STATE OF TENNESSEE
DEPARTMENT OF
ENVIRONMENT AND CONSERVATION
Division of Water Resources

Quality System
Standard Operating Procedure
for
MACROINVERTEBRATE STREAM SURVEYS

Control Number DWR-WP-P-01-QSSOP-Macroinvert-122821

Effective date: December 28, 2021*

*Taxonomic changes, SQSH and biorecon metrics and scoring revision were implemented August 2021.

This SOP is an intra-departmental document intended to govern the internal management of the Tennessee Department of Environment and Conservation and to meet requirements of the U.S. Environmental Protection Agency for a quality system. It is not intended to affect rights, privileges, or procedures available to the public.

DISCLAIMER: This document is policy only and does not create legal rights or obligations. It is intended to provide division staff guidance on how to apply decisions, procedures and practices pertaining to the internal operation or actions of the division. Decisions affecting the public, including the regulated community, in any particular case will be made applying applicable laws and regulations to the specific facts. Mention of trade names or commercial products does not constitute an endorsement or recommendation for use.

This revision has been reviewed and approved. It becomes effective on December 28, 2021.

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DIVISION OF WATER RESOURCES
QUALITY SYSTEMS STANDARD OPERATING PROCEDURES
FOR MACROINVERTEBRATE STREAM SURVEYS

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Document Revision History

(Detailed revision for each document can be found on page 11 and in Appendix G)

Revision Number	Date	Brief Summary of Change
7	12-01-2021	Taxonomic changes, recalibration of biometrics, electronic reporting updates, biorecon QC program updates.
6	08-11-2017	Taxonomic changes, biometric changes, updated field sheets, regional recalibrations, electronic reporting requirements.
5	07-01-2011	Decision making flowcharts, guidelines for headwater streams, updated field sheets, revised field sheets biometric changes, regional recalibrations.
4	10-01-2006	Taxonomic changes, biometric changes, updated field sheets, regional recalibrations.
3	11-01-2003	Clarified all protocols, added subsampling requirements.
2	03-01-2002	First use of regional biocriteria guidelines
1	1996	Incorporated EPA Rapid Bioassessment Protocols.
0	1992	Initial SOP

DIVISION OF WATER RESOURCES

QUALITY SYSTEM STANDARD OPERATING PROCEDURE FOR MACROINVERTEBRAE STREAM SURVEYS

TITLE AND APPROVAL PAGE

DOCUMENT TITLE	Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys
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PLAN COVERAGE	General instructions for macroinvertebrate surveys and habitat assessments of surface waters in Tennessee by the Division of Water Resources.

Concurrences and Review of QSSOP Project 2021

As a part of the 2021 review process, the following individuals reviewed and/or provided comments used in this document.

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REVISIONS AND ANNUAL REVIEW PROCEDURE: QSSOP FOR MACROINVERTEBRATE STREAM SURVEYS

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 TDEC–BOE 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 sent to all appropriate stakeholders. A report shall be made to the Deputy Commissioner and Quality Assurance Manager of any changes that occur. Other stakeholders shall be notified, as appropriate and documented on the "Document Distribution" list.

NOTICE OF REVISIONS RECORD 2021
(Records of Previous Revision are in Appendix G)

Date	Specific Section or Page	Revision Type	Revision Description
08-22-17	I.I Protocol G	Minor	Clarified wording in section c.1 for SQBANK sample collection.
07-01-18	Section II	Major	Updated SQSH lab QC duplicate protocols.
02-04-19	I.I Protocol F	Major	Updated biologist qualifications and electronic reporting for biorecons.
02-04-19	I.G	Major	Updated taxonomic expertise requirements.
02-04-19	Section II	Major	Implemented in-house biorecon QC program and taxonomic proficiency tests.
02-04-19	Section II	Major	Updated EFO Biological QC officer responsibilities.
07-01-21	Appendix B	Major	Updated electronic forms.
07-01-21	I.I Protocol C	Major	Clarified field parameter procedure and added protocol for pH in low conductivity.
07-01-21	I.I Protocols C-F	Major	Added and/or updated electronic reporting requirements.
07-01-21	Appendix C	Minor	Removed intolerant family list.
08-01-21	Appendix A	Major	Recalibrated Biorecon metrics and scoring.
08-01-21	Appendix A	Major	Recalibrate SQSH metrics and scoring.
08-01-21	Appendix C	Major	Revised taxonomic nomenclature and tolerance values Tennessee Taxa Table.
08-01-21	Appendix D	Major	Updated taxonomic keys and taxonomic experts.
08-01-21	I.I Protocol F and J	Major	Updated excluded taxa.
08-01-21	I.I Protocol J	Major	Updated biorecon metric data reduction and score calculation to be done electronically by Waterlog. Moved taxa scoring guidelines to Appendix A.
08-01-21	I.I Protocol K	Major	Updated SQSH metric data reduction to be done by Waterlog electronically. Updated description of modified NCBI scores.
11-01-21	Entire document	Minor	Updated staff and contact information

Date	Specific Section or Page	Revision Type	Revision Description
11-24-21	I.I Protocol A	Major	Added sampling period to decision making.
11-24-21	I.I Protocol J	Major	Updated data and records management to electronic format.
11-24-21	I.I Protocol L	Major	Updated report preparation to electronic format.
11-24-21	Appendix A	Minor	Updated ecoregion reference streams.
11-24-21	Appendix B	Minor	Added information to record of biologist credentials.
11-24-21	Appendix E	Minor	Added new project names and organizations. Updated invasive plant species information.
11-24-21	Appendix F	Minor	Updated SE Monitoring Network protocols.
11-24-21	Entire document	Minor	Updated formatting
11-24-21	I.I Protocol H	Minor	Added time frame for delivery of samples to lab.
11-24-21	I.I Protocol G	Minor	Added riffle habitat description
11-24-21	References	Minor	Updated references
11-24-21	Section I	Minor	Updated acronyms, health and safety warning, cautions, supplies, collection permits.
11-24-21	Section II	Minor	Clarified reference collection requirements.
12-08-21	Protocol E	Major	Added livestock access to channelization affects in habitat assessments.

EVALUATION PROCEDURE:
QSSOP FOR MACROINVERTEBRATE STREAM SURVEYS

As this document is used, needed changes or improvements will be apparent. Specific recommendations for improvements or changes are solicited as well as information concerning typographical or formatting errors.

Send specific recommendations for improvements or changes to:

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QSSOP DOCUMENT DISTRIBUTION LIST

Copies of this document were distributed to the following individuals in TDEC and TDH. The document is also available on the publication page of the division's website http://www.tn.gov/environment/article/wr-wq-water-quality-reports-publications and on SharePoint https://tennessee.sharepoint.com/sites/environment/DWR/PAS/SitePages/Home.aspx

Additional copies were distributed to non-TDEC agencies and individuals upon request (including other state and federal agencies, consultants, universities etc.). An updated distribution list is maintained in the Watershed Planning Unit.

The system for document distribution is described in TDEC-BOE Quality Management Plan, Chapters 5 and 10.

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PREFACE

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.2CFR1500.11; 40CFR35 www.epa.gov/quality. This includes the implementation of a Quality Management Plan as written by the contract holder with Data Quality Objectives (DQOs) set in Quality Assurance Project Plans (QAPPs) for specific projects. The organization may elect to support portions of the QAPP through technical or administrative standard operating procedures (SOPs), as specified by the quality system. As a contract holder and through memoranda of agreement, the Tennessee Department of Environment and Conservation is required to maintain such a system.

This Quality System Standard Operating Procedure (QSSOP) was prepared, reviewed, and distributed in accordance with TDEC's Quality Management Plan and other quality system documents in response to U.S. EPA's requirements for a Quality Management Program. QSSOPs are integral parts of successful quality systems as they provide staff with the information to perform a job properly and facilitate consistency in the quality and integrity of the process.

This QSSOP is specific to the Division of Water Resources, is intended to assist the division in maintaining their quality control and quality assurance processes and ensures compliance with government regulations. It provides specific operational direction for the division's Quality Assurance Project Plan for Macroinvertebrate Stream Surveys.

Although this QSSOP is compiled for TDEC-DWR employees and their contractors, it is recognized that outside agencies will utilize this QSSOP for their sampling purposes. Use of this QSSOP may be required in permits issued by DWR and is highly recommended to ensure consistency and accuracy of any data provided to DWR.

This document will be reviewed annually and revised as needed. Always use the most recent version.

I. PROCEDURES

I.A. Scope, Applicability and Regulatory Requirements

The purpose of this Quality Systems Standard Operating Procedure (QSSOP) is to support the Quality Assurance Program. The document provides a consolidated reference document for use in training and orientation of employees. This guide will also be a reference tool for more experienced employees. It establishes an approach that can be recommended to sister agencies that monitor Tennessee water or stipulated to members of the regulated community given monitoring requirements in receiving streams. This SOP describes the macroinvertebrate stream survey process and will delineate all steps in the process, including habitat assessments, field collections, sample analysis, data reduction and reporting. This SOP is only intended to describe routine conditions encountered during a macroinvertebrate stream survey.

The purpose of this SOP is not to supersede professional judgment, but rather is intended to ensure that appropriate sampling methods and quality assurance procedures are employed. Discuss any deviations from the protocols outlined in this SOP with the in-house EFO QC officer for biological sampling or the central office QC coordinator. Document any departure from this protocol.

Federal Statutory Authority

Federal Water Pollution Control Act (amended through P.L. 106-308, October 13,2000) as Amended by the Clean Water Act of 1977 enacted by Public Law 92-500, October 18, 1972, 86 Stat. 816; 33 U.S.C. 1251 et. seq.
Title III, Sec. 302: Water Quality Related Effluent Limitations
Title III, Sec. 303: Water Quality Standards and Implementation Plans
Title III, Sec. 304: Information and Guidelines
Title III, Sec. 305: Water Quality Inventory

Tennessee Statutory Authority

Tennessee Water Quality Control Act of 1977 (Acts 1971, ch. 164, § 1; 1977 ch. 366, § 1; T.C.A., § 69-3-101, et seq.).

Tennessee Regulatory Authority

General Water Quality Criteria and the Antidegradation Statement: Rule 0400-40-03 Use Classifications for Surface Waters: Rule 0400-40-04

I.B. Method Summary

This document describes procedures for performing two types of macroinvertebrate surveys approved by the Division of Water Resources for assessing biological integrity of streams. The entire procedure is described including protocols for sample collection, habitat assessment, sample analysis, data reduction and reporting.

Macroinvertebrates are used by the Division as indicator organisms to determine if a stream supports fish and aquatic life. Two types of surveys (biorecons and semi-quantitative single habitat) are used depending on the purpose of the survey.

Biorecons (BR) will be used as a screening or reconnaissance tool to provide a quick evaluation of the relative health of the biological community. The biorecon will be used primarily for general watershed assessments and for determining where more intensive monitoring is needed. This method is not comparable to biocriteria referenced in the Water Quality Standards.

Semi-quantitative single habitat surveys (SQKICK or SQBANK) will be conducted whenever a more defensible and/or definable assessment is needed. This method is directly comparable to biocriteria referenced in the Water Quality Standards. The semi-quantitative biological survey is also preferred in situations where the use attainment status of a stream is not obvious from the results of a biorecon. Antidegradation Policy evaluations, enforcement actions and TMDL studies are additional examples of occasions when biorecons provide inadequate amounts of information and a semi-quantitative sample would be preferable. This method should be used by any outside agency or private organization submitting biological data to the Division for review. The semi-quantitative method is required for any individual conducting macroinvertebrate surveys for permit compliance or mitigation

Habitat assessments (high gradient and low gradient) are also described in this document. Habitat assessments are to be conducted in conjunction with all types of biological surveys since habitat is often a limiting factor to the complexity of the benthic community. By following this assessment procedure, habitat can either be confirmed or eliminated as a cause of stress to the macroinvertebrate community.

Macroinvertebrate Survey Quick Field Reference

(Minimum tasks to be completed at all biological sampling sites)

1. Before leaving the office, contact TWRA regional office via email to inform them of sample locations. TWRA sampling permit must be carried at all times.

2. Upon arrival at site, record lat/long in decimal degrees, verify that sample location is correct.

3. Establish minimum 100-yard reach area (walk bank without disturbing stream).

4. Take field measurements near middle of reach area (minimum DO, temp, pH and conductivity). Record on stream survey field sheet.

5. Collect chemicals (if needed) upstream of area disturbed during field measurements.

6. Collect macroinvertebrate sample (biorecon or SQSH).

7. If biorecon collected and score is ambiguous, collect SQSH if assessment cannot be made based on field observations or other information (see flow chart).

8. Collect diatom samples if required.

9. Measure flow if SEMN site.

10. Measure canopy midstream in middle of riffle where macroinvertebrates are collected or in middle of stream reach if collecting SQBANK or multiple riffles. Estimate average canopy of entire reach. If diatoms are collected at same time, measure midstream at 5 transects instead.

11. Complete Bioform (event, stream survey sheet, habitat assessment sheet (and biorecon if collected).

12. Take pictures of upstream/downstream sample reach, any habitat problems, unusual observations and potential pollution sources. (This can be done any time during survey, but additional pictures should be taken after survey is complete if significant disturbance is noted such as pipes, severe erosion, livestock in creek etc.)

I.C. Definitions and Acronyms

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

Biocriteria: Numerical values or narrative expressions that describe the reference biological condition of aquatic communities inhabiting waters of a given designated aquatic life use. Biocriteria are benchmarks for water resources evaluation and management decisions.

Bioform: Electronic reporting workbook used by DWR and TDH staff for reporting field and biorecon data collected during macroinvertebrate stream surveys.

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

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

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 31 (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.

E-Forms: Electronic field and taxonomic reporting forms, including Bioform (DWR and TDH staff only), Field Survey and Habitat Sheets and Macroinvertebrate taxa report (SQSH)

Habitat: The instream and riparian features that influence the structure and function of the aquatic community in a stream.

Headwater stream: Streams with less than or equal to a 2.5 square mile drainage area.

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).

Productive Habitats: Provide niche for colonization by macroinvertebrate or fish.

Reference database: Biological and chemical data from ecoregion reference sites.

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

Stream Order: Strahler order as determined using 7.5 series topographic maps.

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

Waterlog/Hydra: DWR Database for water chemistry, bacteriological, fish tissue, macroinvertebrate, diatom, habitat and stream survey data. Currently in transition from Waterlog to Hydra for these data. All other information including field meter maintenance logs will remain in Waterlog.

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Acronyms

ABS	Aquatic Biology Section
ADB	Assessment Database
BR	Biorecon
BOE	Bureau of Environment
BSERT	Biological Survey Electronic Reporting Tutorial
CADDIS	Causal Analysis/Diagnosis Decision Information System
CALM	Consolidate Assessment and Listing Methodology
Cfs	Cubic feet per second
CHEUM	*Cheumatopsyche* spp.
CHEFO	Chattanooga Environmental Field Office
CKEFO	Cookeville Environmental Field Office
CLEFO	Columbia Environmental Field Office
CMERG	Continuous Monitoring Electronic Guidance
CO	Central Office
COC	Chain of Custody
CRMOL	Crustacea and Mollusca
DO	Dissolved Oxygen
DOR	Division of Remediation
D/S	Downstream
DWR	Division of Water Resources
EDAS	Ecological Data Application System
EDD	Electronic Data Deliverable
ECO	Ecoregion Reference Stream
EFO	Environmental Field Office
EPA	U.S. Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, Trichoptera
EPT-Cheum	EPT abundance excluding *Cheumatopsyche* spp.
ES	Environmental Scientist
ETO	Ephemeroptera, Plecoptera, Odonata
ETW	Exceptional Tennessee Waters
FECO	Headwater Reference Stream
FWS	Society for Fresh Water Sciences
GIS	Geographic Information System
GPS	Global Positioning System
HW	Headwater
HUC	Hydrological Unit Code
IT	Intolerant Taxa
JCEFO	Johnson City Environmental Field Office
JEFO	Jackson Environmental Field Office
KEFO	Knoxville Environmental Field Office
LDB	Left Descending Bank
LDO	Luminescent Dissolved Oxygen

LS	Lab Services
MC	Mid Channel
MEFO	Memphis Environmental Field Office
MS	Mining Section
NEFO	Nashville Environmental Field Office
NCBI	North Carolina Biotic Index (modified)
OC	Oligochaeta and Chironomidae
PFD	Personnel Flotation Device
QA/ QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
QSSOP	Quality System Standard Operating Procedure
RDB	Right Descending Bank
RM	River Mile
SDS	Safety Data Sheet (previously MSDS)
SFS	Society for Freshwater Scientists
SEMN	Southeast Monitoring Network
SOP	Standard Operating Procedure (synonymous with QSSOP)
SPERT	Stream Parameter Reporting Tutorial
SQBANK	Semi-Quantitative Bank Sample
SQKICK	Semi-Quantitative Kick Sample
SQSH	Semi-Quantitative Single Habitat Sample
TDEC	Tennessee Department of Environment and Conservation
TDH	Tennessee Department of Health
T&E	Threatened and Endangered
TMI	Tennessee Macroinvertebrate Index
TMDL	Total Maximum Daily Loading
TNUTOL	Tennessee Nutrient Tolerant Organisms
TOPO	Topographic Map
TR	Taxa Richness
TWRA	Tennessee Wildlife Resources Agency
U/S	Upstream
USGS	United States Geological Survey
WPU*	Watershed Planning Unit

*Note , in this QSSOP, when directed to send forms or contact WPU for information, contact the staff QC biologists Debbie Arnwine Debbie.arnwine@tn.gov 615-532-0703 or Kim Laster Kim.Laster@tn.gov 615-770-1805 at the time of publication. (Contact unit manager at 615-262-0997 to be redirected if current biological QC staff are no longer employed by the unit.)

I.D Health and Safety Warnings

(Adopted from Klemm et al., 1990)

1. Employee safety is the most important principle when collecting samples. If conditions are not safe; reschedule sampling for another date and time.

2. Do not enter water during flood conditions.

3. Know how to swim and/or use a PFD when entering the water.

4. Always wear waders with a belt to prevent them from filling with water in case of a fall (do not wear in a boat or canoe). In high velocity and high flow streams it is advisable to wear a PFD, it is required in a boat. Do not enter water if conditions are unsafe

5. Always secure equipment such as meters when working from a boat or canoe.

6. Follow Tennessee boating laws and regulations. Information is available through the Tennessee Wildlife Resources Agency. PFD are required when operating a boat. Staff born after January 1, 1989 must have a Tennessee Boater Education Certificate issued by TWRA. Annual boat safety training is recommended.

7. Be vigilant, especially in turbid streams, to avoid broken glass, beaver traps or other hazardous objects that may lie out of sight on the stream bottom. Heavy wading boots should be worn in these situations.

8. Keep first aid supplies in the office, lab and field at all times. Training in basic first aid and cardio-pulmonary resuscitation is strongly recommended. Check any expiration dates and replenish first aid kit supplies yearly or more frequently if needed.

9. Any person allergic to bee stings or other insect bites should carry needed medications and instruct team mates on how to use in the event of an allergic reaction.

10. Always perform lab work involving ethanol or CMC-10 in a room containing a properly installed and operating hood.

11. Carry cell phone in the field in case of emergency.

12. Keep a file in the office that contains emergency contacts and physician's name for each employee. Carry a list of emergency contact numbers for the sample area. Know the location of hospitals and law enforcement stations in the area.

13. Consider all surface waters potential health hazards due to toxic substances or pathogens and minimize exposure as much as possible. Do not eat, drink, smoke, apply cosmetics or handle contact lenses while collecting samples. Avoid splashing face and clean exposed body parts

(face, hands and arms) immediately after contact with these waters. Carry soap and an adequate supply of clean water, disinfectant wipes and/or waterless sanitizer for this purpose.

14. If working in water known or suspected to contain human wastes, get immunized against tetanus, hepatitis, typhoid fever and polio.

15. Try to avoid working alone in the field. Make sure the supervisor or their designee knows where you are and when you are expected to return. Check in periodically.

16. Safety Data Sheets (SDS) [previously Material Safety Data Sheets (MSDS)] for ethanol and CMC-10 (if mounting slides) are to be kept in the lab or office. Everyone working with these agents should be familiar with the location and content of the SDS sheets. Ethanol must be stored in fire-proof cabinet and disposed of as a hazardous waste.

17. When traveling in a vehicle always wear a seat belt and follow all Tennessee Department of Safety and Motor Vehicle Management rules. Do not text and drive. Do not use visual navigation aids (maps or electronic) while operating a vehicle.

18. In the event of a life-threatening emergency, go the nearest hospital. Call for emergency assistance if moving the injured person is likely to inflict further injury. If a non-life-threatening injury occurs on the job, seek medical assistance from the authorized state worker's compensation network. A current list of providers may be found on the State Treasurer's homepage under Workers Compensation Provider Directory at www.treasury.tn.gov. Always complete and file an accident report if medical assistance is provided for a work-related injury. https://www.tn.gov/workforce/injuries-at-work/employers/employers/reporting-a-claim.html

21. Be aware of potentially volatile situations. When entering or crossing private property, try to obtain permission from the landowner beforehand in order to avoid confrontation. Have business cards available to leave at residences when appropriate. If approached by someone representing law enforcement, show them a state I.D. and ask to see their I.D. or badge. The Tennessee Highway Patrol can be reached by dialing *THP (*847) from a mobile phone. The phone numbers for the THP district headquarters are listed below.

Knoxville:	(865) 594-5800	Chattanooga:	(423) 634-6898
Nashville:	(615) 741-2060	Memphis:	(901) 543-6256
Fall Branch:	(423) 348-6144	Cookeville:	(931) 528-8496
Lawrenceburg:	(931) 766-1425	Jackson:	(731) 423-6630

I.E Cautions

1. Avoid cross contamination of samples. Thoroughly rinse all buckets, nets and sieves and inspect for clinging organisms before leaving the sample site. Inspect equipment again immediately before sampling the next site. Thoroughly rinse bottles and inspect before re-use.

2. Avoid sampling bias by following these procedures exactly. Document any deviation.

3. Take care not to over-sample, especially on biorecons. Sample only 4 habitats as defined in Protocol F. Only retain representative taxa for vouchers. Take care not to under sample (less than 160 organisms) on SQSH samples. Collect additional kicks (or banks) if needed to achieve minimal sample size.

4. Make sure sample site meets ecoregion, drainage area and sample method requirements before comparing to semi-quantitative or biorecon guidelines. Biocriteria metrics used to calculate the TMI can only be applied to SQKICK or SQBANK samples with a 160-240 subsample identified to genus level. Never calculate quantitative metrics or apply biocriteria to biorecons, samples outside the target count or species level identifications.

5. Use the standardized station ID naming protocol for all samples. Check the DWR assessment map and/or stations table in Waterlog/Hydra to make sure a station has not already been established with a different station ID. Notify WPU of any discrepancies. Make sure the station ID is included on all paperwork associated with the sample.

6. Measure river mile from mouth to headwaters. When measuring embayments, start measuring from confluence with the original channel of the main stem. Use GIS, TDEC on-line assessment map https://tdeconline.tn.gov/dwr/ or USGS Streamstats https://streamstats.usgs.gov/ss/ at the 1:2400 (7.5 minute) scale to measure stream miles. When using GIS use the ArcView measuring tool. Do not use the Reach File Index or the NHD flowline layer which measures in straight lines.

7. Use the USGS stream stats site (see # 6 for link) to calculate drainage area.

8. To avoid errors, calibrate all meters following Protocol C. Ideally all meters should be calibrated daily. Dissolved oxygen must be calibrated daily. Minimally temperature, conductivity and pH must be calibrated once a week; more often if questionable readings are encountered, perform a drift check at the end of each day (or on return if overnight travel is required). If the meter calibration is off by more than 0.2 units for pH, temperature or D.O. when measured in mg/L or by more than 10% for conductivity or D.O when measured in % saturation do not report/upload readings for that parameter from any site collected since the last calibration. Make a note under meter problems on stream survey sheet and/or field parameter data forms.

9. Express all time on a 24-hour (military) clock format without colon.

10. Write all dates in mm/dd/yyyy format.

11. Express all distance measurements in English measurements (inches/feet/yard/miles).

12. Make sure to use appropriate units for all field measurements as indicated protocol C (field parameters) and E (stream survey sheet).

13. Use GPS to confirm location at site. Record latitude and longitude in decimal degrees.

14. If an error is made in any written or printed documentation (COC/sample request), draw a single line through the error, so that it is readable and write the correction above. Date and initial the correction.

15. When possible, chemical and semi-quantitative (SQSH) macroinvertebrate samples should be collected on the same day (required for CADDIS analysis). If this is not possible, chemical and biological samples should not be separated by more than 4 weeks.

16. Make sure drainage area, sample method and ecoregion drainage are appropriate for comparison to biorecon guidelines or SQSH biocriteria.

17. Take care that additional stream information recorded on the stream survey field sheet (or data form) does not contradict information provided on the habitat field sheet (or data form). This is especially important for sediment and riparian information.

18. Document any deviations to protocol on the stream survey form (sampling) and/or invert taxa sheet (taxonomy).

19. Do not collect sample if flow is reduced to isolated pools, flooded or stagnant (including impounded by beavers or bridge obstruction). Wait a minimum of 30 days after water returns to normal flow..

20. Check Waterlog/Hydra stations table before assigning station names to make sure a name has not already been assigned to the site by another sampling team or agency. Check station Ids to verify names follow logical progression from downstream to upstream. Upload new stations to Waterlog/Hydra,

I.F. Interferences

1. Document all deviations from protocol.

2. Semi-quantitative bank samples collected in 65j, 66d, 66e, 66f, 66g, 68a, 68b, 68c, 69d, 71e, 71f, 71g, 71h, and 74a cannot be compared to biocriteria. If sampling in a non-riffle stream in these regions, an upstream or offsite reference must be collected.

3. Semi-quantitative kick samples collected in 65a, 65b, 65e, 65i, 73a and 74b cannot be compared to biocriteria. An upstream or offsite reference must be collected.

4. Additional samples (of the same habitat) should be collected if needed to ensure 200 organisms were found in the semi-quantitative sample collection (document number of samples collected).

5. Avoid sampling in flooded conditions or immediately after a flood.

6. Do not sample if stream is reduced to isolated pools. Only sample if there has been flow for longer than 30 days. Only compare to biocriteria or biorecon guidelines for regions where reference streams routinely went dry (68b, 68c, 69d, and 71i).

7. Do not sample if water is stagnant (backed up by log jams, beavers etc.).

8. To avoid errors, calibrate all meters following Protocol C. (Ideally all meters should be calibrated daily but minimally must follow schedule in Protocol C). Dissolved oxygen must be calibrated daily. Minimally temperature, conductivity and pH must be calibrated once a week, more often if questionable readings are encountered. Perform a drift check at the end of each day (or on return if overnight travel is required). If the meter calibration is off by more than 0.2 units for pH, temperature or D.O. when measured in mg/L or by more than 10% for conductivity or D.O when measured in % saturation do not report readings for that parameter from any site collected since the last calibration. Note under meter problems on stream survey sheet and/or field parameter data forms.

9. Organisms that are not included on the Tennessee taxa list (Appendix C) (or on macroinvertebrate master taxa table in Waterlog/Hydra) must be sent to the state lab for verification and inclusion in the statewide reference collection. After in-house confirmation, the state lab will send any new taxon to a qualified expert for verification (Appendix D).

10. 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.

11. Do not retain threatened and endangered species. Document occurrence and release. Samplers should check data view for records and be able to field ID potential T&E species in sample reach.

I.G. Personnel Qualifications and Training

At least one biologist on a sampling team must meet the following requirements. Trained staff with some coursework in biology and/or specific training and experience may assist in collections.

Minimum Education Requirements: B.S. in a biological science. Coursework in stream ecology and macroinvertebrate taxonomy is desirable. Advanced degree in stream ecology, aquatic biology or similar field is preferable.

Professional credentials must be submitted to WPU and maintained on file in SharePoint: https://tennessee.sharepoint.com/sites/environment/DWR/PAS/SitePages/Home.aspx and at the local office. Credentials must include Name, Education (school and degree), specific experience and publications related to macroinvertebrate stream surveys and taxonomy including any certifications. See form Appendix B.

(QC requirements are described in Section II)

Biorecon Field collections (Not for use by non-DWR/TDH biologists)

Must shadow an experienced biologist for a minimum of one year and successfully pass 10 biorecon field duplicates. Specific classwork involving biological stream surveys and macroinvertebrate taxonomy can be substituted for experience, but not QC requirements. Before biorecon training and QC is completed, biologists may collect SQSH samples.

SQSH Field Collections

Must demonstrate knowledge of stream types including hydrology and macroinvertebrate habitat for various stream classes in each bioregion in collection area. Must pass 2 SQSH Field Duplicates.

Taxonomic Expertise:

Biorecon

Must be proficient in identification at target level (family or genus excluding chironomids or oligochaetes). Proficiency is demonstrated by successfully completing DWR macroinvertebrate taxonomic exam (to be repeated if a new primary key is adopted). The exam will be administered by the Natural Resource Fellow or their designee. Contact Jonathon.Burr@tn.gov or WPU QC biologists to schedule exam. Details are provided in Section II. In lieu of DWR exam, proficiency may be demonstrated by successfully completing the Society of Freshwater Science taxonomic certification tests (genus level, immatures/nymphs/larvae) for Group 1 Crustacea and arthropods other than EPT) and Group 2 (EPT) if funding is available

SQSH (Semi-Quantitative Single Habitat)

- Must be proficient in identification at genus level including chironomids and oligochaetes. Proficiency is demonstrated by passing a minimum of 10 SQSH samples that have been identified by a second taxonomist who has already passed QC requirements. (May be reduced to 2 samples if taxonomist meets 1 or more requirements as taxonomic expert in appendix D).
- Experience in southeast U.S. taxa preferable.
- Society for Fresh Water Science (FWS) or equivalent taxonomic certification in Non-EPT, EPT and Chironomids at the genus level for at least one taxonomist in the laboratory.
- Must show proficiency in sorting (see protocol I) by passing a minimum of 10 samples.

Additional expertise:

- Computation of basic statistics
- Proficiency in use of electronic forms including field devices,
- Use of standard water quality monitoring meters,
- Habitat evaluations
- Familiarity with TN Water Quality Standards
- Stream ecology in Tennessee

Training:

- Protocols outlined in this SOP
- Macroinvertebrate taxonomy
- Macroinvertebrate Sample Collections
- Habitat Assessments
- Physical-Chemical Field Parameters
- Electronic data recording, transmittal and retrieval Quality System Requirements
- Quality Assurance Project Plan for 106 monitoring

Additional requirements for non-DWR/TDH staff.

- Must successfully complete at least one sample collection in accordance with TDEC QSSOP in the presence of a DWR/TDH biologist.
- Must submit and pass QC requirements on one sample submitted to state laboratory for sorting efficiency and taxonomic verification (at permittee's expense). Once QC is passed, internal QC is acceptable.
- Biorecons are not accepted from non-DWR staff for TDEC assessment or regulatory purposes.

I.H. Equipment and Supplies

Prior to any sampling trip, gather and inspect all necessary gear. Replace or repair any damaged equipment. Calibrate DO the morning of the sampling trip and make sure all other meters have been calibrated within the week (daily preferable) and have drift check since the last use. Upon return from a trip, do a drift check on all meters, take care of any equipment repairs or replacements immediately. Necessary equipment will vary per project, but the following is a standardized list.

Field Equipment

- TWRA collection permit
- Natural Area collection permit if collecting in state park/natural area.
- National Park Permit if collecting in National Park
- State ID and business cards
- Waders
- Forceps
- Ethanol
- External sample tags
- Internal sample tags
- Toughbook with biological forms loaded
  - Habitat Assessment Field Sheet (High gradient and/or Low gradient
  - Stream Survey Field Sheet
  - Biorecon Field Sheet (Biorecons only)
- Biological Analysis Request Form (for Chain of Custody and/or samples sent to lab)
- 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 (air calibration on site or at EFO)
- Calibrated pH meter
- Calibrated conductivity meter
- Calibrated temperature meter or thermometer in ºC
- 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 (modified 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)
- Cell phone

Optional Equipment

- USGS maps/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 or Toughbook with survey BioForm.
- Transfer pipette (or equivalent suction device)

Additional equipment needed for SQSH (state lab or consultant)

- Microscope slides and coverslips
- Gridded Tray with subsampling insert
- Small Gridded dish (36 grids)
- CMC-10 or equivalent permanent mounting media
- Random number jar
- Turkey baster (or equivalent suction device)
- Slide storage box

Sample Container and Ethanol Acquisition

Sample containers and ethanol for DWR staff are obtained through the Tennessee Department of Health Environmental Laboratory, Aquatic Section in Nashville Contact Carrie.Perry@tn.gov 615-262-6330.Supplies must be requested at least 30 days in advance. Please specify the amount of the item needed.

Item

- SQSH Jar 1/2 gal
- 1 oz wide-mouth bottle (Biorecon collection)
- Alcohol Ethyl

Collection Permits

TWRA (Tennessee Wildlife Resources)

All individuals collecting macroinvertebrate samples must obtain a collection permit from TWRA which is renewed annually. Permit must be carried at all time when collecting. TWRA regional dispatcher must be contacted by email before sampling. If going to an unscheduled location, email TWRA dispatcher while in field or immediately upon return.

DWR and TDH biological staff are under one permit. Please contact Debbie Arnwine, 615-532-0703 Debbie.Arnwine@tn.gov to be added to permit.

Others can apply for a collection permit at https://www.tn.gov/twra/law-enforcement/permits.html. Contact Rusty Boles with TWRA at 615-934-7505 or Rusty.boles@tn.gov. for additional information.

TWRA CONTACTS FOR DISPATCH NOTIFICATION

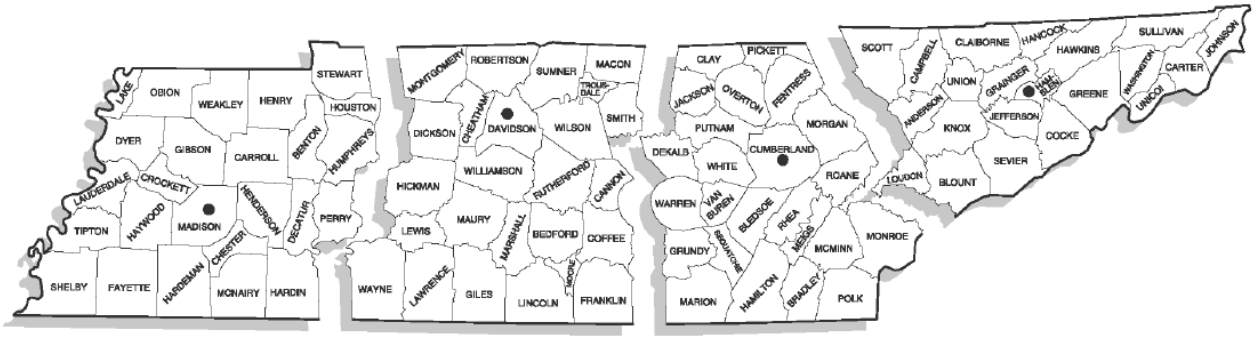
IT IS REQUIRED THAT YOU NOTIFY TWRA PRIOR TO COLLECTING IN THE FIELD.

FAILURE TO REPORT MAY RESULT IN LOSS OF PERMIT.

If you are unable to contact the regional dispatchers via the numbers listed below, you may send an e-mail to satisfy the reporting requirement. Your et mail should contain the following information: Permit Number, Name of Permit Holder, Date of collection, Location of Collection (name of body of water, cave, wma, mile marker, ect), Collection Methods/equipment, and names of personnel that will be in the field collecting specimens. If you have a change, you must notify the region of the change.

You may reach the dispatchers by using the following e-mail addresses:

Region I: twra.dispatchregion1@tn.gov
Region II: twra.dispatchregion2@tn.gov
Region III: twra.dispatchregion3@tn.gov
Region IV: twra.dispatchregion4@tn.gov



Region I	Region II	Region III	Region IV
Jackson, TN	Nashville, TN	Crossville, TN	Morristown, TN
1-800-372-3928	1-800-624-7406	1-800-262-6704	1-800-332-0900
731-423-5725	615-781-6622	931-484-9571	423-587-7037

Figure 1: TWRA Regional Dispatch Contact Information

State Park/Natural Area Collection

An additional collection permit must be obtained when sampling in state parks or natural areas. DWR staff are included under one permit which is renewed annually.

All others will need to submit an application to the TDEC Division of Natural Areas https://www.tn.gov/environment/permit-permits/permit-natural-resources/tennessee-state-parks-scientific-research-and-collecting-permit.html

National Park Collection

A National Park permit will need to be obtained when sampling on National Park Lands. https://www.nps.gov/nature/request-a-permit.htm

I.I. Procedures

Protocol A – Selection of Survey Type, Station Location and Sample Period

1. Determine biological sampling needs.

   The central office will coordinate biological sampling needs with the environmental field offices. The location and type of scheduled biological assessments will be included in the annual water quality monitoring workplan. Additional biological assessments may be conducted as needed.

   Biological sampling will generally follow the watershed cycle. When developing the monitoring workplan within the targeted watershed, macroinvertebrate samples should be collected with the following priority

   a. Antidegradation Monitoring

      - If the waterbody does not have SQSH data from the last five years and there is a possibility that the stream has exceptional biology a SQSH should be collected to determine ETW status.
      - If this is a new or expanded permit on a segment that is not currently assessed, a SQSH should be conducted so it can be determined whether a stream meets biocriteria guidelines. Note this will not be considered an assessment of use-support until the 305(b)/303(d) review.

   b. Southeast Monitoring Network Sites (SEMN)

      Established SEMN sites are monitored for macroinvertebrates (SQSH and individual habitats following SEMN protocols) in spring (April) and fall (September) of each monitoring year (Appendix F). A biorecon is also collected in spring and fall during the watershed cycle. (Diatoms are collected once during the growing season, see Diatom QSSOP).

   c. Ecoregion Reference Streams

      Established ecoregion or headwater reference stations are monitored according to the watershed approach schedule. 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. If field conditions indicate an established reference site may have been compromised, contact the WPU unit.

d. Sites on the 303(d) list for Fish and Aquatic Life

Macroinvertebrate should be collected for impaired sites listed for physical alteration in streamside or littoral vegetation, siltation, metals, abandoned mining, nutrients (SQSH only). Follow flow chart 3 to determine whether a biorecon or SQSH is needed.

e. Sampling upstream and downstream of Major Dischargers and CAFO's:

During each monitoring cycle, the major dischargers are identified. Stations are established at those waterbodies if the facility does not currently have in-stream monitoring requirements built into their permit or if a QC check is needed. 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.) 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.

Location of point source discharges can be found on the water quality assessments data viewer. http://tdeconline.tn.gov/dwr/. Permit requirements can be accessed through Waterlog. To download a spreadsheet by watershed go to the WPC reports, permits by watershed cycle, interactive format.

f. TMDL: 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.

g. 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.

h. 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:

i. 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).

ii. 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, dredging, stream relocations, impoundments, road construction, golf courses or a dramatic increase in impervious surfaces.

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

iv. Sites where the last biological sample was ambiguous (collect SQSH at these).

v. 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. The Natural Resource Unit can provide information on planned activities.

2. Determine Sample Type Needed

The type of macroinvertebrate sample will be determined based on the type of assessment needed. (Figures 2-5). Biorecons will typically be used for routine watershed assessments and screening while SQSH will be used when a more defensible assessment is needed and for clarification of ambiguous biorecons if additional information is needed to make an assessment. It can also be used to confirm passing biorecons where score does not, in the opinion of the biologist, reflect true stream conditions. (For example, richness is high but abundance of intolerant taxa appears low).

Genus level biorecons are more sensitive but require more time and taxonomic expertise. Often family level biorecons are adequate screening tools especially when biological community is obviously diverse or highly stressed. If more sensitivity is needed, a semi-quantitative sample may be more useful than a genus level biorecon especially if richness is high, but abundance is low.

There are occasions when a biorecon will be preferred:

i. Streams in middle and east TN where good quality riffles are naturally not available. (For example, bedrock dominant without seams, boulder step-pool, lower gradient where SQBANK guidelines are not developed and non-wadeable streams). Judgement should be used to determine if the targeted habitat would be the most

productive in the absence of human disturbance. If not, a biorecon should be conducted instead of a SQSH.

ii. Sediment dominated streams where the riffle is the cleanest substrate due to fast flow and may represent refugia. (Conversely if a riffle is inundated by sediment to where it is no longer a high quality riffle it should be sampled using a SQKICK.)

iii. Streams that are obviously impaired with extremely limited habitat (a score of 3 or 5 would be expected on the biorecon).

iv. Streams with a history of good SQSH scores (36 or higher) where no change is expected where land use is unchanged and protected.

Note that if collecting nutrients and habitat is not available for a SQSH, a diatom sample must be collected in addition to a biorecon to determine a biological response.

Figures 2-5 provide guidelines for determining what type of biological sample is most appropriate. Note that SQSH is required when nutrients are collected.

- Ecoregion reference sites (ECO and FECO) – Biorecon and SQSH (Figure 2).
- NPDES permit actions, enforcement, nutrient TMDL, Pre/post BMP, Pre/post ARAP, potential ETW, CADDIS – SQSH (Figure 3).
- Impaired Waters List – SQSH or Biorecon (Figure 4).
- Watershed Assessment – SQSH or Biorecon (Figure 5).

Biological Sample Decision Making Flowcharts

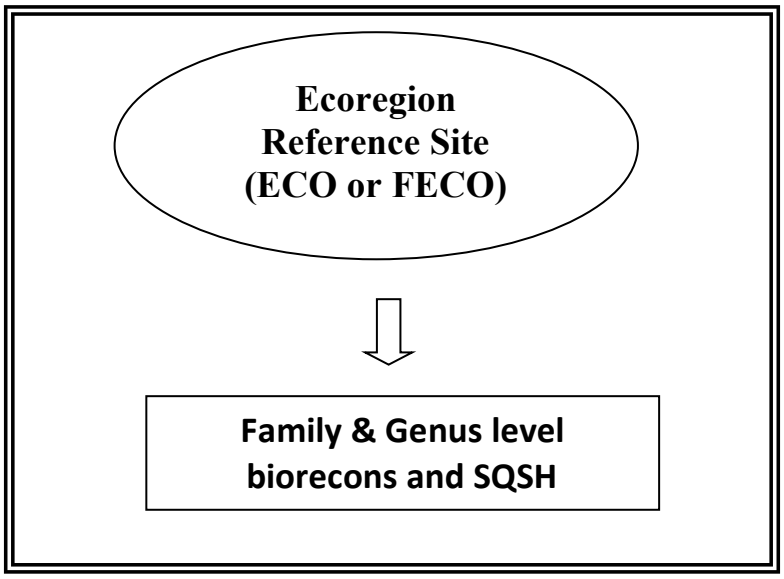


Figure 2: Biological Sample Decision Making Chart for Ecoregion Reference Sites.

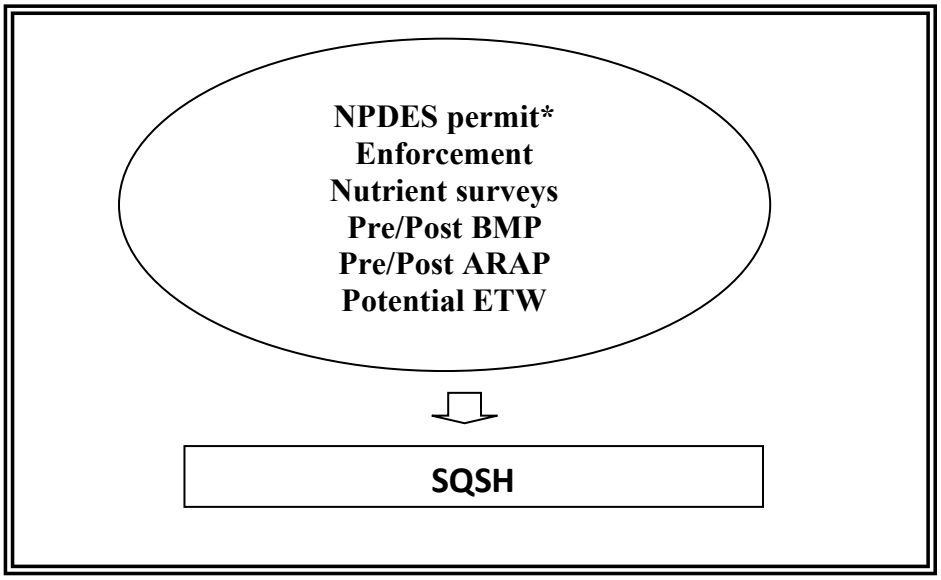


Figure 3: Biological Sample Decision Making Chart for NPDES, Enforcement, Nutrient, BMP, ARAP, and Potential ETW Sites. * Also, do SQSH for new or expanded permit action that is not currently assessed.

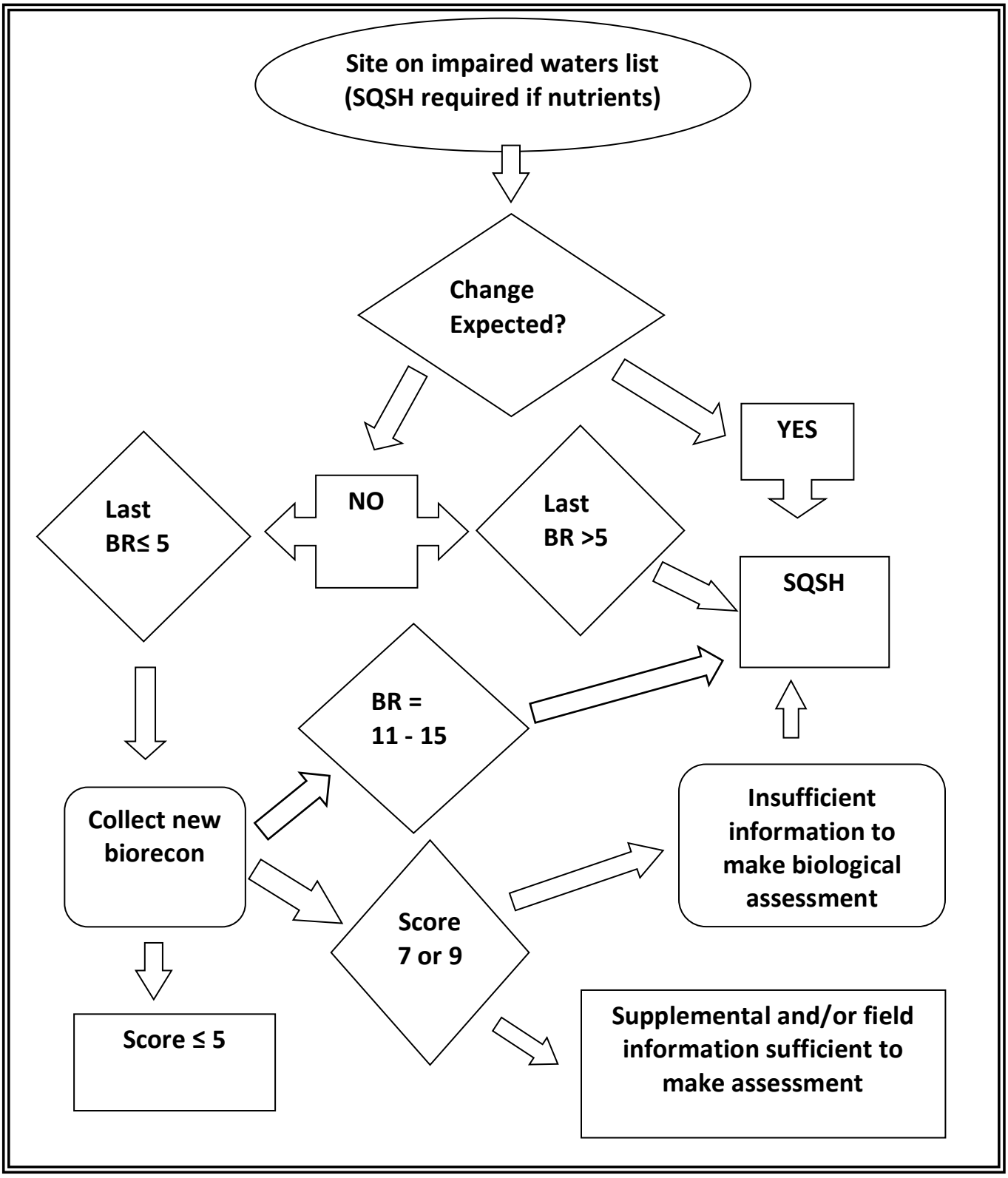


Figure 4: Biological Sample Decision Making Chart for sites on the impaired waters list.

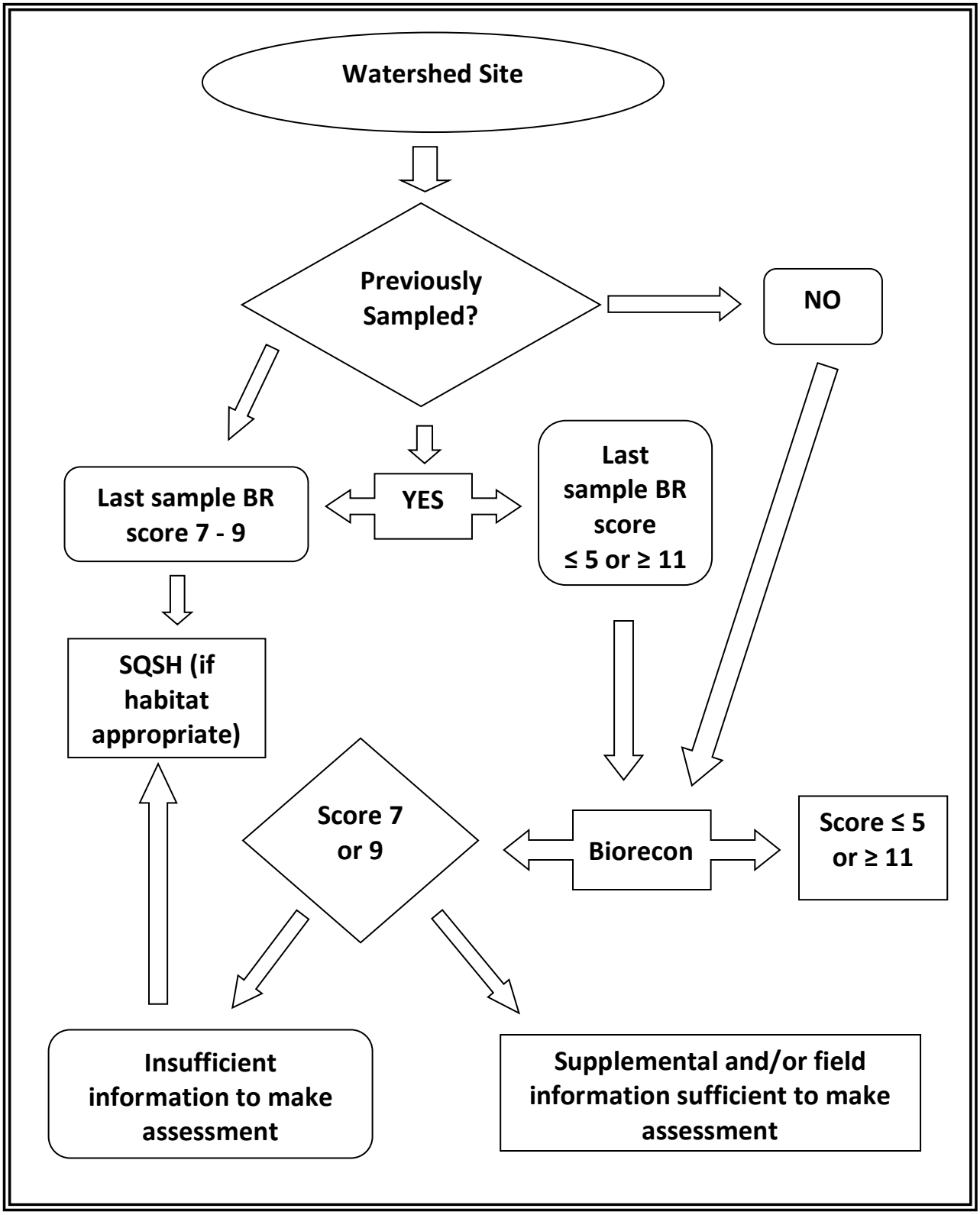


Figure 5: Biological Sample Decision Making Chart for Watershed Sites

3. Determine Sampling Period

Selecting the appropriate season to collect biological samples is critical. Sampling can be conducted year-round but should be planned based on stream size, topography and purpose of sampling.

a. Stream size: Small streams may go dry in low flow so sampling should be scheduled for late winter through spring. Very large streams may only be wadeable during low flow so should be sampled during summer/fall.

b. Topography: Streams in karst areas may be subsurface or reduced to isolated pools during low flow so should be sampled in late winter through spring.

c. Purpose of sampling: If sampling to determine the effects of human disturbance, the sample should be collected in the season the effects would be most severe. Generally, this is during low flow periods (summer through fall). However, spring may be the best time to catch run-off from some agricultural activities. If sampling is required as part of a permit, sampling should always coincide with permit requirements.

4. Select sites

Site selection is dependent on the study objectives. After determining the specific objectives of the study and clearly defining what information is needed, select sampling sites on specific reaches of the stream. Reconnaissance of the waterway is very important. Note possible sources of pollution, access points, substrate types, habitat, flow characteristics, and other physical characteristics that will need to be considered in selecting the sampling sites. Although the number and location of sampling stations will vary with each individual study, the following basic rules should be applied:

a. Determine whether an upstream or watershed reference site is needed or if the study site can be compared to biocriteria or biorecon guidelines derived from the ecoregion reference database. In order to compare to biocriteria, (SQSH) or biorecon guidelines: the watershed upstream of the test site must be at least 80% within the specified bioregion and be of the appropriate upstream drainage area. SQSH must be collected using the collection method designated for that bioregion (SQKICK or SQBANK).

Compare all appropriate semi-quantitative samples to biocriteria. Depending on study purposes or if the study stream does not meet requirements for the reference database, an upstream sample or an appropriate watershed reference may need to be collected. Instructions for comparing data to an alternate reference are provided in Protocol K.
Compare biorecons on streams whose upstream drainage is at least 80% within a bioregion to guidelines developed from the ecoregion reference database (Appendix A). If the test stream crosses multiple bioregions upstream of the test site, select an appropriate upstream or watershed reference. (An alternative is to compare the site to guidelines for each

appropriate bioregion, however if assessments differ another reference must be used). Instructions for comparing data to an alternate reference are provided in Protocol F.

b. For watershed screenings, locate sites near the mouth of each tributary. If impairment is observed, locate additional sites upstream of the impaired stream reach to try to define how far the impairment extends and locate potential sources.

c. For monitoring point source pollution, establish a station downstream of the source of pollution depending on type of discharge and stream size to capture the potential area of impact. If possible, establish stations at various distances downstream from the discharge. Space the collecting stations exponentially farther apart going downstream from the pollution source to determine the extent of the recovery zone.

   For nutrient and dissolved oxygen, the impaired area (sag) may be far downstream of the source. If determining the effect of potential toxins, stations should be located closer to the discharge point. For intermittent discharges, sampling should be within thirty days of last discharge.

d. Unless the stream is small or extremely turbulent, an in-flow will usually hug the stream bank for some distance. This may result in two very different biological populations and an inaccurate assessment of stream conditions. Make sure sample location is within the area influenced by the discharge.

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

f. Sampling stations for macroinvertebrates should be located within the same reach of where sampling for chemical and physical parameters will be located if appropriate habitat is available. If the macroinvertebrates are collected more than 200 yards from the chemical sampling, consider it a separate station and assign it a different station ID number unless there are no tribs, discharges, construction, agriculture, road crossings or other activities that would influence the stream between the chemical and biological sampling points.

g. 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.

h. Ecoregion reference sites may be relocated upstream if localized disturbance is observed during sampling (for example beaver activity, riparian disturbance, 4-wheel activity, dredging etc.)

i. Stream must have had flow for a minimum of 30 days prior to sampling. Avoid habitats that may not have been submerged for 30 days, isolated pools or stagnant water.

Protocol B – Assigning DWR Station ID

A list of existing stations is available as a drop-down on the event tab of e-Forms, Appendix A, the station reference table on Waterlog/Hydra and the TDEC Data Viewer. If a station does not exist, a new station can be assigned using the new stations section on the form. However, before creating a new station ID, always check Waterlog/Hydra station reference table (under waters tab) to make sure a station has not already been created at that location (the e-Forms are updated annually and may not have all the established stations in the drop-down list).

Even if the site has not been collected before by the EFO, a station ID may have already been assigned based on other agency data (NPDES instream sampling, ARAP, special projects, TVA etc.). Do not assume that a station does not exist because it has not been collected by the EFO or is not in the e-Form drop down list. It is very important that all data from a single location be given the same station ID to facilitate assessments based on all available information. Contact the Watershed Planning Unit if there is any question or if there are naming errors associated with existing stations.

If new stations are created, they should be uploaded to the stations staging table in Waterlog/Hydra as soon after the sample collection as possible. They must be uploaded before samples are analyzed by the lab. An e-Form (see Appendix B) has been developed for submitting new stations. The form and guidance documents for completion and Waterlog/Hydra upload (BESERT) are available on the DWR publications page or by contacting WPU QC staff.

DWR station IDs are created using the following protocol. The station ID is used to identify the sample and must be included on all associated paperwork, electronic datasheets, results, tags, etc. This number is to be used to identify this site every time it is sampled for any parameter (benthic, fish, periphyton, bacteria, and chemical).

It is very important that station IDs are assigned consistently with the same location always assigned the same ID regardless of the sample collection type, purpose, samplers or year.

Unless the sites are located upstream and downstream of a point source discharge, tributary confluence or some other factor that would affect the stream, stations collected within 200 yards of each other are considered the same site. (So, if chemical samples were taken off the bridge and biological samples were collected up to
200 yards upstream or downstream, they are still the same station.)

Chemical and biological stations collected more than 200 yards apart can still be considered the same station if there are no tributaries, discharges, construction, agriculture, road crossing or other activities that would influence the stream between sampling points. **It is very important for biological and chemical samplers to coordinate naming of station locations to avoid confusion.**

The official waterbody name is the one published on the USGS 1:24,000 scale (7.5 minute) USGS topographical map or equivalent GIS layer. Do not use other sources such as gazetteer, TDOT bridge signs or local names, which may differ.

It is also important that river miles used in the station ID are measured as accurately as possible using the USGS 1: 24,000 scale (7.5 minute) USGS topographical map and correspond to the latitude and longitude for easy comparison between multiple stations on the same waterbody. There are several options that can be used for measuring river miles:

(1) TDEC online Assessment map http://tdeconline.tn.gov/dwr/. Use the USA Topo Maps or USGS Topo Map base map. Do not use the topographic base map which is not as high resolution and does not have some smaller tributaries. Do not use the assessment layers which follow flow lines and sometime cut off meanders.

(2) USGS Streamstats https://streamstatsags.cr.usgs.gov/streamstats/. Use the National Map Base Layer. Do not use the National Geographic layer uses flow lines which may cut off meanders and not all small tributaries are visible. This application measures distance in feet and will need to be converted to miles.

(3) ArcGIs Map Service. Use a USGS topo base map at the 1:24,000 scale and do not use the NHD flowline layer or Reach File Index which are straight lines and cut off meanders.

For larger rivers, measure from the river mile if identified on the map layer.

When measuring river miles for streams that enter an embayment, begin measurement from the confluence with the original channel of the main stem (not from where the stream becomes an embayment). For example, in Figure 6, river mile 0 for Bearden Creek would start at the confluence with the original channel of the Clinch River as marked on the topo within Melton Hill Lake. Follow the original stream channel line if marked on the topo (do not use "poly lines"). If the original stream channel is not marked on the topo, straight lines may be used through the embayment area.

If there are other stations located on the same stream, make sure the assigned river miles are appropriately upstream or downstream of existing stations. If errors are discovered on existing stations, contact WPU to have the stations reassigned.

Figure 6: Start of River Mile for Measuring Creeks Within Embayment Areas.

The only exception to the naming scheme is sites that have been designated as Ecoregion or headwater reference sites. These sites are always identified with their ECO or FECO designation no matter what the purpose of sampling. If new ecoregion reference sites are added, contact the WPU QC biologists to determine the appropriate station name.

1. Named streams/rivers

If a number does <u>not</u> already exist for the site, create an identification number. All letters in the station name are capitalized.

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a. The first five digits will be the first five letters of the stream name (capitalized). If the stream name has more than one word, use the first letter of each word finishing out the five letters with the last word. For example, South Fork Forked Deer River would be SFFDE. Do not use the words River, Creek Branch etc. (Fork is only used if the stream is also designated river, creek, branch etc.) For example, Dry Fork would be DRY but Dry Fork Creek would be DFORK. **The stream name will be one designated on the 1:24,000 scale (7.5 minute) USGS topographical map or GIS layer. (Do not use the Gazetteer, local name, TDOT signs etc.).**

b. The next five characters designate the river mile. This is recorded as three whole numbers, a decimal and a tenth space. For example, river mile 1.2 would be 001.2. Do not add zeros to make a short stream name longer. It is very important that the river

mile be determined as accurately as possible (see number 3 above). Measure the river miles from the confluence with the next waterbody downstream to the sampling location.

c. The last two characters designate the county (or state if not in Tennessee). Use the County Identification table in Appendix E to determine the appropriate county designation. The county is expressed with two-letters; do not use the numeric state code. If the station is in another state, add an underscore __ before the two-letter state abbreviation.

Example 1: A station located at river mile 2.0 on Puncheoncamp Creek in Cumberland County would be PUNCH002.0CU.

Example 2: A station located at river mile 25 on the North Fork Forked Deer River in Gibson County would be NFFDE025.0GI.

Example 3: A station that is located in Kentucky at river mile 15.2 of Spring Creek would be SPRIN015.2_KY.

If necessary, samples may be collected in a cross-section to isolate effects of contaminants or disturbance. In such instances, the station ID should identify the location of the sample by using the following designations at the end of the ID.

-RDB Right descending bank
-LDB Left descending bank
-MC Mid channel.

For example for 3 sites on the Cumberland River at mile 102.5:

CUMBE102.5ST-RDB
CUMBE102.5ST-LDB
CUMBE102.5ST-MC

If the stream has both a natural channel and a canal, the canal should be designated with 1C after the first five letters and before the river mile. For example:

LOOSA010.1SH = Loosahatchie River at river mile 10.1 in the natural river channel.
LOOSA1C40.5FA = Loosahatchie River Canal at river mile 40.5

2. Unnamed Streams/Tributaries.

Check a 24k scale topographic map (hardcopy or GIS) layer to see if the unnamed stream is within a named geographical features such as a cove, hollow, gulf, gulch or valley.

a. For streams that are not within a named geographical feature:

(1) Use the first five letters of the receiving stream the tributary enters.

(2) Use a 3-5-character stream mile to indicate where the tributary enters the main stem (whole number, decimal and tenth for example river mile 0.1, 2.3, 10.9, 114.6).

(3) Use the letter T to indicate a tributary.

(4) Use the 3-digit river mile of the unnamed tributary where the station is located unless greater than 9.9 in which case use 4 digits. For example 0.1, 2.1 or 10.3

(5) Use the two-letter county abbreviation from Appendix E. If the station is in another state, add an underscore _ before the two-letter state abbreviation.

Example 1: A station located at river mile 0.2 on an unnamed tributary that entered the Harpeth River at river mile 114.6 in Williamson County would be HARPE114.6T0.2WI.

Example 2: A second station at river mile 0.3 on the same trib would be HARPE114.6T0.3WI.

Example 3: A station located at river mile 5.5 on a different unnamed tributary which entered the Harpeth River at mile 115.0 in Williamson County would be HARPE115.0T5.5WI.

(6) When naming an unnamed tributary to an unnamed tributary, start at the named stream (mainstem) and work upstream to the sampling point.

(a) Record the first five letters of the mainstem (named stream).
(b) Record the river mile where the first unnamed tributary enters the main stem followed by a T
(c) Record the river mile where the second unnamed tributary enters the first one, followed by a T
(d) Record the river mile where the station is located, followed by the county designation

Example: A station at river mile 0.2 on an unnamed tributary that flows into a second unnamed tributary at river mile 0.1 which, in turn flows into Cosby Creek at river mile 6.9 in Cocke County would be COSBY6.9T0.1T0.2CO (Figure 7).

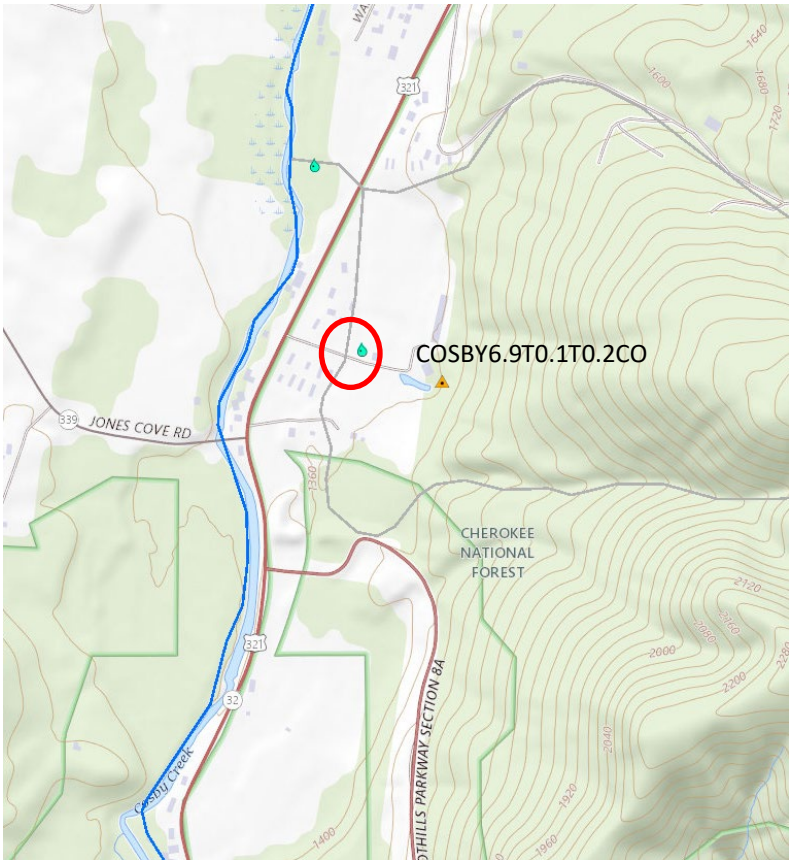


Figure 7: Naming Scheme for Stations Located on Unnamed Tributaries to Unnamed Tributaries. Station ID COSBY6.9T0.1T0.2CO.

b. **For streams that are within a named geographical feature:**

(1) The first five digits will be the first five letters of the name of the geographical feature (capitalized). If the feature name has more than one word, use the first letter of each word finishing out the five letters with the last word. Do not use the words Cove, Hollow, Gulch, Gulf, or Valley. If the feature name has fewer than five letters use the entire name.

(2) Add the underscore _G to indicate that the station is named after a geographical feature and not a named stream. Streams with "_G" will be the main branch running through the feature.

(3) The next three characters designate the miles upstream from the nearest named stream or waterbody. This will be written as one whole number, a decimal and a tenth space. For example, river mile 1.2 would be written as 1.2. If the stream is an unnamed tributary to the main branch (_G streams), the miles will be measured upstream from the main branch instead of the nearest named stream or waterbody (see example 3).

(4) Use the two-letter county or state abbreviation from Appendix E. If the station is not in Tennessee, add an underscore _ before the two-letter state abbreviation.

Example 1: A station that is in Shingle Mill Hollow in Marion County and is 0.3 miles upstream from Nickajack Reservoir, which is the closest named waterbody would be SMILL_G0.3MI.

Example 2: A station that is located on an unnamed main branch in Cave Cove in Marion County that is 0.4 miles upstream of the nearest named stream would be CAVE_G0.4MI.

Example 3: A station at river mile 0.2 on an unnamed tributary that enters main branch in Cave Cove at river mile 1.0 would be CAVE1.0G0.2MI.

3. Wetlands

a. For named wetlands

(1) Use the first five letters of the wetland name if one word – if more than one word use the first letter of each word plus as many letters are needed in the last word to get five total letters (see 2.a).

(2) Add underscore _W.

(3) Use a 3-character stream mile including one whole number, the decimal and a tenth space. For example, river mile 1.2 would be written as 1.2.

(4) Use the two-letter county or state abbreviation from Appendix E. If the station is in another state, add an underscore _ before the two letter state abbreviation.

Example 1: A station located at DUCK wetland would be DUCK_W1.2CH.

Example 2: A station located at BLACK HORSE wetland would be BHORS_W1.2CH.

b. For unnamed wetlands with an associated stream

(1) Use the first five letters of the stream associated with the wetland if one word – if more than one word use the first letter of each word up to five letters (see 2. a.).

(2) Add underscore _W

(3) Use a 3-character stream mile including one whole number, the decimal and a tenth space. For example river mile 1.2 would be written as 1.2.

(4) Use the two-letter county or state abbreviation from Appendix E. If the station is in another state, add an underscore _ before the two-letter state abbreviation.

Example: A wetland associated with a stream Clear Creek would be CLEAR_W1.2SM.

c. For isolated unnamed wetlands with no stream associated with it, use the name associated with the ARAP permit request.

(1) Use the first five letters of the company associated with the wetland, - if more than one word use the first letter of each word up to five letters.

(2) Add underscore _W.

(3) Use a 3-character stream mile including one whole number, the decimal and a tenth space. For example river mile 1.2 would be written 1.2.

(4) Use the two-letter county or state abbreviation from Appendix E If the station is in another state, add an underscore _ before the two-letter state abbreviation.

Example: Company name Boones Farm BFARM_W1.2CO

4. Sinking streams (with no clear channel or surface flow to main stem – use standard naming scheme for streams with clear channel or that resurface)

a. Use the first five letters of the stream name if one word – if more than one word use the first letter of each word up to five letters. For unnamed sinking streams or if the receiving stream is unclear use the first five letters of the closest mapped feature.

b. Add underscore _S.

c. Use a 3-character stream mile including one whole number, the decimal and a tenth space (use additional characters as needed if the stream mile is greater than 9.9). Start mileage from the point where the stream disappears (if the stream resurfaces downstream and it is clearly the same stream, estimate the distance between surface points).

d. Use the two-letter county or state abbreviation from Appendix E. If the station is in another state, add an underscore _ before the two-letter state abbreviation.

Example 1. A station located at river mile 1.2 on Dry Creek would be DRY_S1.2CU.

Example 2. A station located at river mile 11.2 on Stinky Cow Creek would be SCOW_S11.2CU.

Example 3. An unnamed sinking stream station located on Crane Top Ridge with no clear flow pattern would be CTOP_S1.2FR

5. Reservoirs (man-made lakes)

a. Assign the first 5 letters of the impounded stream, river (or embayment).

b. Use a 5-character stream mile if the sample is collected near the river channel. If the sample is collected near the right or left bank (such as at a boat dock) use a 4 character stream mile and the letters RDB or LDB to designate the right or left descending shore.

c. Use the appropriate two-letter county or state abbreviation from Appendix E. Add an underscore _ before the two-letter state abbreviation for stations in another state. For example, a station that was collected from a boat on Fishing Lake which dams Otter Creek in Anderson County would be OTTER012.3AN. If the station was collected off a dock near the left descending shore the station ID would be OTTER012.3AN-LDB

In the station location include the reservoir name as well as location for clarification (for example Otter Lake near boat dock)

6. Natural Lakes

a. Use the first 5 digits of the lake's name.

b. Using an S to designate station and a two-digit whole number, assign the next available station ID. For example, if station IDs 1 through 4 already exist on that lake from previous studies (check Waterlog/Hydra) then use station ID 5. This would be designated S05.

c. Use the appropriate two-letter county or state abbreviation from Appendix E. Add an underscore _ before the two-letter state abbreviation for stations in another state.

For example, a new station located on Reelfoot Lake in Obion County would be REELFS05OB

Protocol C – Field Parameters

Adapted from U.S. Environmental Protection Agency. 2002

Dissolved Oxygen, pH, temperature and conductivity measurements are to be recorded at each biological monitoring station every time the site is sampled. Field parameters are to be entered on the field parameter data e-form and uploaded to Waterlog/Hydra (Protocol E and SPERT). Multi-probe or individual meters meeting specifications in Table 1 can be used.

Measure dissolved oxygen, pH, temperature and conductivity before biological samples are collected. (If also collecting chemical or bacteriological samples, measure field parameters after these samples are collected). Place the probe upstream of where surface water samples were collected. Allow sensors to equilibrate before recording measurements. This may take longer for older sensors. When possible submerge the sonde in the stream. Document all measurements including duplicates on the field parameter electronic data sheets. Record measurements to the nearest tenth.

Table 1: Water Quality Probe Minimum Specifications

Parameter	Range	Accuracy	Resolution
Temperature	-5 °C to 45 °C	+/- 0.20 °C	0.1 °C
Specific Conductivity	0 to 100,000 umhos/cm	+/- 1% of reading	4 digits
pH	2 to 12 units	+/- 0.2 units	0.01 units
Dissolved Oxygen	0 to 20 mg/L	+/- 0.2 mg/L	0.01 mg/L

Label all meters as property of the State of Tennessee, Department of Environment and Conservation. Assign each meter a distinct identifying designation, (i.e. letter or a portion of the serial number) for calibration, maintenance, and deployment records. Mark each meter with this designation. Record the meter's ID number on the field parameter data sheet.

Beyond following the instructions in this SOP for calibrating, maintenance, and logging procedures, it is also recommended to refer to manufacturer's instructions.

1. Calibrate Meter(s)

If probes are factory calibrated, check readings against the appropriate standards to ensure the calibration is still accurate. Maintain calibration SOPs for each type and/or brand of meter. Keep all calibration records in a backed up digital format (preferred) or bound logbook (Figure 8). Include the date, meter designation, project name/number, initials of calibrator, parameter, standards used, meter reading, and adjustments.

Also, record routine maintenance and repairs in the logbook as well as upload to Waterlog Production's Equipment and Assets Inventory. Some probes must be sent to the manufacturer for calibration. Other probes must be replaced when they no longer maintain their calibration. In these cases, refer to manufacturer's instructions.

Meters should be calibrated in the following order: Conductivity, Dissolved Oxygen, pH.

Date	Meter	Project	Init.	Parameter	Standard	Reading	Adj	Comments
08/01/21	YSI-A	Davis Ck	LEE	Conductivity	142	120	142	Cleaned contacts
08/01/21[	YSI-A	Davis Ck	LEE	Conductivity	142	140	NA	Drift Check

Figure 8: Meter Calibration Log

a. **Frequency: To ensure the most accurate data, it is desirable that meters be calibrated each morning before use (or the afternoon during drift check for the next day).** It is necessary to calibrate DO probes each morning of use and at each site where necessary (see # 2). Daily calibration is preferred for the most defensible data, but when necessary, conductivity and pH probes can be calibrated weekly with a drift check performed daily upon return (or at the end of the sampling period if overnight travel is involved). 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 before the next use. A drift check should be performed weekly for temperature. Drift checks for DO probes are not necessary if the meter was recalibrated in the field.

b. **Conductivity:** Calibrate at 0 and the highest expected conductivity value. When using meters where zero is assumed, a higher standard is used for the calibration. For the MS5 or other meters where 0 is not assumed, the flow-through cell must be dried and placed in a dry calibration cup for the zero standard. Then a higher standard is used to calibrate the upper range.

c. **Dissolved Oxygen:** The DO probe must be calibrated using air calibration (% saturation) each morning prior to use. Most probes automatically compensate for temperature changes. Some probes also automatically compensate for pressure changes. An ASTM calibrated thermometer and/or a handheld barometer must be carried in the field if the probe does not compensate for temperature and/or pressure changes. It is only necessary to recalibrate the probe at sites where there is a significant elevation, pressure or temperature change and the meter does not automatically compensate. A significant change in elevation is 1000 feet. A significant change in pressure is ±20 mm Hg (higher or lower) or when a storm front comes through the area. A significant change in temperature includes any ±5ºC change in temperature (higher or lower). If the DO probe is air calibrated, changes in pressure do affect concentration readings. Record the air calibration at the site in a calibration log in the field to the specified resolution in Table 1.

d. **pH**: To calibrate pH, use buffers that will bracket the anticipated sample pH value. If the streams in a particular area are between 7 and 4 pH range, then a 2-point calibration would be sufficient. The same would be true for an anticipated sample value in the 7

and 10 pH range. However, a 3-point calibration should be used for streams and runs where the pH range is unknown. When in doubt do a 3-point calibration. Electrolyte and KCL pellets should be replaced monthly in most cases, every week in low ionic strength environments. pH electrode should not be submerged during storage.

e. **Temperature:** To check the calibration of the temperature probe place an ASTM thermometer in a container of room temperature water large enough to submerge the temperature probe. Place the meter in the water bath and allow it to equilibrate then compare the probe's reading to the thermometer's reading and mathematically adjust the probe's temperature as necessary. Coordinate with TDH laboratory to include the ASTM thermometer in their annual thermometer calibration check against the ASTM certified thermometer. Record this information in the calibration log.

   If conductivity measures < 100 umhos/cm3 and pH < 6, a pH sample should be collected for lab analysis to validate pH measurement. These should be collected in a non-preserved 250 ml bottle with no air space and preserved on ice. Holding time is 72 hours. Place an X next to pH on the lab request sheet and label the bottle as a pH sample. On field form, record field measurement and indicate in the comment that a lab pH was also collected. Load to Waterlog/Hydra with the other field parameter.

2. Probe Placement:

Ideally, measure water parameters after collecting chemical and bacteriological samples and before measuring flow or collecting other samples (i.e. macroinvertebrate, periphyton). Turn on the meter(s) and if there is a DO stirrer, be sure it is activated. Carefully place the meter(s) in the thalweg upstream of the chemical and bacteriological sampling area. Suspend the probe(s) in the water column so it does not touch the bottom. If the water is too shallow to suspend the meter(s), carefully lay it on its side on firm substrate (preferably rock). Do not allow the probe(s) to sink into soft substrate. The probe should be placed in an area of smooth flow (run) not in a pool, backwash, or turbulent area.

Stand downstream of the probe, being careful not to disturb the substrate in the area of the probe(s). Allow enough time for each reading to stabilize before it is recorded. Depending on the meter, it may take a couple of minutes for dissolved oxygen to equilibrate. Record initial readings on the stream survey field sheet e-form (Appndix B) to the specified resolution (Table 1).

If DO readings are erratic or DO is less than 5 mg/l, check the membrane for wrinkles or bubbles or tears. If it is a Luminescent DO meter, check to see if the meter is scratched or sitting in bright sunshine. If sunshine is the problem, shade the probe (for example with your notebook). Erratic readings can also be caused by turbulence or failure to fully submerge the probe. In this case move it.

If DO continues to be erratic, field calibrate. If measurements are less than 5 mg/l, determine potential environmental causes such as algae, chemical spills, stagnant water, lots of organic

matter, groundwater connection (springs) or wetlands. Document observance on stream survey data sheet. If the DO is below 5 mg/l and the post calibration is within 0.2 mg/l then check validated on the field parameter datasheet. If post calibration fails, reading should not be recorded on field parameter datasheet or uploaded to Waterlog/Hydra. Indicate calibration failure under meter problems on the datasheet.

If pH measurements are below 6 or above 9 and post calibration is acceptable, indicate validated under status ID on the field parameter datasheet. If post calibration is off, do not upload results to Waterlog/Hydra. Indicate potential environmental causes of low or high pH in meter problems.

3. **Duplicate Readings:**

Take duplicate measurements at each site. If time is a constraint (short sample holding times or daylight), duplicate readings may be reduced to first and last site each day. To take a duplicate measurement, lift the probe completely out of the water, wait for the readings to change then return it to the original location or slightly upstream if the sediment was disturbed. Allow the meter to equilibrate before recording readings. If the readings are off by more than 0.2 units for pH, temperature, and DO in mg/L or off by more than 10% for specific conductivity, repeat the procedure until reproducible results are obtained. Record the 2 measurements that are within acceptable limits on the stream survey data sheet (bioform) All results are to be recorded to the resolution specified in Table 1. Rinse the probes with clean water after use at each site to avoid contamination.

4. **Record Field Parameters:**

Document the field measurements on the s electronic stream survey form included in the bioform workbook. Specific conductivity must be measured in umhos/cm or uS/cm, dissolved oxygen in ppm (mg/l), and temperature in ºC. If measurement is outside of criteria and there are no meter problems and drift check is OK, mark validated in the appropriate box on the field form.

5. **Drift Check:**

Without post-calibration checks, the accuracy of the water parameter measurements cannot be demonstrated. At the EFO lab, perform a drift check on each meter at the end of the day (or at the end of the trip on multiple night trips) and record results in the logbook (Figure 8). Drift checks can be done in the field, as long as you have the proper equipment. To check that the probes have maintained their calibration for pH and conductivity, compare the probe's readings against the appropriate pH, and conductivity standards. Adjust calibration if the probe is going to be used again that week. If the meter's calibration is off by more than 0.2 for pH or more than 10% for conductivity, all readings between the initial calibration and the drift check should be discarded. To check that the probes have maintained their calibration for temperature, compare the probe's readings against a standard ASTM

thermometer. If the meter's calibration is off by more than 0.2, all the readings between the initial calibration and the drift check should be discarded. When the DO probe has been air calibrated in the field due to pressure, elevation or temperature changes, a drift check is unnecessary at the end of the day. If the DO probe was not re-calibrated since leaving the base office, a drift check should be performed at the end of the day. If the meter's calibration is off by more than 0.2 mg/L (Winkler) or 10% (air), all readings between the initial calibration and the drift check are questionable.

If measurements are criteria violations and the data have been validated, be sure to indicate in the comments section for that parameter that the drift check passed.

If drift check fails for any parameter, do not upload parameter that failed. Upload parameters that pass with a note about the failing parameter. Indicate on electronic stream survey sheet that there was a problem with the meter for that parameter.

6. Other Parameters:

Some multi-parameter probes contain sensors for other water quality parameters such as turbidity or suspended solids. If these parameters are also measured, they should be calibrated following manufacturer's specifications prior to use with drift checks performed at the end of each day. It is recommended that turbidity be measured in the field instead of collecting a sample for lab analysis if a calibrated meter is available. Duplicate measurements should be taken at each site and recorded on the stream survey sheet.

Protocol C-1 Header Information for Field Forms (Protocols D-E-F)

Habitat and Stream Survey Forms must be completed with every biological sampling event. The DWR electronic e-forms are the required method for submitting data. See Biological Survey Electronic Reporting Tutorial (BSERT) or for details on using e-Forms and uploading to Waterlog/Hydra

Most of the header information for the field forms will be populated from the BioEvent tab on the e-form. The following are details on the header information in the BioEvent.

1. **DWR Station ID**: If the station ID is not already on the drop-down list in the BioForm, check current stations table in Waterlog/Hydra or the assessment data viewer to see if a station ID has already been assigned to this location. (Do not rely on memory or assume no-one else has ever collected any type of sample at this location. TVA or a permit holder may already have established a station). If a station has not already been assigned, use standard station naming procedure, protocol B. When assigning new stations, make sure the river miles are in line with existing stations (for example river mile 1 should be upstream of river mile 0.5) or notify WPU biological QC staff if existing stations are named inappropriately. Complete the new station information on in the BioEvent and upload EDD. DWR staff will upload the new station information from the Waterlog /Hydra tab into the station staging table in Waterlog/Hydra (see BSERT).

2. **Date**: Enter date of assessment (MM/DD/YYYY)

3. **Time**: Enter time (24 hour clock no colons)

4. **Samplers:** Include names of all samplers at the event.

5. **Organization**: Environmental field office or other sampling agency. Use code found organization table in Waterlog/Hydra (unless it is a new organization it will be in the drop-down list on the Bioform). If it is a new organization, contact WPU.

6. **Monitoring Location Name**: If it is an existing station, this will be auto populated from the station ID on the BioEvent. If it is a new station, the waterbody name should match USGS topographic map layer on the DWR assessment map viewer, or use unnamed tributary to named receiving stream. Do not use local names (or gazetteer names) that are not on this layer.

7. **Monitoring Location**: This is the point on the waterbody that is being sampled. If it is an existing station, it will be auto populated on the bioform and will match the location in stations table in Waterlog/Hydra. If it is a new station, use road names or features identifiable on topographic map layer if possible. Do not put directions to the site under location. This can be added to comment field if site is hard to find. Unacceptable location descriptions include:

a. Downstream STP (specify what STP and how far downstream).

b. Stinky STP – Specify upstream or downstream, how far and which outfall if there is more than one.

c. Behind Mr. Jones House. – Mr. Jones may move, or next sampler may not know where Mr. Jones lives, use 123 Penny Lane Instead.

d. Playground (camp site, church, landfill, park etc.) – Use name of playground and road location or another map feature.

e. Off Highway 123 – Roads are long, add another landmark (for example off Hwy 123 approx. 0.5 mile upstream of intersection with Bumpass Rd.

f. Highway 123 Bridge – Specify upstream or downstream and how far. (If the road crosses the creek multiple times add additional location information such as 500 yards upstream of Hwy 123 Bridge Crossing near intersection with First Street.

g. Farm Road: There are a lot of farms, be more specific.

8. **Drainage area**: Square mile drainage upstream of sampling location (will be auto populated if using DWR electronic datasheet at an existing station.) Drainage area can be determined using the interactive map at https://streamstats.usgs.gov/ss/

9. **Ecoregion**: Specify ecoregion of stream reach If using DWR electronic datasheets, ecoregion will be auto-populated for existing stations). For new station check station location at http://tdeconline.tn.gov/dwr/

10. **U/S ecoregion**: If the upstream drainage is in another ecoregion record this in U/S ECO. In comment field note if station characteristics are more similar to the upstream ecoregion. Leave blank if the upstream ecoregion is the same as the ecoregion at the sampling location.

11. **County** is the county name where the station is located (even if most of drainage is in another county). If using the BioForm, county will be auto populated for existing stations. For new stations use the county abbreviations in appendix E. For streams which form county boundaries, be consistent with other stations located on the stream.

12. **Latitude and Longitude** are always in decimal degrees. If you are using the bioform, verify coordinates to make sure you are in the right collection. (Otherwise check lat/long on map viewer). If discrepancies are discovered, notify WPU of need to correct database information once you have confirmed the correct location and GPS reading are accurate.

13. **When establishing new stations,** the latitude and longitude should be recorded mid-stream in the middle of the sampling reach with a calibrated GPS. Always check latitude and longitude against the database for existing stations to verify location.

14. **HUC**: is the 8-digit USGS +-Hydrologic Unit Code. The BioForm will auto populate the HUC for existing stations. For new stations use the mapviewer to assign the specific 8- digit HUC number

15. **WS Group** is the watershed assessment group and will be auto populated by the BioForm for existing stations. For new stations the online assessment mapviewer can be used except in split watersheds ((06010102, 06010201 and 06020001). Contact WPU if you are uncertain of the appropriate watershed group.

16. **WBID#**: When possible use Water Body ID Number (WBID#) assigned for the stream segment. The Water Body ID for each segment can be found using the online assessment database http://tdeconline.tn.gov/dwr/.

17. **Field Log Number**

    a. Samples must be assigned a field log number to allow complete reconstruction, from initial field records, through data storage, sample analysis and system retrieval. This includes biorecons that are identified in the field with no vouchers. If using DWR electronic forms, this number will be automatically assigned. Otherwise, the same field log number should be assigned to all samples collected at that site that day (BR, SQSH, Diatoms, Chemicals). Even if different team members are collecting each sample type, one person is considered the primary assessor for the field log number. Use the format (Primary assessor initials followed by date with no separations (MMDDYYYY) and then a 2-digit running number for each site throughout the day. (If it is a duplicate, the second sample is given the next number in line.)

        i. KJL0131202201 would be all of the samples (habitat, biorecon, SQSH, periphyton etc.) collected or assessed by KJL on 01-31-22 at the first site of the day.

        ii. KJL0131202202 would be the duplicate samples collected or assessed by KJL on 01-31-22 at the first site of the day.

        iii. KJL0131202203 would be all of the samples (habitat, biorecon, SQSH, diatoms etc.) collected or assessed by KJL on 01-31-22 at the second site of the day.

        iv. KJL0201202201 would be all of the samples (habitat, biorecon, SQSH, periphyton etc.) collected or assessed by KJL on 02-01-22 at the first site of the day

18. **Project Name**: If using BioForm, select project name associated with the project purpose. which are included on the form as a drop-down list (watershed, 303(d), Antideg, ECO, FECO). Use project codes found in Appendix E or Waterlog/Hydra Reference table if possible. If a new project needs to be added contact WPU.

19. **Project ID**: Indicate project ID associated with the project name. The project ID for DWR surface water samples will always begin with TNPR. The ID will be automatically completed if using the e-Form. Otherwise, use project codes found in Appendix E or Waterlog/Hydra Reference table. If a new project needs to be added contact WPU.

20. **Activity Type**: Indicate the type of activity as listed in Table 2.

Table 2: Stream Survey Activity Types

Activity Type (Official name)	Activity Type Code	Sample Type	Description
Sample-Routine	Sample	BR or SQSH + Habitat Assessment	BR or SQSH sample collected, no QC.
Quality Control Sample-Field Replicate	QC Sample	BR or SQSH Field Duplicate	BR or SQSH Field duplicate may or may not include habitat QC
Field Msr/Obs-Habitat Assessment	Habitat	Habitat Assessment only	Habitat Assessment with no bug sample. No duplicate.
Quality Control Field Replicate Habitat Assessment	QC Habitat	Habitat Assessment QC	Habitat assessment independent duplicates with Consensus uploaded. No bug samples collected.
Quality Control Sample-Lab Duplicate	QC ID	Taxonomic QC	Lab duplicate with 2 taxonomists independently identifying sample.

21. Sample Information

a. **Sample Status**. Indicate the status of the sample using the drop-down list on the e-form. If the sample could not be collected indicate if another attempt will be made to collect the sample when conditions improve by marking the revisit box.

b. **Flow Conditions**: Indicate flow conditions at time of site visit. Do not collect samples if dry, isolated pools, stagnant, bankfull or flooding.

c. Indicate all **sample types** collected at the site. (SQSH, biorecon, periphyton, nutrients, metals, E *coli*, organics, etc.).

Protocol D – Habitat Assessment

The habitat assessment should be completed using the electronic e-Forms. E-Forms are available on the DWR website publications page or by contacting WPU. E-forms. can be completed directly in field (if tablets are available) or transferred from worksheets found in Appendix B to e-Form upon return to office.

a. DWR and TDH staff should upload datasheet from BioForm to Waterlog/Hydra within 30 days of habitat assessment (and/or within 1 week of sending sample to lab). Do not send habitat sheets to the lab. If doing duplicates, only load consensus to Waterlog/Hydra.

b. Habitat assessments conducted by other stakeholders (such as the regulated community) should send a copy of the e-Form workbook to the person designated on the macroinvertebrate QSSOP link on the DWR publications page.

Habitat assessments are primarily used to determine whether various components of the habitat are factors in fish and aquatic life impairment. A qualitative approach is used to minimize field time while still establishing a standardized assessment procedure that can be used for comparison to ecoregion guidelines. Because of the qualitative nature, the habitat assessment is not considered a cause of impairment without a measured biological response. By close adherence to these assessment guidelines and standardized training, a consistent habitat assessment approach can be achieved.

Conduct a habitat assessment every time any macroinvertebrate sample is collected. This assessment must be conducted on the same day the biological sample is collected. Although generally only macroinvertebrate samples are collected, it is important to consider both macroinvertebrates and fish when evaluating habitat. The macroinvertebrate sample is used as an indicator while the habitat assessment is used as a cause of impairment to both fish and aquatic life. It is necessary to walk the entire reach while assessing habitat. It is advisable that two staff members collaborate on the assessment to reduce subjectivity.

Two different habitat assessment e-forms or field sheets will be used dependent on the Level IV ecoregion and/or stream type at the sampling location (Appendix B). These field sheets are modified from *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers* (Barbour et. al., 1999). Habitat guidelines for each ecoregion are provided in Table 3. Guidelines for individual parameters can be found in Appendix A. In ecoregions 65j, 66d, 66e, 66f, 66g, 66i, 66j, 66k, 67f, 67g, 67h, 67i, 68a, 68b, 68c, 68d, 69d, 69e, 71e, 71f, 71g, 71h, and 74a as well as moderate gradient streams in 71i, use the High Gradient Stream assessment field sheet to evaluate habitat. In ecoregions 65a, 65b, 65e, 65i, 73a, 73b and 74b as well as low gradient non-riffle steams in 71i, use the Low Gradient assessment field sheet. Low gradient assessments may also be appropriate in some lower reaches of larger streams in other ecoregions. Copies of these field sheets are located in Appendix B and will be available for upload to field tablets (recommended).

Ecoregions designation based on sample point latitude and longitude can be found at http://tdeconline.tn.gov/dwr/. The Watersheds Planning Unit should be contacted if there is uncertainty about what ecoregion a stream is located in.

Evaluate all ten habitat parameters with 20 being the highest attainable score for each parameter (some are scored independently by bank with a scale of 0 -10). Scores are divided into four categories (optimal, suboptimal, marginal and poor) with a range of scores possible in each category.

The habitat assessment is based on the entire stream reach (typically 100 yards) and encompass all macroinvertebrate samples. If a longer sampling reach was used to collect macroinvertebrate samples (typically in larger streams or when habitat is scarce) or when collecting fish, the entire sampling reach is used for the habitat assessment. The assessment is an average of the conditions within this reach.

Because this assessment is qualitative, it is essential that assessors follow standardized protocols for scoring especially when assigning categories of Optimal, Sub-optimal, Marginal and Poor. This will enable comparison to ecoregion reference streams that have been assessed following the same standardized procedure.

Two steps are used to assign a habitat score for each parameter. The first step is assigning the parameter a condition category of optimal, suboptimal, marginal, or poor. **Assessors must be careful not to focus on the category names, they are meaningless in the state assessment. Scores are calibrated to a pass/fail based on the median reference condition for each ecoregion.** The four broad categories are just a convenient tool to quadrisect the various habitat parameters before ranking. These categories are generally based on quantity of the specified parameter. The second step is assigning a numeric score (rank within that category). This is generally based on the quality of the parameter.

It is important that the assessor does not pre-calibrate the site based on reference expectations while in the field (For example thinking that streams in a certain area should score optimal because that is as good as it gets, even if they do not meet the description). Scores will be adjusted to ecoregion reference conditions during analysis (Table 3). The best streams in some ecoregions may never fall in the "optimal" category but will be considered fully supporting based on comparison to reference condition.

The guidelines on the field sheet and in this document should be followed as closely as possible. If the stream does not fit the descriptions, professional judgment should be used with the comment field used to explain scoring. A comment line is available at the bottom of each parameter. Comments can be used to provide additional descriptions, clarify difficult calls, explain atypical stream conditions, specify what characteristic resulted in the score when there are multiple interpretations, describe any factors that should be taken into consideration when interpreting the score or any other information that would help explain the assessment to a reviewer who has not been to the site.

Header

When using e-Forms, most of the header information will already be populated from the BioEvent, with the exception of the following:

Habitat Assessed By: Include initials of staff member(s) who scored the habitat assessment. Do not include any team members who were not involved with habitat assessment.

Time: 24-hour clock no colons

Note: If this is a QC, two separate habitat field sheets should be completed independently. If using the e-Form unhide the individual parameter worksheets. Consensus scores are marked on the primary habitat assessment worksheet (differentiate between investigator and consensus). Only the consensus data are uploaded to Waterlog/Hydra.

Protocol D-1: Moderate to High Gradient Habitat Assessment Field Sheet.

The moderate to high gradient habitat assessment BioForm or field sheet (Appendix B) will be suitable for most wadeable streams in middle Tennessee (except for some streams in the Inner Nashville Basin – 71i) and in east Tennessee (unless in low gradient areas such as the mouth of large streams where riffles do not naturally occur). It will also be used for two ecoregions in west Tennessee; the Transition Hills (65j) and Bluff Hills (74a).

If riffles are not present due to disturbances such as sedimentation, sludge deposits or channel alterations, but the slope is moderate to high gradient, these field sheets will still be used to evaluate the stream. Some moderate to high gradient streams naturally do not have riffles (steep mountain streams or moderate gradient bedrock streams) however they should still be evaluated with this field sheet. The only time a low gradient field sheet should be used in these ecoregions is if the stream is in a low gradient area (sometimes occurs near the mouth of large streams). Note that the ecoregion reference guidelines cannot be used in low gradient streams in these ecoregions or for non-wadeable streams. Therefore, a suitable upstream or watershed reference must be selected for comparison. In these cases, the test stream should score within 75% of the "reference" stream to have comparable habitat.

1. Epifaunal Substrate/Available Cover

When assessing this parameter, look at various types of natural structures available to macroinvertebrates and/or fish throughout the entire reach. Look for habitat that provides refugia, feeding, spawning or nursery functions. Only count productive habitats, which provide a niche for colonization by macroinvertebrates or fish. For example, do not count "newly fallen trees, leaf litter that is not decaying or unstable habitats that will be washed out. Also, do not include artificial habitat such as fish attractors, tires, appliances, rip-rap, etc.

Natural productive habitats typically found in moderate to high gradient streams include:

- Cobble riffles
- Gravel riffles
- Bedrock crevices
- Boulders (Fish cover)
- Pool rock
- Run Rock
- Submerged trees (not new fall)
- Snags
- Decaying leaf litter
- Rock overhangs (Fish cover)
- Undercut banks
- Submerged Roots
- Macrophyte beds
- Mossy rocks

To assign a condition category, first look at how much of the stream reach is covered by natural, stable, productive habitat. The numeric score (rank) within the condition category is assigned based on the variety and quality of habitat.

For example, in a very high gradient mountain stream, over 70% of the substrate may be available for colonization putting this in the optimal category. Four or more habitats may be present, but is dominated by boulder cover so it may only score a 16. Variations in habitat that provide niches for different faunal types should be considered as different habitat types. For example, cobble in flowing water and cobble in pools count as two types of habitat.

Habitat that is not of sufficient quantity to support faunal populations, does not show evidence of colonization (such as newly fallen leaves), is not productive (such as seamless bedrock) or is likely to wash out should not be included. Artificial or man-made structures such as rip-rap are also not included since the goal is to evaluate natural habitat.

Optimal – Over 70% of the stream reach has natural, stable habitat available for colonization by macroinvertebrates and/or fish. Four or more productive habitats are present. Deadfall, leaf litter, snags etc. are not new-fall but show evidence of decay. If less than four habitats are present drop to Suboptimal.

20	Cobble and/or smaller boulders (≤18") riffle is the dominant habitat.
19	Cobble run is the dominant habitat. Cobble riffles are present.
18	Cobble run is the dominant habitat. Cobble riffles are not present.
17	Productive habitat other than cobble riffle or run is dominant. Cobble riffles or runs are available.
16	Productive habitat other than cobble riffle or run is dominant Cobble riffles and runs are absent.

Suboptimal – Natural, **s**table habitat covers 40 – 70% of stream reach. Three or more productive habitats present. If near 70% and more than three habitats are available go to optimal.

15	Cobble and/or smaller boulders (≤18") riffle is the dominant habitat.
14	Cobble run is the dominant habitat. Cobble riffles are present.
13	Cobble run is the dominant habitat. Cobble riffles are not present.
12	Habitat other than cobble riffle or run is dominant. Cobble riffles or runs are available.
11	Habitat other than cobble riffle or run is dominant Cobble riffles and runs are absent.

Marginal – Natural stable habitat covers 20 - 40% of stream reach **or** only 1 or 2 productive habitats are available in sufficient quantity to support a population. If coverage nears 40% and three or more productive habitats are present go to suboptimal.

10	Cobble and/or smaller boulders (≤18") riffle is the dominant habitat.
9	Cobble run is the dominant habitat. Cobble riffles are present.
8	Cobble run is the dominant habitat. Cobble riffles are not present.

7	Habitat other than cobble riffle or run is dominant. Cobble riffles or runs are available.
6	Habitat other than cobble riffle or run is dominant Cobble riffles and runs are absent.

Poor – Less than 20% stable habitat regardless of number of habitats. Lack of habitat is obvious. Substrate unstable or lacking.

5	At least two natural, stable, productive habitats are present in limited amount including either cobble riffles or runs.
4	At least two natural, stable, productive habitats are present in limited amount. Cobble or riffle runs are absent.
3	Cobble riffle or runs is the only habitat.
2	Only one natural, stable, productive habitat is available. Cobble riffles or runs are absent.
1	There are no natural, stable, productive habitats within the reach.

Comments: Use comment line to indicate what habitats are noticeably missing and describe any additional factors which could affect interpretation of the score.

2. Embeddedness of riffles

Estimate the percent that rocks are covered or sunken into the silt, sand, or mud of the stream bottom. **Observations should be done in cobble riffle areas.** Ideally, riffles should have multiple layers of cobble loosely lying on each other providing niches for macroinvertebrates and fish between and under the rocks. **Gravel riffles or cobble/gravel runs may be substituted if necessary.** However, make sure riffles are not absent due to sedimentation (in which case the parameter should score 1).

In moderate to high gradient streams that naturally do not have cobble riffles (i.e. extremely high gradient boulder streams or some moderate gradient bedrock streams) the parameter would score lower due to lack of niche space even if embeddedness is not high.).
Two factors should be evaluated for this parameter.

To determine the condition category, estimate the amount to which the rock is surrounded by fine sediment or conglomerate. Fine sediments are silt, clay, sand, sludge etc. Niche space may also by compromised by manganese or other deposits that cement the rocks together. Discoloration on the bottom and sides of rocks is a good way to determine the percent of embeddedness. However, take care that additional cobble layers are not buried in sediment and are not visible.

To select the score within the category, examine the amount of niche space that is provided by layering of cobble (ideal). There should be lots of sediment free spaces between and under rocks for macroinvertebrates and small fish to live. If the stream type is not a cobble-riffle, other examples of riffle or run niches affected by embeddedness include the bottom area of round boulders where it curves into the substrate or the spaces between gravel in a bedrock fissure. In moderate gradient bedrock streams without gravel (for example those with bedrock shelves)

examine loose rocks or slabs in areas of relatively fast flow. These are less productive and should be scored lower in the selected condition category.

Optimal: Gravel, cobble and boulders are 0 - 25% surrounded by fine sediment. If embeddedness is close to 25% use quality of niche space to differentiate between optimal and suboptimal condition categories. Optimal would be layered cobble. To determine the rank within this category, consider the available niche space.

20	Niche spaces are free of sediment. Multiple layers of cobble provide niche space for colonization.
19	Niche spaces are free of sediment but natural substrate does not provide multiple layers or is not cobble.
18	Small amount of sediment (up to 10%) but niche spaces are not compromised. Multiple layers of cobble are available for colonization
17	Small amount of sediment (up to 10%) but niche spaces are not compromised. Natural substrate does not provide multiple layers.
16	Sediment is more pronounced affecting up to 25% of niche space. Multiple layers of cobble are available for colonization..

Suboptimal: Gravel, cobble and boulders are 25% - 50% surrounded by fine sediment. If embeddedness is close to 25% use quality of niche space to differentiate between optimal and suboptimal condition categories. Optimal would be layered cobble. Likewise as number approaches 50% use quality of niche space to differentiate between suboptimal and marginal. Suboptimal would be layered cobble.

15	Approximately 25% of niche space is affected. Substrate is not layered cobble.
14	Approximately 30 - 35% of niche space affected. Substrate is layered cobble.
13	Approximately 40 - 45% of niche space affected. Substrate is layered cobble.
12	Approximately 30 - 45% of niche space affected. Substrate is not layered cobble
11	Approximately 50% niche space is affected. Substrate is layered cobble.

Marginal: Gravel, cobble and boulders are 50% - 75% surrounded by fine sediment. As amount approaches 50%, use quality of niche space to differentiate between suboptimal and marginal condition categories. Suboptimal would be layered cobble.

10	Approximately 50% of niche space affected. Substrate is not layered cobble.
9	Approximately 55 - 65% of niche space affected. Substrate is layered cobble.
8	Approximately 55 - 65% of niche space affected. Substrate is not layered cobble
7	Approximately 70 - 75% of niche space affected. Substrate is layered cobble.
6	Approximately 70 - 75% of niche space is affected. Substrate is not layered cobble.

Poor: Gravel, cobble and boulders are more than 75% surrounded by fine sediment.

5	Approximately 80 - 85% of niche space affected. Substrate is layered cobble.
4	Approximately 80 - 85% of niche space affected. Substrate is not layered cobble.
3	Approximately 90 - 95% of niche space affected. Substrate is layered cobble
2	Approximately 90 - 95% of niche space affected. Substrate is not layered cobble.
1	Niche space is completely filled in by sediment.

Comments: Use comment line to describe type of sediment (sand, silt, clay, sludge etc.) and to describe any additional factors that would affect scoring.

3. Velocity/Depth Regime

Determine the patterns of velocity and depth. The four basic patterns are slow-deep, slow-shallow, fast-deep, and fast-shallow. The most productive streams will have all four patterns present. Differentiation between regimes will vary depending on stream size. Focus on habitat function. For example, does the difference between fast-deep and fast-shallow in a small stream provide habitat for different taxa.

Condition Category is based on how many of the four regimes are present. Ranking is based on which ones are prevalent.

Optimal: All four velocity/depth regimes are present.

20	All four velocity/depth regimes are equally available
19	Fast-shallow is the dominant regime
18	Slow-shallow is the dominant regime.
17	Fast-deep is the dominant regime.
16	Slow-deep is the dominant regime.

Suboptimal: Only 3 of the 4 velocity/depth regimes are present.

15	Slow-deep is the only missing regime
14	Fast-shallow is dominant
13	Slow-shallow is dominant
12	Fast-deep is dominant
11	Slow deep is dominant.

Marginal: Only 2 of the 4 regimes are present. Both regimes are adequate to support aquatic population adapted to that habitat.

10	Fast-Shallow and Slow-Shallow are present
9	Fast-Shallow and Fast-Deep are present
8	Fast-Shallow and Slow-Deep are present

7	Slow-Shallow and Fast-Deep are present
6	Fast-Deep and Slow-Deep are present.

Poor: One of the 4 regimes dominates the reach (if another is present it is too small or infrequent to sustain an aquatic population adapted to that habitat.

5	Fast-Shallow is dominant a second regime may be present but is too infrequent to sustain a population.
4	Slow-Shallow is dominant a second regime may be present but is too infrequent to sustain a population.
3	Fast-Deep is dominant a second regime may be present but is too infrequent to sustain a population.
2	Slow-Deep is dominant a second regime is present but is too infrequent to sustain a population.
1	Slow-Deep is the only regime present.

Comments: Use the comment field to describe any additional factors that may affect scoring.

4. Sediment Deposition

This parameter is designed to measure the changes that have occurred to the stream bottom and flow patterns as a result of the deposition of small particles (gravel, sand, silt). It differs from embeddedness which is designed to measure loss of niche space.

Select condition category by estimating the percent of the stream bottom that is affected by sediment deposition. **Areas of deposition occur in pools, bends, natural or man-made constrictions and other areas of slower flow.** Deposition is also observable through the formation of islands, point bars (areas of increased deposition at the beginning of a meander that increase in size as the channel is diverted toward the outer bank) or shoals. Only areas of new, un-vegetated deposition on bars and islands should be considered when scoring.
If pools are too turbid to see bottom and too deep to reach down to feel the deposition, use alternate methods for estimating the bottom deposition. These include observing the amount of deposition in the shallower edges of the pool or probing the bottom with the handle of the net.

Rank within each category is determined by the areas most affected by sediment deposition. Sediment deposition in pools or slow areas will score higher than sediment deposition on point bars and islands. Note sediment deposition includes small particles (sand, silt, gravel etc.).

Optimal: Sediment deposition affects less than 5% of stream bottom in quiet areas. New deposition on islands and point bars is absent or minimal.

20	No islands or point bars. No sediment in pools or slow areas.
19	No new deposition on stable islands or point bars. No sediment in pools or slow areas.
18	No new deposition on islands or point bars. Small amount of sediment in pools or slow areas.
17	Slight amount of new deposition on islands or point bars. No sediment in pools or slow areas.
16	Slight amount of new deposition on islands or point bars. Small amount of sediment in pools or slow areas. Almost 5% of bottom area affected

Suboptimal: Sediment deposition affects 5 – 30% of stream bottom. Slight deposition in pool or slow areas. Some new deposition on islands and point bars.

15	Sediment deposition affects 5 – 15% of the bottom substrate. Most of the deposition is in pools or bends with little new accumulation on islands or point bars.
14	Sediment deposition affects 5 - 15% of the bottom substrate. Deposition occurs in both pool areas and as new accumulation on bars and islands.
13	Sediment deposition affects 20 – 25% of the bottom substrate. Most of the deposition is in pools or bends with little new accumulation on islands or point bars.
12	Sediment deposition affects 20 – 25% of the bottom substrate. Deposition occurs in both pool areas and as new accumulation on bars and islands.
11	Sediment deposition affects 30% of the bottom substrate. The majority of deposition is in pools or bends with little new build-up of islands or point bars. Move to marginal if build-up of islands and point bars approaches 30%.

Marginal: Sediment deposition affects 30 – 50% of stream bottom. Sediment deposits at obstructions, constrictions and bends. Moderate deposition of pools.

10	Sediment deposition affects 30% of stream bottom. Sediment deposits on bars and islands as well as pools and bends.
9	Sediment deposition affects 35 – 45% of stream bottom. Most of deposition is in pools rather than build-up of bars and islands.
8	Sediment deposition affects 35 – 45% of stream bottom. Moderate deposition of pools as well as new deposition on bars and islands.
7	Sediment deposition affects almost half of the stream bottom. Most of deposition is in pools rather than new deposition on bars and islands.
6	Sediment deposition affects almost half of the stream bottom. New sediment accumulation on bars and islands as well as in pools.

Poor: Heavy deposits of fine material. Increased bar development. More than 50% of the stream bottom changing frequently. Pools almost absent due to substantial sediment deposition.

5	Approximately 50% of the bottom substrate is affected by sediment deposition.
4	Approximately 60% of the bottom substrate is affected by sediment deposition.
3	Approximately 70% of the bottom substrate is affected by sediment deposition.
2	Approximately 80% of the bottom substrate is affected by sediment deposition.
1	Sediment blankets stream bottom pools absent due to sediment deposition.

Comment: Use comment field if needed to describe other factors related to score.

5. Channel Flow Status

Condition category will be selected based on the amount of the streambed covered by water. Rank within the category will be determined by how much productive habitat is exposed. **If water has been backed up by obstructions (such as beaver dam, log jams, debris plugs) move assessment reach above or below the affected area**. If this is not possible, determine whether sampling is appropriate or should be postponed until conditions are more representative of actual stream conditions. Use comment field to explain if necessary. Assess flow status based on what is submerged during normal flow conditions, for example naturally exposed gravel beds do not indicate exposed habitat. Use comment field to note if flow is reduced due to natural low flow conditions, drought, irrigation, municipal water withdrawal, impoundment etc.

Optimal: Water reaches base of both lower banks and streambed is covered by water throughout the reach. Minimal amount of productive habitat is exposed. Riffle areas are fully submerged.

20	Water is above the base of each bank. No productive habitats are exposed.
19	Productive habitats such as tree roots and riffles are submerged but some undercut areas may be above water. Riffle areas are fully submerged.
18	Some habitats such as tree roots are exposed but there is plenty of submerged habitat available. Riffle areas are fully submerged.
17	If rooted bank habitat is present, some tree roots are exposed but there is plenty of submerged root habitat available Small areas of riffles may be minimally affected due to shallow water depth but riffle habitat is not compromised
16	Water reaches base of both banks and water still covers streambed. Root, riffle or other habitat is compromised due to water depth although is still available for colonization.

Suboptimal: Water covers more than 75% of the streambed but is less than 100% **or** 25% of productive habitat is exposed.

15	One or more habitats may be absent due to water depth but riffle areas are not affected. (If productive riffle habitat is naturally not present score 11).
14	Water depth in riffles is reduced but this has not affected size or frequency of riffles.
13	Some riffle areas have become limited in size but none are totally exposed.

12	A few smaller riffles have become exposed.
11	Up to 25% of small riffles have become exposed or productive riffle habitat is not naturally available.

Marginal: Water covers 25% - 75% of the streambed, **and/or** stable habitat is mostly exposed.

10	Waters covers 75% of channel. Most small riffles are exposed. (If productive riffle habitat is naturally not present score 11).
9	Water covers 60 – 70% of streambed. All smaller riffles are exposed. Large riffles do not have significant exposed areas.
8	Water covers about 50% of the streambed. Larger riffles are still present but are reduced in size.
7	Water covers 30 – 40% of the streambed. Majority of riffle areas are exposed although small areas of largest riffles are still submerged.
6	Water covers about 25% of streambed. Riffle areas are exposed although other rock habitat is available in run areas.

Poor: Very little water in channel and mostly present as standing pools. Little or no productive habitat due to lack of water.

5	All riffles exposed. Runs extremely reduced. Very limited rock habitat available in running water.
4	All riffles exposed. Runs reduced to trickles. No rock habitat available in running water.
3	All riffles and runs exposed. Long stretches of pooled water provide some productive habitat. Stream may be flowing below surface between pools.
2	Stream reduced to isolated pools with no productive habitat.
1	Stream is dry

Comment: Use comment field to explain factors affecting the amount of water in the stream including natural (beaver activity, karst, drought etc.) and unnatural (dams, log jams at bridges, water withdrawal etc.).

6. Channel Alteration

Determine how much, if at all, the stream reach has been altered by man-made activities (not beavers). Channel alteration is the presence of artificial embankments, riprap, and other forms of artificial bank stabilization or structures; when the stream is very straight for significant distances; when dams, culverts or bridges are present; when dredging or gravel/rock removal is evident, when snags/deadfall is removed, off-road vehicle activity or livestock access has altered the bottom contours/compressed riffles and when other such artificial changes have occurred. Bridges, dams or other man-made structures upstream or downstream of the assessed reach should be considered if they affect flow patterns in the targeted reach.

Optimal: Channelization, gravel dredging, rock removal and off-road vehicle activity (past or present) absent or minimal. Stream has natural meander pattern. Shoring structures including riprap are absent. Artificial structures are not present in stream reach. Bridges, culverts, dams or other structures upstream or downstream are not affecting the stream reach.

20	Stream has never been channelized and there are no artificial structures in stream reach or within impact area of reach. There is no evidence of past or present gravel dredging or rock removal. There is no evidence of off-road vehicle activity or livestock entry. Stream has normal meander pattern.
19	Stream has never been channelized and there are no artificial structures in stream reach or within impact area of reach. Evidence of past rock removal is minimal. There is no evidence of gravel/sand dredging, 4-wheel activity or livestock access. Stream flow pattern and habitat not affected.
18	Stream has never been channelized and there are no artificial structures in stream reach or within impact area of reach. Evidence of past gravel/sand dredging is minimal. There is no evidence of 4-wheel activity or livestock access. Stream flow pattern and habitat not affected.
17	Past channel alteration in small area (less than 5% of reach). Stream flow pattern not affected. Modification is stable, well vegetated with natural vegetation, no erosion potential. There are no artificial structures in stream reach or within impact area. There is no evidence of 4-wheel activity or livestock access
16	Evidence of past 4-wheel vehicle activity or livestock access. Riffle and run areas intact, stream contours not affected. Artificial structures may be present outside of the reach but are not affecting the flow patterns, habitat or stream contours within reach.

Suboptimal: Evidence of channelization, dredging and/or 4-wheel activity or livestock access up to 40%. May be longer reach if channelization is historic). Channel has stabilized and altered flow pattern does not affect colonization. Bridges, culverts, shoring or other artificial structures either within or outside of reach have not affected natural flow patterns.

15	Historic channelization has stabilized (May also include pre-civil war rock walls.) Modification is stable, well vegetated with natural vegetation and no erosion potential.
14	Bridge, culverts, shoring or artificial structures may be present but do not affect natural flow patterns in reach. (Includes structures upstream or downstream as well as within reach).
13	Recent off-road vehicle activity or significant livestock access in stream. Riffle or run areas slightly disturbed. Natural stabilization and re-colonization expected.
12	Evidence of recent rock removal or gravel/sand dredging has had slight impact on reach. Natural stabilization and re-colonization is expected.
11	New channelization in up to 40% of stream reach. Modification is stable, well vegetated with natural vegetation, no erosion potential. (If not stable score 10)..

Marginal: Channelization, dredging or 4-wheel activity or livestock access 40 to 80% or less amount of channelization that has not stabilized or Bridges, culverts, shoring or other artificial structures either within or outside of reach may have slightly affected natural flow patterns.

10	Less than 40% of reach altered but has not stabilized.
9	40 - 80% of reach has been channelized but is stable with natural vegetation.
8	Bridge, culverts, shoring or artificial structures have slight effect on natural flow patterns in reach. (Includes structures upstream or downstream as well as within reach).
7	Dredging, rock removal, 4-wheeling, livestock access or other in-stream activity has impacted habitat in 40 - 80% of reach.
6	6 – 40 - 80% of reach has been altered and has not stabilized.

Poor: Over 80% of the stream reach channelized, dredged or affected by off-road vehicles or livestock activity, Instream habitat greatly altered or removed entirely or artificial structures within reach or upstream/downstream of reach have greatly affected natural flow patterns.

5	Over 80% of the stream reach is channelized and has not stabilized.
4	Over 80% of the stream reach is channelized and has been stabilized with artificial shoring.
3	Over 80% of the stream reach is channelized and has not stabilized.
2	Impoundment, bridge or other artificial structure has a high level of impact on normal stream flow and/or channel pattern. Include upstream or downstream structures that have seriously affected the sample reach.
1	At least part of stream reach is in concrete or other artificial channel (including culverts).

Comment: Use comment field to indicate type of channel alteration (channelization, man-made dams, 4-wheel activity, construction vehicles). Also make note if beaver activity has altered stream (this is a natural condition so would score 20 if there are no artificial modifications but needs to be noted).

7. Frequency of Riffles, Bends or Other Re-Oxygenation Zones

Determine the pattern of stream morphology by estimating the sequencing of riffles. This is the only parameter where the hydrologic (not biological) definition of riffle will apply. Any swift moving re-oxygenation zones count, including bedrock riffles, large boulders, and bends. These areas provide diversity of habitat, control flow and provide refugia during storm events as well as re-oxygenate the water. To score this parameter, a longer segment may need to be incorporated into the evaluation if there are not at least 3 re-oxygenation areas within the sample reach. It may be necessary to pace off or measure distances. In larger streams where bends are the only re-oxygenation areas, maps/aerial photos may be used to determine frequency. Frequency will determine the condition category. Quality of habitat provided will determine the rank within the category.

Optimal: Occurrence of re-oxygenation zones relatively frequent. Distance between areas divided by average width of the stream <7:1.

20	Re-oxygenation areas are high quality cobble small boulder riffles.
19	Re-oxygenation areas are high quality gravel riffles
18	Re-oxygenation areas are not high quality cobble/gravel riffle but provide productive habitat (may include cobble runs or lower quality cobble riffles).
17	Re-oxygenation areas are primarily bedrock, large boulder or other relatively unproductive habitat.
16	Re-oxygenation areas are bends.

Suboptimal: Occurrence of re-oxygenation zones infrequent; distance between areas divided by average width of the stream is from 7 to 15.

15	Re-oxygenation areas are high quality cobble/small boulder riffles.
14	Re-oxygenation areas are high quality gravel riffles.
13	Re-oxygenation areas are not high quality cobble/gravel riffle but provide productive habitat (may include cobble runs or lower quality cobble riffles).
12	Re-oxygenation areas are primarily bedrock, large boulder or other relatively unproductive habitat.
11	Re-oxygenation areas are bends.

Marginal: Occasional re-oxygenation area. Distance between areas divided by average width of the stream is over 15 and up to 25.

10	Re-oxygenation areas are high quality cobble/small boulder riffles.
9	Re-oxygenation areas are high quality gravel riffles.
8	Re-oxygenation areas are not high quality cobble/gravel riffle but provide productive habitat (may include cobble runs or lower quality cobble riffles).
7	Re-oxygenation areas are primarily bedrock, large boulder or other relatively unproductive habitat.
6	Re-oxygenation areas are bends.

Poor: Generally, all flat water or flat bedrock. Little opportunity for re-oxygenation. Distance between areas divided by average width of the stream is over 25.

5	Re-oxygenation areas are high quality cobble/small boulder riffles.
4	Re-oxygenation areas are gravel riffles.
3	Re-oxygenation areas are not high quality cobble/gravel riffle but provide productive habitat (may include cobble runs or lower quality cobble riffles).
2	Re-oxygenation areas are primarily bedrock, large boulder or other relatively unproductive habitat.
1	Re-oxygenation areas are bends.

Comments: Use comment field to describe other factors affecting the score if needed such as atypical reoxygenation areas or poor quality riffles.

8. Bank Stability

Determine whether the stream banks are eroded or have the potential for erosion. Steep banks are more likely to collapse and suffer from erosion than are gently sloping banks and are therefore considered less stable. Signs of instability include crumbling, unvegetated banks, exposed tree roots, slumping and/or exposed soil.

Each bank is evaluated separately on a scale of 0 to 10 and the cumulative score of both banks is used for this parameter. Left and right banks are determined by facing downstream. Bank stability is evaluated as bankfull height. Erosion potential in terraces may lower scores if affecting stream.

Optimal: Banks stable, evidence of erosion or bank failure absent or minimal; little potential for future problems, < 5% of the bank affected. Terrace erosion not affecting stream and no healed-over erosion.

10	No signs of instability evident. Banks sloping. Little erosion potential
9	Steep banks or some potential for erosion.

Suboptimal: Moderately stable, infrequent, small areas of erosion. 5 – 30% of bank in reach has areas of erosion or other signs of instability. Little or no erosion on terraces. May have healed over erosion.

8	More than 5% healed over erosion and no active erosion.
7	5 - 15% of bank has areas of erosion or other signs of instability. Some are not healed over.
6	20 - 30% of bank has areas of erosion or other signs of instability. If approaching 30%, score marginal if banks are steep or if eroding areas on terrace is affecting stream.

Marginal: Moderately unstable; 30-60% of bank in reach has areas of erosion or other signs of instability; high erosion potential during floods. Eroding terrace may be affecting stream.

5	30 - 40% of bank has areas of erosion or other signs of instability. If approaching 40 score lower if banks are steep or eroding terrace is affecting stream.
4	40 - 50% of bank has areas of erosion or other signs of instability. If approaching 50%, score lower if banks are steep or eroding terrace is affecting stream.
3	50 - 60% of bank has areas of erosion or other signs of instability If approaching 60%, score lower if banks are steep or sloughing or eroding terrace is affecting stream.

Poor: Unstable: many eroded areas; raw areas frequent along straight sections and bends; active bank sloughing; Over 60% of banks has areas of erosion or other signs of instability.

2	60 - 75% of bank has areas of erosion or other signs of instability.
1	80 - 90% of bank has areas of erosion or other signs of instability.
0	There are no stable areas on bank.

Comment: Use comment field if needed to describe additional factors affecting scoring.

9. Bank Vegetative Protection

Determine the type and quality of vegetation on the stream bank. This is the area from the base of the bank to the top of the bank. The object is to determine the ability of the bank to resist erosion as well as the ability of the plants to uptake nutrients, control instream scouring, supply food to shredders and provide stream shading. Streams that have various classes of native vegetation providing full natural plant growth including groundcover, shrubs, understory trees and mature trees will score highest.

In some regions, the introduction of exotics, such as kudzu, privet, multi-flora rose or honeysuckle, has virtually replaced all native vegetation. Although exotics may provide erosion control, they do not provide ideal food and habitat to stream organisms that have evolved to utilize native species. Banks that are dominated by non-native vegetation should score lower. A list of commonly encountered non-native species can be found in Appendix B. Species information, county distribution and pictures can be found at the TN Invasive Plant Control website: http://www.tnipc.org/invasive-plants/

Each bank is evaluated separately on a scale of 0 to 10 and the cumulative score of both banks is used for this parameter. Left and right banks are determined by facing downstream.

Condition category is determined by estimating the amount of bank covered by **undisturbed native vegetation**. Rank is determined by complexity of vegetation type.

Optimal: More than 90% of the streambank surfaces and immediate riparian zone covered by undisturbed vegetation. All four classes (mature trees, understory trees, shrubs, groundcover) are represented. All plants allowed to grow naturally. All plants are native.

10	No disruption. All classes of vegetation (mature trees, understory trees, shrubs, groundcover) are represented and allowed to grow naturally.
9	Minimal disruption affecting less than 10% of stream bank. All classes of vegetation are represented and allowed to grow naturally

Suboptimal: The majority (70 - 90%) of the bank is covered by undisturbed native vegetation. One class may not be well represented. Disruption evident but not affecting full plant growth. Non-native vegetation may be present but rare (< 30%).

8	Over 90% of bank area covered by native vegetation but one class not well represented.
7	70-90% of bank area covered by native vegetation. All classes of vegetation (mature trees, understory trees, shrubs, groundcover) are well represented and allowed to grow to full height.
6	70 - 90% of bank area covered by native vegetation but one class not well represented. Other classes allowed to grow to full height.

Marginal: 50 - 70% of the bank covered by undisturbed vegetation. Non-native vegetation may be common (30 - 50%). Two classes of vegetation may not be well represented.

5	All classes of vegetation (mature trees, understory trees, shrubs, groundcover) are represented. If approaching 70% score suboptimal 7 if all vegetation allowed to grow to full height.
4	One class of vegetation not well represented or not allowed to grow to full height. If approaching 70% score suboptimal 6 if all vegetation is native and allowed to grow to full height.
3	Two classes of vegetation not well represented or not allowed to grow to full height or non-native vegetation is common.

Poor: Less than 50% of the bank is covered by undisturbed vegetation or more than two classes of vegetation are not well represented or most vegetation has been cropped. Non-native vegetation may be dominant (> 50%).

2	Vegetation that is present is mostly native and allowed to grow to full height.
1	Most vegetation is not allowed to grow to full height or is non-native.
0	Bank vegetation is absent or too sparse to provide bank protection or habitat.

Comment: Use the comment field to describe what class of plants are missing and/or describe exotic plants.

10. Riparian Vegetative Zone Width

Estimate the width of natural vegetation from the top of the stream bank out through the riparian zone (approximately 18 yards). Disturbance to the riparian zone occurs when there are roads, parking lots, fields, row crops, lawns, parks, bare soil, buildings, logging, campgrounds, golf courses or other human activity.

Each bank is evaluated separately on a scale of 0 to 10 and the cumulative score of both banks is used for this parameter. Left and right banks are determined by facing downstream.

Condition category is determined by estimating the width of the riparian zone from the top of the stream bank, outward. Generally, the riparian ends at first indication of human disturbance with the exception of un-paved footpaths or trails in an otherwise undisturbed riparian.

Scoring within the category should be based on the level of impact the disturbance has. For example, un-grazed fields would score higher than active fields. Lawns would score higher than paved areas.

Paths, and walkways in an otherwise undisturbed riparian zone may be judged to be minimal disturbance if they are narrow, unpaved and show no evidence of erosion. They should not affect condition category but should lower score one point within category.

Optimal: Average width of riparian > 18 yards throughout reach.

10	There is no human disturbance
9	Human disturbance minimal, for example, an un-paved footpath.

Sub-optimal: Average width of riparian 12 – 18 yards throughout reach.

8	Human disturbance, after 12 yards of undisturbed riparian is minimal, for example an un-grazed hay field or areas of riparian that are less than 18 yards are small.
7	Human disturbance, after 12 yards is vegetated but has frequent use or is close cropped. For example lawns, golf-courses, row crops, active pasture.
6	Human disturbance, after 12 yards is not vegetated, for example paved or gravel lots, roads, bare dirt.

Marginal: Average width of riparian 6 – 11 yards throughout reach.

5	Human disturbance, after 6 yards of undisturbed riparian is minimal, for example an un-grazed field, or areas that are less than 12 yards are small.
4	Human disturbance, after 6 yards is vegetated but has frequent use or is close cropped. For example lawns, golf-courses, row crops, active pasture.
3	Human disturbance, after 6 yards is not vegetated, for example paved or gravel lots, roads, bare dirt.

Poor: Average width of riparian < 6 yards throughout reach.

2	Human disturbance is minimal, for example an un-grazed field or areas that are less than 6 yards are small.
1	Human disturbance is vegetated but has frequent use or is close cropped. For example lawns, golf-courses, row crops, active pasture.
0	Human disturbance has removed all vegetation, for example paved or gravel lots, roads, bare dirt.

Comment field: Indicate type of disturbance and any additional factors affecting score.

Protocol D-2: Low Gradient Habitat Assessment Field Sheet

The low gradient habitat field sheet (Appendix B) is used for low gradient streams. This will include streams in ecoregions 65abei, 73ab and 74b in west Tennessee as well as some streams in ecoregion 71i in middle Tennessee. This assessment may also be appropriate in lower reaches of larger streams in other ecoregions.

1. Epifaunal Substrate/Available Cover

When assessing this parameter, look at various types of natural structures available to macroinvertebrates and/or fish throughout the entire reach. Only count productive habitats which are those that provide a niche for colonization by macroinvertebrates or fish. Look for habitat that provides refugia, feeding, spawning or nursery functions. Do not count newly fallen trees, leaf litter that is not decaying or unstable habitats that will be washed out. Also do not include artificial habitat such as fish attractors, tires, appliances, rip-rap etc.

Habitats that are generally found in low gradient streams include:

- Undercut banks
- Submerged roots
- Macrophyte beds
- Submerged trees (not new fall)
- Snags
- Decaying leaf litter
- Run rocks
- Pool Rocks
- Gravel riffles
- Sediment
- Bedrock fissures

To assign a condition category, first look at how much of the stream reach is covered by natural, stable, productive habitat. The numeric score (rank) within the condition category is assigned based on the variety and quality of the habitat. Variations in habitat that provide niches for different faunal types should be considered as different habitat types. For example, undercut banks with submerged tree roots should be considered separate from undercut banks with fine grassy roots.

Habitat that is not of sufficient quantity to provide faunal populations, does not show evidence of colonization (such as newly fallen leaves), is not productive (such as shifting sand) or is likely to wash out should not be included. Artificial structures such as rip-rap are also not included since the goal is to evaluate natural habitat.

Optimal – Over 50% of the stream reach has natural, stable habitat available for colonization by macroinvertebrates and/or fish. Three or more productive habitats are present. Deadfall, leaf litter, snags etc. are not new-fall but show evidence of decay. If less than three habitats are present drop to suboptimal.

20	Deadfall and snags are the dominant habitat. At least two other habitats are available.
19	Rooted banks are the dominant habitat. At least two other habitats are available.
18	Macrophyte beds are the dominant habitat. At least two other habitats are available.
17	Leaf litter is the dominant habitat. At least two other habitats are available.
16	Another habitat is dominant. At least two other habitats are available

Suboptimal – Natural stable habitat covers 30 - 50% of stream reach or less than three habitats are present. If nearing 30% and only one habitat is present, drop to marginal.

15	Deadfall and snags are the dominant habitat
14	Rooted banks are the dominant habitat.
13	Macrophyte beds are the dominant habitat.
12	Leaf litter is the dominant habitat.
11	Another habitat is dominant.

Marginal – Natural stable habitat covers 10 – 30% of the stream reach. Availability less than desirable, substrate frequently disturbed or removed. Habitat diversity is reduced. If nearing 10% and only one habitat is available, drop to poor.

10	Deadfall and snags are the dominant habitat
9	Rooted banks are the dominant habitat.
8	Macrophyte beds are the dominant habitat.
7	Leaf litter is the dominant habitat.
6	Another habitat is dominant.

Poor – Less than 10% stable habitat or 10% and only one habitat available. Lack of habitat is obvious; substrate unstable or lacking.

5	Rooted banks are the dominant habitat
4	Deadfall and snags are the dominant habitat
3	Macrophyte beds are the dominant habitat
2	Leaf litter or another habitat is dominant
1	Habitat is lacking.

Comments: Use comment line to indicate what habitats are noticeably missing, or describe any additional factors which could affect interpretation of the score.

2. Channel Substrate Characterization (replaces Pool Substrate Characterization)

Evaluate the type and condition of the bottom substrate in the channel. Firmer sediment such as gravel, firm sand, and rooted aquatic plants support a wider variety of organisms and should be scored higher than a substrate dominated by soft sand, mud or bedrock with no plants. In addition, a stream that has a uniform substrate will support fewer types of organisms and should score lower than a stream that has a variety of substrate type. Root mats for this parameter are those anchored in the bottom substrate of the channel and should not be confused with rooted undercut banks with grass or trailing tree roots. Firm sand is desirable while soft sand will score lower. Fissured bedrock with crevices and rock shelves will score higher than smooth bedrock.

The type of substrate will determine the condition category. Rank within the category will be based on the ratio of substrate type.

Optimal – Good mixture of substrate materials with gravel and firm sand prevalent. Root mats and submerged vegetation are common.

20	Even mix of gravel and firm sand. Both root mats and submerged vegetation are common.
19	Mixture of substrate including firm sand. Gravel is dominant. Both root mats and submerged vegetation are common.
18	Mixture of substrate including firm sand. Gravel is dominant. Either root mats or submerged vegetation is missing.
17	Mixture of substrate including gravel. Firm sand is dominant. Both root mats and submerged vegetation are common.
16	Mixture of substrate including gravel. Firm sand is dominant. Either root mats or submerged vegetation is missing

Suboptimal - Mixture of soft sand, mud or clay. Substrate may also be fissured bedrock. Some root mats and submerged vegetation present.

15	Mixture of soft sand, mud and clay. No substrate dominant. Both root mats and submerged vegetation present.
14	Mixture of soft sand, mud and clay, mud dominant. Both root mats and submerged vegetation present.
13	Mixture of soft sand and mud, mud dominant. Either root mats or submerged vegetation is missing.
12	Mixture of soft sand and clay or substrate is fissured bedrock with frequent fissures and shelves. Some root mats and submerged vegetation present.
11	Mixture of soft sand and clay or substrate is fissured bedrock with frequent fissures and shelves. Either root mats or submerged vegetation is missing.

Marginal – All mud, clay or soft sand bottom; substrate may also be fissured bedrock; little or no root mat; no submerged vegetation present.

10	Mud bottom, some root mat present.
9	Soft Sand bottom, some root mat present.
8	Clay bottom, some root mat present.
7	Mud or fissured bedrock bottom, no root mat present.
6	Soft sand or clay bottom, no root mat present.

Poor – Hard-pan clay, conglomerate or flat bedrock; no root mat or vegetation.

5	Predominantly flat bedrock, other non-bedrock substrate available.
4	Predominantly flat bedrock, infrequent crevices and/or shelves provide some habitat.
3	Predominantly conglomerate substrate.
2	Predominantly flat bedrock substrate.
1	Predominantly hard-pan clay substrate.

Comments: Use comment field if needed to clarify scoring or describe substrate.

3. Pool Variability

Rate the overall mixture of pool types found in the stream, according to size and depth (this will vary depending on the size of the stream). The four basic types of pools are large-shallow, large-deep, small-shallow, and small-deep. A stream having many different pool types will support a wider variety of aquatic species and should score higher. The variety of pool types will determine condition category. The quality of these pools will determine rank within the category. If a continuous run, look for bar formation or other natural features that break up the flow.

Optimal: Even mix of large-shallow, large–deep, small-shallow, small-deep pools present.

20	Some pools are at least 1 yard deep and are of sufficient length to support fish populations
19	Large-deep pools are less than 1 yard but are of sufficient size and depth to support fish populations.
18	Large-deep pools are at least 1 yard providing distinct habitat but are of insufficient length to support fish populations.
17	Smaller stream, deep pools provide distinct benthic habitat from shallow pools but are not of sufficient depth to support fish populations.
16	Although all 4 pool types are available, some may not provide distinct faunal habitat due to small stream size.

Sub-optimal: Majority of pools large-deep; very few shallow.

15	Some pools are at least 1 yard deep and are of sufficient length to support fish populations
14	Large-deep pools are less than 1 yard but are of sufficient size and depth to support fish populations.
13	Large-deep pools are at least 1 yard providing distinct benthic habitat but are of insufficient length to support fish populations.
12	Smaller stream, deep pools provide distinct benthic habitat but are not of sufficient depth to support fish populations
11	Smaller stream, deep pools though present may not provide distinct habitat.

Marginal: Shallow pools much more prevalent than deep pools.

10	Some pools are at least 1 yard deep and are of sufficient length to support fish populations.
9	Large-deep pools are less than 1 yard deep but are of sufficient size and depth to support fish populations.
8	Large-deep pools are at least 1 yard deep providing distinct habitat but are of insufficient length to support fish populations.
7	Smaller stream, deep pools are less than 1 yard deep and are of insufficient size to support fish populations but do provide distinct benthic habitat from shallow pools.
6	Smaller stream, deep pools though present may not be frequent enough or of sufficient size to provide distinct benthic habitat from shallow pools.

Poor: Majority of pools small-shallow or pools absent. Bar formations or other natural features may create changes in flow regimes.

5	Both large-shallow and small-shallow pools present.
4	Only small-shallow pools present.
3	Pools absent, although slow current areas are present.
2	Pools absent, although there are depth changes within channel
1	Channel is a continuous run with little or no changes in velocity or depth..

Comments: Use the comment field if needed for clarification or to describe atypical characteristics affecting scoring.

4. Sediment deposition

This parameter is designed to measure the changes that have occurred to the stream bottom and flow patterns as a result of the deposition of small particles (gravel, sand, silt). Bar formation indicates more bedload than the stream can carry.

Select condition category by estimating the percent of the stream bottom that is affected by sediment deposition. Areas of deposition occur in pools, bends, natural or man-made constrictions and other areas of slower flow. A naturally shifting sand substrate should not be confused with sediment deposition. A change in particle size is considered deposition (for example silt instead of sand if sand is the natural bed material). Deposition is also observable through the formation of islands, point bars (areas of increased deposition at the beginning of a meander that increase in size as the channel is diverted toward the outer bank) or shoals.

Only areas of new, unvegetated deposition on bars and islands should be considered when scoring. Established bars will have vegetation that remains after high flow events. Deposition in shifting sand streams is usually most evident in bar formations (not pool deposition). Estimate the area of unvegetated sediment bars and look for slugs of excess sand bedload (which occurs in sand bottom streams that are unable to transport and process a heavy bedload of sand material). Sediment bars may be masked if water levels are high. If pools are naturally not present, consider deposition in slower areas.

Rank within each category is determined by the areas most affected by sediment deposition. Sediment in pools or slow areas will score higher than sediment on point bars and islands.

Optimal: Sediment deposition affects less than 20% of stream bottom in quiet areas. New deposition on islands and point bars is absent or minimal.

20	No islands or point bars. No sediment in pools or slow areas.
19	No new deposition on stable islands or point bars. No sediment in pools or slow areas.
18	No new deposition on islands or point bars. Small amount of sediment in pools or slow areas.
17	Small amount of new deposition on islands or point bars. No sediment in pools or slow areas.
16	Small amount of new deposition on islands or point bars. Small amount of sediment in pools or slow areas. Up to 20% of bottom area affected. (As deposition approaches 20% if most of deposition is an increase in island or bars drop to suboptimal.)

Suboptimal: Some new increase in bar formation, mostly from gravel, sand or fine sediment (20 - 50%) of the bottom affected and/or slight deposition in pools or slow areas.

15	Sediment deposition affects 20 - 30% of the bottom substrate. Most of the deposition occurs in pools and slow areas.
14	Sediment deposition affects 20 - 30% of the bottom substrate. Most increase in bar formation possibly slight deposition in pools.
13	Sediment deposition affects 35 - 45% of the bottom substrate. Most of the deposition occurs as in pools and slow areas.
12	Sediment deposition affects 35 - 45% of the bottom substrate. Most increase in bar formation possibly slight deposition in pools.
11	Sediment deposition affects 50% of the bottom substrate. Deposition occurs primarily on pool or slow areas. If new accumulation is primarily bars and islands, drop to marginal.

Marginal: Moderate deposition of new gravel, sand or fine sediment on old and new bars 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; and/or moderate deposition of pools or slow areas prevalent.

10	Sediment deposition affects 50% of stream bottom. Sediment deposition on bars and islands as well as in pools or slow areas.
9	Sediment deposition affects 55 – 65% of stream bottom. Most of deposition is in pools or slow areas.
8	Sediment deposition affects 55 – 65% of stream bottom. Most deposition in bars and islands.
7	Sediment deposition affects 70 - 80% of the stream bottom. Most of deposition is in pools or slow areas.
6	Sediment deposition affects 70 - 80% of the stream bottom. Most sediment accumulation on bars and islands.

Poor: Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools may be almost absent due to substantial sediment deposition.

5	Approximately 85 - 90% of the bottom substrate is affected by sediment deposition. Pools heavily affected but still present or pools naturally absent.
4	Approximately 85- 90% of the bottom substrate is affected by sediment deposition. Pools absent due to sediment deposition.
3	Approximately 95% of the bottom substrate is affected by sediment deposition. Pools heavily affected but still present or pools naturally absent.
2	Approximately 95% of the bottom substrate is affected by sediment deposition. Pools absent due to sediment deposition.
1	Sediment blankets 100% of stream bottom.

Comment: Use comment field if needed to describe other factors related to score.

5. Channel Flow Status

Estimate the degree to which the channel is filled with water. Condition category will be selected based on amount of streambed covered. Rank within the category will be determined by how much productive habitat is exposed. If the stream has no habitat, score lowest rank within condition category and explain in comments. If water has been backed up by obstructions (such as beaver dam, log jams, bedrock during low flow) move assessment reach above or below the affected area or consider postponing sampling until an accurate assessment of stream conditions can be achieved.

Assess flow status based on what is submerged during normal flow conditions, for example naturally exposed gravel beds do not indicate exposed habitat. Evidence of frequent submersion may be change in color of substrate, shelves or eroded areas. Use comment field to note if flow is reduced due to natural low flow conditions, drought, irrigation, municipal water withdrawal, impoundment etc.

Optimal: Water reaches base of both lower banks throughout reach and covers stream bed. Minimal productive habitat is exposed.

20	Water is above the base of each bank and no productive habitats are exposed.
19	Roots are submerged but some undercut areas may be above water. Other productive habitats are not affected.
18	Some shallow roots are exposed but there is submerged root habitat available. Other habitats are not affected.
17	Most shallow roots are exposed, but of submerged root habitat. Other habitats are not affected.
16	Some deeper, rooted areas are partially exposed but there is plenty of submerged root habitat. Other productive habitats are not affected.

Suboptimal: Water covers more than 75% of the streambed and/or at least one productive habitat is fully submerged. If all habitat is mostly exposed, move to marginal, if all habitat is exposed, move to poor.

15	Some submerged rooted areas are totally exposed although the habitat is still plentiful. Other productive habitats are present and not affected.
14	Most root habitat is exposed. Other productive habitats are available. If other habitats ae not available drop to marginal.
13	All root habitat is exposed. Other productive habitats are available and are fully submerged
12	Other near-shore habitat such as macrophyte beds is partially exposed. Mid channel habitats such as fallen trees are available for full colonization.
11	Other near shore habitat not available. Mid-channel habitats such as fallen trees are available for full colonization. If almost 25% of channel is exposed drop to marginal.

Marginal: Water covers 25% - 75% of the streambed, and/or productive habitat is mostly exposed. All near-shore habitat is exposed.

10	Waters covers about 75% of streambed. Mid channel habitats are available and not affected. If mid-channel habitats are not present drop to poor.
9	Water covers 60 – 70% of streambed. Some mid channel habitat such as fallen trees and snags are compromised but still available for full colonization.
8	Water covers about 50% of streambed. Most mid channel habitat is partially exposed limiting colonization.
7	Water covers 30 – 40% of streambed. Most habitat is fully exposed, at least one productive habitat available for limited colonization.
6	Water covers about 25% of streambed. Isolated areas of productive habitat.

Poor: Very little water in channel and mostly present as standing pools. Little or no productive habitat due to lack of water.

5	Very little flow evident. Isolated patches of productive habitat.
4	Very little flow evident. Remaining habitat is un-productive
3	Water reduced to standing pools. Isolated patches of productive habitat.
2	Water reduced to standing pools. No productive habitat.
1	Stream is dry.

Comment: Use comment field to explain factors affecting the amount of water in the stream including natural (beaver activity, karst, drought etc.) and unnatural (man-made dams, log jams at bridges, water withdrawal etc.). Also, use comment field to indicate if there is naturally no productive habitat which would affect ranking within category.

6. Channel Alteration

Determine how much, if at all, the stream reach has been altered by man-made activities (not beavers). Channel alteration is present when artificial embankments, riprap, and other forms of artificial bank stabilization or structures are present; when the stream is very straight for significant distances; when dams, culverts or bridges are present; when dredging or gravel/rock removal is evident, when snags/deadfall is removed, 4-wheel activity or livestock access has altered the bottom contours/compressed riffles and when other such artificial changes have occurred. Bridges, dams or other man-made structures upstream or downstream of the assessed reach should be considered if they affect flow patterns in the targeted reach.

Optimal: Channelization, dredging, 4-wheel activity or livestock access (past or present) absent or minimal. Stream has normal meander pattern. Shoring structures including riprap are absent. Artificial structures are not present in stream reach. Bridges, culverts, dams or other structures upstream or downstream are not affecting the stream reach.

20	Stream has never been channelized and there are no artificial structures in stream reach or within impact area of reach. There is no evidence of past or present dredging or rock removal. There is no evidence of 4-wheel activity or livestock activity. Stream has normal meander pattern.
19	Stream has never been channelized and there are no artificial structures in stream reach or within impact area of reach. Evidence of past rock removal. There is no evidence of gravel/sand dredging, 4-wheel activity or livestock activity. Stream flow pattern and habitat not affected.
18	Stream has never been channelized and there are no artificial structures in stream reach or within impact area of reach. Evidence of past gravel or sand dredging. There is no evidence of 4-wheel activity or livestock activity. Stream flow pattern and habitat not affected.
17	Past channel alteration in small area (less than 5% of reach). Stream flow pattern not affected. Modification is stable, well vegetated with natural vegetation, no erosion potential. There are no artificial structures in stream reach or within impact area.
16	Evidence of recent 4-wheel activity or livestock access. In-stream habitat, stream contours and banks not affected. Artificial structures may be present outside of the reach but are not affecting the flow patterns, habitat or stream contours within reach.

Suboptimal: Channelization, dredging 4-wheel activity or livestock activity up to 40%. May be longer reach if channelization is historic (older than 50 years). Channelization has stabilized and altered flow pattern does not affect colonization. Bridges, culverts, shoring or other artificial structures either within or outside of reach have not affected natural flow patterns.

15	Historic channelization has stabilized. Modification is stable, well vegetated with natural vegetation and no erosion potential
14	Bridge, culverts, shoring or artificial structures may be present but do not affect natural flow patterns in reach. (Includes structures upstream or downstream as well as within reach.)
13	Recent off-road vehicle or livestock activity in stream. Channel substrate slightly disturbed. Natural stabilization and re-colonization expected.
12	Evidence of recent rock removal or gravel/sand dredging has had slight impact on reach. Natural stabilization and re-colonization is expected.
11	New channelization in up to 40% of stream reach. Modification is stable, well vegetated with natural vegetation, no erosion potential. (If not stable, score 10.)

Marginal: Channelization, dredging livestock access or 4-wheel activity 40 - 80% or less amount of channelization that has not stabilized. Bridges, culverts, shoring or other artificial structures either within or outside of reach may have slightly affected natural flow patterns.

10	Less than 40% of reach altered but has not stabilized.
9	40 - 80% of reach has been recently been channelized but is stable with natural vegetation.

8	Bridge, culverts, shoring or artificial structures have slight effect on natural flow patterns in reach. (Includes structures upstream or downstream as well as within reach.)
7	Dredging, rock removal, 4-wheeling, livestock or other in-stream activity has impacted habitat in 40 - 80% of reach.
6	40 - 80% of reach has been altered and has not stabilized.

Poor: Over 80% of the stream reach channelized, dredged or affected by 4-wheel activity or livestock. Instream habitat greatly altered or removed entirely or artificial structures within reach or upstream/downstream of reach have greatly affected natural flow patterns.

5	Over 80% of the stream reach has been channelized but is stable with natural vegetation.
4	Over 80% of the stream reach is channelized and has been stabilized with artificial shoring
3	Over 80% of the stream reach is channelized and has not stabilized.
2	Impoundment, bridge or other artificial structure has a high level of impact on normal stream flow and/or channel pattern. Include upstream or downstream structures that have substantially affected the sample reach.
1	At least part of stream reach is in concrete or other artificial channel (including culverts).

Comment: Use comment field to indicate type of channel alteration (channelization, man-made dams, 4-wheel activity, livestock access etc.) and to explain any score adjustments. Also make note if beaver activity has altered stream (this is a natural condition so would score 20 if there are no artificial modifications but needs to be noted).

7. Channel Sinuosity

Evaluate the meandering or sinuosity of the stream. This includes streams have created a new a meander pattern within an older channel. A high degree of sinuosity provides diverse habitat for macroinvertebrates and the stream is better able to handle surges when the flow fluctuates due to rain events. **To estimate this parameter, a longer segment or reach than that designated for the sampling should be incorporated into the evaluation. This will vary by site, but should include at least 2 bends. Maps may be used to estimate the sinuosity of larger streams where field evaluations are not practical.**

The amount the meanders increase stream length determines the condition category. The quality of the meander (whether additional macroinvertebrate or habitat is provided) determines the rank.

Optimal – The bends in the stream increase the stream length 3-4 times longer than if it was in a straight line.

20	Stream meander increases stream length more than 4 times longer than a straight line.
19	Stream meander increases stream length 4 times longer than a straight line.

18	Stream meander increases stream length 3.5 times longer than a straight line. Bends provide productive macroinvertebrate habitat.
17	Stream meander increases stream length 3.5 times longer than a straight line. Bends do not provide additional macroinvertebrate habitat.
16	Stream meander increases stream length 3 times longer than a straight line. Bends provide productive macroinvertebrate habitat.

Suboptimal - The bends in the stream increase the stream length 2-3 times longer than if it was in a straight line.

15	Stream meander increases stream length 3 times longer than a straight line. Bends do not provide additional macroinvertebrate habitat.
14	Stream meander increases stream length 2.5 times longer than a straight line. Bends provide productive macroinvertebrate habitat.
13	Stream meanders increase stream length 2.5 times longer than a straight line. Bends do not provide additional macroinvertebrate habitat.
12	Stream meander increases stream length 2 times longer than a straight line. Bends provide productive macroinvertebrate habitat.
11	Stream meander increases stream length 2 times longer than a straight line. Bends do not provide additional macroinvertebrate habitat.

Marginal – The bends in the stream increase the stream length 1-2 times longer than if it was in a straight line.

10	Stream meander increases stream length 2 times longer than a straight line. Bends provide additional macroinvertebrate habitat..
9	Stream meander increases stream length 1.5 times longer than a straight line. Bends provide productive macroinvertebrate habitat.
8	Stream meanders increase stream length 1.5 times longer than a straight line. Bends do not provide additional macroinvertebrate habitat.
7	Stream meander increases stream length 1 times longer than a straight line. Bends provide productive macroinvertebrate habitat
6	Stream meander increases stream length 1 times longer than a straight line. Bends do not provide additional macroinvertebrate habitat.

Poor – Channel straight; waterway has been channelized for a long distance.

5	Straight channel offset by some slight curves which, not meanders, do serve to provide some habitat and some energy dissipation during surges.
4	Straight channel with more than one slight curve.
3	Straight channel with a single slight curve.
2	Straight channel with no curves but some bank indentations providing habitat. (Stable indentations not subject to erosion).
1	Channel completely straight with no curves or stable indentations.

Comments: Use comment field if necessary to describe any other factors that influenced scoring.

8. Bank Stability

Determine whether the stream banks are eroded or have the potential for erosion. Steep banks are more likely to collapse and suffer from erosion than are gently sloping banks and are therefore considered less stable. Signs of instability include crumbling, unvegetated banks, exposed tree roots, slumping and/or exposed soil.

Each bank is evaluated separately on a scale of 0 to 10 and the cumulative score of both banks is used for this parameter. Left and right banks are determined by facing downstream. Bank stability is evaluated as bankfull height. Erosion potential in terraces may lower scores if affecting stream.

Optimal: Banks are stable, evidence of erosion or bank failure absent or minimal; little potential for future problems, < 5% of the bank affected. Terrace erosion not affecting stream and no healed-over erosion.

10	No signs of instability evident. Banks sloping. Little erosion potential
9	Steep banks or some potential for erosion.

Suboptimal: Moderately stable, infrequent, small areas of erosion. 5 – 30% of bank in reach has areas of erosion or other signs of instability. Little or no erosion on terraces. May have healed over erosion.

8	More than 5% healed over erosion and no active erosion.
7	5 - 15% of bank has areas of erosion or other signs of instability. Some are not healed over.
6	20 - 30% of bank has areas of erosion or other signs of instability. If approaching 30%, score marginal if banks are steep or if eroding areas on terrace is affecting stream.

Marginal: Moderately unstable; 30-60% of bank in reach has areas of erosion or other signs of instability; high erosion potential during floods. Eroding terrace may be affecting stream.

5	30 - 40% of bank has areas of erosion or other signs of instability. If approaching 40 score lower if banks are steep or eroding terrace is affecting stream.
4	40 - 50% of bank has areas of erosion or other signs of instability. If approaching 50%, score lower if banks are steep or eroding terrace is affecting stream.
3	50 - 60% of bank has areas of erosion or other signs of instability If approaching 60%, score lower if banks are steep or sloughing or eroding terrace is affecting stream.

Poor: Unstable: many eroded areas; raw areas frequent along straight sections and bends; active bank sloughing; Over 60% of banks has areas of erosion or other signs of instability.

2	60 - 75% of bank has areas of erosion or other signs of instability.
1	80 - 90% of bank has areas of erosion or other signs of instability.
0	There are no stable areas on bank.

Comment: Use comment field if needed to describe additional factors affecting scoring.

9. Bank Vegetative Protection

Determine the type and quality of vegetation on the stream bank. This is the area from the base of the bank to the top of the bank. The object is to determine the ability of the bank to resist erosion as well as the ability of the plants to uptake nutrients, control instream scouring, supply food to shredders and provide stream shading. Streams that have various classes of native vegetation providing full natural plant growth including groundcover, shrubs, understory trees and mature trees will score highest.

In some regions, the introduction of exotics, such as kudzu, privet, multi-flora rose or honeysuckle, has virtually replaced all native vegetation. Although exotics may provide erosion control, they do not provide ideal food and habitat to stream organisms that have evolved to utilize native species. Banks that are dominated by non-native vegetation should score lower. A list of commonly encountered non-native species can be found in Appendix B. Species information, county distribution and pictures can be found at the TN Invasive Plant Control website: http://www.tnipc.org/invasive-plants/

Each bank is evaluated separately on a scale of 0 to 10 and the cumulative score of both banks is used for this parameter. Left and right banks are determined by facing downstream.

Condition category is determined by estimating the amount of bank covered by **undisturbed native vegetation**. Rank is determined by complexity of vegetation type.

Optimal: More than 90% of the streambank surfaces and immediate riparian zone covered by undisturbed vegetation. All four classes (mature trees, understory trees, shrubs, groundcover) are represented. All plants allowed to grow naturally. All plants are native.

10	No disruption. All classes of vegetation (mature trees, understory trees, shrubs, groundcover) are represented and allowed to grow naturally.
9	Minimal disruption affecting less than 10% of stream bank. All classes of vegetation are represented and allowed to grow naturally

Suboptimal: The majority (70 - 90%) of the bank is covered by undisturbed native vegetation. One class may not be well represented. Disruption evident but not affecting full plant growth. Non-native vegetation may be present but rare (< 30%).

8	Over 90% of bank area covered by native vegetation but one class not well represented.
7	70-90% of bank area covered by native vegetation. All classes of vegetation (mature trees, understory trees, shrubs, groundcover) are well represented and allowed to grow to full height.
6	70 - 90% of bank area covered by native vegetation but one class not well represented. Other classes allowed to grow to full height.

Marginal: 50 - 70% of the bank covered by undisturbed vegetation. Non-native vegetation may be common (30 - 50%). Two classes of vegetation may not be well represented.

5	All classes of vegetation (mature trees, understory trees, shrubs, groundcover) are represented. If approaching 70% score suboptimal 7 if all vegetation allowed to grow to full height.
4	One class of vegetation not well represented or not allowed to grow to full height. If approaching 70% score suboptimal 6 if all vegetation is native and allowed to grow to full height.
3	Two classes of vegetation not well represented or not allowed to grow to full height or non-native vegetation is common.

Poor: Less than 50% of the bank is covered by undisturbed vegetation or more than two classes of vegetation are not well represented or most vegetation has been cropped. Non-native vegetation may be dominant (> 50%).

2	Vegetation that is present is mostly native and allowed to grow to full height.
1	Most vegetation is not allowed to grow to full height or is non-native.
0	Bank vegetation is absent or too sparse to provide bank protection or habitat.

Comment: Use the comment field to describe what class of plants are missing and/or describe exotic plants.

10. Riparian Vegetative Zone Width

Estimate the width of natural vegetation from the top of the stream bank out through the riparian zone (approximately 18 yards). Disturbance to the riparian zone occurs when there are roads, parking lots, fields, row crops, lawns, parks, bare soil, buildings, logging, campgrounds, golf courses or other human activity.

Each bank is evaluated separately on a scale of 0 to 10 and the cumulative score of both banks is used for this parameter. Left and right banks are determined by facing downstream.

Condition category is determined by estimating the width of the riparian zone from the top of the stream bank, outward. Generally, the riparian ends at first indication of human disturbance with the exception of un-paved footpaths or trails in an otherwise undisturbed riparian.

Scoring within the category should be based on the level of impact the disturbance has. For example, un-grazed fields would score higher than active fields. Lawns would score higher than paved areas.

Paths, and walkways in an otherwise undisturbed riparian zone may be judged to be minimal disturbance if they are narrow, unpaved and show no evidence of erosion. They should not affect condition category but should lower score one point within category.

Optimal: Average width of riparian > 18 yards throughout reach.

10	There is no human disturbance
9	Human disturbance minimal, for example, an un-paved footpath.

Sub-optimal: Average width of riparian 12 – 18 yards throughout reach.

8	Human disturbance, after 12 yards of undisturbed riparian is minimal, for example an un-grazed hay field or areas of riparian that are less than 18 yards are small.
7	Human disturbance, after 12 yards is vegetated but has frequent use or is close cropped. For example lawns, golf-courses, row crops, active pasture.
6	Human disturbance, after 12 yards is not vegetated, for example paved or gravel lots, roads, bare dirt.

Marginal: Average width of riparian 6 – 11 yards throughout reach.

5	Human disturbance, after 6 yards of undisturbed riparian is minimal, for example an un-grazed field, or areas that are less than 12 yards are small.
4	Human disturbance, after 6 yards is vegetated but has frequent use or is close cropped. For example lawns, golf-courses, row crops, active pasture.
3	Human disturbance, after 6 yards is not vegetated, for example paved or gravel lots, roads, bare dirt.

Poor: Average width of riparian < 6 yards throughout reach.

2	Human disturbance is minimal, for example an un-grazed field or areas that are less than 6 yards are small.
1	Human disturbance is vegetated but has frequent use or is close cropped. For example lawns, golf-courses, row crops, active pasture.
0	Human disturbance has removed all vegetation, for example paved or gravel lots, roads, bare dirt.

Comment field: Indicate type of disturbance and any additional factors affecting score.

Habitat Scoring

Total the 10 habitat parameters and compare the score to the appropriate season and drainage are in the Habitat Assessment Guidelines (Table 3) to determine whether the habitat is capable of supporting a healthy benthic community. If score is low indicate whether this is a result of natural conditions (such as drought or beaver activity) or is the result of human disturbance. Write a brief description in space provided. (If more room is needed attach another sheet).

Sometimes it may be useful to evaluate individual parameters in addition to the total habitat score. For example, even if the total habitat score meets regional guidelines, the individual parameters of embeddedness and sediment deposition may be low indicating a problem with sedimentation. Likewise, there may be a problem with riparian removal even though habitat scores meet regional guidelines. On the other hand, a low total score may not indicate a habitat problem if the channel flow status and velocity depth regime score low in a region where reference streams have extremely reduced flow during the summer and fall.

Appendix A provides ecoregion specific expectations for each parameter on the Habitat guidelines field sheet.

Never use words such as supporting or non-supporting on habitat or any other forms including comments. That is an assessment decision based on many factors, not score alone.

Table 3: Habitat Assessment Guidelines

Values listed below are considered to meet regional guidelines. Guidelines are based on 75% of median reference value, adjusted up to lowest habitat score passing TMI in each ecoregion.

Ecoregion	Habitat Type	Streams > 2.5 sq. mile drainage		Headwater Streams ≤ 2.5 sq. mile drainage	
		Jan-June	July-Dec	Jan-June	July-Dec
65abei	Low Grad.	>109	≥ 98	>107	≥ 111
65j	High Grad.	≥ 148	≥ 169	≥ 152	≥ 157
66d	High Grad.	≥ 157	≥ 158	≥ 146	≥ 157
66e	High Grad.	≥ 158	≥ 152	≥ 143	≥ 148
66f	High Grad.	≥ 135	≥ 136	≥ 148	≥ 140
66g	High Grad.	≥ 140	≥ 140	≥ 150	≥ 124
66j	High Grad.	≥ 145	≥ 139	≥ 115	≥ 132
67f	High Grad.	≥ 131	≥ 128	≥ 133	≥ 123
67g	High Grad.	≥ 106	≥ 103	≥ 136	≥ 129
67h	High Grad.	≥ 156	≥ 148	≥ 125	≥ 146
67i	High Grad.	≥ 114	≥ 117	≥ 114	≥ 117
68a	High Grad.	≥ 135	≥ 145	≥ 139	≥ 128
68b	High Grad.	≥ 124	≥ 129	≥ 137	≥ 143
68c	High Grad.	≥ 131	≥ 124	≥ 163	≥ 155
69d	High Grad.	≥ 133	≥ 123	≥ 134	≥ 123
69e	High Grad.	≥ 127	≥ 122	≥ 151	≥ 136
71e	High Grad.	≥ 113	≥ 114	≥ 145	≥ 130
71f	High Grad.	≥ 126	≥ 123	≥ 129	≥ 126
71g	High Grad.	≥ 126	≥ 128	≥ 119	≥ 149
71h	High Grad.	≥ 115	≥ 114	≥ 132	≥ 123
71i	High Grad.	≥ 112	≥ 99	≥ 113	≥ 114
71i	Low Grad.	≥ 106	≥ 114	>100	NA
73a	Low Grad.	≥ 118	≥ 118	≥ 106	≥ 106
74a	High Grad.	≥ 124	≥ 122	≥ 108	≥ 116
74b	Low Grad.	≥ 108	≥ 108	≥ 134	≥ 113

Protocol E – Stream Survey Field Sheet

The stream survey field sheet must be completed every time a biological sample is collected. The field sheet is completed using the SS2 tab on electronic e-Forms (BioForm for DWR/TDH staff or Stream Survey and Habitat Sheet for other stakeholders). Form updates and instructions (BSERT) are sent to EFOs and lab biologists in July and updated on the DWR publications page at the beginning of each fiscal year. They are also accessible to staff on SharePoint PAS website in the electronic forms folder.
https://tennessee.sharepoint.com/sites/environment/DWR/PAS/PAS/

Consultants and other agencies reporting biological data to DWR can download the electronic Bioform and guidance under the QSSOP Procedure for Macroinvertebrate Stream Surveys Field Stream Survey and Habitat Sheet link on the TDEC publication page (Water Quality Assessment Publications) https://www.tn.gov/environment/program-areas/wr-water-resources/water-quality/water-quality-reports---publications.html

The BioForm will generate an Excel spreadsheet that should be uploaded to Waterlog/Hydra by EFO or TDH lab staff within 30 days of collection. See BSERT for complete upload instructions. All others should email completed Habitat/Stream Survey workbooks to WPU biological QC staff for review and upload.

A screen shot of the electronic form can be found in Appendix B of this document, but only electronic forms should be used.

Information on the field sheet is designed to help make assessment decisions and provide supplemental information for interpreting biological sample results. Additional information, not included on the field sheet, should be added as needed to fully document field conditions at the time of the site visit. Consult all personnel present during sampling for additional observations that may have been overlooked before leaving the site.

Header Information

Header information will be filled in from the Bioevent tab on the electronic bioform (see Protocol C-1).

When Using BioForm, the header information is entered in the Bioevent tab (Protocol C-1)

1. Field Parameters

Use calibrated meters for all field measurements (protocol C)

Designate the meter's using identifying name or number that was used to make readings. The measurements for each parameter (including duplicates) are recorded in the appropriate boxes. Record the measurements in the units specified on the field sheet.

If, after the drift check, the meter was found to be off by more than 0.2 units for pH, temperature or dissolved oxygen (or more than 10% for conductivity or percent saturation), do not upload values to Waterlog/Hydra. Indicate meter problem on stream survey sheet.

Do not record values if the reading is suspect for any reason. Indicate in comment field if readings were not recorded for any reason (failing post-calibration, no meter available, air bubble, etc.)

If the value is a criteria violation, verify measurements are correct and check box that it is validated or indicate meter problem if reading is suspect (do not record value)

DWR and TDH staff will upload field parameters using Waterlog/Hydra tab on BioForm directly to the Waterlog/Hydra Chemistry staging table within 30 days.

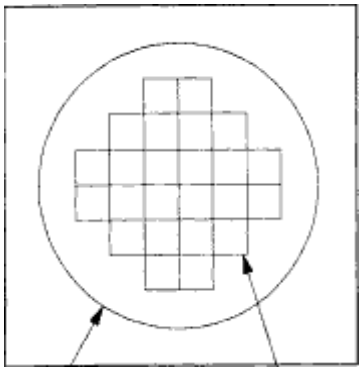
2. **Weather**

Indicate the appropriate level of precipitation for the previous 48 hours. Record approximate air temperature in Fahrenheit.

3. Physical Characteristics and Light Penetration

a. Indicate stream gradient in sample reach.
b. Estimate average stream width of reach area in yards. (This is wetted width.)
c. Estimate stream at deepest point (usually pool) in yards
d. Estimate average canopy for the entire reach and record value.
e. Measure canopy cover using a spherical densiometer mid-stream midway of the area(s) where biological samples were collected (mid-riffle if collecting one riffle, midway between two riffles if collecting multiple riffles, mid-distance between most upstream and most downstream bank sample if collecting bank jabs). The densiometer is a convex mirror etched into 24 ¼-inch boxes (Figure 9). Each box is subdivided into four smaller squares, via an imaginary dot in the center of the box, to create a total of 96 smaller squares that can be counted within the entire densiometer. Hold the densiometer one foot above the water surface. Holding the instrument at this level eliminates errors due to differing heights of samplers and different water depths and includes low overhanging vegetation more consistently than holding the densiometer at waist level. Take four measurements, facing upstream, downstream, the right descending bank, and the left descending bank. Hold the instrument far enough away from the body so that the operator's head is just outside the grid. Count the number of small squares (out of a total of 96) that have tree canopy. Record this number (number of dots **WITH** canopy cover) on the field sheet. In order to get the overall percent canopy cover for that point, sum the four measurements and divide the total by 384 and multiply by 100%. Record this number in the measured field.

Photo provided by Joellyn Brazille, Memphis EFO



Cook et al. 1995

Figure 9: Spherical Densiometer

7. **Channel Characteristics**

   a. Estimate bank height and high-water mark in yards.
   b. Select best description of bank slope for each bank. Up to four may be selected if necessary.
   c. Indicate presence of any man-made modifications. Up to four may be selected.

8. **Stream characteristics:**

   a. Sediment deposits: Select only the one that best describes the reach. Please make sure this is consistent with score on sediment deposition on habitat assessment sheet.

      - Slight is generally a light layer over most of the slow areas that affect niche space.
      - Moderate is a slightly heavier layer over most of the slow areas and possibly in runs. or infrequent heavy deposits. Niche space is starting to be affected.
      - Excessive is a deeper layer over much of substrate that substantially reduces niche space.
      - Blanket is a deep layer coating all substrates (except possibly fast riffles). Niche space is compromised.

   b. Sediment Type. Indicate up to four types of sediment deposits that are affecting the reach.

   c. Turbidity: indicate whether water is clear or select best description if turbid.

   d. Foam/Surface Sheen: Indicate whether a surface foam or sheen is present and type.

   e. Algae: Indicate level of algae through reach. Do not count moss.

      Level of algae

- Slight: Isolated pockets of algae, no effect on stream.
- Moderate: Algae may have limited effect on benthic community (feeding groups and/or reduced niche space.). Diel dissolved oxygen patterns may not be affected.
- High: Algae frequent, possible nutrient loading, probably causing diel DO swings and/or has significant effect on benthic community (feeding groups and/or niche space.)
- Choking: Algae covering most of stream, may form large mats or clumps. Excessive nutrient loading and significant diurnal DO swings indicated, Observable reduction of niche and probable change in biotic community structure.

f. Algae Type: Be careful not to include moss or duckweed
Pictural descriptions can be found at
https://www.townofchapelhill.org/home/showdocument?id=28866

- Diatoms: Generally slick coating on rocks and other hard substrate. Often brown in color.
- Green: Green algal clumps or mats that do not form long strands.
- Filamentous: Long green hair-like strands of algae attached to hard surface.
- Blue-Green: (Cyanobacteria) Appears slimy or oily. Often bright green or bluish green on or near surface of water. May be attached to rocks or other hard surfaces where it is generally darker in color.

g. Dominant Substrate**:** Select up to 4 substrate types (comprising more than 25% of stream) for each flow regime. (Note that for some monitoring projects which target stream disturbance such as ARAP permits a pebble count may be desirable to provide a more concise measure of change in substrate.)

h. Surrounding Land Use: Select up to 4 surrounding land uses that affect the immediate stream reach. Describe any other land uses under stream information.

i. Observed Human Disturbance to Stream: Indicate level of disturbance types observed in area (Up to 4 may be selected for each of the following categories.

- Slight – Minimal effect on stream even during storm events.
- Moderate – Probable effect on stream, may be slight except during storm events.+
- High - Definite effect on stream.

j. Other stream information and Additional Stressors

Describe any other conditions observed at the time of sampling. Include any changes observed from previous sampling efforts. Note anything special or unusual that would assist in assessments. Ask other team members for input. Take care not to contradict information provided on other parts of the sheet or on the habitat field sheet, for example sedimentation, erosion and algae observations.

Examples of information that should be recorded:

- Any necessary deviations to standard sampling protocol (such as collecting more than 2 kicks or banks to ensure 200 organisms in SQSH).
- Physical changes from last sampling event.
- Low abundance of organisms, dominance of early instars.
- Recent evidence of scouring.
- Clarification of human disturbances already indicated such as cattle have full access to stream or fertilizer run-off from crops.
- Additional disturbances not on the drop-down list.
- Description of any outfalls, pipes, drainage ditches etc.
- Powerline/utility line crossings
- Evidence of chemical impact such as bleaching or blackening of rocks.
- Presence of other stakeholders
- Natural disturbances such as beaver activity
- Gravel dredging

9. Photographs

A digital photographic record is to be kept on each sampling station. Photographs of the general stream condition and potential pollution sources should be taken during the original sample visit. Photographs of any changes are taken during subsequent sampling trips. Document the picture identification and a brief description on the field sheet.

Indicate photos on stream survey form with descriptions. When using e-Forms, embed photos in the stream survey sheet.

Protocol F - Biorecon (Reconnaissance/Screening)

The Biorecon method is a modification of EPA's *Rapid Bioassessment for Use in Wadeable Streams and Rivers* (Barbour et. al., 1999).

This method is a standardized screening tool used by division staff for problem identification and/or prioritizing sites for further assessment, monitoring or protection. The method is not intended for use by non-division staff for any purpose.

Because the biorecon is qualitative and involves limited data generation, its effectiveness depends largely on the experience of the biologist performing the assessment. The method is designed to be expedient and requires an experienced and well-trained biologist to be effective and defensible. For these reasons, primary samplers and taxonomists must establish the following qualifications (Adopted from TDEC DWR biorecon monitoring workgroup 2018).

a. Educational requirements specified Section I.G.
b. Completed biological credentials form (Appendix B) loaded to SharePoint: https://tennessee.sharepoint.com/sites/environment/DWR/PAS/SitePages/Home.aspx
c. Successfully pass 10 field duplicates including taxonomic identifications.
d. Successfully pass DWR taxonomic exam at either the family (qualified to collect and identify family biorecons only) or genus (qualified to collect and identify both family and genus biorecons) level (see Section II for details)

Optional Qualifications

e. Taxonomic Certification of at least 1 biologist in each EFO through the Society of Freshwater Science at the genus level for Group 1 (General Arthropods) and Group 2 (EPT) **is not required but is highly recommended.**

Taxonomic Training Opportunities:

Highlands EPT workshop when possible, especially for middle and east TN
DWR Biologist Workshop
SWPBA taxonomic workshops when offered.
Training with other EFO qualified taxonomists
Training with TDH lab taxonomists (coordinate through Watershed Planning Unit)
Other taxonomic workshops as available.
EFO staff are encouraged to contact local universities and seek out other available taxonomic training opportunities.

The biorecon is most useful in discriminating clearly impaired or non-impaired areas from those areas requiring further investigation. However, chemical samples, in-stream water quality measurements, field observations, professional expertise, estimates of taxa abundance, identification to a lower taxonomic level and/or habitat data can help clarify assessment decisions in ambiguous situations.

Biorecons cannot be compared to biocriteria or to semi-quantitative samples. Only qualitative richness biometrics which do not include measurements of relative abundance can be calculated. Metrics may be compared to the biorecon guidance derived from biorecons conducted at ecoregion reference sites (Appendix A). They are not to be used for regulatory purposes such as permit compliance.

There are occasions when a biorecon will be preferred when doing assessments. These may include:

- Streams in middle and east TN where good quality riffles are naturally not available. (For example, bedrock dominant streams with inadequate gravel seams for sampling, boulder step-pool, lower gradient where SQBANK guidelines are not developed and non-wadeable streams). Care should be taken in bedrock streams, a modified kick can be used to sample SQSH. If the only habitat sampled in a biorecon is kick, then a modified SQKICK is appropriate.
- Judgement should be used to determine if the targeted habitat would be the most productive in the absence of human disturbance. If not, a biorecon should be conducted instead of a SQSH.
- Sediment dominated streams where the riffle is the cleanest substrate due to fast flow and may represent refugia. (Conversely if a riffle is inundated by sediment to where it is no longer a high-quality riffle it should be sampled using a SQKICK.)
- Streams that are obviously impaired with extremely limited habitat (Should score a 5 or less on the biorecon.)
- Streams with a history of good SQSH scores (36 or higher) where no change is expected, and land use remains the same.

The flow charts in Protocol A, Figures 2-5 should be used when determining when biorecon sampling is appropriate.

If biorecon IDs are completed by the EFO, final ID should be uploaded to Waterlog/Hydra as soon as possible after ID completion and QC (preferably within a week if workload priorities allow). All IDs must be completed and uploaded by June 30 of the watershed sampling year so assessments can be scheduled in the fall.

Note that habitat and stream survey forms must be uploaded prior to taxa lists to create an event in Waterlog/Hydra.

See Biological Survey Electronic Reporting Tutorial (BSERT) for details on how to complete electronic field sheets and upload to Waterlog/Hydra.

If biorecons are sent to the lab for ID, the lab will upload taxa list to Waterlog/Hydra and will notify the EFO when completed. The EFO is responsible for uploading habitat, water parameters and stream surveys prior to sample delivery to the lab. (Field data should be uploaded and samples delivered to the lab within 30 days of collection.)

Biorecon Field Sheet Header and assigning log numbers.

See BSERT guidance (Biological Survey Electronic Reporting Tutorial for instructions).

Samples will automatically be assigned a Field Log Number when entered on the BioForm. If the sample is a biorecon and the voucher is identified at the EFO, Ben Sample ID (lab log number) will be assigned automatically by the electronic reporting form. If the sample is a biorecon, SQSH or periphyton that is going to the lab for analysis, the lab will assign the Ben Samp ID through their LIMs System.

Taxonomic Level

Unless this is an ecoregion or headwater reference site, either genus level or family level biorecons can be conducted. (Both genus and family must be reported at reference sites). Genus level biorecons are more sensitive but require more time and taxonomic expertise. Often family level biorecons are adequate screening tools especially when biological community is obviously diverse or highly stressed. If more sensitivity is needed, a semi-quantitative sample may be more useful than a genus level biorecon especially if richness is high, but abundance is low for pollution sensitive taxa.

On both genus and family biorecons all individuals in the following taxa groups will be combined and counted as one record for that group,

- Chironomidae
- Oligochaeta (except leeches which will be recorded separately as Hirudinida).
- Unionidae (do not retain voucher)

Do not include any semi-aquatic taxa, Curculionidae, Collembola or micro/meio-crustacea

Taxa Groups Excluded from Metric Calculations (compiled from taxa that have historically been collected by DWR). Note this is not a complete list – check the Master Taxa reference table for the most current acceptable taxa in Waterlog/Hydra when in doubt.

- Anthicidae
- Carabidae
- Chrysomelidae
- Cladocera
- Collembola
- Copepoda
- Culicidae

- Curculionidae
- Gerridae
- Gyrinidae
- Ostrocada
- Staphylinidae
- Veliidae

Select either the BRFieldFamVer or BRGenVer tab on the BioForm depending on the level of identification for the entire sample. (Note in some cases when doing a genus level biorecon, an immature or damaged individual can only be identified to family, this is still considered a genus level biorecon.) To adhere to metric calibrations, no genera should be identified on a family level biorecon even if the taxonomist is able to identify further.

The BioForm should be used for all biorecons. See BSERT for information on completing and uploading the form to Waterlog/Hydra.

Habitat Selection

Determine what habitat is available and the relative percent contribution of each habitat. Record percent habitat on the biorecon field sheet (even for those not sampled).

Select up to four of the most productive habitats for sampling a total of 4 aliquots. Only consider habitats that comprise more than 5% of the available habitat in the stream -reach. Do not split habitats (no half-jabs) – do not collect more than 4 habits. Productive habitats include riffles/swift-runs, slow-run/pool rocks, leaves, woody debris/snags, undercut banks/tree roots, macrophyte beds, and fine sediment. Estimate approximately 0.5 yards of sampling area for any habitat selected.

Proportion the selected habitats into four aliquots based on percent contribution. For example, if the selected habitats are riffle (50%), leaf packs (30%) and undercut banks (20%) the sample would be comprised of two riffle kicks, one leaf collection and one bank collection. Never sample more than four habitats and only collect a total of four aliquots. Record the number of aliquots from each habitat on the Biorecon Field Sheet.

Sample Collection

Sample selected habitat*s* using a 500 micron mesh triangular dip net (13 inches wide). Use the appropriate techniques which are described below depending on the type of habitat. Take care not to over-sample since this could skew results as reference data is calibrated to 4 aliquots from a maximum of 4 habitats.

a. Riffle/Swift-Run Kick:

Position the net on the bottom of the stream and disturb the substrate by shuffling and kicking your feet the width of the net and for approximately 0.5 yard upstream of the net. Use hands or soft brush to scrape clinging organisms off larger rocks. This is considered 1 aliquot from a riffle habitat.

b. Slow-Run and/or Pool Rock:

Select several rocks of various sizes equaling approximately 0.5 square yard of surface area in slow run and/or pool areas. Select equivalent number and size of rocks to approximate the width of the net and extending 0.5 yards. Avoid rocks that are embedded. The net should be positioned under the rock while lifting to capture escapees or place in a sieve bucket or pan before picking. This is considered 1 aliquot from a slow run rock and/or pool rock habitat.

c. Leaf Habitat (pack or accumulation):

Collect three single handfuls (baseball size) of leaves by positioning the net downstream or under the leaves, then scooping the leaves into the net by hand. (If leaves are accumulated in deep area scoop the net to collect approximately the same amount of material). Select leaves from various locations (riffle, run, and pool if possible). The leaves should be submerged and show evidence of being consumed by benthic macroinvertebrates (50% decomposition is optimal). Avoid collecting recently deposited or fully decomposed leaf litter. This is considered 1 aliquot from a leaf habitat.

d. Snags/Woody debris:

Select snags and/or woody debris that have been submerged for a relatively long period (not recent deadfall). Sample submerged woody debris by jabbing in medium-sized snag material (sticks and branches). The snag habitat may be kicked first to help dislodge organisms, after placing the net downstream of the snag. Accumulated woody material in pool areas are also considered snag habitat. A single jab is approximately the width of the net and extending 0.5 yards (skim surface area do not dig deeply into debris). Avoid sampling sediment. This is considered 1 aliquot from snag or woody debris.

e. Undercut Banks and/or Tree Roots

Select bank habitat that is undercut with submerged hanging roots or plants. Submerged tree roots that are not undercut may also be sampled. Thrust the net vigorously under the bank to dislodge clinging organisms. A single aliquot is approximately two net width jabs. Avoid digging into the sediment, as this constitutes another habitat type. This is considered one aliquot from undercut banks and/or tree roots.

f. Macrophytes

In deep water, sample aquatic plants that are rooted on the bottom of the stream by drawing the net through the vegetation from the bottom to the surface of the water. In shallow water, bump or jab the net along the bottom in the rooted area. Avoid collecting sediment if possible. Either type of macrophyte jab should not exceed 0.5 linear yards (two net widths) even if collected from multiple beds. This is considered one aliquot from macrophytes.

g. Fine sediment

Sediment is found in quiet areas of the stream. Select fine silt, sand or muck with minimal gravel. Seek areas with evidence of tunneling by burrowing macroinvertebrates. Gently skim the net through the sediment for 0.5 yard length and approximately two inches deep. This is considered one aliquot from sediment.

Sample Sorting/Identification

Picking should be done in the field (retaining vouchers for confirmation) in a well-lit area and upon a stable surface such as a camp-table, flat boulder, sand bar etc. to avoid disturbing the pan.

Vouchers are combined in one bottle, but it is helpful to pick each habitat separately to help with selecting voucher specimens since different taxa prefer different habitats. Examine large materials (rocks, leaves, sticks) for organisms and then discard. Rinse the remainder of the debris using a sieve, (or swish the net in the creek). Transfer small amounts of debris to a white pan with a little stream water for field sorting. Keep the rest of the sample submerged. Scan the debris and water for organisms.

If doing a family biorecon, record field identification (or description for later identification at field office if uncertain). Unless this is a QC site or identification is uncertain, vouchers do not need to be routinely collected for family biorecons. Vouchers of any families where ID is uncertain and complete vouchers of all taxa at 10% of sites must be collected. Vouchers should also be collected if there is a possibility that more definitive (genus level) identification may be necessary.

If doing a genus level biorecon, record field identification or description of each distinct taxon on the biorecon field sheet (so that you can recognize it back at the office). Voucher specimens of each unique taxon are required for genus level identifications. Any taxa not found on the Tennessee taxa list (Appendix C) must be sent to the lab for expert verification and inclusion in state reference collection and master taxa list

On the biorecon field sheet for both family and genus biorecons, record the relative abundance of each taxon (1, 2, 3, 4). This will help with determination of impairment in ambiguous biorecons. Indicate relative abundance for both field identification and voucher identification (if collected)

in the appropriate boxes for each taxon on the biorecon field sheet. If, after voucher identification, relative abundance cannot be estimated (for example multiple taxa were identified that were not differentiated in the field), place a 0 in the voucher box for that taxon and make a comment about abundance of family.

For reporting and upload to Waterlog/Hydra, only the Final ID and Final estimate are used.

- 1 = rare (1-3 organisms)
- 2 = common (4-9 organisms)
- 3 = abundant (10-49 organisms)
- 4 = dominate (> 50 organisms)
- 0 = uncertain (used to indicate voucher identification with uncertain abundance)

Voucher Specimens

Do not retain any threatened or endangered species or unionid clams. Check coverage to determine whether T&E species are likely in the stream reach and make sure you are able to recognize them in the field. When in doubt do not retain. Indicate in comment area of stream survey sheet identification and number of animals released. If species was not previously recorded in that stream reach complete ETW form and submit to Watershed Planning Unit. Notify Natural Areas Unit. If T&E species are inadvertently added to sample contact TWRA (and USFWS if federally listed).

a. Family level biorecons. Vouchers (of all taxa in sample) are only required at 10% of sites and any taxon where family cannot be field differentiated (for example Leuctridae/Capniidae; Baetidae/Ameletidae; Polymitarcyidae/Ephemeridae; Ephemerellidae/Leptohyphidae/Caenidae; Psychomyiidae/Polycentropodidae; Corduliidae/Libellulidae; Unionidae/Limnephilidae/Odontoceridae; or early instars).

b. Genus level biorecons. Vouchers are required at all sites. Taxa that are not included on Tennessee taxa list (Appendix C) must be sent to the lab for expert verification and inclusion in state reference collection.

Place one or more representatives of each taxon in a small bottle containing 80% ethanol. (May opt to use 90% ethanol to compensate for small amounts of organic matter and/or preserving larger taxa.) If identifying to genus level, preserve several individuals of families that commonly have multiple genera that are difficult to differentiate in the field such as Heptageniidae, Hydropsychidae, and many stonefly families. Include individuals that vary in color and/or size. Since the biorecon is designed to be a fast, screening tool, try to limit voucher specimens to a few representatives that are thought to be distinct taxa. But make sure you have enough representatives to include unique taxon. Select a few from each sampled habitat. Consult historic taxa lists from area streams to get an idea of what taxa are generally found. Fifty animals or less should be adequate in most ecoregion/stream types although up to a hundred may be necessary in

taxa rich streams. This will be easier with experience. If more definitive identifications are necessary, it would probably be more appropriate to collect a semi-quantitative sample.

Place an internal tag with the station ID, date, sampler's initials and sample type inside the bottle (Figure 10). Attach an external sample tag to the outside of the bottle (Figure 11). Internal and external tags may be printed from the tags tab in the BioForm or the BioTags workbook. Internal tags are printed on Rite in the Rain© paper and external tags are printed on Avery Weatherproof© labels on a laser printer. Alternatively, the same information can be written on the outside of the bottle using indelible ink.

DAVIS0011.6CL
COL: JEB/DRM
3/6/2022
BIORECON
Field log #: JEB0306202201

Figure 10: Example of Internal Field Tag.

Station No:	**DAVIS011.6CL**	Name:	Davis Creek	
Location:	D/S of Academy Road Branch at Speedwell Academ			
Sample:	Biorecon	Field Log #:	**JEB0306202201**	
Activity:	Sample-Routine	Project ID:	TNPR0080	
Date:	**3/6/2022**	Time:	900	
Col. By:	J. Burr/D. Murray			

Figure 11: External Tag generated by BioForm

At the EFO, check the voucher organisms using a dissecting scope for accuracy in field identification. When conducting genus level biorecons identify all taxa to genus except chironomids, oligochaetes, acari, nematodes, and nematomorphs. Whichever target taxonomic level is selected, be consistent throughout the sample. For example, do not identify EPT to genus in a family level biorecon. Record appropriate changes for field misidentifications on the biorecon field sheet and indicate relative abundance (or 0 if uncertain) for each verified taxon.

Retain voucher animals for a minimum of five years for QC purposes or in case further identification is needed at a later date. Add the name of the taxonomist, lab log number and date identified to the existing internal and external field tags (Figure 12).

Any genera identified that are not on the taxa list in Appendix C should be sent to the TDH lab for verification and inclusion in the statewide reference collection.

DAVIS0011.6CL
COL: JEB/DRM 3/6/2022
BIORECON Genera
ID: JEB 3/7/2022
Lab log JEB0306202201BG

Figure 12: Example of Internal Tag After Sample Identification

It is important that all taxonomists use the same primary keys for consistency in identification and nomenclature. Merritt, Cummins and Berg, 5th Edition, 2019 is the standard key for all insect identifications.

Biometric Calculation

Waterlog/Hydra will calculate all metrics and score each sample after the invertebrate taxa list is uploaded. Scoring tables used by Waterlog/Hydra are provided in Appendix A. Unless a sample is an ecoregion reference site, only upload the invertebrate taxa list with the lowest level of identification. If a non-reference sample is identified to genera, only upload the genera taxa list. For ecoregion reference sites (both FECO and ECO), upload both the family and genera macroinvertebrate taxa lists.

All ecoregions

a. **Taxa Richness (TR)** – The total number of distinct taxa found at a site. Do not load micro/meio-crustacea, Collembola, Curculionidae, semi-aquatic taxa such as Gerridae and Veliidae, empty caddis cases, empty mollusk shells, exuvia, non-aquatics or winged adults. Do not count unidentified genera as a separate taxon unless they are clearly a different genus (or family) than those identified. Indicate in comment field if unidentified taxa are unique and do not mark it as an excluded taxon. All chironomids are counted as one taxon for both family and genus level biorecons. (Indicate in comment whether red or non-red are more abundant.)

   On both genus and family biorecons all individuals in the following taxa groups are combined and counted as one record (either Chironomidae or Oligochaeta).

   - Chironomidae
   - Oligochaeta

   Taxa Groups Excluded from Metric Calculations (compiled from taxa that have historically been collected by DWR).

- Anthicidae
- Carabidae
- Chrysomelidae
- Cladocera
- Collembola
- Copepoda
- Culicidae
- CurculionidaeGerridae
- Gyrinidae
- Hydrometridae
- Lumbricidae
- Ostrocada
- Staphylinidae
- Veliidae

All ecoregions except 73

b. **Ephemeroptera, Plecoptera and Trichoptera** (EPT) – The total number of distinct taxa found in EPT orders at the site. This does not include empty caddis fly cases, exuia or winged adults.

c. **Intolerant Taxa (IT)** – The number of intolerant taxa (defined as having an NCBI value from 0.00 to 3.00) found at the site.

When doing genus level biorecons, if an animal can only be identified to family and there are no other genera present in that family, it will be considered intolerant if it is an intolerant family. Likewise, for new genera where a tolerance value has not been assigned, it will be considered an intolerant taxon if the family is intolerant (see protocol K for assigning NCBI values).

Ecoregion 73

d. **Ephemeroptera, Trichoptera and Odonata (ETO)** – The total number of distinct taxa found in ETO orders at the site.

e. **Crustacea and Mollusca (CRMOL)** – The number of distinct taxa in the class Crustacea and or the phylum Mollusca taxa found at the site (see master taxa table in Waterlog/Hydra or Appendix C.

Scoring Guidelines – Waterlog/Hydra will calculate biorecon scores from the taxa list for each sample and report the score in the biorecon metrics table. A value of (1, 3, or 5) for each metric is assigned based on ranges at either the family and/or genus level (Appendix A). Scoring ranges

are calibrated by bioregion, stream size and season. The value for each metric is added together to calculate the index score (3-15). Interpret results based on the total index score (page 10).

Do not use the family score if organisms were identified to genus level. The genus level provides a more accurate assessment and may not agree with the family level guidance. For non-reference sites only upload the genera taxa list if the sample was identified at the genera level (do not upload the family list). Keep the following information in mind when using biorecon data:

a. Biorecons are most useful in areas of clear impairment or in areas that are not impaired. (Please note impairment indicates the condition of the biological community at the time of sampling and is not necessarily an assessment of use support which may require additional information.) Sites that fall in the middle range (7 – 9) may be too ambiguous to make assessments using the biorecon technique. These sites may require a more intensive sample method. A Semi-Quantitative Single Habitat Sample (SQKICK or SQBANK) can be collected for clarification of use support (Protocol G). Chemical samples, in-stream water quality measurements, field observations, professional judgment and habitat data may also help clarify assessment decisions.

b. Comparisons to the ecoregion reference guidelines are not appropriate at sites whose upstream watershed has drainage of more than 20% in another bioregion. Data should be scored using both bioregions. If scores disagree, professional judgment should be used to make assessment.

c. Although the biorecon procedure calls for relative abundance to be estimated in the field, these numbers cannot be used for any metric calculations since they are not collected or subsampled in a quantitative manner. This information is very important and is used less formally to evaluate the health of the macroinvertebrate community especially in the case of ambiguous scores. For example, if the number of EPT taxa is high, but only a few individuals were found, it may be indicative of stress in the community.

Score Interpretation for Family and Genus Level Biorecons:

Biorecons are a screening tool that help the biologist evaluate the condition of the benthic community. Generally, the following guidelines can be used when evaluating biorecon scores.

11-15 = Diverse benthic community *
7-9 = Ambiguous (Need Additional Information)
≤ 5 = Stressed benthic community

* Field estimates of the abundance of EPT and Intolerant taxa and dominance of any taxon should be considered when interpreting biorecon scores. Low abundance of intolerant taxa and/or dominance of facultative or tolerant organisms may indicate a stressed community even if scores are good.

Never use words such as supporting or non-supporting on habitat or any other forms including comments. That is an assessment decision based on many factors, not score alone.

Scoring for stream types not included in biorecon index:

In streams that do not fit the drainage area and bioregion or are atypical of the bioregion, it will be necessary to sample a reference site at the same time. For example an upstream or watershed reference could be used. In order to compare sites trisect the reference value for each metric:

- Score 5 > One less than [metric value – (metric value/3)]
- Score 3 < lowest score 5 – (metric value/3) to one less than lowest score 5
- Score 1 < lowest score 3

For example,

To calculate the reference-based scoring for family richness, if the number of distinct families at the reference site were 20:

Score 5 would be ≥ 20 – (20/3) which is 13

Since 13 distinct families is the lowest number that would score a 5, in order to calculate the range for a score of 3 would be < 13 – (13/3) to 13 (or 9 to 12)

Since 9 is the lowest number of families that would score a 3, in order to calculate a range for a score of 1 would be < 9

The same procedure would be used to calculate the scoring ranges for other metrics such as EPT richness and intolerant richness or for genus level.

Report

Once vouchers are identified and taxa lists finalized, upload final IDs to the invert taxa staging table in Waterlog/Hydra (see BSERT for instructions). Waterlog/Hydra will calculate the metrics and report the score in the biorecon metrics table.

Copies of all field forms Appendix B of this document. BioForms are available on SharePoint or by contacting WPU.

Protocol G – Field Collection Techniques for Semi-Quantitative Single Habitat Sample (SQSH)

Collect a semi-quantitative single habitat sample (SQSH) when a quantifiable assessment of the benthic community is needed. See flow charts Figures 2-5, Protocol A for guidance. This method is directly comparable to the Division's numeric translators for biocriteria found in the Water Quality Standards. It is the required method for the regulated community to meet permit requirements. The SQSH is a more defensible and sensitive method than the biorecon. When both sample types have been collected, semi-quantitative sample results will take precedence over biorecon results unless appropriate SQSH habitat was not available and was not the primary habitat sampled for the biorecon.

The semi-quantitative single habitat sample will generally be used for:

a. 303(d) list removal or addition (a biorecon can be used if it shows the site clearly non-supporting but should not be used for removal from the impaired list)
b. Nutrient assessments including TMDLs
c. Permit compliance and enforcement
d. Exceptional Tennessee Water designation for exceptional biological diversity.
e. Pre/post BMP or ARAP
f. CADDIS analysis
g. Trend Analysis
h. Ecoregion or headwater reference sites (along with genus level biorecon)
i. Confirmation of ambiguous biorecons when supporting information is not adequate for assessment.
j. Any study that has the potential of being used in litigation or for regulatory purposes.

In order for the data to be compared to the reference database:

a. Samples must be collected in the exact manner outlined in this section.
b. The upstream watershed must be 80% within the bioregion.
c. The drainage area must be comparable to those in the reference database for that bioregion (Appendix A).

There are three methods of semi-quantitative sample collection:

a. SQKICK (Riffle streams larger than 1 yard wide)
b. Modified SQKICK (Riffle streams less than 1 yard wide or too shallow for the 1 meter kick net)
c. SQBANK (Non-riffle streams)

For SQSH samples, no organisms are picked in the field (exception T&E species). Removal of organisms from collected debris (sorting) is conducted in the laboratory under a dissecting microscope.

Do not retain any threatened or endangered species. Check coverage to determine whether T&E species are likely in the stream reach and make sure you are able to recognize them in the field. When in doubt do not retain. Indicate in comment area of stream survey sheet identification and number of animals released. If species was not previously recorded in that stream reach complete ETW form and submit to Watershed Planning Unit (Debbie.Arnwine@tn.gov or designee). Notify Natural Areas Unit. If T&E species are inadvertently added to sample contact TWRA (and USFWS if federally listed).

The type of sample collected will depend on the stream type and/or ecological subregion. Ecoregions can be determined for specific stream segments by using Tennessee's Online Water Quality Assessment Data viewer http://tdeconline.tn.gov/dwr/. Contact the Watershed Planning Unit if there is uncertainty about what ecoregion a stream is located in.

Method a: Semi-quantitative Riffle Kick (SQKICK)

For the purpose of this method, a riffle will be any area of moderate to fast moving water over productive loose rock habitat in a wadeable stream. Ideally, this will be fast moving shallow water over layered cobble substrate where rock break the surface of the stream. However, the following may be substituted if ideal riffle areas are not present. Always document the comment field on the stream survey form if the area collected falls into one of these categories.

- Cobble run area (typically deeper than riffle where rocks do not break surface)
- Gravel seams in bedrock streams (especially if this is the most productive habitat)
- Gravel riffle or run
- Rapid (generally in large creeks or wadeable areas of rivers, deeper than riffle with rocks > 10 inches in diameter)
- Boulder riffle (rocks > 10 inches diameter are dominant)

Collect a semi-quantitative riffle kick (SQKICK) in ecological subregions 65j, 66d, 66e, 66f, 66g, 67f, 67g, 67h, 67i, 68a, 68b, 68c, 69d, 71e, 71f, 71g, 71h, 74a, and riffle streams in 71i. If a riffle is not present, a semi-quantitative bank sample can be collected in bioregion 67fghi.

If riffles have been compromised by human disturbance such as sedimentation or are embedded, they should still be sampled since impacts are being measured. For small (< 1 yard wide) or shallow streams, use the modified kick method (Protocol G, Method b).

1. Use a (two-person) one square meter kick net with a 500-micron mesh to sample the riffle. If necessary, use rocks to weight the bottom edge to prevent the flow of water beneath the net. At each site, collect two kicks: one from an area of fast current velocity and one from an area of slower current velocity. Always collect the downstream sample first. Avoid areas with large leaf packs caught on the rocks if possible. If the stream is too small to do two riffle kicks in a single riffle, sample two separate riffles. (In extremely small or shallow streams, sample 4 riffles using the modified SQKICK for small streams – method b.)

2. One biologist holds the net at an angle that allows the current to flow into it making sure the bottom is in contact with the substrate and the top of the net is above the surface of the water. The net should have the maximum wetted area by laying it back as far as possible, while keeping the top of the net above the surface of the water. The second biologist disturbs the substrate for approximately one-meter distance and the width of the net (one meter) upstream of the net by kicking and shuffling the substrate. This causes organisms and debris to flow into the net. Larger rocks may be lifted and rubbed with the hands or a soft brush to remove clinging organisms.

3. Once the kick is completed, allow time for the lighter debris to finish floating into the net. The biologist who performed the kick then grabs the two pole ends at the bottom of the net and carefully lifts the net out of the water while the other biologist continues to hold the upper end making sure the top of the net does not dip below the water surface allowing organisms to escape. If the top of the net dips under the water and debris flows out, discard the sample and collect another kick. Carry the net horizontally to the bank for processing.

4. Composite the debris from both kicks. Carefully position the net in a 500 micron sieve bucket. Rinse debris and organisms off the net into the sieve bucket. Make sure to get all debris and organisms. Thoroughly rinse the sample to remove fine sediment. Large rocks or organic material, such as whole leaves, large rocks or sticks, are discarded after rinsing and removing clinging organisms. All other debris is presevered for laboratory sorting under a microscope. Transfer the debris to a wide mouth or plastic container. Using forceps, remove all organisms clinging to the net and add them to the sample container.

5. If upon cursory examination of the debris, it does not appear that a minimum of 200 organisms have been collected after 2 kicks, perform additional kicks in the same reach until at least 200 organisms are assured. Document the number and location of kicks on the stream survey field sheet and write the number of kicks on the sample tag. If all riffle habitat is exhausted before 200 organisms are collected, document on the stream survey field sheet. Note that samples where more than 2 kicks are necessary to find 200 organisms will be evaluated with extra caution regardless of score.

6. Place the composited debris in a wide mouth plastic container. Unless there is a large amount of organic matter preserve with 80% ethanol. If organic matter such as algae or decomposed leaves constitutes 25% or more of the debris, preserve with full strength ethanol. Include an internal tag (written in pencil on water-proof paper) with the DWR Station ID, date, sampler's initials and sample type inside the container with the debris (Figure 10). Attach an external sample tag to the outside of the container (Figure 11).

   Instead of an external tag, the site information can be printed in indelible ink (i.e. Sharpie) on the sample lid. The external tag information must include the Station ID, Stream name, location, sampler's initials, date sampled, time sampled and sample type (Figure 13). A biological sample request form, including chain of custody, must be completed prior to delivery to the state lab for identification (Appendix B).

Figure 13: Example of External Tag Information (on sample lid)

Method b: Modified SQKICK (small and/or shallow streams)

1. In extremely small streams, where riffles are less than one yard wide, are comprised of gravel seams in bedrock or in those that are too shallow to use a 1-meter kick net, collect a one-person stationary kick using an 18-inch single handle rectangular net with a 500-micron mesh.

2. Sample four separate riffles. Starting with a downstream riffle, hold the net perpendicular to the flow making certain the bottom of the net is in contact with the substrate at all times. Disturb the substrate upstream of the net for an area approximately 18 inches long and the width of the net. Do not allow the net to move during the kick as it might cause organisms to drift under the net. Once the kick is complete, allow time for all debris to finish flowing into the net.

3. Composite the debris from all four kicks. Use forceps, to remove all organisms clinging to the net and add them to the debris. Thoroughly rinse the sample to remove fine sediment. Large rocks or organic material such as whole leaves and branches, are discarded after rinsing and removing clinging organisms. If upon cursory examination of the debris, it does not appear that at least 200 organisms are in the composited sample, collect additional kicks and add them to the composite. If all riffle habitat is exhausted before 200 organisms are collected, document on the stream survey field sheet in the comment field and on the sample request form. Document the total number of kicks on the sample tag, the stream survey field sheet and the chain of custody.

4. After removing large rocks, leaves and sticks all debris is sorted in the lab under a microscope. Place the composited debris in a wide mouth plastic container. Unless there

is a large amount of organic matter preserve with 80% ethanol. If organic matter such as algae or decomposed leaves constitutes 25% or more of the debris, preserve with full strength ethanol. Include an internal tag with the DWR station ID, date, sampler's initials and sample type inside the container with the debris (Figure 10).

Attach an external sample tag to the outside of the container or write the information in indelible ink (i.e. Sharpie) on the sample lid. The external tag information must include the DWR Station ID, Stream name, location, sampler's initials, date sampled, time sampled, field log number and sample type (Figures 11 and 13). A biological sample request form including, chain of custody, must be completed prior to delivery to the state lab for identification (Appendix B).

Method c: Semi-Quantitative Bank Sample (SQBANK)

In ecoregions 65a, 65b, 65e, 65i, 73a, 74b, collect a semi-quantitative bank sample (SQBANK) (even if riffles are present) for comparison to the reference criteria. Also, use the SQBANK method in ecoregions 67f and 71i streams without riffle areas.

The SQBANK method can be used in non-wadeable streams with slow current using a canoe or Jon-boat. This method requires two samplers. Never wear waders and always wear pfd when working from boat and make sure meters are secure. Paddle or use trolling motor to access suitable bank habitat. Secure boat to bank when collecting jab samples. If the station is not sampleable using this method at any time of year (for example swift current or no access point), indicate flow condition Too Deep (not Wadeable) and No revisit on the Stream Survey Form. If the station has been sampled in the past using this method (historical data in SQSH metrics table in Waterlog/Hydra) indicate what conditions have changed in the comment field on the stream survey form. Also notify WPU QC staff who will make a notation in the Waterlog/Hydra Station table the site is not sampleable by canoe/Jon-boat. Recon possible other locations in the same reach.

1. Use a triangular dip net with a 500-micron mesh to sample the rooted undercut bank. Collect the samples by jabbing the net below the surface of the water using an upward/forward thrusting motion designed to dislodge macroinvertebrates from the roots. Sample three separate areas of the reach including at least one sample from each bank if possible. Collect samples from different velocities and different bank types (i.e. overhanging tree roots, undercut grass banks) if possible. Macrophyte beds or snags may be substituted if rooted banks are not available. Sample approximately one linear meter (approximately 3 triangular net widths) at each of the three sampling locations. It may be necessary to collect more than 3 sampling location to get 9 linear meters if habitat areas are small.

2. Thoroughly rinse the sample by gently swishing the net through the water. Do not let the net opening dip below the surface of the water. A sieve bucket can be used if fine sediment clogs the net. Visually inspect any large organic matter such as whole leaves and sticks.

Remove any organisms clinging to these materials and add to the smaller debris, before discarding the large material. Using forceps, remove any organisms clinging to the net and add to the sample. Composite the debris from all three bank samples. If upon cursory examination of the debris, it does not appear that 200 organisms have been collected, additional bank samples may be collected. Document the total number and location of bank jabs (and if all available bank habitat was collected) on the stream survey field sheet, sample tag and chain of custody.

3. Only large rocks, leaves and sticks are inspected and discarded in the field. The remaining debris is to be sorted in the laboratory under a microscope. Place the composited debris and any organisms removed from the large debris in a wide mouth plastic container. Unless there is a large amount of organic matter preserve with 80% ethanol. If organic matter such as algae or decomposed leaves constitutes 25% or more of the debris, preserve with full strength ethanol.

   Include an internal tag with the station ID, date, sampler's initials and sample type inside the container with the debris (Figure 10). Instead of an external tag, the site information can be written in indelible ink (i.e. Sharpie) on the sample lid. The external tag information must include the Station ID, stream name, location, sampler's initials, date sampled, time sampled, field log number and sample type (Figures 11 and 13). A biological sample request form, including chain of custody, must be completed prior to delivery to the state lab for identification (Appendix B).

Protocol H - Sample Logging and Lab Transport

Samples must be assigned a field log number to allow complete reconstruction, from initial field records, through data storage, sample analysis and retrieval. This includes biorecons that are identified in the field with no vouchers. If using DWR electronic forms, this number will be automatically assigned. If using paper forms the same field log number should be assigned to all samples collected at that site that day (biorecons, SQSH, diatoms, chemicals). Use the format (Primary assessor initials followed by date (MMDDYYYY) with no separations and then a 2 digit running number _(i.e. 01) for each site throughout the day.

- JEB0131202201 would be all of the routine samples (habitat, biorecon, SQSH, diatoms, etc.) collected or assessed by JEB on 01-31-2022 at the first site of the day.
- JEB0131202202 would be the duplicate or replicate samples (habitat, biorecon, SQSH, diatoms, etc.) collected or assessed by JEB on 01-31-2022 at the first site of the day.
- JEB0131202203 would be all of the routine samples (habitat, biorecon, SQSH, diatoms, etc.) collected or assessed by JEB on 01-31-2022 at the second site of the day.
- JEB0201202201 would be all of the routine samples (habitat, biorecon, SQSH, diatoms, etc.) collected or assessed by JEB on 02-01-2022 at the first site of the day.
- JEB0201202202 would be all of the samples (habitat, biorecon, SQSH, diatoms, etc.) collected or assessed by JEB on 02-01-2022 at the second site of the day.

If the sample is a biorecon and the voucher is identified at the EFO, a Ben Sample ID (BenSampID) must also be assigned. The BioForm auto-populates the Ben Sample ID. The standard naming convention for biorecons is the field log number plus BF if it is a family biorecon or BG if it is a Genus level biorecon. If the sample is a biorecon, SQSH or diatom sample that is going to the lab for analysis, the lab will assign the BenSampID which is also the lab's Activity ID. Contract labs will assign a unique lab number which will also be used for the BenSampID

A log is to be kept in the field office of all biological samples collected. Waterlog/Hydra can be used to generate this log (Figure 14). It is recommended that this be an electronic log. A back-up copy in a separate location must be kept of all logs. The log entry must include the field log number, DWR Station ID, date collected, time collected, collector's initials, monitoring location name, station location, type of sample, and date sent to the lab, date uploaded to Waterlog/Hydra for habitat, stream survey and biorecons identified by the EFO.

A second log will be kept at the lab, which will also include sample identification information (Figure 15).

Transport to Lab

All semi-quantitative samples collected by DWR environmental field offices are to be sent to the Nashville Environmental Laboratory (TDH) for identification within 30 days after collection. Contact the Aquatic Biology Section at 615-262-6327 to coordinate sample drop-off. A biological sample request form, including chain of custody must be completed and accompany all biological samples (Appendix B). Samples collected by non-DWR staff may be identified by any qualified macroinvertebrate taxonomist who has met quality assurance requirements specified in Section II and follows the sorting, subsampling and taxonomic protocols specified in this document.

Routine samples should be delivered to the state laboratory within 30 days of collection. Priority samples (such as antidegradation) must be delivered at least 30 days before the results are needed.

To ensure timely delivery of samples, it is recommended that at least one staff member in each EFO be certified to ship ethanol. This does not have to be a biologist. Shipping is recommended for samples with a priority turn-around such as anti-degradation, enforcement and complaints. Routine watershed samples can be ferried by staff when traveling to Nashville on business within 30 days. Caution: eight gallons (16 samples) is the maximum number that can be legally transported by private vehicle at one time.

Ethanol is considered by OSHA to be a hazardous material. Any certified DWR staff can ship samples directly from the EFO. Certification is obtained by completing the Hazardous Materials Transportation Training Modules, Version 5.1, Modules 1-6D with a score of 70 or above. These Modules are available on CD from the U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration. There are two (2) accompanying CDs entitled *General Awareness and Familiarization* and *Emergency Response Guidebook ERG2008 Mobile Software*.

Sample analysis priorities:

Biological sample priorities are set by the Watershed Planning Unit who coordinates with the state lab. Before completing the "date needed" on the sample request form, contact WPU (Debbie.Arnwine@tn.gov or designee if results are needed outside the following priority.

a. Watershed sample (including TMDLs and ecoregion sites) completed by June 30 of the fiscal year following the monitoring year for the group provided no sample is completed more than one year after receipt. For example, Group 1 sample collection began July 2021 and will end June 2022. Sample analysis is to be completed no later than June 2023. EFO QC samples will be completed the same time as the watershed group due date. It is important that EFOs deliver samples to the lab as soon as possible (within 30 days of collection) to enable the lab to pace sample analysis throughout the year.

b. Anti-degradation samples within 30 days of receipt.

c. Special projects by agreed upon date as stipulated by grant.

d. Priority samples (such as enforcement, complaints, spills) – contact Aquatic Biology Section, if lab receives too many priority requests, WPU will coordinate.

Field Log No.	BenSampID	DWR Station ID	Monitoring Location Name	Location	Date Col.	Time Col.	Sampler	Type	EFO ID	EFO ID Date	Date uploaded to Waterlog Hydra	Date sent to Lab
NRG1117202104	Assigned by Lab	COAHU45.4T0.4T0.2BR	Coahulla Cr UT to UT	Trewhitt Rd	11/17/2021	1300	NRG	SQKICK	NA	NA	NA	12/01/2021
CFW1129202101	SQKICK assigned by Lab CFW1129202101BF	ROCK000.2PO	Rock Creek	Hwy 64	11/29/2021	1200	CFW	SQICK Biorecon Family	CFW	12/09/2021	12/30/2021	NA

Figure 14: Macroinvertebrate Sample Collection and Biorecon ID Log (EFO) – Electronic log preferred- information can be generated through Waterlog/Hydra.

BenSamp ID	Field Log #	Station ID	Source	Location	Date Col.	Time Col.	EFO	Init. Col.	Type	Date Received by Lab	Sort By	Sort Date	ID By	ID Date	Date to Waterlog/ Hydra
N2110193-01	JEB1020202101	CARR1.7T0.1BT	Carr Creek UT	Webb Rd just u/s Carr Creek	10/20/2021	1200	K	JEB	SQKICK	10/26/2021	CAP	11/13/2021	CAP	11/14/2021	11/16/2021

Figure 15: Macroinvertebrate Sample ID Log (lab)

Protocol I - Subsampling Procedures for Semi-Quantitative Samples

All semi-quantitative samples are to be reduced to a 200+/- 20% (160-240) organism subsample using the following technique. This method comes directly from section 7.3 (pages 7-9) of the 1999 guidance, Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers (EPA 841-B-99-002).

1. Thoroughly rinse the sample in a 500-micron mesh sieve to remove preservative and fine sediment. Large organic material (whole leaves, twigs, etc.) not removed in the field should be rinsed, visually inspected and discarded. It may be necessary to soak the sample contents in water for about 15 minutes to hydrate the benthic organisms, which will prevent them from floating on the water surface during sorting. If the sample was stored in more than one container, the contents of all containers for a given sample should be combined at this time. Gently mix the sample by hand while rinsing to make it homogenous.

2. Transfer the cleaned sample to a gridded pick subsampler (or similar apparatus). The subsample is a white plastic cutting tray that measures approximately 18" x 12½" x 2¼." The tray is divided into , 2"x2" grids and marked with indelible ink. Note: it is preferable that a sieve insert or raised grid divider be used to separate the grids. Remove the animals and debris using a combination of scoop and transfer pipette.

3. If the debris will not fit in one tray, use two or more trays. Thoroughly mix the debris and divide equally between the trays. Sort the same grids for both trays. For example, if grid # 5 is randomly selected, both # 5 grids are picked. This will count as one grid out of 28.

4. Add enough water (or ethanol) to evenly distribute the debris. Gently shake and swirl the tray until the organisms are evenly distributed within the tray. Remove the excess water with a suction device (i.e. turkey baster with a 500 micron or smaller screen over the aperture), to the point where the sample is settled onto the bottom of the tray. If a raised grid insert is not being used, care should be taken not to pull organisms towards the area of suction.

5. Randomly select four numbers corresponding to squares (grids) within the gridded subsampling pan. Remove all material (organisms and debris) from the four grids and place the material into a dish or jar with a small amount of water. Any organism that is lying over a line separating two grids is considered to be on the grid containing its head. If it is not possible to determine the location of the head (i.e. oligochaetes), the organism is considered to be in the grid containing most of the body.

6. If there are 160-240 organisms (cumulative of the four grids) then subsampling is completed. If there are fewer than 160 organisms, continue selecting grids one at a time until between 160 and 240 organisms are selected. If more than 240 organisms are contained in the first four grids, transfer the contents of the four grids to a second gridded pan. Randomly select grids for this second subsampling as was done for the first, sorting grids four (and then one) at a time until the second subsample contains 160-240 organisms.

If it is estimated that the first four grids of the second subsample contain more than 240 organisms, transfer the four grids to another pan and conduct a third subsample. Continue creating subsamples until there are 160-240 organisms.

7. Transfer the subsample, a small amount at a time to a petri dish for sorting (removing organisms). Complete all sorting under a dissecting scope, removing and preserving all organisms in 80% ethanol. If the number of organisms from the four-grid subsample does not equal the specified number of 160-240, randomly choose a fifth grid and pick out all organisms in that grid. If the addition of the fifth grid fulfills the quota, then the subsampling is complete. If not, choose additional grids (one at a time) until the quota is reached or surpassed. All the organisms from the final grid that is randomly selected are removed even if the quota is reached midway through the picking of the grid.

   If, after microscopic sorting, more than 240 organisms are found, transfer all organisms to a small gridded dish (36 grids). Subsample by groups of first four and then one random grid until the target of 160-240 organisms is achieved.

8. Place the sorted debris in a separate container and preserve in 80% ethanol. Include both external and internal tags (Figures 11 and 12. Add the words “sorted debris” lab log number and sorrter’s initials to the tag information. Save the remaining unsorted sample debris residue in a separate container labeled “sample residue”. This container should include the original sample label and internal tag.

9. Place the sorted 160-240 organism subsample into a glass vial and preserve in 80% ethanol. Place an internal tag written in pencil on waterproof paper citing the log number, station ID, date collected and taxonomist (Figure 12) inside each vial. Position the label so it can be read through the vial.

   All chironomids and oligochaetes in the subsample are to be identified individually (do not subsample and extrapolate). Mount slides in a permanent mounting media (i.e. CMC-10). Label slides with the station id, date collected, taxonomist initials and slide box number.

10. After sorting is completed, record the appropriate information (log number, station ID, sorters initials, date sorted and the number of organisms found) in the QC logbook (Figure 16, Section II-C).

11. All organisms and debris shall be retained as separately preserved samples for at least 5 years from collection date. Ethanol must be disposed of as a hazardous waste.

Protocol J – Taxonomy of Semi-Quantitative Samples

Semi-quantitative samples collected by DWR are to be sent to the central state lab for analysis in Nashville

1. Identify all organisms to genus except Acari, Nematoda, Nemertea, Brachiobdellida, immature Tubificinae, Lumbriculidae and Nematomorpha using the primary taxonomic keys listed in Appendix D. (Secondary keys will only be used to assist with difficult specimens.) Do not count animals that are missing heads, exuviae, empty shells, empty caddis cases, or terrestrial life stages. Only count aquatic benthic taxa. Do not count semi-aquatic taxa, or mico-crustacea

   The lab will notify WPU (Debbie.arnwine@tn.gov or designee) of new taxa (not in Waterlog/Hydra master taxa table) and send specimen to taxonomic specialist for verification (Appendix D). WPU will add taxon to master taxa table designated pending verification. Once ID is confirmed, the lab will send confirmation information to WPU who will update verification information in the master taxa table.

   Taxa Groups Excluded from 2021 Metric Calculations (included in 2011 and/or 2017 . This is not a complete list, consult Waterlog/Hydra master taxa table to determine if other taxa are included.)

   - Anthicidae
   - Carabidae
   - Chrysomelidae
   - Cladocera
   - Collembola
   - Copepoda
   - Culicidae
   - Curculionidae
   - Gerridae
   - Gyrinidae
   - Hydrometridae
   - Lumbricidae
   - Ostrocada
   - Staphylinidae
   - Veliidae

2. Calculate all biometrics at the specified level only. The primary keys will be updated as new literature is available. It is important that all taxonomists use the same primary keys for consistency in identification and nomenclature.

3. After identifying all taxa in the subsample, return them to the vial and add fresh preservative (80% ethanol). Initial, date and add the BenSamp ID (lab number) to the internal tag (Figure 12). Store the sample for a minimum of five years from collection date. Samples identified for special projects (such as SEMN) will be retained for the life of the project if longer than five years.

4. Mount chironomids, oligochaetes and other small organisms on slides for identification. Use a permanent mounting media such as CMC-10 which clears the mount so a separate clearing agent is not necessary. Use round coverslips (12 mm) for small specimens. Place one organism under each coverslip. A maximum of 10 coverslips can be placed on each slide. Square coverslips (22mm) can be used to mount larger specimens. Place one to three organisms under each coverslip with a maximum of 3 coverslips per slide.

   Mount chironomid larvae so that their bodies are viewed laterally and their heads are viewed ventrally. Apply enough pressure to the coverslip so that the mandibles are opened exposing the mentum. The S1 setae, premandibles and pectin epipharyngias should also be visible. Mount oligochaetes laterally with minimal pressure. The mounting media should extend past the edges of the coverslip to allow for shrinkage during drying. Allow the slides to air-dry at least 24 hours before attempting identification. (A slide dryer can be used to dry mounts faster if desired). Label slides with the log number, station ID, date, taxonomist initials and slide box slot number. Keep labeled slides in a slide box a minimum of five years after completion of the study.

   Note: Do not subsample any organisms including chironomids and oligochaetes further. Identify each organism in the 160-240 organism subsample.

Protocol K - Data Reduction of Semi-Quantitative Samples

A macroinvertebrate index, based on seven biometrics, has been developed by the Division for use in semi-quantitative macroinvertebrate surveys (Arnwine and Denton, 2001) and has been updated in this QSSOP (Appendix A). This index is based on ecoregion reference data and calibrated by bioregion. The calibrated scoring criteria can be used in all streams that fit the sample criteria for that region (habitat sampled, sampling protocol, drainage area) and have at least 80% of their upstream drainage in the same bioregion.

Metrics are automatically calculated after the taxa list is uploaded to Waterlog/Hydra and are reported in the SQSH Metric table. This is the only method DWR and State laboratory staff should use for calculations and scoring. It is also the metric calculations that will be used to QC data submitted by other stakeholders. Stakeholders are encouraged to submit taxa lists to WPU biological QC staff for upload to Waterlog/Hydra and request biometric calculations for reporting purposes. (Once Waterlog/Hydra is made public, biometric calculations and index scoring can be viewed/downloaded from the SQSH metrics table.)

> For streams that do not meet the profile (for instance non-riffle streams in bioregions that are calibrated to a SQKICK sample or streams that have more than 20% of their upstream drainage in other bioregions) calculate the same seven biometrics. However, the index tables cannot be used for scoring since these samples are not comparable to streams in the ecoregion reference database. Compare the biometrics to an appropriate upstream or watershed reference.

1. Using the raw benthic data from the semi-quantitative subsample (kick or bank), calculate a numerical value for each of the seven biometrics. Calculate all biometrics using taxa identified to the genus level except for specified taxa (Acari, Branchiobdellida, Nematomorpha, Nematoda, Hydra, immature Tubificidae, Lumbriculidae) or those too young or too damaged to identify to this level. Species identification is not to be used. Do not count Collembola, semi-aquatic taxa or micro/meio-crustacea.

   When a large proportion of individuals (> 10% for any family) cannot be identified past family, the unknown individuals should be proportionately assigned to identified genera within the family before calculating metrics. (Does not apply to unknown Naididae which can be left at family level.)

   $$X = U * \frac{\text{Genus A}}{T}$$

   Where X = Number of Undetermined organisms in a family to be assigned to genus A
   Genus (A) = Number of individuals within a specific genus.
   U = Total number of individuals within a family not identified to genus
   T = Total number of individuals within a family identified to genus level.

Solve for X for each genera within a family rounding to the nearest whole number.

Add X to Genus A for reporting. Flag as estimated value.

Repeat for each undetermined genus in sample.

For example, if 8 Hydropsychidae could not be identified in a sample containing 37 Cheumatopsyche and 9 Hydropsyche and 1 Ceratopsyche. To determine the number of unknown taxa that would be added to Cheumatopsyche and how many would be assigned to Hydropsyche:

X (Cheumatopsyche) = 8 * 37/47 = 6
X (Hydropsyche) = 8*9/47 = 2
X (Ceratopsyche) = 8*1/47 = 0

The Final count for metric calculations would be:

Family	Initial ID	Count	Final ID	Count	Comment
Hydropsychidae	Ceratopsyche	1	Ceratopsyche	1	
Hydropsychidae	Cheumatopsyche	37	Cheumatopsyche	43	6 unknown + 37 known
Hydropsychidae	Hydropsyche	9	Hydropsyche	11	2 unknown + 9 known
Hydropsychidae	Und spp.	8			

a. **TR** (Taxa Richness)

Total the number of distinct genera found in the subsample. Taxa that could only be identified to family are included only if they exhibit distinct characteristics separating them from other genera in the family. (Document on taxa list if an unidentified organism is determined to be a distinct taxon.)

b. **EPT** (Ephemeroptera, Plecoptera, and Trichoptera Richness)

Total the number of genera within the orders Ephemeroptera, Plecoptera and Trichoptera. Taxa that could only be identified to family are included only if they exhibit distinct characteristics separating them from other genera in the family. (Document on taxa list if an unidentified organism is determined to be a distinct taxon.)

Alternate metric for ecoregion 73

ETO (Ephemeroptera, Trichoptera and Odonata Richness). – The total number of distinct genera within the orders Ephemeroptera, Plecoptera and Odonata. Taxa that could only be identified to family are included only if they are the only taxon found in that family or it is probably that they are distinct from other taxa identified to genus within the family. (Document on taxa list if an unidentified organism is determined to be a distinct taxon.)

c. **% EPT-Cheum** (EPT Abundance excluding *Cheumatopsyche* spp.)

$$\% \text{ EPT} = \frac{\text{Total (Ephemeroptera + Plecoptera + Trichoptera) – Cheumatopsyche}}{\text{Total number of individuals in the subsample}} \times 100$$

Any undetermined Hydropsychidae should be counted as Cheumatopsyche in the same proportion as confirmed identifications.

d. **%OC** (Percent oligochaetes and chironomids)

$$\%\text{OC} = \frac{\text{Total number of Oligochaeta + Chironomidae}}{\text{Total number of individuals in the subsample}} \times 100$$

e. **NCBImod** The modified North Carolina Biotic Index is calculated using the tolerance values found in Appendix C.

f.

$$\text{NCBI} = \Sigma \frac{x_i\, t_i}{N \text{ (exclusive if no } t_i)}$$

where: x_i = number of individuals within a taxon
t_i = tolerance value of a taxon (Appendix C)
N = total number of individuals in the subsample that have been assigned a tolerance value (exclude animals for which no tolerance value is assigned see following note).

Note: Where available, the 2016 North Carolina pollution tolerance values were assigned for each genus excluding taxa that were calibrated primarily to the Atlantic drainage. Family values are an average of genera tolerance values of taxa in the TDEC verified reference collection housed at TDH labs. When representative genus level tolerance values were not available in the 2016 NCBI, they were assigned by using:

i. Average of border states (SOPs) sharing Mississippi/Tennessee Cumberland River Drainages (non-arthropods).
ii. Tolerance Values found in Merritt et al 2019 for Southeast, Midwest, upper Midwest, mid-Atlantic or Northwest in that order
iii.(Insecta).Hilsenhoff Biotic Index (Arthropods) or Bode 2002 (non-arthropods,

f. **% Clingers - CHEUM** (Percent contribution of organisms (primary for genus) that build fixed retreats or have adaptations to attach to surfaces in flowing water excluding Cheumatopsyche spp.)

A list of taxa designated as clingers is located in Appendix C. Merritt and Cummins, 2019 is used as authority for determination of primary clingers (if multiple habits are listed, only those where clinger is listed first are used).

$$\% \text{ Clingers} = \frac{\text{Total number of clinger individuals - Cheumatopsyche}}{\text{Total individuals in the sample}} \times 100$$

Alternative biometric for ecoregion 73

%CRMOL (Percent contribution of Crustacea and Mollusca).

$$\%\text{CRMOL} = \frac{\text{Total number of Crustacea and Mollusca}}{\text{Total individuals in the sample}} \times 100$$

g. **%TNUTOL (% TN Nutrient Tolerant Organisms)**

$$\% \text{ TNUTOL} = \frac{\text{Total number of Cheumatopsyche, Stenelmis, Polypedilum, Cricotopus, Cricotopus/Orthocladius, Isopoda, Caenis, Gastropoda, Oligochaeta}}{\text{Total individuals in the sample}} \times 100$$

After calculating values for the seven biometrics, equalize the data by assigning a score of 0, 2, 4 or 6 based on comparison to the ecoregion reference database for the bioregion and stream size (Appendix A). Total the seven scores to calculate the TMI (Tennessee Macroinvertebrate Index).

A score of 32 or higher is considered to pass biocriteria guidelines in all ecoregions. Never use words such as supporting or non-supporting on habitat or any other forms including comments. That is an assessment decision based on many factors, not TMI score alone.

Alternative Reference Stream Method

Some sites may not meet the conditions necessary for comparison to the biocriteria tables in Appendix A. This will happen when:

a. The stream is less than 80% within a bioregion upstream of the sample site.

b. The stream does not naturally have the habitat specified for comparison (for example low gradient non-riffle streams in bioregions where riffle criteria are specified. However, streams where the riffle is buried in sediment or otherwise compromised due to human disturbance should still be considered riffle streams).

In these cases, an alternative reference sample should be collected. The reference can be upstream, within the same watershed or within the same bioregion. Reference site selection should follow the same guidelines used for selection of ecoregion reference streams as specified in Protocol M. The alternative reference should be collected at the same time and using the same method (SQKICK or SQBANK) used at the test site.

Once the reference sample is collected, scoring ranges for each metric will be calculated based on quadrisection of the reference values for each metric. Reference data and scoring table, including ranges calculated for each metric, should be included with data report.

For metrics that were expected to decrease with increased pollution (TR, EPT, %EPT-Cheum, %Clingers):

Score 6: ≥ reference value –Reference value/4
Score 4: < lowest possible value for 6 to (lowest possible 6 – reference)/4
Score 2: < lowest possible value for 4 to (lowest possible 4 – reference)/4
Score 0: < lowest possible value for 2

For example:
If there were 30 distinct taxa found at the reference site, the scoring for taxa richness would be calculated by

Score 6: 30 – (30/4) or ≥ 22
Score 4: 22 – (30/4) or 14 to 21
Score 2: 14 - (30/4) or 6 to 14
Score 0: < 6

For metrics that were expected to increase with increased pollution (%OC, NCBI, %TNUTOL):

Score 6: < reference value + (highest possible value for metric – reference value)/4
Score 4: > highest possible 6 to highest possible 6 + (highest possible value for metric – reference value)/4
Score 2: > highest possible 4 to 0.1 + highest possible 4 + (highest possible value for metric – reference value)/4
Score 0: > highest possible 2

For example, if the %OC at the reference site was 20%,

Score 6: ≤ 20% + [(100% - 20%)/4] or ≤ 40.0%
Score 4: 40% + (100% - 20%)/4 or 40.1% to 60.0%
Score 2: 60% + (100% - 20%)/4 or 60.1% to 80.0%
Score 0: > 80.0%

Protocol L – Report Preparation

All field information and taxa lists associated with macroinvertebrate surveys must be reported in the approved electronic format. TDEC|DWR staff upload data to Waterlog/Hydra.

Note when using e-Forms (BioForm or Habitat and Stream Survey Form), the BioEvent Worksheet must be completed first (Appendix B) in order to populate header information on other forms. Instructions for completing e-forms and uploading to Waterlog/Hydra can be found in the BSERT on SharePoint or by contacting Kim.Laster@tn.gov (or designee).

Biorecons

DWR and TDH lab staff, are required to use the electronic BioForms for reporting biorecon taxa lists (habitat assessments, field parameters and stream surveys).

Once vouchers are identified, QC completed and taxa lists finalized, select final IDs to appropriate tab (genus or family) on the BioForm. Use the Waterlog/Hydra tab to upload family level ids or GENTaxa Waterlog/Hydra tab to upload genera taxa lists to the invert staging table in Waterlog/Hydra. (Upload both if it is a ECO or FECO reference site.)

Copies of all field forms and examples of excel spread-sheet format are provided in Appendix B of this document. BioForms are available on SharePoint or by contacting Kim.Laster@tn.gov (or designee).

Semi-quantitative Samples

E-forms should be used to record all stream survey and habitat information. Sampler (if TDEC or TDH) staff will upload information directly to Waterlog/Hydra. Other individuals should submit completed forms to Debbie.Arnwine@tn.gov (or designee) for review and upload.

a. Aquatic Biology Section – State Laboratory

After sample completion and QC (by agreed due date) the lab will upload taxa lists in the invert taxa staging tables in Waterlog/Hydra. Notify sampler that data are available.

Results should not be uploaded until QC is complete. However, data should not be held past due date. Instead, QC should be completed prior to completion of group of 10. If the last sample QC'ed fails, the next group of 10 should start after the failed sample. If the sample passes, additional QC does not need to be done until 10 samples are completed for that group.

WPU (Debbie.Arnwine@tn.gov or designee) should be notified when new taxa (not already in Waterlog/Hydra reference table) are found. After review, these will be added to the Waterlog/Hydra master taxa with verification pending. The state lab will send a

specimen to an outside expert for verification. Results of the verification will be sent to WPU and verification status will be updated. The verified taxon will be added to the state reference collection housed at the laboratory.

Copies of Chain of Custody should be uploaded to SharePoint.

b. Biological Consultants (Regulated Community)

After collection the consulting biologists must retain all samples and paperwork (sample request form/COC, habitat assessments, stream survey field sheet) copy of all paperwork and voucher specimens for a minimum of five years from collection date.

After sample completion and QC, electronic spreadsheets in the approved format (see Appendix B) of taxa lists, habitat assessments, field parameters and stream survey sheets should be sent to debbie.arnwine@tn.gov (or designee) for review and upload to Waterlog/Hydra.

Results should not be submitted until QC in accordance with Section II of the QSSOP is complete. However, data should not be held past the due date specified in the permit. Instead, QC should be done prior to completion of a group of 10. If the last sample QC'ed fails, the next group of 10 should start after the failed sample. If the sample passes, additional QC does not need to be done until 10 samples are completed for that group. Consulting biologists shall provide a verification of QC with the report submittal.

Protocol M – Reference Stream Selection

The following guidelines are for selection of ecoregion reference streams. When selecting a project specific reference sites for atypical test streams the same guidelines should apply. Stream size, habitat, gradient and geology should be similar to the test site. Note a site specific reference stream cannot be used if the test stream is typical for the bioregion, in which case the established criteria for that bioregion should be used.

- Stream type, flow regime and substrate are typical of the Level IV ecoregion (or test site for atypical streams). Perennial streams will be targeted. Intermittent streams may be selected if this is typical of headwaters for the ecoregion.

- Streams are in a protected watershed or upstream land-use is primarily forested. In heavily urban or agricultural bioregions, stations will be selected where upstream watershed is least disturbed and is comparable to percent forested of other established reference streams.

- Riparian vegetation zone is well established with all size classes represented. Invasive species constitute less than 10% of streamside vegetation.

- The upstream watershed does not contain a municipality, mining area or permitted discharger and is not heavily impacted by nonpoint source or other non-regulated source of pollution.

- Upstream drainage is at least 80% within a single Level IV ecoregion (preferable) or bioregion.

- The stream flows in its natural channel. There are no flow or water level modification structures such as dams, irrigation canals or field drains.

- No power lines or pipelines or any structure that is routinely cleared crosses upstream of the monitoring station.

- The upstream watershed contains few or no roads.

- Date sample was removed from the incubator and analyzed - Formatted: Month-Date-Year (MM-DD-YYYY).

- Time sample was analyzed.
- Initials of the person who read the test results (analyzed the sample).
- Number of large and small wells that turned a yellow color equal to or darker than the comparator.
- Number of large and small wells that fluoresce under a UV lamp equal to or darker than the comparator.

I.J. Data and Records Management

All biological data and associated field information will be stored in the Division's Waterlog/Hydra database.

Biorecon and semi-quantitative stations are established in Waterlog/Hydra. The Watershed Planning Unit is responsible for maintaining the stations list. New stations should be uploaded to the staging table in Waterlog/Hydra using the new stations form included on the Bioform. WPU will be responsible for QC'ing the new stations, verifying that they are not an established station under another name, assigning a monitoring ID (TNW) and uploading to the final table in Waterlog/Hydra.

Taxa lists identified by the EFO are uploaded to Waterlog/Hydra within 30 days of completion of identification and by June 30 of the watershed assessment year.

Habitat sheets, field parameters and stream survey sheets will no longer be sent to the state laboratory with biological samples. The EFO will be responsible for uploading field information to Waterlog/Hydra within 30 days of field survey.

Taxa lists, from DWR semi-quantitative samples are uploaded to Waterlog/Hydra by the Aquatic Biology Section, Lab Services, TDH on or before sample due date. An email will be sent to the field offices when new SQSH data have been uploaded.

The regulated community will send excel spreadsheets, not pdfs, using standard EDD format macroinvertebrate taxa lists, as well as completed bioforms for habitat sheets, field parameters and field surveys to Debbie.Arnwine@tn.gov or designee (WPU) for QC and upload to Waterlog/Hydra. Electronic forms can be found on the Division's publications website or by contacting WPU.

Metrics for both biorecons and SQSH samples are calculated and scored by Waterlog/Hydra. Scores are reported in either the Birecon or SQSH metric tables using the most current SOP calibrations. For duplicates, one sample will be designated as primary by the WPU QC biologists and will be used for assessments. Generally, this will be the sample-routine unless taxa lists or field information indicate the duplicate sample is more representative. Examples include a high number of immature or damaged organisms identified to family, dominance of a single taxon in one sample and/or field notes indicating differing habitat quality between 2 sites.

Assessment information for each stream segment will be entered in ATTAINS (Assessment, TMDL Tracking and Implementation System) by the Watershed Planning Unit. WPU staff will meet with WPC managers and biologists in each EFO before assessments are finalized. This database is linked to a GIS map and is accessible on the web for public access: http://tdeconline.tn.gov/dwr/

II. QUALITY CONTROL AND QUALITY ASSURANCE

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 also applies to all monitoring activities reported to TDEC in support of the Clean Water Act. 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 Panning 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 (EFO Biological QC officer) - One DWR staff member, qualified as a biologist, 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).

   Areas of Responsibility

   1. Taxonomic Reference Collection and vouchers
   2. 10% duplicate of biorecon collection, identification and habitat assessment.
   3. 10% duplicate collection of SQSH and Diatom.
   4. Train new biological staff and those assisting biologists.
   5. Ensure habitat assessments, field parameters and stream survey forms are uploaded to Waterlog/Hydra in a timely manner weekly.
   6. Ensure biorecons are analyzed within 30 days of collection (preferable) or within 30 days of end of sampling year and uploaded to Waterlog/Hydra.
   7. Ensure samples are delivered to the laboratory within 30 days of collection following requirements for hazardous materials and that chain of custody is maintained.
   8. Proper storage and disposal of ethanol.
   9. Obtaining field and lab supplies and equipment
   10. Maintenance and repair of microscopes.
   11. Maintenance and repair of sampling equipment.
   12. Meter calibration, sampling/taxonomic and QC logs are maintained.
   13. Maintain QSSOP updates and make sure all staff are aware of changes.

3. Training - Unless prohibited by budgetary or other travel restrictions, training will be conducted at least once a year through workshops, seminars and/or field demonstrations in an effort 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.

Taxonomic Training Opportunities:

Highlands EPT workshop when possible, especially for middle and east TN
Annual DWR Biologist Workshop
SWPBA taxonomic workshops when offered.
Training with EFO qualified taxonomists
Training with TDH lab taxonomists (coordinate through Watershed Planning Unit)
Other taxonomic workshops as available.

B. Field Quality Control – Habitat Assessment and Biological Sampling Methodology

1. Habitat Assessments - At minimally 10% of sites, two trained biologists will complete habitat assessment field sheets independently. Scores are compared for each parameter with discrepancies arbitrated while in the field. See BSERT for complete instructions for how to unhide QC habitat forms, identify consensus habitat and upload to Waterlog/Hydra. Note only the consensus form is uploaded to Waterlog/Hydra.

2. Biorecon Collection A second biorecon will be collected at a minimum of 10% of the sites by a separate biologist. This should be conducted at the same time, or at least within two weeks of the original survey. If assessment does not agree (not-impaired, ambiguous, or impaired) biologists should investigate reason for disagreement. Results from the more representative sample should be used. Both are uploaded to Waterlog/Hydra with separate field log numbers. Indicate on comment field which is most representative. If no reason could be determined for discrepancy, both biologists should collect another sample.

3. Semi-quantitative Sample - A second semi-quantitative sample will be collected at 10% of the sites within 2 weeks of the original sample. (If rain or other factor compromises reproducibility, the second sample should not be collected). Since this sampling method requires two people, it will not be possible in most offices for an independent team to conduct the sampling. Therefore, the same team can collect the samples with each investigator independently selecting the sample spot and performing the kick. At least once a year, a team from another EFO or the state lab should collect the QC sample.

   If assessment results do not agree (both scores above or below 32) the following action will take place until agreement is reached:

a. The samplers will be contacted by the lab to determine if there was any discrepancy in habitat, location, environmental factors such as rain or collection methods. If so, the most representative sample will be used. This will not count as part of the required 10% duplicates.

b. If there was no discrepancy in field conditions or collection method, the lab will re-id both samples. If both scores agree, QC is complete.

c. If scores do not agree, the lab will re-examine both subsamples for overlooked organisms and re-id. (If adding all missed samples goes over 240, subsample the extra individuals to achieve a 240 subsample). If both scores agree, QC is complete.

   i. If either the original sample or the duplicate had more than 240 organisms in the pick, only the subsampled debris with less than 240 animals will be re-examined. If scores agree, QC is complete.

   ii. If both the original and duplicate sample had more than 240 organisms, the subsampled debris from both samples will be re-examined and missed individuals will be added to the subsample that was not selected for identification. A random selection will be added until both samples reach 240 organisms. If both scores agree, QC is complete.

d. If scores do not agree, the lab will re-subsample and id both samples

e. If the new subsamples do not agree, all 4 taxa lists will be combined, statistically reduced to a 200-organism subsample and re-scored. A new BensampID will be generated for this sample that combines the original 2 BenSampIDs. This will not count as a field QC sample.

   Only the combined taxa list is loaded to Waterlog/Hydra using the original sample-routine field log number and activity type Quality Control Sample-Lab Duplicate. The following comment should be entered in the comment field for the metrics record: Sample is a combination of sample routine and field replicate that failed field QC. TMI for sample-routine subsample 1 was "score" and subsample 2 was "score". TMI for field replicate subsample 1 was "score" and subsample 2 was "score".

4. Chain of Custody Chain of custody is required by the TDEC Office of General Counsel for samples that have the potential of being used in court, reviewed by state boards, or involved in state hearings. Chain of custody must also accompany any contract samples (semi-quantitative samples being sent to the lab). Chain of custody is the far right column of the biological analysis form. (Appendix B) The entire form must be filled out completely.

   The chain of custody follows the sample through collection, transfer, storage, taxonomic identification, quality assurance and disposal. The biologist who collected the sample must sign (not print) their name in full (not initial) in the Collected By space with the date and time (24-hour clock). If the sample is given to anyone else before it is delivered to the lab, that person must put the receiver's name in the delivered to line with the date and time it is handed off. Then the person receiving the sample must sign their full name on the Received By space

with the same date and time as in the delivered to line (if there are more people in the transfer of the sample than available lines, another COC can be stapled, just make sure to fill out the headings in case the sheets get separated). The person in the laboratory who receives the sample will sign line four. The person who logs the sample in signs the last line.

C. QC Log

A list of all samples sorted and/or identified by each biologist/environmental specialist will be kept in a bound log or electronically with electronic backup on a separate system so that QC requirements and results can be documented (Figure 16). The QC log must contain the following information:

1. Field log number
2. Activity ID
3. DWR Station ID
4. Sample type
5. Initials of taxonomist and sorter
6. Number of organisms picked in subsample (semi-quantitative samples only)
7. Date completed
8. Initials of person performing QC
9. Number of organisms found in re-pick (semi-quantitative samples only)
10. Percent sorting efficiency (semi-quantitative samples only).
11. Date of QC identification
12. Initials of QC taxonomist
13. Results of taxonomic QC (satisfactory/unsatisfactory)

Field Log Number	BenSampID	Station ID	Sample Type	Sort By	Sort Date	# org.	Sort QC	QC Date	QC # org.	Sort Eff.	S/U	ID By	ID Date	QC ID	QC Date	S/U
J0201001	J0201001	BIFFL003.0DY	SQKICK													
J0201002	J0201002	BIGGS000.7WY	SQKICK	AJF	3/11/02	190	PDS	3/20/02	10	95%	S	AJF	3/11/02	PDS	3/20/02	S
J0201003	J0201003	BMHOL002.0OB	SQKICK													
J0201004	J0201004	CANE001.8WY	SQKICK													
J0201005	J0201005	CGROU001.2WY	SQKICK													
J0201006	J0201006	CLEAR001.2HN	SQKICK													
J0201007	J0201007	CLOVE001.4OB	SQKICK													
J0201008	J0201008	CSPRI002.4DY	SQKICK													
J0202001	J0202001	CYPRE00.6WY	SQKICK													
J0202002	J0202002	CYPRE000.6OB	SQKICK													
J0202003	J0202003	DAVID002.6OB	SQKICK													
J0202004	J0202004	GRASS000.8OB	SQKICK													
J0203001	J0203001	HFORK006.8OB	SQKICK													
J0203002	J0203002	HOOSI000.5OB	SQKICK													
J0203003	J0203003	HURRI002.6WY	SQKICK													
J0203004	J0203004	HURRI003.9WY	SQKICK													
J0203005	J0203005	HURRI1T1.1WY	SQKICK													
J0203006	J0203006	MILL004.0OB	SQKICK													
J0203007	J0203007	NFOBI005.9OB	SQKICK	AJF	3/15/02	220	PDS	3/20/02	14	94%	S	AJF	3/15/02	PDS	3/20/02	S
J0203008	J0203008	NFOBI018.0WY	SQKICK													
J0203009	J0203009	NFOBI026.5WY	BR													
J0203010	J0203010	NFOBI040.6HN	BR	NA	NA	NA	NA	NA	NA	NA	NA	AJF	3/16/02	PDS	3/20/02	S
J0203011	J0203011	OBION020.9DY	BR													
J0203012	J0203012	OBION044.3DY	BR													

Figure 16: Example of Macroinvertebrate QC Log

D. Sorting Efficiency (Semi-Quantitative Samples Only)

1. Each biologist responsible for sample sorting, regardless of previous experience, will have every sample QC'ed by a second biologist who has already achieved 90% sorting efficiency (documented) until the original biologist has passed 90% sorting efficiency on a sample. A record of this is kept in the QC log. Once a biologist has passed their first QC, they are QC'ed on 10% of subsequent samples (randomly selected).

2. Each biologist involved in sorting of semi-quantitative benthic macroinvertebrate samples will have 10% of their subsamples (debris) resorted by a second experienced biologist. The sample to be QC'ed is randomly chosen by the person performing the QC after every group of 10 samples has been completed. (Or fewer if less than 10 are completed before due date). A sorting efficiency of 90% must be maintained. If fewer than 90% of the organisms are recovered, every sample prior to that one in the same group of 10 is resorted until a sample that has met the 90% requirement is found. The next group of 10 starts after the unsatisfactory sample.

   The sorting efficiency is calculated by:

   $$\text{Sorting efficiency} = \frac{\text{\# organisms found in initial pick}}{\text{Total \# organisms, both picks}} \times 100$$

   If fewer than 90% of organisms are found, the additional animals are added to the final ID of the first pick. If this puts the final subsample over 240 organisms transfer all organisms to a small gridded dish (36 grids). Subsample by groups of first four and then one random grid until the target of 160-240 organisms is achieved. If permanent mounts have already been made of the first pick, a 200-organism subsample should be calculated statistically:

   $$\text{Taxon a} = 200 * \frac{\text{\# taxon a found in both picks}}{\text{Total \# organisms both picks}}$$

   Round to nearest whole number.

3. Log results in the QC log.

4. All sorting QC must be completed before the data are released to ensure accuracy of results. However, samples should not be held up waiting for QC. Instead, QC should be performed prior to completion of group of 10. If, for any reason, a report is released prior to QC completion, an addendum will be sent to all report recipients with any corrected information after QC is complete.

5. All subsample debris is preserved in 80% ethanol and kept in a labeled container for a minimum of 5 years from collection date. The original sample, from which the subsample was taken, is kept in a separate labeled container for the same period. Samples are disposed of following hazardous waste protocols for ethanol after five years from collection date for routine samples. Samples identified for special projects (such as SEMN) will be retained for the life of the project if longer than five years..

E. Taxonomic Verification

All biologists are to be trained and show proficiency for genus level identification of each group of organisms. (Except Acari, Nematoda, Nematomorpha, Branchiobdellida, Enchytraeidae and Lumbriculidae). If the biologist will only be performing family level biorecons, they need only demonstrate proficiency at the family level. If the biologist will only be performing genus level biorecons, they do not need to demonstrate proficiency in chironomids or oligochaetes. If the biologist will be performing SQSH, they must demonstrate genus level proficiency in all taxa groups.

Once taxonomic proficiency is achieved through successful completion of exams and initial quality control checks, it should be entered in the EFO QC log, the biologist should update the taxonomic certifications field on the biologist credential form on SharePoint and notify the WPU biologist QC staff for record keeping purposes.

Taxonomic Proficiency will be demonstrated by sample type

1. SQSH taxonomists (TDH and private laboratories)

    a. A minimum of one taxonomist in each laboratory will have current (every 5 years) Society of Freshwater Science (SFS) taxonomic certification at the genus level in 3 taxa groups: Group 1 general arthropods, Group2 EPT, Group 3 Chironomidae larvae. All others must pass an in-house exam administered by the QC officer.

    b. Each new taxonomist, regardless of previous experience, will have every sample QC'ed by another taxonomist (who has successfully completed testing and QC) until they have satisfactorily completed taxonomic QC on a sample and successfully completed testing. A record of this is kept in the QC log. Once a taxonomist has satisfactorily completed their QC requirements, 10% of their identified samples will be randomly checked by another taxonomist. The sample to be QC'ed is randomly chosen by the QC'er after every 10^{th} sample is completed (or fewer depending on due date). The QC taxonomist will identify every organism in the sample without consulting the original taxonomist's list. Once the second identification is complete, the two biologists/ES will go over any discrepancies together.

    c. The QC coordinator calculates the following three precision estimates as data quality indicators adapted from the Society for Freshwater Science Taxonomic Certification Program. Quality Control Procedure for Sample-Based Taxonomic Data. If both taxonomic QC is performed on the same sample where sorting efficiency is checked, only the animals found in the original pick will be used for QC.

i. *Percent difference in enumeration* (PDE) quantifies the consistency of specimen counts in samples, and is determined by calculating a comparison of results from two independent laboratories or taxonomists using the formula:

$$PDE = [(n_1-n_2) / (n_1+n_{2)}] \quad x\ 100$$

Where n_1 is the number of organisms in a sample counted by T1, and n_2, by T2. Note that these numbers are from the counts of the taxonomists from their identification results, not from the sorting and subsampling procedures.

ii. *Percent taxonomic disagreement* (PTD) quantifies the sample-based precision of taxonomic identifications by comparing target level taxonomic results from two independent taxonomists, using the formula:

$$PTD = [1-(a/N)] \times 100$$

where *a* is the number of matches (agreements), and *N* is the total number of organisms in the larger of the two counts.

iii. *Percent taxonomic completeness* (PTC) is the percentage of individuals in a sample that are identified to the specified target level, calculated using the formula:

$$PTC – s/n \times 100$$

where *x* is the number of specimens identified to target level, and *n* is the total number of specimens identified in the sample. Target level for each individual is determined by arbitration. Examples:

- If both taxonomists agree the organism can only be identified to family, target level is family.
- If first taxonomist identifies to genera and 2nd to family, but it is agreed that the lower identification is questionable, the target is family.
- If first taxonomist identifies to family and 2nd identifies to genera and it is agreed that the lower identification is valid, the target is genera.

iv. It is also useful to calculate the absolute difference in PTC between T1 and T2 (PTC_{abs}).

Unless specified otherwise by project objectives, measurement quality objectives (MQO) are

$PDE \leq 5$
$PTD \leq 15$
$PTC \geq 95$
$PTDabs_s \leq 5$

Round to tenths (0 – 4 round down, 5-9 round up).

Biorecon Taxonomists

a. For biorecons, 10% of genus level vouchers must be checked by a second qualified biologist (may be another EFO or lab if necessary). For family level biorecons where complete vouchers are not collected on every sample, taxonomic QC will be on every 10th sample when the entire voucher is retained instead of random. Taxonomic agreement must be at least 90% for each group of 10.

b. A taxonomic proficiency exam is required for DWR biologists who are identifying macroinvertebrates at the family or genus level for biorecons used in water quality assessments. The exam is part of the QC process and helps establish defensibility and consistency of the monitoring and assessment program. It is also useful for identifying training needs.

   Test proficiency will not be part of the IPP evaluation. The goal is for the biologist to successfully complete biorecons in accordance with standard operating procedures and quality assurance guidelines.

   General guidelines for test:

   i. Established taxonomists will take the test every time a new primary macroinvertebrate key is adopted by the Division.

   ii. New biologists will take their first test once they have passed field and identification QC

   iii. requirements outlined in the current macroinvertebrate QSSOP and have received sufficient taxonomic training that they are prepared to become a taxonomist at the family or genus level.

   iv. More than one taxonomist can take the exam at the same time. Each taxonomist taking the exam must use a separate scope and key.

   v. If more than one taxonomist is being tested at the same time (or different times from the same field office), they will be given different tests.

   vi. If a taxonomist needs to be retested, they will be given a different test.

   vii. Taxonomists should identify all organisms to either the genus or family level depending on which test they are taking. Genus and family tests are not interchangeable.

Biorecon Test Proctoring Guidelines:

i. The Proctor will be the DWR Technical Fellow or their designee. The Proctor will not currently be working at the same field office as the taxonomist being tested.

ii. Close the lab; no entry while the exam is on-going, no other personnel in the lab other than those taking the exam and the Proctor.

iii. No talking during the exam; no questions may be asked once the exam begins.

iv. All computers in the lab must be turned off during the exam; the taxonomist must turn off their phone or leave it outside the lab or with the proctor during the exam.

v. Exams must be completed in one sitting, without breaking for lunch. Bathroom breaks are allowed but taxonomists must not interact with other personnel during the break, access computers or take anything from the lab with them (including cell phones).

vi. The Proctor must stay in the lab with the taxonomist at all times; if the Proctor has to leave the room for any reason, someone else (not a biologist from the same EFO) must stand in for the Proctor while they are out of the room.

vii. Taxonomists may only utilize Merritt and Cummings 5th edition for the exam; no other keys will be permitted. The Proctor should bring a copy of the 5th edition with them to ensure that the taxonomist has access to the correct text.

viii. Taxonomists should be cautioned to take great care with the benthic specimens – many of them are quite fragile. The exam has been designed so it is not necessary for the taxonomist to dissect parts of specimens to make a correct identification.

ix. If the taxonomist wishes to see one of the back-up specimens, they must request it from the Proctor. The Proctor will decide if the primary specimen(s) are damaged or inadequate to the extent that utilizing a back-up specimen is necessary.

x. Most taxonomists will complete the exam in less than 2 hours, but additional time will be granted upon request. The Proctor should not allow the exam to exceed 3 hours.

xi. It shall be made clear to the taxonomist that their performance on these exams has no bearing on their IPPs, evaluations, or annual ratings.

xii. The Proctor will grade the exam immediately following its conclusion. The Proctor will go through the key with the taxonomist step-by-step for each taxon that was incorrectly identified at that time.

xiii. The goal for taxonomic proficiency is successful identification of 90% of the organisms. If the taxonomist does not meet this goal, they can take a different exam on a later date. The Proctor should avoid using the terms “pass” and “fail”.

F. Voucher Collections

1. Family Level Biorecons – Representative specimens of families difficult to field identify, should always be collected for dissecting scope verification. Voucher collections including representatives of each taxon must be collected at a minimum of 10% of sites for verification by dissecting scope. If misidentifications occur, vouchers should be collected at all sites for those families missed until biologist has demonstrated proficiency in field identifications for that taxon.

2. Genus level – Vouchers collections including representatives of each taxon must be collected at every site for verification by dissecting scope. Ten percent of samples must be re-identified by a second taxonomist who has successfully completed testing and QC requirements (may be in a different field office.) Taxonomic agreement must be 90% for each group of 10.

3. All voucher samples must be maintained for a minimum of five years from collection date.

G. Reference Collections

1. The designated QC officer (quality team member) for each EFO will maintain a permanent reference collection consisting of all taxa identified by that EFO. In addition, a master collection of all taxa identified in the state will be kept in the central laboratory. The organisms in the centralized master reference collection will be verified by outside experts recognized for expertise in a particular taxonomic group (Appendix D)

2. A list of verified organisms found in the state is provided in Appendix C and the master taxa table in Waterlog/Hydra. If new organisms, not on the verified state taxa list, are identified by the EFO, the quality team member will send a representative (preferably 2-3) of that taxon to the central laboratory. The laboratory will have the new taxon identified by the EFO or TDH biologist verified by an outside expert and add the organism to the central reference collection. The lab will return any "extra" verified individuals to the EFO for inclusion in the field office reference collection.

3. The lab will notify all regional offices and WPU of its addition to the verified taxa list for Tennessee. A copy of the expert verification information including the name of the verifier and date will be sent to WPU for inclusion in the master taxa table in Waterlog/Hydra. Experts used for verification must meet the qualifications provided in Appendix D.

4. Each EFO and central laboratory reference collection will be catalogued with discrete collection numbers assigned to each taxon in each facility. Assign unique numbers that identify the reference location to specimens as they are added into the collection. For example, if sequential numbering is used, N0001 would be the first specimen in the Nashville EFO collection. Maintain an accession catalog of all reference material in a permanently bound log or electronic format with backup on a separate system. Each entry must contain the following information:

- Accession number (This must be unique for each group of organisms in each collection)
- Complete name (genus, authority = who ID'ed or verified it, date identified)
- Higher taxa (family, order, class)
- Locality data (Waterbody, location, county, ecoregion, station id)
- Sample habitat
- Name of collector/date of collection
- Name of taxonomist
- Name of verifier if appropriate
- Number of specimens

5. Arrange specimens for ease of use, (according to accession number or in phylogenetic order). Retain wet specimens in 80% ethanol in small screw cap vials with rubber or Teflon lined caps or rubber stoppered vials. Retain large specimens in appropriate size specimen jars sealed with electrical tape to reduce evaporation. Inspect vials monthly for evaporation adding 80% ethanol as needed. Keep permanently mounted microscope slides in a slide storage box. Seal the edges of the coverslips to prevent shrinkage of media over time.

6. Clearly label all reference vials and slides. Place the labels in the vial with wet specimens or attach to slides for mounted specimens. Label information at a minimum must include:

    - Full name of the organism (Order, family, genus)
    - Accession number (reference number)
    - Station ID number
    - Ecoregion
    - Collection date
    - Collector
    - Taxonomist
    - Verifier

H. Data Reduction QC

1. Raw data (taxonomic lists and counts) will be stored in the taxonomic tables in Waterlog/Hydra and in EPA WQX.
2. A second staff member will check all computer data entry for correctness by direct comparison with any field or laboratory handwritten data sheets. This step is not necessary if using tablets loaded with DWR data sheets. The person performing the data entry QC initial and dates each page of the checked printout in red ink
3. QC information is kept a minimum of five years.
4. All QC is completed before results are released.

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IV. APPENDICES

APPENDIX A

ECOREGION REFERENCE INFORMATION

BIOCRITERIA TABLES
BIORECON METRIC TABLE
ECOREGION REFERENCE STREAMS
HEADWATER ECOREGION REFERENCE STREAMS
REGIONAL EXPECTATIONS FOR INDIVIDUAL HABITAT PARAMETERS

Bioregion: 65abei Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQBANK Drainage > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 35	24 - 35	12 - 23	< 12
EPT Richness (EPT)	> 9	7 - 9	3 - 6	< 3
% EPT-Cheum	> 24.7	16.5 - 24.7	8.3 – 16.4	< 8.3
% OC	< 54.9	54.9 – 69.9	70 – 84.9	> 84.9
NCBI	< 6.51	6.51 – 7.67	7.68 – 8.83	> 8.83
% Clingers-Cheum	> 22.7	15.2 – 22.7	7.6 – 15.1	< 7.6
% TNutol	< 28.9	28.9 – 52.6	52.7 – 76.2	> 76.2

Bioregion: 65abei Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQBANK Drainage > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 34	23 – 34	12 - 22	< 12
EPT Richness (EPT)	> 8	6– 8	3 – 5	< 3
% EPT-Cheum	> 30.9	20.7 – 30.9	10.3 – 20.6	< 10.3
% OC	< 47	47 – 64.7	64.8 – 82.3	> 82.3
NCBI	< 6.33	6.33 – 7.55	7.56 – 8.77	> 8.77
% Clingers-Cheum	> 26.9	18 – 26.9	9 – 17.9	< 9
% TNutol	< 28.6	28.6 – 52.4	52.5 – 76.1	> 76.1

Bioregion: 65abei Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQBANK Drainage ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 31	21 - 31	11 - 20	< 11
EPT Richness (EPT)	> 5	4 - 5	2 - 3	< 2
% EPT-Cheum	> 42.2	28.2 – 42.2	14.1 – 28.1	< 14.1
% OC	< 45.6	45.6 – 63.7	63.8 – 81.8	> 81.8
NCBI	< 5.43	5.43 – 6.95	6.96 – 8.47	> 8.47
% Clingers-Cheum	> 26.8	18 – 26.8	9 – 17.9	< 9
% TNutol	< 27.5	27.5 – 51.7	51.8 – 75.8	> 75.8

Bioregion: 65abei Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQBANK Drainage ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 35	24 - 35	12 - 23	< 12
EPT Richness (EPT)	> 8	6 - 8	3 - 5	< 3
% EPT-Cheum	> 34.4	23 – 34.4	11.5 – 22.9	< 11.5
% OC	< 43.1	43.1 – 62.1	62.2 - 81	> 81
NCBI	< 5.68	5.68 – 7.12	7.13 – 8.55	> 8.55
% Clingers-Cheum	> 17.1	11.5 – 17.1	5.7 – 11.4	< 5.7
% TNutol	< 27	27 – 51.3	51.4 – 75.6	> 75.6

Bioregion 65j Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage: > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 30	21– 30	10– 20	< 10
EPT Richness (EPT)	> 11	8 – 11	4 – 7	< 4
% EPT-Cheum	> 44	29.4 - 44	14.7 – 29.3	< 14.7
% OC	< 34.4	34.4 – 56.2	56.3 – 78.1	> 78.1
NCBI	< 4.99	4.99 – 6.66	6.67 – 8.32	> 8.32
% Clingers-Cheum	> 46.9	31.3 – 46.9	15.7 – 31.2	< 15.7
% TNutol	< 27.9	27.9 – 51.9	52 – 75.9	> 75.9

Bioregion 65j Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage: > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 27	19– 27	9 – 18	< 9
EPT Richness (EPT)	> 9	7 – 9	3 – 6	< 3
% EPT-Cheum	> 50.8	34 – 50.8	17.0 – 33.9	< 17
% OC	< 35.3	35.3 – 56.9	57 – 78.4	> 78.4
NCBI	< 5.24	5.24 – 6.83	6.84 – 8.41	> 8.41
% Clingers-Cheum	> 43.6	29.2 – 43.6	14.6 – 29.1	< 14.6
% TNutol	< 29.3	29.3 – 52.9	53 – 76.4	> 76.4

Bioregion 65j January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage: ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 28	20 - 28	10 – 19	< 10
EPT Richness (EPT)	> 10	7 - 10	4 - 6	< 4
% EPT-Cheum	> 52.7	35.2 – 52.7	17.6 – 35.1	< 17.6
% OC	< 31.5	31.5 – 54.3	54.4 – 77.1	> 77.1
NCBI	< 5.49	5.49 – 6.99	7 – 8.49	> 8.49
% Clingers-Cheum	> 33.6	22.5 – 33.6	11.2 – 22.4	< 11.2
% TNutol	< 37.3	37.3 – 58.2	58.3 - 79	> 79

Bioregion 65j Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage: ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 32	22 - 32	11 - 21	< 11
EPT Richness (EPT)	> 11	8 - 11	4 – 7	< 4
% EPT-Cheum	> 49.4	33 – 49.4	16.5 – 32.9	< 16.5
% OC	< 32	32 – 54.7	54.8 – 77.3	> 77.3
NCBI	< 5.5	5.5 - 7	7.01 – 8.49	> 8.49
% Clingers-Cheum	> 47.7	31.9 – 47.7	15.9 – 31.8	< 15.9
% TNutol	< 33.4	33.4 – 55.6	55.7 – 77.7	> 77.7

Bioregion 66deik Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage: > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 32	22 - 32	11 - 21	< 11
EPT Richness (EPT)	> 15	11 - 15	5 - 10	< 5
% EPT-Cheum	> 55.7	37.2 – 55.7	18.6 – 37.1	< 18.6
% OC	< 32.8	32.8 – 55.2	55.3 – 77.5	> 77.5
NCBI	< 4.07	4.07 – 6.04	6.05 – 8.02	> 8.02
% Clingers-Cheum	> 55	36.7 - 55	18.4 – 36.6	< 18.4
% TNutol	< 26.3	26.3 – 50.8	50.9 – 75.4	> 75.4

Bioregion 66deik Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage: > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 31	21 - 31	11 - 20	< 11
EPT Richness (EPT)	> 15	10 - 15	5 - 9	< 5
% EPT-Cheum	> 57.5	38.4 – 57.5	19.2 – 38.3	< 19.2
% OC	< 29.7	29.7 – 53.1	53.2 – 76.5	> 76.5
NCBI	< 4.36	4.36 – 6.24	6.25 - 8.11	> 8.11
% Clingers-Cheum	> 54.4	36.3 – 54.4	18.2 – 36.2	< 18.2
% TNutol	< 26.2	26.2 – 50.8	50.9 – 75.3	> 75.3

Bioregion 66deik Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage: ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 34	23 – 34	12 – 22	< 12
EPT Richness (EPT)	> 14	10 – 14	5 – 9	< 5
% EPT-Cheum	> 50.9	34 – 50.9	17 – 33.9	< 17
% OC	< 32.4	32.4 – 54.9	55 – 77.4	> 77.4
NCBI	< 4.34	4.34 – 6.22	6.23 – 8.11	> 8.11
% Clingers-Cheum	> 49.1	32.8 – 49.1	16.4 – 32.7	< 16.4
% TNutol	< 25.7	25.7 – 50.4	50.5 – 75.2	> 75.2

Bioregion 66deik Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage: ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 31	22 – 31	11 – 21	< 11
EPT Richness (EPT)	> 14	10 – 14	5 – 9	< 5
% EPT-Cheum	> 55.2	36.9 – 55.2	18.4 – 36.8	< 18.4
% OC	< 30.9	30.9 – 53.9	54 – 76.9	> 76.9
NCBI	< 4.54	4.54 – 6.36	6.37 – 8.17	> 8.17
% Clingers-Cheum	> 52.7	35.2 – 52.7	17.6 – 35.1	< 17.6
% TNutol	< 26.6	26.6 - 51	51.1 – 75.5	> 75.5

Bioregion: 66fgj Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage: > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 37	25 - 37	13 - 24	< 13
EPT Richness (EPT)	> 16	12 - 16	6 - 11	< 6
% EPT-Cheum	> 49.9	33.3 – 49.9	16.7 – 33.2	< 16.7
% OC	< 33.6	33.6 – 55.7	55.8 – 77.8	> 77.8
NCBI	< 4.37	4.37 – 6.25	6.26 – 8.12	> 8.12
% Clingers-Cheum	> 53.1	35.5 – 53.1	17.7 – 35.4	< 17.7
% TNutol	< 27.2	27.2 – 51.4	51.5 – 75.7	> 75.7

Bioregion: 66fgj Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage: > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 34	24 - 34	12 - 23	< 12
EPT Richness (EPT)	> 16	11–16	6 –10	< 6
% EPT-Cheum	> 55.6	37.1 – 55.6	18.6 - 37	< 18.6
% OC	< 29.6	29.6 - 53	53.1 – 76.5	> 76.5
NCBI	< 4.55	4.55 – 6.36	6.37 – 8.18	> 8.18
% Clingers-Cheum	> 51	34.1 - 51	17 - 34	< 17
% TNutol	< 28.2	28.2 – 52.1	52.2 - 76	> 76.0

Bioregion: 66fgj Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage: ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 34	24 - 34	12 - 23	< 12
EPT Richness (EPT)	> 13	10 - 13	5 –9	< 5
% EPT-Cheum	> 41.5	27.7 – 41.5	13.9 – 27.6	< 13.9
% OC	< 42.2	42.2 – 61.4	61.5 – 80.7	> 80.7
NCBI	< 4.85	4.85 – 6.56	6.57 – 8.28	> 8.28
% Clingers-Cheum	> 42.7	28.6 – 42.7	14.3 – 28.5	< 14.3
% TNutol	< 28.2	28.2 – 52.1	52.2 - 76	> 76

Bioregion: 66fgj Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage: ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 32	22 - 32	11 - 21	< 11
EPT Richness (EPT)	> 14	10–14	5 – 9	< 5
% EPT-Cheum	> 49.3	32.9 – 49.3	16.5 – 32.8	< 16.5
% OC	< 31.6	31.6 – 54.4	54.5 – 77.1	> 77.1
NCBI	< 4.44	4.44 – 6.29	6.3 – 8.14	> 8.14
% Clingers-Cheum	> 56.3	37.6 – 56.3	18.8 – 37.5	< 18.8
% TNutol	< 27.4	27.4 – 51.6	51.7 – 75.7	> 75.7

Bioregion 67fghi Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 30	21 - 30	10 - 20	< 10
EPT Richness (EPT)	> 12	9 - 12	4 - 8	< 4
% EPT-Cheum	> 40.3	26.9 – 40.3	13.5 – 26.8	< 13.5
% OC	< 27.4	27.4 – 51.5	51.6 – 75.7	> 75.7
NCBI	< 4.7	4.7 – 6.46	6.47 – 8.23	> 8.23
% Clingers-Cheum	> 51.3	34.2 – 51.3	17.1 – 34.1	< 17.1
% TNutol	< 28.8	28.8 – 52.5	52.6 – 76.2	> 76.2

Bioregion 67fghi Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 26	18 – 26	9 – 17	< 9
EPT Richness (EPT)	> 10	7 – 10	4 – 6	< 4
% EPT-Cheum	> 42.7	28.5 – 42.7	14.3 – 28.4	< 14.3
% OC	< 26.6	26.6 - 51	51.1 – 75.5	> 75.5
NCBI	< 5.1	5.1 – 6.73	6.74 – 8.36	> 8.36
% Clingers-Cheum	> 54.1	36.2 – 54.1	18.1 – 36.1	< 18.1
% TNutol	< 31.6	31.6 – 54.3	54.4 – 77.1	> 77.1

Bioregion: 67fghi Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 31	22 - 31	11 – 21	< 11
EPT Richness (EPT)	> 11	8 - 11	4 - 7	< 4
% EPT-Cheum	> 49	32.8 - 49	16.4 – 32.7	< 16.4
% OC	< 28.3	28.3 – 52.2	52.3 - 76	> 76
NCBI	< 4.85	4.85 – 6.56	6.57 – 8.28	> 8.28
% Clingers-Cheum	> 50.5	33.7 – 50.5	16.9 – 33.6	< 16.9
% TNutol	< 27.4	27.4 – 51.6	51.7 – 75.7	> 75.7

Bioregion: 67fghi Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 30	21 - 30	10 - 20	< 10
EPT Richness (EPT)	> 11	8 – 11	4 – 7	< 4
% EPT-Cheum	> 46.3	30.9 – 46.3	15.5 – 30.8	< 15.5
% OC	< 28.5	28.5 – 52.3	52.4 – 76.1	> 76.1
NCBI	< 4.78	4.78 – 6.52	6.53 – 8.25	> 8.25
% Clingers-Cheum	> 55	36.7 - 55	18.4 – 36.6	< 18.4
% TNutol	< 27.4	27.4 – 51.6	51.7 – 75.1	> 75.7

Bioregion: 67fghi Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = **SQBANK** Drainage >2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 28	20 – 28	10 – 19	< 10
EPT Richness (EPT)	> 6	5 – 6	2 – 4	< 2
% EPT-Cheum	> 25.9	17.4 – 25.9	8.7 – 17.3	< 8.7
% OC	< 49.8	49.8 – 66.5	66.6 – 83.2	> 83.2
NCBI	< 6.65	6.65 – 7.76	7.77 – 8.88	> 8.88
% Clingers	> 20.1	13.5 – 20.1	6.7 – 13.4	< 6.7
% TNutol	< 44.9	44.9 – 63.2	63.3 – 81.6	> 81.6

Bioregion: 67fghi Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = **SQBANK** Drainage >2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 27	19 - 27	9 - 18	< 9
EPT Richness (EPT)	> 6	5 - 6	2 - 4	< 2
% EPT-Cheum	> 36.3	24.3 – 36.3	12.1 – 24.2	< 12.1
% OC	< 27.8	27.8 – 51.9	52 - 75.9	> 75.9
NCBI	< 5.97	5.97 – 7.31	7.32 – 8.65	> 8.65
% Clingers	> 33.7	22.6 – 33.7	11.3 – 22.5	< 11.3
% TNutol	< 34	34 - 56	56.1 – 77.9	> 77.9

Bioregion 68ad Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage: > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 34	23 - 34	12 - 22	< 12
EPT Richness (EPT)	> 14	10 - 14	5 - 9	< 5
% EPT-Cheum	> 41.2	27.6 – 41.2	13.8 – 27.5	< 13.8
% OC	< 37.2	37.2 – 58.1	58.2 - 79	> 79
NCBI	< 4.71	4.71 – 6.47	6.48 – 8.23	> 8.23
% Clingers-Cheum	> 48.3	32.3 – 48.3	16.1 – 32.2	< 16.1
% TNutol	< 28.6	28.6 – 52.4	52.5 – 76.1	> 76.1

Bioregion 68ad Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage: > 2.5 square miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 34	23 - 34	12 - 22	< 12
EPT Richness (EPT)	> 13	10 - 13	5 – 9	< 5
% EPT-Cheum	> 48.3	32.3 – 48.3	16.1 – 32.2	< 16.1
% OC	< 29.6	29.6 – 53.1	53.2 – 76.5	> 76.5
NCBI	< 4.83	4.83 – 6.55	6.56 – 8.27	> 8.27
% Clingers-Cheum	> 55.8	37.3 – 55.8	18.6 – 37.2	< 18.6
% TNutol	< 31.1	31.1 - 54	54.1 - 77	> 77

Bioregion 68ad Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage: ≤ 2.5 square miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 31	22 - 31	11 – 21	< 11
EPT Richness (EPT)	> 11	8 – 11	4 – 7	< 4
% EPT-Cheum	> 54.6	36.5 – 54.6	18.2 – 36.4	< 18.2
% OC	< 34.1	34.1 - 56	56.1 - 78	> 78
NCBI	< 5.24	5.24 – 6.83	6.84 – 8.41	> 8.41
% Clingers-Cheum	> 29.6	19.8 – 29.6	9.9 – 19.7	< 9.9
% TNutol	< 29.9	29.9 – 53.2	53.3 – 76.6	> 76.6

Bioregion 68ad Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage: ≤ 2.5 square miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 29	20 - 29	10 - 19	< 10
EPT Richness (EPT)	> 10	7 – 10	4 – 6	< 4
% EPT-Cheum	> 43.2	28.8 – 43.2	14.4 – 28.7	< 14.4
% OC	< 43.2	43.2 – 62.1	62.2 - 81	> 81
NCBI	< 5.81	5.81 – 7.2	7.21 – 8.6	> 8.6
% Clingers-Cheum	> 45.5	30.4 – 45.5	15.2 – 30.3	< 15.2
% TNutol	< 34	34 - 56	56.1 – 77.9	> 77.9

Bioregion 68b Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage: > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 26	18 - 26	9 – 17	< 9
EPT Richness (EPT)	> 11	8 – 11	4 – 7	< 4
% EPT-Cheum	> 55	36.8 - 55	18.4 – 36.7	< 18.4
% OC	< 34.4	34.4 – 56.2	56.3 – 78.1	> 78.1
NCBI	< 4.91	4.91 – 6.6	6.61 – 8.3	> 8.3
% Clingers-Cheum	> 28.6	19.1 – 28.6	9.6 - 19	< 9.6
% TNutol	< 28.9	28.9 – 52.5	52.6 – 76.2	> 76.2

Bioregion 68b Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage: > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 23	16 – 23	8 – 15	< 8
EPT Richness (EPT)	> 9	7 – 9	3 – 6	< 3
% EPT-Cheum	> 41.2	27.5 – 41.2	13.8 – 27.4	< 13.8
% OC	< 31.3	31.1 – 54.1	54.2 - 77	> 77
NCBI	< 5.13	5.13 – 6.75	6.76 – 8.37	> 8.37
% Clingers-Cheum	> 41.6	27.8 – 41.6	13.9 – 27.7	< 13.9
% TNutol	< 34.5	34.5 – 56.3	56.4 – 78.1	> 78.1

Bioregion 68b Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage: ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 27	18 - 27	9 – 17	< 9
EPT Richness (EPT)	> 9	7 – 9	3 – 6	< 3
% EPT-Cheum	> 43.7	29.2 – 43.7	14.6 – 29.1	< 14.6
% OC	< 34.2	34.2 – 56.1	56.2 - 78	> 78.0
NCBI	< 5.36	5.36 – 6.91	6.92 – 8.45	> 8.45
% Clingers-Cheum	> 30.9	20.7 – 30.9	10.3 – 20.6	< 10.3
% TNutol	< 29.6	29.6 - 53	53.1 – 76.5	> 76.5

Bioregion 68b Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage: ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 27	18 - 27	9 - 17	< 9
EPT Richness (EPT)	> 9	7 - 9	3 - 6	< 3
% EPT-Cheum	> 48.3	32.3 – 48.3	16.1 – 32.2	< 16.1
% OC	< 29.6	29.6 – 53.1	53.2 – 76.5	> 76.5
NCBI	< 5.16	5.16 – 6.77	6.78 – 8.38	> 8.38
% Clingers-Cheum	> 41.6	27.8 – 41.6	13.9 – 27.7	< 13.9
% TNutol	< 31.4	31.4 – 54.2	54.3 – 77.1	> 77.1

Bioregion 68c Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage: > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 29	20 - 29	10 - 19	< 10
EPT Richness (EPT)	> 12	9 - 12	4 - 8	< 4
% EPT-Cheum	> 60.4	40.4 – 60.4	20.2 – 40.3	< 20.2
% OC	< 29.2	29.2 – 52.8	52.9 – 76.3	> 76.3
NCBI	< 4.5	4.5 – 6.33	6.34 – 8.16	> 8.16
% Clingers-Cheum	> 43.1	28.8 – 43.1	14.4 – 28.7	< 14.4
% TNutol	< 27	27 – 51.3	51.4 – 75.6	> 75.6

Bioregion 68c Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage: > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 25	17 - 25	9 - 16	< 9
EPT Richness (EPT)	> 8	6 - 8	3 - 5	< 3
% EPT-Cheum	> 40.5	27.1 – 40.5	13.5 - 27	< 13.5
% OC	< 30.7	30.7 – 53.8	53.9 – 76.8	> 76.8
NCBI	< 4.99	4.99 – 6.66	6.67 – 8.32	> 8.32
% Clingers-Cheum	> 44	29.4 - 44	14.7 – 29.3	< 14.7
% TNutol	< 32.4	32.4 – 54.9	55 – 77.4	> 77.4

Bioregion 68c Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage: ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 30	21 - 30	10 - 20	< 10
EPT Richness (EPT)	> 13	9 - 13	5 - 8	< 5
% EPT-Cheum	> 53.5	35.7 – 53.5	17.9 – 35.6	< 17.9
% OC	< 34.4	34.4 – 56.2	56.3 – 78.1	> 78.1
NCBI	< 4.68	4.68 – 6.45	6.46 – 8.22	> 8.22
% Clingers-Cheum	> 36.6	24.4 – 36.6	12.2 – 24.3	< 12.2
% TNutol	< 25.9	25.9 – 50.6	50.7 – 75.2	> 75.2

Bioregion 68c Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage: ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 29	20 - 29	10 - 19	< 10
EPT Richness (EPT)	> 13	9 - 13	5 - 8	< 5
% EPT-Cheum	> 49.9	33.3 – 49.9	16.7 – 33.2	< 16.7
% OC	< 32.7	32.7 – 55.1	55.2 – 77.5	> 77.5
NCBI	< 5.16	5.16 – 6.77	6.78 – 8.38	> 8.38
% Clingers-Cheum	> 35	23.4 - 35	11.7 – 23.3	< 11.7
% TNutol	< 30.1	30.1 – 53.4	53.5 – 76.6	> 76.6

Bioregion 69de Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage: > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 32	22 – 32	11 – 21	< 11
EPT Richness (EPT)	> 15	11 – 15	5 – 10	< 5
% EPT-Cheum	> 61.1	40.8 – 61.1	20.4 – 40.7	< 20.4
% OC	< 33.1	33.1 – 55.4	55.5 – 77.6	> 77.6
NCBI	< 3.9	3.9 – 5.93	5.94 – 7.96	> 7.96
% Clingers-Cheum	> 54.1	36.2 – 54.1	18.1 – 36.1	< 18.1
% TNutol	< 26.7	26.7 – 51.1	51.2 – 75.5	> 75.5

Bioregion: 69de Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage: > 2.5 square miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 29	20 - 29	10 - 19	< 10
EPT Richness (EPT)	> 12	9 – 12	4 – 8	< 4
% EPT-Cheum	> 55.8	37.3 – 55.8	18.6 – 37.2	< 18.6
% OC	< 31.7	31.7 – 54.5	54.6 – 77.2	> 77.2
NCBI	< 4.8	4.8 – 6.53	6.54 – 8.26	> 8.26
% Clingers-Cheum	> 52.6	35.1 – 52.6	17.6 - 35	< 17.6
% TNutol	< 27.9	27.9 – 51.9	52 – 75.9	> 75.9

Bioregion: 69de Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage: ≤ 2.5 square miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 28	19 - 28	10 - 18	< 10
EPT Richness (EPT)	> 10	8 – 10	4 – 7	< 4
% EPT-Cheum	> 59.2	39.5 – 59.2	19.8 – 39.4	< 19.8
% OC	< 31.8	31.8 – 54.5	54.6 – 77.2	> 77.2
NCBI	< 4.18	4.18 – 6.12	6.13 – 8.05	> 8.05
% Clingers-Cheum	> 32.3	21.6 – 32.3	10.8 – 21.5	< 10.8
% TNutol	< 26	26 – 50.7	50.8 – 75.3	> 75.3

Bioregion: 69de Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage: ≤ 2.5 square miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 27	19 – 27	9 – 18	< 9
EPT Richness (EPT)	> 10	8 - 10	4 – 7	< 4
% EPT-Cheum	> 47.7	31.9 – 47.7	15.9 – 31.8	< 15.9
% OC	< 39.4	39.4 – 59.6	59.7 – 79.7	> 79.7
NCBI	< 4.67	4.67 – 6.44	6.45 – 8.22	> 8.22
% Clingers-Cheum	> 45.8	30.6 – 45.8	15.3 – 30.5	< 15.3
% TNutol	< 27.1	27.1 – 51.4	51.5 – 75.6	> 75.6

Bioregion 71e Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage: > 2.5 square miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 27	19 – 27	9 – 18	< 9
EPT Richness (EPT)	> 10	7 – 10	4 – 6	< 4
% EPT-Cheum	> 38.6	25.8 – 38.6	12.9 – 25.7	< 12.9
% OC	< 29.8	29.8 – 53.2	53.3 – 76.5	> 76.5
NCBI	< 5.45	5.45 – 6.97	6.98 – 8.48	> 8.48
% Clingers-Cheum	> 48.2	32.2 – 48.2	16.1 – 32.1	< 16.1
% TNutol	< 37.6	37.6 – 58.4	58.5 – 79.1	> 79.1

Bioregion 71e Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage: > 2.5 square miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 24	17 – 24	8 – 16	< 8
EPT Richness (EPT)	> 8	6 - 8	3 – 5	< 3
% EPT-Cheum	> 43.5	29 – 43.5	14.5 – 28.9	< 14.5
% OC	< 26.0	26 – 50.7	50.8 – 75.3	> 75.3
NCBI	< 5.49	5.49 – 6.99	7 – 8.49	> 8.49
% Clingers-Cheum	> 46.2	30.9 – 46.2	15.4 – 30.8	< 15.4
% TNutol	< 39.3	39.3 – 59.5	59.6 – 79.7	> 79.7

Bioregion 71e Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage: ≤ 2.5 square miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 21	14 - 21	7 - 13	< 7
EPT Richness (EPT)	> 8	6 – 8	3 – 5	< 3
% EPT-Cheum	> 42.5	28.4 – 42.5	14.2 – 28.3	< 14.2
% OC	< 30.8	30.8 – 53.8	53.9 – 76.9	> 76.9
NCBI	< 5.71	5.71 – 7.14	7.15 – 8.56	> 8.56
% Clingers-Cheum	> 24.1	16.1 – 24.1	8.1 - 16	< 8.1
% TNutol	< 39.4	39.4 – 59.6	59.7 – 79.7	> 79.7

Bioregion 71e Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage: ≤ 2.5 square miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 25	17 - 25	9 - 16	< 9
EPT Richness (EPT)	> 7	5 - 7	3 - 4	< 3
% EPT-Cheum	> 41.8	28 – 41.8	14 – 27.9	< 14
% OC	< 36.5	36.5 – 57.7	57.8 – 78.8	> 78.8
NCBI	< 5.29	5.29 – 6.86	6.87 – 8.42	> 8.42
% Clingers-Cheum	> 41.2	27.6 – 41.2	13.8 – 27.5	< 13.8
% TNutol	< 35.7	35.7 – 57.1	57.2 – 78.5	> 78.5

Bioregion 71fgh Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 28	20 - 28	10 - 19	< 10
EPT Richness (EPT)	> 11	8 – 11	4 – 7	< 4
% EPT-Cheum	> 49.3	32.9 – 49.3	16.5 – 32.8	< 16.5
% OC	< 31.1	31.1 - 54	54.1 - 77	> 77.0
NCBI	< 4.89	4.89 – 6.59	6.6 – 8.29	> 8.29
% Clingers-Cheum	> 50.5	33.7 – 50.5	16.9 – 33.6	< 16.9
% TNutol	< 29.3	29.3 – 52.8	52.9 – 76.4	> 76.4

Bioregion 71fgh Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 28	19 – 28	10 – 18	< 10
EPT Richness (EPT)	> 10	7 - 10	4 - 6	< 4
% EPT-Cheum	> 50.2	33.5 – 50.2	16.8 – 33.4	< 16.8
% OC	< 26.7	26.7 – 51.1	51.2 – 75.5	> 75.5
NCBI	< 5.21	5.21 – 6.80	6.81 – 8.40	> 8.40
% Clingers-Cheum	> 52.4	35 – 52.4	17.5 – 34.9	< 17.5
% TNutol	< 31.6	31.6 - 54.4	54.5 – 77.1	> 77.1

Bioregion: 71fgh Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 28	19 - 28	10 - 18	< 10
EPT Richness (EPT)	> 11	8 - 11	4 – 7	< 4
% EPT-Cheum	> 57.7	38.5 – 57.7	19.3 – 38.4	< 19.3
% OC	< 28.9	28.9 – 52.6	52.7 – 76.2	> 76.2
NCBI	< 4.69	4.69 – 6.46	6.47 – 8.22	> 8.22
% Clingers-Cheum	> 41.3	27.6 – 41.3	13.8 – 27.5	< 13.8
% TNutol	< 28.1	28.1 - 52.1	52.2 - 76	> 76

Bioregion: 71fgh Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 29	20 - 29	10 - 19	< 10
EPT Richness (EPT)	> 10	7 - 10	4 - 6	< 4
% EPT-Cheum	> 49.2	32.8 – 49.2	16.4 – 32.7	< 16.4
% OC	< 27.2	27.2 – 51.4	51.5 – 75.7	> 75.7
NCBI	< 5.35	5.35 – 6.9	6.91 – 8.44	> 8.44
% Clingers-Cheum	> 46.3	30.9 – 46.3	15.5 – 30.8	< 15.5
% TNutol	< 30.7	30.7 – 53.8	53.9 – 76.8	> 76.8

Bioregion 71i Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 22	15 – 22	8 – 14	< 8
EPT Richness (EPT)	> 7	6 – 7	3 – 5	< 3
% EPT-Cheum	> 32.6	21.8 – 32.6	10.9 – 21.7	< 10.9
% OC	< 36.6	36.6 – 57.7	57.8 – 78.8	> 78.8
NCBI	< 5.95	5.95 – 7.3	7.31 – 8.64	> 8.64
% Clingers-Cheum	> 44.5	29.7 – 44.5	14.9 – 29.6	< 14.9
% TNutol	< 47.7	47.7 – 65.1	65.2 – 82.5	> 82.5

Bioregion 71i Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 21	15 - 21	7 - 14	< 7
EPT Richness (EPT)	> 6	5 - 6	2 - 4	< 2
% EPT-Cheum	> 33.4	22.3 – 33.4	11.2 – 22.2	< 11.2
% OC	< 29.3	29.3 – 52.8	52.9 – 76.4	> 76.4
NCBI	< 5.83	5.83 – 7.22	7.23 – 8.6	> 8.6
% Clingers-Cheum	> 53.3	35.6 – 53.3	17.8 – 35.5	< 17.8
% TNutol	< 47.8	47.8 – 65.2	65.3 – 82.5	> 82.5

Bioregion 71i Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 25	17 - 25	9 - 16	< 9
EPT Richness (EPT)	> 7	6 - 7	3 - 5	< 3
% EPT-Cheum	> 39.4	26.3 – 39.4	13.2 – 26.2	< 13.2
% OC	< 30.9	30.9 – 53.9	54 – 76.9	> 76.9
NCBI	< 5.75	5.75 – 7.16	7.17 – 8.58	> 8.58
% Clingers-Cheum	> 43.9	29.3 – 43.9	14.7 – 29.2	< 14.7
% TNutol	< 41.4	41.4 – 60.9	61 – 80.4	> 80.4

Bioregion 71i Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 25	17 - 25	9 - 16	< 9
EPT Richness (EPT)	> 7	6 - 7	3 - 5	< 3
% EPT-Cheum	> 39.4	26.3 – 39.4	13.2 – 26.2	< 13.2
% OC	< 30.9	30.9 – 53.9	54 – 76.9	> 76.9
NCBI	< 5.75	5.75 – 7.16	7.17 – 8.58	> 8.58
% Clingers-Cheum	> 43.9	29.3 – 43.9	14.7 – 29.2	< 14.7
% TNutol	< 41.4	41.4 – 60.9	61 – 80.4	> 80.4

Bioregion 71i Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = **SQBANK** Drainage > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 31	21 – 31	11 – 20	< 11
EPT Richness (EPT)	> 6	5 – 6	2 – 4	< 2
% EPT-Cheum	> 19.3	12.9 – 19.3	6.5 – 12.8	< 6.5
% OC	< 34.7	34.7 – 56.4	56.5 – 78.2	> 78.2
NCBI	< 7.11	7.11 – 8.07	8.08 – 9.03	> 9.03
% Clingers-Cheum	> 14.8	9.9 – 14.8	5.0 – 9.8	< 5.0
% TNutol	< 38.7	38.7 – 59.1	59.2 – 79.5	> 79.5

Bioregion 71i Season: July-December (Fall) Scoring calibrated to 160-240 organism sample			Method = **SQBANK** Drainage > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 24	17 – 24	8 – 16	< 8
EPT Richness (EPT)	> 4	3 – 4	2	< 2
% EPT-Cheum	> 31.4	21.0 – 31.4	10.5 – 20.9	< 10.5
% OC	< 29.1	29.1 – 52.7	52.8 – 76.3	> 76.3
NCBI	< 7.2	7.2 - 8.13	8.14 – 9.06	> 9.06
% Clingers-Cheum	> 20.0	13.4 – 20.0	6.7 – 13.3	< 6.7
% TNutol	< 49.4	49.4 – 66.3	66.4 – 83.1	> 83.1

Bioregion 73ab Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQBANK Drainage: > 2.5 sq miles. Includes non-wadeable Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 21	15 - 21	7 - 14	< 7
ETO Richness	> 3	3	1 – 2	< 1
% EPT-Cheum	> 10.7	7.2 – 10.7	3.6 – 7.1	< 3.6
% OC	< 28.1	28.1 - 52	52.1 - 76	> 76
NCBI	< 7.37	7.37 – 8.24	8.25 – 9.12	> 9.12
% CRMOL	> 50.8	34 – 50.8	17 – 33.9	< 17
% TNutol	< 38.8	38.8 – 59.2	59.3 – 79.5	> 79.5

Bioregion 73ab Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQBANK Drainage: > 2.5 sq miles. Includes non-wadeable Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 23	16 - 23	8 - 15	< 8
ETO Richness	> 4	3 – 4	2	< 2
% EPT-Cheum	> 27	18.1 - 27	9 - 18	< 9
% OC	< 43.2	43.2 – 62.1	62.2 - 81	> 81
NCBI	< 7.55	7.55 – 8.36	8.37 – 9.18	> 9.18
% CRMOL	> 29.1	19.5 – 29.1	9.7 – 19.4	< 9.7
% TNutol	< 40.2	40.2 – 60.1	60.2 - 80	> 80

Bioregion 73ab Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQBANK Drainage:≤ 2.5 sq miles. Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 21	15 - 21	7 - 14	< 7
ETO Richness	> 3	3	1 – 2	< 1
% EPT-Cheum	> 10.7	7.2 – 10.7	3.6 – 7.1	< 3.6
% OC	< 28.1	28.1 - 52	52.1 - 76	> 76
NCBI	< 7.37	7.37 – 8.24	8.25 – 9.12	> 9.12
% CRMOL	> 50.8	34 – 50.8	17 – 33.9	< 17
% TNutol	< 38.8	38.8 – 59.2	59.3 – 79.5	> 79.5

Bioregion 73ab Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQBANK Drainage:≤ 2.5 sq miles. Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 23	16 - 23	8 - 15	< 8
ETO Richness	> 4	3 - 4	2	< 2
% EPT-Cheum	> 27	18.1 - 27	9 - 18	< 9
% OC	< 43.2	43.2 – 62.1	62.2 - 81	> 81
NCBI	< 7.55	7.55 – 8.36	8.37 – 9.18	> 9.18
% CRMOL	> 29.1	19.5 – 29.1	9.7 – 19.4	< 9.7
% TNutol	< 40.2	40.2 – 60.1	60.2 - 80	> 80

Bioregion 74a Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 19	13 - 19	7 - 12	< 7
EPT Richness (EPT)	> 5	4 – 5	2 – 3	< 2
% EPT-Cheum	> 28.6	19.1 – 28.6	9.6 - 19	< 9.6
% OC	< 46.2	46.2 – 64.1	64.2 - 82	> 82
NCBI	< 6.4	6.4 – 7.6	7.61 – 8.79	> 8.79
% Clingers-Cheum	> 59.1	39.5 – 59.1	19.7 – 39.4	< 19.7
% TNutol	< 48.2	48.2 – 65.4	65.5 – 82.7	> 82.7

Bioregion 74a Season: July-December (Fall)Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQKICK Drainage > 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 20	14 - 20	7 – 13	< 7
EPT Richness (EPT)	> 5	4 - 5	2 – 3	< 2
% EPT-Cheum	> 42.5	28.4 – 42.5	14.2 –28.3	< 14.2
% OC	< 30.1	30.1 – 53.4	53.5 – 76.6	> 76.6
NCBI	< 6.61	6.61 – 7.74	7.75 – 8.86	> 8.86
% Clingers-Cheum	> 26	17.4 - 26	8.7 – 17.3	< 8.7
% TNutol	< 37.5	37.5 – 58.3	58.4 – 79.1	> 79.1

Bioregion 74a Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 18	13 - 18	6 - 12	< 6
EPT Richness (EPT)	> 2	2	1	< 1
% EPT-Cheum	> 14	9.4 - 14	4.7 – 9.3	< 4.7
% OC	< 54	54 – 69.3	69.4 – 84.6	> 84.6
NCBI	< 6.39	6.39 – 7.59	7.60 – 8.79	> 8.79
% Clingers-Cheum	> 17.3	11.6 – 17.3	5.8 – 11.5	< 5.8
% TNutol	< 46.1	46.1 - 64	64.1 - 82	> 82

Bioregion 74a Season: July- December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 18	13 - 18	6 - 12	< 6
EPT Richness (EPT)	> 3	3	1 - 2	< 1
% EPT-Cheum	> 52.1	34.8 – 52.1	17.4 – 34.7	< 17.4
% OC	< 42.5	42.5 – 61.7	61.8 – 80.8	> 80.8
NCBI	< 5.06	5.06 – 6.7	6.71 – 8.35	> 8.35
% Clingers-Cheum	> 15.4	10.4 – 15.4	5.2 – 10.3	< 5.2
% TNutol	< 33.2	33.2 – 55.4	55.5 – 77.7	> 77.7

Bioregion: 74b Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQBANK Drainage > 2.5 sq miles (includes non-wadeable) Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 34	23 - 34	12 - 22	< 12
EPT Richness (EPT)	> 10	7 – 10	4 – 6	< 4
% EPT-Cheum	> 41.3	27.6 – 41.3	13.8 – 27.5	< 13.8
% OC	< 47.2	47.2 – 64.8	64.9 – 82.3	> 82.3
NCBI	< 6.6	6.6 – 7.73	7.74 – 8.86	> 8.86
% Clingers	> 27.1	18.1 – 27.1	9.1 - 18	< 9.1
% TNutol	< 36.4	36.4 – 57.6	57.7 – 78.7	> 78.7

Bioregion: 74b Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = SQBANK Drainage > 2.5 sq miles (includes non-wadeable) Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 32	22 – 32	11 – 21	< 11
EPT Richness (EPT)	> 7	6 – 7	3 – 5	< 3
% EPT-Cheum	> 29.4	19.7 – 29.4	9.8 – 19.6	< 9.8
% OC	< 47.1	47.1 – 64.7	64.8 – 82.3	> 82.3
NCBI	< 6.55	6.55 – 7.7	7.71 – 8.84	> 8.84
% Clingers	> 26.4	17.7 – 26.4	8.8 – 17.6	< 8.8
% TNutol	< 32.2	32.2 – 54.8	54.9 – 77.3	> 77.3

Bioregion: 74b Season: January-June (Spring) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQBANK Drainage ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 28	19 - 28	10 - 18	< 10
EPT Richness (EPT)	> 3	3	1 - 2	< 1
% EPT-Cheum	> 10.6	7.1 – 10.6	3.6 - 7	< 3.6
% OC	< 55.5	55.5 – 70.3	70.4 – 85.1	> 85.1
NCBI	< 6.88	6.88 – 7.92	7.93 – 8.95	> 8.95
% Clingers	> 33.5	22.4 – 33.5	11.2 – 22.3	< 11.2
% TNutol	< 33.1	33.1 – 55.4	55.5 – 77.6	> 77.6

Bioregion: 74b Season: July-December (Fall) Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQBANK Drainage ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 28	19 - 28	10 - 18	< 10
EPT Richness (EPT)	> 4	4	2 - 3	< 2
% EPT-Cheum	> 24.1	16.2 – 24.1	8.1 – 16.1	< 8.1
% OC	< 50.7	50.7 – 67.1	67.2 – 83.5	> 83.5
NCBI	< 6.36	6.36 – 7.57	7.58 – 8.78	> 8.78
% Clingers	> 14.8	9.9 – 14.8	5 – 9.8	< 5
% TNutol	< 33.1	33.1 – 55.4	5.55 – 77.6	> 77.6

Scoring Guidance for Family Level Biorecons in Streams > 2.5 sq. Mile Drainage

Bioregion	Season	Taxa Richness (TR)			EPT			Intolerant Taxa (IT)		
Score		**5**	**3**	**1**	**5**	**3**	**1**	**5**	**3**	**1**
65abei	Jan-June	> 18	9-18	< 9	> 6	4-6	< 4	> 3	2-3	< 2
65abei	July-Dec	> 18	9-18	< 9	> 7	4-7	< 4	> 2	2	< 2
65j	Jan-June	> 18	9-18	< 9	> 10	5-10	< 5	> 7	4-7	<3
65j	July-Dec	> 17	9-17	< 9	> 7	4-7	< 4	> 5	3-5	< 3
66deik	Jan-June	> 19	10-19	< 10	> 12	7-12	<7	> 10	6-10	<6
66deik	July-Dec	> 20	11-20	< 11	> 12	7-12	< 7	> 9	5-9	< 5
66fgj	Jan-June	> 23	12-23	< 12	> 12	6-12	< 6	> 9	5-9	< 5
66fgj	July-Dec	> 26	14-26	< 14	> 14	8-14	< 8	> 10	5-10	< 5
67fghi	Jan-June	> 19	10-19	< 10	> 10	5-10	< 5	> 7	4-7	< 4
67fghi	July-Dec	> 20	10-20	< 10	> 8	4-8	< 4	> 5	3-5	< 3
68ad	Jan-June	> 22	12-22	< 12	> 9	5-9	< 5	> 6	4-6	< 4
68ad	July-Dec	> 24	12-24	< 12	> 10	5-10	< 5	> 7	4-7	< 4
68b	Jan-June	> 15	8-15	< 8	> 8	4-8	< 4	> 5	3-5	< 3
68b	July-Dec	> 15	8-15	< 8	> 6	4-6	< 4	> 3	2-3	< 2
68c	Jan-June	> 15	8-15	< 8	> 8	4-8	< 4	> 5	3-5	< 3
68c	July-Dec	> 16	8-16	< 8	> 7	4-7	< 4	> 4	2-4	< 2
69de	Jan-June	> 18	10-18	< 10	> 10	5-10	< 5	> 7	4-7	< 4
69de	July-Dec	> 18	9-18	< 9	> 8	5-8	< 5	> 6	4-6	< 4
71e	Jan-June	> 18	9-18	< 9	> 8	4-8	< 4	> 3	2-3	< 2
71e	July-Dec	> 17	9-17	< 9	> 6	4-6	< 4	> 3	2-3	< 2
71fgh	Jan-June	> 19	10-19	< 10	> 9	5-9	< 5	> 6	3-6	< 3
71fgh	July-Dec	> 17	9-17	< 9	> 7	4-7	< 4	> 4	3-4	< 3
71i	Jan-June	> 18	9-18	< 9	> 6	3-6	< 3	> 2	2	< 2
71i	July-Dec	> 18	10-18	< 10	> 6	3-6	< 3	> 2	2	< 2
74a	Jan-June	> 11	6-11	< 6	> 4	2-4	< 2	> 1	1	< 1
74a	July-Dec	> 10	6-10	< 6	> 3	2-3	< 2	> 1	1	< 1
74b	Jan-June	> 15	8-15	< 8	> 4	3-6	< 3	> 1	1	< 1
74b	July-Dec	> 13	7-13	< 7	> 4	2-4	< 2	> 1	1	< 1

Bioregion	Season	Taxa Richness (TR)			ETO			CRMOL		
Score		**5**	**3**	**1**	**5**	**3**	**1**	**5**	**3**	**1**
73ab	Jan-June	> 10	6-10	< 6	> 1	1	< 1	> 3	2-3	< 2
73ab	July-Dec	> 14	8-14	< 8	> 2	2	< 2	> 4	3-4	< 3

Scoring Guidance for Family Level Biorecons in Headwater Streams ≤ 2.5 sq. mile

Bioregion	Season	Taxa Richness (TR)			EPT			Intolerant Taxa ((IT)		
Score		**5**	**3**	**1**	**5**	**3**	**1**	**5**	**3**	**1**
65abei	Jan-June	> 15	8-15	< 8	> 7	4-7	< 4	> 4	2-4	< 2
65abei	July-Dec	> 12	6-12	< 6	> 4	3-4	< 3	> 2	23	< 2
65j	Jan-June	> 19	10-19	< 10	> 7	4-7	< 4	> 5	3-5	< 3
65j	July-Dec	> 15	8-15	< 8	> 6	3-6	< 3	> 5	3-5	< 3
66deik	Jan-June	> 16	9-16	<9	> 10	6-10	< 6	> 9	5-9	< 5
66deik	July-Dec	> 16	8-16	<8	> 10	6-10	< 6	>8	5-8	< 5
66fgj	Jan-June	> 21	11-21	< 11	> 12	7-12	< 7	> 10	5-10	< 5
66fgj	July-Dec	> 20	11-20	<11	> 12	6-12	< 6	> 10	4-10	< 4
67fghi	Jan-June	> 21	11-21	< 11	> 10	6-10	< 6	> 7	4-7	< 4
67fghi	July-Dec	> 22	11-22	< 11	> 10	6-10	< 6	> 7	4-7	< 4
68ad	Jan-June	> 16	9-16	< 9	> 7	4-7	< 4	> 6	3-6	< 3
68ad	July-Dec	> 17	9-17	< 9	> 7	4-7	< 4	> 5	3-5	< 3
68b	Jan-June	> 16	8-16	< 8	> 9	4-9	< 4	> 5	3-5	< 3
68b	July-Dec	> 14	7-14	< 7	> 7	4-7	< 4	> 3	2-3	< 2
68c	Jan-June	> 16	8-16	< 8	> 9	5-9	< 5	> 7	4-7	< 4
68c	July-Dec	> 14	8-14	< 8	> 9	5-9	< 5	> 6	4-6	< 4
69de	Jan-June	> 12	7-12	< 7	> 9	5-9	< 5	> 7	4-7	< 4
69de	July-Dec	> 10	5-10	< 5	> 6	3-6	< 3	> 5	3-5	< 3
71e	Jan-June	> 17	9-17	< 9	> 8	4-8	< 4	> 5	3-5	< 3
71e	July-Dec	> 16	8-16	< 8	> 6	3-6	< 3	> 2	2	< 2
71fgh	Jan-June	> 19	10-19	< 10	> 9	5-9	< 5	> 6	4-6	< 4
71fgh	July-Dec	> 17	9-17	< 9	> 7	4-7	< 4	> 4	3-4	< 3
71i	Jan-June	> 14	8-14	< 8	> 5	3-5	< 3	> 4	2-4	< 2
71i	July-Dec	> 14	8-14	< 8	> 5	3-5	< 3	> 4	2-4	< 2
74a	Jan-June	> 10	5-10	< 5	> 2	2	< 2	> 1	1	< 1
74a	July-Dec	> 12	6-12	< 6	> 2	2	< 2	> 1	1	< 1
74b	Jan-June	> 10	6-10	< 6	> 1	1	< 1	> 1	1	< 1
74b	July-Dec	> 13	7-13	< 7	> 3	2-3	< 2	> 1	1	< 1

Bioregion	Season	Taxa Richness (TR)			ETO			CRMOL		
Score		**5**	**3**	**1**	**5**	**3**	**1**	**5**	**3**	**1**
73ab	Jan-June	> 7	4-7	< 4	> 1	1	< 1	> 3	2-3	< 2
73ab	July-Dec	> 7	4-7	< 4	> 1	1	< 1	> 3	2-3	< 2

Scoring Guidance for Genus Level Biorecons in Streams > 2.5 sq. mile Drainage.

Bioregion	Season	Taxa Richness (TR)			EPT			Intolerant Taxa (IT)		
Score		**5**	**3**	**1**	**5**	**3**	**1**	**5**	**3**	**1**
65abei	Jan-June	> 19	10-19	< 10	> 8	4-8	< 4	> 2	2	< 2
65abei	July-Dec	> 20	10-20	< 10	> 8	4-8	< 4	> 2	1-2	< 1
65j	Jan-June	> 22	11-22	< 11	> 13	7-13	< 7	> 9	5-9	< 5
65j	July-Dec	> 19	10-19	< 10	> 9	5-9	< 5	> 5	3-5	< 3
66deik	Jan-June	> 25	13-25	< 13	> 18	9-18	< 9	> 15	8-15	< 8
66deik	July-Dec	> 27	14-27	< 14	> 15	8-15	< 8	> 13	7-13	< 7
66fgj	Jan-June	> 36	19-36	< 19	> 23	12-23	< 12	> 20	11-20	< 11
66fgj	July-Dec	> 34	17-34	< 17	> 21	11-21	< 11	> 16	8-16	< 8
67fghi	Jan-June	> 28	14-28	< 14	> 14	8-14	< 8	> 10	6-10	< 6
67fghi	July-Dec	> 28	15-28	< 15	> 12	7-12	< 7	> 7	4-7	< 4
68ad	Jan-June	> 36	19-36	< 19	> 19	10-19	< 10	> 12	7-12	< 7
68ad	July-Dec	> 40	21-40	< 21	> 18	9-18	< 9	> 12	7-12	< 7
68b	Jan-June	> 21	11-21	< 11	> 12	7-12	< 7	> 8	4-8	< 4
68b	July-Dec	> 17	9-17	< 9	> 8	5-8	< 5	> 4	2-4	< 2
68c	Jan-June	> 18	9-18	< 9	> 10	5-10	< 5	> 7	4-7	< 4
68c	July-Dec	> 20	11-20	< 11	> 9	5-9	< 5	> 6	4-6	< 4
69de	Jan-June	> 27	14-27	< 14	> 17	9-17	< 9	> 13	7-13	< 7
69de	July-Dec	> 24	12-24	< 12	> 13	7-13	< 7	> 8	5-8	< 5
71e	Jan-June	> 21	11-21	< 11	> 10	6-10	< 6	> 5	3-5	< 3
71e	July-Dec	> 20	11-20	< 11	> 7	4-7	< 4	> 3	2-3	< 2
71fgh	Jan-June	> 25	13-25	< 13	> 12	7-12	< 7	> 9	5-9	< 5
71fgh	July-Dec	> 23	12-23	< 12	> 10	6-10	< 6	> 6	3-6	< 3
71i	Jan-June	> 22	12-22	< 12	> 9	5-9	< 5	> 5	3-5	< 3
71i	July-Dec	> 23	12-23	< 12	> 7	4-7	< 4	> 3	2-3	< 2
74a	Jan-June	> 12	7-12	< 7	> 4	3-4	< 3	> 1	1	< 1
74a	July-Dec	> 13	7-13	< 7	> 4	3-4	< 3	> 1	1	< 1
74b	Jan-June	> 18	10-18	< 10	> 6	3-6	< 3	> 1	1	< 1
74b	July-Dec	> 15	8-15	< 8	> 5	3-5	< 3	> 1	1	< 1

Bioregion	Season	Taxa Richness (TR)			ETO			CRMOL		
Score		**5**	**3**	**1**	**5**	**3**	**1**	**5**	**3**	**1**
73ab	Jan-June	> 11	6-11	< 6	> 1	1	< 1	> 2	2	< 2
73ab	July-Dec	> 14	7-14	< 7	> 3	2-3	< 2	> 4	3-4	< 3

Scoring Guidance for Genus Level biorecons in Headwater Streams ≤ 2.5 sq. mile

Bioregion	Season	Taxa Richness (TR)			EPT			Intolerant Taxa (IT)		
Score		**5**	**3**	**1**	**5**	**3**	**1**	**5**	**3**	**1**
65abei	Jan-June	> 15	8-15	< 8	> 7	4-7	< 4	> 5	3-5	< 3
65abei	July-Dec	> 12	7-12	< 7	> 5	3-5	< 3	> 3	2-3	< 2
65j	Jan-June	> 22	11-22	< 11	> 8	4-8	< 4	> 6	3-6	< 3
65j	July-Dec	> 16	9-16	< 9	> 6	4-6	< 4	> 4	2-4	< 2
66deik	Jan-June	> 21	11-21	< 11	> 14	8-14	< 8	> 14	7-14	< 7
66deik	July-Dec	> 18	10-18	< 10	> 12	7-12	< 7	> 12	7-12	< 7
66fgj	Jan-June	> 32	16-32	< 16	> 20	11-20	< 11	> 20	11-20	< 11
66fgj	July-Dec	> 28	14-28	< 14	> 16	9-16	< 9	> 16	8-16	< 8
67fghi	Jan-June	> 30	15-30	<15	> 14	8-14	< 8	> 11	6-11	< 6
67fghi	July-Dec	> 27	14-27	< 14	> 14	8-14	< 8	> 11	6-11	< 6
68ad	Jan-June	> 19	10-19	< 10	> 9	5-9	< 5	> 6	3-6	< 3
68ad	July-Dec	> 19	10-19	< 10	> 11	6-11	< 6	> 6	4-6	< 4
68b	Jan-June	> 22	12-22	< 12	> 13	7-13	< 7	> 8	5-8	< 5
68b	July-Dec	> 18	10-18	< 10	> 9	5-9	< 5	> 5	3-5	< 3
68c	Jan-June	> 20	10-20	< 10	> 14	8-14	< 8	> 10	6-10	< 6
68c	July-Dec	> 17	9-17	< 9	> 11	6-11	< 6	> 7	4-7	< 4
69de	Jan-June	> 15	8-15	< 8	> 11	6-11	< 6	> 8	5-8	< 5
69de	July-Dec	> 12	6-12	< 6	> 8	4-8	< 4	> 6	4-6	< 4
71e	Jan-June	> 21	11-21	< 11	> 10	6-10	< 6	> 6	4-6	< 4
71e	July-Dec	> 19	10-19	< 10	> 6	4-6	< 4	> 3	2-3	< 2
71fgh	Jan-June	> 22	12-22	< 12	> 13	7-13	< 7	> 10	6-10	< 6
71fgh	July-Dec	> 20	11-20	< 11	> 8	5-8	< 5	> 6	4-6	< 4
71i	Jan-June	> 16	9-16	< 9	> 7	4-7	< 4	> 5	3-5	< 3
71i	July-Dec	> 16	9-16	< 9	> 7	4-7	< 4	> 5	3-5	< 3
74a	Jan-June	> 11	6-11	< 6	> 3	2-3	< 2	> 1	1	< 1
74a	July-Dec	> 13	7-13	< 7	> 2	2	< 2	> 1	1	< 1
74b	Jan-June	> 10	6-10	< 6	> 1	1	< 1	> 1	1	< 1
74b	July-Dec	> 13	7-13	< 7	> 3	2-3	< 2	> 1	1	< 1

Bioregion	Season	Taxa Richness (TR)			ETO			CRMOL		
Score		**5**	**3**	**1**	**5**	**3**	**1**	**5**	**3**	**1**
73ab	Jan-June	> 7	4-7	< 4	> 1	1	< 1	> 4	2-4	< 2
73ab	July-Dec	> 7	4-7	< 4	> 1	1	< 1	> 4	2-4	< 2

Ecoregion Reference Streams:

SITE #	STATUS	STREAM	USGS HUC	LOCATION	COUNTY	LATITUDE	LONGITUDE
ECO65E04	Active	Blunt Creek	06040005 TN Western Valley	RM 0.1 U/S McHee Levee Rd	Carroll	35.95916	-88.26805
ECO65E06	Active	Griffin Creek	08010204 N Fk Forked Deer	RM 5 U/S Stanford Lane Ford	Carroll	35.81861	-88.54055
ECO65E10	Active	Marshall Creek	08010208 Lower Hatchie	RM 2.2 Van Buren Rd	Hardeman	35.1619	-89.0694
ECO65E11	Active	West Fork Spring Creek	08010208 Lower Hatchie	RM 1.7 U/S Van Buren Rd	Hardeman	35.10194	-89.08194
ECO65E19	Active	Trace Creek	08010205 S FK Forked Deer	RM 1.3 U/S Liberty Road	Madison	35.66327	-88.66734
ECO65J04	Active	Pompeys Branch	06030005 TN Pickwick Lake	U/S Pompeys Branch Rd	Hardin	35.05388	-88.16805
ECO65J05	Active	Dry Creek	06030005 TN Pickwick Lake	RM 3.2 Dry Creek Rd	Hardin	35.035	-88.15222
ECO65J06	Active	Right Fork Whites Creek	06040001 TN Western Valley	RM 3.4 U/S Morris Lane	Hardin	35.05305	-88.04777
ECO66D03	Active	Laurel Fork	06010103 Watauga	RM 6.7 U/S Big Branch Off Dennis Cove Rd	Carter	36.2563	-82.10981
ECO66D05	Active	Doe River	06010103 Watauga	RM 26 U/S Picnic Area Roan Mtn State Park	Carter	36.15888	-82.10583
ECO66E04	Active	Gentry Creek	06010102 South Fork Holston	RM 2.1 Gentry Creek Rds end.	Johnson	36.5441	-81.7237
ECO66E09	Active	Clark Creek	06010108 Nolichucky	RM 1.8 National Forest property off Hwy 107 Clarks Creek Rd	Unicoi	36.14818	-82.52835
ECO66E11	Active	Lower Higgins Creek	06010108 Nolichucky	RM 1.7 Lower Higgins Cr Rd 1 mi NW Ernestville	Unicoi	36.08722	-82.52027
ECO66E17	Active	Double Branch	06010201 Fort Loudoun Lake	RM 0.1 U/S Millers Cove Rd	Blount	35.74378	-83.76631
ECO66F06	Active	Abrams Creek	06010204 Little Tennessee	RM 18.3 West end of Cades Cove, 0.6 mi U/S Mill Creek	Blount	35.59305	-83.84694
ECO66F07	Active	Beaverdam Creek	06010102 S Fork Holston	RM 5, 1 mi SW Backbone Rock Park	Johnson	36.58638	-81.8275
ECO66F08	Active	Stony Creek	06010103 Watauga	RM 12.5 U/S SR 91	Carter	36.46811	-81.99569

Ecoregion Reference Streams:

SITE #	STATUS	STREAM	USGS HUC	LOCATION	COUNTY	LATITUDE	LONGITUDE
ECO66G05	Active	Little River	06010201 Ft Loudoun/Little R	RM 50.7 U/S last house Little River Trail above Elkmont	Sevier	35.65333	-83.57727
ECO66G09	Active	North River	06010204 Little Tennessee	RM 3, 500 meters U/S campground on North River Rd	Monroe	35.32777	-84.14583
ECO66G12	Active	Sheeds Creek	03150101 Conasauga	RM 1.8, 0.25 mi U/S Sheeds Creek Rd	Polk	35.00305	-84.61222
ECO66G20	Active	Rough Creek	06020003 Ocoee	RM 1.5 National Forest Road 221 Stream Crossing	Polk	35.05386	-84.48031
ECO67F06	Active	Clear Creek	06010207 Lower Clinch	RM 1, U/S Norris Municipal Park Road	Anderson	36.21361	-84.05972
ECO67F13	Active	White Creek	06010205 Upper Clinch	RM 2, D/S old USGS gauging station next to White Creek Rd	Union	36.34361	-83.89166
ECO67F14	Active	Powell River	06010206 Powell	RM 106.5 McDowell Shoal D/S Fourmile Creek	Hancock	36.57764	-83.3659
ECO67F16	Active	Hardy Creek	06010206 Powell	RM 0.5, U/S SR 660 Powell Valley Rd	Lee County, VA	36.6499	-83.2496
ECO67F17	Active	Big War Creek	06010205 Upper Clinch	RM 0.6 Pawpaw Rd	Hancock	36.42626	-83.34663
ECO67F23	Active	Martin Creek	06010206 Powell	RM 0.5 Powell Valley Rd just U/S Hopkins Rd	Hancock	36.59111	-83.335
ECO67F27	Active	Indian Creek	6010205 Clinch-Upper	Off Indian Creek Rd	Grainger	36.39519	-83.40339
ECO67G05	Active	Bent Creek	06010108 Nolichucky	RM 1.9 East of Hwy 340	Hamblen	36.18793	-83.16414
ECO67G10	Active	Flat Creek	06010107 Lower French Broad	RM 12 D/S Muddy Hollow Rd	Sevier	35.9157	-83.4515
ECO67G12	Active	Dry Creek	06020002 Hiwassee	RM 0.6 U/S of Bridge Crossing on Old Chattanooga Pike Sq	Bradley	35.11091	-84.96396
ECO67H06	Active	Laurel Creek	06010204 Little Tennessee	RM 0.8, D/S Laurel Creek Rd	Monroe	35.44829	-84.28833
ECO6701	Active	Big Creek	06010104 Holston	RM 9.8, D/S Fisher Creek West of Surgoinsville on Stanley Valley Rd	Hawkins	36.4778	-82.9387
ECO6702	Active	Fisher Creek	06010104 Holston	RM 0.6, U/S Bray Road	Hawkins	36.49	-82.94027

Ecoregion Reference Streams:

SITE #	STATUS	STREAM	USGS HUC	LOCATION	COUNTY	LATITUDE	LONGITUDE
ECO6707	Probation	Possum Creek	06010102 South Fork Holston	RM 1.5, Weaver Pike Bridge, Bluff City	Sullivan	36.47964	-82.19932
ECO68A03	Active	Laurel Fork of Station Camp Cr	05130104 S Fork Cumberland	RM 4, Big South Fork NRA	Fentress/ Scott	36.51611	-84.69805
ECO68A08	Active	Clear Creek	06010208 Emory	RM 4, Genesis Rd (HWY 298)	Morgan	36.11916	-84.7425
ECO68A26	Active	Daddy's Creek	06010208 Emory	RM 2.3, U/S Hebbertsburg Rd, Catoosa	Cumberland	36.05861	-84.79138
ECO68A27	Probation	Island Creek	06010208 Emory	RM 2.3, U/S Noah Hambrey Rd, Catoosa	Morgan	36.05138	-84.66805
ECO68B01	Active	Crystal Creek	06020004 Sequatchie	RM 1.2, Approx 0.25 mi D/S Lower East Valley Rd	Bledsoe	35.54083	-85.21694
ECO68B10	Active	Battle Creek	06030001 Guntersville	RM 17, D/S of Martin Spring Confluence	Marion	35.15628	-85.7894
ECO68C13	Active	Mud Creek	06030003 Upper Elk	RM 5.6, U/S E Roarks Cove Rd	Franklin	35.23055	-85.91722
ECO68C20	Active	Crow Creek	06030001 Guntersville Lake	RM 35, Off Ford Spring Rd upstream UT in Tom Pack Hollow	Franklin	35.1155	-85.9110
ECO69D03	Active	Flat Fork	06010208 Emory	RM 5, U/S Flat Fork Rd, U/S Rock Fork Branch	Morgan	36.1235	-84.5122
ECO69D05	Active	New River	05140104 S Fork Cumberland	RM 55.4, approx 0.5 mi U/S HWY 116, 0.3 mi U/S Morgan/Anderson Co. line	Morgan	36.12444	-84.43130
ECO69D06	Probation	Round Rock Creek	05130104 S Fork Cumberland	RM 1, U/S ford off Norma Rd	Campbell	36.24722	-84.28444
ECO69E04	Active	Stinking Creek	05130101 Upper Cumberland	RM 15.1, Approx 0.5 mi south of Stinking Creek Rd near power line	Campbell	36.4258	-84.2618
ECO71E14	Active	Passenger Creek	05130206 Red	RM 1.6, HWY 76	Montgomery	36.53444	-87.19583
ECO71E17	Active	Brush Creek	05130206 Red	Stroudville Rd	Robertson	36.481389	-87.089722
ECO71E18	Active	Santee Creek	05130206 Red	Sprouse Rd	Robertson	36.49778	-86.778333

Ecoregion Reference Streams:

SITE #	STATUS	STREAM	USGS HUC	LOCATION	COUNTY	LATITUDE	LONGITUDE
ECO71E19	Active	Calebs Creek	05130206 Red	U/S Maxie/Carr Rd	Robertson	36.49237	-87.0066
ECO71F19	Active	Brush Creek	06040004 Buffalo	RM 2.1, Paul Reed Rd, U/S Little Brush Creek	Lewis/Lawrence	35.41972	-87.53416
ECO71F27	Active	Swanegan Branch	06030005 Pickwick Lake	RM 0.5, Off Thomas Woodard Rd	Wayne	35.06916	-87.6375
ECO71F28	Active	Little Swan Creek	06040003 Lower Duck	RM 5.6, Meriwether Lewis National Monument	Lewis	35.52888	-87.45361
ECO71F29	Active	Hurricane Creek	06040003 Lower Duck	RM 6.6, Hwy 13	Humphreys	35.980556	-87.761389
ECO71G03	Active	Flat Creek	05130106 Upper Cumberland	RM 1.8, HWY 136	Putnam	36.35944	-85.43138
ECO71G04	Active	Spring Creek	05130106 Upper Cumberland	RM 16.2, Boatman Rd	Overton	36.27277	-85.42333
ECO71G10	Active	Hurricane Creek	06030003 Upper Elk	RM 9.4, Hurricane Creek Rd	Moore	35.32083	-86.29944
ECO71H03	Active	Flynn Creek	05130106 Upper Cumberland	RM 10.2, Flynn Creek Rd, 3 mi NE Nameless TN	Jackson	36.2792	-85.66444
ECO71H09	Active	Carson Fork	05130203 Stones	RM 4.2, Burt-Burgen Rd, 2 mi NE Bradyville	Cannon	35.76495	-86.13263
ECO71H17	Active	Clear Fork Creek	05130108 Caney Fork	RM 6.5, 100 Yds U/S of Cripps Lane (Old Metal Bridge)	Cannon	35.928651	-85.992117
ECO71I10	Probation	Flat Creek	06040002 Upper Duck	RM 6.4, U/S Hazelwood Rd	Marshall	35.68583	-86.80166
ECO71I12	Active	Cedar Creek	05130201 Cumberland	RM 4.6, Centerville Rd	Wilson	36.28425	-86.20339
ECO71I15	Active	Harpeth River	05130204 Harpeth	RM 105.7, D/S McDaniel Rd	Williamson	35.8325	-86.70019
ECO73A02	Active	Middle Fork Forked Deer	08010100 Mississippi	RM 3.3, 0.5 miles upstream Watkins Rd	Lauderdale	35.81777	-89.65611
ECO73A03	Active	Cold Creek	08010100 Mississippi	RM 2.3, Approx 1.4 mi u/s Crutcher Lake Rd, U/S Adams Bayou	Lauderdale	35.66305	-89.81222
ECO73A04	Active	Bayou du Chien	08010202 Obion	RM 3.2, Approx 1.5 mi U/S boat ramp on Walnut Log Rd and 0.75 mi U/S last cabin	Lake	36.475	-89.30916

Ecoregion Reference Streams:

SITE #	STATUS	STREAM	USGS HUC	LOCATION	COUNTY	LATITUDE	LONGITUDE
ECO74A06	Active	Sugar Creek	08010100 Mississippi	RM 2.3, U/S Copper Rd	Tipton	35.49944	-89.91914
ECO74A08	Active	Pawpaw Creek	08010202 Obion	RM 3.1, U/S Upper Crossing of Putnam Hill Rd	Obion	36.30527	-89.35666
ECO74B04	Active	Powell Creek	08010202 Obion	RM 2.2, McClains Levee Rd	Weakley	36.48027	-88.64

Headwater Ecoregion Reference Streams:

SITE #	STATUS	STREAM	USGS HUC	LOCATION	COUNTY	LATITUDE	LONGITUDE
FECO65E03	Active	Dabbs Creek UT to UT	06040001 Tennessee Western Valley-Beech	RM 0.1, Natchez Trace State Park off Todd Trail	Henderson	35.79006	-88.30636
FECO65E04	Active	Cubb Creek UT	06040001 Tennessee Western Valley-Beech	RM 0.1, Natchez Trace State Park of Taylor Trail	Henderson	35.78489	-88.26502
FECO65E05	Active	Tuscumbia River UT	08010207 Hatchie-Lower	RM 0.6, Big Hill State Park at footbridge on Tuscumbia Trail bend	McNairy	35.05162	-88.74677
FECO65J01	Active	Haw Branch	06030005 Tennessee-Pickwick lake	RM 0.9, U/S Pickwick Embayment	Hardin	35.0852	-88.1916
FECO65J02	Active	Horse Creek UT	06040001 Tennessee Western Valley-Beech	RM 0.3, Sugar Camp Hollow	Hardin	35.15521	-88.19176
FECO66D01	Active	Black Branch	06010103 Watauga	RM 2.0, Above Hwy 231 near Elk Mills TN 195 Black Br Rd-West of US 321	Carter	36.2825	-82.0275

Headwater Ecoregion Reference Streams:

SITE #	STATUS	STREAM	USGS HUC	LOCATION	COUNTY	LATITUDE	LONGITUDE
FECO66D06	Active	Tumbling Creek	06010108 Nolichucky	RM 1.5, Just U/S where tumbling Creek ends	Unicoi	36.0180	-82.48194
FECO66D07	Active	Little Stony Creek	06010103 Watauga	RM 2.0, Next to Little Stony Rd and 3.0 miles D/S conf with Goodwin Field Branch	Carter	36.2867	-82.0667
FECO66E01	Active	Clark Creek Unnamed Tributary In Hell Hollow	06010108 Nolichucky	In Hell Hollow off Hell Hollow Trail	Unicoi	36.13367	-82.53281
FECO66E03	Active	Birch Branch	06010102 South Fork Holston	RM 0.6, In Birch Branch Sanctuary Approximately 0.7 Mile Upstream Hwy 133 NW of Shady Valley	Johnson	36.555368	-81.869055
FECO66F01	Active	Laurel Creek Unnamed Tributary In Negro Grave Hollow	06010102 South Fork Holston	RM 0.3, Off Hwy 91 in Negro Grave Hollow	Johnson	36.57956	-81.75013
FECO66G01	Active	Indian Branch	06010204 Little Tennessee	RM 0.1, North River Rd	Monroe	35.33102	-84.06733
FECO66G02	Active	Texas Creek	06010107 French Broad-Lower	RM 0.1, Immediately U/S Hwy 321 border of GSMNP	Sevier	35.76229	-83.31250
FECO66G03	Active	Laurel Cove Creek	06010201 Ft Loudoun, Little River	RM 0.1; 100 Uds U/S of Laurel Creek Road GSMNP	Blount	35.61635	-83.73689
FECO66J01	Active	Negro Creek Unnamed Tributary	06020002 Hiwassee	RM 1.2; U/S of Bridge Crossing on Hwy 68 Near Stansbury Road From Negro Creek at RM 3.01	Polk	35.08725	-84.37862
FECO66J02	Active	Negro Creek Unnamed Tributary	06020002 Hiwassee	RM 0.9; U/S of Bridge Crossing on Hwy 68 just Before Cedar Spring Road at Negro Creek at RM 1.3	Polk	35.10821	-84.36329
FECO66J03	Active	Turtletown Creek Unnamed Tributary	06020002 Hiwassee	RM 1.6; Off Three Oaks Dr/ 150 Yards Past 107 Three Oaks Drive	Polk	35.08041	-84.34409
FECO67F02	Active	Mill Creek	06010207 Clinch-Lower	RM 1.1, Off Cave Rd	Roane	35.84999	-84.38210
FECO67F04	Active	Sutton Branch	06010206 Powell	RM 0.1, Off Rob Camp Church Rd	Claiborne	36.558	-83.422

Headwater Ecoregion Reference Streams:

SITE #	STATUS	STREAM	USGS HUC	LOCATION	COUNTY	LATITUDE	LONGITUDE
FECO67F05	Active	Cave Spring Branch	06010201 Tennessee-Watts Bar	RM 0.1; U/S of Unimproved Road off Cate Road and Watts Bar Lake	Roane	35.7927	-84.44112
FECO67G05	Active	Happy Creek Unnamed Tributary	06010107 French Broad-Lower	RM 0.1, South of 1316 George Harrison Way 150 M U/S of Happy Creek	Sevier	35.86314	-83.70003
FECO67G11	Active	North Prong Fishdam Creek	06010102 Houlston- South Fork	RM 1.6 ,U/S SR 34 (2.0 miles from US 421)	Sullivan	36.5344	-82.0192
FECO67H01	Active	Taliaferro Branch	06020001 Tennessee	RM 2.4, Firetower Rd	Hamilton	35.16383	-85.01247
FECO67I12	Active	Mill Branch	06010207 Clinch-Lower	RM 1.2, Below the confluence of two tributaries just off Tuskegee Dr	Anderson	35.98833	-84.28888
FECO68A01	Active	Douglas Branch	06010208 Emory	RM 0.1, Barnett Bridge Rd	Morgan	36.14852	-84.77823
FECO68A03	Active	South Fork Elmore Creek	06010208 Emory	RM0.7; U/S Myatt Creek Road Catoosa WMA	Cumberland	36.083822	-84.955226
FECO68B04	Active	Daniel Creek	06020004 Sequatchie	RM1.4; U/S of Old Dunlap Road Bridge @ 5807 Dunlap Road	Marion	35.26088	-85.48222
FECO68C01	Active	Crow Creek Unnamed Tributary	06030001 Guntersville	U/S of Lost Cove Road	Franklin	35.10204	-85.92001
FECO68C02	Active	Coops Creek	06020004 Sequatchie	Rm 3.1; Mountain Review Road	Sequatchie	35.38127	-85.40402
FECO68C12	Active	Ellis Gap Branch	06020001 Tennessee	RM 0.4, 0.2 miles U/S Mullens Cove Rd in Prentice Cooper State Park	Marion	35.0492	-85.4728
FECO68C13	Active	Gilbreath Creek	06020001 Tennessee	RM 0.1; Cove Loop Lower Road Crossing	Rhea	35.47931	-85.07603
FECO69D01	Active	New RV 1 UT	05130104 Cumberland-South Fork	RM 0.1, U/S Hwy 116	Morgan	36.12090	-84.43214
FECO69D03	Active	Bear Branch	06010205 Clinch-Upper	RM 0.1, U/S Hwy 68	Campbell	36.39916	-84.30928
FECO69D04	Active	Wheeler Creek UT	05130104 Cumberland-South Fork	RM 0.6, Big Bruce Bridge	Campbell	36.30771	-84.27522

Headwater Ecoregion Reference Streams:

SITE #	STATUS	STREAM	USGS HUC	LOCATION	COUNTY	LATITUDE	LONGITUDE
FECO69E01	Active	Titus Creek UT	06010205 Clinch-Upper	RM 1.9, U/S of Stinking Creek Rd	Campbell	36.41966	-84.29011
FECO71F02	Active	Wolfpen Branch	06040004 Buffalo	RM 0.1 U/S confluence Little Buffalo River (Laurel Hill WMA)	Lawrence	35.34597	-87.49881
FECO71F03	Active	Ethridge Hollow	06040003 Duck-Lower	RM 0.1, U/S Hwy 230	Humphreys	35.9407	-87.6530
FECO71F05	Active	Kelley Creek	05130204 Harpeth	RM 2.4, Off Taylor Cemetery Rd	Williamson	35.89778	-87.10004
FECO71F06	Active	Mark's Creek	05130202 Cumberland-Cheatham	HWY 12	Cheatham	36.28544	-87.07753
FECO71G01	Active	Flat Creek	05130106 Cumberland-Upper (Cordell Hull)	RM 8.3, Upper Hillman Rd	Overton	36.41239	-85.37442
FECO71G02	Active	Long Fork UT	05110002 Barren	RM 0.1, U/S Tanyard Rd	Macon	36.48909	-85.93973
FECO71H01	Active	Riley Creek UT	06040002 Duck-Upper	RM 0.6; U/S Holland Hill Lane	Coffee	35.49518	-86.22351
FECO71H02	Active	East Fork Stones River UT	05130203 Stones	RM 0.1; Stones River Road 0.8 Mi West of Hwy 146 Intersection	Cannon	35.84485	-85.95803
FECO71H03	Active	Haws Spring Fork	05130203 Stones	RM 2.7, Off Farm Rd off Jimtown Rd	Cannon	35.761291	-86.08854
FECO71H04	Active	Wilmouth Creek UT	05130108 Caney Fork	RM 0.1; Melton Hollow Road ~ 0.25 Miles U/S From Wilmouth Road Intersection	Cannon	35.8914	-85.9897
FECO71I02	Active	Young Branch	05130201 Cumberland-Old Hickory Lake	RM 1.6, U/S Hwy 70N	Wilson	36.24031	-86.16099
FECO71I03	Active	McKnight Branch UT	05130203 Stones	RM 2.4, U/S Ford off Elrod McElroy Rd	Rutherford	35.896901	-86.18094

Headwater Ecoregion Reference Streams:

SITE #	STATUS	STREAM	USGS HUC	LOCATION	COUNTY	LATITUDE	LONGITUDE
FECO71I06	Active	Cedar Creek Unnamed Tributary	05130201 Cumberland-Old Hickory Lake	RM 0.3, 2280 Beckwith Road U/S TVA Substation	Wilson	36.20362	-86.46275
FECO73A01	Active	Bayou Duchien Unnamed Tributary	08010202 Obion	RM 0.1; U/S Walnut Log Road	Obion	36.46288	-89.32092
FECO74A04	Active	Barnishee Bayou UT	08010101 Mississippi	RM 0.89, U/S of Riddick Rd in Meeman Shelby State Park	Shelby	35.35198	-90.04863
FECO74A05	Active	Reelfoot Creek UT	08010202 Obion	RM 0.5; U/S Hwy 22	Lake	36.407306	-89.325336
FECO74B01	Active	North Fork Wolf River UT	08010210 Wolf	RM 0.2, Ames Plantation	Fayette	35.10770	-89.31641
FECO74B03	Active	North Fork Obion River UT	08010202 Obion	RM 2.3, U/S Terrapin Rd	Henry	36.48688	-88.48829
FECO74B04	Active	Bull Branch	08010209 Loosahatchie	RM 0.8; U/S Bethel Rd	Shelby	35.3915	-89.7998

Regional Expectations for Individual Habitat Parameters - streams > 2.5 sq mile drainage

(Values represent 75% of median reference score and may indicate impairment regardless of total habitat score)

ECO	Season *	Epifaunal Substrate	Embed dedness	Channel Substrate	Velocity Depth	Pool Variability	Sediment Deposition	Flow Status	Channel Alteration	Riffle Frequency	Channel Sinuosity	Bank Stability (either bank)	Vegetative Protection (either bank)	Riparian Vegetation (either bank)
65a	Spring	11	NA	8	NA	10	10	12	14	NA	9	5	7	7
65a	Fall	10	NA	8	NA	8	10	12	12	NA	8	5	6	7
65b	Spring	11	NA	8	NA	10	10	12	14	NA	9	6	7	7
65b	Fall	10	NA	8	NA	8	10	12	12	NA	8	5	6	7
65e	Spring	11	NA	8	NA	10	10	12	14	NA	9	5	7	7
65e	Fall	10	NA	8	NA	8	10	12	12	NA	8	5	6	7
65i	Spring	11	NA	8	NA	10	10	12	14	NA	NA	5	7	7
65i	Fall	10	NA	8	NA	8	10	12	12	NA	NA	5	6	7
65j	Spring	13	13	NA	11	NA	11	14	15	14	NA	7	6	8
65j	Fall	13	14	NA	12	NA	11	11	14	13	NA	7	8	8
66d	Spring	15	15	NA	15	NA	13	14	15	15	NA	8	8	8
66d	Fall	15	15	NA	14	NA	14	14	15	15	NA	8	8	8
66e	Spring	14	14	NA	14	NA	14	15	15	15	NA	8	8	8
66e	Fall	14	14	NA	14	NA	13	13	15	15	NA	8	8	8
66f	Spring	14	14	NA	12	NA	13	14	14	13	NA	8	8	8
66f	Fall	14	14	NA	13	NA	14	14	14	14	NA	8	8	8
66g	Spring	14	15	NA	14	NA	14	14	15	14	NA	8	8	8
66g	Fall	14	14	NA	14	NA	14	12	14	15	NA	8	8	8
67f	Spring	14	14	NA	13	NA	12	14	14	14	NA	7	7	7
67f	Fall	14	13	NA	12	NA	11	14	14	13	NA	7	7	7
67g	Spring	12	11	NA	11	NA	11	12	11	12	NA	4	4	2
67g	Fall	10	12	NA	11	NA	10	12	11	11	NA	5	4	2
67h	Spring	13	12	NA	12	NA	9	12	11	14	NA	6	7	7
67h	Fall	12	11	NA	11	NA	9	11	13	12	NA	6	6	7
67i	Spring	11	12	NA	11	NA	14	13	13	11	NA	6	7	6
67i	Fall	13	13	NA	12	NA	14	13	14	12	NA	6	7	6
68a	Spring	14	13	NA	14	NA	13	14	14	14	NA	8	5	8
68a	Fall	13	13	NA	12	NA	14	13	14	12	NA	8	5	8
68b	Spring	11	14	NA	13	NA	11	14	14	14	NA	6	7	7
68b	Fall	15	13	NA	14	NA	13	11	14	12	NA	7	7	5
68c	Spring	14	12	NA	13	NA	13	13	15	13	NA	7	8	8
68c	Fall	12	13	NA	13	NA	13	14	14	15	NA	7	8	8
69d	Spring	12	12	NA	14	NA	13	13	14	14	NA	7	8	8

Regional Expectations for Individual Habitat Parameters - streams > 2.5 sq mile drainage cont.

ECO	Season *	Epifaunal Substrate	Embed dedness	Channel Substrate	Velocity Depth	Pool Variability	Sediment Deposition	Flow Status	Channel Alteration	Riffle Frequency	Channel Sinuosity	Bank Stability (either bank)	Vegetative Protection (either bank)	Riparian Vegetation (either bank)
69d	Fall	12	12	NA	11	NA	12	10	14	13	NA	7	7	7
69e	Spring	12	12	NA	12	NA	10	12	14	14	NA	6	7	7
69e	Fall	13	13	NA	11	NA	10	7	14	14	NA	6	6	7
71e	Spring	12	11	NA	143	NA	11	14	12	13	NA	5	5	4
71e	Fall	11	10	NA	11	NA	10	13	12	12	NA	4	4	4
71f	Spring	12	14	NA	13	NA	10	12	14	12	NA	5	7	6
71f	Fall	13	13	NA	13	NA	11	13	14	13	NA	6	7	6
71g	Spring	12	13	NA	12	NA	12	13	13	13	NA	7	7	7
71g	Fall	11	13	NA	11	NA	13	12	14	13	NA	7	7	6
71h	Spring	12	13	NA	12	NA	12	13	11	13	NA	6	5	4
71h	Fall	12	11	NA	12	NA	12	12	12	13	NA	7	6	3
71i	Spring	11	11	11	11	10	10	13	13	11	9	6	7	4
71i	Fall	10	10	9	10	10	10	9	13	10	8	5	5	4
73a	Spring	8	NA	8	NA	10	8	12	13	NA	7	4	6	8
73a	Fall	8	NA	6	NA	9	8	13	13	NA	6	4	6	8
74a	Spring	9	6	NA	10	NA	6	6	11	12	NA	3	3	4
74a	Fall	8	8	NA	10	NA	6	6	12	11	NA	4	4	7
74b	Spring	9	NA	7	NA	6	8	11	13	NA	8	3	6	8
74b	Fall	8	NA	9	NA	6	8	9	11	NA	7	4	5	8

* Spring is January through June, Fall is July through December

Regional Habitat Expectations for Headwater Streams - ≤ 2.5 square mile drainage

(Values represent 75% of median reference score and may indicate impairment regardless of total habitat score)

ECO	Season *	Epifaunal Substrate	Embeddedness	Channel Substrate	Velocity Depth	Pool Variability	Sediment Deposition	Flow Status	Channel Alteration	Riffle Frequency	Channel Sinuosity	Bank Stability (either bank)	Vegetative Protection (either bank)	Riparian Vegetation (either bank)
65a	Spring	13	NA	8	NA	5	11	11	15	NA	9	5	6	8
65a	Fall	10	NA	8	NA	9	8	11	15	NA	13	6	6	8
65b	Spring	13	NA	8	NA	5	11	11	15	NA	9	5	6	8
65b	Fall	10	NA	8	NA	9	8	11	15	NA	13	6	6	8
65e	Spring	13	NA	8	NA	5	11	11	15	NA	9	5	6	8
65e	Fall	10	NA	8	NA	9	8	11	15	NA	13	6	6	8
65i	Spring	13	NA	8	NA	5	11	11	15	NA	9	5	6	8
65i	Fall	10	NA	8	NA	9	8	11	15	NA	13	6	6	8
65j	Spring	13	14	NA	10	NA	11	14	15	14	NA	6	6	8
65j	Fall	11	14	NA	10	NA	13	13	15	12	NA	6	7	8
66d	Spring	14	14	NA	14	NA	12	15	15	15	NA	8	8	8
66d	Fall	14	14	NA	13	NA	12	13	15	15	NA	8	8	8
66e	Spring	14	14	NA	12	NA	13	14	14	13	NA	6	8	8
66e	Fall	15	15	NA	12	NA	14	8	15	15	NA	8	8	8
66f	Spring	15	14	NA	14	NA	14	15	14	15	NA	7	6	6
66f	Fall	15	14	NA	14	NA	14	15	14	15	NA	7	6	6
66g	Spring	14	11	NA	11	NA	13	14	14	14	NA	8	8	7
66g	Fall	14	12	NA	9	NA	12	8	14	15	NA	8	7	8
66j	Spring	12	11	NA	14	NA	8	14	12	14	NA	6	4	6
66j	Fall	1	13	NA	10	NA	9	12	14	14	NA	6	5	5
67f	Spring	14	12	NA	11	NA	14	14	12	14	NA	7	8	8
67f	Fall	12	14	NA	10	NA	14	13	14	14	NA	7	6	7
67g	Spring	13	14	NA	10	NA	12	12	15	14	NA	8	8	8
67g	Fall	12	14	NA	9	NA	12	11	15	12	NA	8	8	8
67h	Spring	15	13	NA	10	NA	11	9	12	15	NA	5	7	8
67h	Fall	15	12	NA	14	NA	14	12	12	15	NA	6	5	7
67i	Spring	11	14	NA	11	NA	14	13	13	11	NA	6	7	6
67i	Fall	13	12	NA	12	NA	14	13	14	12	NA	6	7	6
68a	Spring	12	13	NA	12	NA	10	15	14	14	NA	7	7	7
68a	Fall	12	12	NA	10	NA	11	8	12	10	NA	6	6	7
68b	Spring	15	13	NA	13	NA	13	14	14	15	NA	7	4	2
68b	Fall	13	15	NA	9	NA	14	12	12	15	NA	7	2	2

Regional Habitat Expectations for Headwater Streams - ≤ 2.5 square mile drainage cont.

ECO	Season *	Epifaunal Substrate	Embeddedness	Channel Substrate	Velocity Depth	Pool Variability	Sediment Deposition	Flow Status	Channel Alteration	Riffle Frequency	Channel Sinuosity	Bank Stability (either bank)	Vegetative Protection (either bank)	Riparian Vegetation (either bank)
68c	Spring	15	14	NA	12	NA	12	12	14	15	NA	6	7	8
68c	Fall	15	14	NA	14	NA	12	12	13	15	NA	6	7	8
69d	Spring	14	12	NA	8	NA	12	12	14	14	NA	8	8	8
69d	Fall	14	11	NA	8	NA	8	12	14	14	NA	7	7	7
69e	Spring	14	14	NA	10	NA	14	14	14	14	NA	7	8	7
69e	Fall	14	14	NA	10	NA	12	14	14	14	NA	7	7	7
71e	Spring	12	12	NA	12	NA	11	14	9	13	NA	6	6	6
71e	Fall	9	11	NA	8	NA	8	8	11	13	NA	4	6	6
71f	Spring	11	14	NA	11	NA	12	13	15	14	NA	6	8	8
71f	Fall	14	14	NA	10	NA	11	12	14	14	NA	6	7	8
71g	Spring	14	11	NA	12	NA	10	13	15	14	NA	6	6	3
71g	Fall	12	11	NA	11	NA	9	11	15	12	NA	6	6	4
71h	Spring	13	13	NA	11	NA	12	14	14	14	NA	7	7	7
71h	Fall	12	12	NA	8	NA	11	12	13	14	NA	6	8	6
71i high grad.	Spring	13	12	NA	10	NA	10	13	11	13	NA	5	5	4
71I high grad	Fall	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
73a	Spring	8	NA	9	NA	3	12	13	12	NA	6	7	7	8
73a	Fall	8	NA	9	NA	3	12	13	12	NA	6	7	7	8
74a	Spring	9	6	NA	9	NA	5	8	15	14	NA	3	4	8
74a	Fall	13	6	NA	10	NA	5	7	12	10	NA	3	4	8
74b	Spring	10	NA	4	NA	7	11	12	15	NA	11	6	7	8
74b	Fall	12	NA	5	NA	7	12	10	12	NA	7	7	8	8

* Spring is January through June, Fall is July through December

APPENDIX B

FORMS, FIELD SHEETS AND REPORTS

RECORD OF BIOLOGIST CREDENTIALS
NEW STATION E-FORM
SAMPLING EVENT E-FORM
FIELD PARAMETER E-FORM
HABITAT ASSESSMENT FIELD SHEETS
STREAM SURVEY INFORMATION E-FORM
BIORECON FIELD SHEET
MACROINVERTEBRATE TAXA REPORTING FORMAT
BIOLOGICAL SAMPLE REQUEST INCLUDING CHAIN OF CUSTODY FORM

See SharePoint
https://tennessee.sharepoint.com/sites/environment/DWR/PAS/SitePages/Home.aspx
or contact WPU for copies of all e-Forms and guidance documents for completing e-forms and upload to Waterlog/Hydra (BSERT and SPERT).

Record of Biologist Credentials for Macroinvertebrate Surveys and/or Taxonomy
Revised 12/27/21
DWR/TDH staff maintain updated copy on SharePoint
https://tennessee.sharepoint.com/sites/environment/DWR/PAS/SitePages/Home.aspx
All others send copy to WPU (Kim.Laster@tn.gov or Debbie.Arnwine@tn.gov) for posting.

Name	**Title**
Organization	**Date**
University	**B.S. major**
University	**M.S. major**
University	**Doctorate**
Macroinvertebrate Field Surveys # Years Experience	
Describe Specific Experience:	
Date Passed Initial DWR Field QC	**QC'd by**
Date passed company In-House Field QC	**QC-d by**
Macroinvertebrate Taxonomy # Years Experience:	
Taxonomic Expertise (Circle Lowest Level) **Family** **Genus** **Species**	
Date Passed Initial TDEC/TDH Taxonomic ID QC	**QC'd by**
Date completed taxonomic testing	**Level**
Date completed company In-house Taxonomic ID QC	**QC-d by**
Taxonomic Certifications (SFS)	
Date Passed Initial DWR SQSH Sorting QC	**QC'd by**
Additional Information/Publications Concerning Macroinvertebrate Survey and/ or Taxonomic Expertise	

New Station e-Form – Surface Water Stations Only

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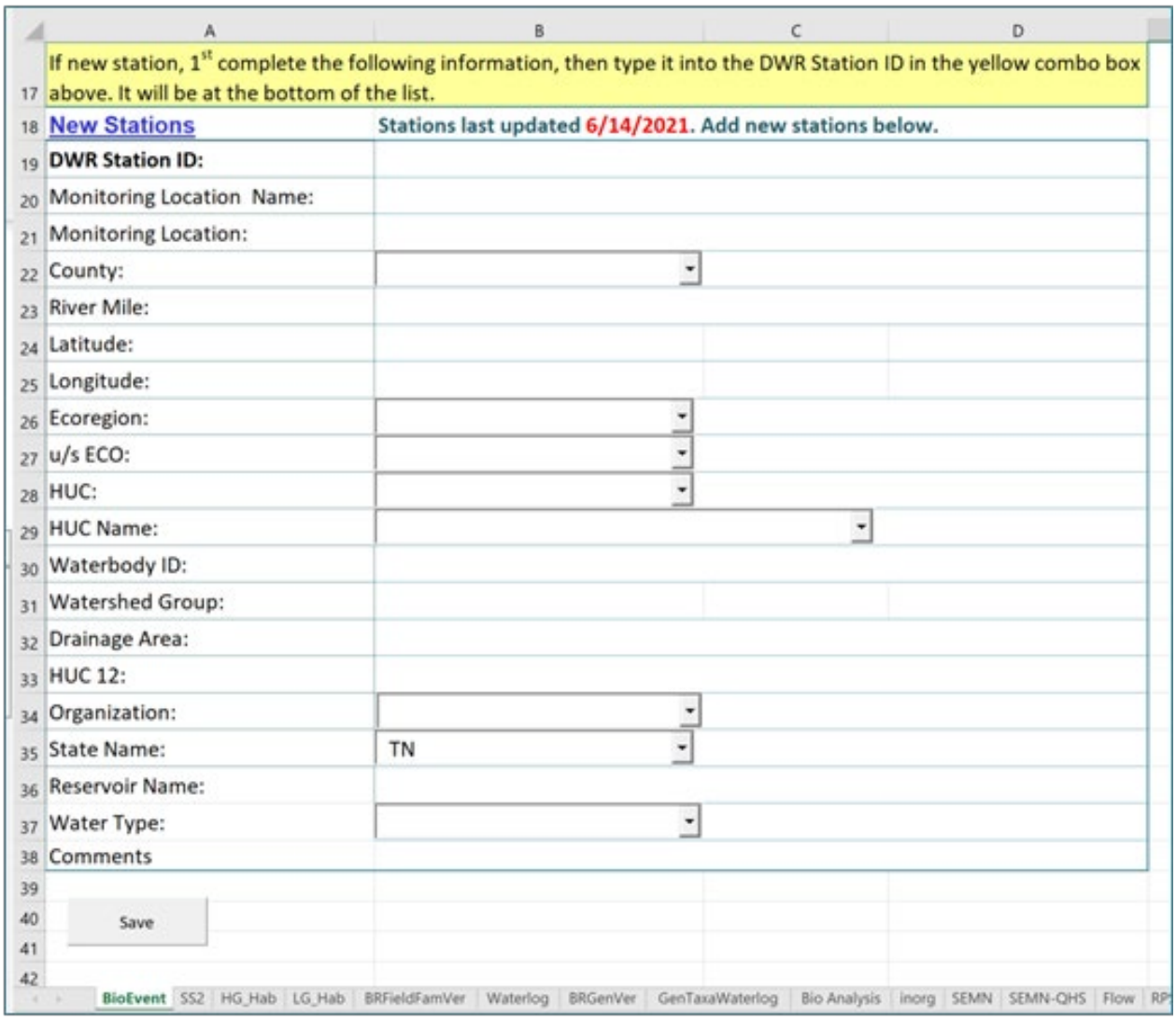
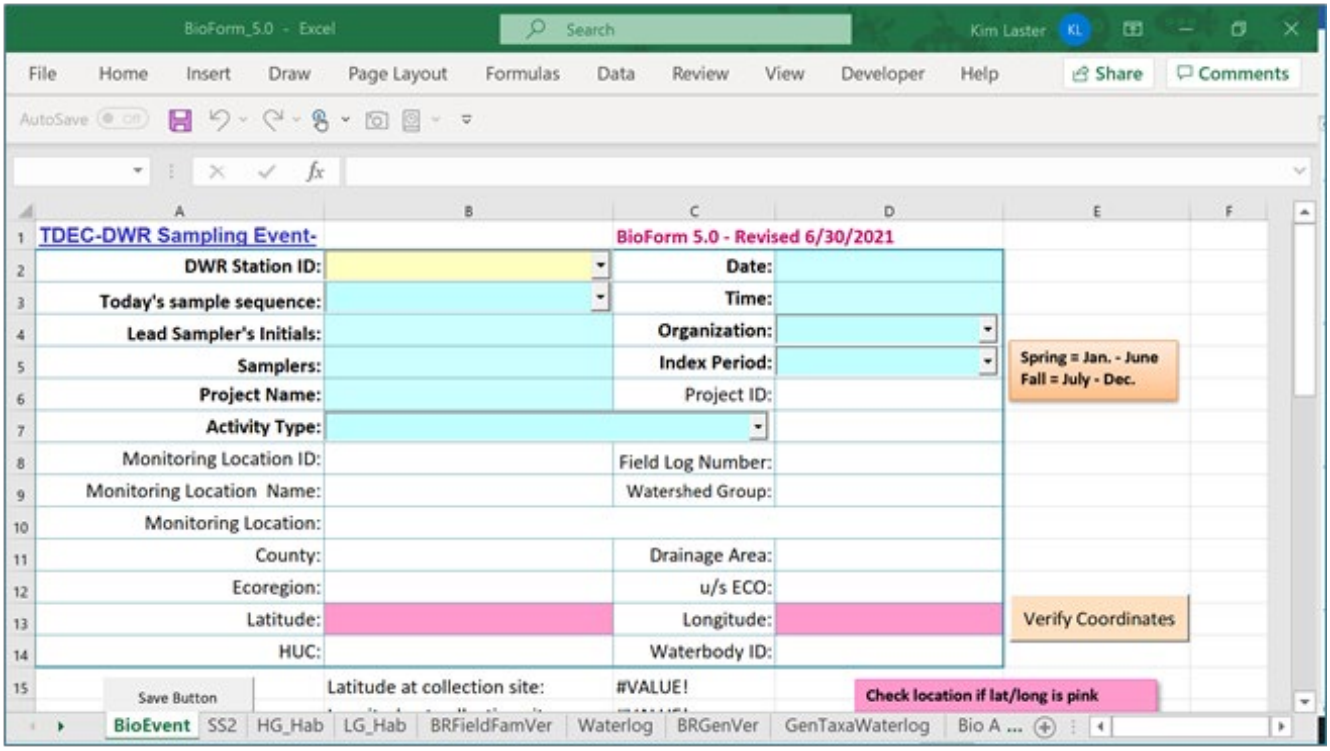


	A	B	C	D
17	If new station, 1st complete the following information, then type it into the DWR Station ID in the yellow combo box above. It will be at the bottom of the list.			
18	New Stations	Stations last updated 6/14/2021. Add new stations below.		
19	DWR Station ID:			
20	Monitoring Location Name:			
21	Monitoring Location:			
22	County:			
23	River Mile:			
24	Latitude:			
25	Longitude:			
26	Ecoregion:			
27	u/s ECO:			
28	HUC:			
29	HUC Name:			
30	Waterbody ID:			
31	Watershed Group:			
32	Drainage Area:			
33	HUC 12:			
34	Organization:			
35	State Name:	TN		
36	Reservoir Name:			
37	Water Type:			
38	Comments			
39				
40	Save			
41				
42				

BioEvent | SS2 | HG_Hab | LG_Hab | BRFieldFamVer | Waterlog | BRGenVer | GenTaxaWaterlog | Bio Analysis | inorg | SEMN | SEMN-QHS | Flow | RP

Sampling Event e-Form



Field Parameter e-Form

Sample Sequence:	10						Time:	
DWR Station ID:				Monitoring Location ID:	#N/A		Field Log Number:	0100190010
Monitoring Location Name	#N/A			Monitoring Location	#N/A			
Project Name:		Project ID:	#N/A		Activity Type:			
Field Parameters:	1st	2nd	Meter Problems:		1st	2nd	Meter Problems:	
pH (su):				DO %:				
Conductivity (umhos):				Turbidity (NTU):				
Temperature (C°):				TDS (mg/L):				
Dissolved Oxygen (mg/L):				Flow (cfs):				
Notes:								

HABITAT ASSESSMENT FIELD SHEET- MODERATE TO HIGH GRADIENT STREAMS (FRONT)

See Protocol E for detailed descriptions and rank information). See BSERT for instructions on completing e-form)

DWR Station ID:		**Habitat Assessment By:**	
Monitoring Location Name:		**Date:**	**Time:**
Monitoring Location:		**Field Log Number:**	
HUC:	WS Group:	Ecoregion:	QC: ☐ Duplicate ☐ Consensus

	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
Comments				
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 boulder s 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
Comments				
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
Comments				
4. Sediment Deposition	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
Comments				
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
Comments				

HABITAT ASSESSMENT FIELD SHEET- MODERATE TO HIGH GRADIENT STREAMS (BACK)				
DWR Station ID_____ Date_____ Assessors_____				
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration	Channelization, dredging rock removal, 4-wheel or livestock 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 4-wheel or livestock 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 4-wheel or livestock 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 or livestock. 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
Comments				
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
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 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___(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE___(RB)	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 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE___(RB)	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 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE___(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Comments				

Total Score _____ Comparison to Ecoregion Guidelines (circle): ABOVE or BELOW
If score is below guidelines , result of (circle): Natural Conditions or Human Disturbance
Describe:

HABITAT ASSESSMENT FIELD SHEET- LOW GRADIENT STREAMS (FRONT)

See Protocol E for detailed descriptions and rank information). See BSERT for instructions on completing e-form)

DWR Station ID:		**Habitat Assessment By:**	
Monitoring Location Name:		**Date:**	**Time:**
Monitoring Location:		**Field Log Number:**	
HUC:	WS Group:	Ecoregion:	QC: ☐ Duplicate ☐ Consensus

	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	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				

HABITAT ASSESSMENT FIELD SHEET- LOW GRADIENT STREAMS (BACK)

DWR Station ID		Date	Assessor:	
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration	Channelization, dredging 4-wheel, or livestock activity absent or minimal; natural meander pattern. NO artificial structures in reach. Upstream or downstream structures do not affect reach.	Channelization, dredging, 4-wheel or livestock 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, 4-wheel or livestock 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 or livestock. Instream habitat greatly altered or removed. Artificial structures may have greatly affected flow pattern.
SCORE	20 19 18 17 6	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 6	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 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 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE___(RB)	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___(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE___(RB)	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___(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE___(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Comments				

Total Score _____ Comparison to Ecoregion Guidelines (circle): ABOVE or BELOW
If score is below guidelines , result of (circle): Natural Conditions or Human Disturbance
Describe:

STREAM SURVEY INFORMATION (see protocol E for detailed information and BSERT for Completing E-Form)

DWR Station ID:	**Samplers:**	
Monitoring Location Name:	**Date:**	**Time:**
Monitoring Location:	**Organization:**	Drainage Area:
County:	Ecoregion:	u/s ECO:
Latitude:	HUC:	WS Grp:
Longitude:	WBID:	Field Log #:

Project Name: ☐ **Watershed** ☐ **303(d)** ☐ **Antideg** ☐ **ECO** ☐ **FECO** **Other:**

Project ID: TNPR

Activity Type: ☐ Sample ☐ QC Sample ☐ Habitat ☐ QC habitat ☐ QC ID

Sample Status: ☐Collected ☐Seasonally Dry ☐Frequently Dry ☐No Channel
☐Too Deep (Not Wadeable) ☐Too Deep (Temporary) ☐Permanent Barrier ☐Fenced
☐Landowner Denial: ☐Temporary Barrier ☐Posted Plan to revisit? ☐Yes ☐No

Flow Conditions: ☐Dry ☐Isolated Pools ☐Stagnant ☐Low ☐Moderate ☐High ☐Bankful ☐Flooding

Chemicals/Bacteria: ☐None ☐Routine ☐Nutrient ☐Metals ☐*E. coli* ☐Organics ☐Other_____

Field Parameters: Meter(s) Used:

pH (su)			Dissolved Oxygen %		
Conductivity (umhos)			Turbidity (NTU)		
Temperature (C°)			TDS (mg/L)		
Dissolved Oxygen (ppm = mg/L)			Flow (cfs)		

Meter Problems?_____

Photos Taken? ☐ No ☐Yes: Description: _____

Previous 48 hours precipitation: ☐Unknown ☐None ☐Slight ☐Moderate ☐Heavy ☐Flooding
Air Temperature (°F) _____

Physical Characteristics & Light Penetration:

Gradient (sample reach): ☐Flat ☐Low ☐Moderate ☐High ☐Cascades

Average Stream Width: ☐Very Small (<1.5yd) ☐Small (1.5-3yd) ☐Med. (3-10yd) ☐Large (10-25yd) ☐Very Large (>25yd)

Maximum Stream Depth: ☐Shallow (<0.3yd) ☐Medium (0.3-0.6yd) ☐Deep (0.6 – 1yd) ☐Very Deep(>1yd)

% Canopy Cover Estimated for Reach: _____%

% Canopy Cover Measured (mid-reach): _____u/s + _____d/s + _____LDB + _____RDB = Total/384*100 ___

Channel Characteristics:

Bank Height: _____ (yd.) High Water Mark: _____(yd.)

Bank Slope LDB: ☐Deeply incised ☐Bluff/Wall ☐Undercut ☐Sloughing ☐Steep terrain ☐Gentle Slope

Bank Slope RDB: ☐Deeply incised ☐Bluff/Wall ☐Undercut ☐Sloughing ☐Steep terrain ☐Gentle Slope

Manmade Modification: ☐None ☐Rip-Rap ☐Cement ☐Gabions ☐Channelized ☐Dam ☐Dredging ☐Bridge ☐ATV

Stream Characteristics:

Sediment Deposits: ☐None ☐Slight ☐Moderate ☐Excessive ☐Blanket

Sediment Type: ☐None ☐Sand ☐Silt ☐Mud ☐Clay ☐Sludge ☐Mn Precipitant ☐Orange Flocculent

Turbidity: ☐Clear ☐Slightly Turbid ☐Muddy ☐Milky ☐Tannic ☐Planktonic Algae ☐Dyed

Foam/Surface Sheen: ☐None ☐Nutrient ☐Surfactant ☐Bacteria

Algae: ☐None ☐Slight ☐Moderate ☐High ☐Choking **Type**: ☐Diatoms ☐Green ☐Filamentous ☐Blue-green

TDEC-DWR Stream Survey Field Sheet (Back)

DWR Station ID:	Date:	Assessors:

Dominate Substrate: (More than 25%) Select up to 4

Riffle	Run	Pool
☐ Boulders (>10")	☐ Boulders (>10")	☐ Boulders (>10")
☐ Cobble (2.5-10")	☐ Cobble (2.5-10")	☐ Cobble (2.5-10")
☐ Gravel (0.1-2.5")	☐ Gravel (0.1-2.5")	☐ Gravel (0.1-2.5")
☐ Bedrock	☐ Bedrock	☐ Bedrock
☐ Sand	☐ Sand	☐ Sand
☐ Silt (not gritty)	☐ Silt (not gritty)	☐ Silt (not gritty)
☐ Clay (Slick)	☐ Clay (Slick)	☐ Clay (Slick)

Surrounding Land Uses (list additional land uses under comments)

☐ Forest	☐ Grazing	☐ Stormwater	☐ STP/WWTP	☐ Construction
☐ Wetland	☐ Row Crops	☐ Urban	☐ Industry	☐ Impoundment
☐ Park	☐ CAFO/Dairy	☐ Commercial	☐ Mining/Dredging	☐ ATV/OHV
☐ Hay/Fields	☐ Logging	☐ Residential	☐ Road/Hwy/RR	☐ Golf Course

Observed Human Disturbance to Stream: Blank (not observed) S (Slight) M (Moderate) H (High)

Riparian Loss		**Logging**		**Industry**		**ATV/OHV**	
Channelization		Urban		Mining/ Dredging		Golf Course	
Active Grazing		Commercial		Road/Hwy/RR		Garbage/Trash	
Row Crops		Residential		Construction		Landfill	
CAFO/Dairy		STP/WWTP		Impoundment		Water Withdrawal	

Other Stream Information and Stressors:

Stream Sketch: (include road name or landmark, flow direction, reach distance, distance from bridge or road, sampling points, tributaries, outfalls, livestock access, riparian, potential impacts, north arrow, immediate land use, buildings, etc.) Use additional sheet if necessary.

BIORECON FIELD SHEET: (Revised 6/9/17) **see BSERT for BioForm instructions**

DWR Station ID:			**Samplers:**	
Monitoring Location Name:			**Date:**	**Time:**
Monitoring Location:			Ecoregion:	u/s Ecoregion:
HUC:		Watershed Group:	Drainage Area:	
Project Name:		Project ID:	**Field Log Number:**	
Taxonomic Level:	☐ Family	☐ Genera	**Voucher Verification Date:**	**Initials:**
QA/QC:	☐ Duplicate Sample		☐ ID QC	Activity ID:

Habitats sampled:	Riffle/Swift-Run	Slow Run/Pool Rock	Leaf Habitat	Snags/ Woody Debris	Undercut Banks/Tree Root	Macro-phytes	Fine Sediment	Other	Total
Percent habitat (max 100%):									
No. jabs per habitat (max 4):									

Indicate estimated abundance (EA): **1** = Rare (1-3 organisms) **2** = Common (4-9 organisms) **3** = Abundant (10-49 organisms) **4** = Dominate (>50 organisms)

Field Taxa ID	EA	Notes	Field Taxa ID	EA	Notes	Field Taxa ID	EA	Notes
Ephemeroptera			Oligochaeta			Diptera		
			Amphipoda			Chironomidae		
			Decapoda - Cambaridae					
			Isopoda - Asellidae					
			Acari					
			Odonata					
Plecoptera								
						Mollusca		
			Hemiptera					
Trichoptera								
			Megaloptera					
			Coleoptera			Other		

Macroinvertebrate Taxa Reporting Format (both Biorecons and SQSH)

DWR_STATION_ID	ACTIVITY_START_DATE	FIELD_LOG_NUMBER	BENSAMPID	FINALID*	INDIVIDUALS	EXCLUDED_TAXA	COMMENTS	ACTIVITY_TYPE	LAB_ORG	ID_BY	MONITORING_LOCATION_ID	PROJECT_ID	ORGANIZATION	SAMPLER	INDEX_PERIOD	SAMPLE_COLLECTION_METHOD_ID	PROJECT_NAME
FECO65E07	06/01/15	AJF1707001	J1506001	Perlidae	2	FALSE	-	Sample-Routine	Jackson EFO	-	TNW000002296	TNPR0038	Jackson EFO	AJF/BES	Spring	BIORECON FAMILY	FECO
FECO65E07	06/01/15	AJF1707001	J1506001	Hydropsychidae	2	FALSE	-	Sample-Routine	Jackson EFO	-	TNW000002296	TNPR0038	Jackson EFO	AJF/BES	Spring	BIORECON FAMILY	FECO
FECO65E07	06/01/15	AJF1707001	J1506001	Limnephilidae	3	FALSE	-	Sample-Routine	Jackson EFO	-	TNW000002296	TNPR0038	Jackson EFO	AJF/BES	Spring	BIORECON FAMILY	FECO
FECO65E07	06/01/15	AJF1707001	J1506001	Chironomidae	3	FALSE	Red Dominant	Sample-Routine	Jackson EFO	-	TNW000002296	TNPR0038	Jackson EFO	AJF/BES	Spring	BIORECON FAMILY	FECO
FECO65E07	06/01/15	AJF1707002	J1506002	Baetidae	1	FALSE	-	Quality Control Sample-Field Replicate	Jackson EFO	-	TNW000002296	TNPR0038	Jackson EFO	AJF/BES	Spring	BIORECON FAMILY	FECO
FECO65E07	06/01/15	AJF1707002	J1506002	Leuctridae	1	FALSE	-	Quality Control Sample-Field Replicate	Jackson EFO	-	TNW000002296	TNPR0038	Jackson EFO	AJF/BES	Spring	BIORECON FAMILY	FECO

* *Report final Id found in Tennessee Taxa List Appendix C*

TN Department of Environment & Conservation

STATE OF TENNESSEE - ENVIRONMENTAL LABORATORI					**Biological Analysis**	
Please Print Legibly					**Schedule must be Arranged in advance for all tests (615)262-6327	
Project/Site No.			**Screening Bioassays**	**Chronic Bioassays**	Branch Lab Number	
Project Name	0		(Cannot be used for permitting)	Chronic Cd	**Chain of Custody (sign full name)**	
Station No.		County	48 hr Static Screening Cd	Log Number	1. Collected by	
Description			Log Number	LC50 @ 24 hrs	Date	Time
Stream Mile		Depth	LC50 @ 24 hrs	LC50 @ 48 hrs	Delivered to	
Collection Date		Time	LC50 @ 48 hrs	LC50 @ 72 hrs	Date	Time
Sampler's Name (Prir			48 hr Static Screening Pp	LC50 @ 96 hrs	2. Received by	
Sampling Agency			Log Number	Survival	Date	Time
Billing Code			LC50 @ 24 hrs	NOAEC	Delivered to	
If Priority, Date Need			LC50 @ 48 hrs	LOAEC	Date	Time
Send Report to	G. Denton, DWR/PAS/CO Nashville			Reproduction	3. Received by	
			48 hr Static Definitive Cd	NOAEC	Date	Time
Field Log Number:	**01001900**		Log Number	LOAEC	Delivered to	
Contact Hazard	Unknown		LC50 @ 24 hrs	IC25	Date	Time
Date Reported		By	LC50 @ 48 hrs	Chronic Pp	4. Rec'd in Lab by	
Reviewed By			NOAEC	Log Number	Date	Time
Reviewed by			LOAEC	LC50 @ 24 hrs	Logged in by	
BIOLOGICAL SURVEYS			96 hr Static Definitive Pp	LC50 @ 48 hrs	Date	Time
Macroinvertebrate Recon			Log Number	LC50 @ 72 hrs	**Additional Information**	
Rapid Bioassessment (State SOP)			LC50 @ 24 hrs	LC50 @ 96 hrs	1. Approx. volume of sample	
Intensive Survey - Surber			LC50 @ 48 hrs	LC50 @ 120 hrs	2. Nearest town or city	
Intensive Survey - Dendy			NOAEC	LC50 @ 144 hrs		
Fish Population Recon			LOAEC	LC50 @ 168 hrs	3. Others present at collection	
Fish Population Intensive			96 hr Static Definitive Cd	Survival		
Fish Tissue Collection			Log Number	NOAEC	4. Number of other samples collected at same	
Chlorophyll Analysis			LC50 @ 24 hrs	LOAEC	time at this point	
Log Number			LC50 @ 48 hrs	Growth		
Chlorophyll a			LC50 @ 72 hrs	NOAEC	5. Field collection procedure, handling and/or	
Pheophyton			LC50 @ 96 hrs	LOAEC	preservation of this sample	
SPECIAL STUDIES			NOAEC	IC25	TDEC SOP	
(Please Specify)			LOAEC			
			96 hr Static Definitive Pp	Chlorine Residual	6. Mode of transportation to lab	
BR Family Lab Log No:			Log Number			
BR Genera Lab Log No:			LC50 @ 24 hrs	Lab Parameters	7. Sample/cooler sealed by	
SQKICK Lab Log No:			LC50 @ 48 hrs	pH		
SQBank Lab Log No:			LC50 @ 72 hrs	Cond.	8. Date sample/cooler sealed	
Periphyton Lab Log No:			LC50 @ 96 hrs	D.O.	9. Remarks	
Other Lab Log No:			NOAEC	Temp.	**Biological EDD uploaded to Waterlog.**	
Describe Other:			LOAEC			

APPENDIX C

Tennessee Macroinvertebrate Taxa List

(INCLUDING MODIFIED NCBI SCORES AND, CLINGER LIST)

Tennessee Taxa List

Phylum	Class	Order	Family	Genus	*Finalid**	NCBI *modified*	Clinger primary
Annelida	Clitellata	Branchiobdellida	Branchiobdellidae	Branchiobdella	Branchiobdella	6	
Annelida	Clitellata	Branchiobdellida	Branchiobdellidae		Branchiobdellidae	6	
Annelida	Oligochaeta				Oligochaeta (Oligochaeta)	8	
Annelida	Oligochaeta	Aeolosomatida	Aeolosomatidae	Aeolosoma	Aeolosoma	8	
Annelida	Oligochaeta	Aeolosomatida	Aeolosomatidae		Aeolosomatidae	8	
Annelida	Oligochaeta	Haplotaxida	Haplotaxidae	Haplotaxis	Haplotaxis	5	
Annelida	Oligochaeta	Hirudinida	Erpobdellidae	Mooreobdella	Mooreobdella	8.6	
Annelida	Oligochaeta	Hirudinida	Erpobdellidae		Erpobdellidae	8.6	
Annelida	Oligochaeta	Hirudinida	Erpobdellidae	Erpobdella	Erpobdella	8.6	
Annelida	Oligochaeta	Hirudinida	Glossiphoniidae	Helobdella	Helobdella	9.3	
Annelida	Oligochaeta	Hirudinida	Glossiphoniidae	Placobdella	Placobdella	8.55	
Annelida	Oligochaeta	Hirudinida	Glossiphoniidae		Glossiphoniidae	8.82	
Annelida	Oligochaeta	Hirudinida			Hirudinida	8.8	
Annelida	Oligochaeta	Lumbriculida	Lumbriculidae	Eclipidrilus	Eclipidrilus	5	
Annelida	Oligochaeta	Lumbriculida	Lumbriculidae		Lumbriculidae	5	
Annelida	Oligochaeta	Lumbriculida	Lumbriculidae	Lumbriculus	Lumbriculus	5	
Annelida	Oligochaeta	Tubificida	Enchytraeidae		Enchytraeidae	10	
Annelida	Oligochaeta	Tubificida	Enchytraeidae	Enchytraeus	Enchytraeus	10	
Annelida	Oligochaeta	Tubificida	Enchytraeidae	Fridericia	Fridericia	10	
Annelida	Oligochaeta	Tubificida	Enchytraeidae	Hemienchytraeus	Hemienchytraeus	10	
Annelida	Oligochaeta	Tubificida	Enchytraeidae	Marionina	Marionina	10	
Annelida	Oligochaeta	Tubificida	Enchytraeidae	Mesenchytraeus	Mesenchytraeus	10	
Annelida	Oligochaeta	Tubificida	Naididae	Aulodrilus	Aulodrilus	7	
Annelida	Oligochaeta	Tubificida	Naididae	Bothrioneurum	Bothrioneurum	7	
Annelida	Oligochaeta	Tubificida	Naididae	Branchiodrilus	Branchiodrilus	8	
Annelida	Oligochaeta	Tubificida	Naididae	Branchiura	Branchiura (Tubificidae)	8.6	
Annelida	Oligochaeta	Tubificida	Naididae	Bratislavia	Bratislavia	8	
Annelida	Oligochaeta	Tubificida	Naididae	Chaetogaster	Chaetogaster	7	
Annelida	Oligochaeta	Tubificida	Naididae	Dero	Dero	9.8	
Annelida	Oligochaeta	Tubificida	Naididae	Haemonais	Haemonais	8	
Annelida	Oligochaeta	Tubificida	Naididae	Ilyodrilus	Ilyodrilus	9.3	
Annelida	Oligochaeta	Tubificida	Naididae	Limnodrilus	Limnodrilus	8.5	
Annelida	Oligochaeta	Tubificida	Naididae		Naididae	9	
Annelida	Oligochaeta	Tubificida	Naididae		Naidinae	8	

Phylum	**Class**	**Order**	**Family**	**Genus**	***Finalid****	**NCBI** *modified*	**Clinger** primary
Annelida	Oligochaeta	Tubificida	Naididae	Nais	Nais (Animalia)	8.7	
Annelida	Oligochaeta	Tubificida	Naididae	Ophidonais	Ophidonais	6	
Annelida	Oligochaeta	Tubificida	Naididae	Piguetiella	Piguetiella	6	
Annelida	Oligochaeta	Tubificida	Naididae	Pristina	Pristina	7.7	
Annelida	Oligochaeta	Tubificida	Naididae	Quistadrilus	Quistadrilus	10	
Annelida	Oligochaeta	Tubificida	Naididae	Rhyacodrilus	Rhyacodrilus	10	
Annelida	Oligochaeta	Tubificida	Naididae	Slavina	Slavina	8.4	
Annelida	Oligochaeta	Tubificida	Naididae	Specaria	Specaria	6	
Annelida	Oligochaeta	Tubificida	Naididae	Spirosperma	Spirosperma	6	
Annelida	Oligochaeta	Tubificida	Naididae	Stephensoniana	Stephensoniana	10	
Annelida	Oligochaeta	Tubificida	Naididae	Stylaria	Stylaria	8.4	
Annelida	Oligochaeta	Tubificida	Naididae		Tubificinae	10	
Annelida	Oligochaeta	Tubificida	Naididae	Tubifex	Tubifex	9.9	
Annelida	Oligochaeta	Tubificida	Naididae	Varichaetadrilus	Varichaetadrilus	10	
Arthropoda	Arachnida	Trombidiformes			Acari	6	
Arthropoda	Crustacea	Amphipoda	Crangonyctidae	Crangonyx	Crangonyx	7.2	
Arthropoda	Crustacea	Amphipoda	Crangonyctidae	Stygobromus	Stygobromus		
Arthropoda	Crustacea	Amphipoda	Crangonyctidae		Crangonyctidae	7.2	
Arthropoda	Crustacea	Amphipoda	Gammaridae	Gammarus	Gammarus	7.1	
Arthropoda	Crustacea	Amphipoda	Gammaridae		Gammaridae	7.1	
Arthropoda	Crustacea	Amphipoda	Hyalellidae	Hyalella	Hyalella	7.2	
Arthropoda	Crustacea	Amphipoda	Hyalellidae		Hyalellidae	7.2	
Arthropoda	Crustacea	Amphipoda			Amphipoda	7.2	
Arthropoda	Crustacea	Decapoda	Cambaridae		Cambaridae	7.5	
Arthropoda	Crustacea	Decapoda	Cambaridae	Cambarus	Cambarus	7.5	
Arthropoda	Crustacea	Decapoda	Cambaridae	Orconectes	Orconectes	2.7	
Arthropoda	Crustacea	Decapoda	Cambaridae	Procambarus	Procambarus	9.3	
Arthropoda	Crustacea	Decapoda	Palaemonidae	Palaemonetes	Palaemonetes	8.7	
Arthropoda	Crustacea	Decapoda	Palaemonidae		Palaemonidae	8.7	
Arthropoda	Crustacea	Decapoda			Decapoda	7	
Arthropoda	Crustacea	Isopoda	Asellidae	Asellus	Asellus	7.9	
Arthropoda	Crustacea	Isopoda	Asellidae	Caecidotea	Caecidotea	8.4	
Arthropoda	Crustacea	Isopoda	Asellidae	Lirceus	Lirceus	7.4	
Arthropoda	Crustacea	Isopoda	Asellidae		Asellidae	7.9	
Arthropoda	Crustacea	Isopoda			Isopoda	7.4	
Arthropoda	Crustacea	Mysidacea	Mysidae	Mysis	Mysis		
Arthropoda	Crustacea	Mysidacea	Mysidae		Mysidae		
Arthropoda	Insecta	Coleoptera	Dryopidae	Helichus	Helichus	4	Yes

Phylum	**Class**	**Order**	**Family**	**Genus**	***Finalid****	**NCBI** *modified*	**Clinger** primary
Arthropoda	Insecta	Coleoptera	Dryopidae	Pelonomus	Pelonomus	4.1	
Arthropoda	Insecta	Coleoptera	Dryopidae		Dryopidae	4.1	Yes
Arthropoda	Insecta	Coleoptera	Dytiscidae	Acilius	Acilius	6	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Agabetes	Agabetes	5	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Agabus	Agabus	5	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Bidessonotus	Bidessonotus	6	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Copelatus	Copelatus	9.1	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Coptotomus	Coptotomus	8.5	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Desmopachria	Desmopachria	5	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Heterosternuta	Heterosternuta	6	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Hydaticus	Hydaticus	5	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Hydroporus	Hydroporus	7	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Hydrovatus	Hydrovatus	6	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Hygrotus	Hygrotus	6	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Laccodytes	Laccodytes	6	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Laccophilus	Laccophilus	9.8	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Liodessus	Liodessus	4.7	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Lioporeus	Lioporeus	4	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Matus	Matus	6	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Neoporus	Neoporus	4.45	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Platambus	Platambus	5	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Rhantus	Rhantus	6	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Uvarus	Uvarus	6	
Arthropoda	Insecta	Coleoptera	Dytiscidae		Dytiscidae	6	
Arthropoda	Insecta	Coleoptera	Elmidae	Ancyronyx	Ancyronyx	6.8	Yes
Arthropoda	Insecta	Coleoptera	Elmidae	Dubiraphia	Dubiraphia	5.5	Yes
Arthropoda	Insecta	Coleoptera	Elmidae	Gonielmis	Gonielmis	5	Yes
Arthropoda	Insecta	Coleoptera	Elmidae	Macronychus	Macronychus	4.7	Yes
Arthropoda	Insecta	Coleoptera	Elmidae	Microcylloepus	Microcylloepus	3.3	Yes
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservus	Optioservus	2.6	Yes
Arthropoda	Insecta	Coleoptera	Elmidae	Oulimnius	Oulimnius	1.8	Yes
Arthropoda	Insecta	Coleoptera	Elmidae	Stenelmis	Stenelmis	5.6	Yes
Arthropoda	Insecta	Coleoptera	Elmidae		Elmidae	4.4	Yes
Arthropoda	Insecta	Coleoptera	Haliplidae	Haliplus	Haliplus	5	
Arthropoda	Insecta	Coleoptera	Haliplidae	Peltodytes	Peltodytes	8.4	
Arthropoda	Insecta	Coleoptera	Haliplidae		Haliplidae	6.2	
Arthropoda	Insecta	Coleoptera	Helophoridae	Helophorus	Helophorus	7.9	
Arthropoda	Insecta	Coleoptera	Helophoridae		Helophoridae	7.9	

Phylum	**Class**	**Order**	**Family**	**Genus**	***Finalid****	**NCBI** *modified*	**Clinger** primary
Arthropoda	Insecta	Coleoptera	Hydraenidae	Ochthebius	Ochthebius	5	Yes
Arthropoda	Insecta	Coleoptera	Hydraenidae		Hydraenidae	5	Yes
Arthropoda	Insecta	Coleoptera	Hydrochidae	Hydrochus	Hydrochus	5	
Arthropoda	Insecta	Coleoptera	Hydrochidae		Hydrochidae	5	
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Berosus	Berosus	8.8	
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Cymbiodyta	Cymbiodyta	6.9	
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Dibolocelus	Dibolocelus	6.9	
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Enochrus	Enochrus	8.5	
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Helochares	Helochares	5	
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Helocombus	Helocombus	6.9	
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Hydrobiomorpha	Hydrobiomorpha	6.9	
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Hydrobius	Hydrobius	8	
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Hydrophilus	Hydrophilus	6.9	
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Laccobius	Laccobius	6.5	
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Paracymus	Paracymus	5	
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Sperchopsis	Sperchopsis	4.4	Yes
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Tropisternus	Tropisternus	9.3	
Arthropoda	Insecta	Coleoptera	Hydrophilidae		Hydrophilidae	6.9	
Arthropoda	Insecta	Coleoptera	Lutrochidae	Lutrochus	Lutrochus	2.9	Yes
Arthropoda	Insecta	Coleoptera	Lutrochidae		Lutrochidae	2.9	Yes
Arthropoda	Insecta	Coleoptera	Noteridae	Hydrocanthus	Hydrocanthus	6.9	
Arthropoda	Insecta	Coleoptera	Noteridae	Suphisellus	Suphisellus		
Arthropoda	Insecta	Coleoptera	Noteridae		Noteridae	6.9	
Arthropoda	Insecta	Coleoptera	Psephenidae	Ectopria	Ectopria	4.3	Yes
Arthropoda	Insecta	Coleoptera	Psephenidae	Psephenus	Psephenus	2.3	Yes
Arthropoda	Insecta	Coleoptera	Psephenidae		Psephenidae	3.3	Yes
Arthropoda	Insecta	Coleoptera	Ptilodactylidae	Anchytarsus	Anchytarsus	2.4	Yes
Arthropoda	Insecta	Coleoptera	Ptilodactylidae		Ptilodactylidae	2.4	Yes
Arthropoda	Insecta	Coleoptera	Scirtidae	Cyphon	Cyphon	7	
Arthropoda	Insecta	Coleoptera	Scirtidae	Elodes	Elodes	5	
Arthropoda	Insecta	Coleoptera	Scirtidae	Prionocyphon	Prionocyphon	5	
Arthropoda	Insecta	Coleoptera	Scirtidae	Scirtes	Scirtes	5	
Arthropoda	Insecta	Coleoptera	Scirtidae		Scirtidae	5	
Arthropoda	Insecta	Diptera	Athericidae	Atherix	Atherix	2.1	
Arthropoda	Insecta	Diptera	Athericidae		Athericidae	2.1	
Arthropoda	Insecta	Diptera	Blephariceridae	Blepharicera	Blepharicera	0	Yes
Arthropoda	Insecta	Diptera	Blephariceridae		Blephariceridae	0	Yes
Arthropoda	Insecta	Diptera	Ceratopogonidae	Alluaudomyia	Alluaudomyia	6	

Phylum	**Class**	**Order**	**Family**	**Genus**	***Finalid****	**NCBI** *modified*	**Clinger** primary
Arthropoda	Insecta	Diptera	Ceratopogonidae	Atrichopogon	Atrichopogon	6.1	
Arthropoda	Insecta	Diptera	Ceratopogonidae	Bezzia	Bezzia	6	
Arthropoda	Insecta	Diptera	Ceratopogonidae	Ceratopogon	Ceratopogon	6	
Arthropoda	Insecta	Diptera	Ceratopogonidae		Ceratopogonidae	6	
Arthropoda	Insecta	Diptera	Ceratopogonidae	Dasyhelea	Dasyhelea	6	
Arthropoda	Insecta	Diptera	Ceratopogonidae	Forcipomyia	Forcipomyia	6	
Arthropoda	Insecta	Diptera	Ceratopogonidae	Mallochohelea	Mallochohelea	6	
Arthropoda	Insecta	Diptera	Ceratopogonidae	Monohelea	Monohelea	6	
Arthropoda	Insecta	Diptera	Ceratopogonidae	Serromyia	Serromyia	6	
Arthropoda	Insecta	Diptera	Ceratopogonidae	Sphaeromias	Sphaeromias	6	
Arthropoda	Insecta	Diptera	Chaoboridae	Chaoborus	Chaoborus	8.5	
Arthropoda	Insecta	Diptera	Chaoboridae	Mochlonyx	Mochlonyx	8	
Arthropoda	Insecta	Diptera	Chaoboridae		Chaoboridae	8	
Arthropoda	Insecta	Diptera	Chironomidae	Ablabesmyia	Ablabesmyia	6.4	
Arthropoda	Insecta	Diptera	Chironomidae	Acampptocladius	Acamptocladius		
Arthropoda	Insecta	Diptera	Chironomidae	Acricotopus	Acricotopus	10	
Arthropoda	Insecta	Diptera	Chironomidae	Alotanypus	Alotanypus	9	
Arthropoda	Insecta	Diptera	Chironomidae	Antillocladius	Antillocladius		
Arthropoda	Insecta	Diptera	Chironomidae	Apedilum	Apedilum	5.69	
Arthropoda	Insecta	Diptera	Chironomidae	Apsectrotanypus	Apsectrotanypus	0	
Arthropoda	Insecta	Diptera	Chironomidae	Axarus	Axarus		
Arthropoda	Insecta	Diptera	Chironomidae	Brillia	Brillia	5.7	
Arthropoda	Insecta	Diptera	Chironomidae	Brundiniella	Brundiniella	2	
Arthropoda	Insecta	Diptera	Chironomidae	Cardiocladius	Cardiocladius	6.2	
Arthropoda	Insecta	Diptera	Chironomidae	Chaetocladius	Chaetocladius	6	
Arthropoda	Insecta	Diptera	Chironomidae	Chernovkiia	Chernovskiia		
Arthropoda	Insecta	Diptera	Chironomidae		Chironomini	5.4	
Arthropoda	Insecta	Diptera	Chironomidae	Chironomus	Chironomus	9.3	
Arthropoda	Insecta	Diptera	Chironomidae	Cladopelma	Cladopelma	2.5	
Arthropoda	Insecta	Diptera	Chironomidae	Cladotanytarsus	Cladotanytarsus	4	
Arthropoda	Insecta	Diptera	Chironomidae	Clinotanypus	Clinotanypus	7.8	
Arthropoda	Insecta	Diptera	Chironomidae	Coelotanypus	Coelotanypus	6.9	
Arthropoda	Insecta	Diptera	Chironomidae	Conchapelopia	Conchapelopia	8.7	
Arthropoda	Insecta	Diptera	Chironomidae	Constempellina	Constempellina	6	
Arthropoda	Insecta	Diptera	Chironomidae	Corynoneura	Corynoneura	5.7	
Arthropoda	Insecta	Diptera	Chironomidae	Crico./Ortho.	Cricotopus/Orthocladius	7.6	Yes
Arthropoda	Insecta	Diptera	Chironomidae	Cricotopus	Cricotopus	8.7	Yes

Phylum	**Class**	**Order**	**Family**	**Genus**	***Finalid****	**NCBI** *modified*	**Clinger** primary
Arthropoda	Insecta	Diptera	Chironomidae	Cryptochironomus	Cryptochironomus	6.4	
Arthropoda	Insecta	Diptera	Chironomidae	Cryptotendipes	Cryptotendipes	6.2	
Arthropoda	Insecta	Diptera	Chironomidae	Demeijerea	Demeijerea		
Arthropoda	Insecta	Diptera	Chironomidae	Demicryptochironomus	Demicryptochironomus	2.2	
Arthropoda	Insecta	Diptera	Chironomidae		Diamesa	6.6	
Arthropoda	Insecta	Diptera	Chironomidae	Diamesinae	Diamesinae	2	Yes
Arthropoda	Insecta	Diptera	Chironomidae	Dicrotendipes	Dicrotendipes	7.2	
Arthropoda	Insecta	Diptera	Chironomidae	Diplocladius	Diplocladius	7.7	
Arthropoda	Insecta	Diptera	Chironomidae	Djalmabatista	Djalmabatista		
Arthropoda	Insecta	Diptera	Chironomidae	Doithrix	Doithrix		
Arthropoda	Insecta	Diptera	Chironomidae	Einfeldia	Einfeldia	8	
Arthropoda	Insecta	Diptera	Chironomidae	Endochironomus	Endochironomus	7.5	Yes
Arthropoda	Insecta	Diptera	Chironomidae	Endotribelos	Endotribelos		
Arthropoda	Insecta	Diptera	Chironomidae	Epoicocladius	Epoicocladius		
Arthropoda	Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	2.7	
Arthropoda	Insecta	Diptera	Chironomidae	Eukiefferiella	Tokunagaia	2.7	
Arthropoda	Insecta	Diptera	Chironomidae	Euryhapsis	Euryhapsis		
Arthropoda	Insecta	Diptera	Chironomidae	Fittkauimyia	Fittkauimyia		
Arthropoda	Insecta	Diptera	Chironomidae	Glyptotendipes	Glyptotendipes	8.6	
Arthropoda	Insecta	Diptera	Chironomidae	Goeldichironomus	Goeldichironomus	10	
Arthropoda	Insecta	Diptera	Chironomidae	Guttipelopia	Guttipelopia	5	
Arthropoda	Insecta	Diptera	Chironomidae	Harnischia	Harnischia	7.5	
Arthropoda	Insecta	Diptera	Chironomidae	Heleniella	Heleniella	0	
Arthropoda	Insecta	Diptera	Chironomidae	Heterotrissocladius	Heterotrissocladius	5.4	
Arthropoda	Insecta	Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	9.2	
Arthropoda	Insecta	Diptera	Chironomidae	Kiefferulus	Kiefferulus	10	
Arthropoda	Insecta	Diptera	Chironomidae	Kloosia	Kloosia		
Arthropoda	Insecta	Diptera	Chironomidae	Krenopelopia	Krenopelopia	4	
Arthropoda	Insecta	Diptera	Chironomidae	Krenosmittia	Krenosmittia	1	
Arthropoda	Insecta	Diptera	Chironomidae	Kribiodorum	Kribiodorum	7	
Arthropoda	Insecta	Diptera	Chironomidae	Labrundinia	Labrundinia	6.2	
Arthropoda	Insecta	Diptera	Chironomidae	Larsia	Larsia	6.5	
Arthropoda	Insecta	Diptera	Chironomidae	Lauterborniella	Lauterborniella	8	
Arthropoda	Insecta	Diptera	Chironomidae	Limnophyes	Limnophyes	3.1	
Arthropoda	Insecta	Diptera	Chironomidae	Lopescladius	Lopescladius	1.2	
Arthropoda	Insecta	Diptera	Chironomidae	Mesosmittia	Mesosmittia		
Arthropoda	Insecta	Diptera	Chironomidae	Metriocnemus	Metriocnemus		

Phylum	**Class**	**Order**	**Family**	**Genus**	***Finalid****	**NCBI** *modified*	**Clinger** primary
Arthropoda	Insecta	Diptera	Chironomidae	Microchironomus	Microchironomus		
Arthropoda	Insecta	Diptera	Chironomidae	Micropsectra	Micropsectra	2.4	
Arthropoda	Insecta	Diptera	Chironomidae	Microtendipes	Microtendipes	4.6	Yes
Arthropoda	Insecta	Diptera	Chironomidae	Nanocladius	Nanocladius	7.4	
Arthropoda	Insecta	Diptera	Chironomidae	Natarsia	Natarsia	9.5	
Arthropoda	insecta	Diptera	Chironomidae	Neostempellina	Neostempellina		
Arthropoda	Insecta	Diptera	Chironomidae	Neozavrelia	Neozavrelia		
Arthropoda	Insecta	Diptera	Chironomidae	Nilotanypus	Nilotanypus	4.1	
Arthropoda	Insecta	Diptera	Chironomidae	Nilothauma	Nilothauma	5.1	
Arthropoda	Insecta	Diptera	Chironomidae	Odontomesa	Odontomesa	4.9	
Arthropoda	Insecta	Diptera	Chironomidae	Omisus	Omisus		
Arthropoda	Insecta	Diptera	Chironomidae		Orthocladiinae	5.4	
Arthropoda	Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	4.4	
Arthropoda	Insecta	Diptera	Chironomidae	Pagastia	Pagastia	2.2	
Arthropoda	Insecta	Diptera	Chironomidae	Pagestiella	Pagastiella	2.6	
Arthropoda	Insecta	Diptera	Chironomidae	Paraboreochlus	Paraboreochlus	1	
Arthropoda	Insecta	Diptera	Chironomidae	Parachaetocladius	Parachaetocladius	0	
Arthropoda	Insecta	Diptera	Chironomidae	Parachironomus	Parachironomus	8	
Arthropoda	Insecta	Diptera	Chironomidae	Paracladopelma	Paracladopelma	6.3	
Arthropoda	Insecta	Diptera	Chironomidae	Paracricotopus	Paracricotopus	4	
Arthropoda	Insecta	Diptera	Chironomidae	Parakiefferiella	Parakiefferiella	4.8	
Arthropoda	Insecta	Diptera	Chironomidae	Paralauterborniella	Paralauterborniella	8	Yes
Arthropoda	Insecta	Diptera	Chironomidae	Paramerina	Paramerina	4.1	
Arthropoda	Insecta	Diptera	Chironomidae	Parametriocnemus	Parametriocnemus	3.9	
Arthropoda	Insecta	Diptera	Chironomidae	Paraphaenocladius	Paraphaenocladius	4	
Arthropoda	Insecta	Diptera	Chironomidae	Parapsectra	Parapsectra		
Arthropoda	Insecta	Diptera	Chironomidae	Paratanytarsus	Paratanytarsus	8	
Arthropoda	Insecta	Diptera	Chironomidae	Paratendipes	Paratendipes	5.6	
Arthropoda	Insecta	Diptera	Chironomidae	Paratrichocladius	Paratrichocladius	5	
Arthropoda	Insecta	Diptera	Chironomidae	Parochlus	Parochlus		
Arthropoda	Insecta	Diptera	Chironomidae	Pectrotanypus	Psectrotanypus	10	
Arthropoda	Insecta	Diptera	Chironomidae	Pentaneura	Pentaneura	5	
Arthropoda	Insecta	Diptera	Chironomidae	Phaenopsectra	Phaenopsectra	7.6	Yes
Arthropoda	Insecta	Diptera	Chironomidae	Platysmittia	Platysmittia		
Arthropoda	Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	6.7	
Arthropoda	Insecta	Diptera	Chironomidae	Potthastia	Potthastia	4.7	
Arthropoda	Insecta	Diptera	Chironomidae	Procladius	Procladius	8.8	
Arthropoda	Insecta	Diptera	Chironomidae		Prodiamesinae		

Phylum	**Class**	**Order**	**Family**	**Genus**	***Finalid****	**NCBI** *modified*	**Clinger** primary
Arthropoda	Insecta	Diptera	Chironomidae	Psectrocladius	Psectrocladius	3.8	
Arthropoda	Insecta	Diptera	Chironomidae	Pseudochironomus	Pseudochironomus	4.9	
Arthropoda	Insecta	Diptera	Chironomidae	Pseudorthocladius	Pseudorthocladius	0	
Arthropoda	Insecta	Diptera	Chironomidae	Pseudosmittia	Pseudosmittia		
Arthropoda	Insecta	Diptera	Chironomidae	Psilometriocnemus	Psilometriocnemus	4	
Arthropoda	Insecta	Diptera	Chironomidae	Rheocricotopus	Rheocricotopus	4.7	
Arthropoda	Insecta	Diptera	Chironomidae	Rheopelopia	Rheopelopia	0.3	
Arthropoda	Insecta	Diptera	Chironomidae	Rheosmittia	Rheosmittia	6.8	
Arthropoda	Insecta	Diptera	Chironomidae	Rheotanytarsus	Rheotanytarsus	6.5	Yes
Arthropoda	Insecta	Diptera	Chironomidae	Robackia	Robackia	3.3	
Arthropoda	Insecta	Diptera	Chironomidae	Saetheria	Saetheria	7.3	
Arthropoda	Insecta	Diptera	Chironomidae	Smittia	Smittia	6	
Arthropoda	Insecta	Diptera	Chironomidae	Stempellina	Stempellina	2	
Arthropoda	Insecta	Diptera	Chironomidae	Stempellinella	Stempellinella	5.6	
Arthropoda	Insecta	Diptera	Chironomidae	Stenochironomus	Stenochironomus	6.3	
Arthropoda	Insecta	Diptera	Chironomidae	Stictochironomus	Stictochironomus	5.4	
Arthropoda	Insecta	Diptera	Chironomidae	Stilocladius	Stilocladius	3	
Arthropoda	Insecta	Diptera	Chironomidae	Sublettea	Sublettea	1.7	
Arthropoda	Insecta	Diptera	Chironomidae	Symbiocladius	Symbiocladius	6	
Arthropoda	Insecta	Diptera	Chironomidae	Sympotthastia	Sympotthastia	4.5	
Arthropoda	Insecta	Diptera	Chironomidae	Synorthocladius	Synorthocladius	4.2	
Arthropoda	Insecta	Diptera	Chironomidae		Tanypodinae	5.4	
Arthropoda	Insecta	Diptera	Chironomidae	Tanypus	Tanypus	9.6	
Arthropoda	Insecta	Diptera	Chironomidae		Tanytarsini	5.4	
Arthropoda	Insecta	Diptera	Chironomidae	Tanytarsus	Tanytarsus	6.6	
Arthropoda	Insecta	Diptera	Chironomidae	Thienemanniella	Thienemanniella	6.4	
Arthropoda	Insecta	Diptera	Chironomidae	Thienemannimyia	Thienemannimyia	8.4	
Arthropoda	Insecta	Diptera	Chironomidae	Tribelos	Tribelos	6.4	
Arthropoda	Insecta	Diptera	Chironomidae	Trissopelopia	Trissopelopia	4	
Arthropoda	Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	3.9	
Arthropoda	Insecta	Diptera	Chironomidae	Unniella	Unniella	0	
Arthropoda	Insecta	Diptera	Chironomidae	Xenochironomus	Xenochironomus	7	
Arthropoda	Insecta	Diptera	Chironomidae	Xestochironomus	Xestochironomus		
Arthropoda	Insecta	Diptera	Chironomidae	Xylotopus	Xylotopus	6.6	
Arthropoda	Insecta	Diptera	Chironomidae	Zavrelia	Zavrelia	6.1	
Arthropoda	Insecta	Diptera	Chironomidae	Zavreliella	Zavreliella	2.7	
Arthropoda	Insecta	Diptera	Chironomidae	Zavrelimyia	Zavrelimyia	8.6	
Arthropoda	Insecta	Diptera	Chironomidae		Chironomidae	5.4	

Phylum	**Class**	**Order**	**Family**	**Genus**	***Finalid****	**NCBI** *modified*	**Clinger** primary
Arthropoda	Insecta	Diptera	Corethrellidae	Corethrella	Corethrella		
Arthropoda	Insecta	Diptera	Corethrellidae		Corethrellidae		
Arthropoda	Insecta	Diptera	Dixidae	Dixa	Dixa	2.5	
Arthropoda	Insecta	Diptera	Dixidae	Dixella	Dixella	4.9	
Arthropoda	Insecta	Diptera	Dixidae		Dixidae	3.7	
Arthropoda	Insecta	Diptera	Dolichopodidae	Rhaphium	Rhaphium	4	
Arthropoda	Insecta	Diptera	Dolichopodidae		Dolichopodidae	4	
Arthropoda	Insecta	Diptera	Empididae	Chelifera	Chelifera	6	
Arthropoda	Insecta	Diptera	Empididae	Clinocera	Clinocera	6	Yes
Arthropoda	Insecta	Diptera	Empididae		Empididae	6	
Arthropoda	Insecta	Diptera	Empididae	Hemerodromia	Hemerodromia	6	
Arthropoda	Insecta	Diptera	Empididae	Neoplasta	Neoplasta	6	
Arthropoda	Insecta	Diptera	Empididae	Roederiodes	Roederiodes	6	Yes
Arthropoda	Insecta	Diptera	Empididae	Trichoclinocera	Trichoclinocera	6	Yes
Arthropoda	Insecta	Diptera	Ephydridae	Ephydra	Ephydra	6	
Arthropoda	Insecta	Diptera	Ephydridae	Notiphila	Notiphila	6	
Arthropoda	Insecta	Diptera	Ephydridae	Scatella	Scatella	6	
Arthropoda	Insecta	Diptera	Ephydridae		Ephydridae	6	
Arthropoda	Insecta	Diptera	Limoniidae	Antocha	Antocha	4.4	Yes
Arthropoda	Insecta	Diptera	Limoniidae	Cryptolabis	Cryptolabis	4.7	
Arthropoda	Insecta	Diptera	Limoniidae	Dactylolabis	Dactylolabis	4.7	
Arthropoda	Insecta	Diptera	Limoniidae	Eloeophila	Eloeophila	4	
Arthropoda	Insecta	Diptera	Limoniidae	Epiphragma	Epiphragma	4.7	
Arthropoda	Insecta	Diptera	Limoniidae	Erioptera	Erioptera	3	
Arthropoda	Insecta	Diptera	Limoniidae	Gonomyia	Gonomyia	4.7	
Arthropoda	Insecta	Diptera	Limoniidae	Helius	Helius	4	
Arthropoda	Insecta	Diptera	Limoniidae	Hexatoma	Hexatoma	3.5	
Arthropoda	Insecta	Diptera	Limoniidae	Limnophila	Limnophila (Animalia)	4	
Arthropoda	Insecta	Diptera	Limoniidae	Lipsothrix	Lipsothrix	4.7	
Arthropoda	Insecta	Diptera	Limoniidae	Molophilus	Molophilus	4	
Arthropoda	Insecta	Diptera	Limoniidae	Ormosia	Ormosia (Eriopterini)	6.5	
Arthropoda	Insecta	Diptera	Limoniidae	Paradelphomyia	Paradelphomyia	4.7	
Arthropoda	Insecta	Diptera	Limoniidae	Pilaria	Pilaria	7	
Arthropoda	Insecta	Diptera	Limoniidae	Pseudolimnophila	Pseudolimnophila	6.2	
Arthropoda	Insecta	Diptera	Limoniidae	Rhabdomastix	Rhabdomastix	4.7	
Arthropoda	Insecta	Diptera	Limoniidae		Limoniidae	4.7	
Arthropoda	Insecta	Diptera	Muscidae	Limnophora	Limnophora	7	

Phylum	**Class**	**Order**	**Family**	**Genus**	***Finalid****	**NCBI** *modified*	**Clinger** primary
Arthropoda	Insecta	Diptera	Muscidae		Muscidae	6	
Arthropoda	Insecta	Diptera	Nymphomyiidae	Nymphomyia	Nymphomyia		Yes
Arthropoda	Insecta	Diptera	Nymphomyiidae		Nymphomyiidae		Yes
Arthropoda	Insecta	Diptera	Pediciidae	Dicranota	Dicranota	0	
Arthropoda	Insecta	Diptera	Pediciidae	Pedicia	Pedicia	6	
Arthropoda	Insecta	Diptera	Pediciidae		Pediciidae	3	
Arthropoda	Insecta	Diptera	Phoridae	Dohrniphora	Dohrniphora		
Arthropoda	Insecta	Diptera	Phoridae		Phoridae		
Arthropoda	Insecta	Diptera	Psychodidae	Pericoma	Pericoma	5.6	
Arthropoda	Insecta	Diptera	Psychodidae	Psychoda	Psychoda	10	
Arthropoda	Insecta	Diptera	Psychodidae		Psychodidae	7.8	
Arthropoda	Insecta	Diptera	Ptychopteridae	Bittacomorpha	Bittacomorpha	7	
Arthropoda	Insecta	Diptera	Ptychopteridae	Ptychoptera	Ptychoptera	7	
Arthropoda	Insecta	Diptera	Ptychopteridae		Ptychopteridae	7	
Arthropoda	Insecta	Diptera	Sciomyzidae	Dictya	Dictya	6	
Arthropoda	Insecta	Diptera	Sciomyzidae	Sepedon	Sepedon	6	
Arthropoda	Insecta	Diptera	Sciomyzidae		Sciomyzidae	6	
Arthropoda	Insecta	Diptera	Simuliidae	Cnephia	Cnephia	4	Yes
Arthropoda	Insecta	Diptera	Simuliidae	Ectemnia	Ectemnia	4.9	Yes
Arthropoda	Insecta	Diptera	Simuliidae	Prosimulium	Prosimulium	4.5	Yes
Arthropoda	Insecta	Diptera	Simuliidae		Simuliidae	4.7	Yes
Arthropoda	Insecta	Diptera	Simuliidae	Simulium	Simulium	4.9	Yes
Arthropoda	Insecta	Diptera	Simuliidae	Stegopterna	Stegopterna	4.9	Yes
Arthropoda	Insecta	Diptera	Stratiomyidae	Allognosta	Allognosta	7	
Arthropoda	Insecta	Diptera	Stratiomyidae	Caloparyphus	Caloparyphus	7	
Arthropoda	Insecta	Diptera	Stratiomyidae	Euparyphus	Euparyphus	7	
Arthropoda	Insecta	Diptera	Stratiomyidae	Myxosargus	Myxosargus	7	
Arthropoda	Insecta	Diptera	Stratiomyidae	Nemotelus	Nemotelus	7	
Arthropoda	Insecta	Diptera	Stratiomyidae	Odontomyia	Odontomyia	7	
Arthropoda	Insecta	Diptera	Stratiomyidae	Oxycera	Oxycera	7	
Arthropoda	Insecta	Diptera	Stratiomyidae		Stratiomyidae	7	
Arthropoda	Insecta	Diptera	Stratiomyidae	Stratiomys	Stratiomys	7	
Arthropoda	Insecta	Diptera	Syrphidae	Neoascia	Neoascia	10	
Arthropoda	Insecta	Diptera	Syrphidae	Syrphidae	Syrphidae	10	
Arthropoda	Insecta	Diptera	Tabanidae	Chlorotabanus	Chlorotabanus	7.6	
Arthropoda	Insecta	Diptera	Tabanidae	Chrysops	Chrysops	6.7	
Arthropoda	Insecta	Diptera	Tabanidae	Diachlorus	Diachlorus	7.6	
Arthropoda	Insecta	Diptera	Tabanidae	Hybomitra	Hybomitra	7.6	

Phylum	**Class**	**Order**	**Family**	**Genus**	***Finalid****	**NCBI** *modified*	**Clinger** primary
Arthropoda	Insecta	Diptera	Tabanidae	Tabanus	Tabanus	8.5	
Arthropoda	Insecta	Diptera	Tabanidae		Tabanidae	7.6	
Arthropoda	Insecta	Diptera	Tanyderidae	Protoplasa	Protoplasa	4	
Arthropoda	Insecta	Diptera	Tanyderidae		Tanyderidae	4	
Arthropoda	Insecta	Diptera	Tipulidae	Leptotarsus	Leptotarsus	8.4	
Arthropoda	Insecta	Diptera	Tipulidae	Limonia	Limonia (Limoniini)	9.3	
Arthropoda	Insecta	Diptera	Tipulidae	Tipula	Tipula	7.5	
Arthropoda	Insecta	Diptera	Tipulidae		Tipulidae	8.4	
Arthropoda	Insecta	Diptera			Nematocera		
Arthropoda	Insecta	Ephemeroptera	Ameletidae	Ameletus	Ameletus	1.2	
Arthropoda	Insecta	Ephemeroptera	Ameletidae		Ameletidae	1.2	
Arthropoda	Insecta	Ephemeroptera	Baetidae	Acentrella	Acentrella	2.5	
Arthropoda	Insecta	Ephemeroptera	Baetidae	Acerpenna	Acerpenna	3.7	
Arthropoda	Insecta	Ephemeroptera	Baetidae	Anafroptilum	Anafroptilum	3.8	
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	Baetis	4.18	
Arthropoda	Insecta	Ephemeroptera	Baetidae	Callibaetis	Callibaetis	9.2	
Arthropoda	Insecta	Ephemeroptera	Baetidae	Centroptilum	Centroptilum	3.8	
Arthropoda	Insecta	Ephemeroptera	Baetidae	Cloeon	Cloeon	7.3	
Arthropoda	Insecta	Ephemeroptera	Baetidae	Diphetor	Diphetor	1.1	
Arthropoda	Insecta	Ephemeroptera	Baetidae	Fallceon	Fallceon	6	
Arthropoda	Insecta	Ephemeroptera	Baetidae	Heterocloeon	Heterocloeon	3.7	
Arthropoda	Insecta	Ephemeroptera	Baetidae	Iswaeon	Iswaeon	4.4	
Arthropoda	Insecta	Ephemeroptera	Baetidae	Labiobaetis	Labiobaetis	4.6	
Arthropoda	Insecta	Ephemeroptera	Baetidae	Neocloeon	Neocloeon	7.3	
Arthropoda	Insecta	Ephemeroptera	Baetidae	Paracloeodes	Paracloeodes	8	
Arthropoda	Insecta	Ephemeroptera	Baetidae	Plauditus	Plauditus	2.2	
Arthropoda	Insecta	Ephemeroptera	Baetidae	Procloeon	Procloeon	1.9	
Arthropoda	Insecta	Ephemeroptera	Baetidae	Pseudocentroptioides	Pseudocentroptiloides	6	
Arthropoda	Insecta	Ephemeroptera	Baetidae		Baetidae	6	
Arthropoda	Insecta	Ephemeroptera	Baetiscidae	Baetisca	Baetisca	3.2	
Arthropoda	Insecta	Ephemeroptera	Baetiscidae		Baetiscidae	3.7	
Arthropoda	Insecta	Ephemeroptera	Caenidae	Brachycercus	Brachycercus	2.1	
Arthropoda	Insecta	Ephemeroptera	Caenidae	Caenis	Caenis	6.8	
Arthropoda	Insecta	Ephemeroptera	Caenidae	Sparbarus	Sparbarus	3.5	
Arthropoda	Insecta	Ephemeroptera	Caenidae	Susperatus	Susperatus	3.5	
Arthropoda	Insecta	Ephemeroptera	Caenidae		Caenidae	5	
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Attenella	Attenella	1.1	Yes

Phylum	Class	Order	Family	Genus	*Finalid**	NCBI *modified*	Clinger primary
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Dannella	Dannella	1.9	Yes
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	Drunella	0.1	Yes
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella	Ephemerella	2.1	Yes
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae		Ephemerellidae	2	Yes
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Eurylophella	Eurylophella	4	Yes
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Penelomax	Penelomax	2.1	Yes
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Serratella	Serratella	2.1	Yes
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Teloganopsis	Teloganopsis	2.6	Yes
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Tsalia	Tsalia	0	Yes
Arthropoda	Insecta	Ephemeroptera	Ephemeridae	Ephemera	Ephemera (Ephemeridae)	2	
Arthropoda	Insecta	Ephemeroptera	Ephemeridae		Ephemeridae	2.2	
Arthropoda	Insecta	Ephemeroptera	Ephemeridae	Hexagenia	Hexagenia	4.4	
Arthropoda	Insecta	Ephemeroptera	Ephemeridae	Litobrancha	Litobrancha	0	
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Cinygmula	Cinygmula	0	Yes
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Epeorus	Epeorus	1.2	Yes
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Heptagenia	Heptagenia	1.9	Yes
Arthropoda	Insecta	Ephemeroptera	Heptageniidae		Heptageniidae	3	Yes
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Leucrocuta	Leucrocuta	2.9	Yes
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Nixe	Nixe	2	Yes
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Rhithrogena	Rhithrogena	0	Yes
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Stenacron	Stenacron	4.6	Yes
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Stenonema	Stenonema	3.4	Yes
Arthropoda	Insecta	Ephemeroptera	Isonychiidae	Isonychia	Isonychia	3.6	
Arthropoda	Insecta	Ephemeroptera	Isonychiidae		Isonychiidae	3.6	
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae		Leptohyphidae	5	
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	Tricorythodes	Tricorythodes	5	
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Choroterpes	Choroterpes	4	Yes
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Habrophlebia	Habrophlebia	0.3	
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Habrophlebiodes	Habrophlebiodes	0	
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Leptophlebia	Leptophlebia	6	
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae		Leptophlebiidae	1.9	
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Neochoroterpes	Neochoroterpes	2.5	
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Neoleptophlebia	Neoleptophlebia	1.2	
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia	Paraleptophlebia	1.2	
Arthropoda	Insecta	Ephemeroptera	Metropodidae	Siphloplecton	Siphloplecton	3.1	
Arthropoda	Insecta	Ephemeroptera	Metropodidae		Metretopodidae	3.1	
Arthropoda	Insecta	Ephemeroptera	Neoephemeridae	Neoephemera	Neoephemera	1.5	

Phylum	**Class**	**Order**	**Family**	**Genus**	***Finalid****	**NCBI** *modified*	**Clinger** primary
Arthropoda	Insecta	Ephemeroptera	Neoephemeridae		Neoephemeridae	1.5	
Arthropoda	Insecta	Ephemeroptera	Palingeniidae	Pentagenia	Pentagenia		
Arthropoda	Insecta	Ephemeroptera	Palingeniidae		Palingeniidae		
Arthropoda	Insecta	Ephemeroptera	Polymitarcyidae	Ephoron	Ephoron	1.5	
Arthropoda	Insecta	Ephemeroptera	Polymitarcyidae		Polymitarcyidae	1.5	
Arthropoda	Insecta	Ephemeroptera	Potamanthidae	Anthopotamus	Anthopotamus	1.5	
Arthropoda	Insecta	Ephemeroptera	Potamanthidae		Potamanthidae	1.5	
Arthropoda	Insecta	Ephemeroptera	Siphlonuridae	Siphlonurus	Siphlonurus	6	
Arthropoda	Insecta	Ephemeroptera	Siphlonuridae		Siphlonuridae	6	
Arthropoda	Insecta	Ephemeroptera			Ephemeroptera		
Arthropoda	Insecta	Hemiptera	Belostomatidae	Belostoma	Belostoma	9.5	
Arthropoda	Insecta	Hemiptera	Belostomatidae	Lethocerus	Lethocerus	9.5	
Arthropoda	Insecta	Hemiptera	Belostomatidae		Belostomatidae	9.5	
Arthropoda	Insecta	Hemiptera	Corixidae		Corixidae	5.9	
Arthropoda	Insecta	Hemiptera	Corixidae	Hesperocorixa	Hesperocorixa	5	
Arthropoda	Insecta	Hemiptera	Corixidae	Palmacorixa	Palmacorixa	5	
Arthropoda	Insecta	Hemiptera	Corixidae	Sigara	Sigara	8.7	
Arthropoda	Insecta	Hemiptera	Corixidae	Trichocorixa	Trichocorixa	5	
Arthropoda	Insecta	Hemiptera	Gelastocoridae	Gelastocoris	Gelastocoris		
Arthropoda	Insecta	Hemiptera	Gelastocoridae		Gelastocoridae		
Arthropoda	Insecta	Hemiptera	Hebridae	Hebrus	Hebrus		
Arthropoda	Insecta	Hemiptera	Hebridae	Lipogomphus	Lipogomphus		
Arthropoda	Insecta	Hemiptera	Hebridae		Hebridae		
Arthropoda	Insecta	Hemiptera	Naucoridae	Pelocoris	Pelocoris	7	
Arthropoda	Insecta	Hemiptera	Naucoridae		Naucoridae	7	
Arthropoda	Insecta	Hemiptera	Nepidae	Ranatra	Ranatra	6.3	
Arthropoda	Insecta	Hemiptera	Nepidae		Nepidae	6.3	
Arthropoda	Insecta	Hemiptera	Notonectidae	Buenoa	Buenoa		
Arthropoda	Insecta	Hemiptera	Notonectidae	Notonecta	Notonecta		
Arthropoda	Insecta	Hemiptera	Notonectidae		Notonectidae		
Arthropoda	Insecta	Hemiptera	Pleidae	Neoplea	Neoplea	5	
Arthropoda	Insecta	Hemiptera	Pleidae	Paraplea	Paraplea		
Arthropoda	Insecta	Hemiptera	Pleidae		Pleidae		
Arthropoda	Insecta	Hemiptera	Saldidae	Micracanthia	Micracanthia	10	
Arthropoda	Insecta	Hemiptera	Saldidae	Pentacora	Pentacora	10	
Arthropoda	Insecta	Hemiptera	Saldidae	Saldidae	Saldidae	10	
Arthropoda	Insecta	Lepidoptera	Crambidae	Parapoynx	Parapoynx	5	Yes
Arthropoda	Insecta	Lepidoptera	Crambidae		Crambidae	5	

Phylum	**Class**	**Order**	**Family**	**Genus**	***Finalid****	**NCBI** *modified*	**Clinger** primary
Arthropoda	Insecta	Lepidoptera	Nepticulidae		Nepticulidae		
Arthropoda	Insecta	Lepidoptera	Noctuidae		Noctuidae		
Arthropoda	Insecta	Lepidoptera	Noctuidae	Simyra	Simyra		
Arthropoda	Insecta	Lepidoptera	Pyralidae	Acentria	Acentria	5	
Arthropoda	Insecta	Lepidoptera	Pyralidae	Microcrambus	Microcrambus	5	
Arthropoda	Insecta	Lepidoptera	Pyralidae	Munroessa/Syncllita	Munroessa/Synclita	5	
Arthropoda	Insecta	Lepidoptera	Pyralidae	Petrophila	Petrophila	5	Yes
Arthropoda	Insecta	Lepidoptera	Pyralidae		Pyralidae	5	
Arthropoda	Insecta	Lepidoptera	Pyralidae	Synclita	Synclita	5	
Arthropoda	Insecta	Lepidoptera	Tortricidae	Archips	Archips	5	
Arthropoda	Insecta	Lepidoptera	Tortricidae		Tortricidae	5	
Arthropoda	Insecta	Megaloptera	Corydalidae	Chauliodes	Chauliodes	4	Yes
Arthropoda	Insecta	Megaloptera	Corydalidae	Corydalus	Corydalus	5.2	Yes
Arthropoda	Insecta	Megaloptera	Corydalidae	Nigronia	Nigronia	5.35	Yes
Arthropoda	Insecta	Megaloptera	Corydalidae		Corydalidae	5.28	Yes
Arthropoda	Insecta	Megaloptera	Sialidae	Sialis	Sialis	7	
Arthropoda	Insecta	Megaloptera	Sialidae		Sialidae	7	
Arthropoda	Insecta	Megaloptera			Megaloptera	6.79	Yes
Arthropoda	Insecta	Neuroptera	Sisyridae	Climacia	Climacia	6.5	
Arthropoda	Insecta	Neuroptera	Sisyridae	Sisyra	Sisyra		
Arthropoda	Insecta	Neuroptera	Sisyridae		Sisyridae	6.5	
Arthropoda	Insecta	Neuroptera			Neuroptera	6.5	
Arthropoda	Insecta	Odonata	Aeshnidae	Anax	Anax	5	
Arthropoda	Insecta	Odonata	Aeshnidae	Basiaeschna	Basiaeschna	7.7	
Arthropoda	Insecta	Odonata	Aeshnidae	Boyeria	Boyeria	6.3	
Arthropoda	Insecta	Odonata	Aeshnidae	Nasiaeschna	Nasiaeschna	6.6	
Arthropoda	Insecta	Odonata	Aeshnidae		Aeshnidae	6.5	
Arthropoda	Insecta	Odonata	Calopterygidae	Calopteryx	Calopteryx	7.5	
Arthropoda	Insecta	Odonata	Calopterygidae	Hetaerina	Hetaerina	4.9	
Arthropoda	Insecta	Odonata	Calopterygidae		Calopterygidae	6.2	
Arthropoda	Insecta	Odonata	Coenagrionidae	Amphiagrion	Amphiagrion	5	
Arthropoda	Insecta	Odonata	Coenagrionidae	Argia	Argia	8.3	
Arthropoda	Insecta	Odonata	Coenagrionidae	Chromagrion	Chromagrion	7.8	
Arthropoda	Insecta	Odonata	Coenagrionidae	Enallagma	Enallagma	8.5	
Arthropoda	Insecta	Odonata	Coenagrionidae	Ischnura	Ischnura	9.5	
Arthropoda	Insecta	Odonata	Coenagrionidae		Coenagrionidae	7.8	
Arthropoda	Insecta	Odonata	Cordulegastridae	Cordulegaster	Cordulegaster	5.7	

Phylum	**Class**	**Order**	**Family**	**Genus**	***Finalid****	**NCBI** *modified*	**Clinger** primary
Arthropoda	Insecta	Odonata	Cordulegastridae	Zoraena	Zoraena	5.7	
Arthropoda	Insecta	Odonata	Cordulegastridae		Cordulegastridae	5.7	
Arthropoda	Insecta	Odonata	Corduliidae	Epitheca	Epitheca	8	
Arthropoda	Insecta	Odonata	Corduliidae	Helocordulia	Helocordulia	5.8	
Arthropoda	Insecta	Odonata	Corduliidae	Neurocordulia	Neurocordulia	5.3	
Arthropoda	Insecta	Odonata	Corduliidae	Somatochlora	Somatochlora	8.9	
Arthropoda	Insecta	Odonata	Corduliidae		Corduliidae	7	
Arthropoda	Insecta	Odonata	Gomphidae	Arigomphus	Arigomphus	5.2	
Arthropoda	Insecta	Odonata	Gomphidae	Dromogomphus	Dromogomphus	5.6	
Arthropoda	Insecta	Odonata	Gomphidae		Gomphidae	4.2	
Arthropoda	Insecta	Odonata	Gomphidae	Gomphurus	Gomphurus	5.9	
Arthropoda	Insecta	Odonata	Gomphidae	Hagenius	Hagenius	4.4	
Arthropoda	Insecta	Odonata	Gomphidae	Hylogomphus	Hylogomphus	5.9	
Arthropoda	Insecta	Odonata	Gomphidae	Lanthus	Lanthus	1.6	
Arthropoda	Insecta	Odonata	Gomphidae	Ophiogomphus	Ophiogomphus	6	
Arthropoda	Insecta	Odonata	Gomphidae	Phanogomphus	Phanogomphus	5.9	
Arthropoda	Insecta	Odonata	Gomphidae	Progomphus	Progomphus	8.2	
Arthropoda	Insecta	Odonata	Gomphidae	Stenogomphurus	Stenogomphurus	5.9	
Arthropoda	Insecta	Odonata	Gomphidae	Stylogomphus	Stylogomphus	5	
Arthropoda	Insecta	Odonata	Gomphidae	Stylurus	Stylurus	4	
Arthropoda	Insecta	Odonata	Lestidae	Archilestes	Archilestes	9	
Arthropoda	Insecta	Odonata	Lestidae	Lestes	Lestes	9	
Arthropoda	Insecta	Odonata	Lestidae		Lestidae	9	
Arthropoda	Insecta	Odonata	Libellulidae	Erythemis	Erythemis	7.7	
Arthropoda	Insecta	Odonata	Libellulidae	Libellula	Libellula	9.1	
Arthropoda	Insecta	Odonata	Libellulidae	Nannothemis	Nannothemis	9.1	
Arthropoda	Insecta	Odonata	Libellulidae	Pachydiplax	Pachydiplax	9.6	
Arthropoda	Insecta	Odonata	Libellulidae	Perithemis	Perithemis	9.4	
Arthropoda	Insecta	Odonata	Libellulidae	Plathemis	Plathemis	9.8	
Arthropoda	Insecta	Odonata	Libellulidae		Libellulidae	9.1	
Arthropoda	Insecta	Odonata	Macromiidae	Didymops	Didymops	6.2	
Arthropoda	Insecta	Odonata	Macromiidae	Macromia	Macromia	6.2	
Arthropoda	Insecta	Odonata	Macromiinae		Macromiinae	6.2	
Arthropoda	Insecta	Odonata	Petaluridae	Tachopteryx	Tachopteryx		
Arthropoda	Insecta	Odonata			Zygoptera		
Arthropoda	Insecta	Odonata			Anisoptera		
Arthropoda	Insecta	Odonata			Odonata		
Arthropoda	Insecta	Plecoptera	Capniidae	Allocapnia	Allocapnia	3.3	Yes

Phylum	**Class**	**Order**	**Family**	**Genus**	***Finalid****	**NCBI** *modified*	**Clinger** primary
Arthropoda	Insecta	Plecoptera	Capniidae		Capniidae	1.8	
Arthropoda	Insecta	Plecoptera	Capniidae	Paracapnia	Paracapnia	0.2	
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Alloperla	Alloperla	1	Yes
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Haploperla	Haploperla	1.4	Yes
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Rasvena	Rasvena	0	
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Suwallia	Suwallia	2.6	Yes
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Sweltsa	Sweltsa	0.2	Yes
Arthropoda	Insecta	Plecoptera	Chloroperlidae		Chloroperlidae	1	Yes
Arthropoda	Insecta	Plecoptera	Leuctridae	Leuctra	Leuctra	1.5	Yes
Arthropoda	Insecta	Plecoptera	Leuctridae	Paraleuctra	Paraleuctra	0	
Arthropoda	Insecta	Plecoptera	Leuctridae	Zealeuctra	Zealeuctra	0	
Arthropoda	Insecta	Plecoptera	Leuctridae		Leuctridae	0.8	
Arthropoda	Insecta	Plecoptera	Nemouridae	Amphinemura	Amphinemura	3.8	
Arthropoda	Insecta	Plecoptera	Nemouridae	Nemoura	Nemoura	1	
Arthropoda	Insecta	Plecoptera	Nemouridae	Ostrocerca	Ostrocerca	2	
Arthropoda	Insecta	Plecoptera	Nemouridae	Paranemoura	Paranemoura	2	
Arthropoda	Insecta	Plecoptera	Nemouridae	Prostoia	Prostoia	6.1	
Arthropoda	Insecta	Plecoptera	Nemouridae	Shipsa	Shipsa	0.3	
Arthropoda	Insecta	Plecoptera	Nemouridae	Soyedina	Soyedina	2	
Arthropoda	Insecta	Plecoptera	Nemouridae		Nemouridae	2.6	
Arthropoda	Insecta	Plecoptera	Peltoperlidae	Peltoperla	Peltoperla	2	Yes
Arthropoda	Insecta	Plecoptera	Peltoperlidae	Tallaperla	Tallaperla	1.3	Yes
Arthropoda	Insecta	Plecoptera	Peltoperlidae	Viehoperla	Viehoperla	2	Yes
Arthropoda	Insecta	Plecoptera	Peltoperlidae		Peltoperlidae	2.6	Yes
Arthropoda	Insecta	Plecoptera	Perlidae	Acroneuria	Acroneuria	1.8	Yes
Arthropoda	Insecta	Plecoptera	Perlidae	Agnetina	Agnetina	1.1	Yes
Arthropoda	Insecta	Plecoptera	Perlidae	Attaneuria	Attaneuria	1.8	Yes
Arthropoda	Insecta	Plecoptera	Perlidae	Beloneuria	Beloneuria	0	Yes
Arthropoda	Insecta	Plecoptera	Perlidae	Eccoptura	Eccoptura	4.7	Yes
Arthropoda	Insecta	Plecoptera	Perlidae	Hansonoperla	Hansonoperla	1.8	
Arthropoda	Insecta	Plecoptera	Perlidae	Neoperla	Neoperla	2.1	Yes
Arthropoda	Insecta	Plecoptera	Perlidae	Paragnetina	Paragnetina	1.8	Yes
Arthropoda	Insecta	Plecoptera	Perlidae	Perlesta	Perlesta	2.9	Yes
Arthropoda	Insecta	Plecoptera	Perlidae	Perlidae	Perlidae	1.8	Yes
Arthropoda	Insecta	Plecoptera	Perlidae	Perlinella	Perlinella	0	Yes
Arthropoda	Insecta	Plecoptera	Perlodidae	Clioperla	Clioperla	5.2	Yes
Arthropoda	Insecta	Plecoptera	Perlodidae	Cultus	Cultus	1.5	Yes
Arthropoda	Insecta	Plecoptera	Perlodidae	Diploperla	Diploperla	2.8	Yes

Phylum	**Class**	**Order**	**Family**	**Genus**	***Finalid****	**NCBI** *modified*	**Clinger** primary
Arthropoda	Insecta	Plecoptera	Perlodidae	Helopicus	Helopicus	1.2	Yes
Arthropoda	Insecta	Plecoptera	Perlodidae	Hydroperla	Hydroperla	1.8	Yes
Arthropoda	Insecta	Plecoptera	Perlodidae	Isogenoides	Isogenoides	0	Yes
Arthropoda	Insecta	Plecoptera	Perlodidae	Isoperla	Isoperla	2.3	Yes
Arthropoda	Insecta	Plecoptera	Perlodidae	Malirekus	Malirekus	1.4	
Arthropoda	Insecta	Plecoptera	Perlodidae		Perlodidae	0.45	Yes
Arthropoda	Insecta	Plecoptera	Perlodidae	Remenus	Remenus	0.9	Yes
Arthropoda	Insecta	Plecoptera	Perlodidae	Yugus	Yugus	0	Yes
Arthropoda	Insecta	Plecoptera	Plecoptera	Plecoptera	Plecoptera		
Arthropoda	Insecta	Plecoptera	Pteronarcyidae	Pteronarcys	Pteronarcys	1.8	Yes
Arthropoda	Insecta	Plecoptera	Pteronarcyidae		Pteronarcyidae	1.5	Yes
Arthropoda	Insecta	Plecoptera	Taeniopterygidae	Oemopteryx	Oemopteryx	4.3	
Arthropoda	Insecta	Plecoptera	Taeniopterygidae	Strophopteryx	Strophopteryx	3.3	
Arthropoda	Insecta	Plecoptera	Taeniopterygidae	Taenionema	Taenionema	2	
Arthropoda	Insecta	Plecoptera	Taeniopterygidae	Taeniopteryx	Taeniopteryx	6	
Arthropoda	Insecta	Plecoptera	Taeniopterygidae		Taeniopterygidae	4.3	
Arthropoda	Insecta	Trichoptera	Apataniidae	Apatania	Apatania	0.6	Yes
Arthropoda	Insecta	Trichoptera	Apataniidae		Apataniidae	0.6	Yes
Arthropoda	Insecta	Trichoptera	Beraeidae	Beraea	Beraea		
Arthropoda	Insecta	Trichoptera	Beraeidae		Beraeidae		
Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentrus	Brachycentrus	2.2	Yes
Arthropoda	Insecta	Trichoptera	Brachycentridae	Micrasema	Micrasema	0	Yes
Arthropoda	Insecta	Trichoptera	Brachycentridae		Brachycentridae	1.1	Yes
Arthropoda	Insecta	Trichoptera	Calamoceratidae	Anisocentropus	Anisocentropus	1.3	
Arthropoda	Insecta	Trichoptera	Calamoceratidae	Heteroplectron	Heteroplectron	2	
Arthropoda	Insecta	Trichoptera	Calamoceratidae		Calamoceratidae	1.65	
Arthropoda	Insecta	Trichoptera	Dipseudopsidae	Phylocentropus	Phylocentropus	4.8	
Arthropoda	Insecta	Trichoptera	Dipseudopsidae		Dipseudopsidae	4.8	
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Agapetus	Agapetus	0	Yes
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Culoptila	Culoptila	0	Yes
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Glossosoma	Glossosoma	1.4	Yes
Arthropoda	Insecta	Trichoptera	Glossosomatidae		Glossosomatidae	0.8	Yes
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Padunia	Padunia	0	Yes
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Protoptila	Protoptila	2.8	Yes
Arthropoda	Insecta	Trichoptera	Goeridae	Goera	Goera	0.7	Yes
Arthropoda	Insecta	Trichoptera	Goeridae	Goerita	Goerita	0.85	Yes
Arthropoda	Insecta	Trichoptera	Goeridae		Goeridae	0.85	Yes
Arthropoda	Insecta	Trichoptera	Helicopsychidae	Helicopsyche	Helicopsyche	0	Yes

Phylum	**Class**	**Order**	**Family**	**Genus**	***Finalid****	**NCBI** *modified*	**Clinger** primary
Arthropoda	Insecta	Trichoptera	Helicopsychidae		Helicopsychidae	0	Yes
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Arctopsyche	Arctopsyche	0	Yes
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	6.6	Yes
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Diplectrona	Diplectrona	2.3	Yes
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Homoplectra	Homoplectra	4.1	Yes
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsyche	Hydropsyche	3.3	Yes
Arthropoda	Insecta	Trichoptera	Hydropsychidae		Hydropsychidae	3.03	Yes
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Macrostemum	Macrostemum	3.4	Yes
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Parapsyche	Parapsyche	0	Yes
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Potamyia	Potamyia	2.5	Yes
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Agraylea	Agraylea	5.7	
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Dibusa	Dibusa	2.6	Yes
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Hydroptila	Hydroptila	6.5	Yes
Arthropoda	Insecta	Trichoptera	Hydroptilidae		Hydroptilidae	4.6	
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Leucotrichia	Leucotrichia	4.3	Yes
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Mayatrichia	Mayatrichia	6	Yes
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Metrichia	Metrichia	4.6	
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Neotrichia	Neotrichia	3.6	Yes
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Ochrotrichia	Ochrotrichia	6	Yes
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Orthotrichia	Orthotrichia	6	Yes
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Oxyethira	Oxyethira	5.2	
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Stactobiella	Stactobiella	2	Yes
Arthropoda	Insecta	Trichoptera	Lepidostomatidae	Lepidostoma	Lepidostoma	1	
Arthropoda	Insecta	Trichoptera	Lepidostomatidae		Lepidostomatidae	1	
Arthropoda	Insecta	Trichoptera	Lepidostomatidae	Theliopsyche	Theliopsyche	1	
Arthropoda	Insecta	Trichoptera	Leptoceridae	Ceraclea	Ceraclea	2.2	
Arthropoda	Insecta	Trichoptera		Leptoceridae	Leptoceridae	3.6	
Arthropoda	Insecta	Trichoptera	Leptoceridae	Mystacides	Mystacides	2.6	
Arthropoda	Insecta	Trichoptera	Leptoceridae	Nectopsyche	Nectopsyche	4.2	
Arthropoda	Insecta	Trichoptera	Leptoceridae	Oecetis	Oecetis	5.1	Yes
Arthropoda	Insecta	Trichoptera	Leptoceridae	Setodes	Setodes	0	Yes
Arthropoda	Insecta	Trichoptera	Leptoceridae	Triaenodes	Triaenodes	4.1	
Arthropoda	Insecta	Trichoptera	Limnephilidae	Frenesia	Frenesia	3.8	
Arthropoda	Insecta	Trichoptera	Limnephilidae	Glyphopsyche	Glyphopsyche	1	
Arthropoda	Insecta	Trichoptera	Limnephilidae	Hesperophylax	Hesperophylax	5	
Arthropoda	Insecta	Trichoptera	Limnephilidae	Hydatophylax	Hydatophylax	2.4	

Phylum	**Class**	**Order**	**Family**	**Genus**	***Finalid****	**NCBI** *modified*	**Clinger** primary
Arthropoda	Insecta	Trichoptera	Limnephilidae	Ironoquia	Ironoquia	6.7	
Arthropoda	Insecta	Trichoptera		Limnephilidae	Limnephilidae	3.8	
Arthropoda	Insecta	Trichoptera	Limnephilidae	Limnephilus	Limnephilus	5	
Arthropoda	Insecta	Trichoptera	Limnephilidae	Pycnopsyche	Pycnopsyche	2.5	
Arthropoda	Insecta	Trichoptera	Molannidae	Molanna	Molanna	3.9	
Arthropoda	Insecta	Trichoptera	Molannidae		Molannidae	2.8	
Arthropoda	Insecta	Trichoptera	Odontoceridae	Psilotreta	Psilotreta	0	
Arthropoda	Insecta	Trichoptera	Odontoceridae		Odontoceridae	0.25	
Arthropoda	Insecta	Trichoptera	Philopotamidae	Chimarra	Chimarra	3.3	Yes
Arthropoda	Insecta	Trichoptera	Philopotamidae	Dolophilodes	Dolophilodes	1	Yes
Arthropoda	Insecta	Trichoptera	Philopotamidae	Fumonta	Fumonta	2.54	
Arthropoda	Insecta	Trichoptera	Philopotamidae		Philopotamidae	2.54	Yes
Arthropoda	Insecta	Trichoptera	Philopotamidae	Wormaldia	Wormaldia	2.4	Yes
Arthropoda	Insecta	Trichoptera	Phryganeidae	Oligostomis	Oligostomis	6.2	
Arthropoda	Insecta	Trichoptera	Phryganeidae	Ptilostomis	Ptilostomis	5.9	
Arthropoda	Insecta	Trichoptera	Phryganeidae		Phryganeidae	6.05	
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Cernotina	Cernotina	3.7	Yes
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Cyrnellus	Cyrnellus	6.8	Yes
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Holocentropus	Holocentropus	3.1	Yes
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Neureclipsis	Neureclipsis	4	Yes
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Nyctiophylax	Nyctiophylax	0.8	Yes
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Plectrocnemia	Plectrocnemia	3.1	Yes
Arthropoda	Insecta	Trichoptera	Polycentropodidae		Polycentropodidae	3.7	Yes
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Polycentropus	Polycentropus	3.1	Yes
Arthropoda	Insecta	Trichoptera	Psychomyiidae	Lype	Lype	4.3	Yes
Arthropoda	Insecta	Trichoptera	Psychomyiidae	Psychomyia	Psychomyia	2.6	Yes
Arthropoda	Insecta	Trichoptera	Psychomyiidae		Psychomyiidae	3.45	Yes
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	Rhyacophila	0	Yes
Arthropoda	Insecta	Trichoptera	Rhyacophilidae		Rhyacophilidae	1.02	Yes
Arthropoda	Insecta	Trichoptera	Sericostomatidae	Agarodes	Agarodes	0	
Arthropoda	Insecta	Trichoptera	Sericostomatidae	Fattigia	Fattigia	0	
Arthropoda	Insecta	Trichoptera	Sericostomatidae		Sericostomatidae	0	
Arthropoda	Insecta	Trichoptera	Thremmatidae	Neophylax	Neophylax	1.6	Yes
Arthropoda	Insecta	Trichoptera	Thremmatidae		Thremmatidae	1.56	Yes

Phylum	**Class**	**Order**	**Family**	**Genus**	***Finalid****	**NCBI** *modified*	**Clinger** primary
Arthropoda	Insecta	Trichoptera			Trichoptera		
Cnidaria	Hydrozoa	Anthoathecatae	Oceanidae	Cordylophora	Cordylophora		
Cnidaria	Hydrozoa	Hydroida	Hydridae	Hydra	Hydra	5	
Kamptozoa	Entoprocta	Solitaria	Barentsiidae	Urnatella	Urnatella		
Mollusca	Bivalvia	Unionoida	Unionidae	Alasmidonta	Alasmidonta	6	
Mollusca	Bivalvia	Unionoida	Unionidae	Plectomerus	Plectomerus	6	
Mollusca	Bivalvia	Unionoida	Unionidae		Unionidae	6	
Mollusca	Bivalvia	Veneroida	Corbiculidae	Corbicula	Corbicula	6.6	
Mollusca	Bivalvia	Veneroida	Corbiculidae		Corbiculidae	6.6	
Mollusca	Bivalvia	Veneroida	Dreissenidae	Dreissena	Dreissena	8	
Mollusca	Bivalvia	Veneroida	Dreissenidae		Dreissenidae	8	
Mollusca	Bivalvia	Veneroida	Pisidiidae	Eupera	Eupera	6	
Mollusca	Bivalvia	Veneroida	Pisidiidae	Musculium	Musculium	6	
Mollusca	Bivalvia	Veneroida		Pisidiidae	Pisidiidae	6.9	
Mollusca	Bivalvia	Veneroida	Pisidiidae	Pisidium	Pisidium	6.6	
Mollusca	Bivalvia	Veneroida	Pisidiidae	Sphaerium	Sphaerium	7.2	
Mollusca	Bivalvia	Veneroida			Bivalvia		
Mollusca	Gastropoda	Architaeniogloss a	Viviparidae	Campeloma	Campeloma	5.8	
Mollusca	Gastropoda	Architaeniogloss a	Viviparidae	Viviparus	Viviparus	6	
Mollusca	Gastropoda	Architaeniogloss a	Viviparidae		Viviparidae	5.9	
Mollusca	Gastropoda	Basommatophor a	Ancylidae	Ferrissia	Ferrissia	6.6	
Mollusca	Gastropoda	Basommatophor a	Ancylidae	Laevapex	Laevapex	6.6	
Mollusca	Gastropoda	Basommatophor a	Ancylidae		Ancylidae	6.6	
Mollusca	Gastropoda	Basommatophor a	Lymnaeidae	Fossaria	Fossaria	6	
Mollusca	Gastropoda	Basommatophor a	Lymnaeidae	Lymnaea	Lymnaea	6	
Mollusca	Gastropoda	Basommatophor a	Lymnaeidae	Pseudosuccinea	Pseudosuccinea	7.7	
Mollusca	Gastropoda	Basommatophor a	Lymnaeidae	Stagnicola	Stagnicola	8.1	
Mollusca	Gastropoda	Basommatophor a	Lymnaeidae		Lymnaeidae	6.95	
Mollusca	Gastropoda	Basommatophor a	Physidae	Physa	Physa	8.7	
Mollusca	Gastropoda	Basommatophor a	Physidae	Physella	Physella	8	
Mollusca	Gastropoda	Basommatophor a	Physidae		Physidae	8.35	

Phylum	**Class**	**Order**	**Family**	**Genus**	***Finalid****	**NCBI** *modified*	**Clinger** primary
Mollusca	Gastropoda	Basommatophora	Planorbidae	Gyraulus	Gyraulus	8	
Mollusca	Gastropoda	Basommatophora	Planorbidae	Helisoma	Helisoma	6.6	
Mollusca	Gastropoda	Basommatophora	Planorbidae	Menetus	Menetus (Menetus)	7.6	
Mollusca	Gastropoda	Basommatophora	Planorbidae	Planorbella	Planorbella	6	
Mollusca	Gastropoda	Basommatophora	Planorbidae	Planorbula	Planorbula	6	
Mollusca	Gastropoda	Basommatophora	Planorbidae		Planorbidae	6	
Mollusca	Gastropoda	Heterostropha	Valvatidae	Valvata	Valvata	8	
Mollusca	Gastropoda	Heterostropha	Valvatidae		Valvatidae	8	
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	Amnicola	Amnicola	4.1	
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae		Hydrobiidae	4.1	
Mollusca	Gastropoda	Neotaenioglossa	Lithoglyphidae	Somatogyrus	Somatogyrus	8	
Mollusca	Gastropoda	Neotaenioglossa	Lithoglyphidae		Lithoglyphidae	8	
Mollusca	Gastropoda	Neotaenioglossa	Pleuroceridae	Elimia	Elimia	5.75	
Mollusca	Gastropoda	Neotaenioglossa	Pleuroceridae	Leptoxis	Leptoxis	1.7	
Mollusca	Gastropoda	Neotaenioglossa	Pleuroceridae	Pleurocera	Pleurocera	6	
Mollusca	Gastropoda	Neotaenioglossa	Pleuroceridae		Lithasia		
Mollusca	Gastropoda	Neotaenioglossa	Pleuroceridae		Pleuroceridae	6	
Mollusca	Gastropoda				Gastropoda	6.79	
Nematoda	Adenophorea	Mermithida	Mermithidae		Mermithidae		
Nematoda					Nematoda		
Nematomorpha	Gordioidea	Gordiida	Gordiidae	Gordius	Gordius		
Nematomorpha	Gordioidea	Gordiida	Gordiidae		Gordiidae		
Nematomorpha	Nematomorpha				Nematomorpha		
Nemertea	Enopla	Haplonemertea	Tetrastemmatidae	Prostoma	Prostoma	6.6	
Nemertea	Enopla				Nemertea		
Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	Cura	Cura	5.5	
Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	Dugesia	Dugesia	7.1	
Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	Girardia	Girardia	6	
Platyhelminthes	Turbellaria	Tricladida	Dugesiidae		Dugesiidae	6.2	
Platyhelminthes	Turbellaria	Tricladida	Kenkiidae	Sphalloplana	Sphalloplana	6	

Phylum	**Class**	**Order**	**Family**	**Genus**	***Finalid****	**NCBI** *modified*	**Clinger** primary
Platyhelminthes	Turbellaria	Tricladida	Kenkiidae		Kenkiidae	6	
Platyhelminthes	Turbellaria	Tricladida	Planariidae	Phagocata	Phagocata	6	
Platyhelminthes	Turbellaria	Tricladida	Planariidae		Planariidae	6	
Platyhelminthes	Turbellaria	Tricladida			Tricladida	6	
Platyhelminthes					Platyhelminthes	6.2	

APPENDIX D

TAXONOMIC INFORMATION

GENUS LEVEL TAXONOMIC KEYS
CRITERIA FOR TAXONOMIC EXPERTS
TAXONOMIC SPECIALISTS FOR REFERENCE VERIFICATION

GENUS LEVEL TAXONOMIC KEYS (Primary Key for each group is listed first)

INSECTA

Merritt, R.W., K.W. Cummins, and M.B. Berg (eds.). 2019. An Introduction to the Aquatic Insects of North America, 5th edition revised. Kendall/Hunt Publishing Co., Dubuque, IA. 1480 pp.

TURBELLARIA

Kenk, R. 1972. *Freshwater Planarians (Turbellaria) of North America*. EPA-WPCRS, 18050/ELD 02/72. Supt. Doc. No. 5501-0365. Washington, D.C.

MOLLUSCA

Gastropoda

Burch, J.B. 1989. North American Freshwater Snails. Malacological Publications, Hamburg, MI.

Bivalvia

Burch, J.B. 1972. *Freshwater Sphariacean clams (Mollusca: Pelecypoda) of North America*. EPA-WPCRS 18050, ELD03/72. Supt. Doc. No. 5501-0367. Washington, D.C.

Thorp A.P. and A.P. Covich (eds.) 1991. *Ecology and Classification of North American Freshwater Invertebrates*. Academic Press, Inc., San Diego, Ca

Starnes, L.B. and A.E. Bogan. 1988. *The Mussels (Mollusca: Bivalvia: Unionidae) of Tennessee*. Amer. Malacological Bull. 6:19-38.

Cummings, K.S. and Mayer, C.A. 1992. *Field Guide to Freshwater Mussels of the Midwest.* Illinois Natural History Survey Manual 5. 194 pp.

Mackie, G.L. 2007. *Biology of Freshwater Corbiculid and Sphaeriid Clams of North America.* Ohio Biological Survey Bulletin New Series. Volume Number 3. Ix + 36 p.

Bogan, P.E. and Parmalee, P.W. 1998. *The Freshwater Mussels of Tennessee.* The University of Tennessee Press. Knoxville, TN

William, J.D. et al. 2008. *Freshwater Mussels of Alabama and the Mobile Basin in Georgia, Mississippi and Tennessee.* The University of Alabama Press. Tuscaloosa, AL.

ANNELIDA

Naididae

Brinkhurst, R.O. and Kathman, R.D. 1999. *Guide to the Freshwater Oligochaetes of North America.* Aquatic Resources Center. Thompsons Station, TN

Other Oligochaetes & Branchiobdellida

Thorp, A.P. and A.P. Covich (eds.) 1991. *Ecology and Classification of North American Freshwater Invertebrates*. Academic Press, Inc., San Diego, Ca.

Hirudinea

Klemm, D. J. 1985. *A Guide to the Freshwater Annelida (Polychaeta, Naidid and Tubificid Oligocahaeta, and Hirudinea) of North America*. Kendall/Hunt Publ. Co., Dubuque, Ia.

CRUSTACEA

Amphipoda

Thorp, A.P. and A.P. Covich (eds.) 1991. *Ecology and Classification of North American Freshwater Invertebrates*. Academic Press, Inc., San Diego, Ca.

Bousfield, E.L. 1958. *Fresh-Water Amphipod Crustaceans of Glaciated North America.* Queens Printer, Ottawa, Canada

Smith, D.G. 2001. *Pennak's Freshwater Invertebrates of the United States.* John Wiley & Sons, Inc. New York, NY

Decapoda

Hobbs, H.H., Jr. 1972 *Crayfishes (Astacidae) of North and Middle America*. EPA-WPCRS No. 18050, ELD05/72. Supt. Doc. No. 5501-0399, Washington, D.C. 173 pp.

Isopoda

Williams, W.D. 1972. *Freshwater Isopods (Asellidae) of North America*. EPA-WPCRS No. 18050 ELD05/72. Supt. Doc. No. 5501-0390. Washington, D.C. 45 pp.

Criteria for Taxonomic Experts

(adapted from the Taxonomic Certification Program established in 2004 by the North American Benthological Society.)

In order to be considered an expert an individual must meet **at least four** of the following criteria:

1. **Authorship.** Author/coauthor of two or more peer-reviewed publications in the group for which the applicant seeks recognition as a taxonomic/systematic expert. Or, has prepared and presented two or more papers at professional meetings focusing on the taxonomy/systematics of the group for which the applicant seeks recognition as a taxonomic expert.

2. **Academic Qualification**. Has been presented and earned a graduate degree (MS/PhD) related to the field of invertebrate taxonomy, with MS or PhD thesis focused on the taxonomy/systematics of group for which the applicant seeks recognition as a taxonomic expert. Post-doctoral employment/experience focusing on taxonomy/systematics of group for which the applicant seeks recognition as a taxonomic expert will fulfill this criterion.

3. **Employment**. Currently serves (or has previously served) in a professional capacity (e.g., at place of employment - institution, business, agency, department, company) as curator or manager of an invertebrate collection (one or more groups) including that for which the applicant seeks recognition as a taxonomic/systematic expert.

4. **Experience**. Has a history of / currently is performing taxonomic identification / verification services for individuals, businesses, agencies, companies, and/or organizations outside of primary place of employment in the group for which the applicant seeks recognition as a taxonomic/systematic expert.

5. **Teaching**. Has organized, prepared, and successfully presented one or more taxonomic training workshops focusing on the group for which expertise is sought; the workshop or course must have been inclusive of the group for which the applicant seeks recognition as a taxonomic/systematic expert. Or, has served as an individual or as a collaborative instructor in the teaching of one or more college or university courses focusing on the taxonomy of one / several group(s) of aquatic macroinvertebrates; the course must have been inclusive of the group for which the applicant seeks recognition as a taxonomic/systematic expert.

6. **Influence and Recognition**. Has served / currently is serving as a peer-reviewer for one or more manuscripts received from a journal editor prior to its publication in the primary literature, with focus of the manuscript(s) on the group for which taxonomic expertise is sought. Service as a guest or assistant editor for a journal publishing peer-reviewed articles focusing on taxonomic / systematic issues shall satisfy this criterion.

7. **Research**. Has submitted (as PI, co-PI, or collaborating researcher) one or more proposals to (currently pending at time of request for recognition as expert) or has received research funds (grant/contract/gift) from provincial, federal, state, regional, and/or private sources that support taxonomic/systematic studies in the group for which the applicant seeks recognition as a taxonomic/systematic expert.

TAXONOMIC SPECIALISTS who have verified reference taxa identified in the master taxa table. The verified reference collection is maintained at the TDH environmental laboratory, aquatic biology section.

Oligochaeta

Deedee Kathman, PhD (Current)
Thompson Station, TN 7692
615-790-7692

Michael R. Milligan (deceased)
Center for Systematics and Taxonomy
Sarasota, FL

Decapoda

Horton H. Hobbs, III, PhD
Wittenberg University Department of Biology
Springfield, OH

Mollusca

Art Bogan, PhD
N.C. State Museum of Natural Sciences
Raleigh, NC
Arthur.Bogan@naturalsciences.org
919-707-8063

Odonata

Ken J. Tennessen, PhD (Current)
Watauma, WI
850-926-3700
ktennessen@centurytel.net

Megaloptera

Don C. Tarter, PhD (retired)
Marshall University Department of Biological Science

Hemiptera

John H. Epler, PhD (current)
Crawfordville, FL

Cecil L. Smith, PhD
The University of Georgia Museum of Natural History

Coleoptera

John H. Epler, PhD (current)
Crawfordville, FL

Paul J. Spangler (deceased)
Dept. of Entomology
National Museum of Natural History, Smithsonian Institution

Ephemeroptera

Boris C. Kondratieff, PhD (current)
Dept. of Bioagricultural Sciences and Pest Management
Colorado State University

Plecoptera

Bill Stark (Current)
Mississippi College

Boris C. Kondratieff, PhD (current)
Dept. of Bioagricultural Sciences and Pest Management
Colorado State University

Ken W. Stewart, PhD (No longer available)
University of North Texas

Trichoptera

John C. Morse, PhD (current)
Department of Entomology, Clemson University

Lepidoptera

M. Alma Solis, John W. Brown, Michael G. Pogue (current)
Systematic Entomology Laboratory, Communications & Taxonomic Services Unit (SELCTS)

Beltsville, MD 20705-2350

Chironomidae

John H. Epler, PhD (current)
Crawfordville, FL

Simuliidae

Robert V. Peterson (Retired)
Systematic Entomology Laboratory CTSU
Beltsville, MD

Ceratopogonidae

William L. Grogan, PhD (Retired)
Cooperating Scientist for Systematic Entomology Lab., CTSU
Beltsville, MD

Steve Murphee, PhD
Dept. of Biology, Belmont University

Empididae and **Stratiommyidae**

Norman E. Woodley (current)
Systematic Entomology Lab, CTSU
Beltsville, MD

Athericidae, Blephariceridae, Dixidae, Ephydridae, Psychodidae, Sciomyzidae

No specialists available.

APPENDIX E

SUPPLEMENTARY INFORMATION

PROJECT NAMES AND IDS
ORGANIZATIONS
COUNTY ABBREVIATIONS AND CODE NUMBERS
EXOTIC PLANTS IN TENNESSEE

Project Names and IDs (Projects added after 2021 on projects reference table Waterlog/Hydra)

Project ID	Short Name	Project Name	Project Purpose
TNPR0080	303(d)	303(d)	The 303(d)/Impaired Waters List 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.
TNPR0029	71iPM	71iPM	In FY-08 90 probabilistic monitoring stations were established on wadeable streams across the 71i ecoregion.
TNPR0098	AG-303(d)	Agriculture on 303(d) list	319 grant for impaired sites where source is agriculture.
TNPR0084	AIR DEPOSITION	AIR DEPOSITION	Test air deposition model in predicting mercury and selenium bioaccumulation in fish.
TNPR0005	ARAP	ARAP	Streams are evaluated as needed generally in response to requests for new or expanded ARAP permits.
TNPR0082	ATV Park	ATV Park	Investigation of off road vehicle facility.
TNPR0002	Agriculture	Agriculture	Data collected in collaboration with the Department of Agriculture.
TNPR0003	Ambient	Ambient	For water quality trend analyses established sites are monitored. These sites include some of the original 23 ambient stations along with about 70 additional ambient sites. Chemical samples are collected and field parameters are measured at least quarterly at each of these stations every year.
TNPR0004	Antidegradation	Antidegradation	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.
TNPR0071	Auburn University	Auburn University	Samples collected for lake study conducted by Auburn University.

Project ID	Short Name	Project Name	Project Purpose
TNPR0089	Border State not TDEC	Border State not TDEC	Samples collected by a state bordering TN in a shared watershed.
TNPR0065	Clean Lakes Statewide Assessment	Clean Lakes Statewide Assessment	The Clean Lakes Statewide Assessment is part of the National Lakes Assessment (NLA).
TNPR0006	Coalfields	Coalfields	Special project to sample metals in fish tissue and water column in streams draining TN coalfields
TNPR0019	Complaint	Complaint	Sampling performed in response to citizen complaints.
TNPR0063	Compliance	Compliance	Sampling related to departmental compliance activities.
TNPR0043	Conductivity	Conductivity	Conductivity Study
TNPR0020	Construction	Construction	Sampling performed due to construction activities.
TNPR0044	Copperhill	Copperhill	The Tennessee Department of Health (TDH) Environmental Epidemiology Program (EEP) was asked on September 3 2008 by the Tennessee Department of Environment and Conservation (TDEC) Division of Remediation (DoR) to provide guidance on the possibility of adverse health effects from iron in soil and sediment in the Davis Mill Surface Water - Sub OU 1-D Gypsum Pond Area (the Gypsum Pond Area).
TNPR0045	Corridor K	Corridor K	Corridor K is a route on the Appalachian Development Highway System which starts at I-75 near Cleveland Tennessee and ends near Dillsboro North Carolina. The portion of Corridor K lying within the project area follows US 64 and is part of the Ocoee Scenic Byway which was designated as the nation's first National Forest Scenic Byway. Sampling is being conducted as part of the Environmental Impact Statement.
TNPR0092	DEIDS	Determining Ecological Integrity and Developing Success Criteria for Streams	Geomorphological Reference Sites established by Natural Resource Section.

Project ID	Short Name	Project Name	Project Purpose
TNPR0007	DOR	DOR (previously DOE-O)	Data collected in collaboration with the Division of Remediation (previously Department of Energy Oversight).
TNPR0047	Dissolved Oxygen	Dissolved Oxygen	Sampling is conducted to investigate natural diurnal fluctuations in dissolved oxygen.
TNPR0046	Diurnal	Diurnal	The primary purpose of this study was to investigate natural diurnal fluctuations of dissolved oxygen levels in 15 major ecological subregions in Tennessee. Historic daylight readings were used to supplement this information and to evaluate dissolved oxygen patterns in the other 9 subregions. This study was funded in part by a FY 2002 104(b)(3) grant (CP-97449702-0).
TNPR0086	Drinking Water Lake Study	Drinking Water Lake Study	Drinking Water Lake Study
TNPR0008	EPA	EPA	Data collected in collaboration with the Federal Environmental Protection Agency.
TNPR0037	Ecoregion	Ecoregion	The data obtained from the ecoregion (ECO) delineation and reference site monitoring project will be used as a tool to implement the requirements of the Tennessee Water Quality Control Act.
TNPR0048	Elk River	Elk River	This project was designed to provide the information necessary to quantify nutrient-load reductions for development and implementation of nutrient TMDLs and for long-term management of nutrient loading in the Elk River watershed including potential watershed-based nutrient trading strategies.
TNPR0021	Enforcement	Enforcement	Sampling performed in response to enforcement activities.
TNPR0038	FECO	FECO	The data obtained from the first-order ecoregion (FECO) delineation and reference site monitoring project will be used as a tool to implement the requirements of the Tennessee Water Quality Control Act.
TNPR0088	Fish Kill	Fish Kill	Sampling conducted to identify the pollutants associated with a fish kill.
TNPR0061	Flood	Flood	Sampling associated with effects of major flood events.
TNPR0059	HRWA	HRWA	Data collected by the Harpeth River Watershed Association.

Project ID	Short Name	Project Name	Project Purpose
TNPR0090	Healthy Watersheds	Healthy Watersheds	Samples collected as part of Healthy Watersheds Initiative.
TNPR0030	ISP	Impounded Stream Project	In 2003 the Tennessee Department of Environment and Conservation Division of Water Pollution Control was awarded a 104(b)(3) grant to perform a probabilistic monitoring study of 75 streams below small impoundments. The study measured effects of the impoundments on aquatic life nutrients dissolved oxygen pH iron manganese habitat flow and periphyton in the downstream reaches.
TNPR0022	Inspection	Inspection	Sampling related to departmental inspection activities.
TNPR0024	Kingston	Kingston	Sampling performed in response to the December 22, 2008 dike failure at the TVA Kingston Fossil Plant in Roane County Tennessee.
TNPR0083	Landfill	Landfill	Landfill water quality investigation.
TNPR0027	MS4	MS4	Sampling performed by municipal separate storm sewer systems (MS4s) permitees to meet permit requirements.
TNPR0057	Mercury	Mercury	Mercury study of possible contamination caused by bridge degradation in Wayne and surrounding counties.
TNPR0064	Mercury Sediment Study	Mercury Sediment Study	Although it is not commonly done samples of the sediment at the bottom of a creek or lake can be collected to determine the presence of harmful amounts of metals or carcinogens.
TNPR0097	Mining Ambient	Mining Ambient	Annual quarterly chemical sampling collected by surface mining unit.
TNPR0096	Mitigation	Mitigation	Pre or post mitigation survey
TNPR0041	NLS	National Lakes Study	EPA National Lakes Assessment is designed to provide statistically valid regional and national estimates of the condition of lakes.
TNPR0053	NPDES Permit	NPDES Permit	Upstream and downstream sampling required by NPDES discharge permits.
TNPR0058	NRCS	NRCS	Sampling conducted by the Natural Resources Conservation Service
TNPR0009	NRDA	NRDA	Data collected in collaboration with the U.S. Department of the Interior's (DOI) Natural Resource Damage Assessment and Restoration Program

Project ID	Short Name	Project Name	Project Purpose
TNPR0010	ORNL	ORNL	Data collected in collaboration with Oak Ridge National Laboratory
TNPR0094	PAA	Peracetic Acid	Study to determine the effects of PAA as substitute for Chlorine to instream macroinvertebrates.
TNPR0076	Periphyton Study	Periphyton Study	Periphyton sampling conducted in conjunction with other monitoring activities
TNPR0049	Post Flood	Post Flood	Sampling conducted following the May 2010 Nashville flood.
TNPR0077	Pre Excavation	Pre Excavation	Sampling performed before an excavation event for the purpose of establishing pre-excavation norms.
TNPR0035	QC	QC	Quality Assurance/Quality Control
TNPR0054	REFERENCE	REFERENCE	The data obtained from the ecoregion (ECO) delineation and reference site monitoring project will be used as a tool to implement the requirements of the Tennessee Water Quality Control Act.
TNPR0055	RESERVOIR	RESERVOIR	Reservoir sampling.
TNPR0068	Recreational Area	Recreational Area	Samples collected to measure the impacts of a recreational area
TNPR0095	Relocation	Relocation	Monitoring of relocated waterbodies.
TNPR0062	Restoration	Restoration	Samples collected to measure the effects of stream restoration projects.
TNPR0093	SE Comparability	Southeast Comparability Study	Test biological method comparability between EPA region IV states.
TNPR0039	SEMN	SEMN	A Southeast Region Monitoring Network (SEMN) was established by the southeastern states to develop a joint reference stream monitoring network.
TNPR0091	Special Studies Project	Special Studies Project	Samples collected for limited study.
TNPR0023	Spill	Spill	Potentially harmful spill investigation.
TNPR0060	Superfund - External	Superfund - External	Sampling conducted by consultant on Superfund sites.
TNPR0087	Superfund - TDEC	Superfund - TDEC	Sampling conducted by TDEC on Superfund sites.
TNPR0028	Surface Mining	Surface Mining	Sampling performed by TDEC Division of Water Resource's Mining Section and permitees in response to regulated mining activity.

Project ID	Short Name	Project Name	Project Purpose
TNPR0012	TDOT	TDOT	Data collected in collaboration with Tennessee Department of Transportation.
TNPR0001	TMDL	Total Maximum Daily Load	Waterbody monitoring is required to develop Total Maximum Daily Loads or TMDLs as a result of being placed on the 303(d) list.
TNPR0050	TN-KY	Tennessee-Kentucky Project	Joint project with Kentucky to sample shared watersheds.
TNPR0013	TVA	TVA	Data collected in collaboration with the Tennessee Valley Authority
TNPR0014	TWRA	TWRA	Data collected in collaboration with the Tennessee Wildlife Resources Agency.
TNPR0018	Tissue	Tissue	Fish tissue sampling.
TNPR0036	Training	Training	Samples collected as part of training exercises.
TNPR0056	UNIDENTIFIED	UNIDENTIFIED	UNIDENTIFIED
TNPR0078	URS Corporation	URS Corporation	Data collected by URS Corporation consulting firm.
TNPR0015	USACE	USACE	Data collected in collaboration with the United States Army Corps of Engineers.
TNPR0016	USGS	USGS	Data collected in collaboration with the United States Geological Survey.
TNPR0017	UTC	UTC	Data collected in collaboration with the University of Tennessee Chattanooga.
TNPR0085	WSA	WSA	The Wadeable Streams Assessment (WSA) establishes a national baseline that can be used to compare Tennessee's streams with other states' streams.
TNPR0031	WSA 2004	WSA 2004	The Wadeable Streams Assessment (WSA) establishes a national baseline that can be used to compare Tennessee's streams with other states' streams. This project number denotes the 2004-2005 sampling events.
TNPR0032	WSA 2008	WSA 2008	The Wadeable Streams Assessment (WSA) establishes a national baseline that can be used to compare Tennessee's streams with other states' streams. This project number denotes the 2008-2009 sampling events.

Project ID	Short Name	Project Name	Project Purpose
TNPR0033	WSA 2010	WSA 2010	The Wadeable Streams Assessment (WSA) establishes a national baseline that can be used to compare Tennessee's streams with other states' streams. This project number denotes the 2010-2011 sampling events.
TNPR0081	WSA-SE	WSA-SE	The Wadeable Streams Assessment (WSA) establishes a national baseline that can be used to compare Tennessee's streams with other states' streams. This project number denotes the 2007-2008 sampling events.
TNPR0051	Watershed	Watershed	Sampling to confirm continued support of designated uses and to increase the number of assessed waterbodies.
TNPR0066	Willamette Clearcutting Project	Willamette Clearcutting Project	Study to measure the effects of clearcutting.

Organizations added after 2021 available in organizations reference table Waterlog/Hydra

Organization	Organization Full Name
A & L AL	A & L AL
ADVENT	Advent Consulting Group, LLC
AEDC	Arnold Engineering Development Center - U.S. Air Force
AIR	AIRL, INC
ANSDU	Academy of Natural Sciences of Drexel University
ARC	Aquatic Resource Center
ARCADIS	ARCADIS Consulting
ARI	ARI Environmental Inc.
ARM	Aquatic Resource Management
AST	AST Environmental
AUB	Auburn University
AquAeTer	AquAeTer, Inc
BDY	BDY Environmental LLC
BHA	Brophy-Heinke & Associates, Inc
BNA	Nashville Airport
BOWATER	Bowater Paper Mill
BSC	Biological Systems Consultants
C&EC	Civil and Engineering Consultants Inc
CAS	Columbia Analytical Services
CEC	Copperhead Environmental Consulting Inc.
CGS	CG Services Corporation
CH2M	CH2M Hill Companies Ltd
CHSW	City of Chattanooga Storm Water
CLEVESW	Cleveland Stormwater
CRWA	Clinch River Watershed Association
Chattanooga EFO	TDEC Chattanooga Environmental Field Office
Columbia EFO	TDEC Columbia Environmental Field Office
Cookeville EFO	TDEC Cookeville Environmental Field Office
DAT	Data Analysis Technologies Inc
DBC	Dinkins Biological Consulting, LLC
DEPA	Development and Environmental Planning Association
DOE-O	TDEC Department of Energy Oversight
DOR	TDEC Division of Remediation
DOR-OR	Division of Remediation (Previously DOE-O)
DRAA	D.R. Allen and Associates
DWR	TDEC Division of Water Resources
EASTMAN	Eastman Chemical Company

Organization	Organization Full Name
ECOA	EcoAnalysts Inc.
ENSAFE	ENSAFE consulting
ENVIRON	Environ Environmental Corporation
ENVSCI	Enviroscience
EPA	United States Environmental Protection Agency
ESC	Environmental Science Corporation
ETC	Environmental Testing Laboratories
ETSU	East Tennessee State University
FLLA	Fort Loudoun Lake Association
G&M	Griggs & Maloney Incorporated
GEOS	GEOServices LLC
GEPD	Georgia Environmental Protection Division
GSH	Glenn Springs Holding, Inc.
HCWQ	Hamilton County Water Quality
HHNT	Hodges, Harbin, Newberry and Tribble, Inc.
HRA	HRA Environmental Services
HUC	Hiwassee Utilities Commission
JCWWTP	Johnson City Waste Water Treatment Plant
Jackson EFO	TDEC Jackson Environmental Field Office
Johnson City EFO	TDEC Johnson City Environmental Field Office
KCI	KCI Technologies
KDOW	Kentucky Division of Water
KMM	Kalina Manoylov Phycologist, Georgia College and State University
Knoxville EFO	TDEC Knoxville Environmental Field Office
MBEL	Moccasin Bend Environmental Lab
MDEQ	Mississippi Department of Environmental Quality
MEAD	Mead Paper
MRNA	Mitigation Resources of North America
Memphis EFO	TDEC Memphis Environmental Field Office
Metro Nash	Metro Nashville
Microbac	Microbac Laboratory
Mid M	Middlesboro Mining
Mining Section	TDEC Mining Section
NAL	National Analytical Laboratories (aka NWA & NWALAB)
NASHVILLE ZOO	Nashville Zoo
NC	National Coal
NCDWQ	North Carolina Division of Water Quality
NCO	TDEC DWR Nashville Central Office

Organization	Organization Full Name
NEWFIELDS	Newfields Consulting
NORM	Normandeau Associates Inc.
NYRSTAR	NYRSTAR
Nashville EFO	TDEC Nashville Environmental Field Office
OCEAN	Oceana
OLIN	Olin Corporation
ORNL	Oak Ridge National Laboratory
PACE	Pace Analytical Services
PAI	Pennington and Associates Inc.
PAS	TDEC Planning and Standards Unit (now WPU)
PCC	Premium Coal Company
PFWD	Pigeon Forge Water Development
PFWD 03403	Pigeon Forge Water Development
RE	Ramboll Environ
RJS	Jan Stevenson, Phycologist Michigan State University
SBC	S. Bradford Cook Consultant
SHWWTP	Springhill Waste Water Treatment Plant
SLI	Skelly and Loy Consultants
SME	S&ME Inc.
SSG	Sevier Stormwater Group
Stantec	Stantec
TA	Test America
TDA	Tennessee Department of Agriculture
TDEC	Tennessee Department of Environment and Conservation
TDH ABS	Tennessee Department of Health Aquatic Biology Section
TDH LABS	Tennessee Department of Health Environmental Laboratory.
TDH Labs-Knox	TDH Labs-Knoxville
TDOT	Tennessee Department of Transportation
TEC	TEC Environmental Laboratories Inc
TLI	Technical Laboratories Inc
TRC	Third Rock Consultants, LLC
TRIAD	Triad Environmental Consultants
TSMP	Tennessee Stream Mitigation Program
TTU	Tennessee Tech University
TUB	Tullahoma Utility Board
TVA	Tennessee Valley Authority
TVR	Tennessee Valley Recycling
TWL	Technical Water Laboratories

Organization	Organization Full Name
TWRA	Tennessee Wildlife Resources Agency
UNION U	Union University
URS	URS Corporation
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
UTC	University of Tennessee Chattanooga
UTK	University of Tennessee Knoxville
Unknown	Historical data - organization not recorded
VA	State of Virginia Environmental Program
VE	Vindicated Environmental
WATeR	Watershed Association for Tellico Reservoir
WLLC	Waypoint, LLC
WMS	TDEC Watershed Management Unit
WP	Waypoint Analytical Inc
WP-J	Waypoint Analytical Inc
WP-M	Waypoint Analytical Inc
WPC	TDEC Water Pollution Control
WPU	Watershed Planning Unit

County Abbreviations and Code Numbers

COUNTY NAME	WPC CO ABBR	TN CO NO	NATIONAL TN FIPS	COUNTY NAME	WPC CO ABBR	TN CO NO	NATIONAL TN FIPS
ANDERSON	**AN**	01	001	LAUDERDALE	**LE**	49	097
BEDFORD	**BE**	02	003	LAWRENCE	**LW**	50	099
BENTON	**BN**	03	005	LEWIS	**LS**	51	101
BLEDSOE	**BL**	04	007	LINCOLN	**LI**	52	103
BLOUNT	**BT**	05	009	LOUDON	**LO**	53	105
BRADLEY	**BR**	06	011	MCMINN	**MM**	54	107
CAMPBELL	**CA**	07	013	MCNAIRY	**MC**	55	109
CANNON	**CN**	08	015	MACON	**MA**	56	111
CARROLL	**CR**	09	017	MADISON	**MN**	57	113
CARTER	**CT**	10	019	MARION	**MI**	58	115
CHEATHAM	**CH**	11	021	MARSHALL	**ML**	59	117
CHESTER	**CS**	12	023	MAURY	**MY**	60	119
CLAIBORNE	**CL**	13	025	MEIGS	**ME**	61	121
CLAY	**CY**	14	027	MONROE	**MO**	62	123
COCKE	**CO**	15	029	MONTGOMERY	**MT**	63	125
COFFEE	**CE**	16	031	MOORE	**MR**	64	127
CROCKETT	**CK**	17	033	MORGAN	**MG**	65	129
CUMBERLAND	**CU**	18	035	OBION	**OB**	66	131
DAVIDSON	**DA**	19	037	OVERTON	**OV**	67	133
DECATUR	**DE**	20	039	PERRY	**PE**	68	135
DE KALB	**DB**	21	041	PICKETT	**PI**	69	137
DICKSON	**DI**	22	043	POLK	**PO**	70	139
DYER	**DY**	23	045	PUTNAM	**PU**	71	141
FAYETTE	**FA**	24	047	RHEA	**RH**	72	143
FENTRESS	**FE**	25	049	ROANE	**RO**	73	145
FRANKLIN	**FR**	26	051	ROBERTSON	**RN**	74	147
GIBSON	**GI**	27	053	RUTHERFORD	**RU**	75	149
GILES	**GS**	28	055	SCOTT	**SC**	76	151
GRAINGER	**GR**	29	057	SEQUATCHIE	**SE**	77	153
GREENE	**GE**	30	059	SEVIER	**SV**	78	155
GRUNDY	**GY**	31	061	SHELBY	**SH**	79	157
HAMBLEN	**HA**	32	063	SMITH	**SM**	80	159
HAMILTON	**HM**	33	065	STEWART	**ST**	81	161
HANCOCK	**HK**	34	067	SULLIVAN	**SU**	82	163
HARDEMAN	**HR**	35	069	SUMNER	**SR**	83	165
HARDIN	**HD**	36	071	TIPTON	**TI**	84	167
HAWKINS	**HS**	37	073	TROUSDALE	**TR**	85	169
HAYWOOD	**HY**	38	075	UNICOI	**UC**	86	171

COUNTY NAME	WPC CO ABBR	TN CO NO	NATIONAL TN FIPS	COUNTY NAME	WPC CO ABBR	TN CO NO	NATIONAL TN FIPS
HENDERSON	**HE**	39	077	UNION	**UN**	87	173
HENRY	**HN**	40	079	VAN BUREN	**VA**	88	175
HICKMAN	**HI**	41	081	WARREN	**WA**	89	177
HOUSTON	**HO**	42	083	WASHINGTON	**WN**	90	179
HUMPHREYS	**HU**	43	085	WAYNE	**WE**	91	181
JACKSON	**JA**	44	087	WEAKLEY	**WY**	92	183
JEFFERSON	**JE**	45	089	WHITE	**WH**	93	185
JOHNSON	**JO**	46	091	WILLIAMSON	**WI**	94	187
KNOX	**KN**	47	093	WILSON	**WS**	95	189
LAKE	**LA**	48	095				

Exotic Plants in Tennessee

Compiled by the Tennessee Exotic Plant Pest Council. More information on these species including links to pictures can be found at: http://www.tnipc.org/invasive-plants/

Threat Level	Scientific Name	Common Names	Category
Established	*Ailanthus altissima* (Mill.) Swingle	Tree of Heaven	Tree
Established	*Albizia julibrissin* Durazz.	Mimosa Silktree Silky Acacia	Tree
Established	*Alliaria petiolata* (Bieb.) Cavara & Grande	Garlic Mustard	Forb/Herb
Established	*Alternanthera philoxeroides* (Mart.) Griseb.	Alligatorweed	Forb/Herb
Established	*Arthraxon hispidus* (Thunb.) Makino	Hairy Jointgrass Small Carpetgrass	Grass
Established	*Bromus inermis* Leyss.	Hungarian Brome Smooth Brome	Grass
Established	*Celastrus orbiculatus* Thunb.	Asian Bittersweet Oriental Bittersweet	Vine
Established	*Centaurea stobe* L. ssp. *micranthos* (S.G.Gmel. ex Gugler) Hayek.	Centaurea biebersteinii DC. Spotted Knapweed	Forb/Herb
Established	*Clematis terniflora* DC.	Sweet Autumn Clematis	Vine
Established	*Dioscorea polystachya Turez.*	Chinese Yam Cinnamon Vine Dioscorea oppositifolia L.	Vine
Established	*Elaeagnus umbellata* var. *parviflora* (Wall. ex Royle) C.K.Schneid.	Autumn Olive	Shrub

Threat Level	Scientific Name	Common Names	Category
Established	*Euonymus alatus* (Thunb.) Sieb.	Burning Bush Winged Euonymus	Shrub
Established	*Euonymus hederaceus Champ. & Benth.*	Euonymus fortunei (Turcz.) Hand.-Mazz. Winter Creeper	Vine
Established	*Fallopia japonica* (Houtt.) Ronse Decr.	Fleeceflower Japanese Knotweed Mexican Bamboo Polygonum cuspidatum Seib. & Zucc.	Forb/Herb
Established	*Hedera helix* L.	English Ivy	Vine
Established	*Hydrilla verticillata* (L.f.) Royle	Hydrilla Water Thyme	Aquatic
Established	*Lespedeza bicolor* Turcz.	Bicolor Lespedeza Shrubby Bushclover Shrubby Lespedeza	Shrub
Established	*Lespedeza cuneata* (Dum.-Cours) G. Don	Chinese Lespedeza Sericea Lespedeza	Forb/Herb
Established	*Ligustrum sinense* Lour.	Chinese Privet	Shrub
Established	*Lonicera japonica* Thunb.	Japanese Honeysuckle	Vine
Established	*Lonicera maackii* (Rupr.) Herder.	Amur Bush Honeysuckle	Shrub
Established	*Lythrum salicaria* L.	Purple Loosestrife	Forb/Herb
Established	*Microstegium vimineum* (Trin.) A. Camus	Japanese Stiltgrass Nepalese Browntop Nepalgrass	Grass

Threat Level	Scientific Name	Common Names	Category
Established	*Miscanthus sinensis* Anderss.	Chinese Silver Grass Eulalia Grass Maiden Grass Zebra Grass	Grass
Established	*Murdannia keisak* (Hassk.) Hand.-Maz.	Asian spiderwort Marsh Dayflower	Forb/Herb
Established	*Myriophyllum aquaticum* (Vell.) Verdc.	Brazilian Watermilfoil Parrot Feather	Aquatic
Established	*Myriophyllum spicatum* L.	Eurasian Water-milfoil	Aquatic
Established	*Paulownia tomentosa* (Thunb.) Sieb. & Zucc. ex Steud.	Empress Tree Princess Tree Royal Paulownia	Tree
Established	*Perilla frutescens* (L.) Britton	Beefsteak Plant Chinese basil Perilla Perilla Mint	Forb/Herb
Established	*Phragmites australis* (Cav.) Trin. ex Steud.	Common Reed	Grass
Established	*Pueraria montana* var. *lobata* (Willd.) Maesen & S. Almeida	Kudzu	Vine
Established	*Pyrus calleryana* Dcne.	Bradford Pear Callery Pear	Tree
Established	*Rosa multiflora* Thunb. ex Murr.	Multiflora Rose	Shrub
Established	*Rubus phoenicolasius* Maxim.	Wine Raspberry Wineberry	Shrub
Established	*Sorghum halepense* (L.) Pers.	Johnson Grass	Grass

Threat Level	Scientific Name	Common Names	Category
Established	*Spiraea japonica* L.f.	Japanese Meadowsweet Japanese Spiraea	Shrub
Established	*Tussilago farfara* L.	Coltsfoot	Forb/Herb
Established	*Vinca minor* L.	Common Periwinkle	Vine
Established	*Wisteria sinensis* (Sims) DC.	Chinese Wisteria	Vine
Established	*Wisteria floribunda* (Willd.) DC.	Japanese Wisteria	Vine
Emerging	*Acroptilon repens* (L.) DC.	Centaurea repens (L.) Russian Knapweed	Forb/Herb
Emerging	*Akebia quinata* (Houtt.) Dcne.	Chocolate vine Five-leaf akebia	Vine
Emerging	*Ampelopsis glandulosa* var. *brevipedunculata* (Maxim.) Momiy.	_Ampelopsis brevipedunculata_ (Maxim.) _Trautv_ _Ampelopsis heterophylla_ (Thunb.) Siebold & Zucc. Amur peppervine Creeper Porcelain berry Wild grape	Vine
Emerging	*Arundo donax* L.	Elephant Grass Giant Reed	Grass
Emerging	*Buddleja davidii* Franch.	Butterfly Bush	Shrub

Threat Level	Scientific Name	Common Names	Category
Emerging	*Firmiana simplex* (L.) W. Wight	_Firmiana platanifolia_ (L. f.) Schott & Endl. _Sterculia platanifolia_ L. f.) Chinese Parasol Tree Phoenix Tree Varnish Tree	Tree
Emerging	*Heracleum mantegazzianum* Sommier & Levier	Giant cow parsnip Giant hogweed	Forb/Herb
Emerging	*Humulus japonicus* Siebold & Zucc.	Japanese Hops	Vine
Emerging	*Imperata cylindrica* (L.) Beauv.	Cogongrass Japanese Bloodgrass	Grass
Emerging	*Liriope spicata* (Thunb.) Lour.	Creeping Lilyturf Creeping Liriope Lilyturf Monkey-grass	Forb/Herb
Emerging	*Lygodium japonicum* (Thunb. ex Murr.) Swartz	Japanese Climbing Fern	Forb/Herb
Emerging	*Mahonia bealei* (Fortune) Carr.	Beale's Barberry Leatherleaf Mahonia	Shrub
Emerging	*Melia azedarach* L.	Chinaberry	Tree
Emerging	*Nandina domestica* Thunb.	Heavenly Bamboo Nandina Sacred Bamboo	Shrub
Emerging	*Persicaria perfoliata* (L.) H. Gross	Asiatic Tearthumb Mile-a-minute Weed	Forb/Herb
Emerging	*Phyllostachys aurea Carr.* Ex A.& C. Rivère	Golden Bamboo	Grass

Threat Level	Scientific Name	Common Names	Category
Emerging	*Ranunculus ficaria* L.	_Ficaria verna_ Huds. Fig Buttercup Lesser Celandine	Forb/Herb
Emerging	*Rhamnus cathartica* L.	Common Buckthorn European Buckthorn Purging Buckthorn	Shrub
Emerging	*Rottboellia cochinchinensis* (Lour.) W.D. Clayton	Itchgrass	Grass
Emerging	*Salvinia molesta* Mitchell	Aquarium Water-moss Giant Salvinia	Aquatic
Emerging	*Solanum viarum* Dunal	Tropical Soda Apple	Shrub
Emerging	*Trapa natans* L.	Water Caltrop Water Chestnut	Aquatic
Emerging	*Triadica sebifera* (L.) Small	Chinese Tallowtree	Tree
Emerging	*Tribulus terrestris* L.		

APPENDIX F

TN PROTOCOLS
SOUTHEAST MONITORING NETWORK

SITE LIST AND MONITORING RESPONSIBILITY
MONITORING PROTOCOLS
DATA MANAGEMENT
TN SEMN FIELD SHEET

SEMN Site List and Monitoring Responsibility

Station ID	EFO	Stream Name	Location	Lat	Long	ECO IV	HUC
ECO66E09	JC	Clark Creek	Off Hwy 107 Clarks Creek Rd	36.14818	-82.52835	66e	06010108
ECO66G05	K	Little River	U/S Last house Little River Trail above Elkmont	35.65333	-83.5773	66g	06010201
ECO66G12	CH	Sheeds Creek	0.25 mi u/s Sheeds Creek Rd Crossing	35.00305	-84.61211	66g	03150101
ECO66G20	CH	Rough Creek	FR 221	35.05386	-84.48031	66g	06020003
ECO6702	JC	Fisher Creek	U/s Bray Rd. Crossing	36.49	-82.9403	67	06010204
ECO67F06	KEFO	Clear Creek	U/S Norris Municipal Park Rd	36.21361	-84.05972	67f	06010207
ECO67F13	KEFO	White Creek	D/S old USGS gaging station next to White Creek Rd	36.34361	-83.89166	67f	06010205
ECO68A03	MS	Laurel Fork Station Camp Creek	BSF NRRA RM4	36.51296	-84.71617	68a	05130104
ECO68C20	CH	Crow Creek	Off Ford Spring Rd U/S UT in Tom Pack Hollow	35.1155	-85.9111	68c	06030001
ECO71F19	CL	Brush Creek	Paul Reed Rd. just d/s Little Brush Creek	35.4217	-87.5355	67f	06040004
ECO71H17	CK	Clear Fork Creek	100 yds. u/s Cripps Ln. (Old Metal Bridge)	35.928651	-85.992117	71H	05130108
CITICO12.3MO	TVA	Citico Creek	Jack Best Campground	35.445524	-84.110308	66g	06010204
FIGHT000.6_GA	TVA	Fightingtown Creek	TN Ave/Mobile Rd Bridge Crossing just inside Georgia	34.9854	-84.3855	66d	06020003
WOLF002.7CO	TVA	Wolf Creek	Off Hwy 25/70 Near Wolf Creek Road	35.92242	-82.94656	66g	06010105

SEMN Monitoring Protocols

I. Sampling Frequency

April:

1. Collect SQKICK following TDEC protocols
2. Collect qualitative habitats sample (QHS) using 3 jabs – field pick all unique species, keep in separate bottles (see below for more detail).
3. Complete and upload Habitat Assessment (Bioform)
4. Complete and upload Stream Survey Sheet (Bioform)
5. Complete and upload SEMN Field Sheet (Bioform)
6. Collect periphyton sample and complete Rapid Periphyton Survey Data Sheet (Bioform)
7. Measure canopy using densiometer at 5 transects
8. Deploy Hobo continuous temperature/water depth loggers
9. Take instantaneous measurements of DO, Temp, Cond, pH
10. Measure flow along same transect where logger is deployed.
11. Collect water quality samples listed below.

July

1. Complete and upload Habitat Assessment (Bioform)
2. Complete and upload Stream Survey Sheet (Bioform)
3. Measure canopy using densiometer at 1 transects
4. Download data from Hobo continuous temperature/water depth loggers
5. Take instantaneous measurements of DO, Temp, Cond, pH
6. Measure flow along same transect where logger is deployed.
7. Collect water quality samples listed below.

September

1. Collect SQKICK following TDEC protocols
2. Collect qualitative habitats using 3 jabs – field pick all unique species, keep in separate bottles (see below for more detail).
3. Complete and upload Habitat Assessment (Bioform)
4. Complete and upload Stream Survey Sheet (Bioform)
5. Complete and upload SEMN Field Sheet (Bioform)
6. Measure canopy using densiometer at 1 transects
7. Download Hobo continuous temperature/water depth data.
8. Take instantaneous measurements of DO, Temp, Cond, pH

9. Measure flow along same transect where logger is deployed.
10. Collect water quality samples listed below.

January

1. Complete Stream Survey Sheet
2. Complete Climate Change Field Sheet (below)
3. Measure canopy using densiometer at 1 transects
4. Download data from Hobo continuous temperature/water depth loggers
5. Take instantaneous measurements of DO, Temp, Cond, pH
6. Measure flow along same transect where logger is deployed.
7. Collect water quality samples listed below.

II. SEMN Sampling:

The initial macroinvertebrate sample will be collected in April 2013. Subsequent samples will be collected annually within 2 weeks of the original collection. If flooding/high water prevents sample collection within the specified time period, samples will be taken as closely as reasonable to the target period.

500 micron mesh nets will be used for all sample collection.
The following samples will be collected within a 100 meter reach at each site:

A. Semi-quantitative Riffle Kick (SQKICK)

Approximate total area = 2 meters square. In larger streams, collect 2 riffles or upper or lower end of a large riffle. In smaller streams, multiple riffles may need to be collected to achieve the desired area. Follow TDEC DWR most recent QSSOP for Macroinvertebrate Stream Surveys Protocol.

Kicks will be composited and debris will be returned to laboratory for microscopic sub-sampling and species identification.

B. Qualitative Habitat Sampling (QHS)

Three “jabs” will be collected from all available habitats. Samples will be picked in the field targeting all unique taxa (it is recommended that all taxa be collected due to difficulty in differentiating species in field). Taxa from each habitat will be kept in a separate container with separate species lists generated for each habitat.

The following are examples of habitats that should be collected if present, other productive habitats such as moss can also be collected:

Habitat	Definition of 3 jabs (approximate)
Rooted undercut banks/tree roots	3 net widths
Macrophytes	3 net widths
Leaf Packs	3 handfuls
Woody Debris/Snags	3 net widths or 3 handfuls of loose material
Fine sediment	3 net widths approx. 4 cm deep
Pool Rock	6.cobble size (3 if approaching boulder)

C. Fish

Fish population samples will be collected in April- June of each year starting in 2013. Each agency will follow their own protocols. TVA will help coordinate sampling in states that need assistance. (TVA will collect all TN sites.)

D. Diatoms

The initial diatom sample will be collected in April 2013. Subsequent samples will be collected annually within 2 weeks of the original collection. If flooding/high water prevents sample collection within the specified time period, samples will be taken as closely as reasonable to the target period.

- Sampling protocols will follow EPA SPNBR or equivalent 9(TDEC protocols)..
- Subsample will consist of 600 valve (300 cell).
- Taxonomic level will be species (or lowest practical).

E. Field Documentation (Use BioForm and upload to Waterlog/Hydra)

- EPA Rapid Habitat Assessment Field Data Sheet for High Gradient Streams (1-200 scale).
- Canopy measurement midstream along 5 transects facing upstream/downstream/left bank and right bank using spherical densiometer held 12 inches above water surface.
- Digital photo documentation facing upstream and downstream as well as location of depth/temperature logger and any indications of human disturbance.
- Document dominant riparian vegetation type.
- Complete Field Observation Sheet (may substitute in-house form as long as all requested information is included.)

F. Temperature and Flow Loggers

- One continuous temperature logger will be deployed at each site with measurements taken every 30 minutes if a flow gauge is present.
- Two continuous water depth loggers will be deployed at each ungaged site (one in water and one in air) with measurements taken every 30 minutes. Water temperature should be measured at same depth/location as continuous monitoring sensor as QC check on each field visit. Instantaneous flow measurements should also be recorded along same transect during field visits for calibration.

G. Physical/chemical parameters

- Instantaneous measurements of flow, temperature, DO, conductivity and pH at each site visit.
- Minimal water quality samples:
    - Total Alkalinity
    - Ammonia Nitrogen
    - Arsenic
    - Cadmium
    - Chromium
    - Color (True and apparent)
    - Copper
    - Iron
    - Lead
    - Manganese
    - Nitrate+nitrite
    - Dissolved Residue
    - Suspended Residue
    - Selenium
    - Sulfates
    - Total Hardness
    - Total Kjeldahl Nitrogen
    - Total Organic Carbon
    - Total Phosphorus
    - Turbidity
    - Zinc

Macroinvertebrate Sample Analysis:

All samples are to be sent to aquatic biology section for subcontracting. Contractor will identify all samples using keys agreed upon by monitoring network to ensure consistency. New taxon will be verified by outside expert and retained in reference collection. Sample and sorted debris will be retained a minimum of five years. Identified organisms will be retained for the life of the project.

A. Semi-quantitative Riffle Kick (SQKICK):

Subsample to 300 +/- 10% organisms following EPA 841-B-99-002 section 7.3 protocols.

Identify each organism in subsample to lowest possible taxon (usually species). Taxa list should include count of each taxon in subsample.

B. Qualitative Habitat Sample (QHS)

Identify organisms in each habitat to lowest possible taxon (usually species). Maintain separate taxa lists for each habitat including estimated abundance:

- Rare = 1-3
- Common = 4-9
- Abundant = 10-49
- Dominant = > 50

C. Quality Assurance

Each agency will follow approved QAPP for sorting and taxonomy. A voucher collection of each unique taxon will be housed by each agency and will be made available for verification or comparison to other identifications if needed. One riffle sample per year collected will be randomly selected from the 40 reference sites to be identified by all participating agencies.

V. Data Management

Continuous monitoring data will be downloaded by EFO and run through ConDataQC R Shiny app https://tetratech-wtr-wne.shinyapps.io/ContDataQC/ by EFO. Both the original and QC'd file is saved on H:\TDEC Share\DWR Continuous Monitoring Data until TNCON development is complete. Macroinvertebrate and diatom data will be uploaded to Waterlog/Hydra/HYDRA and WQX every six months by TDH Lab or WPU. SEMN Field Sheets will be uploaded to Waterlog/Hydra SEMN field staging table by EFO sampler.

TN SEMN Field Sheet
(See BSERT for BioForm instructions and upload).

	A	B	C	D	E	F	G	H	I	J
1	**TN Southeast Monitoring Network (SEMN) Field Sheet**									
2	**DWR Station ID:**		Samplers:				Organization:			
3	Monitoring Location ID:		Date:		**Time:**					
4	Monitoring Location Name:			Location:						
5	Field Log Number:			Periphyton Field Log #: (**April**) P				Project:		
6	**SEMN Protocol**									
7	**Pre-Visit Check:**									
8	HoboWare Pro software updated?			Date:						
9	uttle batteries checked and synced with computer?			Date:						
10	**SEMN Biological Samples Collected**									
11	SEMN 500 SQKICK:									
12	**Qualitative Individual Habitats Sampled**									
13	**Habitat**	**Jab Definition**	**Sampled?**							
14	Rooted Bank	3 net widths								
15	Macrophytes	3 net widths								
16	Pool Rocks	6 cobbles or 3 boulders								
17	Fine Sediment	3 net widths ~4 cm deep								
18	Leaf Pack	3 handfuls								
19	Woody Debris/Snags	3 net widths or 3 handfuls								
20	Record chemical water samples collected and physical parameters and flow measurements in Stream Survey tab (SS2).									
21										
22	**HOBO U20 Logger Information**									
23	Water temperature beside water probe:			°C						
24	Water depth from surface to HOBO sensor hole:			feet						
25	Any changes to probes or location?			If yes describe below in observed changes, such as probe moved...						
26	Air Logger Downloaded/Re-deployed:		Time:		Battery Status:		Latitude:		Longitude:	
27	Describe any problems or changes to air sensor:									
28	Water Logger Downloaded/Re-deployed:		Time:		Battery Status:		Latitude:		Longitude:	
29	Describe any problems or changes to water sens									
30	**SEMN Stream Information:**									
31	Dominate streamside vegetation:									
32	Dominate composition of leaf packs:									
33	Describe any observed changes, such as probe moved, dewatered, buried in sediment, or fouled since last site visit:									
34	Describe any deviation from protocol:									
35	Describe any changes to the site such as beaver activity, logging, fire, agriculture, construction:									

TN Southeast Monitoring Network (SEMN) Field Sheet

DWR Station ID:		Samplers:				Organization:		
Monitoring Location ID:		Date:		**Time:**				
Monitoring Location Name:			Location:					
Field Log Number:			Periphyton Field Log #: (**April**)		P		Project:	

SEMN Protocol

Pre-Visit Check:

HoboWare Pro software updated?		Date:	
Shuttle batteries checked and synced with computer?		Date:	

SEMN Biological Samples Collected

SEMN 500 SQKICK:

Qualitative Individual Habitats Sampled

Habitat	Jab Definition	Sampled?
Rooted Bank	3 net widths	
Macrophytes	3 net widths	
Pool Rocks	6 cobbles or 3 boulders	
Fine Sediment	3 net widths ~4 cm deep	
Leaf Pack	3 handfuls	
Woody Debris/Snags	3 net widths or 3 handfuls	

Record chemical water samples collected and physical parameters and flow measurements in Stream Survey tab (SS2).

HOBO U20 Logger Information

Water temperature beside water probe:		°C						
Water depth from surface to HOBO sensor hole:		feet						
Any changes to probes or location?		If yes describe below in observed changes, such as probe moved…						
Air Logger Downloaded/Re-deployed:	Time:		Battery Status:		Latitude:		Longitude:	
Describe any problems or changes to air sensor:								
Water Logger Downloaded/Re-deployed:	Time:		Battery Status:		Latitude:		Longitude:	
Describe any problems or changes to water sensor:								

SEMN Stream Information:

Dominate streamside vegetation:	
Dominate composition of leaf packs:	
Describe any observed changes, such as probe moved, dewatered, buried in sediment, or fouled since last site visit:	
Describe any deviation from protocol:	
Describe any changes to the site such as beaver activity, logging, fire, agriculture, construction:	

APPENDIX G

NOTICE OF REVISIONS 2006-2017

NOTICE OF REVISIONS RECORD 2006
NOTICE OF REVISIONS RECORD 2011
NOTICE OF REVISIONS RECORD 2017

NOTICE OF REVISION(S) RECORD 2006

Date	Specific Section or Page	Revision Type (major or minor)	Revision Description
10-1-03	xii	Minor	Replace MEFO recipient
10-01-03	II/B/1	Minor	Clarify Station Naming Protocol
10-01-03	II/D/4	Minor	Additional Information for Habitat Assessments
10-01-03	II/D/5 Table 1	Major	Revised Regional Habitat Guidelines
10-01-03	II/F/5	Major	Provide Biorecon Scoring Guidelines for 73a
10-01-03	II/F/6 Table 2	Major	Revised family level biorecon assessment guidelines
10-01-03	II/F/8 Table 3	Major	Revised Genus level biorecon assessment guidelines
10-01-03	II/G/1	Minor	Add online assessment database as source for determining ecoregions.
10-01-03	II/G/2	Minor	Clarify procedures for additional SQKICK sampling to ensure 200 organisms sample.
10-01-03	II/G/4	Minor	Clarify procedures for additional modified SQKICK sampling to ensure 200 organism sample
10-01-03	II/G/5	Minor	Clarify procedures for additional SQBANK sampling to ensure 200 organism sample.
10-01-03	Appendix A 2-7	Major	Updated biocriteria tables.
10-01-03	Appendix A 8-14	Major	Added location and status to ecoregion reference stream table. Added new reference streams.
10-01-03	Appendix A 15-16	Major	Added Table of regional expectations for individual habitat parameters.
10-01-03	Appendix B 4-7	Minor	Revised header information on habitat assessment field sheets.
03-03-03	Appendix B 12	Minor	Revised macroinvertebrate assessment report sheet.
10-01-03	Appendix C 2	Major	Added Peltoperlidae to list of intolerant macroinvertebrate families for biorecons.
10-01-03	Appendix C 3-6	Major	Updated intolerant macroinvertebrate genera for biorecons.

Date	Specific Section or Page	Revision Type (major or minor)	Revision Description
10-01-03	Appendix C 7-21	Major	Updated NCBI scores for Tennessee Taxa.
10-01-03	Appendix C 22-25	Major	Added taxa to list of clinger organisms.
10-01-03	Appendix E	Major	Added taxa to verified taxa list.
10-12-06	V	Minor	Change Commissioner's name
10-12-06	V	Minor	Change QA manager's name.
10-12-06	VIII	Minor	Update reviewers
10-12-06	X	Minor	Update notice of revisions.
10-12-06	Section 1.1, Protocol B, Page 2	Minor	Add naming scheme of UT to UT
10-12-06	Section 1.1, Protocol C, Page 1	Minor	Update meter specifications to match chemical QSSOP.
10-12-06	Section 1.1, Protocol F, page 4	Minor	Clarify how chironomids are counted in richness metric for biorecons.
10-12-06	Section 1.1, Protocol F, Page 6 and 7	Major	Tables 2 and 3 updated based on reference data.
10-12-06	Section 1.1, Protocol J Page 2	Minor	Clarification of Slide labeling procedure.
10-12-06	Section II, Protocol K Page 2 Item f	Major	%NUTOL replaced %Dominant
10-12-06	Appendix A	Major	Biocriteria tables updated based on new reference data. Tables separated by season, metric ranges and target scores adjusted. Bioregion 66f combined with 66deg.
10-12-06	Appendix A	Major	Update ecoregion reference stream list.
10-12-06	Appendix B	Minor	Revised header information on habitat assessment field sheets, stream survey field sheet and biorecon field sheet.

Date	Specific Section or Page	Revision Type (major or minor)	Revision Description
10-12-06	Appendix B	Minor	Macroinvertebrate Assessment report revised.
10-12-06	Appendix C	Minor	Added additional taxa to NCBI score list.
10-12-06	Appendix C	Minor	Added Nymphoridae to list of clingers.
10-12-06	Appendix E	Minor	Added taxa to the verified taxa list.

This revision(s) has been reviewed and approved. It becomes effective on: 10 – 23 - 2006

Paul E. Davis — 10/24/06

Paul Davis
Director
Division of Water Pollution Control
Date

Charles L. Head — 10-23-06

Charles Head
TDEC Quality Assurance Manager
Date

NOTICE OF REVISION(S) RECORD 2011

Date	Specific Section or Page	Revision Type (major or minor)	Revision Description
10-21-10	Section I.D	Minor	Updated Health and Safety Warnings and Cautions.
10-21-10	Section II.A	Minor	Added provision to relocate ecoregion reference sites upstream if localized problem develops.
10-21-10	Section I.C	Minor	Added definitions and acronyms.
10-21-10	Section I.I Protocol .A	Major	Added sample priority list.
10-21-10	Section I.I Protocol A	Major	Added biological sample decision making flowcharts.
10-21-10	Section I.I Protocol A	Minor	Added provision for intermittent discharges to site selection protocol.
10-21-10	Section I.I Protocol A	Minor	Clarified site selection.

Date	Specific Section or Page	Revision Type (major or minor)	Revision Description
10-21-10	Section I.I Protocol B	Minor	Added quick field reference method summary.
10-21-10	Section I.I Protocol B	Minor	Updated station naming protocols.
10-21-10	Section I.I. Protocol D Table 2.	Major	Re-calibrated habitat assessment guideline scores. Removed impairment categories.
10-21-10	Section I.I Protocol D Table 2.	Major	Added habitat assessment guidelines for headwater streams.
10-21-10	Section I.I Protocol D Appendix B	Major	Revised habitat assessment protocols and field sheets.
10-21-10	Section I.I Protocol F	Major	Revised biorecon voucher requirements for family.
10-21-10	Section I.I Protocol F	Minor	Clarified biometric calculation information.
10-21-10	Section I.I Protocol F Tables 3 and 4.	Major	Recalibrated biorecon scoring guidelines.
10-21-10	Section I.I Protocol F Tables 3 and 4.	Major	Added biorecon scoring guidelines for headwater streams.
10-21-10	Section I.I Protocol G	Minor	Added shallow streams to modified kick protocol.
10-21-10	Section I.I Protocol H.	Major	Added supply and bottle acquisition procedure.
10-21-10	Section I.I Protocol H	Minor	Updated logging information.
10-21-10	Section I.I Protocol H	Minor	Added sample transport information to protocol H.
10-21-10	Section I.I. Protocol J	Minor	Clarified report preparation information. Added digital picture submittal.
10-21-10	Section I.I Protocol L	Major	Added protocol for scoring SQSH in streams that do not fit biocriteria guidelines.
10-21-10	Section I.I. Protocol L Appendix A	Major	Calibrated %NUTOL to Tennessee taxa, renamed %TNUTOL.

Date	Specific Section or Page	Revision Type (major or minor)	Revision Description
10-21-10	Section I.I. Protocol L Appendix A	Major	Replace %EPT with %EPT-Cheum.
10-21-10	Section I.I. Protocol L	Minor	Rearranged order of biometrics to correspond with biometrics tables.
10-21-10	Section I.I Protocol L	Major	Removed biological condition table 4. Added information on index interpretation (pass/fail).
10-21-10	Section I.J.	Minor	Update data and records management.
10-21-10	Section I.I Protocol M	Major	Added protocols for reference stream site selection.
10-21-10	Section II	Major	Added corrective actions to QA/QC.
10-21-10	Appendix A	Minor	Updated reference streams table. Added headwater reference stream table.
10-21-10	Appendix B	Minor	Added list of exotic plants.
10-21-10	Appendix B	Minor	Revised macroinvertebrate assessment report.
10-21-10	Appendix C	Major	Updated Appendix C
10-21-10	Appendix D	Minor	Updated taxonomic keys
01-06-11	Appendix C and E	Major	Combined Verified taxa list, NCBI scores and clinger designation into one list called Tennessee taxa list 2011.
02-09-11	Section I.H	Minor	Changed alcohol acquisition procedure.
02-09-11	Section I.I.	Minor	Changed procedure for transporting samples to lab.
5-2-11	Section I.C and I.I Protocol E	Minor	Clarified location of canopy measurements.
5-2-11	Section I.I Protocol A	Minor	Clarified sample priorities.
5-2-11	Section I.I Protocol B	Minor	Clarified stream mile measurements.
5-2-11	Section I.I Protocol B	Major	Revised naming protocols for unnamed tribs.

Date	Specific Section or Page	Revision Type (major or minor)	Revision Description
5-2-11	Section I.I Protocol D	Major	Added further clarification for scoring of habitat assessments especially for channel flow status and channel alteration categories.
5-2-11	Section I.I Protocol F	Minor	Added clarification in biorecon method.
5-2-11	Section I.I Protocol F Table 4 and 5	Major	Recalibrated scoring criteria for family and genus level biorecons.
5-2-11	Section I.I Protocol G	Minor	Added clarification in SQSH method.
5-2-11	Section II	Major	Added clarification for biorecon vouchers and reference collections.
5-2-11	Appendix A	Major	Revised biocriteria tables (drainage area, taxonomic level, recalibrated ranges). Added headwater tables.
5-2-11	Appendix B	Major	Revised stream survey field sheet.
5-2-11	Appendix B	Major	Revised Habitat assessments field sheets to further clarify category scoring.
5-2-11	Appendix B	Major	Revised biorecon field sheet
5-2-11	Appendix E	Major	Added criteria for taxonomic experts adapted from NABs.
5-16-11	Section I.I Protocol J	Minor	Clarification of tolerance value sources for North Carolina Biotic Index.
5-25-11	Appendix D	Minor	Added supplemental taxonomic keys Updated list of taxonomic specialists

This revision has been reviewed and approved. It becomes effective on July 1, 2011.

Paul E. Davis /by GW — 6/9/11

Paul Davis, Director — Date
Division of Water Pollution Control

Charles L Head — 6/9/11

Charles Head
TDEC Quality Assurance Manager — Date

NOTICE OF REVISIONS RECORD 2017

Date	Specific Section or Page	Revision Type (major or minor)	Revision Description
07-01-17	Title	Minor	Updated division name.
07-01-17	Throughout document	Minor	Updated staff
07-01-17	Throughout document	Major	Changed headwater stream drainage from $\leq$ 2 square miles to $\leq$ 2.5 square miles.
07-01-17	Notice of Revisions 2006-11	Minor	Moved to Appendix
07-01-17	Equipment and Supplies	Major	Added requirements on obtaining TWRA collection permit.
07-01-17	Section 1D-F	Minor	Updated safety, cautions and interferences.
07-01-17	Protocol B	Minor	Clarified station naming scheme and added requirements for electronic reporting.
07-01-17	Protocol C	Minor	Clarified pH calibration and DO measurements. Added requirements for electronic reporting.
07-01-17	Protocol D	Major	Refined habitat assessment protocols in response to statewide DWR regional QC workshops. Added requirements for electronic reporting.
07-01-17	Table 2	Major	Recalibrated habitat assessment guidelines. Split scoring by season.
07-01-17	Protocol G	Minor	Updated sampling priorities to match CALM.
07-01-17	Protocol G	Major	Clarified Personnel Qualifications, added credentials form.
07-01-17	Protocol E	Major	Revised Stream Survey Sheet. Added requirements for electronic reporting.
07-01-17	Protocols F and G	Major	Added information on Threatened and Endangered Species.
07-01-17	Protocol F	Minor	Clarified when to collect biorecons.
07-01-17	Protocol F	Major	Eliminated semi-aquatic taxa, collembolan and micro/meio-crustacea from biorecon metric counts. Combined Chironomidae for genus level.
07-01-17	Protocol F	Minor	Clarified descriptions for collection of various habitat types.

Date	Specific Section or Page	Revision Type (major or minor)	Revision Description
07-01-17	Protocol F	Minor	Clarified retention of vouchers.
07-01-17	Protocol F	Major	Added electronic reporting requirements.
07-01-17	Table 4	Major	Revised biometrics for biorecons in ecoregion 73. Replaced EPT with ETO and added CRMOL. Recalibrated metrics for all bioregions. Replace %Clingers with %Clingers-Cheumatopsyche. Split by stream size and season. Split ecoregion 74b from 65e. Revised language for scoring interpretation.
07-01-17	Protocol F	Major	Eliminated semi-aquatic taxa, collembolan and micro/meio-crustacea from SQSH biometric calculations.
07-01-17	Protocol F	Major	Added electronic reporting requirements.
07-01-17	Protocol H	Minor	Revised field number reporting format for DWR samples.
07-01-17	Protocol J	Major	Eliminated semi-aquatic taxa, collembolan and micro/meio-crustacea from taxonomy. Added electronic reporting requirements..
07-01-17	Protocol K	Major	Added protocol for proportioning undetermined taxa. Replaced %Clingers with %Clingers-Cheumatopsyche. Added 2 metrics and revised target score for ecoregion 73. Added electronic reporting requirements.
07-01-17	Protocol L	Major	Added electronic reporting requirements.
07-01-17	Section I.J	Major	Added electronic reporting requirements for all data types for all samplers. Added Waterlog/Hydra upload requirements for DWR staff.
07-01-17	Section II	Major	Defined responsibilities of In-house QC officer. Revised taxonomic QC requirements for SQSH samples.

Date	Specific Section or Page	Revision Type (major or minor)	Revision Description
07-01-17	Appendix A	Major	Revised SQSH Biocriteria Tables. Recalibrated all metrics. Split by stream size and season. Split 7b from bioregion 65abei. Added SQBANK criteria for bioregion 67fhi (Fall only/non-headwater only). Changed drainage area for headwater streams. Removed headwater stream cautions.
07-01-17	Appendix A	Minor	Updated ecoregion reference streams.
07-01-17	Appendix A	Major	Recalibrated regional expectations for individual habitat parameters. Split all ecoregions by season.
07-01-17	Appendix B	Major	Updated field worksheets and reporting forms. Added electronic reporting formats..
07-01-17	Appendix C	Major	Updated list of intolerant families for biorecons. Updated master taxa list
07-01-17	Appendix E	Major	Updated Exotic Plants List and moved to Appendix E. Moved county abbreviations to appendix E. Added reference tables for project names, organizations and activity types to appendix E.
07-01-17	Appendix F	Major	Added protocols for Southeast Monitoring Network.

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