample according to Protocol H in the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017). Protocol H of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) describes the process for assigning log numbers for periphyton samples.

B3.6 Sample Custody Procedure: Summary of Standard Procedures

From the time of sample collection through analyses and sample disposal, custody of samples is documented via the chain of custody. A custody seal assures the sample integrity has not been compromised. Once chemical and bacteriological samples have been placed on ice, a signed and dated custody seal is attached to the cooler if the sample is transferred from the custody of the original sampler. The seal must be broken to open the cooler. If the seal is broken on receipt of the next custodian, the broken seal is documented.
Protocol I of Section 1 and Protocol C of Section II of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* provides chain of custody

procedures for chemical and bacteriological sample collection. Section II of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) addresses biological chain of custody procedures. Section II of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) provides chain of custody procedures for periphyton sample collection.

B4 ANALYTICAL METHODS REQUIREMENTS

Valid and reliable analytical methods for the analyses of surface water samples are essential to yield precise, accurate, and comparable data. Laboratories conducting chemical analyses for 106 monitoring activities are NELAC (or equivalent) certified. Laboratories performing bacteriological analysis are drinking water (or equivalent) certified. The division requires the use of EPA approved methods or approved Standard Methods for all laboratory analyses. The reference documents for these methods are listed in Table 34. Analytical methods numbers and sensitivity requirements are found in Section B4.1 Table 35.

Table 34: Analytical Method Documents

Parameter	SOP Name
Macroinvertebrate	*QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) *
Bacteriological	*Standard Methods for Examination of Water and Wastewater, 22nd Edition* (APHA, 2012) *
Periphyton	*QSSOP for Periphyton Stream Surveys* (TDEC, 2010) *
Inorganic Chemistry	*TDH Environmental Inorganic SOPs* (TDH, 2002-2020) *†
Organic Chemistry	*TDH Environmental Organic SOPs* (TDH, 2002-2014) *†

*Regulatory citation: *The Tennessee Water Quality Control Act of 1977 including the 1998 amendments* (Tennessee Secretary of State, 2020).
†A complete list of Environmental Laboratory SOPs is included in the reference list.

B4.1 Analytical Methods and Method Sensitivity Requirements

The required analytical methods, method detection limits and reporting units are found in Table 35. Information on sample container, preservation, and holding times are found in Appendix D. The use of non-standard or unpublished methods, or deviations from the published approved Standard Methods or EPA approved methods at Title 40 of the Code of Federal Regulations is not allowed.

Table 35: Method detection limits, Reporting Units, and Analyses Methods**

Test	MDL***	Units	Method*
Field Determinations			
pH		pH units	In situ
Specific conductance		µmho	In situ
Dissolved Oxygen		mg/L	In situ
Temperature		Celsius	In situ
Environmental Microbiology			
Total Coliform		CFU/100 mL	SM9221B, 9223B
E. Coli		CFU/100 mL & MPN/100 mL	SM9221B, 9223B
Fecal Coliform		CFU/100 mL	SM9221E, 9222D
Enterococcus		CFU/100 mL	SM9230B/C
General Inorganics			
Acidity	3.63	mg/L	SM2310 B
Alkalinity, Total	2.71	mg/L	SM2320-B
BOD, 5 day	3.33	mg/L	SM5210B
CBOD, 5 day	3.33	mg/L	SM5210B
Chloride	0.231	mg/L	USEPA 300.1
Chlorine, Residual	0.053	mg/L	SM4500Cl G
Chromium, hexavalent	0.00002	µg/L	SM3500-Cr B contracted out
Color, Apparent	5	Pt CO units	SM2120C
Color, True	5	Pt CO units	SM2120C
Specific conductance	NA	µmhos	SM2510B contracted out

Test	MDL***	Units	Method*
Cyanide (H_2O) Total	NA	mg/L	USEPA 335.4 contracted out
Fluoride	0.0188	mg/L	USEPA 300.1
Oil and Grease	NA	mg/L	USEPA 1664A contracted out
pH	NA	pH units	SM4500H+B
Phenols, Total	0.0083	µg/L	USEPA 420.1 contracted out
Sulfate	0.199	mg/L	USEPA 300.1
Residue, Dissolved	NA	mg/L	SM2540C
Residue, Settleable	NA	mL/L	SM2540F
Residue, Suspended	NA	mg/L	SM2540D
Residue, Total	NA	mg/L	SM2540B
Silica	25	mg/L	SM4500-SiO2C
Turbidity	1	NTU	EPA 180.1
Nutrients			
COD	3	mg/L	SM5220D Contracted Out
Nitrogen, Ammonia	0.0262	mg/L	USEPA 350.1
Nitrogen, Nitrite	0.00766	mg/L	USEPA 300.1
Nitrogen, Nitrate	0.00623	mg/L	USEPA 300.1
Nitrogen, NO_3 & NO_2	0.0196	mg/L	USEPA 353.2
Nitrogen, Total Kjeldahl	0.111	mg/L	USEPA 351.2
Nitrogen, Total Organic	0.15	mg/L	USEPA 351.2
Orthophosphate	0.00254	mg/L	USEPA 300.1
Phosphorus, Total	0.00756	mg/L	SM 4500-P-H
TOC	0.0869	mg/L	SM5310C
Metals			
Aluminum	6.5	µg/L	USEPA 200.8
Antimony	0.365	µg/L	USEPA 200.8
Arsenic	0.829	µg/L	USEPA 200.8
Barium	0.179	µg/L	USEPA 200.8
Beryllium	0.194	µg/L	USEPA 200.8
Cadmium	0.161	µg/L	USEPA 200.8
Calcium	0.065	mg/L	USEPA 200.7

Test	MDL***	Units	Method*
Chromium, Total	1.2	µg/L	USEPA 200.8
Cobalt	0.139	µg/L	USEPA 200.8
Copper	0.583	µg/L	USEPA 200.8
Iron	3.89	µg/L	USEPA 200.7
Lead	0.142	µg/L	USEPA 200.7
Magnesium	0.0247	mg/L	USEPA 200.7
Manganese	0.231	µg/L	USEPA 200.8
Mercury	0.0458	µg/L	USEPA 245.1
Mercury –Low Level	0.00176	ug/L	USEPA 245.7
Nickel	0.252	µg/L	USEPA 200.8
Potassium	0.0238	mg/L	USEPA 200.7
Selenium	0.896	µg/L	USEPA 200.8
Silver	0.103	µg/L	USEPA 200.8
Sodium	0.0212	mg/L	USEPA 200.7
Thallium	0.354	µg/L	USEPA 200.8
Vanadium	3.62	µg/L	USEPA 200.8
Zinc	1.48	µg/L	USEPA 200.8
Total Hardness by Calculations	0.115	mg/L	USEPA 200.7
Ca Hardness by Calculation	0.152	mg/L	USEPA 200.7
Boron	4.6	ug/L	USEPA 200.7
Digestions of all metals (except Mercury)			USEPA 200.2

*****_Environmental Inorganic SOPs_ (TDH, 2002-2020) detail specific methods and required instrumentation.
**QC for laboratory analyses criteria is found in _Environmental Laboratories Laboratory Quality Assurance Plan_ (TDH, 2017).
*******MDLs are currently under revision by state lab.

B4.2 Equipment and Instrumentation

The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) lists equipment needed for macroinvertebrate analyses. The *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) lists equipment needed for periphyton analyses. The *Environmental Inorganic SOPs* (TDH, 2002-2020) and the *Environmental Organic SOPs* (TDH, 2002-2014) provide detailed information about the type of equipment and instrumentation needed for chemical analyses. All equipment used in the field or in the lab must be calibrated, maintained and repaired according to the equipment instruction manual. All instruments used by the lab must be calibrated, maintained, and repaired according to the specifications in the instrument instructions manual. Table 36 lists the methods requiring analytical instrumentation and the type of instrument used for detection of the specified analyte.

Table 36: Analytical Methods and Instrumentation*

Test	Method	Instrumentation
Environmental Microbiology		
Total Coliform	SM9221B, 9223B	NA
E. Coli	SM9221B, 9223B	NA
Enterococcus	SM9230B/C	NA
Fecal Strep	SM9223B	NA
General Inorganics		
Acidity	SM2310 B	pH Meter and Probe
Alkalinity	SM2320-B	KoneLab Discrete Analyzer
BOD, 5 day	SM5210B	Dissolved Oxygen Meter
CBOD, 5 day	SM5210B	Dissolved Oxygen Meter
Chloride	USEPA 300.1	IC
Chlorine, Residual	SM4500Cl- G	Spectrophotometer
Chromium, hexavalent	SM3500-Cr B	Subcontracted
Color, Apparent	SM2120C	KoneLab Discrete Analyzer
Color, True	SM2120C	KoneLab Discrete Analyzer
Specific conductance	SM2501B	Conductivity Meter
Cyanide	USEPA 335.4	Subcontracted
Fluoride	USEPA 300.0	IC

Test	Method	Instrumentation
Nitrogen, Nitrite	USEPA 353.2	Spectrophotometer/IC
Oil and Grease	USEPA 1664A	Subcontracted
pH	SM4500-H+B	pH Meter
Phenols, Total	USEPA 420.1	Subcontracted
Sulfate	USEPA 300.1	IC
Residue, Dissolved	SM2540C	NA
Residue, Settleable	SM2540F	NA
Residue, Suspended	SM2540D	NA
Residue, Total	SM2540B	NA
Silica	SM4500-SiO2C	Subcontracted
Turbidity	USEPA 180.1	Turbidimeter
Nutrients		
COD	USEPA 410.4	KoneLab Discrete Analyzer
Nitrogen, Ammonia	USEPA 350.1	Flow Injection Analyzer
Nitrogen, Nitrite	USEPA 300.1	Ion Chromatograph
Nitrogen, Nitrate	USEPA 300.1	Ion Chromatograph
Nitrogen, NO_3 & NO_2	USEPA 353.2	Flow Injection Analyzer
Nitrogen, Total Kjeldahl	USEPA 351.2	Flow Injection Analyzer
Nitrogen, Total Organic	USEPA 351.2	Autoanalyzer
Orthophosphate	USEPA 300.1	KoneLab Discrete Analyzer/IC
Phosphorus, Total	SM4500-P-H	Flow Injection Analyzer
TOC	SM5310C	TOC Autoanalyzer
Metals		
Aluminum	USEPA 200.8,	ICP-OES, ICP-MS
Antimony	USEPA 200.8,	ICP-OES, ICP-MS
Arsenic	USEPA 200.8,	ICP-OES, ICP-MS
Barium	USEPA 200.8,	ICP-OES, ICP-MS
Beryllium	USEPA 200.8,	ICP-OES, ICP-MS
Boron	USEPA 200.7	ICP-OES, ICP-MS
Cadmium	USEPA 200.8,	ICP-OES, ICP-MS
Calcium	USEPA 200.7	ICP-OES
Chromium, Total	USEPA 200.8,	ICP-OES, ICP-MS
Cobalt	USEPA 200.8,	ICP-OES, ICP-MS
Copper	USEPA 200.8,	ICP-OES, ICP-MS
Iron	USEPA 200.7	ICP-OES

Test	Method	Instrumentation
Lead	USEPA 200.8,	ICP-OES, ICP-MS
Magnesium	USEPA 200.7	ICP-OES
Manganese	USEPA 200.8,	ICP-OES, ICP-MS
Mercury	USEPA 245.1	FIMS (Flow Injection Mercury System)
Mercury-Low Level	USEPA 245.7	Cold Vapor Atomic Fluorescence Spectrometry
Nickel	USEPA 200.8,	ICP-OES, ICP-MS
Potassium	USEPA 200.7	ICP-OES
Selenium	USEPA 200.8,	ICP-OES, ICP-MS, GFAA
Silver	USEPA 200.8,	ICP-OES, ICP-MS
Sodium	USEPA 200.7	ICP-OES
Thallium	USEPA 200.8,	ICP-OES, ICP-MS, GFAA/FAA
Vanadium	USEPA 200.8,	ICP-OES, ICP-MS/FAA
Zinc	USEPA 200.8,	ICP-OES, ICP-MS
Hardness, Total	SM2340B	ICP-OES
Hardness ($CaCO_3$)	USEPA 200.7	ICP-OES
Digestion of all metals (except Mercury)	USEPA 200.2	

Environmental Inorganic SOPs (TDH, 2002-2020) detail specific methods and required instrumentation.

B4.3 TDH Environmental Laboratories Management (Table 37)

Table 37: TDH Environmental Laboratories Management

Name	Role
Dr. R. Steece	Director of TDH Laboratory Services
M. Rumpler	Director of TDH Environmental Laboratories
P. Gibbs	Director of TDH Microbiology Laboratories
TBD	Assistant Director of TDH Microbiological Laboratories
C. Edwards	Assistant Director of TDH Environmental Laboratories TDH Nashville
P. Leathers	Inorganic Chemistry Routines & Special Projects Coordinator Manager TDH Nashville

A. Wilson	Inorganic Chemistry Metals Supervisor TDH Nashville
P. Alicea	Aquatic Biology & E. Micro Manager TDH Nashville
B. Moore	Quality Assurance Manager, Special Projects Coordinator, TDH Environmental Laboratories

B4.4 Laboratory Turnaround Time Requirements

Generally, Inorganic and Organic analyses should be sent by TDH Environmental Laboratories and private laboratories within 25 days of receipt of the sample. Microbiological sample results should be sent to DWR within 7 days of receipt of the sample. If results are not received in the expected time period, EFO staff contact the Environmental Laboratory section manager. Questionable results are referred by WPU staff to the appropriate TDH Environmental Laboratory or EFO. If possible, these issues are resolved within two weeks. Macroinvertebrate biological analyses for watershed samples are uploaded to Waterlog within one year of receipt or the end of December of the monitoring year (whichever is first). Antidegradation results are uploaded within 30 days of sample receipt. If results are needed sooner than standard turnaround times, the needed priority date is recorded on the Analysis Request Form.

B4.5 Laboratory Data Report

The chemical and bacteriological analyses reports are uploaded to the TDH report site. The report site serves as a collaboration tool for all TDH groups to provide up-to-date information in accordance with the TDH mission. One technical staff member in WPU, Natalie Moore (Environmental Scientist 3), oversees all water quality data management. The Laboratory uploads macroinvertebrate and diatom taxa directly to Waterlog. (Bireocon taxa are uploaded by EFOs.) WPU technical staff members (Deborah Arnwine, Environmental Consultant 2 and Kim Laster, Environmental Consultant 2) oversees all biological data management. The Water Quality and Biological Database is located in Waterlog. TDH sends WPU an electronic Excel file of the data chemical results in the EPA WQX EDD format. Data are reviewed then uploaded to the database in Waterlog. The data are also uploaded to EPA's CDX WQX database. https://www.epa.gov/waterdata/water-quality-data-wqx

The biological reporting package includes:

- Taxonomic EDD (macroinvertebrate or diatom).
- Bioform (habitat, stream survey, photographs and field parameters) including EDD and macroinvertebrate taxa list (biorecons only).
- Biological Analysis Request/Chain of Custody Form

B4.6 Sub-Sampling

Protocol I of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) describes sub-sampling procedures for SQSH samples. Protocol I of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) describes sub-sampling procedures for periphyton samples. Subsampling protocols for chemical samples are provided in the *Environmental Inorganic SOPs* (TDH, 2002-2020).

B4.7 Method Performance Criteria

The *Environmental Inorganic SOPs* (TDH, 2002-2020) have specific method performance criteria and failure policies for inorganic analyses. Section II of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) provides quality control, failure policies, and sorting criteria and taxonomic verification documentation procedures. Section II of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) provides quality control, failure policies, and taxonomic verification documentation procedures.

B4.8 Sample Disposal Procedures

Macroinvertebrate samples are maintained at least five years after the sample is processed and identified. Since macroinvertebrate samples are preserved in 80% ethanol, they are considered hazardous waste and are disposed in accordance with MSDS. Since diatom samples are preserved in formaldehyde, they are considered hazardous waste and are disposed in accordance with

MSDS. The *Environmental Inorganic SOPs* (TDH, 2002-2020) and the *Environmental Organic SOPs* (TDH, 2002-2014) provide various laboratory sample disposal procedures.

B4.9 Method Validation

Before adopting the *EPA Rapid Bioassessment Protocols for Use in Streams and Rivers* (Plafkin et al, 1989), SQSH samples were compared to Hester-Dendy and Surber samples and found to have comparable assessment results. Species saturation curves were completed at 100, 200, and 300 organisms. Two hundred organisms were found to provide the majority of taxa in most cases. When the 1999 revision of EPA's *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers* was published (Barbour et al, 1999) single habitat samples were compared to multihabitat samples in 13 ecoregions with no significant difference in index results.

Chemical analyses results are validated by periodically comparing data systems results with manually calculated results and reviewing all data. The *Environmental Laboratories Laboratory Quality Assurance Plan* (TDH, 2020) and the *Environmental Organic SOPs* (TDH, 2002-2014) provide method validation information. A complete list of TDH Environmental Standard Operating Procedures is included in the reference list. No non-standard or unpublished analyses methods are approved for 106 monitoring.

B4.10 Required Equipment and Reagents

The *Environmental Inorganic SOPs* (TDH, 2002-2020) and the *Environmental Organic SOPs* (TDH, 2002-2014) describe required equipment and reagents.

B4.11 Corrective Action Process for Analytical System Failure

Any instrument failing QC standard is removed from service until the problem is corrected. Corrective action procedures for TDH Environmental Laboratories analyses are described in the *Environmental Laboratories Laboratory Quality*

Assurance Plan (TDH, 2020) and the *Environmental Organic SOPs* (TDH, 2002-2014).

B4.12 Safety and Hazardous Material Disposal Requirements

All hazardous materials are handled and disposed of in accordance with MSDS requirements. The predominant hazardous materials used by field staff are calibration standard, ethyl alcohol and formalin. The *Environmental Inorganic SOPs (TDH, 2002-2020)* and the *Environmental Organic SOPs (TDH, 2002-2014)* describe handling and disposal protocols for chemicals used in sample analyses.

B5 QUALITY CONTROL REQUIREMENTS

Quality control is an integral part of the Division of Water Resources monitoring program. Section II of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) stipulates quality assurance requirements, including duplicate samples, sorting efficiency, and taxonomic verification of macroinvertebrate sample collection, analyses and habitat assessment. Section II of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* contains quality assurance requirements for field, trip, and equipment blanks, duplicate, flow meters calibration, and field quality control measures. Section II of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) contains quality assurance requirements for duplicate, flow meters calibration, and field quality control measures.

The *Environmental Inorganic SOPs* (TDH, 2002-2020) and the *Environmental Organic SOPs* (TDH, 2002-2014) stipulate quality assurance requirements for chemical analyses including blanks, spikes, calibration check samples, and duplicates. Quality control requirements for microbiological analyses are outlined in Part 9000 of the *Standard Methods for Examination of Water and Wastewater*, 22nd Edition (APHA, 2012).

B5.1 Quality Control Acceptance Criteria for Measurement Data (Statistical Analyses)

Data reduction procedures vary depending on:

- Type of data
- Number of data points
- Data distribution
- Purpose of data

Outlying data are generally included in the data set, unless they are considered atypical due to a qualifier (Table 33) or field notes. If it is determined that outlying data are atypical, the results are disregarded. Duplicate samples are averaged. Half of the detection limit is used for values below the detection limit. Analytical data associated with QC failures are not used. Data are tested for normality prior to statistical calculation. Procedures vary dependent on sample size (Table 38). Data are transformed prior to analyses if necessary. Generally, logarithmic or square root transformations are used.

Table 38: Tests Used to Determine Data Normality

Sample Size	Test
≤ 50	Shapiro Wilks
	Coefficient of Variation
> 50	Fillibens
	Skewness and Kurtosis
	Chi-Square
	Lillie for Kolmogorov-Smirnov
Any Size	Graphical

Applied statistical methods are used to summarize water quality data and make inferences from the data. Statistical methods are also used to determine the precision and bias/accuracy of the data. Basic statistical tests used to determine measures of relative standing, measures of central tendency, measures of dispersion, and measures of association are listed in Table 39.

Table 39: Tests Used for Statistical Analysis

Measure	Test
Relative Standing	Percentile
	Quantile
Central Tendency	Mean
	Median
	Mode
	Geomean
Dispersion	Range
	Variance
	Standard Deviation
	Coefficient of Variation

Measure	Test
	Analysis of Variance
	Interquartile Range
Association	Pearson's Correlation Coefficient
	Spearman's Rank Correlation Coefficient
	Serial Correlation Coefficient
Trending	Mann-Kendall Test
	Partial Mann-Kendall Test

Graphical representations of the data are used to identify patterns and trends, confirm or disprove hypotheses, discover new phenomena, and identify potential problems. Graphs utilized to represent water quality data are listed in Table 40.

Table 40: Graphical Representations

Type of Data	Graph
Univariable Data	Histogram
	Frequency Plot
	Stem-and-Leaf Plot
	Box and Whisker Plot
	Ranked Data Plot
	Quantile Plot
	Normal Probability Plot
Multivariable Data	Profile Plot
	Glyph Plot
	Star Plot
	Scatter Plot
	Coded Scatter Plot
	Parallel Coordinate Plot
	Matrix Scatter Plot
	Empirical Quantile-Quantile Plot
Temporal Data	Time Plot

Type of Data	Graph
	Correlogram
Spatial Data	Posting Plot
	Symbol Plot
	H-scatter Plot
	Contour Plot

B5.2 Quality Control Checks and Procedures

Section II of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018),* of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017), and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) describe field quality control procedures. QC activities are listed in Table 41.

The *Environmental Laboratories Laboratory Quality Assurance Plan* (TDH, 2020) stipulates inorganic laboratory quality control procedures. Data precision and accuracy are described in section XXVII of the *Environmental Laboratories Laboratory Quality Assurance Plan* (TDH, 2020). Protocol M in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* and *Standard Methods for Examination of Water and Wastewater* (APHA, 2012) have QC procedures for bacteriological analyses.

B5.3 Quality Control for Fish Tissue Processing

Samples are generally composited, although large fish may be analyzed individually. Only fillets (including belly flap) are analyzed. Collection, filleting and packaging protocols follow the Aquatic Biology Section, TDH SOP as is agreed upon and reviewed by DWR. Analysis follows protocols found in *Fish Tissue Collection No.: Env-AqBio-SOP-512*, Revision 6 (TDH, 2020).

To check sample processing and analysis between labs, a round robin is performed on both processed and unprocessed samples between the TDH, TVA and ORNL labs. When funding permits, this is conducted annually. Results are used to target potential problems and refine techniques where needed.

If time and funding are available, one staff member from the Watershed Planning Unit (DWR, TDEC) attends the National Forum on Contaminants in Fish annually. Information from this conference is used to refine protocols, enhance assessments, and gain knowledge of emerging contaminants.

Table 41: QC Activities

Activity	QC Require-ment	Frequency	Desired Endpoint	Corrective Action
Biorecon Field Collection	Duplicate	10%	Same Index Range.	Determine reason for variability and retrain field staff if needed. Continue training and duplicate every sample until desired endpoint is consistently achieved.
Biorecon Field ID	Duplicate	10%	Same Index Range.	Arbitrate final ID and retrain if needed. Require re-tention of all specimens and QC all identifications un-til desired endpoint is consistently achieved.
Biorecon Field ID	Voucher Col-lection	New taxa	Office/lab voucher speci-mens for each site.	Correct field identification as necessary.
SQSH Field Collec-tion	Duplicate	10%	Same Index Score.	Determine reason for variability and retrain field staff if needed. Continue training and duplicate every sample until desired endpoint is consistently achieved.
SQSH Sorting	Re-sort by 2nd taxonomist.	10%	90% sorting efficiency.	Re-sort all samples until desired endpoint is consist-ently achieved.
SQSH Identifica-tion	Re-ID by 2nd taxonomist.	10%	PDE<5; PTD<15; PTC>95; PTDabs<5	Re-ID all samples until desired endpoint is consist-ently achieved.
SQSH Identifica-tion	Reference Collection	New taxa	Expert verification.	Correct initial lab identification as necessary.
SQSH Taxa Data Entry	Verify Data Entry	10%	100% agreement.	Check all data entry until desired endpoint is achieved.

Activity	QC Requirement	Frequency	Desired Endpoint	Corrective Action
Habitat Assessment	Completion of Habitat Assessment by Independent Assessor	10%	Same Final Assessment Category.	Arbitrate scores. Retrain if necessary. Continue training and continued 2^{nd} independent assessment until desired endpoint is consistently achieved.
Rapid Periphyton Survey	Duplicate	10%	Same Index Range	Determine reason for variability and retrain field staff if needed. Continue training and duplicate every sample until desired endpoint is consistently achieved.
Multi-Habitat Diatom Sample	Duplicate	10%	Same Index Range	Determine reason for variability and retrain field staff if needed. Continue training and duplicate every sample until desired endpoint is consistently achieved.
Multi-Habitat Diatom Sample	Re-ID by 2^{nd} taxonomist.	10%	Percent community similarity > 75%	Re-ID all samples until desired endpoint is consistently achieved.
Chemical and Bacteriological Collections	Trip Blank	10% of trips per EFO	Less than detection limit.	Determine source of contamination (field or lab). Retrain or alter procedures depending on source. Flag data from samples collected on same trip (same parameter) and use data with caution.
Chemical and Bacteriological Collections	Field Blank	10%	Less than detection limit.	Determine source of contamination (field or lab). Retrain or alter procedures depending on source. Flag data from samples collected on same trip (same parameter) and use data with caution.
Chemical and Bacteriological Collections	Duplicates	10%	Within acceptable parameters*	Determine source of variability (natural, field contamination or analysis error). Re-sample, retrain, or alter procedures depending on source.

Activity	QC Require-ment	Frequency	Desired Endpoint	Corrective Action
Chemical and Bacteriological Collections	Temperature Blank	Every cooler	Less than or equal to 6 de-grees centigrade.	Flag results. Use data from samples in the same cooler with caution. Re-sample if necessary.
Chemical and Bacteriological collection using reusable equip-ment (buckets, bailers, automatic samplers etc.)	Equipment Field Blank	10%	Less than detection limit.	Determine source of contamination. Flag results use data from sample collected with questionable equip-ment with caution.
Instantaneous Field Parameters	Duplicate	Every site rec-ommended (First and last each day re-quired)	Within 0.2 units for pH, and temperature DO. (10% for DO measured in % saturation.) Within 10% of reading for Specific con-ductance.	Repeat procedure until reproducible results are achieved. If reproducible results are not achieved, discard data and repair probe.
Instantaneous Field Parameters	Calibration	Beginning and end of each sampling trip.	Pre-calibration, probe must be able to be ad-justed to standards. Post calibration must be within 0.2 units for pH, DO (mg/L) and temperature and within 10% of reading for Specific conductance and DO when measured in % concentration.	Pre-calibration do not use probe if cannot be ad-justed to standards. Repair, clean or change mem-branes as necessary. Post-calibration out of range, flag all measurement taken that trip, notify WPU by email if measurements already uploaded to Waterlog. Determine source of problem and remedy before meter is used again.

Activity	QC Requirement	Frequency	Desired Endpoint	Corrective Action
Continuous Field Parameters	Duplicate	10%	Measurements within 10%.	Determine source of discrepancy (probe placement, siltation, algal growth, malfunction, calibration drift etc.) Flag data and use with caution.
Flow Measurement	Duplicate	10%	Velocity within 10%.	Flag results, use with caution.
Chemical analyses blanks, spikes and duplicates.	TDH Environmental Lab SOP is specific for each parameter.	TDH Environmental Lab SOPs is specific for each parameter.	TDH Environmental Lab SOP is specific for each parameter.	TDH Environmental Laboratories SOPs are specific for each parameter. See references for a complete list. The *Environmental Laboratories Laboratory Quality Assurance Plan* (TDH, 2020) details quality assurance procedures.
TDH Laboratories data precision	Duplicate samples	10%	Warning limits and control limits are calculated.	*Environmental Laboratories Laboratory Quality Assurance Plan* (TDH, 2020) has specific information.
TDH Laboratories data accuracy	• Lab fortified blanks • Lab fortified matrices	As needed	Measure analyses accuracy (precision + bias).	*Environmental Laboratories Laboratory Quality Assurance Plan* (TDH, 2020) has specific information.
TDH Laboratories method blanks	Method blank	As needed	Determine if activity is added to sample from reagent.	*Environmental Laboratories Laboratory Quality Assurance Plan* (TDH, 2020) has specific information.

Activity	QC Requirement	Frequency	Desired Endpoint	Corrective Action
TDH Laboratories data reduction	• Hand calculation • Excel program • Instrument readout	Every sample	Correct interpretation of analyses results.	*Environmental Laboratories Laboratory Quality Assurance Plan* (TDH, 2020) has specific information.
TDH Laboratories data validation	Computer calculation are checked against hand calculated results	Periodically	Confirm computer calculations are correct.	*Environmental Laboratories Laboratory Quality Assurance Plan* (TDH, 2020) has specific information.
E. coli analysis	Media reagent check	Each new lot	Compare to standards.	Do not use media lot.
E. coli analysis	Methods check	10%	Compare to expected results.	Flag results as questionable. Use with caution.
E. coli analysis	Sealer check	Monthly	Dye outside wells.	Replace sealer.

*Duplicates to be within acceptable parameters for specific analytes. These are currently under review.
The assessment of duplicates is commonly undertaken by expressing the duplicate results as the Relative Percent Difference (RPD). As a rule of thumb, an RPD of ≤ 20% may indicate an acceptable result for duplicate aqueous samples (Equation 1), provided the result is five to ten times the limit of reporting (LOR). In those circumstances where the result is close to the LOR, RPD may exceed 20%. However, the acceptable RPD can be strongly influenced by the analyte and matrix.

$$RPD = \frac{|C_1 - C_2|}{\left(\frac{C_1 + C_2}{2}\right)} \times 100 \qquad \textbf{Equation 1}$$

Where: RPD is relative percentage difference

C_1 is the concentration of analyte from sample 1

C_2 is the concentration of analyte from sample 2

B6 INSTRUMENT AND EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE REQUIREMENTS

B6.1 Field Equipment

All field equipment and on site-testing equipment for chemical and bacteriological sampling are listed in Section I.H of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018).* Field equipment required for macroinvertebrate sampling is described in Section I.H of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017). Field equipment required for periphyton sampling is described in Section I.H of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010). The equipment lists are also located in Appendix G of this document.

B6.2 Field Equipment and Instrument Testing, Inspection, Maintenance, Repair, and Criteria for Acceptability

Protocols G, J, K, and L of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* stipulates acceptance criteria, testing and maintenance procedures and documentation requirements for field instruments including composite samplers, field parameter meters and flow meters. All field equipment is inspected, calibrated and tested each day the equipment is used. Generally spare parts are not warehoused for field equipment. In the event of malfunction, equipment is immediately sent for repair or replacement if spare equipment is not available. It is the responsibility of the EFO manager and/or in-house QC officer to verify procedures are followed.

B6.3 Laboratory Equipment and Instrument Testing, Inspection, Maintenance, and Repair

All TDH Environmental Laboratories' instruments undergo regularly scheduled preventative maintenance either by the instrument manufacturer via service agreement or by laboratory personnel, as stipulated in the *Environmental Laboratories Laboratory Quality Assurance Plan* (TDH, 2020). The *Environmental*

Inorganic SOPs (TDH, 2002-2020) and the *Environmental Organic SOPs* (TDH, 2002-2014) stipulate laboratory equipment and instrument acceptance criteria, testing criteria, inspection, maintenance and repair protocols and documentation procedures.

B6.4 Consumable Supplies

Buffer solutions, calibration standards, and required meter calibration are described in Protocol J of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* , Protocol C of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) and Protocol C of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010). In each EFO, the In-house QC Officer is responsible for ensuring the appropriate number of sample containers and other consumable supplies are available. The *Environmental Inorganic SOPs* (TDH, 2002-2020) and the *Environmental Organic SOPs* (TDH, 2002-2014) detail solvents, reagents, and buffer solutions used for sample analyses. TDH Environmental Laboratory Inventory Control Section is responsible for ensuring appropriate amounts of solvents, reagents, buffer solutions, and other consumable supplies are available for analyses.

B7 INSTRUMENT CALIBRATION AND FREQUENCY

Protocols G, J, K, and L of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* describe calibration procedures and documentation for field instruments including composite samplers, field parameter meters and flow meters. All field equipment is calibrated minimally once a week, followed by post drift check.

Calibration records are documented in the appropriate bound calibration logbook. If instruments do not maintain calibration, the source of the problem is determined and resolved with maintenance. If the problem cannot be solved in-house, a repair authorization is requested. Any maintenance or repairs are documented in the appropriate instrument logbook.

B7.1 Field Instrumentation Calibration

Protocols J, K, and L of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* stipulate instrument calibration, calibration frequency, and documentation procedures for instantaneous field parameter meters, continuous monitoring field parameter meters, and flow meters. Protocol C of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) and Protocol D of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) stipulate instrument calibration, calibration frequency, and documentation procedures for instantaneous field parameter meters. Logbook requirements, calibration acceptance criteria, calibration of standards and equipment, and documentation are also specified in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018).* Field meters used are the multi-parameter probe, flow meter, dissolved oxygen meter, conductivity meter, pH meter, temperature meter or thermometer in ^{o}C.

B7.2 Laboratory Instrumentation Calibration

According to the *Environmental Laboratories Laboratory Quality Assurance Plan (TDH, 2020)* "all service maintenance records and protocols are kept in permanent logbooks and/or electronic files" (TDH, 2014). The *Environmental Inorganic SOPs* (TDH, 2002-2020) and the *Environmental Organic SOPs* (TDH, 2002-2012) stipulate calibration acceptance criteria, calibration of standards and equipment, requirements, procedures, frequency, documentation, equipment certification, and protocols for repairing/recalibrating laboratory equipment.

B8 INSPECTION/ACCEPTANCE REQUIREMENTS FOR SUPPLIES AND CONSUMABLES

B8.1 Acceptance Criteria for Supplies and Consumables

Sections I.H of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018),* the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) provide a list of supplies required for field sampling. These documents also outline acceptance requirements. The *Environmental Inorganic SOPs* (TDH, 2002-2020) and the *Environmental Organic SOPs* (TDH, 2002-2014) stipulate supply acceptance criteria for chemical analyses. Managers in the Aquatic Biology, Inorganic and Organic TDH labs are responsible for ensuring all supplies and consumables meet acceptance criteria. See B6.4 for requirements for solvents, reagent, buffer solution and other consumable supplies.

Necessary field equipment varies depending on the project and monitoring objectives. Table 42 is a standardized list of general field equipment. Detailed lists of field equipment can be found in Appendix G.

Table 42: Acceptance Criteria for General Field Equipment

General Field Equipment	Acceptance Criteria*
GPS Unit	Must be calibrated and capable of measuring latitude and longitude to four decimal places
Conductivity Meter	Must be calibrated and capable of measuring Specific conductance in uMhos/cm or µs/cm to four digits or one decimal place. Range 0 -100,000 uMhos/cm, accuracy +/- 1% of reading
Dissolved Oxygen Meter	Must be calibrated and capable of measuring dissolved oxygen in % to one decimal place and in mg/L to

General Field Equipment	Acceptance Criteria*
	two decimal places, range 0 to 20 mg/L, accuracy +/- 0.2mg/L
pH Meter	Must be calibrated and capable of measuring pH to one decimal place. Range 2 to 12 units, accuracy +/- 0.2 mg/L
Thermometer	If thermometer used can be – calibrated and capable of measuring temperature in °C to two decimal places. Range –5°C to 45°C. Accuracy +/- 0.20°C
Turbidimeter	Acceptance if within ±2% of standard reading (plus stray light from 0 to 1000 NTU)
Flow Meter	Must be calibrated and capable of measuring flow in cfs to two decimal places
Wading Rod	Must be able to measure in feet to one decimal place
Surveyors or Measuring Tape	Must be capable of measuring in feet to one decimal place
Gloves	Must be powder-free latex or nitrile gloves (required for nutrient sampling) or shoulder length powder-free gloves (required for trace metals or mercury sampling)
Triangular Dip Net	Must be 500-micron mesh
Square Kick Net	Must be one-meter square with 500-micron mesh
Rectangular Net	Must be 18” long with 500-micron mesh

General Field Equipment	Acceptance Criteria*
Sample Bottles	Must be in accordance with QSSOPs for Chemical and Bacteriological Sampling and Macroinvertebrate Sampling as described in Section I.H of each QSSOP
Bacteriological Bottles	Must be sterile polypropylene, screwcap 250mL bottles
Nutrient Bottles	Must be certified clean single use 500mL plastic bottles
Metal Bottles	Must be certified clean single use 1-L plastic bottles
Mercury Bottles	Must be certified clean single use 1-L plastic bottles.
Cyanide Bottles	Must be certified clean single use 1-L plastic bottles
Sulfide Bottles	Must be pre-cleaned 500mL glass bottles
Boron Bottles	Must be pre-cleaned 125mL plastic bottles
TOC Bottles	1-250mL plastic
Low pH bottles	1-250 mL plastic
Base/Neutral/Acid Extractable Bottles	Must be pre-cleaned 1-gallon amber bottles with Teflon®-lined cap
Volatiles and Petroleum Hydrocarbons	Must be pre-cleaned 40-mL amber vials with Teflon®-lined septa cap
Extractable Petroleum Hydrocarbons	Must be pre-cleaned 1-gallon amber bottles with Teflon®-lined lid

* containing appropriate preservative when required.

Necessary laboratory equipment varies depending on the type of analysis performed. Table 43 is a standardized list of general laboratory equipment.

Table 43: Acceptance Criteria for General Laboratory Equipment

General Laboratory Equipment	Acceptance Criteria
Dissecting Microscope	Must have 10X, 15X, or 20X oculars with an objective 0.67-4.0 variable
Compound Microscope	Must have 10X ocular with objectives 100, 40, 10, and 3.2 variable
Balance measured to 0.1 gram or 0.0001 mg.	Must be verified and certified calibrated by a manufacturer certified technician and capable of measuring mass to four decimal places or method specified accuracy to be within ±1 in the final decimal place
Conductivity Meter	Must be calibrated and capable of measuring Specific conductance in uMhos or S/m to three digits or one decimal place
Thermometer	NIST traceable/certified thermometers or non-NIST thermometers that have been calibrated against NIST traceable/certified thermometer or calibrated infrared thermometer, must be capable of measuring in °C to two decimal places
Incubator for *E. coli* analyses	Must have a NIST traceable/certified thermometer or calibrated thermometer and capable of measuring at 35°C ± 0.5
Refrigerator	Must be capable of holding a constant temperature ±1° C
Freezer	Must be capable of holding a constant temperature ± 1° C

General Laboratory Equipment	Acceptance Criteria
Drying Oven	Must be capable of holding a constant temperature 65-210 $\pm$ 1° C
Autoclave	Must be verified sterilized and capable of reaching a maximum temperature of 121°C or greater
Centrifuge	Must be capable of reaching a speed of at least 3000 rpm
Mechanical Volumetric Dispensing Devices	Must be checked for accuracy against Class A glassware

Major instrumentation includes items such as: Inductively Coupled Plasma Emission Spectrometer (ICP-AES). All major instrumentation is maintained in accordance with manufacturer's recommendations and operational guidance.

Table 44 is a list of major instrumentation used in the laboratory.

Table 44: Acceptance Criteria for Laboratory Instrumentation

Laboratory Instrumentation	Acceptance Criteria
Inductively Coupled Plasma Emission Spectrometer (ICP-AES)	Must have background-correction capability, a radio-frequency generator, refrigerated recirculator, variable speed peristaltic pump, mass flow controllers, and gas supply. Light source must either be a hollow cathode lamp (HCL) or an electrodeless discharge lamp (EDL).
Laboratory Instrumentation	**Acceptance Criteria**
Inductively Coupled Plasma Mass Spectrometer (ICP-MS)	The spectrometer shall consist of an inductively coupled plasma ion source, a quadruple mass filter, and an ion detection system. A micro computer system and necessary software shall be provided for

Laboratory Instrumentation	Acceptance Criteria
	instrument control and for data acquisition, reduction, presentation, and storage. The spectrometer system shall include all equipment necessary for the maintenance of high vacuum and the introduction of samples by conventional solution nebulization. All other equipment, special tools, and software necessary for the operation of the system in accordance with the requirements of this specification shall be provided. The function of the Inductively Coupled Plasma Mass Spectrometer (ICP-MS) System shall include the introduction, atomization, ionization and mass analysis of dissolved samples so the qualitative identification, quantitative composition and isotopic composition of the elemental constituents of the samples can be determined.
Automated Discreet Analyzers	Must be capable of detecting analytes at the appropriate wavelengths as required by the method.

Necessary laboratory supplies vary depending on the type of analysis performed. Table 45 is a standardized list of general laboratory supplies.

Table 45: Acceptance Criteria for Laboratory Supplies

Laboratory Supplies	Acceptance Criteria
Glassware	Must be high quality borosilicate glass
Volumetric Glassware	Must be Class "A" quality
Reagents, Chemicals, Solvents	Must be in accordance with purity criteria for specified method
Laboratory Quality Water	Must be in accordance with purity criteria for specified method
Deionized Water	Must be deionized by cation, anion, and mixed bed units in the laboratory and have a resistivity > 1 megaohm-cm @ 25ºC
Nanopure Water	Must be reagent grade water and have a resistivity > 10 megaohm-cm @ 25ºC

B8.2 Inspection or Acceptance Testing Requirements and Procedures

The *Environmental Inorganic SOPs* (TDH, 2002-2020) and the *Environmental Organic SOPs* (TDH, 2002-2014) stipulate inspection or acceptance testing requirements and procedures. Managers in the Aquatic Biology, Inorganic and Organic TDH labs are responsible for ensuring all supplies, and consumables meet acceptance criteria.

B8.3 Tracking of Supplies and Consumables – update with new lab info

The Inventory Control Section of TDH Laboratories purchases, tracks, receives, and stores supplies required for chemical, bacteriological, and biological analyses. The Lab routinely test purchased sample containers that are pre-cleaned, pre-preserved and pre-certified because they have already been tested and certified by the vendor. As supplies are needed, they are ordered directly from Inventory Control. Supplies are also received from the contract labs. In each EFO, the DWR manager or their designee is responsible for ordering and inspecting supplies (Table 46).

Table 46: Inventory Inspectors

Name	Location
M. Baggett	TDH Environmental Laboratories – Inventory Supplies
D. Cutshaw	TDEC DWR JCEFO
T. Jennette	TDEC DWR NEFO
B. Ulmer	TDEC DWR CKEFO
C. Franklin	TDEC DWR JEFO
J. Brazile	TDEC DWR MEFO
J. Innes	TDEC DWR CHEFO
M. Atchley	TDEC DWR KEFO
S. Glass	TDEC DWR CLEFO
B. Epperson	TDEC DWR KSM

B9 DATA ACQUISITION REQUIREMENTS (NON-DIRECT MEASUREMENTS)

Acceptance Criteria

Non-direct measurement techniques are used to supplement measured data. The primary non-direct measurements are historical data in literature and visual assessments. Historical information is available infrequently and visual assessments are available sporadically. These data are never used alone for water quality assessments, but rather used for historical context or as a screening for further direct monitoring. These data are noted in the comment section of the ATTAINS entry for the specific waterbody.

B10 DATA MANAGEMENT

B10.1 Purpose and Background

Due to the large amount of data collected in monitoring activities, it was paramount that the division develop an electronic database to store and easily retrieve data for analyses and assessment. Data from the early 1970s through 1999 were stored in what is now called Legacy STORET. In 1998 the division developed an Access database, called the Water Quality Database (WQDB), to store not only station location and chemical and bacteriological results, but also fish tissue, biorecon, SQSH, habitat assessment, and periphyton results. These data are now being stored in an Oracle database called Waterlog.

Quarterly, station location, chemical and bacteriological data were uploaded into the modernized USEPA STORET Database. In September 2009 EPA ceased support of modernized STORET, as such the last upload of TDEC WPC data was sent to EPA the end of September 2009. The data can be located at STORET at https://www.epa.gov/waterdata/water-quality-data-wqx.

USEPA developed the CDX Exchange node for agencies to upload water quality data. DWR chemical and bacteriological data from 2009 – 2021 have been uploaded to WQX https://www.epa.gov/waterdata/water-quality-data-wqx . All electronically available fish tissue data since 1983 and macroinvertebrate taxa and habitat data since 1992 have also been uploaded. Diatom taxa should be uploaded in 2022.

B10.2 Record Keeping

Electronic records stored on the TDEC Central Office server are backed-up nightly on 22-cycle tape by STS personnel. Electronic copies of lab pdf files are permanently stored for reference in the Watershed Planning Unit (Table 18). TDH Environmental Laboratories' logs, instrument printouts, calibration records, and QC documents are stored at TDH Environmental Laboratories. The TDH Environmental Laboratories policy on electronic storage of data records is outlined below:

1. After completion of sample analysis and report generation, the sample report from the LIMS, StarLIMS, and the original sample request sheets will be matched together. In addition, any pertinent Sample Non-Compliance forms are included as well. A copy of the complete matched set is scanned as a pdf to a Laboratory network drive for storage and later retrieval.

2. Electronic (pdf) copies of the complete matched set (i.e. sample report plus original request sheets) are uploaded to the Lab data site and email notification is sent to the appropriate individuals (i.e. to individuals listed on the request sheets and to individuals in the Program Areas that have made prior requests to receive analytical reports).

3. After it has been verified that the electronic (pdf) copies are all complete and legible, the sample report plus original request sheets will be shredded. There is no storage of hard copy documents.

4. Electronic (pdf) copies of sample reports plus original request sheets are stored and retained electronically according to the following criteria:

    a. All drinking water compliance sample chemical analytical data and Laboratory reports will be kept by the Laboratory for a period of ten (10) years (40 CFR Part 141.33), and lead and copper for a period of twelve (12) years (40 CFR 141.91).

    b. Public water systems are required to maintain records of microbiological analyses of compliance samples for a period of five (5) years (40 CFR Part 141.33). The Environmental Microbiological Laboratory will maintain easily accessible records for five (5) years or until the next certification audit is complete, whichever is longer.

    c. All other noncompliance sample analytical data will be stored for five years, and then destroyed.

B10.3 Data Recording

Field staff upload field parameters, habitat, stream survey and biorecon taxa into a staging area in Waterlog. Original copies of field forms are uploaded to Waterlog. Laboratory personnel upload biological data analyzed at the lab. Chemical and bacteriological data are reported in electronic format from state and contract labs. After the quality assurance checks are performed, WPU technical staff upload station identification information and chemical, bacteriological, macroinvertebrate, habitat, field, fish tissue and periphyton data into the final tables of Waterlog.

B10.4 Standardized Forms

Copies of electronic data entry forms for Waterlog are provided in Appendix E. A copy of Environmental Field Office Monitoring Audit Report is provided in Appendix F. Electronic forms have been developed that increase efficiency and quality control and are uploaded to a SharePoint for access by all users.

B10.5 Data Quality Assurance Checks (Validation)

Chemical, bacteriological, macroinvertebrate, habitat, fish tissue, and periphyton analyses reports are reviewed by WPU technical staff for correct cost code, appropriate chain of custody, station identification number, and unusual parameter results. Only WPU technical staff upload the data from staging into final tables of Waterlog. Questionable results are referred to the TDH Environmental Laboratories or the collecting office for verification or correction. Quality assurance checks are performed on all data.

B10.5.1 Computer Requirements WQX upload

- The data transfers to WQX use WQX WEB on the Environmental Exchange Network in Tennessee.

B10.5.2 Software Requirements WQX

- Excel
- Waterlog
- ATTAINS

B10.5.3 Software Used for Data Analysis

- JMP
- Waterlog
- Excel
- OS4 – OpenStat4
- MULTMK/PARTKMK – Multivariate and Partial Mann-Kendall Test
- GIS – Geographic Information System
- LIMS (Lab)
- Attains

B10.6 Data Transformation

DWR receives electronic data from the state lab and contract labs to receive data electronically in Excel files. These data are uploaded to the DWR Waterlog and the EPA WQX framework. The Water Quality Exchange (WQX) is the EPA's framework that makes it easier for States, Tribes, and others to submit and share water quality monitoring data over the Internet.

B10.7 Data Transmittal

DWR staff collects chemical, bacteriological and biological samples across the state. The data are used for watershed assessments, ecoregion reference sampling and TMDL development. The QSSOP *for Macroinvertebrate Stream Surveys* (TDEC, 2017), the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) are followed for sampling protocol. Samples are delivered to TDH Environmental Laboratory or approved private laboratories for analyses. The TDH Environmental Laboratories provide chemical and bacteriological analyses reports approximately 25 days after samples are collected. Contract laboratories for bacteriological samples reports are sent to DWR approximately one week after samples are collected. It may take as long as a year for biological samples to be analyzed depending on the project and are uploaded directly to Waterlog staging area by the laboratory. Biorecon, habitat, stream survey and field parameters are uploaded to Waterlog staging areas directly by field staff.

B10.8 Data Reduction

Environmental Laboratory data reduction is calculated manually using, Microsoft Excel or direct instrument readout. Data are used for a number of programs, including watershed assessments, ecoregion reference sampling and TMDL development. Queries are made from Waterlog for the appropriate information by technical staff. Various statistical programs such as JMP are used to test data.

Waterlog calculates and scores biorecon and SQSH data for assessment purposes. The index scores are compared to biocriteria (SQSH) and biorecon guidelines. ATTAINS stores waterbody assessment information.

B10.9 Data Tracking

TDH Environmental Laboratories email the chemical and bacteriological reports to the samplers and QC officers of EFO. DWR staff are responsible for checking their email on a routine basis for analyses reports. If EFO staff are missing analyses reports, then TDH Environmental Laboratories are contacted to locate the missing reports. Once a month, chemical, bacteriological and fish tissue data are reported electronically from the laboratory and are uploaded to Waterlog after review by WPU staff. Macroinvertebrate and diatom data are loaded directly to a staging area by the laboratory (or EFO for biorecons.). Samplers upload field parameters, habitat assessments and stream survey data directly to a staging table in waterlog where it is reviewed by WPU staff. A unique station identification number (DWR Station ID) is assigned to each sampling location is used to track all sampling activities at that station. A unique field log number is assigned by sampling staff to identify each sample event. TDH Environmental Laboratories or a contract laboratory assign a unique lab number (activity id number) to each sample.

The division's 106 monitoring plan (TDEC, 2021) includes a list of all waterbodies to be sampled for the fiscal year. At the end of each quarter of the fiscal year, WPU and EFO staff review the monitoring plan list, to ensure that chemical and bacteriological analyses reports were received from TDH Environmental Laboratory Services for all stations sampled. TDH Environmental Laboratories are contacted if there are missing reports.

B10.10 Data Storage and Retrieval

Chemical, bacteriological, biological, fish tissue and habitat data are stored electronically in the Waterlog, on an external hard drive, DWR WPU H: drive and on SharePoint. Paper copies of older data are in files in WPU and are being digitized as time permits. Waterlog is housed on the TDEC server and is back-upped nightly.

Chemical, bacteriological, habitat, macroinvertebrate and fish tissue data are sent to EPA's WQX STORET database. Upload of diatom data will begin in 2022. WQX STORET is a repository for water quality, biological, and physical data and is used by state environmental agencies, EPA and other federal agencies, universities, private citizens, and many others. The STORET website https://www.epa.gov/waterdata/water-quality-data-wqx includes data retrieval instructions. Data retrievals also can be made by querying Waterlog. Chemical, bacteriological and fish tissue data are currently public facing and may be found on the Division's Data and Map Viewer page under Ambient Water Quality Monitoring data at https://dataviewers.tdec.tn.gov/pls/enf_reports/f?p=9034:34510::::::

PART C

ASSESSMENT AND OVERSIGHT

C1 ASSESSMENTS AND RESPONSE ACTIONS

C1.1 Purpose/Background

During the planning process, many options for sampling design, handling, cleanup and analyses, and data reduction were evaluated and chosen for this project. In order to ensure data collections are conducted as planned, a process of evaluation and validation is necessary. This element of the QAPP describes the internal and external checks necessary to ensure:

1. all elements of the QAPP are correctly implemented as prescribed,
2. the quality of the data generated by implementation of the QAPP is adequate, and
3. corrective actions, when needed, are implemented in a timely manner and their effectiveness is confirmed.

EPA, Region 4, conducts any external assessments. The most important part of this element is documenting all planned internal assessments. Generally, internal assessments are initiated or performed by the designated internal QAPP Manager. The activities described in this element are related to the responsibilities of the QAPP Manager as discussed in Section A4.

C1.2 Organizational Assessments

Readiness reviews. A readiness review is a technical check to determine if all components of the project are in place so work can commence on a specific phase. A readiness review will be conducted in conjunction with annual 106 program plan development to ensure enough equipment, staffing, and funding are available. EFO managers communicate any needs to the QAPP Project Manager during the readiness review. At a minimum, the following issues will be addressed:

1. Availability and accessibility of an up-to-date copy of the Quality Assurance Project Plan and all associated quality system standard operating procedures relating to the project.

2. Availability of current reference documents including the following:

    - Most recent TDEC *DWR Surface Water Monitoring and Assessment Program Plan* (TDEC, 2021)
    - Most recent *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017)
    - Most recent *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)*
    - Most recent version of the *List of Impaired and Threatened Waters* (TDEC, 2020)
    - Most recent version of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010)
    - *Rules of the TDEC*, Chapter 0400-40-03 General Water Quality Criteria (TDEC-WQOB, 2019)
    - *Rules of the TDEC,* Chapter 0400-40-04 *Use* Classifications of Surface Waters (TDEC-WQOB, 2019)

3. Availability of electronic data sources including:

    - ATTAINS
    - WATERLOG
    - STORET/WQX
    - Tennessee Ambient Surface Water Data Online
    - SharePoint

4. Availability of equipment, operating and calibration instructions for the equipment, records sheets and other necessary supplies.

5. Availability of appropriate sampling supplies and equipment.

6. Proper alignment of appropriate laboratory to receive the samples and accessibility of lab sheets, tags, and other necessary supplies.

7. Availability of staff.

8. Appropriate training of staff and opportunity for staff to resolve questions, concerns and issues prior to the onset of the project.

C1.3 Assessment of Project Activities

1. *Readiness Review.* Monitoring, analyses, and assessment staff are contacted to ensure appropriate equipment, staffing, and funding are available.

2. *Surveillance.* Surveillance is the continual or frequent monitoring of the status of a project and the analyses of records to ensure specified requirements are being fulfilled. WPU staff will maintain contact with EFO staff concerning project status and review databases for data gaps.

3. *Technical Systems Audit (TSA).* A TSA is a thorough and systematic onsite qualitative audit, where facilities, equipment, personnel, training, procedures, and record keeping are examined for conformance to the QAPP. It has broad coverage and its application may reveal weaknesses in management structure, policy, practices, or procedures. The TSA is ideally conducted after work has commenced, but before it has progressed very far, thus giving opportunity for corrective action.

4. Historically the EFO Deputy Director and or QAPP Project Manager will conduct audits to determine if the project is on-task. A quarterly visit is made to each field office to conduct routine surveillances of various project activities and assist staff in addressing on-going concerns. Historically an audit report was completed and is on file at the field office (Appendix F).

5. *Performance Evaluation (PE).* A PE is a type of audit in which the quantitative data generated by the measurement system are obtained independently and compared with routinely obtained data to evaluate the proficiency of an analyst or laboratory. “Blind” PE samples are those whose identity is unknown to those operating the measurement system. Blind Pes often produce better performance assessments because they are handled routinely and are not given the special treatment undisguised Pes sometimes receive. TDH Environmental Laboratories perform blind PE studies each year on specific parameters according to protocols described in the *Environmental Laboratories Laboratory Quality Assurance Plan* (TDH, 2020).

6. *Audit of Data Quality (ADQ).* An ADQ reveals how the data were handled, what judgments were made, and whether uncorrected mistakes were made. Data are reviewed by WPU technical staff prior to use and production of a project’s final report. ADQs identify the means to correct systematic data reduction errors.

7. *Management System Review.* Management system review is a quality function as well as a function for scientific review of the plan. An extensive review team was used for this project. Names, titles, and positions of the reviewers are included in Part A of this QAPP. Also included are their report findings, the QAPP authors’ documented responses to their findings, and reference to where responses to review comments are on file, if necessary.

8. *Data Quality Assessment (DQA).* DQA involves the application of statistical tools to determine whether the data meet the assumptions that the DQOs and data collection design were developed under and whether the total errors in the data are tolerable. *Guidance for Data Quality Assessment* (USEPA QA/G-9, 2000) provides non-mandatory guidance for planning, implementing, and evaluating retrospective assessments of the quality of the results from environmental data

operations. This document is used as guidance by DWR when reviewing data for this project.

C1.4 Assessment Personnel

Internal audits will be performed by the QAPP Project Manager. Qualifications of assessment personnel and considerations for assessments are specified in TDEC's QAPP and will be followed during this project. Key assessment personnel are identified in Table 47. In the event deviations from the QAPP are needed to efficiently conduct this program component, the issue will be discussed with the QAPP Manager and documented in the assessment report provided as part of this project.

Table 47: Assessment Activities Personnel

Assessment Activities	Responsible Personnel
Readiness Review	EFO Managers
Surveillance	WPU staff
Technical System Audit	QAPP Manager
Performance Evaluation	QA Manager of Environmental Laboratories
Audits of Data Quality	WPU Staff
Management System Review	Planning Team Members
Data Quality Assessment	WPU Staff

C1.5 Number, Frequency, and Schedule of Assessment Activities

This section specifies the schedule of audit activities and relevant criteria for assessment, to the extent it is known in advance of project activities. Specifics will be developed in conjunction with the assessment and with current needs at the time. The QAPP will be reviewed annually and revised as necessary. Table 48 lists the minimum QAPP assessment schedule.

Table 48: QAPP Assessment Schedule

Assessment Type	Frequency	Approx. Date	Type (oral, written or both)	Minimum number of reports
Readiness review	Annually	January	Both	1
Surveillance	Monthly	End of Month	Both	1
Technical system audit	Quarterly	January April July October	Both	4
Performance evaluation	Annually	Varies	Written	4
Audits of data quality	Annually	September	Both	1
Management System review	Once/ Revision	September	Written	Per revision
Data quality assessments	Annually	September	Both	1

C1.6 Reporting and Resolution of Issues

Audits, peer reviews, and other assessments often reveal practice or procedure findings that do not conform to the written QAPP. This section defines the protocol for resolving them. Proposed actions to ensure corrective actions were performed effectively are specified in this section. The staff person to whom concerns should be addressed, decision-making hierarchy, schedule and format for oral and written reports, and responsibility for corrective action are also discussed.

Findings from the assessments conducted shall be included in a written report. The format of the report and information to be included will comply with at least the minimum requirements of the Bureau of Environment *Quality Management Plan* (TDEC, 2021) for assessment reports. These reports are filed in WPU. For the purposes of this QAPP, assessment reports shall be made available to the division director.

In reviewing and responding to the report findings, the director may appoint a staff person or committee to conduct required activities. This person or committee shall be empowered to act on behalf of the director to correct any items addressed in the assessment. For conflicts that may arise during this project or any of its assessments, the process defined in the Bureau of Environment *Quality Management Plan* (TDEC, 2021) shall be followed. All issues relating to this QAPP shall be appropriately documented and attached to this document.

C2 REPORTS TO MANAGEMENT

This section describes documentation and reporting requirements for the assessment activities described in Section C1. Reports to management include project status, results of assessments and significance of quality assurance and recommended solutions.

C2.1 Purpose/Background

Effective communication between all personnel is an integral part of a quality system. Planned reports provide a structure for apprising management of the project schedule. Deviations from approved QA and test plans, impact of these deviations on data quality, and potential uncertainties in decisions based on the data shall be included in these reports.

C2.2 Frequency, Content, and Distribution of Reports

This QAPP indicates frequency, content, and distribution of reports so management may anticipate events and move to improve potentially adverse results. An important benefit of the status reports is the opportunity to alert management of data quality problems, propose viable solutions, and procure additional resources (Table 49).

If program assessment (including technical systems evaluations, the integrity of performance measurement and data assessment) is not conducted on a continual basis, data integrity generated in the program may not meet quality requirements. QAPP Reports will be stored in the central office for at least five years. These audit reports (Table 50), submitted in a timely manner, provide an opportunity to implement corrective actions when most appropriate.

Table 49: Project Status Reports

Project Status Reports	Frequency	Distribution
Quarterly Activity Reports	Quarterly	CO Managers Deputy Director of Field Operations EFO Managers WPU staff
TDEC Division of Water Resources Surface Water Monitoring and Assessment Program Plan	Annually	USEPA CO Managers EFO Managers Deputy Director of Field Operations TDH Environmental Lab Director
Annual Performance Report	Annually	USEPA
106 Electronic Workplan	Annually	USEPA CO Managers EFO Managers EFO QC Officers
Data Audits	Continuously	TDH Environmental Labs QAPP Manager
Data Quality	Continuously	QAPP Manager
QA Audit Report (Historic)	Annually	QAPP Planning Team Members

Table 50: QAPP Reports

Assessment Report Type	Report Fre-quency	Report Preparer	Report Distribution
Readiness review	Annually	EFO managers, supervisors	Chris Rhodes
Surveillance	Annual	WPU staff	EFO Managers Chris Rhodes
Technical Systems Audit	Quarterly	EFO staff	EFO Managers WPU staff
Performance Evaluation	Annually	TDH Env. Lab staff	Elaine Boyd
Audits of Data Quality	Annually	WPU, EFO and TDH lab	Rich Cochran EFO Managers
Management Systems Review	Per Revision	WPU and EFO staff	Natalie Moore
Data Quality Assessments	Annually	WPU staff	Rich Cochran

C2.3 Report Description

A written report of findings from the assessments conducted shall be prepared. The format of the report and information to be included will comply with at least the minimum requirements of the Bureau of Environment *Quality Management Plan* (TDEC, 2021) for assessment reports. Report descriptions are listed in Table 51.

Table 51: Report Descriptions

Assessment Report Type	Type of Response Required as Result of Assessment Report Findings
Readiness review	Report monitoring staff, equipment, supplies, reference, and training needs to the deputy director.
Surveillance	WPU will inform EFOs if additional data are needed.
Technical systems audit	EFOs take necessary steps to repair audit deficiencies.
Performance Evaluation	TDH Environmental Laboratories will provide report and support documentation regarding analyses discrepancies with Blind Pes.
Audits of data quality	WPU staff will work with TDH Environmental Laboratories and EFOs to improve data quality.
Management Systems Review	All peer review comments will be considered, and applicable comments will be included in QAPP revisions.
Data Quality Assessment	Steps will be taken to ensure data assessments follow valid design and statistical analyses as outline in *Guidance for Data Quality Assessment* (USEPA QA/G-9, 2000).

It is recognized that changes made in one area or procedure may affect another part of the project. Documentation for all changes shall be maintained and included in the reports to management. The procedure specified in the Documents and Records Section of Bureau of Environment *Quality Management Plan* (TDEC, 2021) shall be followed in documenting and maintaining all documents, changes and distribution of documents and changes to them. Deviations from this procedure may be obtained by working with TDEC's Quality Assurance Manager and documenting them in a report attached to this QAPP.

PART D

DATA VALIDATION AND USABILITY

D1 DATA REVIEW, VERIFICATION, AND VALIDATION REQUIREMENTS

Data verification is defined by EPA as "the process of evaluating the completeness, correctness, and conformance/compliance of a specific data set against the method, procedural, or contractual requirements. Data validation is defined by EPA as an "analyte and sample-specific process that extends the evaluation of data beyond method, procedural, or contractual compliance to determine the analytical quality of a specific data set". Tools and techniques used to meet the data quality goals of Tennessee's state-wide water quality monitoring program, including data integrity and data suitability, are discussed in this section.

One of the responsibilities of each project or task supervisor and manager is to review, verify, and validate all data collected in the field and laboratory to determine if the data meet QAPP objectives. This includes quantitative, qualitative, and narrative data. Completeness and correctness of records and data are primary goals of the verification and validation process. The review, verification and validation process starts from the beginning of any project and continues throughout.

All sampling equipment are checked by the field team members prior to sampling. The integrity of the equipment is determined at that time. Equipment manuals for each make and model of sampling and field equipment are referred to when the integrity of the equipment has been compromised. Corrective actions are taken in accordance with the equipment manual instructions and recorded in the equipment log. Field water parameter meters and flow meters are calibrated at the regional field offices. Protocol J in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* describes calibration methods, record keeping, and QA/QC requirements for each instantaneous field parameter. The field log, equipment log, and forms are reviewed for errors by the field team members prior to sending the data to WPU. When field equipment results are outside the calibration range during post drift checks, data should not be reported. WPU is notified by email if data were already uploaded so it can be removed. Any analyses flagged by the TDH

Environmental Laboratories are viewed with caution and excluded when outside of the existing data set. Flags used are listed in Table 33.

Field collection, handling, and documentation procedures for chemical and bacteriological samples are specified in Protocols A-I of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018).* Data acquired in the field are recorded in a logbook and on appropriate field forms at the sample site and checked by the field team members. Data collected during rainfall are noted in the comment field and viewed with caution. All field data are checked by the field team members for field record consistency and QC information. Sample collection, deviations in the data, and impacts on data quality are reviewed by the responsible environmental field office supervisor and verified. The data are then uploaded to the staging table of production Waterlog.

The data are checked by WPU for discrepancies and errors. When an error is found, the field team members are contacted about the error. Once the data are acceptable, they are promoted to the final table. Field logbooks and forms are kept in the field offices and are available for supplementary review if needed. Table 52 lists examples of improper field practices that would compromise field data and the warning signs that are checked by WPU (Adapted from EPA QA/G-8, 2002).

Table 52: Warning Signs of Improper Field Sampling Practices

Improper Practice	Description	Warning Signs
Improper Sampling	Collection of biological samples from an area with inappropriate habitat or from an area other than the actual sample location	Macroinvertebrate data inconsistent with historical or known biological index scores and metrics
	Collection of water samples from an area of known contamination to increase contaminant concentration, mixing known contaminated water samples with water from the actual sample location, or directly adding a contaminant to the sample	Inconsistencies among sample collection logs, field notebook, photos, and COC Laboratory notes that the water samples were not homogenous
	Collection of water samples from an area known as "clean" or collecting samples from somewhere else entirely different from the actual sample location and forging the location information	Data with concentrations lower than historical or known concentrations at the sample location
	Collecting many samples from one location to avoid the time/cost of sampling other required locations	Similar results for samples from multiple station locations
Mislabeled Sample Containers	Misrepresenting the sample date, location, or other key parameter by falsifying information on the sample container label	Crossed-out information, inconsistent information between the field logs, collection logs, and the sample label
Documentation Issues	Filling in field sheets and logbooks improperly	Inconsistencies among field logs, collection logs, sample labels, sample locations, and times between samples

Field collection, handling, and documentation procedures for macroinvertebrate samples are specified in Protocols A-L of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017). Biological samples with fewer than 160 organisms found in a SQSH sample are flagged and results are viewed with caution. The site is re-sampled if necessary, to obtain acceptable results. All biological samples are checked by the taxonomist and the Aquatic Biology Laboratory supervisor. Sample collection, deviations in the data, and impacts on data quality are reviewed by the laboratory supervisor and verified. The data are transmitted electronically to the staging tables of Waterlog. The data are checked by WPU for discrepancies and errors. When an error is found, the field team members are contacted about the error. Field sheets, forms, and logbooks are kept in the field office and laboratory and are available for supplementary review if needed.

Field collection, handling, and documentation procedures for diatom samples are specified in Section I Protocols A-H of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010). All periphyton samples are to be sent to the central lab for analysis.

Field, trip, equipment blanks, and routine samples are sent to the laboratory for analysis. All samples examined by the laboratory are analyzed according to methods described in the *Environmental Inorganic SOPs* (TDH, 2002-2020) and the *Environmental Organic SOPs* (TDH, 2002-2014). When contamination is found in the blanks, the field team members and the laboratory supervisor are contacted to determine and correct the source of contamination. All samples collected that day by the same team are viewed with caution and excluded from the data set if outside of the existing range. Duplicate, laboratory fortified blanks, spikes, and method blanks that fail to meet goals are immediately reviewed for the source of error and samples analyzed that day are viewed with caution and excluded from the data set if outside of the existing range. Laboratory logbooks and forms are kept at the TDH laboratories and are available for supplementary review if needed. WPU is notified by email if data were already recorded and flagged in Waterlog accordingly.

Sometimes the source of error in chemical data is due to instrument inaccuracy or failure. Instruments are calibrated, maintained, and repaired according to the specifications in the instrument instructions manual. Calibration records must be kept in logbooks in the laboratory. The calibration of each instrument is performed with a minimum of three concentrations of standards for linear curves, a minimum of five concentrations of standards for nonlinear curves, or as specified by the method of choice. When the calibration verification is out of control, the source of error is determined, and corrective action is taken. Any instrument that fails QC procedures outlined in the *Environmental Laboratories Laboratory Quality Assurance Plan* (TDH, 2020) is not be used until the problem is corrected. All data from samples analyzed that day by the same instrument are viewed with caution and excluded from the data set if outside of the existing range. Any samples affected by instrument inaccuracy or failure should be re-analyzed once the problem is resolved. The source of error and corrective action, as well as any results from reanalysis should be recorded in the laboratory logbook. WPU is notified by email if data were already recorded and flagged in the Waterlog accordingly.

Some data acquired in the laboratory are automatically entered into the LIMS system. The automated calculations and algorithms used for the calculations were verified during the installation of the system. Data are periodically checked by the laboratory analyst by recalculating results produced by the automated system. Instrument outputs or recorded measurements for samples and standards, along with sample-specific preparation information are used for "raw data calculation verifications". Prior to transmitting the data, it is reviewed by the laboratory analytical supervisor and verified. It is transmitted electronically to WPU. The data are checked by WPU for discrepancies and errors. When an error is found, the laboratory analyst is contacted about the error. Once the data are validated, they are entered into the Waterlog. Table 53 lists examples of improper laboratory practices that would compromise chemical data and the warning signs that are checked by WPU (Adapted from EPA QA/G-8, 2002). Laboratory logbooks and forms are kept at the TDH laboratories and are available for supplementary review if needed.

Procedure to determine potential contamination of results of field, trip and equipment blanks.

Laboratory

For DWR and DoR trip, field and equipment blanks with measurable and verifiable values above the MQL (i.e. within the calibration curve), these blanks are rerun and noted as such in the comments field below the results entry.

EFO staff (In-house QC officer)

1. Contact the lab to verify accuracy of report and request repeat analysis if within holding time.

2. Verify blank water was obtained in accordance with SOP from a new container from an approved source, stored less than 28 days and that gloves were used to collect blank water.

3. Verify chemical collection SOP was followed, including wearing of gloves while pouring field blank sample.

4. Verify all coolers in contact with sample have been cleaned in accordance with SOP.

5. If contamination was determined to have only affected blank and not associated samples, discard blank data, correct problem and repeat QC set. Notify WPU by email of corrective action and provide lab id number of blanks to be discarded.

6. If contamination source could not be determined or could not be proven to be isolated to the blank, flag the questionable parameter on all 10 samples (or sample trips)

associated with the QC sample with a B which designates analyte present in lab blank. Data will be disregarded or viewed with caution during assessments. Sampling should be repeated. Notify WPU of which samples/parameters need to be flagged, include Lab ID Number, collection date, station ID.

7. If source of contamination is isolated, take corrective action immediately to avoid contamination of future samples. Notify WPU of corrective action.

8. WPU and the lab will review statewide QC results on a regular basis. If repeated contamination (above the mdl) is found for any parameter, the lab and central office will coordinate corrective action to isolate problem and resolve.

Table 53: Warning Signs of Improper Laboratory Practices

Improper Practice	Description	Warning Signs
Dry Labbing	Reporting results without analyzing samples	Overlapping analysis times on the same instrument
QC Issues	Failure to conduct specified analytical steps by reporting previously conducted successful QC results instead of conducting specified QC analyses	QC measurements that are identical to those submitted in the past. Inadequate run times for sample analysis (may suggest that specified QC checks were skipped)

Improper Practice	Description	Warning Signs
Manipulation of Sample Prior to Analysis	Fortifying water sample with additional analyte	High chemical concentrations for chemicals that are typically found to be low at the location the sample was collected.
	Over dilution of a sample	Low chemical concentrations or non-detects for chemicals that are typically found to be high at the location the sample was collected.
Manipulation of Results During Analysis	Peak shaving – manually adjusting results to produce a desired outcome	Repeated manual integrations, especially on QC measurements
	Time-traveling – falsifying date of analysis to disguise exceedance of holding times	Inconsistencies in dates for holding times, extractions, and analyses
Manipulation of Results After Analysis	Figures transposed to produce a desired result	Erased or handwritten changes in the printed data report
	Laboratory selection of preferred data from a larger data set	Raw data incompatible with calculated results

Data review, verification, and validation for all DWR monitoring projects are completed internally at the field offices, laboratory, and central office. Required records and logs used in the verification and validation process are discussed in section A9 of this QAPP. Documents used to review, verify, and validate data are as follows:

- *Rules of the TDEC, Chapter 0400-40-04, Use Classifications for Surface Waters. 2019*
- *Rules of the TDEC, Chapter 0400-40-03, General Water Quality Criteria. 2019*

- *2020 EPA Approved Lists of Impaired and Threatened Waters*
- *QSSOP for Macroinvertebrate Stream Surveys. 2017*
- *QSSOP for Chemical and Bacteriological Sampling of Surface Waters. 2018*
- *Consolidated Assessment and Listing Methodology (CALM). 2021.*

The U.S. EPA requires that a centrally planned, directed and coordinated quality assurance and quality control program be applied to efforts supported by them through grants, contracts or other formalized agreements. This time allocation is an essential component of biological sampling and analysis and will be included in annual work plans. This is not an optional or "as time allows" activity. The goal is to demonstrate the accuracy and precision of the biologists, as well as the reproducibility of the methodology, and to ensure unbiased treatment of all samples.

A. General QC Practices

1. Quality Team Leader (QC Coordinator) – A centralized biological QC coordinator will be designated with the responsibility to ensure that all QC protocols are met. This person will be an experienced water quality biologist in the Watershed Planning Unit. Major responsibilities will include monitoring QC activities to determine conformance, distributing quality related information, training personnel on QC requirements and procedures, reviewing QA/QC plans for completeness, noting inconsistencies, and signing off on the QA plan and reports.

2. Quality Team Member (In-house QC officer) - One DWR biologist/environmental specialist/scientist in each EFO will be designated as the Quality Team Member (in-house QC officer.) This person will be responsible for performing and/or ensuring that quality control is maintained and for coordinating activities with the central Quality Team Leader (QC coordinator).

3. Training - Unless prohibited by budgetary travel restrictions, training will be conducted at least once a year through workshops, seminars and/or field demonstrations to maintain consistency, repeatability and precision between biologists/environmental specialists conducting macroinvertebrate surveys. This will also be an opportunity for personnel to discuss problems they have encountered with the methodologies and to suggest SOP revisions prior to the annual SOP review. Note: topics of discussion should be submitted to the central Quality Team Leader (QC coordinator) before the meeting so that a planned agenda can be followed, thus making the best use of limited time.

D2. VERIFICATION AND VALIDATION METHODS

D2.1 Process for Verifying Data

TDEC DWR EFO personnel verify data produced by the field office in-house. The data are reviewed by the field team members and other EFO personnel. When the data are received by WPU staff, they are reviewed for unusual or unlikely results. EFO field staff are contacted about questionable field data. Documents such as sample collection logs, field screening results, field logbooks, field meter calibration logs, and COC records are also used in the review process for data verification.

TDH Environmental Laboratories personnel verify data produced by the laboratory or their sub-contractors. When analyses results from TDH Environmental Laboratories are received by WPU staff, the data are reviewed. The appropriate TDH Environmental Laboratory analytical supervisor is contacted to confirm unusual or unlikely results (outliers). The *Environmental Laboratories Laboratory Quality Assurance Plan* (TDH, 2020) provides additional information. Documents such as hard copies of the raw data, bench notes, calibration logbooks, lab notebooks, internal tracking forms, and COC records are also used in the review process for data verification.

There is no specific software used for data verification at WPU. Table 54 lists the personnel responsible for data verification and resolution procedures.

Table 54: Data Verification Process and Resolution Procedures

Data Quality Check Points	Person Responsible for Verification	Issue Resolution
Biological Check Points		
Biological logs	In-house QC Officer*	Contact sampler and/or TDH Aquatic Biology Laboratory
Biological QC logs	In-house QC Officer*	Contact sampler and/or taxonomist
Taxa list entry in SQDATA and Waterlog.	TDH Aquatic Biology Laboratory Supervisor EFO biologist WPU staff	Check Waterlog reference table for valid nomenclature; verify new taxa.
Biological scoring	WPU staff TDH Aquatic Biology Laboratory Supervisor	Check Waterlog metric criteria table and calculation.
Field Meter Check Points		
Calibration logs	In-house QC Officer*	Contact Sampler
QC readings	In-house QC Officer*	Contact Sampler
Waterlog Upload	EFO staff	Contact Sampler
Chemical and Bacteriological Check Points		
QC sample collections	In-house QC Officer*	Contact Sampler
Analyses QC	TDH Analytical Supervisor	Contact Analyst
Data review	WPU staff	Contact Analyst
Waterlog upload	WPU staff	Contact Analyst

* In-house QC officer refers to the TDEC EFO staff member designated by the manager to ensure quality control measures are applied and performed in accordance with the SOPs. See table 55.

Table 55: DWR EFO In-House Officers

EFO	BIOLOGICAL IN-HOUSE OFFICER	WATER QUALITY IN-HOUSE OFFICER
MEFO	Heather N. Smith	Heather N. Smith
JEFO	Amy Fritz	Brad Smith
NEFO	Joel Worsham	Jordan Fey
CHEFO	Charles Walton	Jessica Rader
CKEFO	Shawn Puckett	Shawn Puckett
CLEFO	Eddie Gordon	Eddie Gordon
KEFO	Larry Everett	Christie Renfro
KMS	Dan Murray	Christopher Pracheil
JCEFO	Beverly Brown	Franklin Colyer

D2.1.1 Field Data Verification

Field data are verified according to the *QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018)* the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010). Section II of these documents provides details about QA/QC activities. The field team members take duplicate field measurements at 10% of the sampling locations to verify data quality in the field. The field team members, and Environmental Field Office supervisors are responsible for verifying COC, receipt log, field forms, field meter calibration log, and that all applicable quality assurance protocols are properly followed for collection of data in the field. Questionable data are not loaded to Waterlog.

When field data are uploaded to Waterlog from the Environmental Field Offices. WPU staff review the data for unusual or unlikely results (outliers). Additional QC checks are built into Waterlog. Field staff are contacted concerning any questionable information or data. Field staff review equipment calibration logs and field notes to verify results. WPU staff make corrections in Waterlog.

D2.1.2 Chemical and Bacteriological Data Verification

Chemical data are verified according to the *Environmental Organic SOPs* (TDH, 2002-2014) and the *Environmental Inorganic SOPs* (TDH, 2002-2020). Bacteriological data are verified according to *Standard Methods for Examination of Water and Waste Water* (APHA, 2012). The SOPs and Standard Methods provide details about QA/QC activities. Duplicate samples, blank samples, and standards are analyzed to verify data quality in the laboratory. TDH Environmental Laboratories personnel are responsible for verifying COC, receipt log, TDH calibration logs, and that all applicable quality assurance protocols are properly followed for chemical and bacteriological analyses. The TDH Environmental Laboratory analytical supervisor is responsible for chemical and bacteriological final data verification and ensuring the results are emailed to the data users. The lab flags any questionable data.

When chemical and bacteriological data are received from TDH Environmental Laboratories, WPU staff review the data for unusual or unlikely results (outliers). Additional QC checks are built into Waterlog. The appropriate lab manager is contacted by email regarding any questionable results. The lab manager reviews sample analyses, blanks analyses, and data recording errors. Issues with TDH Environmental Laboratories analyses results are documented in the Verification Database. The corrections are emailed to WPU. WPU staff make corrections in Waterlog.

D2.1.3 Biological Data Verification

All biological data are verified through quality control checks described in Section II of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2017) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) The field team members take duplicate samples at 10% of the sampling locations to verify data quality in the field. The Environmental Field Office personnel are responsible for verifying COC, receipt log, taxa lists, and that all applicable quality assurance protocols are properly followed for macroinvertebrate collection as well as upload of biorecon and field data to waterlog. The TDH Aquatic Biology Laboratory supervisor is responsible for final biological data verification, upload to waterlog of lab samples and notifying samplers of availability of results. The lab includes comments on certainty of identifications or deviations from protocol such as subsample size.

Waterlog scores biorecons and SQSH samples to reduce the potential for errors. If taxa are uploaded that are not in the master reference table, Waterlog generates a QC report. If identification cannot be resolved, specimens are sent to outside experts for verification. Once the discrepancies are corrected and agreed upon, WPU staff make corrections in waterlog.

D2.2 Process for Validating Data

Verified data are validated to determine the analytical quality of the data set. Data validation applies to data acquired in the field and in the laboratory. The goal of validation is to determine data quality. Once data are reviewed and verified by the responsible field and laboratory staff, the project or task supervisor validates the data. Oftentimes professional judgment is exercised in order to maximize the benefits of the data validation process. Any corrections or changes to the verified data are reflected in the validated data and a record of those corrections or changes is kept.

D2.2.1 Field Data Validation

Documents such as sample collection logs, field screening results, field logbooks, field meter calibration logs, and COC records are reviewed for data validation. Field records are reviewed for consistency. Quality control information is reviewed for completeness and correctness. Any deviations such as changes in sample locations, samples collected, sample analyses, time, or unusual readings from field meters are considered during the validation process for their effect on data quality. All field data results are compared to the data quality objectives presented in the division's program plan (TDEC, 2020). Once the data are validated, they are uploaded to Waterlog. Any field data limitations are recorded the comment field of the Waterlog.

D2.2.2 Chemical and Bacteriological Data Validation

Documents such as hard copies of the raw data, bench notes, calibration logbooks, lab notebooks, internal tracking forms, and COC records are reviewed for data validation. Laboratory logbooks and notebooks are reviewed for consistency. The calculations used to determine sample results are checked for accuracy. Quality control checks such as duplicates, blanks, and standards are reviewed for completeness and correctness. Any QC deficiencies are considered during the validation process to determine their effect on data quality. All chemical and bacteriological data results are compared to the data quality objectives presented in the division's program plan (TDEC, 2020). Once the data are validated, they are uploaded to Waterlog. Any bacteriological or chemical data limitations are recorded in the laboratory notebooks and are flagged in the Waterlog.

D2.2.3 Biological Data Validation

Documents such as sample collection logs, field forms, lab bench sheets, internal tracking forms, and COC records are reviewed for data validation. Laboratory logbooks and notebooks are reviewed for consistency. Taxa lists are reviewed for completeness and correctness. Quality control checks such as duplicate samples are reviewed for conformity. Any QC deficiencies are considered during the validation process to determine their effect on data quality. All biological data results are compared to the data quality objectives presented in the division's program plan (TDEC, 2021). Once the data are validated, they are uploaded to Waterlog. Any biological data limitations are recorded in the field and laboratory worksheets and are noted in the comment field of Waterlog.

D3 RECONCILIATION WITH USER REQUIREMENTS

Reconciliation is the final assessment of data quality and the conclusion of the quality assurance process. Once the review, verification, and validation process is completed, assessment of the data quality is applied to the data quality objectives presented in the division's program plan (TDEC, 2021). This ensures data credibility for defensible decisions. EWPU five-step process for data quality assessment is followed (EPA QA/G-9, 2000):

- Review the Data Quality Objectives and Sampling Design
- Conduct a Preliminary Data Review
- Select the Statistical Test
- Verify the Assumptions of the Statistical Test
- Draw Conclusions from the Data

D3.1 Review the Data Quality Objectives and Sampling Design

The monitoring and assessment objectives as outlined in Part A5 of this document and the data quality objectives as outlined in Part A7 of this document are reviewed to determine how the data will be evaluated. Sampling design is dependent upon the type of monitoring specified. Although sample design may be different for each type of monitoring, all samples are collected and measured following the same protocols and are not dependent on the type of monitoring. The statewide monitoring program is comprehensive and is outlined in Part B1 of this document. Activities involved in each five-year cycle include planning and data collection, monitoring, assessment, TMDL determination and waste load allocation, permit issuance, and development of watershed management plans.

D3.2 Conduct a Preliminary Data Review

The first activity of the preliminary data review is to review the quality assurance documentation associated with the data collection and reporting process. The type of data acquired, listed in Table 9, is dependent on the monitoring objectives. Any anomalies in recorded data, missing values, or deviations from sample location and design are addressed. At this stage, the data have been verified and validated and are ready for use. In the event data at this point cannot be validated and reconciled with data quality objectives, it is removed from the data set. If possible, additional monitoring is conducted. WPU staff are responsible for ensuring data reconciliation or data removal, if reconciliation is not possible. All values within a data set that are below detection limits are given a value of half the detection limit. Hypotheses are constructed about the data set. Statistical quantities are computed. In addition to statistical methods, graphical representations of the data are used to identify patterns or trends. Specific statistical methods and graphical representations employed are determined by the data quality objectives for each type of monitoring.

D3.3 Select the Statistical Test

The results of the preliminary data review are used to determine which statistical test is legitimate for the type of data collected for each type of monitoring. The statistical test chosen is based on the data quality objectives, preliminary data review, and assumptions concerning the data set or sample site and the hypotheses about the data set. Once a test is chosen, the underlying assumptions of the test are identified as appropriate for the data set. Once the test and underlying assumptions are determined to be appropriate for the data set, it is further determined how sensitive or robust the test is to departures from the underlying assumptions. Specific tests of hypotheses are listed in Part B5 of this document. When an objective is to compare data to a fixed threshold of regulatory limit, the appropriate hypothesis tests in Section 3.2 of EPA's *Guidance for Data Quality Assessment Practical Methods for Data Analysis* (EPA QA/G-9, 2000) are selected for use. When an objective is to compare data from different locations or processes, the appropriate hypothesis tests in Section 3.3 of EPA's *Guidance for Data Quality Assessment Practical Methods for Data Analysis* (EPA QA/G-9, 2000) are selected for use.

D3.4 Verify the Assumptions of the Statistical Test

The validity of the statistical test chosen is determined by examining the underlying assumptions regarding the data set. The primary objective of this step-in data reconciliation is to determine whether the data support the underlying assumptions of the test. This determination can be performed quantitatively using statistical analysis of the data to confirm or reject assumptions that accompany the test. Standard tests for normal distribution are conducted when adequate data are available. Once normality is confirmed other statistical methods are applied to test the hypothesis. Appropriate tests chosen for detecting and estimating trends, outlier tests, tests for dispersion, and tests for independence or correlation are determined by the hypothesis and the data set. When normality is rejected, the appropriate transformations are performed on the data set, such as a logarithmic transformation. Nonparametric tests are used when the data cannot be transformed to fit a normal distribution. The level of significance of each statistical test is determined by the amount of data in the data set, the hypothesis, and the statistical method chosen to test the hypothesis.

D3.5 Draw Conclusions from the Data

Specific quantitative conclusions are drawn from the data using statistical methods. Other conclusions drawn from the data are made using a qualitative approach. There are many aspects to the decision-making process. Chemical, bacteriological, biological, and physical/habitat data are all used to assess water quality. To gauge Tennessee's progress toward meeting the goals of the *Federal Water Pollution Control Act* (U.S. Congress, 2000) and *Tennessee Water Quality Control Act* (TN Secretary of State, 2021), water quality data are compared to *Rules of the TDEC*, Chapter 0400-40-03, General Water Quality Criteria (TDEC-WQOB, 2019) and the Level IV Ecoregion reference data set (Table 7).

D3.5.1 Chemical Data

Chemical data collected are used in the water quality assessment process. The null hypothesis is that the waterbody associated with the data set does not exceed criteria or regional guidelines. The waterbody is considered unimpaired when 90% of the chemical data points fall within criteria or guidelines. The decision is made to not reject the null hypothesis. Data sets from waterbodies that do not fulfill the requirements of the null hypothesis are considered impaired and the decision is made to reject the null hypothesis. When there are biological data and chemical data sets for a waterbody, best professional judgment is used in the assessment. Where chemical data exceed criteria and macroinvertebrate data indicate support of fish and aquatic life, the decision is based on the macroinvertebrate results. Any waterbody placed on the List of Impaired and Threatened Waters is revisited in accordance with the CALM and additional data are collected to determine corrective action and identify any TMDL development needs.

D3.5.2 Bacteriological Data

Bacteriological data collected are used in the water quality assessment process. The null hypothesis is that the waterbody associated with the data set does not exceed criteria. The waterbody is considered unimpaired when the calculated geomean and/or single criterion meet criteria. The decision is made to not reject the null hypothesis. Data sets from waterbodies that do not fulfill the requirements of the null hypothesis are considered impaired and the decision is made to reject the null hypothesis. When the calculated geomean meets criteria, but a single sample exceeds criteria due to rain, the decision is based on the criteria and best professional judgment. Any waterbody placed on the EPA Approved List of Impaired and Threatened Waters for impairment are revisited and additional data are collected to determine corrective action and identify TMDL development needs.

D3.5.3 Biological Data

Biological data collected are used in the water quality assessment process. The null hypothesis is that the waterbody associated with the data set does not fall below regional guidelines. The waterbody is considered unimpaired when the index values and/or biorecon scores meet or exceed regional guidelines. The decision is made to not reject the null hypothesis. Data sets from waterbodies that do not fulfill the requirements of the null hypothesis are considered impaired and the decision is made to reject the null hypothesis. When biorecon scores are ambiguous, the decision is based on habitat and/or chemical data. The decision, using best professional judgment, can be made to consider the waterbody unassessed until a single habitat semi-quantitative sample can be collected. Any waterbody placed on the EPA Approved List of Impaired and Threatened Waters for impairment is revisited and additional data are collected to determine corrective action.

D3.5.4 Physical/Habitat Data

Physical/habitat data collected are used in the water quality assessment process. The null hypothesis is that the waterbody associated with the data set does not fall below regional guidelines. The waterbody is considered unimpaired when the habitat scores meet or exceed regional guidelines. The decision is made to not reject the null hypothesis. Data sets from waterbodies that do not fulfill the requirements of the null hypothesis are considered impaired and the decision is made to reject the null hypothesis. Where the habitat scores fall below regional guidelines and macroinvertebrate data indicate support of fish and aquatic life, the decision is based on the macroinvertebrate results. Any waterbody placed on the EPA Approved List of Impaired and Threatened Waters for impairment is revisited and additional data are collected to determine corrective action.

D3.6 Interpreting and Communicating Conclusions

Water quality assessments are completed by applying water quality criteria to the monitoring results to determine if waters are supportive of all designated uses. Water quality criteria are defined in Water Quality Standards published minimally every three years. The support or impairment status of a waterbody is entered in ATTAINS. Impaired waterbodies are identified and listed on the List of Impaired and Threatened Waters published biennially. Waterbodies that pose a potential human health threat from fish tissue contamination or elevated bacteria levels are posted and published on the impaired and threatened waters list and on the TDEC website. Waterbodies in need of TMDL development are identified through water quality assessments and reported per civil action (Tennessee Environmental Council et. Al., 2001). Watershed management plans are updated as needed and all documents are made available to the public on the TDEC website at: https://www.tn.gov/environment/program-areas/wr-water-resources/water-quality/water-quality-reports---publications.html.

As technologies improve we are transitioning from a document type of inventory plan to a GIS based web application. The most recent information can be found at https://www.tn.gov/environment/program-areas/wr-water-resources/water-quality/river-basins-regulated-by-the-inter-basin-transfer.html

A final report is published for any special project funded through grant money in accordance with the grant requirements. All publications are made available to the public on the TDEC website at: https://www.tn.gov/environment/program-areas/wr-water-resources/water-quality/water-quality-reports---publications.html

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Appendix A:

ACRONYMS AND DEFINITIONS

LIST OF ACRONYMS

AB	Aquatic Biology
ADQ	Audit of Data Quality
APHA	American Public Health Association
ARAP	Aquatic Resource Alteration Permit
ATTAINS	Assessments TMDL Tracking and Implementation System
BR	Biorecon
BS	Bachelor of Science
BSERT	Biological Survey Electronic Reporting Tutorial
CALM	Consolidated Assessment and Listing Methodology
CHEFO	Chattanooga Environmental Field Office
CKEFO	Cookeville Environmental Field Office
CLEFO	Columbia Environmental Field Office
CFR	Code of Federal Regulations
CO	Central Office
COC	Chain of Custody
DoR	Division of Remediation
DQA	Data Quality Assessment
DQI	Data Quality Indicator
DQO	Data Quality Objective
DVD	Digital video disk
DWR	Division of Water Resources
EFO	Environmental Field Office
EPA	Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, Trichoptera
ESRI	Environmental Systems Research Institute
ETW	Exceptional Tennessee Water
FAL	Fish and Aquatic Life
GIS	Geographic Information System
HASP	Health and Safety Plan

LIST OF ACRONYMS

HUC	Hydrologic Unit Code
IS	Information Systems
ISO	International Organization for Standardization
JCEFO	Johnson City Environmental Field Office
JEFO	Jackson Environmental Field Office
KEFO	Knoxville Environmental Field Office
KLAB	Knoxville Laboratory
MS	Surface Mining
MDL	Method detection limit
MEFO	Memphis Environmental Field Office
MQL	Minimum Quantitation Limit
MPS	Multihabitat Periphyton Survey
NEFO	Nashville Environmental Field Office
NELAC	National Environmental Laboratory Accreditation Conference
NHD	National Hydrology Dataset
NLAB	Nashville Laboratory
NPDES	National Pollution Discharge Elimination System
ONRW	Outstanding National Resource Waters
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
PDE	Percent Difference in Enumeration
PTDabs	Absolute Difference in Percent Taxonomic Completeness
PE	Performance Evaluation
PTC	Percent Taxonomic Completeness
PTD	Percent Taxonomic Disagreement
QA	Quality Assurance
QAD	Quality Assurance Division (EPA)
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMP	Quality Management Plan

LIST OF ACRONYMS

QSSOP	Quality System Standard Operating System
RAM	Random Access Memory
RPS	Rapid Periphyton Survey
SDS	Safety Data Sheet
SOP	Standard Operating Procedure
SPERT	Stream Parameter Reporting Tutorial
SQBANK	Semi-Quantitative Bank
SQDATA	Semi-Quantitative Database
SQKICK	Semi-Quantitative Kick
SQSH	Semi-Quantitative Single Habitat
STORET	Storage and Retrieval Database
TAL	Target analyte list
TDEC	Tennessee Department of Environment and Conservation
TDEC-E	Tennessee Department of Environment and Conservation Bureau of Environment
TDH	Tennessee Department of Health
TMDL	Total Maximum Daily Load
TMI	Tennessee Macroinvertebrate Index
TOC	Total Organic Carbon
TSA	Technical Systems Audit
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
USACE	United States Army Corp of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WPU	Watershed Planning Unit
WQB	Water Quality Branch
WQOG	Water Quality Oil and Gas Board
WQX	Water Quality Exchange (EPA)

List of Definitions

Ambient Monitoring: Routine sampling and evaluation of receiving waters not necessarily associated with periodic disturbance.

Analyte: The chemical, physical or biological parameter(s) measured during sample analysis.

Assessment: The evaluation process used to measure the performance or effectiveness of a system and its elements. As used here, assessment is an all-inclusive term used to denote any of the following: audit, performance evaluation, management systems review, peer review, inspection, or surveillance.

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

Bias: Consistent deviation of measured values from the true value, caused by systematic errors in a procedure.

Bioassay: Exposure of biological organisms to a chemical(s), which determines the concentration of the chemical, that impairs or causes the death of the organism.

Biocriteria: Numerical values or narrative expressions that describe the reference biological condition of aquatic communities inhabiting waters of a given designated aquatic life use. 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.

List of Definitions (Continued)

Bioregion: An ecological subregion, or group of ecological subregions, with similar aquatic macroinvertebrate communities that have been grouped for assessment purposes. Tennessee has defined 15 bioregions.

Chain-of-Custody: A procedure which documents the collection, transport, analyses and disposal of a sample by requiring each person who touches the sample to provide the date and time of sample collection/receipt and sample transfer/disposal.

Composite Sample: Composite samples can be time or flow proportional. Time integrated composite samples are collected over time, either by continuous sampling or mixing discrete samples. Flow proportional composite samples are composed of several samples sized relative to flow. Composite samples may also be combined manually by collecting grab samples at various intervals in a waterbody.

Diurnal Dissolved Oxygen: Cyclic fluctuations in dissolved oxygen levels of water between day and night.

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. There are 25 (Level IV) ecological subregions in Tennessee.

Ecoregion: A relatively homogenous area defined by similarity of climate, landform, soil, potential natural vegetation, hydrology, and other ecologically relevant variables. There are eight (Level III) ecoregions in Tennessee.

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

List of Definitions (Continued)

Flash point: Temperature at which a liquid will yield enough flammable vapor to ignite.

Grab Sample: Grab samples consist of either a single discreet sample or individual samples collected over a period of time not to exceed 15 minutes.

Habitat: The instream and riparian features 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: Algae attached to submerged substrate in aquatic environments

Quality Assurance (QA): Includes quality control functions and involves a totally integrated program for ensuring the reliability of monitoring and measurement data; the process of management review and oversight at the planning, implementation and completion stages of date collection activities. Its goal is to assure the data provided are of high quality and scientifically defensible.

Quality Control (QC): Refers to routine application of procedures for obtaining prescribed standards of performance in the monitoring and measurement process; focuses on detailed technical activities needed to achieve data of the quality specified by data quality objectives. QC is implemented at the field or bench level.

Rain Event: A qualifying event is a precipitation event of 0.5 inches or greater in a 24-hour period.

List of Definitions (Continued)

Reference Database: Biological, chemical, physical, and bacteriological data from ecoregion reference sites.

Recommend: Advise as the best course of action. Synonyms: optional, may, should.

Require: Obligatory or necessary. Synonyms: must or shall.

Riparian Zone: An area that borders a waterbody (approximately 18 meters wide).

Split Sample: A sample that has been portioned into two or more containers from a single sample container or sample mixing container. The primary purpose of a split sample is to measure sample handling variability.

Thalweg: A line representing the greatest surface flow and deepest part of a channel.

Trace Metals: Low-level metal analyses requiring ultra-clean sample collection and laboratory analyses generally reported in the low parts per trillion range.

Wadeable: Rivers and streams less than 4 feet deep unless there is a dangerous current.

Watershed: The area that drains to a particular body of water or common point.

Appendix B:

ORGANIZATIONAL CHARTS

Division of Water Resources Monitoring Staff

Jennifer Dodd
Director
(615)-532-0643

April Grippo
Deputy Director
(615)-532-0774

Watershed Planning Unit
Rich Cochran
(615)-532-0997

- Program Planning
- Water Quality Standards
- Ecoregions Project
- Water Quality Assessment
- Planning Standards
- STORET Database
- Stream Posting
- GIS Management
- Nonpoint Source Activity Coord.
- WLA/TMDL
- Watershed Management Plans

Chris Rhodes
Deputy Director
(423-854-5419)

Jonathan Burr
Fellow
(865)-594-5520

Paula Mitchell
Deputy Director
(615)-532-0663

INFORMATION MAN-AGEMENT

Vacant

- Personnel
- Training & Travel
- Fiscal Services
- Contracts
- EPF Fees

CHATTANOOGA EFO
Jennifer Innes
(423) 634-5719

COLUMBIA EFO
Sherry Glass
(931) 380-3397

COOKEVILLE EFO
Brad Ulmer
(931) 432-7627

JACKSON EFO
Conner Franklin
(731) 512-1302

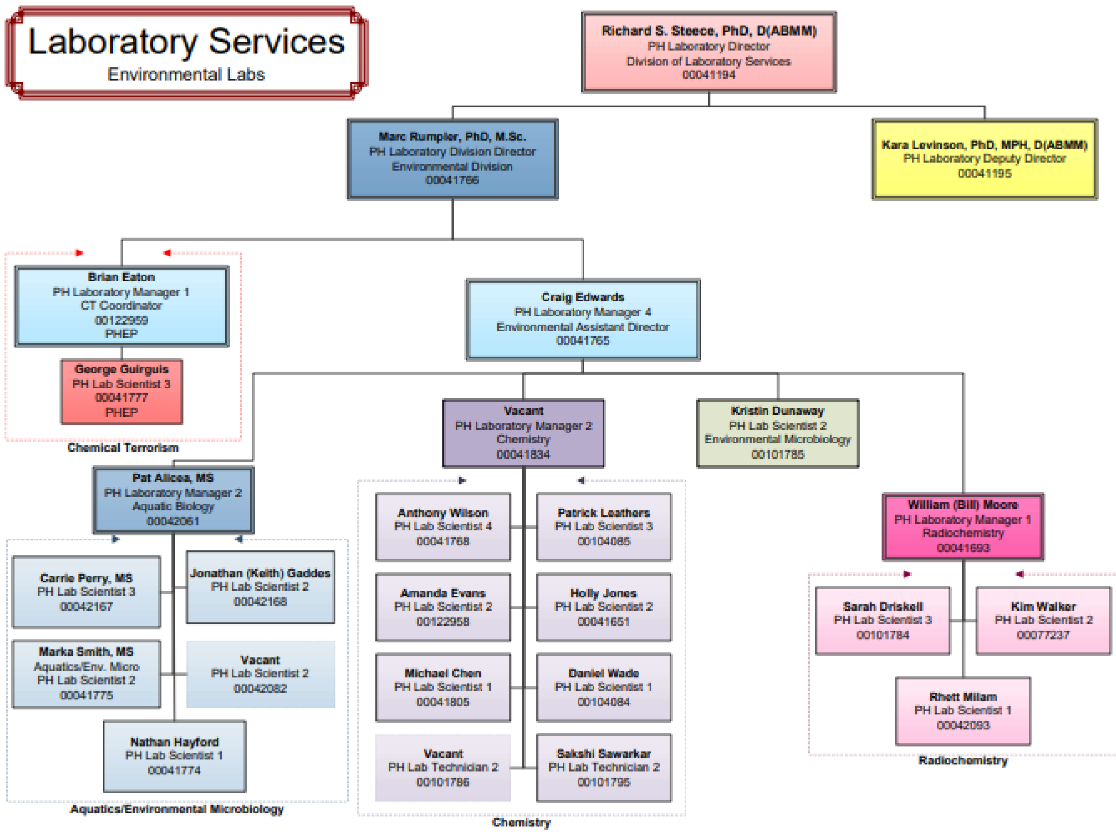
JOHNSON CITY EFO
Dane Cutshaw
(423) 854-5421

MEMPHIS EFO
Joellyn Brazile
(901) 371-3025

MINING SEC-TION
Bryan Epperson
(865)-308-3699

NASHVILLE EFO
Tim Jennette
(615)-687-0760

KNOXVILLE EFO
Michael Atchley
(865) 202-8134

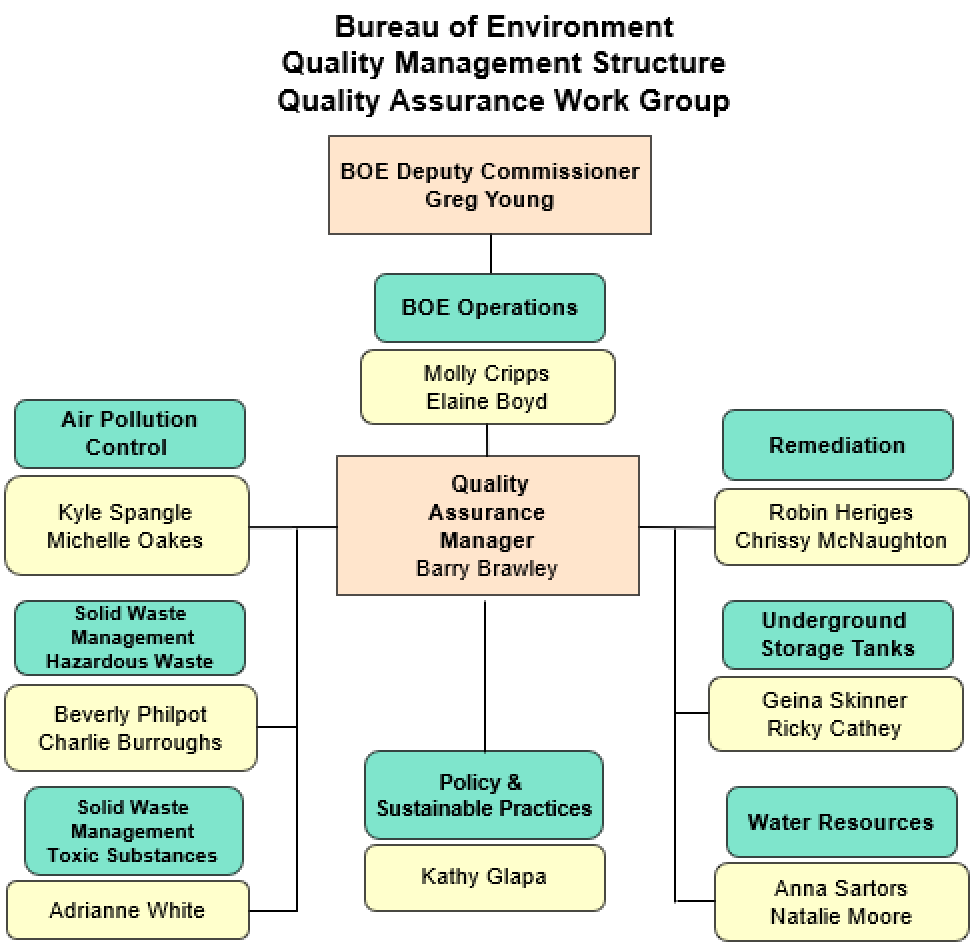


Tennessee Department of Health Laboratories Nashville Org Chart

TDEC Quality Management Program Organization

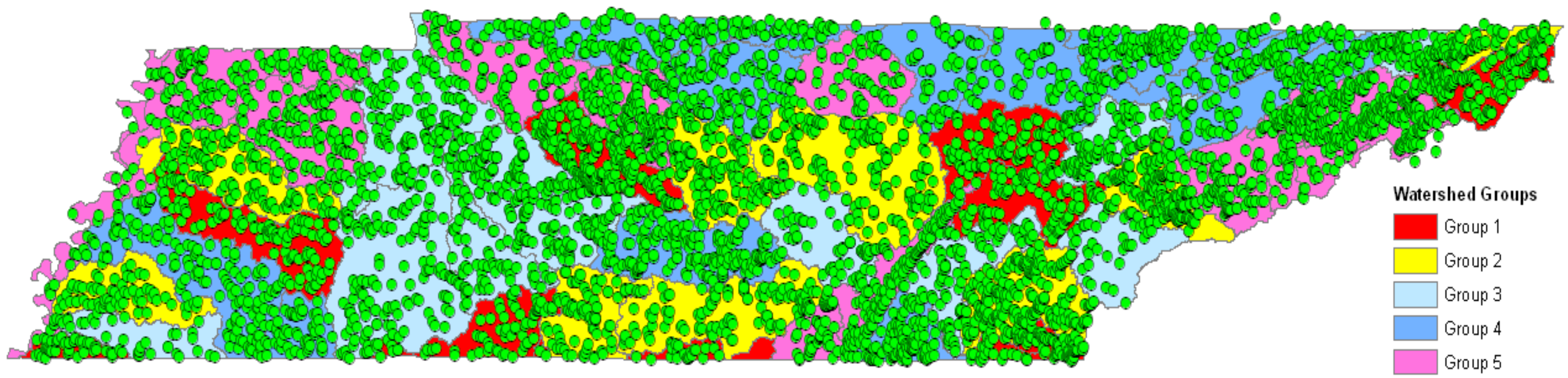
As required by EPA, TDEC's Quality Assurance Manager, Barry Brawley, is responsible for quality system activities within TDEC. Specifically, the Quality Assurance Manager functions independently of direct environmental data generation, model development and technology development responsibility. This person reports on quality issues directly to the Deputy Commissioner for Environment and has free access to senior management on all issues relating to TDEC's quality system.

Quality Assurance Work Group members are independent of groups generating, compiling and evaluating environmental data and technology. The members are part of the Environmental divisions included in the Quality Management Program. Members are responsible for participating in activities to ensure a quality system is established, implemented and maintained within their respective division in accordance with TDEC-BOE's Quality Management Program and for reporting on the performance of the quality system to management for review and development of recommended improvements. The members participate in review of the quality system at defined intervals and maintain appropriate records for the division.


Bureau of Environment
Quality Management Structure
Quality Assurance Work Group
BOE Deputy Commissioner
Greg Young
BOE Operations
Molly Cripps
Elaine Boyd
Quality Assurance Manager
Barry Brawley
Air Pollution Control
Kyle Spangle
Michelle Oakes
Solid Waste Management Hazardous Waste
Beverly Philpot
Charlie Burroughs
Solid Waste Management Toxic Substances
Adrianne White
Policy & Sustainable Practices
Kathy Glapa
Remediation
Robin Heriges
Chrissy McNaughton
Underground Storage Tanks
Geina Skinner
Ricky Cathey
Water Resources
Anna Sartors
Natalie Moore

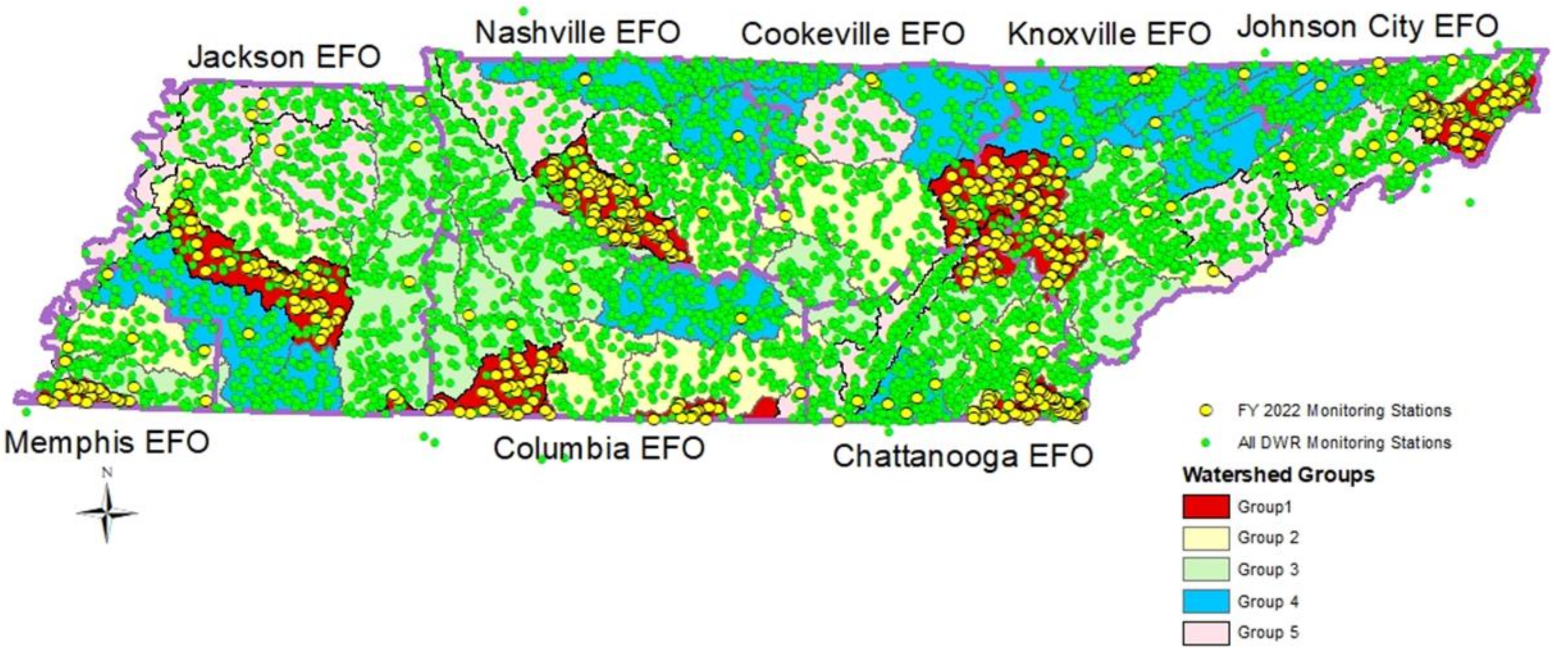
Appendix C:

MAPS



Water Quality Monitoring Stations

(Includes chemical, bacteriological, fish tissue and biological)



2021-2022 Water Quality Monitoring Collection Stations

Appendix D:

TESTS,

METHOD DETECTION LIMITS,

HOLDING TIMES,

CONTAINERS,

AND PRESERVATIVES

TDH and Regional Bacteriological Analyses*

Test	Required MDL	Holding Time	Container	Preservative
Coliform, total		30 hours	Two 250 mL plastic, only 1 bottle is needed if only *E. coli* is analyzed. Bottles are sterilized.	Sodium Thiosulfate ($Na_2S_2O_3$). Bottles are labeled with preparation date and expiration date. Do not use expired bottles.
E. coli		6 hours		

Store on ice ≤ 10°C.

TDH Routine Analyses*

Test	Required MDL	Holding Time	Containers	Preservative
Acidity	NA	14 days	250 ml for IC parameters, color and turbidity. 250 mL for low pH, zero headspace 1 L plastic for acidity, alkalinity, total dissolved solids, suspended solids and total residue solids. 1 L plastic for settable solids. 1 L plastic for BOD or COD.	None
Alkalinity	NA	14 days		
Alkalinity, phen.	NA	14 days		
BOD, 5-day	NA	48 hours		
CBOD, 5-day	NA	48 hours		
Chloride	0.18 mg/L	28 days		
Chlorine, residual	0.1.0mg/L	Test immed.		
Chromium, hexavalent	NA	24 hours		
Color, apparent	NA	48 hours		
Color, true	NA	48 hours		
Specific conductance	NA	28 days		
Fluoride	0.19 mg/L	28 days		
Nitrogen, Nitrate*	0.0025 mg/L	48 hours		
Nitrogen, Nitrite*	0.0018mg/L	48 hours		
Orthophosphate*	0.0073 mg/L	48 hours		
Oxygen, dissolved		Field		
pH		Field		
Low pH	NA	72 Hours		

Test	Re-quired MDL	Holding Time	Containers	Preservative
Silica	TBD	28 days	1-liter plastic for all other parameters	
Sulfate	0.81 mg/L	28 days		
Turbidity	NA	48 hours		
Residue, dis-solved	NA	7 days		
Residue, sus-pended	NA	7 days		
Residue, settlea-ble	NA	48 hours		
Residue, total	NA	7 days		
MBAS	MBAS	48 hours	1-gallon plas-tic	

All plastics are one-time use. Store on ice ≤6°C.
No preservative is needed for Routine Samples.
*not routinely collected unless for a specific reason

TDH Nutrient Analyses Available

Test	Required MDL	Holding Time	Container	Preservative
COD	1.94 mg/L	28 days	500 mL plastic	1 mL sulfuric acid (H_2SO_4)
Nitrogen, ammonia	0.030 mg/L	28 days		
Nitrogen, ni-trate*	0.0025 mg/L	48 hours		
Nitrogen, NO_3 & NO_2	0.031 mg/L	28 days		
Nitrogen, to-tal kjeldahl (TKN)	0.15 mg/L	28 days		
Nitrogen, to-tal organic	0.15 mg/L	28 days		
Phosphorus, total	0.01mg/L	28 days		

All plastics are one-time use. Store on ice ≤ 6°C.
Powder free gloves must be worn with collecting nutrients.
*not routinely collected unless for a specific reason

TDH Metals Analyses Available

Test	Required MDL	MQL	Holding Time	Con-tainer	Preserva-tive
Aluminum, Al	6.5 ug/L	10 ug/L	6 months	1-liter plas-tic	None.
Antimony, Sb	0.365µg/L	1 ug/L			
Arsenic, As	0.829 µg/L	5 ug/L			
Barium, Ba	0.179 µg/L	5 ug/L			
Beryllium, Be	0.194 µg/L	1 ug/L			
Cadmium, Cd	0.161µg/L	1 ug/L			
Calcium, Ca	0.065 mg/L	0.1 mg/L			
Chromium, Cr	1.20µg/L	5 ug/L			
Cobalt, Co	0.139 µg/L	1 ug/L			
Copper, Cu	0.583µg/L	1 ug/L			
Iron, Fe	3.89µg/L	10 ug/L			
Lead, Pb	0.142µg/L	1 ug/L			
Magnesium, Mg	0.0247 mg/L	0.1 mg/L			
Manganese, Mn	0.231 µg/L	1 ug/L			
Molybdenum – Mo	0.336 µg /L	1 ug/L			
Nickel, Ni	0.252 µg/L	1 ug/L			
Potassium, K	0.0238 mg/L	0.1 mg/L			
Selenium, Se	0.896 µg/L	5 ug/L			
Silver, Ag	0.103 µg/L	0.25 ug/L			
Sodium, Na	0.0212 mg/L	0.1 mg/L			
Thallium, Tl	0.354 µg/L	1 ug/L			
Uranium- U	0.21 ug/L	1 ug/L			
Vanadium, V	3.62 µg/L	5 ug/L			
Zinc, Zn	1.48 µg/L	5 ug/L			
Ca Hardness by Calcula-tion	0.152 mg/L	0.25 mg/L	6 months		

Test	Required MDL	MQL	Holding Time	Con-tainer	Preserva-tive
Hardness, Total by Cal-culation	0.115mg/L	0.25 mg/L	6 months		

TDH Metals Analyses Available - Mercury

Test	Required MDL	MQL	Holding Time	Con-tainer	Preserva-tive
Mercury, Hg	0.0458 µg/L	0.005 ug/L	28 days	1-liter plas-tic (same as Metals con-tainer)	None.
Low Level Mercury	0.00176 ug/L	0.005 ug/L	28 days	1-liter plas-tic (same as above)	None.

All plastics are one-time use.

Trace metals and low-level mercury samples are collected using the modified clean technique.
* 500mL mercury bottle if mercury is the only metal that is being analyzed, otherwise, the 1-liter metals bottle is enough for mercury analysis.

TDH Miscellaneous Inorganic Analyses Available

Test	Required MDL	Holding Time	Container	Preservative
Cyanide	0.0067 mg/L	14 days	1-liter plastic	pH>12; 5 mL of 50% sodium hydroxide (NaOH) at collection. If KI paper indicates chlorine, add 0.6g ascorbic acid ($C_6H_8O_6$) before adding NaOH. If sulfides are detected by lead acetate paper, add 1g of Cadmium Chloride ($CdCl_2$) after adding NaOH.
Oil & Grease	NA	28 days	1-liter glass, wide mouth with Teflon® lined lid	2 mL sulfuric acid (H_2SO_4)
Phenols, total	NA	28 days	1-liter glass, amber	2 mL sulfuric acid (H_2SO_4)
Sulfide	NA	7 days	500 mL glass	5 mL 50% sodium hydroxide (NaOH) in field, 2 mL zinc acetate (ZnAc) in laboratory.
Boron	12 µg/L	6 months	125 mL plastic	0.75 mL hydrochloric acid (HCl)
Flash Point		None specified	16-ounce glass Teflon® lined lid	None
TCLP		28 days	16-ounce glass jar*	None
TOC	0.0869 mg/L	28 days	1-250mL plastic	1 mL phosphoric acid (H3PO4)

All plastics are one-time use. Store on ice ≤ 6°C.
*Due to analysis requirements, this could require much more sample (Protocol C *QSSOP Chemical and Bacteriological Sampling of Surface Waters* (2018). Contact Dr. Rumpler, 615-262-6302, at the state lab if TCLP or other parameters that are out of the ordinary are to be run. TDH needs lead time for some analysis to take place.

TDH Organic Analyses Available

Test	Required MDL	Holding Time	Container	Preservative
Base/Neutral/Acid Extractables				
NPDES Extrac.		7 days to extract; 40 days to analyze; PCBs by themselves have 1 year holding time	PACE: 2 - 1L Amber Glass ESC: 2- 100mL Amber Glass	None
Pesticides/PCBs				
TAL Extrac.				
Nitrobodies				
Semivolatiles				
Volatiles and Petroleum Hydrocarbons				
NPDES Volatiles		1 year (contact lab)	Five 40-mL amber vials, Teflon®-lined septa caps, no headspace.	1:1 hydrochloric acid (HCl)
TAL Volatiles		14 days		
BTEX		14 days	Five 40-mL amber vials, Teflon®-lined septa caps, no headspace	1:1 hydrochloric acid (HCl)
GRO				
EPH		14 days	One 1-gallon amber bottle with Teflon® lined lid	1:1 Hydrochloric Acid (HCl)

Store on ice ≤ 6°C.

The TDH Environmental Laboratory subcontracts the organics. The TDH Environmental Laboratory is contacted for collection instruction for other types of analyses.

Laboratory MDLs for Metals (Subject to change)

Parameter	unit	MQL	2013 MDL	2015 MDL	2020 MDL	2021 MDL	2019 WQS Criteria
Aluminum - Al	ug/L	10	4.6	5.9	6.5	6.51	
Antimony - Sb	ug/L	1	0.12	0.49	0.365	0.48	5.6
Arsenic - As	ug/L	5	0.57	0.47	0.829	1.35	10
Barium - Ba	ug/L	5	0.4	0.48	0.179	0.198	
Beryllium - Be	ug/L	1	0.19	0.41	0.194	0.243	
Cadmium - Cd	ug/L	1	0.38	0.40	0.161	0.274	
Calcium - Ca	mg/L	0.1	0.045	0.049	0.065	0.0483	
Chromium - Cr	ug/L	5	0.75	0.85	1.2	3.11	
Cobalt - Co	ug/L	1	0.41	0.37	0.139	0.182	
Copper - Cu	ug/L	1	0.3	0.54	0.583	0.583	
Iron - Fe	ug/L	10	5.3	7.7	3.89	4.27	
Lead - Pb	ug/L	1	0.16	0.36	0.142	0.144	
Lithium - Li	ug/L	1	0.35	0.46	0.39	0.384	
Magnesium - Mg	mg/L	0.1	0.013	0.026	0.0247	0.03	
Manganese - Mn	ug/L	1	0.32	0.43	0.231	0.813	
Mercury - Hg	ug/L	0.2	0.034	0.042	0.0458	0.0405	0.05
Mercury-Low Level	Ug/L	0.005			0.00176	0.00176	
Molybdenum - Mo	ug/L	1	0.13	0.68	0.336	0.442	
Nickel - Ni	ug/L	1	0.18	0.38	0.252	0.27	610
Potassium - K	mg/L	0.1	0.011	0.028	0.0238	0.0507	
Selenium - Se	ug/L	5	1.0	1.1	0.896	2.22	170
Silver - Ag	ug/L	0.25	0.037	0.080	0.103	0.195	
Sodium - Na	mg/L	0.1	0.019	0.024	0.0212	0.027	
Thallium - Tl	ug/L	1	0.12	0.60	0.354	1.53	0.24
Uranium - U	ug/L	1	0.36	0.39	0.21	0.154	
Vanadium - V	ug/L	5	2.6	2.3	3.62	4.65	
Zinc - Zn	ug/L	5	1.5	1.9	1.48	3.47	7400

Laboratory MDLs for Non-Metals -Inorganics (Subject to change)

Parameters	Units	MQL	2013 MDL	2015 MDL	2020 MDL	2021 MDL
Ammonia	mg/L	0.10	0.046	0.030	0.0262	0.01937
TKN	mg/L	0.50	0.20	0.15	0.111	0.362
Nitrogen, NO3& NO2	mg/L	0.10	0.03	0.031	0.0196	0.01389
Nitrogen, Nitrate	mg/L	0.050	0.0046	0.0025	0.00623	0.0221
Nitrogen, Nitrite	mg/L	0.050	0.0062	0.0018	0.00766	0.01814
Orthophosphate	mg/L	0.025	0.0068	0.0073	0.00254	0.0046
Total Phosphorus	mg/L	0.050	0.0052	0.0095	0.00756	0.01^
TOC	mg/L	0.50	0.13	0.26	0.0869	0.34482
COD	mg/L	10 (PACE)	1.6	1.9	3 (PACE)	3 (PACE)
Sulfate	mg/L	2.5	0.20	0.081	0.199	1.348
Phenol	mg/L	0.04	x	x	0.0083 (PACE)	x
Fluoride	mg/L	0.10	0.023	0.019	0.0188	0.0224
Cyanide	mg/L	x	0.0067	x	x	x
Hardness (Total) by Calculation	mg/L	0.25	0.16	0.23	0.115	0.115
Hardness, Calcium by Calculation	mg/L	0.25	0.11	0.12	0.152	0.152
Alkalinity	mg/L	20		*	2.71 (PACE)	10
Acidity	mg/L	10	*	*	3.63 (PACE)	3.63 (PACE)
BOD/CBOD	mg/L	3.33	*	*	3.33	3.33
Color	Color Units	5.0	*	*	5	5
MBAS	mg/L	x	0.083	x	x	x
Turbidity	NTU	1	*	*	1	1
Settleable Solids	mg/L	0.20	*	*	0.2	0.2
Suspended Residue	mg/L	2.5 (PACE)	*	*	0.35 (PACE)	10
Dissolved Residue	mg/L	10(PACE)	*	*	2.82 (PACE)	10
Total Residue	mg/L	10 (PACE)	*	*	10 (PACE)	10
Sulfide	mg/L	x	x	x	x	x
Chloride	mg/L	2.5	0.21	0.18	0.231	1.1091
Hexavalent Chromium	mg/L	0.0005	x	X	0.00002 (PACE)	0.00002 (PACE)
Silica	mg/L	100	TBD	x	25	25
Conductivity	µohms/cm	10	*	*	10	10
Residual Free Chlorine	mg/L	0.25	0.032	0.10	0.053	0.053
Boron	ug/L	50	6.3	12		

TBD = To Be Determined
x = Not Performed by Lab
** = MDL not required*
^= MDL is in review

Appendix E:

FIELD AND DATA ENTRY FORMS

All forms are available electronically on SharePoint

https://tennessee.sharepoint.com/sites/environment/DWR/PAS/SitePages/Home.aspx or by contacting WPU.

Waterlog Station Entry Form

New DWR Station -DWR Surface Water Only

DWR Station ID:	
Monitoring Location Name:	
Monitoring Location:	
County:	
River Mile:	
Latitude:	
Longitude (include -):	
Ecoregion:	
u/s ECO:	
HUC:	
HUC Name:	
WBID:	
WS Grp:	
Drainage Area:	
HUC 12:	
Organization:	
State Name:	
Reservoir Name:	
Water Type:	
Station Comment:	

Field Parameter e-Form for upload to waterlog (see SharePoint or contact WPU for electronic copy)

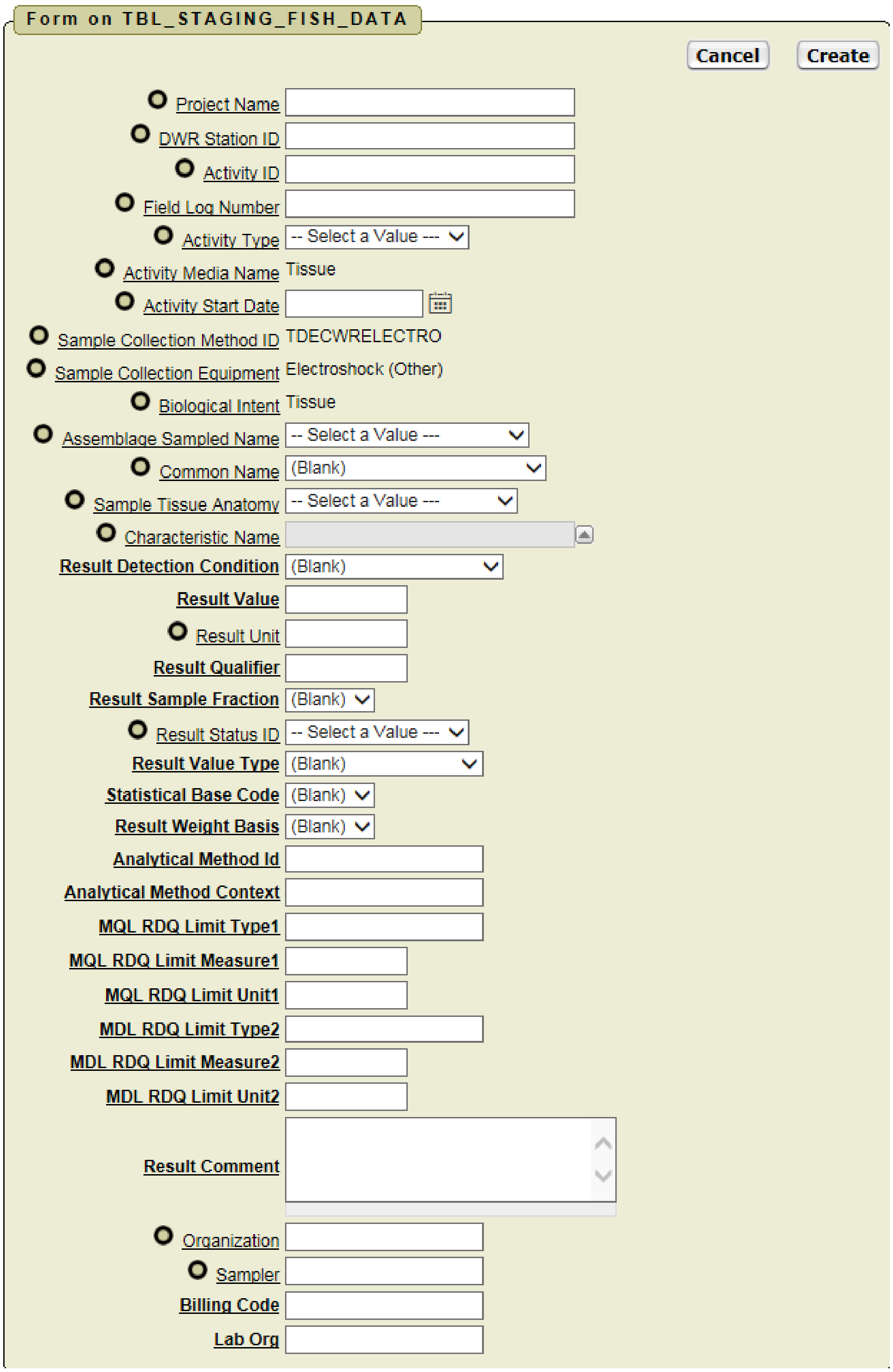
TDEC-DWR Sampling Event- Surface Water Only — Version 5.0 for FY 2021-2022 106 Workplan (revised 6/11/2021)

Sampling Team:				Organization:		Date:	
Lead Sampler's Initials:		Meters Used:			Send Report To:		

Inorganic Analyses — Stations were last updated 6/2/2021. Add new stations at the bottom of this worksheet.

Sample Sequence:	01						Time:	
DWR Station ID:			Monitoring Location ID:				Field Log Number:	
Monitoring Location Name:			Monitoring Location:					
Project Name:		Project ID:			Activity Type:			
Billing Code:								
E. coli sample collected for analysis by Contract Lab?		☐ Check if E. coli will be delivered to Contract Lab			1st	2nd	Meter Problems:	
Field Parameters:	1st	2nd	Meter Problems: ☑ if Validated		DO %:			
Conductivity (umhos):			☐		Turbidity (NTU):			
Dissolved Oxygen (mg/L):			☐		TDS (mg/L):			
Temperature (C°):			☐		Flow (cfs):			
pH (su):			☐		Secchi Depth (ft):			
Notes:								

Waterlog Fish Tissue Data Entry Form

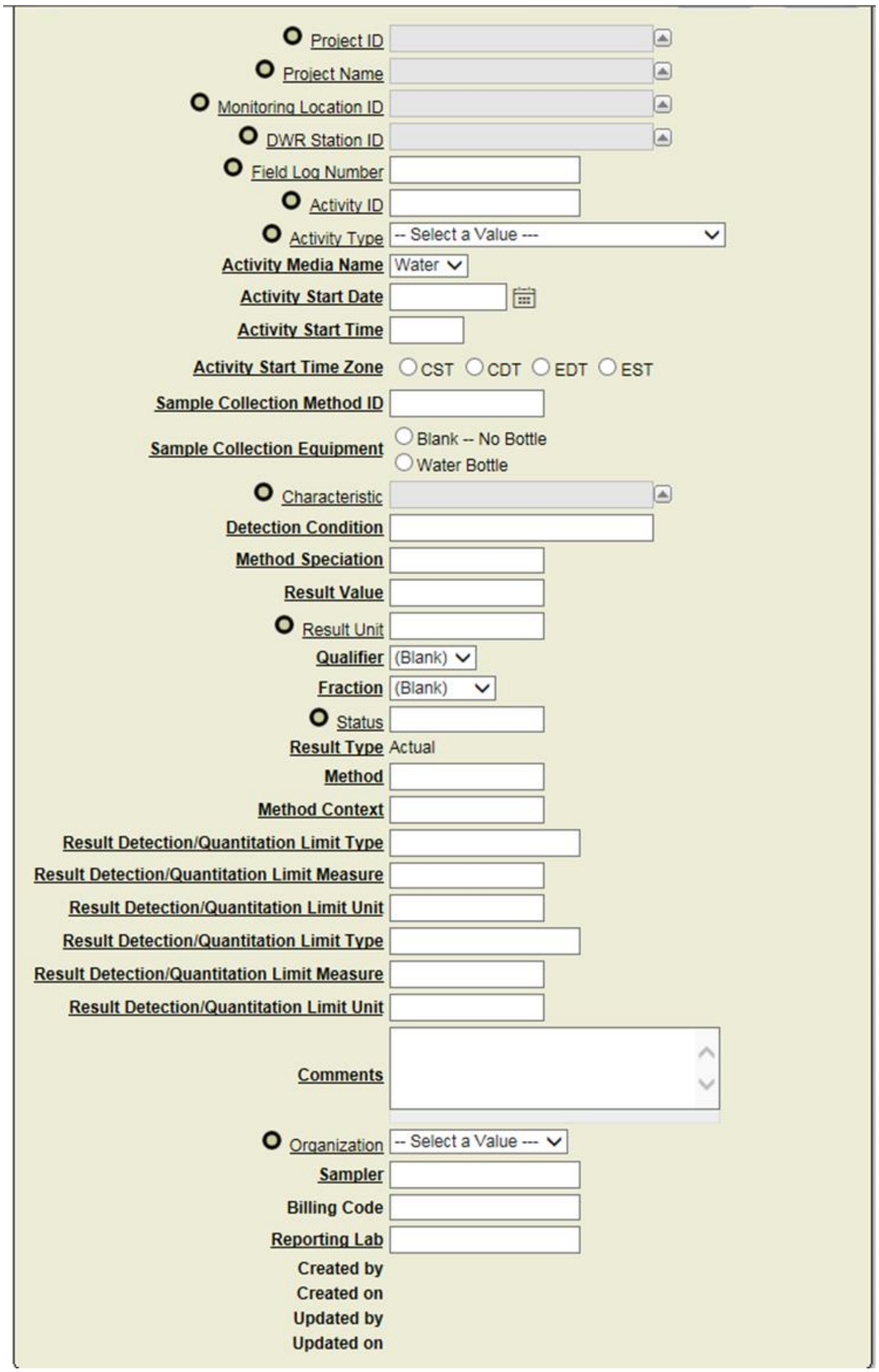


Form on TBL_STAGING_FISH_DATA

Cancel Create

Project Name	
DWR Station ID	
Activity ID	
Field Log Number	
Activity Type	-- Select a Value ---
Activity Media Name	Tissue
Activity Start Date	
Sample Collection Method ID	TDECWRELECTRO
Sample Collection Equipment	Electroshock (Other)
Biological Intent	Tissue
Assemblage Sampled Name	-- Select a Value ---
Common Name	(Blank)
Sample Tissue Anatomy	-- Select a Value ---
Characteristic Name	
Result Detection Condition	(Blank)
Result Value	
Result Unit	
Result Qualifier	
Result Sample Fraction	(Blank)
Result Status ID	-- Select a Value ---
Result Value Type	(Blank)
Statistical Base Code	(Blank)
Result Weight Basis	(Blank)
Analytical Method Id	
Analytical Method Context	
MQL RDQ Limit Type1	
MQL RDQ Limit Measure1	
MQL RDQ Limit Unit1	
MDL RDQ Limit Type2	
MDL RDQ Limit Measure2	
MDL RDQ Limit Unit2	
Result Comment	
Organization	
Sampler	
Billing Code	
Lab Org	

Waterlog Chemical and Bacteriological Results Entry Form


Project ID
Project Name
Monitoring Location ID
DWR Station ID
Field Log Number
Activity ID
Activity Type -- Select a Value ---
Activity Media Name Water
Activity Start Date
Activity Start Time
Activity Start Time Zone CST CDT EDT EST
Sample Collection Method ID
Sample Collection Equipment Blank -- No Bottle / Water Bottle
Characteristic
Detection Condition
Method Speciation
Result Value
Result Unit
Qualifier (Blank)
Fraction (Blank)
Status
Result Type Actual
Method
Method Context
Result Detection/Quantitation Limit Type
Result Detection/Quantitation Limit Measure
Result Detection/Quantitation Limit Unit
Result Detection/Quantitation Limit Type
Result Detection/Quantitation Limit Measure
Result Detection/Quantitation Limit Unit
Comments
Organization -- Select a Value ---
Sampler
Billing Code
Reporting Lab
Created by
Created on
Updated by
Updated on

High Gradient Habitat Assessment Snapshot

HABITAT ASSESSMENT FIELD SHEET- MODERATE TO HIGH GRADIENT STREAMS

(See Protocol E for detailed descriptions and rank information)

DWR Station ID:		Habitat Assessment By:	
Monitoring Location Name:		Date	Time
Monitoring Location:		Field Log No.:	
HUC:	WS Group: Ecoregion:	QC: ☐	Consensus

Habitat Type: HG If this event is a duplicate benthic sample, check box above. (Only upload one habitat per event to Waterlog.)

If QA/QC and 2 habitats are completed independently, check box above and only upload consensus (this tab) to Waterlog.

Select from dropdown box in blue cells

Hyperlink to SOP		Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover		Over 70% of stream reach has natural stable habitat suitable for colonization by fish and/or macroinvertebrates. Four or more productive habitats are present.	Natural stable habitat covers 40-70% of stream reach. Three or more productive habitats present. (If near 70% and more than 3 go to optimal.)	Natural stable habitat covers 20 -40% of stream reach or only 1-2 productive habitats present. (If near 40% and more than 2 go to suboptimal.)	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
Score		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Comment					
2. Embeddedness of Riffles		Gravel, cobble, and boulders 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space. If near 25% drop to suboptimal if riffle not layered cobble.	Gravel, cobble and boulders 25-50% surrounded by fine sediment. Niches in bottom layers of cobble compromised. If near 50% & riffles not layered cobble drop to marginal.	Gravel, cobble, and boulders are 50-75% surrounded by fine sediment. Niche space in middle layers of cobble is starting to fill with fine sediment.	Gravel, cobble, and boulders are more than 75% surrounded by fine sediment. Niche space is reduced to a single layer or is absent.
Score		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Comment					
3. Velocity/ Depth Regime		All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow).	Only 3 of the 4 regimes present (if fast-shallow is missing score lower). If slow-deep missing score 15.	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/depth regime. Others regimes too small or infrequent to support aquatic populations.
Score		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Comment					
4. Sediment Deposition	Does this rating match sed. desc. in SS?	Sediment deposition affects less than 5% of stream bottom in quiet areas. New deposition on islands and point bars is absent or minimal.	Sediment deposition affects 5-30% of stream bottom. Slight deposition in pool or slow areas. Some new deposition on islands and point bars. Move to marginal if build-up approaches 30%.	Sediment deposition affects 30-50% of stream bottom. Sediment deposits at obstruction, constrictions and bends. Moderate pool deposition.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
Score		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Comment					
5. Channel Flow Status		Water reaches base of both lower banks and streambed is covered by water throughout reach. Minimal productive habitat is exposed.	**Water covers > 75% of** streambed or 25% of productive habitat is exposed.	Water covers 25-75% of streambed and/or productive habitat is mostly exposed.	Very little water in channel and mostly present as standing pools. Little or no productive habitat due to lack of water.
Score		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Comment					

6. Channel Alteration		Channelization, dredging rock removal or 4-wheel activity (past or present) absent or minimal; natural meander pattern. NO artificial structures in reach. Upstream or downstream structures do not affect reach.					Channelization, dredging or 4-wheel activity up to 40%. Channel has stabilized. If larger reach, channelization is historic and stable. Artificial structures in or out of reach do not affect natural flow patterns.					Channelization, dredging or 4-wheel activity 40-80% (or less that has not stabilized.) Artificial structures in or out of reach may have slight affect.					Over 80% of reach channelized, dredged or affected by 4-wheelers. Instream habitat greatly altered or removed. Artificial structures have greatly affected flow pattern.				
Score		20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Comment																					
7. Frequency of re-oxygenation zones Use frequency of riffle or bends for category. Rank by quality.		Occurrence of re-oxygenation zones relatively frequent; ratio of distance between areas divided by average stream width <7:1.					Occurrence of re-oxygenation zones infrequent; distance between areas divided by average stream width is 7 - 15.					Occasional re-oxygenation area. The distance between areas divided by average stream width is over 15 and up to 25.					Generally all flat water or flat bedrock; little opportunity for re-oxygenation. Distance between areas divided by **average stream width >25.**				
Score		20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Comment																					
8. Bank Stability (score each bank) Determine left or right side by facing downstream.		Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems <5% of bank affected.					Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion. If approaching 30% score marginal if banks steep.					Moderately unstable; 30-60 % of bank in reach has areas of erosion; high erosion potential during floods, If approaching 60% score poor if banks steep.					Unstable; many eroded area; raw areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.				
SCORE (Left Bank)			10		9		8		7		6	5		4		3	2		1		0
SCORE (Right Bank)			10		9		8		7		6	5		4		3	2		1		0
Comment																					
9. Vegetative Protective (score each bank) includes vegetation from top of bank to base of bank. Determine left or right side by facing downstream.		More than 90% of the bank covered by undisturbed vegetation. All 4 classes (mature trees, understory trees, shrubs, groundcover) are represented and allowed to grow naturally. All plants are native.					70-90% of the bank covered by undisturbed vegetation. One class may not be well represented. Disruption evident but not effecting full plant growth. Non-natives are rare (< 30%)					50-70% of the bank covered by undisturbed vegetation. Two classes of vegetation may not be well represented. Non-native vegetation may be common (30-50%).					Less than 50% of the bank covered by undisturbed vegetation or more than 2 classes are not well represented or most vegetation has been cropped. Non-native vegetation may dominate **(> 50%)**				
SCORE (Left Bank)			10		9		8		7		6	5		4		3	2		1		0
SCORE (Right Bank)			10		9		8		7		6	5		4		3	2		1		0
Comment																					
10. Riparian Vegetative Zone Width (score each bank.) Zone begins at top of bank.		Average width of riparian **zone > 18 meters. Unpaved** footpaths may score 9 if run-off potential is negligible.					Average width of riparian zone 12-18 meters. Score high if areas < 18 meters are small or are minimally disturbed.					Average width of riparian zone 6-11 meters. Score high if areas less than 12 meters are small or are minimally disturbed.					Average width of riparian zone <6 meters. Score high if areas less than 6 meters are small or are minimally disturbed.				
SCORE (Left Bank)			10		9		8		7		6	5		4		3	2		1		0
SCORE (Right Bank)			10		9		8		7		6	5		4		3	2		1		0
Comment																					
Total Score:		**Skipped One**					Habitat Guidelines					Ecoregion:					Drainage Area:				

Comparison to Ecoregion Guidelines: ☐ Above ☐ Below
If score is below guidelines, result of ☐ Natural Condition ☐ Human Disturbance Describe:

Low Gradient Habitat Assessment

HABITAT ASSESSMENT FIELD SHEET - LOW GRADIENT STREAMS

(See Protocol E for detailed descriptions and rank information)

DWR Station ID:			Habitat Assessment By:		
Monitoring Location Name:			Date:	Time	
Monitoring Location:			Field Log No:		
HUC:	WS Group:	Ecoregion:	QC:	☐	Consensus

Habitat Type: LG If this event is a duplicate benthic sample, check box above. (Only upload one habitat per event to Waterlog.)

If QA/QC and 2 habitats are completed independently, check box above and only upload consensus (this tab) to Waterlog.

Hyperlink to SOP		Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover		Over 50% of reach has natural, stable habitat for colonization by macroinvertebrates and/or fish. Three or more productive habitats are present.	Natural stable habitat covers 30-50% of stream reach or less than three habitats are present.	Natural stable habitat 10-30% of stream reach. Availability less than desirable, substrate frequently disturbed or removed. Habitat diversity is reduced.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
Score		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Comments					
2. Channel Substrate Characterization		Good mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud or clay; or substrate is fissured bedrock, some root mats and submerged vegetation present.	All mud, clay, soft sand or fissured bedrock bottom, little or no root mat, no submerged vegetation present.	Hard-pan clay, conglomerate or predominantly flat bedrock; no root mat or submerged vegetation.
Score		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Comments					
3. Pool Variability		Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools are large-deep very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
Score		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Comments					
4. Sediment Deposition	Does this rating match sed. desc. in SS?	Sediment deposition affects less than 20% of stream bottom in quiet areas. New deposition on islands and point bars is absent or minimal.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of bottom affected. Slight deposition in pools.	Moderate deposition of fine material on old and new bars, 50-80% of bottom affected; sediment deposits at obstructions, constrictions and bends; moderate deposition of pools.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
Score		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Comments					
5. Channel Flow Status. If water backed up by obstructions (beaver dam, log jams, bedrock during low flow) move assessment reach above or below affected area or consider postponing sampling until accurate assessment of stream can be achieved.		Water reaches base of both lower banks throughout reach. Streambed is covered. Minimal productive habitat is exposed.	Water covers > 75% of streambed and/or < 25% of productive habitat is exposed.	Water covers 25-75% of streambed and/or stable habitat is mostly exposed.	Very little water in channel and mostly present as standing pools. Little or no productive habitat due to lack of water.
Score		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Comments					

6. Channel Alteration		Channelization, dredging or 4-wheel activity absent or minimal; natural meander pattern. NO artificial structures in reach. Upstream or downstream structures do not affect reach.					Channelization, dredging or 4-wheel activity up to 40%. Channel has stabilized. If larger reach, channelization is historic and stable. Artificial structures in or out of reach do not affect natural flow patterns.					Channelization, dredging or 4-wheel activity 40-80% (or less that has not stabilized.) Artificial structures in or out of reach may have slight affect.					Over 80% of reach channelized, dredged or affected by 4-wheelers. Instream habitat greatly altered or removed. Artificial structures may have greatly affected flow pattern.				
Score		20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Comments																					
7. Channel Sinuosity (Entire meander sequence not limited to sampling reach)		The bends in the stream increase the stream length 3-4 times longer than if it was in a straight line.					The bends in the stream increase the stream length 2-3 times longer than if it was in a straight line.					The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.					Channel straight; waterway has been channelized for a long distance.				
Score		20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Comments																					
8. Bank Stability (score each bank) Determine left or right side by facing downstream.		Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems <5% of bank affected.					Moderately stable; infrequent, small areas of erosion o 5-30% of bank eroded. If approaching 30% score marginal if banks steep.					Moderately unstable; 30-60 % of bank in reach has areas of erosion; high erosion potential during floods, If approaching 60% score poor if banks steep.					Unstable; many eroded area; raw areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.				
SCORE (Left Bank)			10		9		8		7		6	5		4		3	2		1		0
SCORE (Right Bank)			10		9		8		7		6	5		4		3	2		1		0
Comments																					
9. Vegetative Protective (score each bank) includes vegetation from top of bank to base of bank. Determine left or right side by facing downstream.		More than 90% of the bank covered by undisturbed vegetation. All 4 classes (mature trees, understory trees, shrubs, groundcover) are represented and allowed to grow naturally. All plants are native.					70-90% of the bank covered by undisturbed vegetation. One class may not be well represented. Disruption evident but not effecting full plant growth. Non-natives are rare (< 30%)					50-70% of the bank covered by undisturbed vegetation. Two classes of vegetation may not be well represented. Non-native vegetation may be common (30-50%).					Less than 50% of the bank covered by undisturbed vegetation or more than 2 classes are not well represented or most vegetation has been cropped. Non-native vegetation may dominate (> 50%)				
SCORE (Left Bank)			10		9		8		7		6	5		4		3	2		1		0
SCORE (Right Bank)			10		9		8		7		6	5		4		3	2		1		0
Comments																					
10. Riparian Vegetative Zone Width (score each bank.) Zone begins at top of bank.		Average width of riparian zone > 18 meters. Unpaved footpaths may score 9 if run-off potential is negligible.					Average width of riparian zone 12-18 meters. Score high if areas < 18 meters are small or are minimally disturbed.					Average width of riparian zone 6-11 meters. Score high if areas less than 12 meters are small or are minimally disturbed.					Average width of riparian zone <6 meters. Score high if areas less than 6 meters are small or are minimally disturbed.				
SCORE (Left Bank)			10		9		8		7		6	5		4		3	2		1		0
SCORE (Right Bank)			10		9		8		7		6	5		4		3	2		1		0
Comments																					
Total Score:		Skipped One					Habitat Guidelines					Ecoregion:					Drainage Area:				

Comparison to Ecoregion Guidelines: ☐ Above ☐ Below
If score is below guidelines, result of ☐ Natural Condition ☐ Human Disturbance Describe:

Waterlog Habitat Assessment Entry Form

Field Log Number

Monitoring Location ID

DWR Station ID

Project ID

Project Name

Activity Start Date

Index Period

Organization -- Select a value ---

Sampler

Habitat Assessor

Habitat Type

Activity Type -- Select a Value --

Epifaunal Substrate

Epifaunal Substrate Comments

Embeddedness

Embeddedness Comments

Velocity Depth Regime

Velocity Depth Regime Comments

Sediment Deposition

Sediment Deposition Comments

Channel Flow Status	
Channel Flow Status Comments	
Channel Alteration	
Channel Alteration Comments	
Frequency Of Reoxygenation	
Frequency Of Reox Comments	
Bank Stability LDB	
Bank Stability LDB Comments	
Bank Stability RDB	
Bank Stability RDB Comments	
Vegetative Protection LDB	
Veg Protection LDB Comments	
Vegetative Protection RDB	
Veg Protection RDB Comments	
Riparian Width LDB	
Riparian Width LDB Comments	
Riparian Width RDB	
Riparian Width RDB Comments	
Channel Substrate Char	
Channel Sub Char Comments	
Pool Variability	
Pool Variability Comments	
Channel Sinuosity	
Channel Sinuosity Comments	
Total Habitat Score	

TDEC-DWR Stream Survey Field Sheet

TDEC-DWR Stream Survey Field Sheet

STREAM SURVEY INFORMATION (Revised 7/2/2021)

DWR Station ID:	Date:	Time:
Samplers:	Organization:	
Project Name:	Activity Type:	
Field Log Number:	Ecoregion:	
Monitoring Location Name:		
Monitoring Location:		

Sample Status:		If not collected do you plan to revisit?	
Flow Condition:			

Samples Collected: "Yes" if collected, "Yes w/ QC-Field Rep." if assoc QC-Field Replicate sample is planned.

Biorecon:		Periphyton:	
SQKICK:		Other:	Describe:
SQBANK:		Chemical/Bact:	

Field Parameters: (Note: mg/L = ppm) **Meters Used:**

	1st	2nd	☑ if Validated. Describe meter problems.
pH (su):			☐
Conductivity (umhos):			☐
Temperature (C°):			☐
Dissolved Oxygen (mg/L):			☐
Dissolved Oxygen %:			
Turbidity (NTU):			
TDS (mg/L):			
Flow (cfs):			

Weather:

Previous 48 hours precipitation:		Approx. Air Temperature (F°):	

Physical Characteristics:

Gradient:		**Avg. Stream Width:**	
		Max. Stream Depth:	

Light Penetration:

% Canopy Cover Estimated for Reach: %

% Canopy Cover Measured (mid-reach):

(u/s +) (d/s +) (LDB +) (RDB =) 0

Channel Characteristics:

Bank Height:	yards	**High Water Mark:**	yards

Other Stream Information and Stressors:

Photos and descriptions may be attached below:

Photos Taken?

Open Camera

Insert pictures below:

U/S Image

Insert us/Image

D/S Image

Insert ds/Image

Describe below:

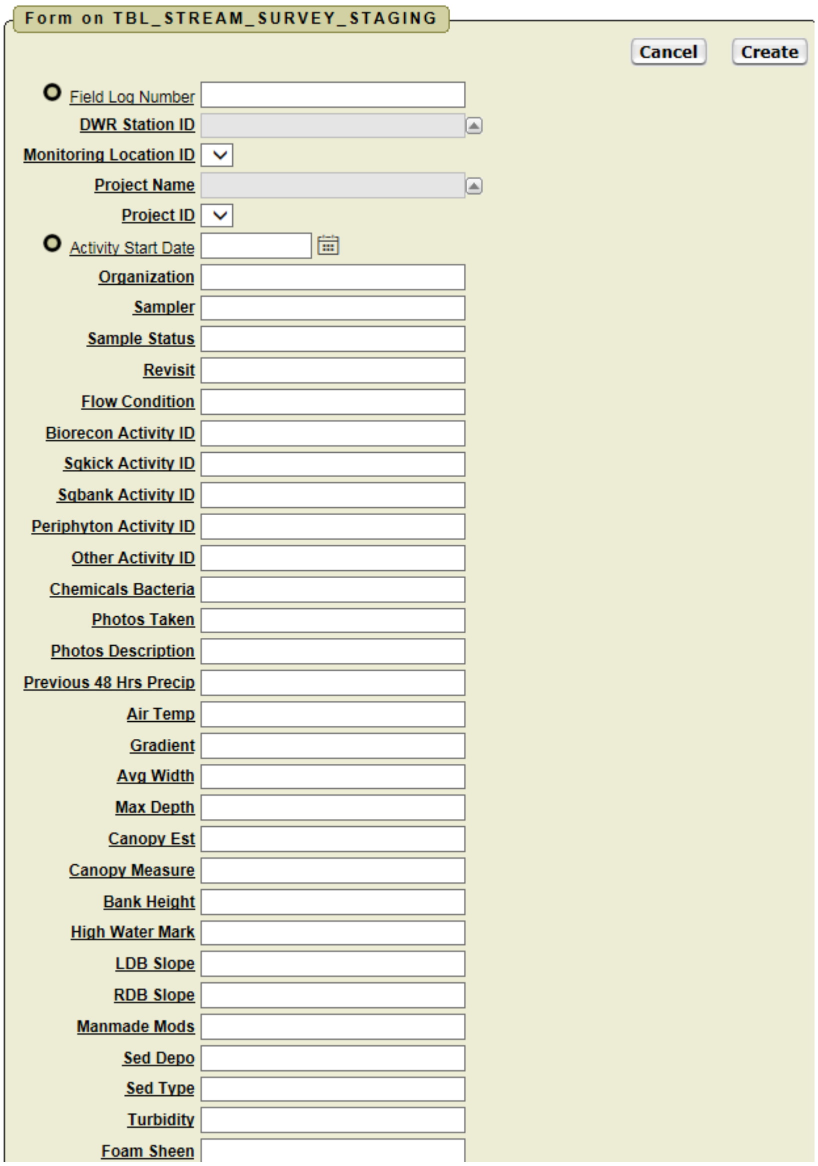
Additional Image

Describe below:

Additional Image

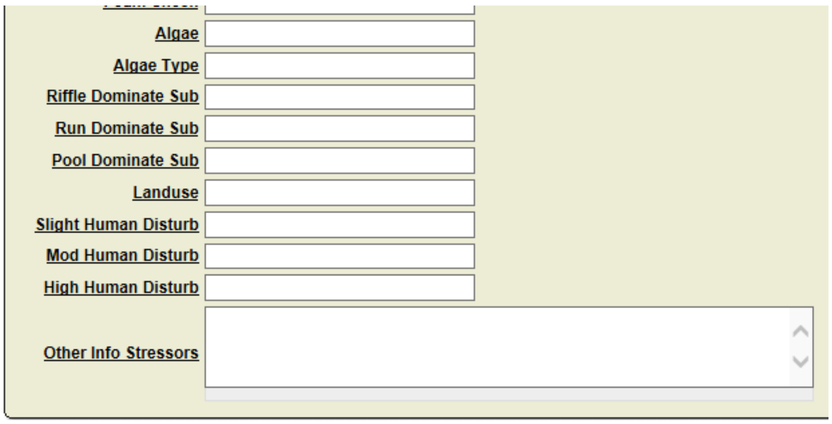
Include stream sketch below or draw on paper and photograph and include as picture.

Waterlog Stream Survey Data Entry Form


Form on TBL_STREAM_SURVEY_STAGING

Cancel Create

Field Log Number
DWR Station ID
Monitoring Location ID
Project Name
Project ID
Activity Start Date
Organization
Sampler
Sample Status
Revisit
Flow Condition
Biorecon Activity ID
Sqkick Activity ID
Sqbank Activity ID
Periphyton Activity ID
Other Activity ID
Chemicals Bacteria
Photos Taken
Photos Description
Previous 48 Hrs Precip
Air Temp
Gradient
Avg Width
Max Depth
Canopy Est
Canopy Measure
Bank Height
High Water Mark
LDB Slope
RDB Slope
Manmade Mods
Sed Depo
Sed Type
Turbidity
Foam Sheen


Algae
Algae Type
Riffle Dominate Sub
Run Dominate Sub
Pool Dominate Sub
Landuse
Slight Human Disturb
Mod Human Disturb
High Human Disturb
Other Info Stressors

BIORECON FIELD SHEET:

BIORECON FIELD SHEET AND FAMILY VERIFICATION Revised 6/21/2021

Biorecon **Family** Verification Form Final ID Only

Monitoring Location Name:		Samplers:			Date:		Time:
Verification ID Initials:		Verification Org:		Activity Type:			
Field Log Number:		Ben Sample ID:		Eco:		Drainage Area:	
QA/QC Activity:			QA/QC Taxonomic Verification Date:			QC Initials:	

Habitats Sampled:	No. jabs/habitat	% Habitat
Riffle/Swift Run		
Slow Run/Pool Rock		
Leaf Habitat		
Snags/Woody Debris		
Undercut Banks/Tree Roots		
Macrophytes		
Sediment		
Total (Max 4 jabs)	0	0

Taxonomic Level:	Family
SOP Date:	2017

Biorecon metrics are calculated in Waterlog.

Row Count

Delete or correct taxa in **Family Verification** column.

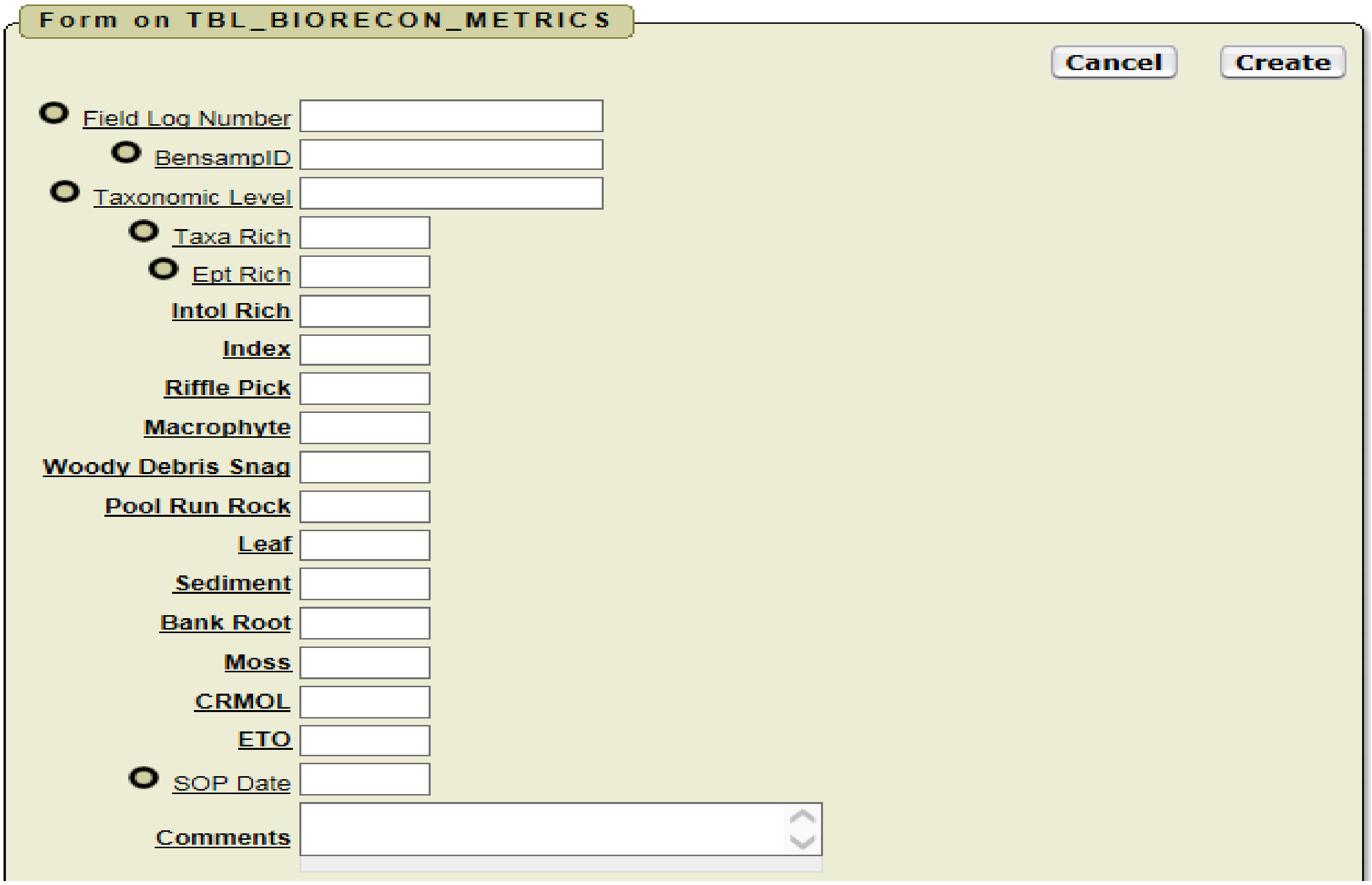
Confirm row count matches number of verified taxa.

ID all samples with Merritt and Cummins, 5th Edition.

Field Abundance Estimate: 1 = Rare (1-3 organisms) 2 = Common (4-9 organisms) 3 = Abundant (10-49 organisms) 4 = Dominate (>50 organisms)

	Family Field ID	Field Abundance Estimate	Family Verification	No. of Specimens in Voucher	Notes	Exclude Taxa (not unique)	Row Number
Ephemeroptera							
Plecoptera							

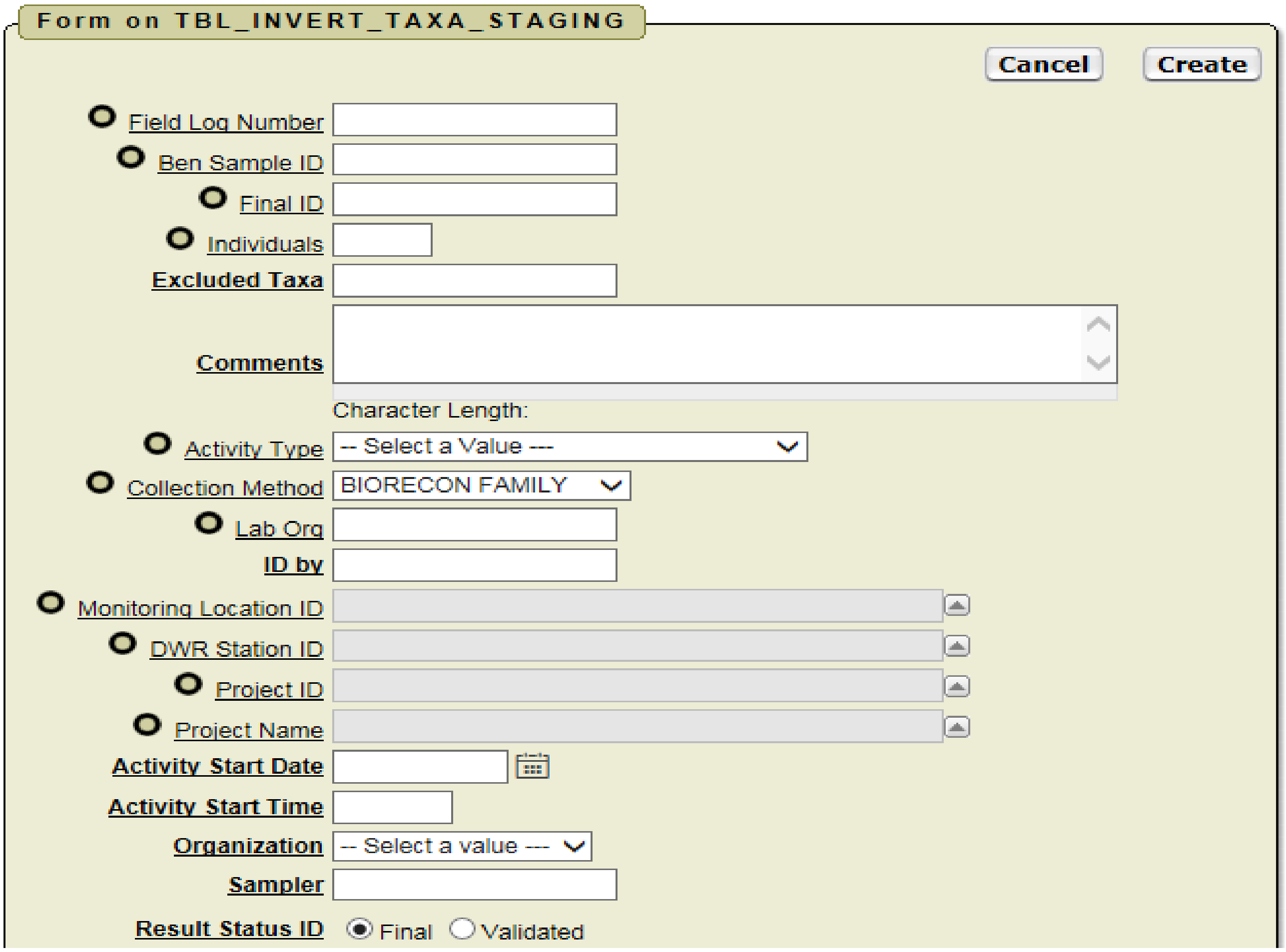
Waterlog Biorecon Metric Data Entry Form


Form on TBL_BIORECON_METRICS

Cancel Create

Field Log Number
BensampID
Taxonomic Level
Taxa Rich
Ept Rich
Intol Rich
Index
Riffle Pick
Macrophyte
Woody Debris Snag
Pool Run Rock
Leaf
Sediment
Bank Root
Moss
CRMOL
ETO
SOP Date
Comments

Waterlog Macroinvertebrate Taxa Entry Form



Biorecon Taxa Entry   Data Sheet

BIORECON GENERA VERIFICATION Revised 6/21/2021

Biorecon Genera Verification Form **Final ID Only**

Monitoring Location Name:		Location:		Samplers:	
Verification Initials:		Verification ID Organization:			
Field Log Number:		Ben Sample ID:	Date:		Time:
HUC:		Drainage Area:	ECO:		u/s ECO:
QA/QC Activity:		QA/QC Taxonomic Verification Date:			QC Initials:

Habitats Sampled:	No. jabs/habitat	% Habitat
Riffle/Swift Run		
Slow Run/Pool Rock		
Leaf Habitat		
Snags/Woody Debris		
Undercut Banks/Tree Roots		
Macrophytes		
Sediment		
Total (Max 4 jabs)	0	0

Biorecon metrics are calculated in Waterlog.

Taxonomic Level:	Genera
SOP Date:	2017

Row Count
0

Confirm row count matches number of verified taxa.

ID all samples with Merritt and Cummins, 5th Edition.

Verified Genera ID   Only ID Family and Genera for ECO and FECO sites. All other surveys need only 1 taxon level.

Field Abundance Estimate: 1= Rare (1-3 organisms) 2 = Common (4-9 organisms) 3 = Abundant (10-49 organisms) 4 = Dominate (>50 organisms)

Genera	Field Est	No. of Specimens in Voucher	Notes	Exclude Taxa (not unique)	Row Num
Ephemeroptera					
Plecoptera					

Rapid Periphyton Survey Data Sheet

Rapid Periphyton Survey Data Sheet

DWR Station ID:		Date:	
Field Log Number:		Ben Samp ID:	
Sampler:		EFO:	

Record aliquots for all RPS samples. **Waterlog upload is below transects.**

MPS-Habitats Sampled (Specify number of aliquots - total 10)

Riffle Rock:		Sand Dep Area:		Pool Rock:	
Leaf Packs:		Sediment Dep Area:		Woody Debris:	
Aquatic Plants or Roots:		Comments:		Total aliquots=	0

Complete transects for SEMN sites. Transects optional for other algae samples.

Coverage Class (Moss and Macro-Algae)					
0	1	2	3	4	5
0%	< 5%	5 to 25%	26 to 50%	51 to 75%	> 75%
Biofilm Thickness (Micro-Algae)					
0	1	2	3	4	5
0 mm	< 0.5 mm	0.5 to 1 mm	1 to 5 mm	5 to 20 mm	> 20 mm

Rapid Periphyton Survey Data Sheet

Transect Number	Point	Moss	Macro	Micro	Substrate >2cm (Y/N)
1	1				
1	2				
1	3				
1	4				
1	5*				
1	6				
1	7				
1	8				
1	9				
1	10				

Canopy Cover	Trans 1
u/s	
d/s	
RDB	
LDB	
% (Total/384)	

Transect Number	Point	Moss	Macro	Micro	Substrate >2cm (Y/N)
2	1				
2	2				
2	3				
2	4				
2	5*				
2	6				
2	7				
2	8				
2	9				
2	10				

Canopy Cover	Trans 2
u/s	
d/s	
RDB	
LDB	
% (Total/384)	

Transect Number	Point	Moss	Macro	Micro	Substrate >2cm (Y/N)
3	1				
3	2				
3	3				
3	4				
3	5*				
3	6				
3	7				
3	8				
3	9				
3	10				

Transect Number	Point	Moss	Macro	Micro	Substrate >2cm (Y/N)
4	1				
4	2				
4	3				
4	4				
4	5*				
4	6				
4	7				
4	8				
4	9				
4	10				

Transect Number	Point	Moss	Macro	Micro	Substrate >2cm (Y/N)
5	1				
5	2				
5	3				
5	4				
5	5*				
5	6				
5	7				
5	8				
5	9				
5	10				

Comments:

BioEvent | SS2 | HG_Hab | LG_Hab | BRFieldFamVer

Waterlog Rapid Periphyton Survey Data Sheet

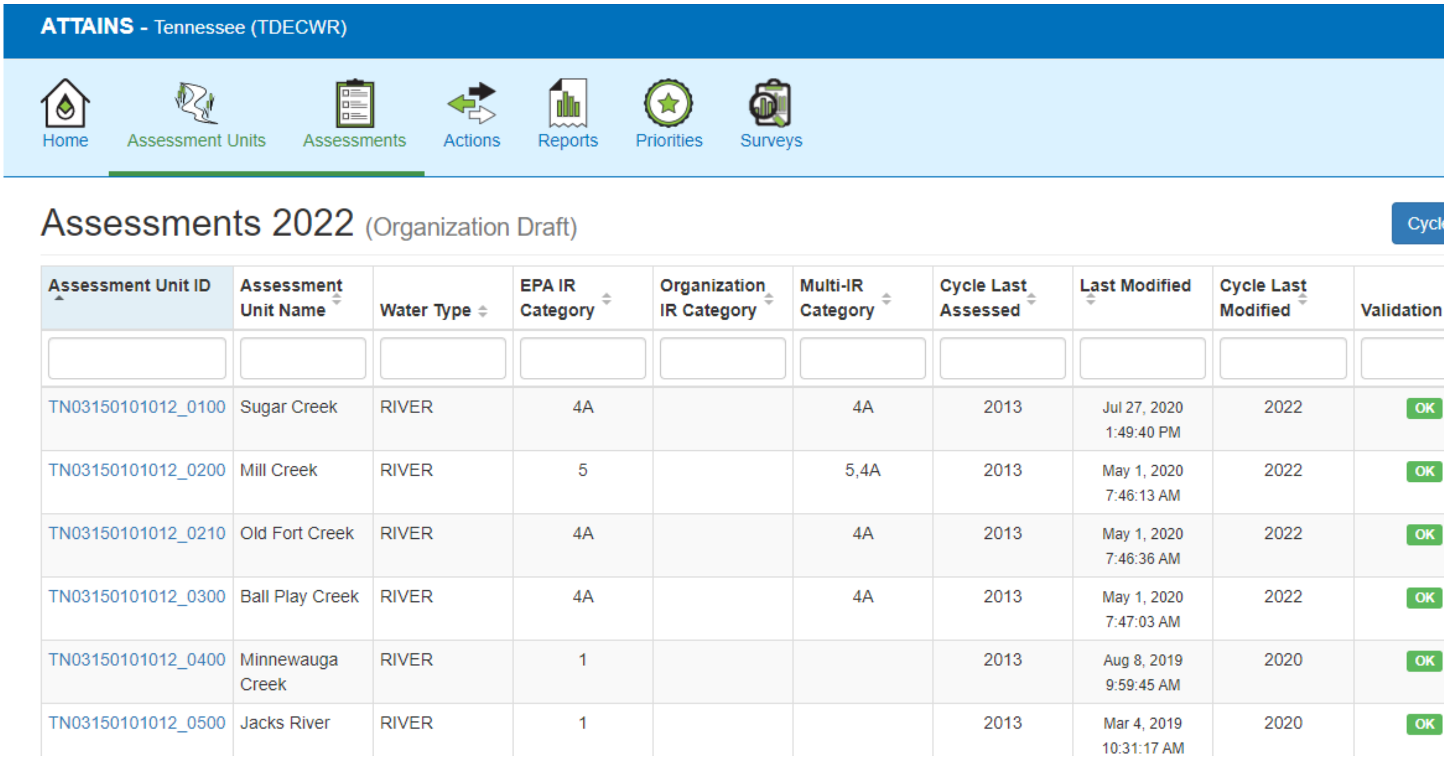
Form on Rapid Periphyton Staging

Cancel Create

Monitoring Location Id	
DWR Station ID	
Activity Start Date	
Field Log Number	
Organization	
Project Id	
Project Name	
Activity Type	
Sampler	
X1 Avg Moss	
X1 Avg Macro	
X1 Avg Micro	
X1 Sub	
X1 Canopy	
X2 Avg Moss	
X2 Avg Macro	
X2 Avg Micro	
X2 Sub	
X2 Canopy	

DWR-PAS-P-02-QAPP-102017
Quality Assurance Project Plan For 106 Monitoring

Assessment Tool ATTAINS



Assessment Unit ID	Assessment Unit Name	Water Type	EPA IR Category	Organization IR Category	Multi-IR Category	Cycle Last Assessed	Last Modified	Cycle Last Modified	Validation
TN03150101012_0100	Sugar Creek	RIVER	4A		4A	2013	Jul 27, 2020 1:49:40 PM	2022	OK
TN03150101012_0200	Mill Creek	RIVER	5		5,4A	2013	May 1, 2020 7:46:13 AM	2022	OK
TN03150101012_0210	Old Fort Creek	RIVER	4A		4A	2013	May 1, 2020 7:46:36 AM	2022	OK
TN03150101012_0300	Ball Play Creek	RIVER	4A		4A	2013	May 1, 2020 7:47:03 AM	2022	OK
TN03150101012_0400	Minnewauga Creek	RIVER	1			2013	Aug 8, 2019 9:59:45 AM	2020	OK
TN03150101012_0500	Jacks River	RIVER	1			2013	Mar 4, 2019 10:31:17 AM	2020	OK

Appendix F

AUDIT REPORT

Environmental Field Office Monitoring Audit Report (HISTORICAL)

Front

EFO	Date
Fiscal Year Watershed Group	Auditor
In-house Chemical/Bacteriological QC Officer	In-house Biological QC Officer

Are current versions of the following documents accessible to all samplers?			
• DWR Monitoring & Assessment Program Plan (TDEC, FY 2020)	Yes □	No □	Comments____________________________
• QSSOP for Macroinvertebrate Stream Surveys (TDEC, 2017)	Yes □	No □	Comments____________________________
• QSSOP for Chemical and Bacteriological Sampling (TDEC, 2018)	Yes □	No □	Comments____________________________
• QSSOP for Periphyton Sampling (TDEC, 2010)	Yes □	No □	Comments____________________________
• EPA Approved List of Impaired and Threatened Waters (TDEC, 2020)	Yes □	No □	Comments____________________________
• Rules of the TDEC- Chapters 0400-40-03 & 0400-40-04(WQOG 2019)	Yes □	No □	Comments____________________________
• MSDS available for ethanol, nitric acid, sulfuric acid, hydrochloric acid, and any other chemical or preservatives present in EFO?	Yes □	No □	Comments____________________________
Are the following databases available to all samplers?			
• ATTAINS	Yes □	No □	Comments____________________________
• Water Quality Database	Yes □	No □	Comments____________________________
• TN's Online Water Quality Assessment	Yes □	No □	Comments____________________________
Do samplers know how to use them?	Yes □	No □	Comments____________________________
Are SOPs being followed for sample handling?	Yes □	No □	Comments
Are deviations from SOPs being documented?	Yes □	No □	Comments
Are sampling priorities specified in Program plan being met?	Yes □	No □	Comments
Is a list of needed analyses/site available?	Yes □	No □	Comments
Chemical/Bacteriological Sample Collections			
• Is Chain of Custody being maintained?	Yes □	No □	Comments

• Are custody seals being used on coolers?	Yes □	No □	Comments
• Are QC samples (Duplicate, Trip and Field Blanks) collected at 10% of sites?	Yes □	No □	Comments
• Are gloves being worn for collection of nutrient samples?	Yes □	No □	Comments
• Are sterile sampling devices being used to collect bact. samples?	Yes □	No □	Comments
• Is proper field cleaning procedure being used for reusable equipment?	Yes □	No □	Comments
• Are samples being delivered to TDH Lab within holding time?	Yes □	No □	Comments
Water Parameter Probes			
• Are field water parameter probes working properly?	Yes □	No □	Comments
• Are calibration standards available and used?	Yes □	No □	Comments
• Are chemicals stored properly?	Yes □	No □	Comments
• Are pre calibrations and post drift checks being performed each day of use?	Yes □	No □	Comments
• Is calibration logbook maintained?	Yes □	No □	Comments
Flow Meters			
• Are flow meters working properly?	Yes □	No □	Comments
• Are pre calibrations and post drift checks being performed each day of use?	Yes □	No □	Comments
• Is calibration logbook maintained?	Yes □	No □	Comments
• Are flow measurements being sent to WPU?	Yes □	No □	Comments
Biological			
• Are QC duplicate biological samples collected at 10% of sites?	Yes □	No □	Comments
• Are biological samples logged-in?	Yes □	No □	Comments
• Are 10% biological samples ID’ed in EFO QC’ed?	Yes □	No □	Comments
• Are 10% of SQSH sorting in EFO QC’ed?	Yes □	No □	Comments
• Are QC results recorded in a logbook?	Yes □	No □	Comments

• Are all biological and habitat assessments and field data being sent to WPU?	Yes □	No □	Comments
• Are field water parameters recorded when biological samples are collected?	Yes □	No □	Comments
Data Management			
• Are watershed files accessible?	Yes □	No □	Comments
• Are station Ids being assigned to all sampling locations?	Yes □	No □	Comments
• Are station Ids sent to WPU before analyses results are received?	Yes □	No □	Comments
Bacteriological Analyses			
• Is sterile water used for IDEXX Quanti-Tray®/2000 dilutions? NA□	Yes □	No □	Comments
• Are sterile containers used for analyses? NA□	Yes □	No □	Comments
• Are 10% QC samples being run? NA□	Yes □	No □	Comments
• Is pathogen log being maintained? NA□	Yes □	No □	Comments
• Are bacteriological data from EFO, contractor, or univ. sent to WPU?	Yes □	No □	Comments

Issues of Concern:

Auditor Signature Date EFO Manager Signature Date

In-house Chemical/Bacteriological QC Officer Date In-house Biological QC Officer Date

APPENDIX G

FIELD EQUIPMENT

Chemical and Bacteriological General Field Equipment

- Waders
- External sample tags
- Sample request forms
- Field Flow Sheet or field computer
- Topographic maps (USGS quadrangle maps) may be digital
- Tennessee Atlas and Gazetteer
- GPS unit or field computer
- Cell Phone (recommended)
- Calibrated dissolved oxygen meter
- Field barometer if needed for on-site DO calibration
- Calibrated pH meter
- Calibrated conductivity meter
- Calibrated temperature meter or thermometer in ^{o}C
- Repair kit for water parameter meters (DO replacement membrane for multi-day trips)
- Calibrated flow meter, wading rod (10th of feet markings), and sensor cable if needed
- Measuring or surveyors tape (10th of feet markings) and rope long enough to span the river or stream if measuring flow
- Stakes (minimum 3), clamps (minimum 4), and hammer or other means of securing measuring tape if measuring flow
- Flow meter manual and screwdriver if measuring flow
- Spare batteries for all electronic equipment
- Waterproof pens (Sharpies®), pencils and black ballpoint ink pens (not rollerball)
- Flashlights in case detained after dark
- Duct tape for emergency repairs
- First aid kit
- Watch
- Electronic mapping device (for calculating stream miles if determining stations in the field)
- Sample bottles + 10% QC bottles
- Disposable beakers if needed for shallow stream sample collection

- 1-gallon plastic zip-type bags (recommended)
- Powder-free latex or nitrile gloves (Required for when preparing QC blanks and metal samples). Either powder-free nitrile or latex gloves can be used for other sampling. Latex gloves may provide more protection from pathogens.
- Shoulder length powder-free gloves (if collecting trace metals or low-level mercury)
- State ID badge and business cards
- Ice stored in coolers (ice may be placed in plastic bags for easier handling)
- Clean coolers
- Temperature blank bottle (1/cooler)
- Custody seals if required
- Camera for documenting potential pollution sources and waterbody conditions
- Graduated Cylinder if needed for measuring adequate sample amounts

Additional Items Needed for Non-Wadeable Sites

- Bacteriological sampling: swing sampler or other appropriate bottle holder or sterile sampling device
- Inorganic chemical sampling: Teflon® or High Density Polyethylene (Nalgene®) bucket attached to a rope, Teflon® Kemmerer, bailer, or peristaltic pump
- Organic chemical sampling: stainless steel bucket (attached to a rope), Kemmerer, or bailer
- Stopwatch or watch capable of measuring seconds for estimating flow

If Using a Boat

Boat with appropriate safety equipment paddles and PFDs

Additional Items Needed for Field Cleaning Equipment

- Phosphate-free laboratory-grade detergent
- Tap water stored in a clean covered tank, or squeeze bottle
- Deionized water stored in a clean covered tank or squeeze bottle

Additional Items Needed for Continuous Monitoring

- Continuous monitoring probe
- Sensor cable
- Laptop computer programmed for the continuous monitoring multi-probe
- Field manual for the probe and software
- Stainless steel cable or chain
- Crimps
- Crimp and wire cutter pliers
- Nylon or stainless steel cable

Appropriate anchoring and/or flotation device such as:

- Rebar and hammer (firm substrate)
- Wooden board (soft sand/silt substrate)
- Concrete block (soft sand/silt substrate)
- Float with probe holder to suspend the probe in the water column and a weight to hold it in place (deeper waters)

Additional Items Needed for Automatic Sampling

- Automatic sampler
- New Silastic® or equal tubing
- New Teflon® or Tygron® or equal tubing
- Clamps and/or electrical ties
- Spare batteries
- Ice

Biological Sampling Field Equipment

- TWRA collection permit (and NPS if on National Park lands)
- Waders
- Forceps
- Ethanol
- External sample tags
- Internal sample tags
- Toughbook© loaded with most current biological forms and field sheets
- Habitat Assessment Field Sheet (High gradient for riffles, Low gradient for glide-pool) if not using field computer with electronic biological forms.
- Stream Survey Field Sheet if not using field computer with electronic biological forms.
- Biorecon Field Sheet (Biorecons only) if not using field computer with electronic biological forms.
- Biological Analysis Request Form (for Chain of Custody and/or samples sent to lab)
- Rapid periphyton assessment sheet if not using field computer with electronic biological forms.
- ½ gallon wide mouth plastic sample bottles for Semi-Quantitative samples
- Small wide mouth plastic bottles for biorecons
- Calibrated GPS unit or Toughbook©
- Calibrated Dissolved Oxygen meter and replacement membrane kit (if needed)
- Calibrated pH meter
- Calibrated conductivity meter
- Calibrated temperature meter or thermometer in °C
- Spare batteries for all electronic equipment
- Camera (preferably digital) with memory cards or Toughbook©
- Triangular dip net with 500-micron mesh (Biorecons and SQBANK samples only)
- One meter square kick net with 500 micron mesh (SQKICK samples only)

- Rectangular net (18”) with 500 micron mesh (SQKICK in small streams only)
- Sieve bucket with 500 micron mesh
- White enamel or plastic pans for sorting debris (biorecons only)
- Waterproof marking pens (Sharpies), pencils and black ballpoint ink pens (not roller-ball or gel pens)
- Flashlights
- Duct Tape
- First Aid Kit
- Time keeping device
- Spherical Densiometer (for canopy measurements)
- GIS capability (to calculate stream miles to assign station ID in field if needed) or Toughbook©
- Cell phone

Optional Equipment

- Topographic maps (USGS quadrangle maps) may also be referred to as topos or quads
- Tennessee Atlas and Gazetteer
- Magnifying lens

Laboratory Equipment

Biorecons (EFO)

- Dissecting Microscope
- Jewelers Forceps
- Petri dish
- Ethanol
- Glass vials with rubber or Teflon line lid for reference specimens
- Taxonomic Bench Sheet
- Transfer pipette (or equivalent suction device)

Additional equipment needed for SQSH (state lab or consultant)

- Microscope slides
- Round 12 mm coverslips
- Square 22 mm coverslips
- Gridded Tray with subsampling insert
- Small Gridded dish (36 grids)
- CMCP-10 or equivalent permanent mounting media
- Random number jar
- Turkey baster (or equivalent suction device)
- Slide storage box

Periphyton Field Equipment

- Waders
- Forceps
- External sample tags

- Rapid Periphyton Survey Data Sheet if not using field computer with electronic biological forms.
- Habitat Assessment Sheet (High gradient for riffles, Low gradient for glide-pool) if not using field computer with electronic biological forms.
- Stream Survey Sheet if not using field computer with electronic biological forms.
- Biological Analysis Request Sheet (for Chain of Custody and/or samples sent to lab) if not using field computer with electronic biological forms.
- Topographic maps (USGS quadrangle maps) may be digital
- Tennessee Atlas and Gazetteer
- Calibrated GPS unit or Toughbook©
- Calibrated Dissolved Oxygen meter and replacement membrane kit if needed
- Calibrated pH meter
- Calibrated conductivity meter
- Calibrated temperature meter or thermometer in ^{o}C

- Spare batteries for all electronic equipment
- Camera (preferably digital) with memory cards for documentation of potential pollution sources and waterbody conditions or Tough-book(c)
- Magnifying lens
- Waterproof marking pens (Sharpies), pencils and black ballpoint ink pens (not roller-ball)
- Flashlights
- Duct Tape
- First Aid Kit
- Watch
- Spherical Densiometer (for canopy measurements)
- GIS capability (for calculating stream miles) if station ID is to be assigned in the field
- Disposable pipettes (approx 2.5ml)
- Preservative (buffered formalin)
- 500 mL wide mouth sample jar (approx. 9-cm inner diameter), marked at the 100 mL fill point
- Scissors or knife
- 125 mL amber wide-mouth sample bottle to hold final sample
- Rapid Periphyton Survey Board
- Small ruler

APPENDIX H

DATA QUALIFIERS

Result Qualifier	Result Qualifier Description
B	Detection in blank:
BH	Detection in blank. Holding time exceeded.
BU	Detection in blank. Not Detected: The analyte was analyzed for but was not detected at a level greater than or equal to the level of the adjusted Contract Required Quantitation Limit (CRQL) for sample and method.
D	Contract Required Quantitation Limit (CRQL) not met due to sample matrix interference, dilution required.
DB	Contract Required Quantitation Limit (CRQL) not met due to sample matrix interference, dilution required. Detection in blank.
DH	Contract Required Quantitation Limit (CRQL) not met due to sample matrix interference, dilution required. Holding time exceeded
DJ	Contract Required Quantitation Limit (CRQL) not met due to sample matrix interference, dilution required. Estimated: The analyte was positively identified, and the associated numerical value is the approximate concentration of the analyte in the sample.
DR	Contract Required Quantitation Limit (CRQL) not met due to sample matrix interference, dilution required. Rejected: The sample results are unusable due to the quality of the data generated because certain criteria were not met. The analyte may or may not be present in the sample.
DU	Contract Required Quantitation Limit (CRQL). Not Detected: The analyte was analyzed for but was not detected at a level greater than or equal to the level of the adjusted Contract Required Quantitation Limit (CRQL) for sample and method.
EE	Identifies compounds whose concentration exceed the calibration range addition of the instrument for that specific analysis.
H	Holding time exceeded:
HBJ	Holding time exceeded. Detection in blank. Estimated: The analyte was positively identified, and the associated numerical value is the approximate concentration of the analyte in the sample.
HL	Holding time exceeded. Lowest available reporting limit for the analytical method used.
HLBL	high labeled compound recovery in sample, estimated value, estimated value
HMSR	high matrix spike recovery, potential high bias
HNRO	high native analyte recovery in OPR (or LCS), potential high bias
HSSR	high surrogate spike recovery, potential high bias
HVER	high calibration verification standard recovery, estimated value
ITNA	Incubation time not attained

ITNM	Incubation temperature not maintained
J	Estimated: The analyte was positively identified, and the associated numerical value is the approximate concentration of the analyte in the sample.
J+	Estimated: The analyte was positively identified and the associated numerical value. +++.
JB	Estimated: The analyte was positively identified, and the associated numerical value is the approximate concentration of the analyte in the sample. Detection in blank.
JH	Estimated: The analyte was positively identified, and the associated numerical value is the approximate concentration of the analyte in the sample. Holding time exceeded.
JL	Estimated: The analyte was positively identified, and the associated numerical value is the approximate concentration of the analyte in the sample. Lowest available reporting limit for the analytical method used.
KK	True bacterial concentration is assumed to be less than the reported value.
L	Lowest available reporting limit for the analytical method used.
LL	True bacterial concentration is assumed to be greater than the reported value.
LLBL	low labeled compound recovery in sample, estimated value
LLRO	low labeled compound recovery in the OPR (or LCS), estimated value
LMSR	low matrix spike recovery, potential low bias
LNRO	low native analyte recovery in OPR (or LCS), potential low bias
LOPR	low OPR (or LCS) recovery, potential low bias
LVER	low calibration verification standard recovery, potential low bias
MTRX	possible matrix interference, estimated value
NCNF	not confirmed or not found, estimated value
NLBL	no labeled compound recovery in sample, rejected
NLRO	no labeled compound recovery in OPR (or LCS), rejected
NMSR	no matrix spike recovery, rejected
NNRO	no native analyte recovery in OPR (or LCS), rejected
NOPR	no OPR (or LCS) recovery, rejected
NVER	no calibration verification standard recovery, rejected
R	Rejected: The sample results are unusable due to the quality of the data generated because certain criteria were not met. The analyte may or may not be present in the sample.
RMAX	result is a maximum value

RNAF	result no affected by noted QC issue
RNF2	results of 2 columns not within factor of 2, estimated value
RNON	result reported as non-detect due to blank contamination
RPDX	RPD is MS/MSD pair exceeds criterion, estimated value
U	Not Detected: The analyte was analyzed for but was not detected at a level greater than or equal to the level of the adjusted Contract Required Quantitation Limit (CRQL) for sample and method.
UH	Not Detected: The analyte was analyzed for but was not detected at a level greater than or equal to the level of the adjusted Contract Required Quantitation Limit (CRQL) for sample and method. Holding time exceeded.
UJ	Not Detected/Estimated: The analyte was not detected at a level greater than or equal to the adjusted CRQL or the reported adjusted CRQL is approximate and may be inaccurate or imprecise.
JL, U	Result estimated low. Result is less than the MDL.
LMSRJ	Low matrix spike recovery, potential low bias. Result is less than the MQL but greater than or equal to the MDL and the concentration is an approximate value.
OA3	Outlier, across stations
OS3	Outlier, single station
J-QC	Approximate value due to quality control problems
IQCOL	ICV, CCV, ICB, CCB, ISA, ISB, CRI, CRA, DLCK or MRL standard: Instrument related QC is outside acceptance limits
SCX	Suspected Contamination, unknown
SCP	Suspected Contamination, lab preparation
HMSRJ	High matrix spike recovery, potential high bias, estimated: The analyte was positively identified, and the associated numerical value is the approximate concentration of the analyte in the sample
HU	Holding time exceeded. Not Detected: The analyte was analyzed for but was not detected at a level greater than or equal to the level of the adjusted Contract Required Quantitation Limit (CRQL) for sample and method.
FQC	Quality Control, failed
FQC, U	Quality Control, failed, Not Detected
FDL	Lab Duplicate, failed
EST	Estimated Value, outside limit of precision
I	Estimated value; compound failed initial calibration value (WQX deprecated)

CB+, J	CCB out high. Estimated value between MDL and MQL.
CB+	CCB out high
LMSRU	Low matrix spike recovery, potential low bias. Result is less than the MDL.
SCF	Suspected Contamination, Field
BJ	Detection in blank. Estimated: The analyte was positively identified, and the associated numerical value is the approximate concentration of the analyte in the sample
FEQ	Field equipment questionable

APPENDIX I

RECORD OF REVISIONS

DWR-PAS-P-02-QAPP-102017
Quality Assurance Project Plan For 106 Monitoring

Concurrences and Reviews. The following staff in the Division of Water Pollution Control participated in the planning and development of this project:

Kimberly J. Sparks — 2/13/2006

Signature — Date

Kimberly J. Sparks
Biologist III
Tennessee Department of Environment and Conservation

Deborah H. Arnwine — 2/13/06

Signature — Date

Deborah H. Arnwine
Environmental Specialist V
Tennessee Department of Environment and Conservation

Gregory M. Denton — 2/15/06

Signature — Date

Gregory M. Denton
Environmental Program Manager I
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2/15/06

Signature — Date

Sherry H. Wang
Environmental Program Manager I
Tennessee Department of Environment and Conservation

Garland P. Wiggins III — 2/9/06

Signature — Date

Garland P. Wiggins
Deputy Director
Tennessee Department of Environment and Conservation

NOTICE OF REVISION(S) RECORD

Date	Section/Page Draft Version 1	Section/ Page Version 3	Revision Type	Revision Description
07/13/05	Throughout document	Throughout document	Minor	Acronyms were defined at first reference in document.
07/13/05	A4.2.1.A/Page 18	A4.2.1.A/ Page 18	Minor	Radon Program Manager was removed from the list of environmental managers.
07/13/05	A4.2.1C/Page 19	A4.2.1 C/ Page 21	Minor	Changed wording of sentence.
07/13/05	A6.1/Page 25	A6.1/Page 28	Minor	Reversed sentence order.
07/13/05	A6.1 1./Page 27	A6.1 1./ Page 33	Minor	Changed “Waters” to “Waterbodies”.
07/13/05	A6.1 1./Page 28	A6.1 1./ Page 33	Minor	Added the word macroinvertebrate.
07/13/05	A6.1.1/Page 31 Table 8	A6.1.1/Page 34	Major	Changed table for surface water sampling.
07/13/05	A6.1 2./Page 27	A6.1 2./ Page 35	Minor	Removed the last word, TMDLs, from the last sentence of the paragraph.
07/13/05	A6.1 3./Page 27	A6.1 3./ Page 35	Minor	Changed semi-quantitative to Semi-Quantitative Single Habitat.
07/13/05	A6.1.6/Page 33	A6.1.3/Page 36	Minor	Clarified the section of QSSOP with QC requirements.
07/13/05	A7.2 Step 2 c./ Page 41	A7.2 Step 2 c./Page 45	Minor	Reversed wording in sentences.
07/13/05	A7.2 Step 5 a./ Page 42	A7.2 Step 5 a./ Page 45	Minor	Revised wording on 3,4, and 5.
07/13/05	A7.2 Step 5 b./ Page 42	A7.2 Step 5 b./ Page 46	Minor	Removed “Type of data used (from list)”.
07/13/05	A9.1 /Page 59	A9.1/Page 62	Minor	Added the word “Form”.
07/13/05	A9.3/Page 60	A9.3/Page 62	Minor	Changed wording to clarify analyses turnaround times.

Date	Section/Page Draft Version 1	Section/ Page Version 3	Revision Type	Revision Description
07/13/05	A9.4.A/Page 60	A9.4.A/ Page 63	Minor	Changed wording to “provide required laboratory documentation”.
07/13/05	A9.4.B/Page 61 Table 16	A9.4.B/Page 63 Table 16	Minor	Specified which manifest and chain of custody sheets.
07/13/05	A9.7/Page 61	A9.7/Page 64	Minor	Removed the specific version of ADB used.
07/13/05	A9.8/Page 62	A9.8/Page 65	Minor	Specified that the WQDB is backed up nightly.
07/13/05	A9.8/Page 62 Table 17	A9.8/Page 65	Minor	Specified the title of forms.
07/13/05	B1.1/Page 64	B1.1/Page 67	Minor	Deleted part of the sentence beginning “The division”.
07/13/05	B1.3.A Year 5/ Page 67	B1.3.A/Page 69	Minor	Reworded to “public notices are released”.
07/13/05	B1.4/Page 71	B1.4/Page 72	Minor	Specified laboratories used.
07/13/05	B1.4 4./Page 73	B1.4 4./ Page 76	Minor	The word “readings” was changed to “measurements”.
07/13/05	B1.8.C/Page 83 & Table 25/Page 84	B1.10.C/Page 90 & Table 25/Page 91	Major	Updated parameters needed for TMDLs.
07/13/05	B1.8.C 3./Page 88	B1.10.C/ Page 94	Minor	Clarified wording.
07/13/05	B1.9/Page 91 Table 29	B1.11/Page 97 Table 29	Minor	Removed sentence from table footnote.
07/13/05	B2.1.3/Page 94	B2.1.3/ Page 100	Minor	Clarified where meters are calibrated.
07/13/05	B2.1.5/Page 95	B2.1.5/ Page 101	Minor	Clarified how bacteriological samples are collected and where additional information can be found.
07/13/05	B2.7/Page 98	B2.7/Page 104	Minor	Specified where additional water safety cautions may be found.

Date	Section/Page Draft Version 1	Section/ Page Version 3	Revision Type	Revision Description
07/13/05	B3.1/Page 98	B3.1/Page 104	Minor	Added the title of the laboratory chain of custody.
07/13/05	B3.1 & 3.2/Page 99	B3.1 & B3.2/ Page 104-105	Minor	Specified which laboratories are secured facilities.
07/13/05	B3.2/Page 99	B3.2/Page 105	Minor	Added a sentence that lists paperwork sent to WPC.
07/13/05	B3.2/Page 99	B3.2/Page 105	Minor	Clarified wording on first sentence in 4th paragraph.
07/13/05	B3.4/Page 100	B3.4/Page 106	Minor	Changed wording of the last sentence in the 1st paragraph.
07/13/05	B3.5/Page 100	B3.5/Page 107	Minor	Changed wording of the last sentence in the 1st paragraph.
07/13/05	B4.8/Page 104	B4.8/Page 110	Minor	Removed nonstandard method reference.
07/13/05	B6.4/Page 111	B6.4/Page 116	Minor	Clarified wording of last sentence in 1st paragraph.
07/13/05	C1.1/Page 119	C1.1/Page 125	Minor	Reworded the 1st sentence of the 1st paragraph.
07/13/05	D1.5/Page 130	D1.5/Page 136	Minor	Specified where QC procedures are describes.
07/13/05	D2.1/Page 130	D2.1/Page 136	Minor	Clarified the 1st sentence of the 1st paragraph.
02/06/06	A6.1 1./Page 27	A6.1 1./ Page 30	Minor	Removed description of high quality water.
02/06/06	A6.1 4./Page 27-28 A6.1.1 3./Page 30	A6.1 4./ Page 30-31 A6.1.1 3./ Page 33	Minor	Biological samples are not needed for 303(d) waters listed only for pathogens.
02/06/06	A7.3 /Pages 49-51 Table 14	A7.3/ Page 52-54 Table 14	Minor	Standard Methods, 19th Edition is the SOP for pathogen analyses only.
02/06/06	B1.4 1./ Page 71	B1.4/Page 74	Major	Changed procedure for determining high quality waters.

Date	Section/Page Draft Version 1	Section/ Page Version 3	Revision Type	Revision Description
02/06/06	B1.4 5./Page 75-76	B1.4 5./ Page 77-82	Major	Revised monitoring for EPA Approved List of Impaired and Threatened Waters Waterbodies. Replaced Table 21 with new monitoring requirements and removed Draft Table 22.
02/06/06	B1.4 6./Page 77 Table 23	B1.4 6./ Page 82 Table 22	Major	Draft Table 23 was renumbered to Table 22.
02/06/06	B1.4/Page 78 Table 24	B1.6/Page 85 Table 24	Minor	Added SQSH sample type to 303(d) and watershed monitoring.
02/06/06	B1.8 C/ Page 86 Table 27	B1.10/Page 94 Table 27	Minor	Added SQSH as core monitoring activity for 303(d) monitoring.
02/06/06	B2.3.1 a./Page 94	B2.3.1 a./ Page 102	Minor	EFO WPC Manager or their designee may be contacted if a sample cannot be collected as scheduled.
02/06/06		Throughout document	Minor	Revised workplan fiscal year to 2006 and publication date to 2005.
02/06/06		Throughout document	Minor	Revised 303(d) from Proposed to Final 2004.
02/07/06	A6.1/Page 29	A6.1/Page 31	Minor	Added fish tissue monitoring description.
02/07/06	A6.1.1/Page 30	A6.1/Page 33	Minor	Long term monitoring expected measurements added.
02/07/06	A7.2 b./Page 41	A7.2 b.10./ Page 44	Minor	Added description of postings due to fish tissue contamination.
02/07/06	B1.4 1./Page 71	B1.4 1./ Page 74	Major	Revised antidegradation monitoring section.
02/07/06	B1.4/Page 77	B1.4 7./Pages 82-84 Table 23	Major	Added fish tissue monitoring section and new Table 23 list of monitoring stations.

Date	Section/Page Draft Version 1	Section/ Page Version 3	Revision Type	Revision Description
02/07/06	B1.9/Page 88 Table 29 Appendix D/ Pages 156-157	B1.11/Page 96 Table 29 Appendix D/ Page 164-166	Major	Nutrient MDLs have changed.
02/07/06	B2.1.1/Page 92 References/ Page 140	B2.1.1/ Page 100 References/ Page 148	Minor	Added fish tissue collection protocol reference.
02/07/06	B5.3/Page 104	B5.3/Page 112	Major	Added QC requirements for fish tissue collection and processing.
02/07/06		Throughout Document	Minor	Numerous employees, positions, and titles have changed. These are not individually documented.
02/08/06	B1.4 4./Page 74 Table 20	B1.4 4./ Page 77 Table 20	Major	Changed COD to CBOD
02/09/06	B6.3/Page 37	B6.3/Page 40	Minor	Updated budget figures.
5/02/06		B1.4/Page 76 Table 18	Minor	Updated minimum TMDL requirements.
5/2/06		B1.10.C/Page 93 Table 25	Minor	Added TOC to nutrient TMDL.
6/21/06		A6.1.1/Page 34 Table 8	Minor	Added cyanide to long term monitoring parameters

This revision(s) has been reviewed and approved. This revision(s) becomes effective on: February 15, 2006.

Date	Section/Page Draft Version 1	Section/ Page Version 3	Revision Type	Revision Description
02/07/06	B2.1.1/Page 92 References/ Page 140	B2.1.1/ Page 100 References/ Page 148	Minor	Added fish tissue collection protocol reference.
02/07/06	B5.3/Page 104	B5.3/Page 112	Major	Added QC requirements for fish tissue collection and processing.
02/07/06		Throughout Document	Minor	Numerous employees, positions, and titles have changed. These are not individually documented.
02/08/06	B1.4 4./Page 74 Table 20	B1.4 4./ Page 77 Table 20	Major	Changed COD to CBOD
02/09/06	B6.3/Page 37	B6.3/Page 40	Minor	Updated budget figures.

This revision(s) has been reviewed and approved. This revision(s) becomes effective on: February 15, 2006.

Paul E. Davis
Director
TDEC Division of Water Pollution Control

2/9/06
Date

Charles L. Head
Health and Safety/Quality Assurance Director
Tennessee Department of Environment and Conservation

[illegible]
Date

Paul Sloan
Deputy Commissioner for Environment
Tennessee Department of Environment and Conservation

2/18/06
Date

Date	Section/ Page Draft Version 4	Revision Type	Revision Description
02/27/07	Throughout Document	Minor	Numerous employees, positions, and titles have changed. These are not individually documented.
2/27/07	Appendix G	Minor	Deleted Appendix G, added names to Peer Review list
2/27/07	Throughout Document	Minor	Corrected dates of benthic SOP, workplan and 303dlist
2/27/07	A. Table 11	Minor	Updated Deliverable Due Dates
2/27/07	A. 9.8 Table 17	Minor	Added data types
2/27/07	B.1.6 Table 24	Minor	Added more projects
2/27/07	B.1.11	Major	Relocated B1.11 and Table 29 to B4.
2/27/07	D	Major	Major rewrite of D
2/28/07	A6.1.4	Major	Added equipment list for moni-toring

Date	Section/ Page Draft Version 4	Revision Type	Revision Description
2/28/07	A6.	Minor	Combined 2 paragraphs about fish tissue monitoring and advisories
3/1/07	A6.1.3	Minor	Regulatory Criteria Added sentences about criteria
3/1/07	B1.4	Minor	Added frequency info to monitoring types.
3/1/07	B.1.4	Minor	Added parameter list for fish tissue analysis.
3/1/07	B.1.9	Minor	Added sentence about the location of stations.
3/1/07	B2.1.2	Minor	Added sentence about sampling equipment
3/1/07	B4.2	Minor	Updated info on turnaround time for results.
3/1/07	B5.1	Minor	Added sentence about QC failures.
3/1/07	B7.1	Minor	Listed meters used in sampling. Added info on calibration of standards and equipment.
3/1/07	B.7.2	Minor	Added info on calibration of standards and equipment.
3/1/07	B8.1	Minor	Added info about acceptance criteria.
3/1/07	B10.3	Minor	Added software info for Data Analysis
3/2/07	Appendix	Minor	Corrected staff on lab org chart
3/13/07	A.9.3	Minor	Corrected turnaround time for lab results.
3/26/07	A.6-1	Minor	Updated project info
3/26/07	A7.1	Minor	Corrected protocol info
3/26/07	A.7.2	Minor	Typo
3/26/07	A7.3	Major	Major rewrite and additions

Date	Section/ Page Draft Version 4	Revision Type	Revision Description
3/26/07	B.2	Minor	Clarified objectives
3/26/07	B.2-1	Minor	Revised wording for protocols
3/26/07	B-2.3-4	Major	Moved to section D-2
3/26/07	B.2.5	Minor	Table 31 Flag key moved to Section D-2
3/26/07	B.2.6	Minor	Renumbering
3/26/07	B.3.4	Minor	Added info about chain of custody.
3/26/07	B.3.6	Minor	Corrected protocol letters.

Date	Section/ Page Draft Version 4	Revision Type	Revision Description
3/26/07	B.4	Minor	Added method info
3/26/07	B.4 Table 29 and 33	Minor	Changed table numbers
3/26/07	B.4.2	Major	Added equipment and instrumentation, analytical methods and instruments
3/29/07	B.8	Major	Added data about supplies and consumables.

This revision(s) has been reviewed and approved. This revision(s) becomes effective on: April 15, 2007.

Paul E. Davis
Director
TDEC Division of Water Pollution Control

4/2/07
Date

Charles L. Head
Health and Safety/Quality Assurance Director
Tennessee Department of Environment and Conservation

4/02/07
Date

David Draughon
Senior Director for Water Resources Group
Tennessee Department of Environment and Conservation

3/30/07
Date

Date	Section/Page Draft Version 5	Revision Type	Revision Description
9/25/08	Throughout document	Minor	Employee names and positions updated
9/25/08	Appendix B	Minor	Employee names and positions updated
9/25/08	Appendix	Minor	Took out station check form – not being used
9/25/08	A6.1 p.38	Minor	Updated # of stations to be monitored
9/25/08	Throughout document	Minor	Updated citation date for numerous documents
9/25/08	A.7.1	Minor	Corrected spelling - workplan
9/25/08	Table 14	Minor	Corrected spelling - chemical
9/25/08	Table 15	Minor	Corrected spelling - year
9/25/08	Table 16	Minor	Added Selenium to fish parameter table
9/25/08	B4.4	Minor	Corrected – to EFO should contact lab if results are not returned in correct time frame
9/25/08	A9.3	Minor	Corrected – to EFO should contact lab if results are not returned in correct time frame
9/25/08	Table 50	Minor	Deleted staff person that retired
9/25/08	D1	Minor	Corrected spelling – acquired
9/25/08	References	Minor	Deleted duplicate reference
9/25/08	A4.2.1.B	Minor	Corrected spelling – bacteriological
9/25/08	A5.2	Minor	Corrected Division of Water Pollution Control
9/25/08	B.1.4	Major	Change wording about Tiers

9/25/08	128	Minor	Delete page break
9/25/08	Table 41	Major	Change 10% to 20% on t duplicates
9/25/08	C1.2	Minor	Corrected WPC
9/25/08	A7.3.6	Minor	Corrected spelling – macroinvertebrate
1/28/09	A.5.2.6	Minor	Corrected number of staff positions.
1/29/09	References and document	Minor	Corrected title
1/29/09	A.9.8	Minor	Corrected years for data results to be kept at lab
2/9/09	Appendix B	Minor	Corrected spelling - Noncritical
2/9/09	Throughout	Major	Added periphyton to Ecoregion sampling
2/9/09	B5.3	Minor	Added reference title
2/11/09	Table 10	Minor	Corrected spacing in table
2/11/09	Page 97	Minor	Corrected spacing in document
2/11/09	D2.2.2	Minor	Reworded sentence
2/12/09	Appendix C	Minor	Added missing watershed numbers to 2 watersheds
2/13/09	Table 13	Minor	Updated position requirements
2/13/09	B10.7	Minor	Corrected spelling
2/27/09	A7.2 page 52	Minor	Rearranged sentences
3/5/09	Throughout	Minor	Corrected TDH lab staff names and positions
3/5/09	B4.1Table 35	Major	Corrected TDH lab methods

3/5/09	B4.2 Table 36	Major	Corrected DH lab methods and instrumentation
3/5/09	B.4.3 Table 37	Minor	Corrected TDH lab staff name and positions
3/5/09	Appendix D	Major	Corrected MDLs and Holding times
3/12/09	Throughout	Major	Added periphyton everywhere macroinvertebrate is mentioned
3/12/09	List of tables	Minor	Lined up table of contents
3/12/09	A52.1	Major	Corrected number of ecoregions

3/12/09	Table 7	Minor	Corrected antidegradation terminology
3/12/09	A6.1	Minor	Corrected terminology
3/12/09	A6.1.1	Minor	Added info about periphyton and sampling
3/12/09	A6.1.4.	Major	Added field and lab equipment for periphyton sampling
3/12/09	Table 10	Minor	Corrected date QAPP due
3/26/09	Throughout	Minor	Corrected email addresses
4/3/09	Throughout	Minor	Corrected temperature
4/3/09	B3.1	Minor	Added info about custody seal
4/3/09	B1.10c	Major	Changed flow info for pathogen TMDL
4/8/09	Throughout	Minor	Corrected parameter conductivity to Specific conductance
4/8/09	B.1.5	Minor	Corrected time
4/8/09	Table 42	Minor	Corrected container for TOC

These revisions have been reviewed and approved. These revisions become effective on April 15 2009.

4/13/09

Paul E. Davis **Date**
Director
TDEC Division of Water Pollution Control

4/13/09

Charles L. Head **Date**
Health and Safety/ Quality Assurance Director
Tennessee Department of Environment and Conservation

Revisions Jan 2010

Date	Section/Page Draft Version 6	Revision Type	Revision Description
1/4/10	Throughout	Minor	Corrected TDEC and TDH staff and positions
1/4/10	Throughout	Major	Updated reference dates and titles
1/4/10	Throughout	Minor	Quarterly to monthly to send database to EFOS.
1/4/10	B.7	Minor	Calibration to minimally once a week
1/4/10	Appendix D	Minor	Changed container requirement for TOC and hardness
1/4/10	B.1.10c	Minor	For pathogen TMDL take flow – recommended as time allows
1/4/10	Appendix D	Minor	Changed MDL for Magnesium
1/4/10	Appendix D	Minor	Changed MDL for Mercury and added Jackson MDL for Mercury
1/4/10	Appendix D	Minor	Corrected temp for storing parameter on ice to ≤ 6°
1/12/10	Table 8	Minor	Added info about FECO parameters
1/12/10	Table 23	Minor	Updated fish sampling dates
1/13/10	B10.9	Minor	Program plan list reviewed quarterly
1/14/10	Table 42	Minor	Updated probe specifications
1/14/10	B10.5,6,7	Major	Updated info on changes in storing data and sending to EPA
1/14/10	Appendix D	Minor	Store bacti samples at on ice ≤ 10° C.
1/14/10	Table 44	Major	Added info about ICP-MS
1/14/10	Appendix C	Minor	Updated maps of sampling stations
1/22/10	Table 41	Minor	Added DO saturation info

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1/22/10	B2.4	Minor	Added- also EFO Quality Team Member
1/28/10	A5.2.5	Minor	Added TDEC storage room
2/1/10	Appendix D	Major	Updated mdls

These revisions have been reviewed and approved. These revisions become effective on February 05, 2010.

Paul E. Davis — 2/4/10

Paul E. Davis
Director
TDEC Division of Water Pollution Control

Date

Charles L. Head — 2/5/10

Charles L. Head
Health and Safety/Quality Assurance Director
Tennessee Department of Environment and Conservation

Date

Revisions January 2011

Date	Section/Page Draft Version 7	Revision Type	Revision Description
1/20/11	Throughout document	Minor	Updated WPC personnel
1/20/11	Throughout document	Minor	Updated WPC references
1/24/11	B4	Minor	Clarified approved methods
1/24/11	B41	Minor	Clarified approved methods
1/24/11	B5	Minor	Corrected blank info
1/24/11	B10.2	Major	Updated time frame that TDH maintains records
1/24/11	Appendix b	Major	Updated QM organization chart
1/25/11	Throughout document	Minor	Updated TDH lab personnel
1/25/11	Throughout document	Minor	Updated TDH lab references
1/25/11	A 9.8	Minor	Updated info on TDH data storage process
1/25/11	B4.1	Major	Updated info on TDH mdl process
1/27/11	B10.7	Minor	Updated info on electronic data transmittal with TDEC, TDH, and EARTHSOFT EQUIS software
1/27/11	B8.3	Minor	Updated TDH policy on test-ing sample containers
1/27/11	Table 23	Minor	Updated fish monitoring sites
1/28/11	B2.3.1	Minor	Updated info if meter is not working
1/28/11	Table 32	Minor	Added C flag for Comment

1/28/11	B5.2	Minor	Corrected reference to TDH QAP
1/28/11	B4.4	Minor	Added bold and not ASAP to priority sampling
1/31/11	B2.3.1	Minor	Reworded statement about instrument failure and field parameters
1/31/11	B1.4 section 7	Minor	Added info about fish fillets/whole fish
1/31/11	B2.3.1	Minor	Info about meters and field parameters
1/31/11	Table 41	Minor	Corrected info about DO and meter calibration
2/-4/11	Table 32	Minor	Added L flag -- lab not able to verify results lab destroyed records
2/8/11	Table 19	Minor	Added flow to ecoregion sampling
2/8/11	B3.1	Minor	Added Memphis-Shelby County Laboratory
3/1/11	Throughout document	Major	Lab will send data results electronically not mail results
3/14/11	Table of contents	Minor	Corrected page numbers
3/16/11	Approval and Concurrences/ peer review pages	Minor	Updated EPA staff

Paul E. Davis ______ Date 5/5/11

Paul E. Davis
Director
TDEC
Division of Water Pollution Control

Charles E. Head ______ Date 5/4/11

Charles E. Head
Health and Safety/Quality Assurance Project Director

Revisions February 2013

Date	Section/Page Draft Version 8	Revision Type	Revision Description
2/27/12	Throughout document	Minor	Updated WPC personnel
2/27/12	Throughout document	Minor	Updated WPC references
3/14/12	Throughout document	Minor	Updated TDH Lab personnel
3/14/12	B.4.1	Minor	Updated date THD lab info available.
6/14/12	References	Minor	Added revised TDH SOPs
7/16/12	B1.4	Major	Revised procedure for sampling 303(d) listed streams
11/30/12	Throughout document	Minor	Updated TDH lab personnel
11/30/12	Table 35	Major	Updated parameter list and MDLS
12/11/12	B.3.1 and B.3.4	Major	TDH policy on receiving samples
1/10/13	Table 8	Minor	Removed parameters from required list – cyanide, fecal coliform, orthophosphate
1/31/13	Numerous tables		Metals do not have to stored in cooler at or below 6 degrees C

These revisions have been reviewed and approved. These revisions become effective on February 28, 2013

Jennifer Dodd ______________________ **Date** 2-13-13
Deputy Director
Watershed Stewardship and Support Branch
TDEC Division of Water Resources

Brenda Apple Brenda K. Apple ______________________ **Date** 2/13/13
Environmental Quality Program Director TDEC

Revisions January 2014

Date	Section/Page Final Version 9	Revision Type	Revision Description
1/17/14	Throughout document	Minor	Updated DWR personnel and titles
1/7/14	Throughout document	Minor	Updated DWR references
1/17/14	Appendix b	Major	Updated QM organization chart
1/17/14	Throughout document	Minor	Updated TDH lab personnel
2/4/14	Page 62 section b	Minor	Grammar
2/4/14	Table 23	Minor	Corrected station location
2/4/14	Page 112	Minor	Corrected table number
2/4/14	Page 146, 148 section B3	Minor	Punctuation
2/4/14	Page 175 B10.1	Minor	Grammar
2/21/14	Table 35	Minor	Added Heterotrophic Plate Count (HPC) SM 9215B and SM9215E
2/21/14	Table 44	Minor	Remove GFAA instrument
2/21/14	Table 35	Major	Updated methods
2/28/14	B10.5	Major	Updated information on data transmittal from TDH to DWR and from DWR to EPA WQX

These revisions have been reviewed and approved. These revisions become effective on May 15 2014.

Jennifer Dodd________________________________**Date** 5-13-14
Deputy Director
Watershed, Stewardship and Support Branch
TDEC Division of Water Resources

Brenda Apple Brenda K. Apple **Date** 5-13-14
Environmental Quality Program Director TDEC

2015 revisions

Date	Section/Page Final Version 10	Revision Type	Revision Description
2/19/15	Throughout document	Minor	Updated DWR personnel and titles
2/19/15	Throughout document	Minor	Updated DWR references
2/19/15	Appendix b	Major	Updated QM organization chart
2/19/15	Page 62 section b	Minor	Grammar
2/19/15	Table 23	Minor	Corrected station location
2/19/15	Page 112	Minor	Corrected table number
2/19/15	Section B3	Minor	Punctuation
2/19/15	B10.1	Minor	Grammar
2/19/15	Table 35	Minor	Added Heterotrophic Plate Count (HPC) SM 9215B and SM9215E
2/19/15	Table 44	Minor	Remove GFAA instrument
3/2/5	Table 35 and Table 36	Major	Updated methods
2/19/15	B10.5	Major	Updated information on data transmittal from TDH to DWR and from DWR to EPA WQX
3/18/15	Throughout document	Major	Updated TDH lab personnel
3/18/15	Throughout document	Major	Updated TDH references
4/21/15	B3.1	Minor	Updated information on sample handling procedures
4/30/15	Throughout document	Major	Corrected sampling priorities
4/30/15	Throughout document	Minor	Grammar
5/20/15	Pages 30, 79-80, 89	Major	Updated pathogen monitoring protocol

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These revisions have been reviewed and approved. These revisions become effective on April 30, 2015

Jennifer Dodd __________ Date 4-30-15
Environmental Program Director Water Quality Branch
TDEC Division of Water Resources

Brenda Apple __________ Date 4/30/15
Environmental Quality Program Director
TDEC Bureau of Environment

2016 Revisions

Date	Section/Page Final Version 11	Revision Type	Revision Description
2-28-16	Pages 29-33	Major	Revised Monitoring Priorities
2-28-16	Section B1.4	Major	Revised Monitoring Priorities

These revisions have been reviewed and approved. These revisions become affective February 28, 2016.

Jennifer Dodd __________ Date 2-26-16
Environmental Program Deputy Director Division of Water Resources

Brenda Apple __________ Date 2/24/2016
Environmental Quality Program Director
TDEC Bureau of Environment

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Quality Assurance Project Plan For 106 Monitoring

2017 Revisions

Date	Section/Page Final Version 11	Revision Type	Revision Description
02-10-17	Throughout	Minor	Revised dates and staff
03-13-17	Throughout	Major	Removed flow from required sampling activities
03-15-17	Throughout	Major	Revised LAB SOP reference information
05-15-17	B3 and B4	Major	Clarified certification requirements for chemical and bacteriological labs.
06-26-17	Section A.5.2.3	Minor	Refined definition of TMDL
06-26-17	Section B	Minor	Changed minimum number of data to preferred for TMDLS. Removed exception for sampling in flood conditions.
06-26-17	Section B10	Major	Revised data reporting and storage.
06-27-17	Table 17	Major	Data storage locations updated.

These revisions have been reviewed and approved. These revisions become effective October 20, 2017.

Jennifer Dodd *[signature]* Date 11-3-17
Environmental Program Deputy Director, Division of Water Resources

Brenda Apple *Brenda K. Apple* Date 11-3-17
Environmental Quality Program Director
TDEC Bureau of Environment

NOTICE OF REVISIONS RECORD 2018

Date	Section/Page	Revision Type	Revision Description
06/28/18	A6.1.1	Minor	Updated Table 8 for clarification
06/28/18	Appendix C	Minor	Updated TDH laboratory Org Chart
06/28/18	Appendix C	Minor	Updated DWR Org Chart
7/25/18	A6.1.1	Minor	Clarified Table 8 QC parameters
7/26/18	Throughout	Minor	Updated year for QSSOP for Chemical and Bacteriological Sampling of Surface Water
6/11/19	A6.1.1	Minor	Added SEMN to Table 8
9/4/19	Table 55	Minor	Updated QC Officer Table

No major changes were made therefore no revision and approval was needed.

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Quality Assurance Project Plan For 106 Monitoring

1.) **Effective Date:** September 2020
2.) **Signatures:**

Jennifer Dodd, Division Director, TN Division of Water Resources

Barry Brawley
Reviewer
TDEC Quality Assurance Manager

Natalie Moore

Natalie Moore, Preparer, TDEC DWR-Watershed and Planning Unit

Elizabeth Belk

Elizabeth Belk, Reviewer, EPA Regional Monitoring Coordinator

NOTICE OF REVISIONS RECORD 2020

Date	Section/Page	Revision Type	Revision Description
6/11/19	A6.1.1	Minor	Added SEMN to Table 8
9/4/19	Table 55	Minor	Updated QC Officer Table
10/10/19	Throughout	Minor	Update all personal changes
11/18/19	Table 41	Minor	Clarify Trip Blank Frequency is 10% of all trips per EFO not 10% of samples
11/25/19	Appendix D	Minor	Update Watershed sampling map
11/26/19	Table 24.	Minor	Clean up the table
11/26/19	Table 23	Minor	Update the stations
11/26/19	Table 35	Minor	Update the MDL's for TDH
11/26/19	Table 35	Minor	Added Low Level Mercury to list
11/26/19	Table 36	Minor	Added Low Level Mercury to list
11/27/19	Table 42	Minor	Updated sample bottles
1/21/2020		Minor	Update TDH Lab Org Chart
1/22/2020	Appendix A	Minor	Update Manager Responsibilities
1/22/2020	Table 9	Minor	Primary Roles of Key Personnel
1/22/2020	Table 15	Minor	Qualifications and Titles
1/22/2020	Table 3	Minor	Update Planning Team Members
1/22/2020	Table 5	Minor	Update Data Sources to include Attains
1/22/2020	Table 1	Minor	Update Distribution List Members
2/4/2020	Table 15	Minor	Add TDEC Manager 4

2/4/2020	Throughout	Minor	Remove Linda Cartwrights name and add Natalie Moore
2/4/2020	Table 37	Minor	Update Names
2/4/2020	Appendix H	Minor	Add new table of qualifiers
2/4/2020	Appendix D	Minor	Update Lab Nonmetal MDL's 2019
2/4/2020	Appendix D	Minor	Update MQL's
2/4/2020	Appendix D	Minor	Update MDL's in Lab. MDL's for metals 2019
2/4/2020	Appendix D	Minor	Update TDH Organic analysis bottle requirements
2/4/2020	Appendix D	Minor	Add TDH misc. Inorganic analysis Boron and TOC
2/4/2020	Appendix D	Minor	Add Low Level Mercury
2/4/2020	Appendix D	Minor	Update Metals analysis preservative
2/4/2020	Appendix D	Minor	Update TDH Routine analysis added low conductivity pH
2/4/2020	Table 41	Minor	Make note for duplicate % difference
2/4/2020	Appendix B	Minor	Update Org. Chart for TDH Lab
2/4/2020	Appendix B	Minor	Update Org Chart for DWR Monitoring Staff
2/4/2020	Table 42	Minor	Add Low pH bottles to general field equipment
2/6/2020	Table 2	Minor	Update Team Members
2/6/2020	Table B	Minor	Remove pH "Field" from regular criteria
2/11/2020	Table 1	Minor	Update names in QAPP distribution list
2/27/2020	Table 36	Minor	Update EPA to USEPA for analytical methods
2/27/2020	Table 36	Minor	Update EPA to USEPA for analytical methods

5/20/2020	Appendix A	Major	Added Lab Certification Requirements
8/12/2020	A1	Minor	Updated list of peer reviewer
8/12/2020	Table 5	Minor	Updated data source list
8/12/2020	Table 3	Minor	Updated Planning Roles
8/12/2020	A4.2.1.A	Minor	Updated Management Roles
8/12/2020	Throughout	Minor	Replaced logbook with logbook
8/12/2020	Throughout	Minor	Updated Personnel names and titles
8/12/2020	Throughout	Major	Updated Sampling Watershed Cycle
8/12/2020	Appendix D	Major	Updated Sampling Watershed Graph
8/12/2020	Throughout	Minor	Updated all document citations and dates
8/12/2020	A6.3	Major	Update budget numbers
8/12/2020	A5.2.6	Minor	Update TDEC employee numbers
8/12/2020	Appendix H	Major	Update Field Equipment
8/12/2020	Throughout	Major	Update document storage
8/12/2020	Throughout	Major	Replace ADB with ATTAINS
8/12/2020	Throughout	Major	Replace 303(d) list with EPA Approved Lists of Impaired and Threatened Water
8/12/2020	Throughout	Major	Replace 305b report to ATTAINS
8/12/2020	Throughout	Major	Replace WQDB to Waterlog
8/12/2020	References	Minor	Add CALM reference
8/12/2020	References	Minor	Add Nutrient Criteria Development Reference
8/12/2020	Table 5	Minor	Update Table 5 to include landfills

8/12/2020	Table 23	Major	Replace old fishing sites with FY 20-21 fishing sites
8/12/2020	Appendix H	Minor	Update Qualifier Codes
8/12/2020	Table 33	Minor	Deleted Table 33 and updated all other table numbers accordingly
8/28/2020	Throughout	Major	Added new Table 8. Shifting previous table 8-54 up to next number to new tables of 9-55

NOTICE OF REVISIONS 2021

Date	Section/Page	Revision Type	Revision Description
9/22/2020	1st Page	Minor	Add EPA signature line for future approvals
9/23/2020	Table 5	Minor	Clarified “Acceptance Criteria” to “Data Type”
9/23/2020	References	Minor	Added webpage link for each QSSOP
3/24/2021	Table 9	Minor	Added Chlorides to reference and ambient sites
4/27/2021	Appendix D	Major	Update MDL’s (TP MDL is higher than water quality criteria)
10/27/2021	Table 3	Minor	Personnel Changes
10/27/2021	Table 10	Minor	Personnel Changes
10/28/2021	Throughout	Minor	Update the number of sites to be visited this FY
10/29/2021	Throughout	Minor	Reformat and update control number
11/1/2021	Table 24	Major	Update Fishing sites

11/15/2021	Throughout	Major	Removed outdated TDH lab organic SOP's-to be updated with contract lab SOP reference
11/15/2021	Table 41	Major	Updated SQSH desired endpoint
11/15/2021	Table 4	Major	Added stakeholders
11/15/2021	A4	Major	Updated CHEFO performing E. coli analysis
11/15/2021	A6	Minor	Updated project budget
11/15/2021	Throughout	Minor	Replace Periphyton with Diatom
11/17/2021	Throughout	Minor	Update NPDES permits in state
11/17/2021	Throughout	Major	Update broken hyperlinks throughout document
11/18/2021	Appendix D	Major	Updated TP MDL to acceptable criteria-under review by TDH lab
11/19/2021	Throughout	Minor	Update Personnel names and titles
12/01/21	Table 9	Major	Update Mercury from optional to required for long term trend sites
12/8/21	Appendix B	Minor	Update TDH org chart
12/8/21	Throughout	Major	Update old organic SOP's with SOP's from contract lab
12/14/21	Table 16	Minor	Added TDEC ENV Consultant 3 & 4
12/14/21	Throughout	Minor	Changed "Conditions" to "Parameters"
12/14/21	Throughout	Minor	Change "minimum detection limit" to "Method detection limit"