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Framework and Implementation Recommendations for Tiered Aquatic Life Uses: Minnesota Rivers and Streams

A Report to:
Minnesota Pollution Control Agency

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CLEAN WATER LAND & LEGACY AMENDMENT

Foreword

The Minnesota Pollution Control Agency (MPCA) has embarked on a detailed developmental effort to determine how the concept of TALU can be applied to Minnesota rivers and streams. This effort is the result of work that began in the early 1990s to develop a robust biological monitoring and assessment program in Minnesota. In the last 20 years Minnesota has developed many of the tools and program capabilities needed to implement a TALU framework. When this process is completed MPCA will be one of a handful of states in the U.S capable of supporting a TALU framework.

The MPCA commissioned this project to determine the key steps and attributes of a process for implementing TALU and biocriteria as part of the MPCA water quality regulatory and management programs. The framework and rationale outlined in this report is based on the TALU and biocriteria developmental experiences of other states and guidance and methods documents that have been produced by U.S. EPA. The process outlined by this report is a collection of existing "best practices" in the development and implementation of a state-based TALU framework. In addition, draft language for the Minnesota Water Quality Standards (WQS) is recommended and will support the rulemaking that will be proposed for adoption in 2014.

This report was completed in fulfillment of Task 3 of the MBI TALU work plan (Appendix A). It contains recommendations by MBI to MPCA based on the best scientific evidence and "best practices" that are currently available. It is advisory in terms of how MPCA might choose to implement the recommendations herein. The recommendations are the result of a participatory process by which MBI was involved in every step of the TALU and biocriteria development with MPCA staff and management. The underpinnings and conceptual tenets of a TALU-based approach have been carefully explained to MPCA management and staff via internal stakeholder engagement. In addition, external stakeholders have been informed at the same level of detail via various meetings and workshops at MPCA headquarters and regional offices.

The report is organized into major sections and subsections as follows:

1. Section 1.0 describes the Minnesota TALU initiative and origins.
2. Section 2.0 provides a detailed description of the TALU framework and its components.
3. Section 3.0 outlines the recommendations for a framework for developing and applying TALUs and biocriteria in the Minnesota WQS.
4. Section 4.0 describes recommendations and examples about how TALUs should be implemented in Minnesota.
5. Section 5.0 describes the likely effects that a TALU approach will have on major Minnesota PCA management programs.

This report reflects the detailed needs within MPCA and how a TALU-based approach might change the current Minnesota WQS and how that in turn might affect current MPCA water quality management programs. As such this report is advisory in nature and implementation of all or parts of the recommendations in this report are solely at the discretion of MPCA who will decide based on internal and external stakeholder consultation. Regulatory adoption of a TALU framework and affiliated standards and criteria will undergo the normal public rule making processes as outlined in the Minnesota Administrative Procedures Act.

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Glossary of Terms

Ambient Monitoring — Sampling and evaluation of receiving waters not necessarily associated with episodic perturbations.

Antidegradation Policy — The part of state water quality standards that protects existing uses, prevents degradation of high quality water bodies unless certain determinations are made, and which protects the quality of outstanding national resource waters. (Currently nondegredation in MN)

Aquatic Assemblage — An association of interacting populations of organisms in a given water body, for example, the fish assemblage or the benthic macroinvertebrate assemblage.

Aquatic Community — An association of interacting assemblages in a given water body, the biotic component of an ecosystem.

Aquatic Life Use (ALU) — A beneficial use designation in which the water body provides suitable habitat for survival and reproduction of desirable fish, shellfish, and other aquatic organisms; classifications specified in State water quality standards relating to the level of protection afforded to the resident biological community by the custodial State agency.

Attainment Status — The state of condition of a water body as measured by chemical, physical, and biological indicators. Full attainment is the point at which measured indicators signify that a water quality standard has been met and it signifies that the designated use is both attained and protected. Non-attainment is when the designated use is not attained based on one or more of these indicators being below the required condition or state for that measure or parameter.

Attribute — A measurable part or process of a biological system.

Beneficial Uses — Desirable uses that acceptable water quality should support. Examples are drinking water supply, primary contact recreation (such as swimming), and aquatic life support.

Benthic Macroinvertebrates — Animals without backbones, living in or on the substrates, of a size large enough to be seen by the unaided eye, and which can be retained by a U.S. Standard No. 30 sieve (0.595 mm openings). Also referred to as benthos, infauna, or macrobenthos.

Best Management Practice (BMP) An engineered structure or management activity, or combination of these that eliminates or reduces an adverse environmental effect of a pollutant, pollution, or stressor effect.

Biological Assessment An evaluation of the biological condition of a water body using surveys of the structure and function of a community of resident biota; also known as bioassessment. It also includes the interdisciplinary process of determining condition and relating that condition to chemical, physical, and biological factors that are measured along with the biological sampling.

Biological Criteria (Biocriteria) Scientific meaning: quantified values representing the biological condition of a water body as measured by structure and function of the aquatic communities typically at reference condition; also known as biocriteria.

Regulatory meaning: narrative descriptions or numerical values of the structure and function of aquatic communities in a water body necessary to protect a designated aquatic life use, implemented in, or through state water quality standards.

Biological Condition Gradient (BCG) A scientific model that describes the biological responses within an aquatic ecosystem to the increasing effects of stressors.

Biological Diversity Refers to the variety and variability among living organisms and the ecological complexes in which they occur. Diversity can be defined as the number of different taxa and their relative frequencies. For biological diversity, these taxa are organized at many levels, ranging from complete ecosystems to the biochemical structures that are the molecular basis of heredity. Thus, the term encompasses different ecosystems, species, and genes; also known as biodiversity.

Biological Indicator An organism, species, assemblage, or community characteristic of a particular habitat or indicative of a particular set of environmental conditions; also known as a bioindicator.

Biological Integrity — The ability of an aquatic ecosystem to support and maintain a balanced, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats within a region (after Karr and Dudley 1981).

Biological Monitoring — The use of a biological entity (taxon, species, assemblage) as a detector and its response as a measure of response to determine environmental conditions. Ambient biological surveys and toxicity tests are common biological monitoring methods; also known as biomonitoring.

Biological Survey — The collection, processing, and analysis of a representative portion of the resident aquatic community to determine its structural and/or functional characteristics and hence its condition using standardized methods.

Bioregion — Any geographical region characterized by a distinctive flora and/or fauna.

Clean Water Act (CWA) — An act passed by the U.S. Congress to control water pollution (formally referred to as the Federal Water Pollution Control Act of 1972). Public Law 92-500, as amended. 33 U.S.C. 1251 et seq.; referred to herein as the Act.

CWA Section 303(d) — This section of the Act requires States, territories, and authorized Tribes to develop lists of impaired waters for which applicable water quality standards are not being met, even after point sources of pollution have installed the minimum required levels of pollution control technology. The law requires that these jurisdictions establish priority rankings for waters on the lists and develop TMDLs for these waters. States, territories, and authorized Tribes are to submit their list of waters on April 1 in every even-numbered year.

CWA Section 305(b) — Biennial reporting required by the Act to describe the quality of the Nation's surface waters, to serve as an evaluation of progress made in maintaining and restoring water quality, and describe the extent of remaining problems.

Criteria A limit on a particular pollutant or condition of a water body presumed to support or protect the designated use or uses of a water body. Criteria may be narrative or numeric and are commonly expressed as a chemical concentration, a physical parameter, or a biological assemblage endpoint.

DELT Anomalies The percentage of Deformities, Erosions (e.g., fins, barbels), Lesions and Tumors on fish assemblages (DELT). An important fish assemblage attribute that is a commonly employed metric in fish IBIs.

Designated Uses Those uses specified in state water quality standards for each water body or segment whether or not they are being attained.

Disturbance Any activity of natural or human causes that alters the natural state of the environment and its attributes and which can occur at or across many spatial and temporal scales.

Ecological integrity The summation of chemical, physical, and biological integrity capable of supporting and maintaining a balanced, integrated adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats in the region.

Ecoregion A relatively homogeneous geographical area defined by a similarity of climate, landform, soil, potential natural vegetation, hydrology, or other ecologically relevant variables; ecoregions are portioned at increasing levels of spatial detail from level I to level IV.

Existing Uses Those uses actually attained in a water body on or after November 28, 1975, whether or not they are included in the state water quality standards (November 28, 1975 is the date on which U.S. EPA promulgated its first water quality standards regulation in 40CFR Part 131). Existing uses must be maintained and cannot be removed.

Functional Organization	The summation of processes required for normal performance of a biological system (may be applied to any level of biological organization).
Index of Biotic Integrity (IBI)	An integrative expression of site condition across multiple metrics comprised of attributes of a biological assemblage. It refers to the index developed by Karr (1981) and explained by Karr et al. (1986). It has been used to express the condition of fish, macroinvertebrate, algal, and terrestrial assemblages throughout the U.S. and in each of five major continents.
Metric	A calculated term or enumeration representing an attribute of a biological assemblage, usually a structural aspect, that changes in a predictable manner with an increased effect of human disturbance.
Monitoring and Assessment	The entire process of collecting data from the aquatic environment using standardized methods and protocols, managing that data, analyzing that data to make assessments in support of multiple program objectives, and disseminating the assessments to stakeholders and the public.
Multimetric Index	An index that combines assemblage attributes, or metrics, into a single index value. Each metric is tested and calibrated to a scale and transformed into a unitless score prior to being aggregated into a multimetric index. Both the index and metrics are useful in assessing and diagnosing ecological condition.
Narrative Biocriteria	Written statements describing the narrative attributes of the structure and function of aquatic communities in a water body necessary to protect a designated aquatic life use.
Natural Condition	This includes the multiplicity of factors that determine the physical, chemical, or biological conditions that would exist in a water body in the absence of measurable impacts from human activity or influence.
Numeric Biocriteria	Specific quantitative and numeric measures of the structure and function of aquatic communities in a water body necessary to protect a designated aquatic life use.

Reference Condition

The condition that approximates natural, unimpacted to best attainable conditions (biological, chemical, physical, etc.) for a water body. Reference condition is best determined by collecting measurements at a number of sites in a similar water body class or region under minimally or least disturbed conditions (by human activity), if they exist. Since undisturbed or minimally disturbed conditions may be difficult or impossible to find in some states, least disturbed conditions, combined with historical information, models or other methods may be used to approximate reference condition as long as the departure from natural or ideal is comprehended. Reference condition is used as a benchmark to establish numeric biocriteria and can be further described as follows:

Minimally Disturbed Condition (MDC) – This term describes the condition of the biota in the absence of significant human disturbance and it is the best approximation of biological integrity.

Historical Condition (HC) - The condition of the biota at some point in its history. It may be a more accurate estimator of true reference condition (i.e., biological integrity) if the historical point chosen is before the effect of any adverse human disturbance. However, more than one historical reference point is possible (e.g., pre-industrial, pre-Columbian).

Least Disturbed Condition (LDC) – Least disturbed condition is found in conjunction with the best available physical, chemical, and biological habitat conditions given today's state of the landscape.

Best Attainable Condition (BAC) – This is the expected condition of least disturbed sites under the implementation of BMPs for a sufficient period of time. This is a condition that results from the convergence of management goals, best available technologies, and a public commitment to achieving environmental goals (e.g., as established by WQS) under prevailing uses of the landscape. BAC may be equivalent to either to either MDC

	or LDC depending on the prevailing level of human disturbance in a region.
Reference Site	A site selected to represent an approximation of reference condition and by comparison to other sites being assessed. For the purpose of assessing the ecological condition of other sites, a reference site is a specific locality on a water body that is minimally or least disturbed and is representative of the expected ecological condition of other localities on the same water body or nearby water bodies.
Regional Reference Condition	A description of the chemical, physical, or biological condition based on an aggregation of data from reference sites that are representative of a water body type in an ecoregion, subregion, bioregion, or major drainage unit.
Stressors	Physical, chemical, and biological factors that can adversely affect aquatic organisms. The effect of stressors is apparent in the biological responses.
Use Attainability Analysis (UAA)	A structured scientific assessment of the physical, chemical, biological or economic factors affecting attainment of the uses of water bodies.
Use Classes	A broad capture of a designated use for general purposes such as recreation, water supply, and aquatic life.
Use Subclasses	A subcategorization of use classes into discrete and meaningful descriptions. For aquatic life this would include a hierarchy of warmwater and cold water uses and additional stratification provided by different levels of warmwater uses and further stratification by water body types.
TALU-Based Approach	The TALU-based approach includes tiered aquatic life uses (TALU) based on numeric biological criteria and implementation via an adequate monitoring and assessment program that includes biological, chemical, and physical measures, parameters, indicators and a process for stressor identification.
Tiered Aquatic Life Uses (TALUs)	As defined: The structure of designated aquatic life uses that incorporates a hierarchy of use subclasses and

stratification by natural divisions that pertain to geographical and water body class strata. TALUs are based on representative ecological attributes and these should be reflected in the narrative description of each TALU tier and be embodied in the measurements that extend to expressions of that narrative through numeric biocriteria and by extension to chemical and physical indictors and criteria.

As used: TALUs are assigned to water bodies based on the protection and restoration of ecological potential. This means that the assignment of a TALU tier to a specific water body is done with regard to reasonable restoration or protection expectations and attainability. Hence knowledge of the current condition of a water body and an accompanying and adequate assessment of stressors affecting that water body are needed to make these assignments.

Total Maximum Daily Load (TMDL) The maximum amount of a pollutant that a body of water can receive while still meeting water quality standards. Alternatively, a TMDL is an allocation of a water pollutant deemed acceptable to attain the designated use assigned to the receiving water.

Water Quality Standards (WQS) A law or regulation that consists of the designated use or uses of a water body, the narrative or numerical water quality criteria (including biocriteria) that are necessary to protect the use or uses of that particular water body, and an antidegradation policy.

Water Quality Management A collection of management programs relevant to a water resource protection that includes problem identification, the need for and placement of best management practices, pollution abatement actions, and measuring the effectiveness of management actions.

List of Acronyms

ALU	Aquatic Life Use
BCG	Biological Condition Gradient
BMPs	**Best Management Practices**
CFR	Code of Federal Regulations
CWA	Clean Water Act
EPT	Ephemeroptera, Plecoptera, Trichoptera
FIBI	Fish Index of Biotic Integrity
IBI	Index of Biotic Integrity
M&A	Monitoring and Assessment
MIBI	Macroinvertebrate Index of Biotic Integrity
MPCA	Minnesota Pollution Control Agency
MSHA	Minnesota Stream Habitat Assessment
NPDES	National Pollutant Discharge Elimination System
QHEI	Qualitative Habitat Evaluation Index
TALU	Tiered Aquatic Life Use
TMDL	Total Maximum Daily Load
UAA	Use Attainability Analysis
WLA	Waste Load Allocation
WQS	Water Quality Standards
WWTP	Wastewater Treatment Plant

Executive Summary

Background

Stream biology integrates watershed water quality conditions because biological communities integrate multiple stressors which occur at both local and watershed-level scales. Fish and macroinvertebrates communities have different ecological requirements, so they respond to different stressors thereby providing a more comprehensive measure aquatic life condition. Minnesota's water quality standards (WQS) are designed to protect aquatic life and apply to most waters of the state. However, the current WQS are not sufficient to protect or manage the wide diversity of aquatic resources in Minnesota and are in need of an update to improve water quality management outcomes.

Water Quality Standards

The objective of the Clean Water Act is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." As part of this objective, Minnesota protects all Class 2 waters for aquatic life. For example, cold water streams (Class 2A) are protected to "permit the propagation and maintenance of a healthy community of cold water sport or commercial fish and associated aquatic life and their habitats". To achieve protection of aquatic life designated uses, conditions are set using chemical, physical, and biological criteria, which are sometimes also referred to as standards. All three types of criteria are used, with chemical criteria historically the most prevalent. For example in cold water streams, these waters need to meet a minimum condition of 7.0 mg/L of dissolved oxygen to protect for fish growth and survival. Although historically less common, biological criteria or "biocriteria" have become more widespread because they have the advantage of directly measuring attainment of the aquatic life use. Because the designated use determines the criteria that are applied, it is imperative that the correct use is applied to a water body; otherwise management efforts could be less effective. The development and implementation of numeric biocriteria create the opportunity to improve WQS by refining uses for Minnesota's rivers and streams.

Overview of Tiered Aquatic Life Uses (TALU)

Tiered aquatic life uses or "TALU" are a water quality standard structure that is based on the biological potential of appropriately classified water bodies. The TALU framework recognizes that the ecological potential of a water body can legitimately vary in accordance with the natural features of aquatic ecosystems. This supports defining classes and subclasses of water bodies in accordance with their ecological attributes within a structure of designated aquatic life uses. In addition, TALUs for streams and rivers further refines Minnesota's WQS which recognizes that there are differences in the potential for restoration and protection among all waters. TALU achieves these goals by providing additional protection to high quality waters and setting more appropriate biological and chemical goals for waters impacted by historical impacts (for example channelized streams). TALUs are an outgrowth of the cumulative knowledge about aquatic ecosystems that have become central to aquatic ecological assessment and represent an integration of WQS and monitoring and assessment. Adoption within a TALU framework will provide a more direct assessment of the biological condition of

Minnesota's rivers and streams and will result in better environmental outcomes. This revision will only impact Minnesota's aquatic life uses (Classes 2 and 7) for streams and rivers.

Tiered Designated Uses and Criteria

As noted earlier, the existing WQS for protecting aquatic life uses are a statewide, one-size-fits-all approach. A In contrast, TALU is a framework of refined designated aquatic life uses and biological and chemical criteria that are linked to the condition of similar water bodies that are managed appropriately. This is achieved through *representative ecological attributes* that are reflected in the narrative description of each TALU tier and are protected by numeric biocriteria and by the associated chemical and physical indictors and criteria. TALUs are assigned to water bodies based on the protection and restoration of *ecological potential*. This means that the assignment of a TALU tier to a specific water body is done with regard to reasonable restoration or protection expectations and their attainability. Knowledge of the current condition of a water body and adequate assessment of stressors affecting that water body are needed to make these assignments. Conversely TALU does not provide a basis for *"user preferences"* (i.e., accommodations for effluent conveyance, drainage conveyance, land use practices, prior existing conditions). TALUs are based first on ecological attributes and potentials, not on the activities that affect a water body. They also do not serve as a rationale for the *a priori* relaxation of pollution controls or impairment determinations. Finally, a TALU framework does not provide an "easy exit" from an *impaired waters* listing. While TALU may provide more than one "choice" for WQS that determine TMDL listings and requirements, a rigorous and objective process of assessment is required (i.e., a TALU structured use attainability analysis [UAA]) to determine if the original basis for a TMDL needs to be reconsidered or revised. As a result, TALUs could affect existing pollution control or water quality management requirements that may not have been adequately considered in the development of existing requirements.

TALU Implementation Recommendations for Minnesota

It is recommended that Minnesota Pollution Control Agency (MPCA) adopt the framework of detailed narratives measured by numeric biological criteria as described in this report. The framework consists of a set of designated use subcategories within a framework of warmwater and cold water ecotypes. Added to this is the stratification provided by the stream classification structure for fish and macroinvertebrate assemblages and with numeric expectations being calibrated to water body class specific goals.

TALU Use Tier	Description
Exceptional	High quality waters
General	Good quality waters – Equivalent to Minnesota's current aquatic life use goal
Modified	Waters with modified habitat – Examples include channelized streams
Limited	Waters with limited habitat – Examples include ephemeral channelized streams and concrete revetments

The proposed framework has a number of implications for Minnesota's WQS and to programs associated with water quality management. As part of the development of a TALU framework, the MPCA has been working to develop new and improved tools and engaging with internal and external stakeholders to determine how TALU will be implemented in WQS programs. The goal is to develop the tools that will be employed to effectively and efficiently manage refined stream uses and will fit with existing programs. Some of the major implications of the TALU framework are as follows:

- **Exceptional Use Waters:** The designation of these high quality waters is based on the demonstration that the water body meets exceptional biological goals. These waters will need to be protected or restored using more stringent biological goals and for some pollutants, more stringent chemical standards.
- **Modified Use Waters:** These water bodies will be designated by demonstration that general use goals are not met and a UAA determines that the biology is limited by habitat that has been modified in a legal manner (e.g., legal under ditch law). To protect this use tier less restrictive biological criteria and some chemical criteria would be applied.
- **Limited Use Waters:** Limited use waters will be designated by demonstration that modified use goals are not met and a UAA determines that the biology is severely limited by habitat that has been modified in a legal manner (e.g., legal under ditch law). Many of these water bodies will be ephemeral. To protect limited Use waters they will need to meet chemical criteria that could be equivalent to the current Class 7 standard.
- **Monitoring and assessment:** The current intensive watershed management approach is sufficient to support a TALU framework, however the selection of monitoring stations and the number of stations could be increased to better address use designations and other water quality management activities (e.g., permitting).
- **Documentation of changes over time:** As part of a TALU monitoring and assessment program, incremental changes in water quality can be documented. This allows entities working to improve water quality to document and show progress toward a goal.
- **Stressor Identification and UAA Tools:** When the biology is determined to not be attaining the General Use, the MPCA will need to have the tools and knowledge to determine in a timely manner if a lower use is appropriate (i.e, UAA) and if the water body does not attain the designated use, what stressors are resulting in nonattainment. TALU incorporates the concept of pollution into assessments of condition and provides an opportunity to address the key stressors that are the most determinant of biological condition. In doing so, TALU allows assessment and water quality management efforts to focus on the correct problems
- **Data Management:** To support a TALU framework new database and GIS tools are needed to document designated uses, criteria, assessments, and other water quality management actions in these waters. This will need to include a transparent system that allows stakeholders to review and participate in decisions made in these waters.
- **How TALU Can Affect Major MPCA Water Quality Management Programs**: The data collected to support a TALU framework also provides information that can be integral for development of total maximum daily loads (TMDLs), watershed planning, Pollutant Discharge Elimination System (NPDES) permitting, and any other program that has the protection of designated aquatic life uses as a goal.

Adoption of TALU in Minnesota is planned for 2014. Through the adoption of a TALU framework for Minnesota streams, refined designated uses and their associated criteria will result in improved management of these systems by producing better more appropriate assessments of goals and by providing support to associated water quality management programs.

Framework and Implementation Recommendations for Tiered Aquatic Life Uses: Minnesota Rivers and Streams

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1. Introduction & Project Description

The Minnesota Pollution Control Agency (MPCA) is seeking to develop a framework for the development and adoption of tiered aquatic life uses (TALUs) for Minnesota rivers and streams. Specifically the MPCA requested that MBI assist with the following tasks:

1) Leading discussions regarding the regulatory and technical applications of biological standards and a TALU framework to internal and external stakeholder groups;

2) Identifying the implications of the proposed changes to each stakeholder's program activities and interests;

3) Developing an implementation plan for internal stakeholders that will suggest options to modify their programmatic activities in response to the new biological standards and TALU framework; and,

4) Providing technical assistance on biological criteria and TALU, including review and recommendations related to index of biotic integrity (IBI) development, the Biological Condition Gradient (BCG), habitat indicators of beneficial uses, impairment thresholds, and the other criteria used to designate an aquatic life use that are legally and scientifically defensible, environmentally effective, understandable by stakeholders, and amenable to implementation by a public agency.

In brief, the MPCA requested assistance for developing a framework for TALU and biological criteria for Minnesota rivers and streams. This entails the detailed description of designated use tiers (i.e., the narrative description of each), how biological criteria are derived for each tier, and how such a system of tiered uses and biocriteria can be implemented via monitoring and assessment to support all relevant water quality management programs. The full details of the work plan appear in Appendix A.

1.1 Project Accomplishments to Date

The MPCA TALU project was initiated by contract on February 18, 2008. Since that time several work plan tasks have been either fully or partially executed. These are summarized by work plan task as follows:

Task 1 – Internal and External Stakeholder Meetings

Between June and September 2008 a series of presentations about the basic fundamentals of a TALU-based approach[1] and the potential implications for changes to the Minnesota WQS were made to MPCA management and staff. These were intended to educate and inform MPCA about the basic principles of a TALU approach and to seek input from managers and staff about the potential impacts of TALU.

At about the same time a general presentation was made to invited external stakeholders. More detailed and focused stakeholder meetings were held in January 2009 at five regional MPCA locations across the state. This was followed up by a more detailed and focused series of meetings and presentations organized by major management programs and interests (e.g., municipalities, industries, stormwater interests, agricultural interests, state agencies, etc.). The feedback gained from these events was used to adjust and modify both the TALU work plan and the technical approach to developing the various tools and criteria that comprise a TALU approach.

Task 2 – Exploratory Data Analyses and Indicator Development

The work plan includes a series of technical development tasks to provide the tools and products that are seen as being essential for TALU development and implementation in Minnesota. These included five specific technical tasks:

Task 2a consisted of a detailed review of the MPCA biological indices and assessment criteria. This led to the revision of the statewide indices and their replacement with a set of fish and macroinvertebrate IBIs that were based on a natural classification scheme developed by MPCA staff. These indices are the basis of the numeric biocriteria that are an essential component of TALU-based biocriteria.

Task 2b consisted of a review of the current structure of designated aquatic life uses and how these might be changed by a transition to tiered uses. The results of that process are documented in this implementation plan and reflect the detailed narratives of the new TALU-based TALUs.

Task 2c consisted of the detailed development of a calibrated Biological Condition Gradient (BCG). This was accomplished under the leadership of Jeroen Gerritsen and included technical sessions with MPCA staff that resulted in the development of BCG levels for each fish and macroinvertebrate stream and river class. The principal product of this effort were detailed rules for the use of a fuzzy set model that is a key implementation mechanism for determining the BCG membership of a sample. This process produced a draft report that details these technical developments (Gerritsen et al. 2009).

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[1] The "TALU based approach" includes tiered aquatic life uses (TALU) based on numeric biological criteria and implementation via an adequate monitoring and assessment program that includes biological, chemical, and physical measures, parameters, indicators and a process for stressor identification.

Task 2d examined the comparability of boat electrofishing data collected by the MPCA and the MDNR. Each agency utilizes different sampling approaches and protocols. This task determined how comparable are the results, particularly in terms of using the MDNR data to determine attainment of the TALU-based biocriteria. This project was executed in 2010 and included a final report (Mueller et al. 2010).

Task 2e involved the development of detailed relationships between the MPCA fish and macroinvertebrate IBIs and metrics with the Minnesota Stream Habitat Assessment (MSHA) and its component attributes. This was accomplished by analyzing the extant MPCA statewide database and is needed to conduct the use attainability analyses (UAA) that are inherent to the implementation of a TALU-based approach. That project is nearing completion and is currently documented in a draft report by MBI (Rankin and Yoder 2011).

These are the principal technical products that are currently completed or near completion. Additional technical tasks are ongoing and include Tasks 4 and 5 that are detailed in a newly revised work plan (Appendix A).

2. Rationale for Tiered Aquatic Life Uses

Designated aquatic life uses are State or Tribal descriptions of the biological goals for their water bodies. Ideally, use designations are assigned to a water body based on the *potential* aquatic assemblage that can realistically be sustained given the regional reference condition and the level of protection afforded by the applicable criteria. The TALU framework recognizes that the ecological potential of a water body or can legitimately vary in accordance with the natural features of aquatic ecosystems. As such this supports defining classes and subclasses of water bodies in accordance with their ecological attributes and within a structure of designated aquatic life uses. U.S. EPA's current thinking (U.S. EPA 2005, 2011) is that a TALU framework can accomplish the following:

- accommodate and account for observable differences in expected biological condition in water bodies in different ecological regions;
- provide an objective means of describing the biological potential for a specific classes or subclasses of water bodies;
- recognize and accommodate observable differences in biological restoration potential among waters with different types and levels of legacy and background stressors;
- reflect an understanding of the relationship between stressors and biological community response (i.e., the BCG/human disturbance gradient [HDG] intersection);
- guide the selection of environmental indicators for monitoring and assessment and make fuller use of available biological data as an incremental measure of condition; and,
- better articulate a stressor-response model that maximizes the likelihood of success of water quality based management actions (WQS, assessment, 303[d] listings/Total Maximum Daily Load (TMDL), National Pollution Discharge Elimination System (NPDES) permits, nonpoint source assessment, stormwater management, etc.).

TALUs are an outgrowth of the cumulative knowledge about aquatic ecosystems that have become central to aquatic ecological assessment and are consistent with 30+ years of empirical observation. These include:

- surface waters and the biological assemblages they support are predictably and consistently different across the continent (stratification of ecotypes, classification along natural gradients, ecological regions concept);
- within the same ecological regions, different water body types (e.g., headwater streams, wadeable streams, small rivers, large rivers, lakes, reservoirs, wetlands, etc.) support predictably different compositional properties of key aquatic assemblages (water body classification);
- within a given class or subclass of water bodies, observed biological condition in a specific water body is a function of the level of stress (mostly of anthropogenic origin) to which the water body has been subjected (U.S. EPA's Biological Condition Gradient; Davies and Jackson 2006);

- similar stressors at similar intensities produce predictable and consistent biological responses in waters within a water body ecotype, and those responses can be detected and quantified along the BCG and also in terms of deviations from expected conditions (i.e., reference condition);
- water bodies exposed to higher levels of stress will exhibit biological performance that increasingly departs from the applicable reference condition than do waters exposed to lesser levels of stress (congruence of the BCG and the HDG; U.S. EPA 2005, Davies and Jackson 2006), and,
- the routine and systematic application of adequate monitoring and assessment (Yoder 1998) will generate sufficient data such that empirical relationships between biological condition and response and stressor/exposure variables can be produced and used to diagnose causes and set more detailed and stratified management criteria and goals; key to success in this function is the capacity to incrementally measure biological condition along the BCG (Yoder et al. 2008).

In essence TALUs represent a distinct refinement of the traditional application of general and fishery-based uses that are commonplace in state WQS and status-based monitoring and assessment. TALU brings about an integration of WQS and monitoring and assessment that generally does not exist under a general uses framework.

2.1 Defining TALUs

TALUs conjure up varied expectations among diverse stakeholder groups. This is likely because they represent both a change in the general operation of state water quality management programs and stand to alter certain decisions that were made on the basis of single-dimension uses and criteria. Hence it is important to clarify here what TALUs are and what they are not.

2.1.1 What TALUs Are

TALUs are a framework of refined designated uses and narrative and numeric biological criteria that are linked to the BCG. In brief, TALUs are:

- A reflection of the whole ecosystem. TALUs are based on *representative ecological attributes* and these should be reflected in the narrative description of each TALU tier and be embodied in the measurements that extend to expressions of that narrative through numeric biocriteria and by extension to chemical and physical indictors and criteria.
- Assigned to water bodies based on the protection and restoration of *ecological potential*. This means that the assignment of a TALU tier to a specific water body is done with regard to reasonable restoration or protection expectations and attainabilities. Hence knowledge of the current condition of a water body and an accompanying and adequate assessment of stressors affecting that water body are needed to make these assignments.

An acceptable TALU program will incorporate these properties into the narratives of the designated aquatic life use tiers, how the numeric biological criteria are derived, and how specific TALUs are assigned to specific water bodies.

2.1.2 What TALUs Are Not

While the incorporation of TALUs into a state's WQS may represent a modification in how water quality goals are visualized and how prior decisions were made, they *are not* intended to provide for, accommodate, or accomplish any of the following:

- TALUs do not provide a basis for *"user preferences"* (i.e., accommodations for effluent conveyance, drainage conveyance, land use practices, prior existing conditions, etc.) – TALUs are based on ecological attributes and potentials, not on the activities that affect a water body;
- TALUs do not serve as a rationale for the *a priori* relaxation of pollution controls – TALUs may affect existing pollution control or water quality management requirements making them more or less stringent depending on site-specific circumstances that may not have been adequately considered in the development of existing requirements; and,
- TALUs do not provide an "easy exit" from an *impaired waters* listing – while TALUs may now provide more than one "choice" for WQS that in turn determine TMDL requirements, a rigorous and objective process of assessment is required (i.e., a TALU structured use attainability analysis) to determine if the original basis for a TMDL needs to be reconsidered or revised.

This does not mean that TALUs might not play a role in resolving issues that include some of the above that have gone unresolved under a framework of general uses. Relative to how some decisions were made under such a system, some new decisions may be viewed as being more or less stringent. The more accurate view of such changes is that because these decisions are now based on a more rigorous and systematic assessment process and the closer approximation of true potential, that such represents neither an "upgrade" or "downgrade", but rather a more accurate reflection of verified potential and site-specific circumstances.

2.2 *Clean Water Act Goals – The "Drivers"*

A critical objective of the 1972 Clean Water Act (CWA) is to . . . "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (CWA sec 101[a][2]). In the scientific literature, an aquatic ecosystem that possesses chemical, physical, and biological integrity is described as being capable of "supporting and maintaining a balanced, integrated, adaptive community of organisms having a composition and diversity comparable to that of the natural habitats of the region" (Frey 1977). Over the intervening years, our understanding of how to define and measure the integrity of aquatic systems has been better developed. The term integrity has been further refined in the literature to mean . . . "a balanced, integrated, adaptive system having a full range of ecosystem elements (genes, species, assemblages) and processes (mutation, demographics, biotic interactions, nutrient and energy dynamics, metapopulation dynamics) expected in areas with no or minimal human influence" (Karr 2000). The aquatic biota residing in a water body are the result of complex and interrelated chemical, physical, and biological processes that act over time and on multiple scales (e.g., instream, riparian, landscape; Karr et al. l986; Yoder l995). By directly measuring the condition of the aquatic biota, we are able to more accurately define the aquatic community that is the "product" of these factors.

2.2.1 Water Quality Standards Overview

Section 101[a][2] of the CWA establishes broad national goals and objectives such as the chemical, physical, and biological integrity provision. Other sections of the CWA establish the programs and authorities for implementation of those goals and objectives. Section 303[c] sets up the basis of the current WQS program. WQS are parts of State (or, in certain instances, federal) law that define the water quality goals of a water body, or parts of a water body, by designating the use or uses of the water body and by setting criteria necessary to protect those uses. The standards also include an antidegradation policy consistent with 40 CFR Part 131.12.

In recognition of the uncertainties regarding the attainment of biological integrity, the CWA also established an interim goal for the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water as a guiding principle for the development of WQS. The interim protection and propagation goal for aquatic life has been interpreted by U.S. EPA to include the protection of the full complement of aquatic organisms residing in or migrating through a water body. The protection afforded by WQS includes a representative aquatic community (e.g., fish, benthic macroinvertebrates, algae, etc.), not just the protection of commercially important or special status (e.g., rare, threatened, endangered) species.

> "The fact that sport or commercial fish are not present does not mean that the water may not be supporting an aquatic life protection function. An existing aquatic community composed entirely of invertebrates and plants, such as may be found in a pristine tributary alpine stream, should be protected whether or not such a stream supports a fishery. Even though the shorthand expression 'fishable/swimmable' is often used, the actual objective of the Act is to restore the chemical, physical and biological integrity of our Nation's waters (Section 101[a][2]). The term 'aquatic life' would more accurately reflect the protection of the aquatic community that was intended in Section 101[a][2] of the Act." (Appendix G, EPA-823-B-94-005)

The representative assemblage of aquatic organisms residing in, or migrating through, a water body will vary depending on the water body type and other factors that are considered in the development and derivation of TALUs. For example, fish, benthic macroinvertebrates, and increasingly periphyton, are common aquatic assemblages that are typically measured by States and Tribes when assessing the condition of their streams and rivers. In headwater streams and many wetlands, amphibians are an important component of the biotic assemblages for this water body ecotype and functionally replace fish when they are absent or cannot be used as a reliable indicator assemblage. Hence the concept is clearly to protect the whole ecosystem and its representative attributes.

2.2.2 U.S. EPA "TALU Methods" Development

U.S. EPA has supported the development of state and tribal bioassessment programs via the production of methods documents, case studies, regional workshops, and evaluations of individual state and tribal programs since 1990 when they released national program guidance (U.S. EPA 1990). This was followed by a series of workshops, pilot program documents, and limited technical assistance to the states. In 2000, EPA convened an intensive developmental and implementation process for incorporating TALUs and numeric biocriteria in state and tribal water quality programs. This included a steering committee comprised of EPA staff, States, and active researchers and a working group comprised of EPA program and research staff, state managers, and leading academic researchers. This process culminated in the release of the document entitled *Use of Biological Information to Better define Designated Aquatic Life Uses in State and Tribal Water Quality Standards: Tiered Aquatic Life Uses (August 2005).* This document provides examples of practical and scientifically sound approaches to using biological information to tier designated aquatic life uses. As such U.S. EPA believes that the use of biological information can help improve water quality protection and encourages States and Tribes to incorporate biological information into their decision making processes.

The successful development and implementation of TALUs is directly dependent on the rigor, comprehensiveness, and integration of the bioassessment program as a component of the broader monitoring and assessment (M&A) and water quality standards (WQS) programs. The quality and make-up of these programs ultimately determines the quality and accuracy of the outputs of the primary water quality management programs such as NPDES permitting, TMDLs, nonpoint source management (319 program), and watershed planning. A TALU-based approach plays a key role in determining not only the WQS that are applied to a given management scenario, but also in determining the extent and severity of impaired waters through the application of numeric biocriteria via adequate M&A (Yoder and Barbour 2009). Hence the development and implementation of TALUs may alter prior determinations and actions that were based on general uses and less than adequate M&A.

2.2.3 State TALU Program Development

In addition to the U.S. EPA supported framework and tool documentation, selected states have implemented TALU-based programs. Ohio and Maine have the most tenured and mature programs and each has been described in detail in U.S. EPA (2005) and each state has posted their TALU documentation and program products on their respective websites[2].

EPA has supported a state program review process which has been conducted at least once with 22 different states and several tribes. An essential component of this review is determining a state's status in terms of meeting needs for developing and implementing a TALU-based approach to monitoring and assessment and WQS. A hypothetical timeline that describes the sequence of steps including the development of a baseline bioassessment program, initial support for management programs, development of biocriteria, increasingly

[2] Ohio EPA: http://www.epa.ohio.gov/dsw/bioassess/ohstrat.aspx;
Maine DEP: http://www.maine.gov/dep/water/monitoring/biomonitoring/index.html.

sophisticated support for all relevant water quality management programs, and long-term maintenance of a TALU-based program. The ultimate goal is use of biological information to more precisely define aquatic life uses and the development of numeric biological criteria (Figure 2-1). The essential first step is for a state to determine where their program is along this timeline. MPCA used this process to determine that rigor of their program in 2005 and what tasks were yet to be accomplished to reach the above stated goals. The next step is for the state to undergo a critical technical elements review (Yoder and Barbour 2009) that determines the technical level of rigor of the bioassessment program. This process helped MPCA produce a detailed work plan for the eventual development and adoption of numeric biocriteria and TALUs in their WQS, supported by a Level 4 program by 2013 (Table 5-1). This constitutes a working example of how states can use the results of the overall program review and critical technical elements process to develop a "blueprint" for making orderly improvements and attaining full TALU status.

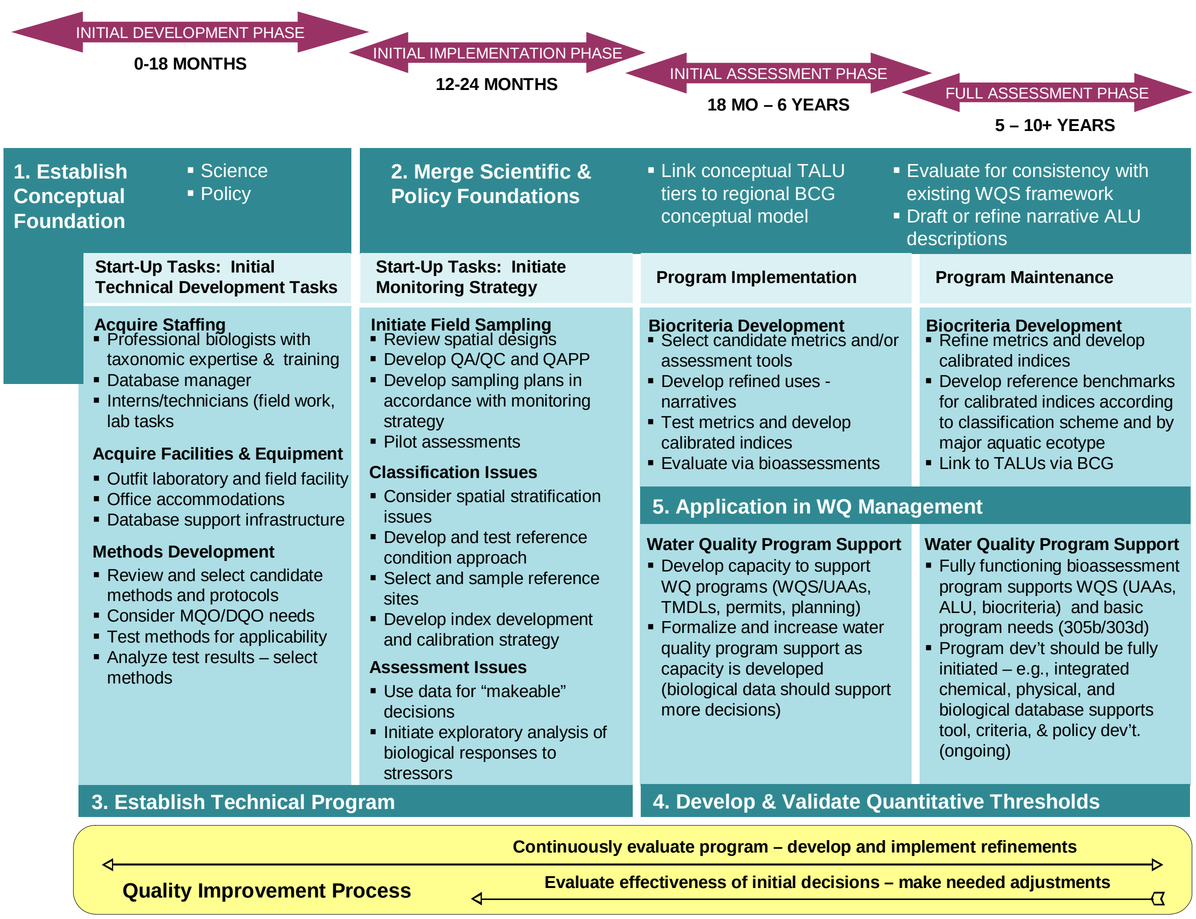


Figure 2-1. Timeline for full TALU program development and implementation intended to be used by States/Tribes to determine current program status with respect to the development and implementation goals of the TALU approach (from U.S. EPA 2005).

The results of the 22 state reviews indicate that 12 States function at a technical rigor consistent with a Level 2 program. Of the remaining States, two are consistent with a Level 4 program, and nine are at Level 3; no program is currently at Level 1. There were no strong geographic or jurisdictional patterns evident in the results. The relationship of the level of rigor to whether a state has or is capable of developing TALUs and numeric biocriteria is depicted in Table 2-1. Of the 22 states that have been part of the program evaluation process, two have fully developed TALUs and biocriteria in their WQS (each has a level 4 programs). One level 3+ program has TALUs in their WQS, but has not fully completed the process. Of the five other states that have TALU development programs in place (with the eventual adoption in their WQS as a goal) two are level 3+ and three are level 3. Only two of the remaining level 3 programs have no TALU developments underway at present. Of the remaining states that have no TALU development activities, all are level 2 programs.

Table 2-1. Status of state adoption and/or development of tiered aquatic life uses and numeric biological criteria in their water quality standards with respect to the latest level of rigor as determined by the critical technical elements process.

Level of Rigor [# states]	TALU in WQS	TALU in Development	None
L4 [2]	2		
L3+ [3]	1	2	
L3 [5]		3	2
L2 [12]			12
Total [22]	2	6	14

2.3 State Water Quality Standards

Although the CWA gives the U.S. EPA an important role in determining appropriate minimum levels of protection and providing national oversight, it also gives considerable flexibility and discretion to States and Tribes to design their own programs and establish levels of protection beyond a minimally acceptable program. Section 303 directs States and authorized Tribes to adopt WQS to protect public health and welfare, enhance the quality of water, and serve the purposes of the CWA. “Serve the purposes of the Act” (as defined in Sections 101[a][2], and 303[c] of the CWA) means that WQS should:

- include provisions for restoring and maintaining chemical, physical, and biological integrity of State and Tribal waters;
- provide, wherever attainable, water quality for the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water (i.e., “fishable/swimmable”); and,
- consider the use and value of State and Tribal waters for public water supplies, propagation of fish and wildlife, recreation, agricultural and industrial purposes, and navigation.

State WQS provide an important foundation for water quality-based management programs. With the public participating in their adoption (see 40 CFR 131.20), such standards serve the dual purposes of establishing the water quality goals for specific water bodies and serving as the regulatory basis for the establishment of water quality-based management strategies beyond the technology-based levels of treatment required by Sections 301 and 306 of the CWA.

WQS are an integral part of state water quality management programs under the CWA. Designated or beneficial uses are intended to describe the existing and potential "uses" of a water body and as such establish and articulate the goals for a water body. The attendant chemical, physical, and biological criteria are intended to provide the measurable properties of the designated use and can be used to measure existing quality and to develop requirements for managing activities that impact the quality of that water body. Criteria have predominantly been written in chemical concentration terms, but also have included physical properties and narrative statements of desired conditions. In 1990 U.S. EPA issued national guidance for the development and adoption of biological criteria recommending that states adopt narrative biocriteria by 1993 and numerical biological criteria by 1996 (U.S. EPA 1990). As such biological criteria represent a significant advancement over a purely chemical approach to WQS by incorporating a more complete and reliable measure of designated use attainment status (Rankin 2003; Yoder 1995) and incorporating monitoring and assessment as an integral part of the overall process of defining and setting designated aquatic life uses.

2.3.1 Designated Uses

It is in designating uses that States and Tribes establish the environmental goals for their water resources and then measure attainment of these goals. In designating uses, a State or Tribe weighs the environmental, social, and economic consequences of its decisions. The regulation allows the State or Tribe, with public participation, some flexibility in weighing these considerations and adjusting these goals over time. However, reaching a conclusion about the uses that appropriately reflect the current and potential future uses for a water body, determining the attainability of those goals, and appropriately evaluating the consequences of a designation can be a difficult and controversial task. A principal function of designated uses in WQS is to communicate the desired state of surface waters to water quality managers, the regulated community, and the interested public. An effective designated use system is one that translates readily into indicators (e.g., numeric water quality criteria, biological indices) that respond in predictable ways to stress and can be evaluated using data collected from the water body. Experience with implementation of various State designated use systems suggests that, regardless of the system employed, States that use biological data as part of their assessment program apply some type of refined, or tiered, aquatic life use approach to guide interpretation of their biological data. Some states have either made this explicit by adopting the tiers directly into their WQS as designated uses or implicit by using tiers in their monitoring and assessment protocols. Although the benefits of more specificity may apply to any of the designated uses described in CWA section 303, it may be most relevant for aquatic life uses.

A water body's designated use(s) are those uses specified in WQS, whether or not they are being attained (40 CFR 131.3[f]). The "use" of a water body is the most fundamental description of its role in the aquatic and human environments. All of the water quality protections established by the CWA emanate from the water body's designated use. As designated uses are critical in determining the water quality criteria that apply to a given water body, determining the appropriate designated use is of paramount importance in establishing criteria that are appropriately protective of that designated use. Section 131.10 of the regulation describes the State's responsibilities for designating and protecting uses. The regulation requires or allows for:

- that States and Tribes specify the water uses to be achieved and protected;
- protection of downstream uses;
- establishing sub-categories and seasonal uses;
- the definition of criteria for determining attainability;
- the consideration of six factors of which at least one must be satisfied to justify the removal of a designated use that is not an existing use;
- the maintenance of existing uses;
- the upgrading of uses that are presently being attained but which are not designated; and,
- the establishment of conditions and requirements for conducting use attainability analyses (UAAs).

In addition, the regulations effectively establish a "rebuttable presumption" that uses consistent with the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water are attainable and should apply to all water bodies, unless it has been demonstrated that such uses are not attainable via an acceptable UAA process. The classification of the waters of a State must also take into consideration the use and value of the water body for public water supply, protection and propagation of fish, shellfish, and wildlife, recreation in and on the water, and agricultural, industrial, and other purposes, including navigation.

Changes to the designated use(s) of a specific water body are subject to U.S. EPA review and approval (40 CFR 131.21). The regulations allow States to subcategorize or refine the aquatic life use designations for a water body and set the appropriate criteria to reflect the varying needs of such subcategories of uses (see 40 CFR 131.10[c]). While this has generally been described as differentiating such broad concepts as cold water and warm water fisheries, the implications are such that it can extend to more detailed distinctions provided the mechanisms are consistent and sufficiently predictable. As such this is what a TALU framework offers in the way of refining designated uses.

2.3.2 Aquatic Life Uses

Aquatic life uses are a significant component of state WQS. They are intended to provide for the restoration and protection of aquatic life in all surface water bodies as has already been described. Designated aquatic life uses are the most broadly applicable of all designated uses and the application of the criteria usually result in the most stringent requirements for water quality management. While criteria for other uses may have lower concentrations, aquatic life are generally applied at critical low flows which translates to lower discharge loading allowances. This is especially true of water quality based limitations for NPDES permits under steady-state assumptions of receiving water dilution and effluent flows. The management requirements for the most widely applicable chemical/physical parameters such as dissolved oxygen (D.O.), ammonia-N, temperature, and common heavy metals are generally dictated by aquatic life protection endpoints. Exceptions to this are bioaccumulative parameters such as mercury and PCBs which are usually dictated by human and wildlife health effects. Nevertheless, virtually all water quality management issues will involve requirements for the protection of aquatic life. More recently criteria based directly on attributes of the aquatic biota have been developed. Termed biological criteria these are based on sampling of aquatic assemblages and employ numeric indices that are anchored in regional reference conditions and developed and calibrated to provide a linear measure of ecological quality across the entirety of the stressor gradients that impact aquatic systems. Where they have been developed and used in a systematic monitoring and assessment program the result is a more comprehensive approach to water quality management and more accurate and comprehensive criteria including previously deemphasized components such as habitat, flow, and more importantly their interactions with chemical/physical attributes.

2.3.3 Tiered Aquatic Life Uses (TALUs)

It has been long established that aquatic communities can vary significantly from water body to water body hence it makes equivalent sense that the goals set for each can likewise vary – that is one of the major tenets of the TALU framework. A major challenge in assigning designated use tiers is distinguishing the natural variability that is a function of aquatic ecotype (e.g., cold water vs. warmwater, headwater vs. large river, high gradient vs. low gradient wetland dependent streams) and geographic location (e.g., ecoregions) from the variability that results from exposure to stressors. By accounting for natural variability in aquatic systems via stratification of similar attributes and expectations, biologically-based TALUs account for a major source of uncertainty and error in otherwise one-size-fits-all water quality management efforts. TALU is an enhancement of the rote replication of CWA section 303 uses in that it is a more refined framework that expresses designated uses in very specific terms and includes subclassifications that also exact different levels of protection. TALU includes subcategories based on aquatic assemblage types, including descriptions of the core assemblage attributes that are representative of each subcategory (e.g., cold water and warmwater fisheries).

States and Tribes have adopted varying levels of TALUs in their programs. These range from what is effectively informal policy application via monitoring and assessment to narrative biocriteria to the full adoption of TALUs and numeric biocriteria. Most are presently developing the technical program in an effort to further tighten the linkage between their narrative use statements and numeric biological criteria (U.S. EPA 2002). Thus far three States (Maine, Ohio, and Vermont) have either sufficiently developed both their technical program and WQS rule language to qualify as "TALU States". While their approaches for tiering aquatic life uses may differ in detail and bioassessment methods, their TALU frameworks share the following core elements:

- Biological information is the basis for the use designations.
- Numeric biological indicators or biocriteria are developed for each use.
- Development of tiers is based on data from comprehensive, robust monitoring program.

The insights and experiences from States and Tribes that have adopted TALUs and numeric biocriteria in their WQS, as well as from those currently developing biological assessment and criteria programs, reveal the values of TALUs implemented in State and Tribal WQS (Table 2-2).

2.3.4 TALU Options for States

A TALU approach describes ecologically-based subcategories of water body types, such as A, B, C or descriptive titles such as Warmwater Habitat, Exceptional Warmwater Habitat, Modified Warmwater Habitat, etc. Furthermore, subclassifications within each subcategory that pertain to regionally specific (i.e., ecoregions, subregions, bioregions) or other attributes (i.e., stream size, gradient, temperature) are assigned as each is apparent in the development and application process. Also, to the extent that there are other waterways that may share the same characteristics, an approach that describes categories and subcategories of use classifications in sufficient detail allows similar waterways to be consistently and predictably classified, thereby eliminating the need or risk of having to continually develop "new use classification categories" via a site specific UAA process. This is a more workable and clearer approach to establishing a multi-tiered use classification system under state water quality regulations. As we have learned via the state program evaluation process (e.g., including the critical technical elements evaluation; Yoder and Barbour 2009) most state aquatic life use designations are either too vague, too broad, or rely too much on site-specific assumptions rather than the above described classification and subclassification scheme. Furthermore, by integrating the task of determining the appropriate classification of specific water bodies with a routine spatial monitoring and assessment program the task of vetting the appropriateness of a use designation is resolved ahead of its use in water quality management (e.g., NPDES permits, TMDLs). One problem with most conventional UAAs at present is that they are initiated by the realization that the use designation may be inappropriate as revealed by the application of a TMDL or permit, which places an inappropriate burden on the WQS program and not enough on the M&A program to resolve these issues ahead of their application in WQ management.

Based on past and current practice among states that use biological data at some level to make assessment decisions, there are four options that are available (Figure 2-2). These include:

1. Applying biological data as described in methods or guidance manuals for making general decisions about water body status, mostly for 305b/303d purposes, and under a "one-size-fits-all" general or fishery based use designation framework;

2. Applying biological data under a specific policy adopted by the state for the use of such data to make decisions;

3. Adoption of a narrative biocriterion in the WQS that consists of qualitative goal statements for biological condition and a translator mechanism adopted as policy for applying biological data to make decisions; and,

Table 2-2. The value added features of a TALU-based framework in a state water quality management context with references to applicable EPA regulations (after U.S. EPA 2005, Table 1-2).

Value-added Attribute	Explanation	Supporting WQS Regulation
Set more appropriate designated ALUs	Define ALUs in a more precise way that is nether under-protective of existing high quality resources nor overprotective for waters that have been extensively or irretrievably altered.	40 CFR 131.10 40 CFR 131.12 (protect high quality waters) 40 CFR 130.23 (Support attainment decisions and diagnose causes)
Strengthen the linkage between designated ALUs and how attainment is assessed	TALUs help to clarify and refine water quality goal statements so numeric biological, chemical, and physical criteria can be adopted to protect the use.	40 CFR 131.10 40 CFR 131.12 (protect high quality waters) 40 CFR 130.23 (Support attainment decisions and diagnose causes)
Enhance public understanding and participation in setting water quality goals	TALUs provide a common frame of reference for generic yardstick to more clearly recognize common ground and differences in desired environmental goals of various stakeholders as designated uses are adopted.	40 CFR 131.20[a][b]

4. Adoption of TALUs that represent detailed narrative goal statements for biological tiers that are directly relevant to the Biological Condition Gradient and as measured by numeric biological endpoints that serve as quantitative measures of attainment of each tier; the narrative language should specify how the numeric endpoints are derived in terms of resource stratification and reference thresholds and how they are to be measured; the numeric endpoints are adopted as biocriteria in the WQS.

Options 1 and 2 seem to be the "easiest" to implement, but they lack a firm regulatory foundation and may be seen as being "optional" for decision-making. Option 3 provides for a direct link to the WQS, but it lacks the specificity needed for applying TALUs and for supporting certain regulatory decisions - it can also encumber a "rule by reference" label. Option 4 may be the more "difficult" and time consuming to develop and implement, but it provides the strongest and most compelling legal foundation.

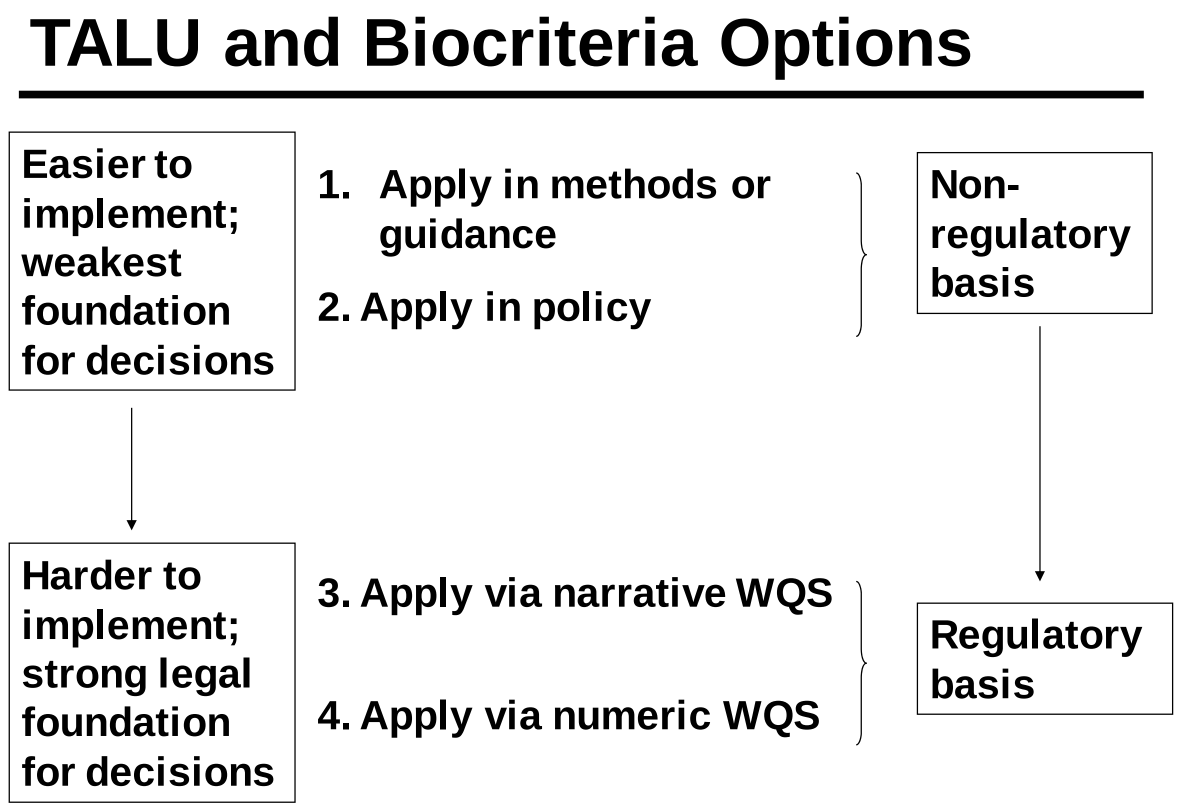


Figure 2-2. Options presently available to states and tribes for developing and implementing biological criteria and tiered aquatic life uses. The numbers correspond to the discussion of each in the text.

2.3.5 Narrative and Numeric Biocriteria

Elements of a narrative biocriterion generally include the following:

- Waters of the State shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.
- Without detrimental changes in the resident biological communities *means no loss of ecological integrity when compared to natural conditions at an appropriate reference site or region.*
- Ecological integrity *means the summation of chemical, physical, and biological integrity capable of supporting and maintaining a balanced, integrated adaptive community of*

> *organisms having a species composition, diversity, and functional organization comparable to that of natural habitats in the region.*

Narrative biocriteria necessarily contain general language (e.g., without detrimental change) that cannot be precisely measured, thus a numeric translator is required and is usually implemented via a policy statement and/or methods guidance. While the above narrative contains the appropriate ecological intent and language, it lacks the quantitative aspects of what EPA expects for a TALU.

Numeric biological criteria require additional defining language in the designated use narrative that pertains to stratification between different types of streams and rivers (e.g., headwaters, small streams, large rivers, great rivers, etc.), ecotype specificity (cold and warmwater, low or moderate gradient, etc.) biogeographical regions, and the level of protection afforded by tiered uses as illustrated by the following example from the Ohio WQS (Warmwater Habitat use tier):

> "Warmwater" – these are waters capable of supporting and maintaining a balanced, integrated, adaptive community of warmwater aquatic organisms having a species composition, diversity, and functional organization comparable to the twenty-fifth percentile of the identified reference sites within each of the following ecoregions: the interior plateau ecoregion, the Erie/Ontario lake plains ecoregion, the western Allegheny plateau ecoregion and the eastern corn belt plains ecoregion. For the Huron/Erie lake plains ecoregion, the comparable species composition, diversity and functional organization are based on the ninetieth percentile of all sites within the ecoregion. For all ecoregions, the attributes of species composition, diversity, and functional organization will be measured using the index of biotic integrity, the modified index of well-being, and the invertebrate community index as defined in "Biological Criteria for the Protection of Aquatic Life: Volume II, Users Manual for Biological Field Assessment of Ohio Surface Waters," as cited in paragraph (B) of rule 3745-1-03 of the Administrative Code. In addition to those water body segments designated in rules 3745-1-08 to 3745-1-32 of the Administrative Code, all upground storage reservoirs are designated warmwater habitats. Attainment of this use designation (except for upground storage reservoirs) is based on the criteria in Table 7-14 of this rule. A temporary variance to the criteria associated with this use designation may be granted as described in paragraph (F) of rule 3745-1-01 of the Administrative Code.

This represents a fully developed TALU narrative that accomplishes the following:

- it defines the overall goal of the TALU tier;
- it identifies and quantifies the reference benchmarks that correspond to this TALU tier;
- it explicitly states a linkage to the accepted methodologies;
- it explains the relationships with other non-aquatic life uses and any exceptions;
- it states any variance provisions; and,

- it references the quantitative numeric biological criteria and these are further stratified by water body ecotype and ecological region.

When combined with a systematic and routine re-sampling of regional reference sites it sets the stage for potential future revisions based on any cues from empirically measured reference condition. In this case the regional reference sites are re-sampled once every ten years.

2.3.6 Biocriteria Application Language in WQS
Biocriteria are a relatively new concept in WQS and they serve primarily as a direct measure of aquatic life use attainment status hence their application in water quality management needs to be defined. This will also clarify their relationship with other chemical, physical, and narrative water quality criteria. We recommend that this be accomplished by appropriately modifying the already detailed application language in the Minnesota WQS (7050.0150). Such language indicates the most commonly occurring options that are available to the state (i.e., the Director, Board, Commissioner, etc.) when biocriteria indicate attainment and non-attainment of aquatic life uses. This also presumes that the state is operating a bioassessment program that is consistent with at least an upper Level 3 and preferably Level 4 under the U.S. EPA *Critical Technical Elements of a Bioassessment Program* (Barbour and Yoder 2008; Yoder and Barbour 2009) and is implemented following the principles of Adequate Monitoring and Assessment (Yoder 1998). Less rigorous programs will simply not be equipped to reliably produce the assessment outcomes and implement the management options that are detailed by the following guidelines. The biocriteria implementation language should explicitly emulate the following and also include detailed options for various management responses:

1) **Define what role the biological criteria will play in the WQS**: This includes stating the extent of their "presumptive applicability", i.e., the biological criteria provide a direct measure of the attainment of the specified designated aquatic life use tiers (i.e., in lieu of a former reliance on chemical/physical surrogates).

2) **State the data requirements**: This includes how the determination of aquatic life use attainment status and the accompanying stressor identification processes are executed. Options include:

    - Frequency, magnitude, and duration provisions – while biocriteria inherently transcend these existing issues that are common to chemical/physical surrogate indicators, a clear statement about what comprises an exceedence is needed;
    - For multiple assemblage assessments (at least two assemblages comprise a level 4 program) mixed findings by each assemblage will need to be addressed;
    - Tier-specific provisions, i.e., higher than CWA minimum use tiers will require a showing of attainment by both assemblages.

3) **State the options for a finding of full attainment**: This includes stating the relationship of biological criteria to other water quality criteria including chemical-specific, narrative, and whole effluent toxicity criteria and endpoints. Management response options include:

- Designating biocriteria as the preferred arbiter of aquatic life use attainment.
- Detailing options for chemical/physical and whole effluent criteria when these are exceeded to include alternate management responses consistent with the biocriteria attainment, revising reasonable potential assumptions within a WLA or TMDL, conducting a site-specific criteria modification, or developing a UAA.

4) **State the options for a finding of non-attainment**: This includes any situation, in which the biocriteria indicate non-attainment, including when the biocriteria are the only indication of non-attainment. Management response options can include:

- A UAA will be conducted to determine the attainability of the designated use tier that is currently assigned to the water body(ies) in question; this will be especially important in previously unassessed, inadequately assessed, and/or default use designated waters.
- The appropriate use will be established prior to new or additional regulatory or management actions.
- When the appropriate use tier is established, the cause(s) of any biocriteria non-attainment *will be* determined based on an *adequate* assessment of the river or stream segment subject to the application of the WQS and subsequent management actions (i.e., NPDES permit, TMDL, 401 certification, stormwater permitting, etc.); designating biocriteria impairments with unknown causes should be extremely rare in this process.
- This is not a justification to supersede other management policies such as anti-backsliding.

Furthermore, language about how a finding of biocriteria non-attainment will affect the consideration of additional regulatory controls on permitted point sources is usually requested to clarify the relationship to a previously issued NPDES permit. Additional permit requirements are based on the following assessment and will generally not be imposed unless:

- The point source is reasonably shown to be a contributing cause to the biocriteria non-attainment; this can include the showing of non-attainment triggering a review of prior reasonable potential determinations or other WLA assumptions.
- The application of alternate treatment/control technologies can reasonably be expected to restore the impaired status.
- Due consideration has been given to the technological and economic feasibility of alternate treatment/control technology required to attain the limitations imposed by this process.

The above comprise the principles by which TALU narratives, numeric biological criteria, and specific application language can be written in the Minnesota WQS. However, given that the Minnesota WQS already include a structure of aquatic life uses, narrative biological criteria, and language for the application of chemical, physical, and biological monitoring data in making use assessments, that existing structure will need to be considered in adapting the new TALUs and numeric biocriteria within that existing framework.

3. A TALU Framework for Minnesota

An important objective of this project is to describe a detailed framework of TALUs and biological criteria for Minnesota rivers and streams. Furthermore, it is implied that such a framework should be consistent with current and emerging U.S. EPA guidance (e.g., U.S. EPA 2005), published methods (e.g., Davis and Simon 1995), and the precedents established by other states that are developing (e.g., Illinois, Vermont, Florida, California), or that already have adopted tiered uses and biocriteria in their WQS (e.g., Ohio, Maine). U.S. EPA, Region V initiated a process in 2002 by which the status of the monitoring and assessment, bioassessment, and WQS programs of the six state's (including Minnesota) would be assessed and in relation to their capacity to support TALU development and implementation. This was initially detailed in a 2004 status report (MBI 2004) and in two major workshops and follow-up visits to each state including Minnesota.

3.1. Minnesota WQS

The primary objective of the CWA is the restoration and maintenance of the chemical, physical and biological integrity of the Nation's waters. States are responsible for adopting and revising WQS and must consider their use and value in protecting public water supplies, propagation of fish and wildlife, recreation, agriculture, industrial and navigation purposes. Minnesota adopted a beneficial use framework that includes uses for drinking water, aquatic life and recreation, industry, agriculture and wildlife, aesthetic enjoyment and navigation, limited resource value waters and other uses. Implicit in the CWA and the federal regulations was the presumption that the aquatic life use should be considered attainable unless proven otherwise through the completion of a use-attainability analysis. Thus, in Minnesota, all waters are considered fishable and swimmable with the exception of waters designated as limited resource value waters (Class 7), which are protected for secondary body contact only.

The Minnesota WQS are codified in the Minnesota Administrative Rules at Chapter 7050, Waters of the State. Parts 7050.0130 to 7050.0227 apply to all waters of the state, both surface and underground. This includes a classification system of beneficial uses applicable to waters of the state, narrative and numeric WQS that protect specific beneficial uses, antidegradation provisions, and other provisions to protect the physical, chemical, and biological integrity of waters of the state. Parts 7050.0400 to 7050.0470 classify all surface waters within or bordering Minnesota and designate the beneficial uses for which these waters are protected. This applies to point source and nonpoint source discharges and to the physical alterations of wetlands. Other water quality rules of general or specific application that include any more stringent WQSs or prohibitions are preserved.

The WQS exist in part for Minnesota to meet the goals of the Federal CWA. With respect to the protection of aquatic life, the Minnesota WQS comprise what we refer to as a "general use" framework in which the designated use consists of a generalized statement of intent and the accompanying criteria are comprised of a list of chemical and physical parameters. The beneficial uses are codified at Chapter 7050.0140 and include the protection of aquatic life, recreation, water supply, and fish consumption and they are specified across seven distinct classes as follows:

> ***Subpart 1. Introduction.*** *Based on considerations of best usage and the need for water quality protection in the interest of the public, and in conformance with the requirements of Minnesota Statutes, section 115.44, the waters of the state are grouped into one or more of the classes in subparts 2 to 8. The classifications are listed in parts 7050.0400 to 7050.0470. The classifications should not be construed to be in order of priority, nor considered to be exclusive or prohibitory of other beneficial uses.*
>
> ***Subpart 2. Class 1 waters, domestic consumption.***
> *Domestic consumption includes all waters of the state that are or may be used as a source of supply for drinking, culinary or food processing use, or other domestic purposes and for which quality control is or may be necessary to protect the public health, safety, or welfare.*
>
> ***Subpart 3. Class 2 waters, aquatic life and recreation.***
> *Aquatic life and recreation includes all waters of the state that support or may support fish, other aquatic life, bathing, boating, or other recreational purposes and for which quality control is or may be necessary to protect aquatic or terrestrial life or their habitats or the public health, safety, or welfare.*
>
> ***Subpart 4. Class 3 waters, industrial consumption.***
> *Industrial consumption includes all waters of the state that are or may be used as a source of supply for industrial process or cooling water, or any other industrial or commercial purposes, and for which quality control is or may be necessary to protect the public health, safety, or welfare.*
>
> ***Subpart 5. Class 4 waters, agriculture and wildlife.***
> *Agriculture and wildlife includes all waters of the state that are or may be used for any agricultural purposes, including stock watering and irrigation, or by waterfowl or other wildlife and for which quality control is or may be necessary to protect terrestrial life and its habitat or the public health, safety, or welfare.*
>
> ***Subpart 6. Class 5 waters, aesthetic enjoyment and navigation.***
> *Aesthetic enjoyment and navigation includes all waters of the state that are or may be used for any form of water transportation or navigation or fire prevention and for which quality control is or may be necessary to protect the public health, safety, or welfare.*
>
> ***Subpart 7. Class 6 waters, other uses and protection of border waters.***
> *Other uses includes all waters of the state that serve or may serve the uses in subparts 2 to 6 or any other beneficial uses not listed in this part, including without limitation any such uses in this or any other state, province, or nation of any waters flowing through or originating in this state, and for which quality control is or may be necessary for the declared purposes in this part, to conform with the requirements of the legally constituted state or national agencies having jurisdiction over such waters, or for any other considerations the agency*

may deem proper.

Subpart 8. Class 7 waters, limited resource value waters.
Limited resource value waters include surface waters of the state that have been subject to a use attainability analysis and have been found to have limited value as a water resource. Water quantities in these waters are intermittent or less than one cubic foot per second at the $7Q_{10}$ flow as defined in part 7050.0130, subpart 3. These waters shall be protected so as to allow secondary body contact use, to preserve the groundwater for use as a potable water supply, and to protect aesthetic qualities of the water. It is the intent of the agency that very few waters be classified as limited resource value waters. The use attainability analysis must take into consideration those factors listed in Minnesota Statutes, section 115.44, subdivisions 2 and 3. The agency, in cooperation and agreement with the Department of Natural Resources with respect to determination of fisheries values and potential, shall use this information to determine the extent to which the waters of the state demonstrate that:

A. *The existing and potential faunal and floral communities are severely limited by natural conditions as exhibited by poor water quality characteristics, lack of habitat, or lack of water;*

B. *The quality of the resource has been significantly altered by human activity and the effect is essentially irreversible; or*

C. *There are limited recreational opportunities, such as fishing, swimming, wading, or boating, in and on the water resource.*

The conditions in items A and C or B and C must be established by the use attainability analysis before the waters can be classified as limited resource value waters.

This framework and implementation plan will deal primarily with subparts 3 and 8 (Class 2 and 7) in terms of how a TALU-based approach will be structured by the Minnesota WQS. The current Minnesota WQS include specific classes for aquatic life and primarily for distinctions between warmwater and cold water aquatic life in subpart 3. These are currently defined at 7050.0222 "Specific WQS for Class 2 waters of the state; aquatic life and recreation" as follows:

Subpart 2. Class 2A; Aquatic Life Cold water Habitat *The quality of Class 2A surface waters shall be such as to permit the propagation and maintenance of a healthy community of cold water sport or commercial fish and associated aquatic life, and their habitats (see definitions in subp. 2b). These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable. This class of surface waters is also protected as a source of drinking water.*

Subpart 4. Class 2B; Aquatic Life Warmwater Habitat. *The quality of Class 2B surface waters shall be such as to permit the propagation and maintenance of a healthy community* *of cool or warm water sport or commercial fish and associated aquatic life, and their habitats (see definitions in subp. 4b). These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable. The applicable standards are given below.*

Proposed new tiered uses will replace these "general" uses and follow the rationale described in Sections 3.1.1. and 3.1.2 as follows. In addition, we recommend that Class 7 be eliminated and replaced by the new tiered uses. Existing Class 7 waters will be evaluated the same as current 2A and 2B waters via the UAA process described in Section 4.

3.1.1 The Need for a Minnesota TALU Framework

Over the past 30+ years the Minnesota WQS have been modified to reflect more recent scientific understanding of certain criteria in order to better protect both human health and aquatic life. However the current aquatic life use framework has not reflected the most recent advances in our understanding of the CWA aquatic life goals and how to achieve them. MPCA has initiated a long term project to develop and implement a TALU-based approach to WQS and monitoring and assessment. Minnesota is working to revise its WQS (MN Rule Chapter 7050) to incorporate a TALU framework for rivers and streams in the state. The TALU framework represents a significant revision to the WQSs of the state's aquatic life use classification. The TALU framework builds upon existing WQSs with a goal of improving how water resources are monitored and managed. Additionally, these changes advance the ability to identify "stressors" and develop effective mechanisms to improve and maintain the condition of waters in the state of Minnesota.

The CWA requires states to assign beneficial uses to water bodies and to develop WQS to protect those uses. Most surface waters in Minnesota are protected for aquatic life and recreation, which means they must be "fishable and swimmable". There are two primary sub-classes of streams protected for aquatic life including a cold water stream class (2A) and a warmwater stream class (2B). While the current system of beneficial uses and WQS has served Minnesota well, advances in the fields of biological assessment and stream ecology have led to the recognition that all waters are not the same and that there exists a diversity of the water body types. For example, within rivers and streams, factors like water body size, geographic location, hydrology, water temperature, and stream gradient influence chemical, physical and biological composition. The inherent differences in water bodies combined with a rigid and inflexible set of standards and beneficial uses have led to chemical and biological goals that are often under protective of the highest-quality resources and overprotection of some water bodies that for various reasons will likely never achieve certain chemical and biological standards. In short, MPCA now recognizes that proper management of our water bodies requires a more considered and comprehensive approach, one in which the goals are tailored to specific water body types and uses. In response to these challenges, MPCA is proposing to modify the beneficial use framework for aquatic life. The new TALU framework would allow for better goal-setting processes through the application of a framework that recognizes tiers, or levels of aquatic life-use based on a stream's type and potential. For example, under a tiered system of aquatic life uses, our highest-quality rivers and streams might belong to an "exceptional use" subclass, with water chemistry and biological standards designed to protect the higher use. Additionally, under a TALU framework, uses could be designed to more appropriately reflect the potential of channelized streams and ditches. The fundamental goal of TALU is to set biological and chemical goals that are protective, yet attainable following U.S. EPA guidelines for conducting use attainability analyses (UAA). The TALU framework fully complies with CWA requirements which allow for the establishment of subcategories of the major uses, as long as existing uses are protected. At the same time, it allows MPCA to utilize the latest scientific knowledge to develop appropriate standards and uses and meet the increasingly complex challenges of protecting our water resources.

Traditionally, aquatic life has been protected primarily through the application of water chemistry based standards. For example, the Minnesota standard for dissolved oxygen in all non-cold water streams is 5 parts per million (ppm). These chemically-based standards have been, and will remain, an important aspect of our protection measures. However, the addition of biological monitoring and biological standards will complement and enhance the chemical standards by:

- Providing a direct way to monitor, assess, and ultimately to protect aquatic life.
- Providing a mechanism to identify water quality problems that chemical measurements might miss or underestimate.
- Improving our ability to accurately identify the wide diversity of stressors that impact Minnesota's water resources.

Even if Minnesota recognized aquatic life as a stand-alone use designation, it would not completely satisfy the interim goal of the CWA for states to support healthy, self-sustaining populations of fish, shellfish and other aquatic life in surface waters. While it has been recognized for some time that there is natural variability within aquatic assemblages in Minnesota streams, the current WQS do not adequately reflect the detail of those differences. These include differences in habitat types (i.e., stream size, substrates, flow regime, thermal regime, etc.) and patterns of geological and geographical attributes across the state. MPCA engaged in a process to incorporate this in the development of revised biological indices (i.e., the partitioning accomplished by stream and river classes) as a necessary first step towards adopting a TALU framework in the Minnesota WQS. Furthermore, present assessments of aquatic life use attainment are based on a simple pass/fail framework, even though the stratification accomplished by the biological index refinements is an advancement over applying a uniform statewide IBI. Within the water bodies that are considered to be fully attaining the current set of general aquatic life uses, some have inherently better water quality and biodiversity than others. As such a one-size-fits-all aquatic life use framework is unable to distinguish an adequate level of protection for these higher quality waters. Conversely, it could also result in waters that are of an inherent or irretrievably lower quality being listed as impaired because of unrealistic expectations. This can result in water quality management resources being devoted to issues with a minimal or no environmental return on investment.

Once a TALU framework for Minnesota is developed and implemented a "one-size-fits-all" approach may still be applicable for some numeric chemical criteria such as xenobiotic and bioaccumulative substances. However, simply keeping streams and rivers free from these compounds does not necessarily provide a measure as to whether or not existing high quality waters are being adequately protected. A preoccupation with keeping waters free from toxics also fails to acknowledge that some waters are simply not going to provide for high or even moderate quality aquatic assemblages due to natural conditions or legacy impacts that are irreversible. As a result of the aforementioned limitations, Minnesota's WQS framework is in need of refinement to enhance the designation of appropriate aquatic life uses and the assessment of the attainment of those uses.

3.1.2 Minnesota TALU Framework

The Minnesota TALU framework is built upon a scientific model called the biological condition gradient (BCG; Davies and Jackson 2006). This model describes how biological communities change with increasing levels of stress. The BCG is based on the concept that water bodies receiving higher levels of stress have biological communities with lower condition compared to water bodies receiving lower levels of stress (Figure 3-1). The BCG provides a common framework to interpret changes in biological condition regardless of geography or water resource type. It permits a more accurate determination and classification of Minnesota's aquatic resources which improves the ability to make well-informed decisions on aquatic life designations. Another advantage of the BCG is that it provides a means to communicate existing and potential uses to the public. The development of a set of BCGs specific to each of the aquatic resource classes was accomplished (Gerritsen et al. 2009) by MPCA biologists with assistance from MBI and Tetratech. The development of warmwater BCG models involved input from biological experts familiar with biological communities in Minnesota from the MPCA and Minnesota DNR. BCG models were developed for fish and macroinvertebrates for each of the 7 warmwater stream classes. A cold water BCG is currently in development via a U.S. EPA funded regional project and involved experts from Minnesota, Wisconsin, Michigan, and several tribes located in those states. In Minnesota this included 2 classes each for fish and macroinvertebrates. Model development for each class involved reviewing biological community data from monitoring sites and then assigning that community to a BCG level. A sufficient number of samples were assessed to develop a model which can duplicate the panel's BCG level assignments. Using the BCG and reference condition stream stations permits the MPCA to develop biological criteria that are protective, consistent, and attainable across the State (MPCA 2012a). The adoption of a TALU framework for Minnesota achieves several goals:

Biological Standards. Numeric water quality criteria that are codified in the Minnesota WQS are currently based on chemical and physical criteria such as dissolved oxygen, temperature, and pH. These criteria do not directly measure the health or condition of biological communities which include fishes, insects, mussels, aquatic plants and algae. Although chemical and physical measures can tell us a lot about water quality, these criteria are essentially surrogates for a direct measure of the biological community. This can be problematic due to the large number and diversity of the stressors that impact biological communities which include chemicals, reduced oxygen, sedimentation, increased temperature, and habitat degradation (Figure 3-2). As a result, the monitoring of chemical and physical parameters for all potential stressors can become too cumbersome to be practical. Rather than measuring the wide variety of stressors, biological communities can be monitored as they are a direct measure of the response of the biota to a wide range of physical and chemical stressors. In other words, their condition is a reflection of all the impacts of multiple stressors over time. A major goal of the CWA and Minnesota's WQS is to protect the fish, invertebrates, and other aquatic organisms in Minnesota's waters. Therefore, it is sensible that we use a direct measurement of these communities to monitor their condition. Furthermore, if water resources are not suitable to support healthy aquatic communities, they may not be suitable for a variety of human activities such as fishing and swimming.

Natural Variability. One of the strengths of the TALU approach is its ability to address the natural variation in water resources across Minnesota. Minnesota's diverse water resources mean that "one-size-fits-all" standards lead to errors in assessment and management. In other words, we need to have different expectations for different water resources. For example, streams along the North Shore are very different from streams in southern Minnesota and we would expect that the biological communities in those streams under natural conditions to be different. The TALU framework takes into account these natural differences and requires that comparisons be made between streams with similar expectations.

The BCG and Reference Condition. The biological monitoring program in Minnesota relies on BCG models and the "reference condition" approach to set expectations for water bodies. The BCG is a conceptual model of aggregated biological knowledge used to describe changes in biological communities along a gradient of increasing stress. The BCG provides a common "yardstick" of biological condition that is rooted in the natural condition. As a result, the BCG can be used to develop of biocriteria that are consistent across regions and stream types in Minnesota. This is particularly important for a state such as Minnesota where the range of existing quality is regionally distinct and extreme (i.e., near pristine to highly degraded). The reference condition approach identifies waterbodies that are least stressed and uses them to establish the "reference condition." Once this reference condition has been established, then waterbodies with unknown condition can be compared to this baseline. If the condition of the waterbody is lower than that of the reference condition, it would be considered impacted or stressed. The use of a reference condition relies on the development of accurate expectations for least stressed sites. Using the BCG and reference condition approach biological criteria were developed to protect Minnesota's aquatic life goals (MPCA 2012a).

High Quality Water Resources. A shortcoming of the current water quality framework is that high quality resources are often under protected. At present there is a framework to protect the degradation of high quality waters called antidegradation, but there are still elements of Minnesota's antidegradation provisions in rule that can allow considerable degradation of these waters without violating the CWA. TALU establishes a higher tier of use to protect these high quality waters. Once a water body has been established as meeting the requirements of a high quality water resource, the resource needs to be protected to maintain that status. The concept of protecting the "existing" use of a water body is one of the most important tenets of the CWA.

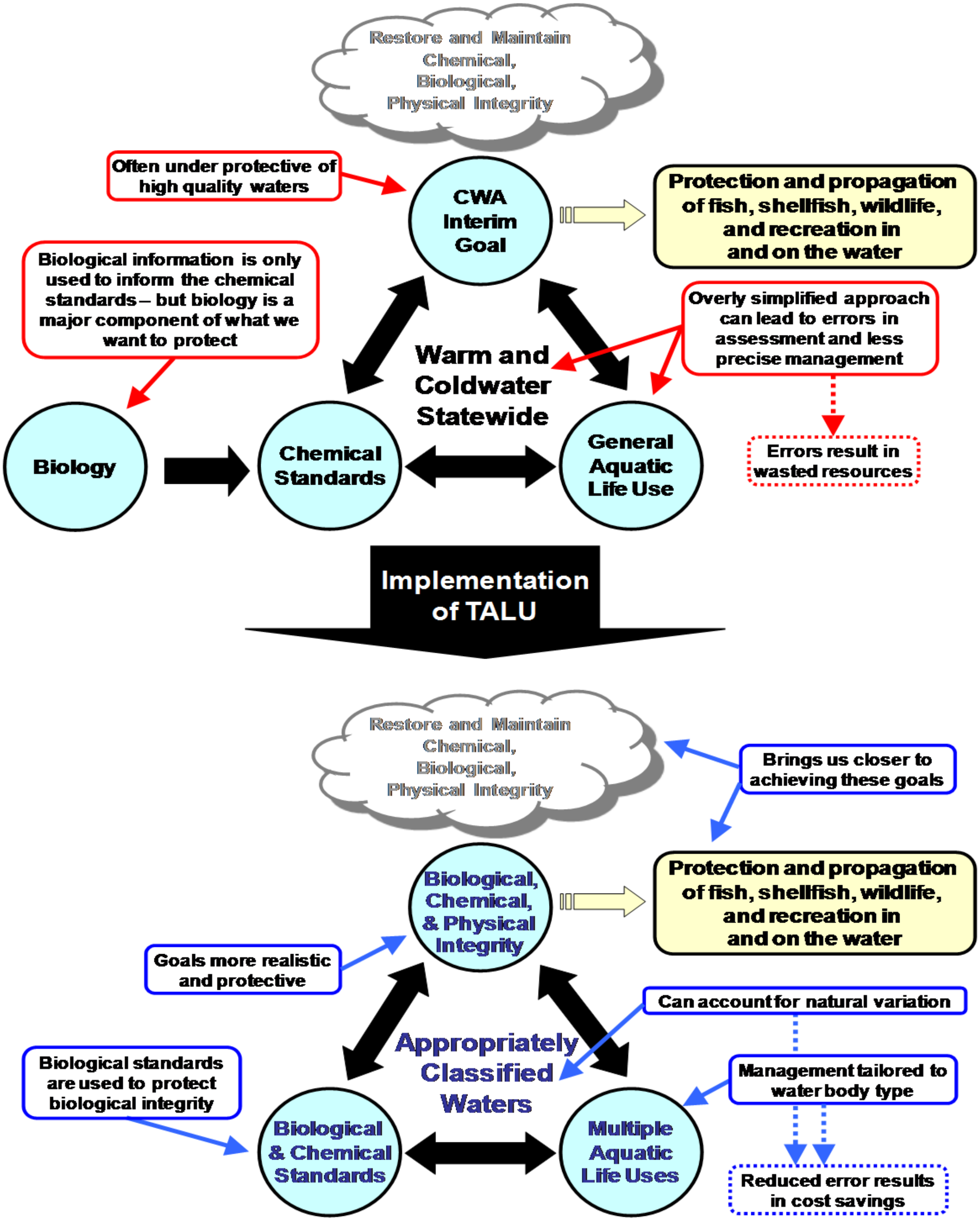


Figure 3-2. The characterization of CWA goals, Minnesota aquatic life uses, and new biological standards before and after implementation of a TALU framework.

Modified or Limited Water Resources. There are water resources in this State that will not in the near future meet the CWA interim goals due to historical or legacy impacts. These legacy impacts include streams under drainage maintenance or other irreversible hydromodification that preclude attainment of goals. For example, channelized streams and ditches would be included under this category. TALU provides a mechanism to monitor and set realistic expectations for waters that are unlikely to meet goals due to legacy impacts. The expectations are fully protective of the existing uses for each water body and recognize their historical and current site specific context. This element of TALU allows for the establishment of realistic expectations for water bodies that have multiple and well established uses.

Some other goals/benefits of TALU adoption include:

- Monitoring of incremental improvements in water quality. This allows entities working to improve water quality to document and show progress toward a goal.
- TALU helps guide development and modification of WQS to produce improved standards.
- TALU merges the design and practice of monitoring and assessment with the development and implementation of WQS.

Achieving these goals through the TALU framework will bring Minnesota closer to the protection and maintenance of the biological, chemical, and physical integrity of water resources in the state.

3.2 A Revised Aquatic Life Use Framework for Minnesota

We propose here the following conceptual structure of designated aquatic life uses as either a modification or outright replacement for the current General Use standards framework as it applies to aquatic life. This would also seem to eventually necessitate the clarification of the other non-aquatic life use subcategories that are currently bundled together under General Use standard, but that is not a purpose of this plan. However, it will be an MPCA decision about how the new TALU-based WQS will be structured within chapter 7050.

There are several factors that we considered in recommending a revised structure for designated aquatic life uses in Minnesota. The current framework of the biological assessment approach including the development and use of multimetric indices and their derivation and calibration based on “minimally disturbed” to “least impacted” regional reference condition makes a tiered structure the most attractive option. As such this framework consists of distinct descriptions of categorical use subcategories or “tiers” of expected condition and potential quality. This also includes distinct “warmwater” and “cold water” assemblage baselines for Minnesota rivers and streams that will be directly included in the TALU framework. The major aquatic life use subcategories proposed herein are described as follows:

Exceptional - These are waters that exhibit the highest quality of “exceptional” assemblages (as measured by assemblage attributes and indices) on a Minnesota Biological Condition Gradient (BCG) basis; narrative descriptors such as “exceptional” can be used as the distinguishing descriptors in the designated use narrative, but other descriptive terms are possible. These communities have minimal changes in structure of the biotic assemblage and in ecosystem function which is the ultimate goal of the CWA. It functions as a preservation use, which means it is intended for waters that already exhibit or have the realistic potential to attain an exceptional quality as measured by the biological criteria.

General – These are waters that harbor "typically good" assemblages of freshwater organisms (as measured by assemblage attributes and indices) and that reflect the lower range of the central tendency of "least impacted" regional reference condition. In the language of the BCG, they are communities that can be characterized as possessing "*overall balanced distribution of all expected major groups; ecosystem functions largely maintained through redundant attributes*". As such this use represents the minimum CWA goal attainment threshold and it serves as the principal restoration use for management programs. It also serves as the "triggering threshold" for when a UAA is required to determine the attainability of this designated use tier for specific river or stream segments.

Modified – These are waters that have been extensively altered and currently exhibit legacy physical modifications that pre-date the November 28, 1975 existing use date in the Federal Water Quality regulations (40CFR Part 131). These waters have been determined to be in non-attainment of the General use biological criteria and have been determined to be incapable of attaining those criteria via a UAA. The biological criteria for the Modified use are established based on a separate population of "modified reference sites" that exhibit these types of modifications with little presence of other types of stressors. Possible subcategories include channelization for flood control and agricultural drainage and impoundments created by run-of-river low head dams. Separate reference populations are needed to derive the numeric biocriteria for each subcategory.

Limited - These are waters that have been substantially altered and currently exhibit severe and essentially irretrievable legacy modifications that pre-date the November 28, 1975 existing use date in the Federal Water Quality regulations (40CFR Part 131). These waters have been determined to be in non-attainment of the Modified biological criteria and have been determined to be incapable of attaining those criteria via a UAA. The biological criteria for the Limited Resource use are established at the "poor" level of biological performance in keeping with preventing nuisance conditions. As such the biocriteria for this use are not based on a distinct set of "limited reference" sites. Possible subcategories include small drainageway maintenance for flood control and severe restrictions of the channel for different purposes (e.g., via concrete revetments).

The preceding describes the general circumstances under which one of the four categorical tiers would apply. However, the narrative language for each use will need to include more detailed and descriptive language to include the following:

1) A definitive statement about the overall goal of the use tier. An example is using the definition of biological integrity (Frey 1977; Karr and Dudley 1981) as follows:

". . . these are waters capable of supporting and maintaining a balanced, integrated, adaptive community of warmwater aquatic organisms that are comparable to . . ."

2) A description of the geographic applicability of the use tier (or subclass) – an example for Minnesota would be the fish and macroinvertebrate stream and river classes.
3) A clear statement about how attainment of each use tier is to be measured, at least by reference to numeric endpoints in rule.
4) A reference to the method(s) documentation that must be followed to generate the data from which the biological data is processed and attainment can be determined. This could also include any certifications or credible data qualifications.
5) Any exceptions to the applicability of the use tier, i.e., that the use does not apply to non-aquatic life uses and their criteria, variance provisions, etc.

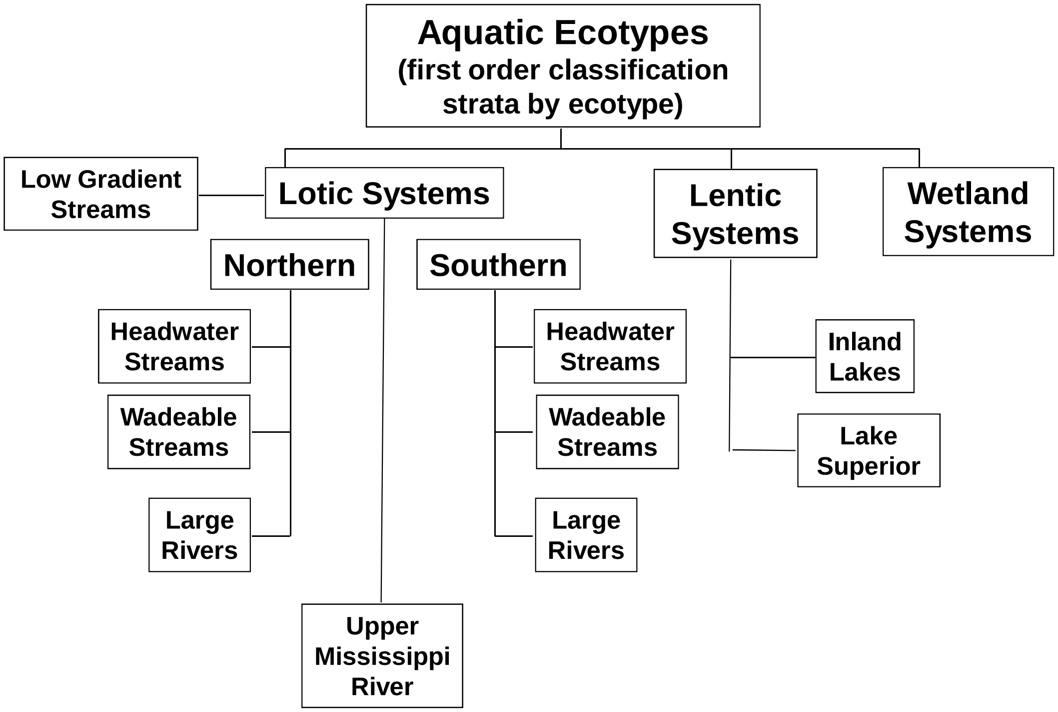
The specific narrative language and accompanying numeric biological criteria for each use tier within the warmwater and cold water subclasses is developed next and serve as the narratives for the new tiered designated uses for adoption in chapter 7050. There will be cold water and warmwater distinctions for at least the exceptional and general subcategories. The modified and limited resource use subcategories will be applicable to warmwater streams and rivers exclusively.

Figures 3-3 through 3-5 depict the organizational hierarchy of the new aquatic life use structure including the overall distinction of aquatic ecotypes (Figure 3-2), the distinctions between warmwater (Figure 3-3) and cold water (Figure 3-4), and the use tiers and subcategories within each (Figures 3-3 and 3-4). This is the organization that we expect based on the developmental work accomplished by MPCA. However, modifications to the ecotype classifications and refinements to the TALU tiers (the tier specific subcategories in particular) are possible in the future as they are recognized based on the feedback provided by consistent TALU program implementation.

3.2.1 Proposed Tiered Uses and Numeric Biocriteria for Minnesota

Based on the preceding guidelines, four overall aquatic life use tiers are recommended for Minnesota that includes numeric biocriteria for fish and macroinvertebrates and within each of the nine natural classes for rivers and streams for each assemblage. We feel that the already developed bioassessment methods and indices for Minnesota (MPCA 2012b) are sufficiently rigorous for supporting the implementation of numeric biocriteria. Our purpose herein is to describe a framework and structure for tiered uses with linkages to the current bioassessment methodologies used by MPCA.

The four general "tiers" described in Section 3.2 are recommended at this time while also recognizing the possibility that further refinements or subclasses may become apparent as the TALU framework is implemented by MPCA. At present Minnesota has what might be



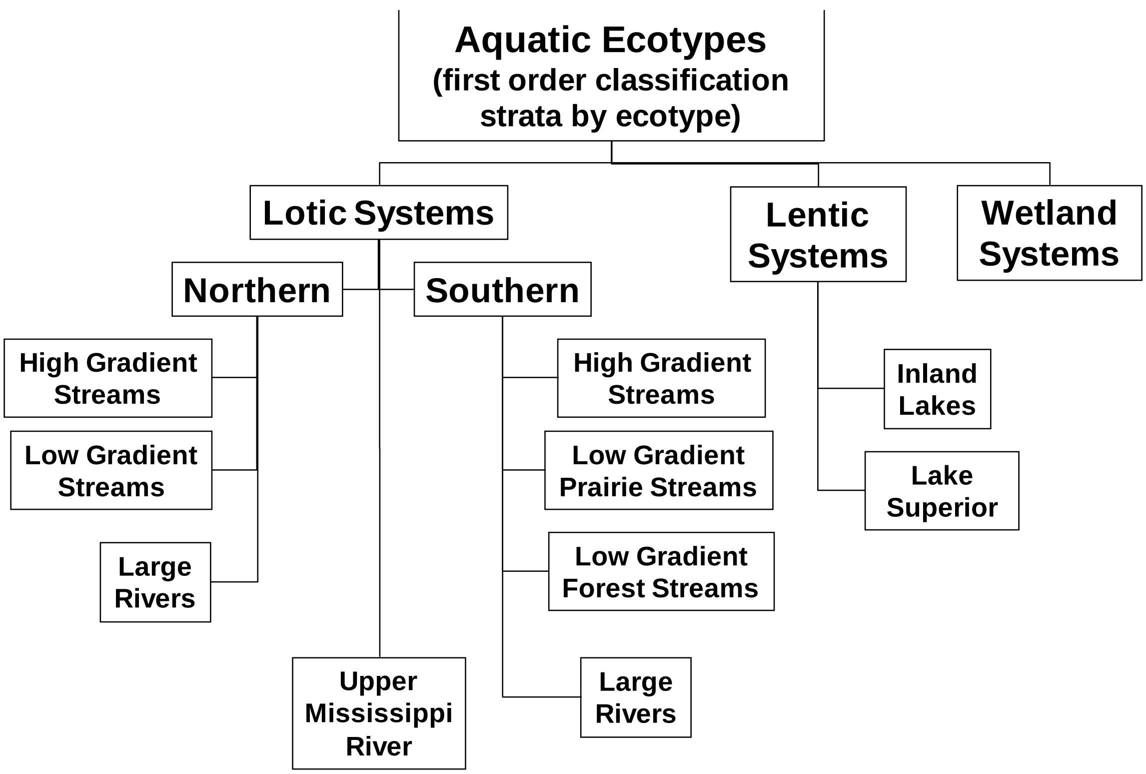


Figure 3-3. First order classification of aquatic ecotypes for fish (upper) and macroinvertebrates (lower) showing the classification strata for the lotic ecotype in Minnesota. Classification strata are possible for lentic and wetland systems, but are not the subject of this project. Upper Mississippi River is below Twin Cities Lock and Dam #1.

MINNESOTA SPECIFIC TEMPLATE FOR TALU TIERS: I

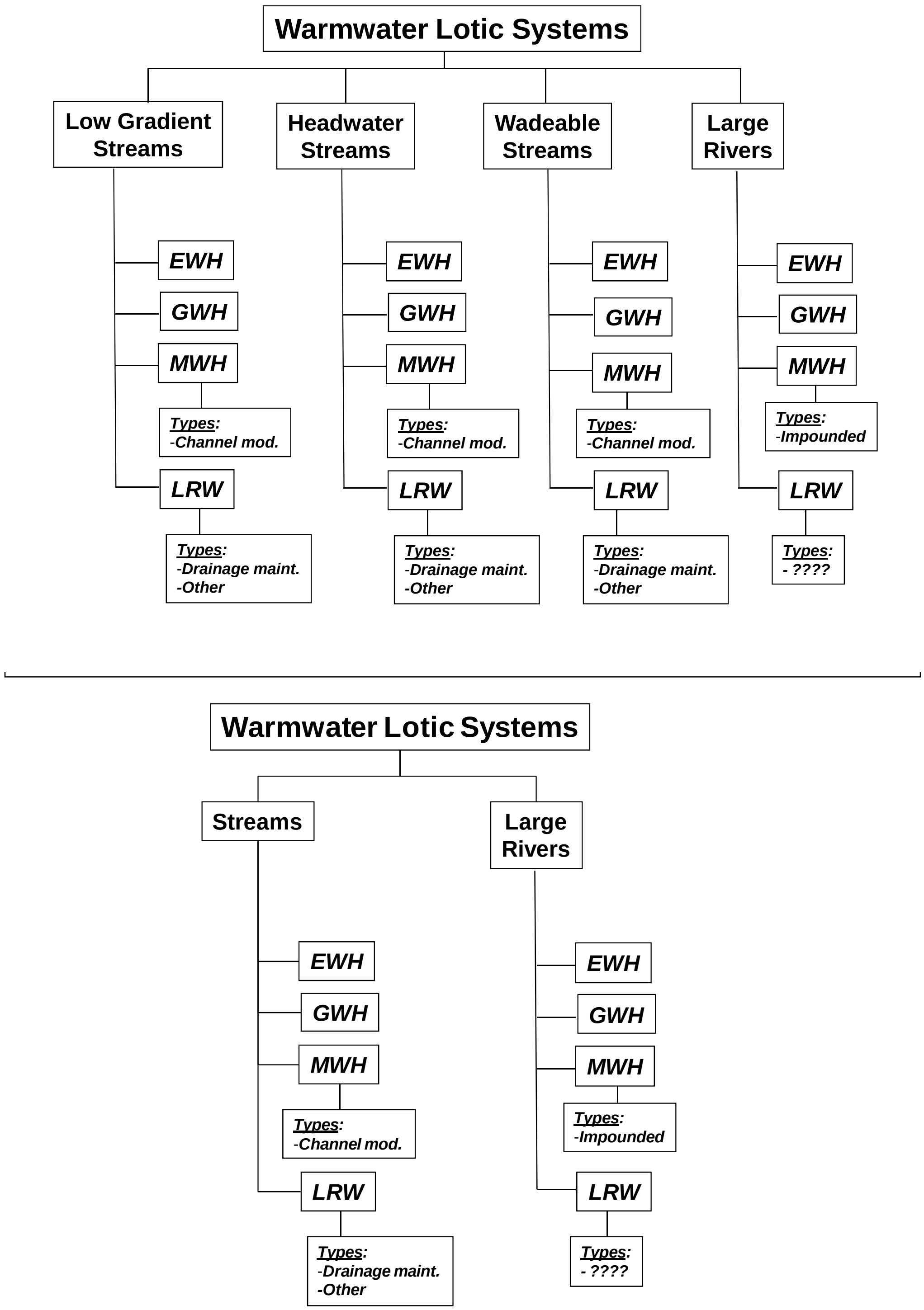


Figure 3-4. Tiered aquatic life uses for fish (upper) and macroinvertebrates (lower) for the warmwater lotic ecotype classifications to which it is expected to apply. Distinct fish and macroinvertebrate IBIs and BCG rules apply to each lotic classification. Numeric biocriteria are derived for each tier (EWH = Exceptional Warmwater Habitat; GWH = General Warmwater Habitat; MWH = Modified Warmwater Habitat; LRW = Limited Resource Water) and by disturbance type for MWH and LRW.

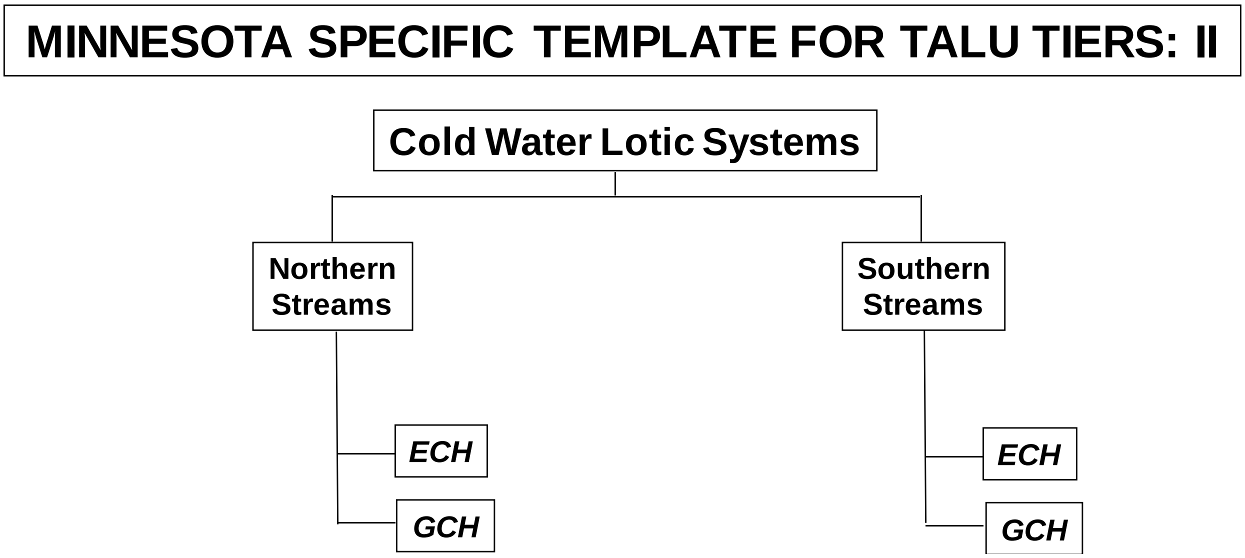


Figure 3-5. Tiered aquatic life uses for the cold water lotic ecotype classifications to which it is expected to apply. Distinct fish and macroinvertebrate IBIs and BCG rules apply to each lotic classification and numeric biocriteria are derived for each tier (ECH = Exceptional Cold water Habitat; GCH = General Cold water Habitat).

considered as "non-regulatory" biological criteria (see Figure 2-1) that are largely applied via methodological guidance detailed in their 305[b] reporting and 303[d] listing process (MPCA 2011). Adopting the TALU framework described herein will result in a firmer regulatory basis via the tiered uses and numeric biocriteria.

3.2.2 Designated Use Narratives Applicable to Minnesota Rivers and Streams

The recommended designated use narratives are composed here to reflect the previously described provisions in Sections 3.1 and 3.2 about what each use tier narrative should include and to reflect the biological methods and indices/models upon which the numeric biocriteria and their application will take place. The following is the recommended 7050 rule language for the warmwater use subclass as follows:

> *"Exceptional Warmwater" – these are waters capable of supporting and maintaining an exceptional and unusual balanced, integrated, adaptive community of warmwater aquatic organisms having a species composition, diversity, and functional organization comparable to the 75th percentile of Biological Condition Gradient Level 3 as specified in Calibration of the Biological Condition Gradient for Streams of Minnesota (Gerritsen et al. 2009). For all stream and river classes, the attributes of species composition, diversity, and functional organization will be measured using the fish-based Index of Biotic Integrity as defined in "Manual for Calculating Fish Index of Biotic Integrity Scores for Streams and Rivers in Minnesota" and the macroinvertebrate Index of Biotic Integrity as defined in "Manual for Calculating Macroinvertebrate Index of Biotic Integrity Scores for Streams and Rivers in Minnesota" as cited in [reference to analytical methods part of 7050 goes here]. Attainment of this use designation is*

based on the criteria in [refers to table of biocriteria values in 7050.0222].

"General Warmwater" – these are waters capable of supporting and maintaining a balanced, integrated, adaptive community of warmwater aquatic organisms having a species composition, diversity, and functional organization comparable to the median of Biological Condition Gradient Level 4 as specified in Calibration of the Biological Condition Gradient for Streams of Minnesota (Gerritsen et al. 2009). For all stream and river classes, the attributes of species composition, diversity, and functional organization will be measured using the fish-based Index of Biotic Integrity as defined in "Manual for Calculating Fish Index of Biotic Integrity Scores for Streams and Rivers in Minnesota" and the macroinvertebrate Index of Biotic Integrity as defined in "Manual for Calculating Macroinvertebrate Index of Biotic Integrity Scores for Streams and Rivers in Minnesota" as cited in [reference to analytical methods part of 7050 goes here]. Attainment of this use designation is based on the criteria in [refers to table of IBI biocriteria values in 7050.0222] except in instances where biological data is not readily available.

"Modified Warmwater" – these are waters that have been the subject of a use attainability analysis and have been found to be incapable of supporting and maintaining a balanced, integrated, adaptive community of warmwater organisms due to irretrievable modifications of the physical habitat. Such modifications are of a long-lasting duration (i.e., twenty years or longer) and may include the following examples: extensive stream channel modification activities permitted under sections 401 and 404 of the act or [Minnesota Statutes Chapter 103E], and extensive permanent impoundment of free flowing water bodies. [any other precluding categorical activities added here] Numeric biocriteria are derived from a distinct population of "impacted reference" sites reflecting only the categorical impacts implied in this definition (MPCA 2012a). For all stream and river classes, the attributes of species composition, diversity, and functional organization will be measured using the fish-based Index of Biotic Integrity as defined in "Manual for Calculating Fish Index of Biotic Integrity Scores for Streams and Rivers in Minnesota" and the macroinvertebrate Index of Biotic Integrity as defined in "Manual for Calculating Macroinvertebrate Index of Biotic Integrity Scores for Streams and Rivers in Minnesota" as cited in [reference to analytical methods part of 7050 goes here]. Attainment of this use designation is based on the criteria in [refers to table of IBI biocriteria values in 7050.0222] and by the categorical subclasses based on the modification type.

"Limited Resource Water" - these are waters that have been the subject of a use attainability analysis and have been found to lack the potential for any resemblance of any other aquatic life subclass. The use attainability analysis must demonstrate that the extant fauna is substantially degraded and that the potential for recovery of the fauna to the level characteristic of any other aquatic life habitat is realistically precluded.

While a hierarchy of four tiers of aquatic life uses is recommended here, the specific language included above can be modified to accommodate the specific needs of the Minnesota WQS (i.e., other rule references, exclusions, variances, etc.) or it can be accounted for in the MPCA implementation language described in Section 3.5.

3.3 Numerical Biological Criteria for Minnesota Rivers and Streams

The just described designated use narratives are the essential first part of a TALU. The numerical biological criteria are the essential second part and they are derived in accordance with the stated conditions of the narrative. As such the thresholds that are described in the narrative are the numerical biocriteria as derived from the class-specific BCG models and the regional reference datasets that are used to derive and calibrate the biological indices. The rigor of these datasets is an important linchpin in this process and is evaluated as part of the Critical Elements process (Yoder and Barbour 2009). At this point we recommend utilizing the newly developed set of calibrated biological indices and the classification scheme employed for each as the basis of the numeric biocriteria. The narratives are written such that future changes can be accommodated without making any changes to the designated use narratives themselves.

Key to the derivation of numeric biocriteria is the reference threshold for each biological index that is selected for each aquatic life use tier. The biocriteria applicable to the highest TALU tiers are intended to correspond to the upper levels of the BCG, i.e., levels 1, 2, and 3. The upper tiers that represent level 1 and upper level 2 conditions can also be used to develop more refined antidegradation tiers.

3.3.1 Regional Reference Condition

The most recent available guidance on reference condition can be found in Stoddard et al. (2006). This paper describes a framework for organizing reference condition and recognizing that there are differences between minimally disturbed and least impacted reference conditions. The concept of a reference condition is used to describe the standard or benchmark against which current condition is compared. However the phrase itself can have many meanings and different contexts. Stoddard et al. (2006) stated the need for reference condition to refer to the "naturalness" of the aquatic biota in terms of its structure and function. As such this anchors reference condition in the upper levels of the Biological Condition Gradient (BCG). To organize and standardize the use of reference condition Stoddard et al. (2006) defined the following hierarchy of reference condition:

- **Minimally Disturbed Condition (MDC)** – This term describes the condition of the biota in the absence of significant human disturbance and it is the best approximation of biological integrity. It is acknowledged that finding actual sampling sites that are truly undisturbed by the global influence of human activities is probably not possible. This would be especially true of the agricultural, urbanized, and industrialized Midwestern U.S. of which Minnesota is a part. MDC also recognizes that some natural variability in biological indicators will always occur and needs to be recognized when empirically describing this condition.

- **Historical Condition (HC)** – This term describes the condition of the biota at some point in their history. It may be an accurate estimator of true reference condition (i.e., biological integrity) if the historical point chosen is before the start of any human disturbance. However, many of the historical reference points are possible (e.g., pre-industrial, pre-Columbian). A recent example of developing and accessing historical conditions was described by Armitage and Rankin (2009) for the Wabash River basin of Indiana and by Rankin and Yoder (2010) for the Upper Mississippi River.

- **Least Disturbed Condition (LDC)** – Least disturbed condition is found in conjunction with the best available physical, chemical, and biological habitat conditions given today's state of the landscape. It is ideally described by evaluating at data collected at sites selected according to a set of explicit criteria defining what is ''best'' or least disturbed by human activities. The resulting least disturbed biological conditions will vary from region to region and/or water body type and class and are developed iteratively with the goal of establishing the least amount of human disturbance based primarily on stressors that can be delineated by geographic information system data, proximity to obvious sources of impact (e.g., large point sources), and other evidence of disturbance at a site. As such this represents an evaluation and ranking of the "cultural setting" represented by candidate reference sites. The first attempts at selecting reference sites were largely based on qualitative measures (e.g., Yoder and Rankin 1995a), but more recently they have included more quantitative measures of landscape disturbance (U.S. EPA 2006). Because the condition of the overall environment may change through time as restoration and/or degradation proceeds, this condition may change through time. Hence the expectation that a level 4 bioassessment program will provide for the regular re-sampling of reference condition (e.g., once every 10 years). This enables the tracking of any changes in reference condition to include a recalibration of the biological indices, the biological criteria, or both on a predictable basis (Yoder and Rankin 1995a). The CWA and federal regulations preclude any lowering of the numeric biocriteria once they are established in the WQS.

- **Best Attainable Condition (BAC)** – This is the expected condition of least disturbed sites under the implementation of best management practices (BMPs) for a sufficient period of time. This is a condition that results from the convergence of management goals, best available technologies, and a public commitment to achieving environmental goals (e.g., as established by WQS) under prevailing uses of the landscape. BAC may be equivalent to either to either MDC or LDC depending on the prevailing level of human disturbance in a region. It is not invariable because the above factors can vary over time. In some cases where historical disturbance has been extensive and widespread it may not satisfy the minimum CWA goals for aquatic life, hence alternate approaches to setting biological criteria may be needed.

The span of reference conditions represented by the just described hierarchy is illustrated as it relates to the Biological Condition Gradient (BCG) in Figure 3-6 (modified from Stoddard et al. 2006). In a region where the majority if not all of the reference sites truly represent minimally disturbed conditions the reference sites would score in levels 1 and 2 of the BCG along the axis

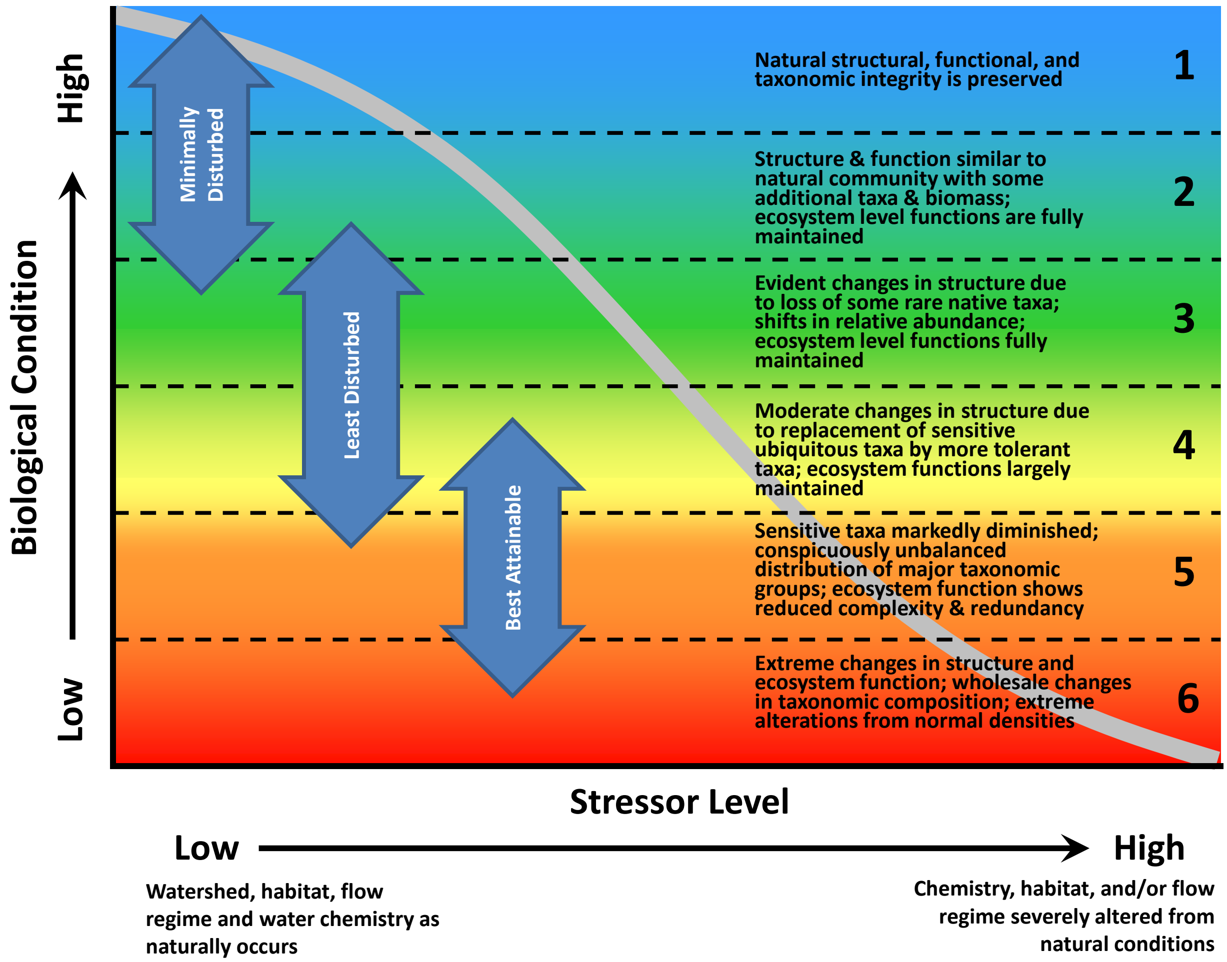


Figure 3-6. The distribution of minimally disturbed, least disturbed, and best attainable reference condition along the axis of biological condition against the level of stress. Minimally disturbed, least disturbed, and best attainable are shown as they relate to their position in the Biological Condition Gradient (BCG; Davies and Jackson 2006). Adapted from Stoddard et al. (2006).

of the biological index. In a region with fewer minimally disturbed reference sites and an increasing number of least impacted reference sites, the range along the biological index axis would extend into levels 3 and 4 of the BCG. In regions that have no minimally disturbed sites and a majority of least disturbed and best attainable sites, the range along the biological index axis would extend into tier 4 and perhaps even tier 5 of the BCG. Under no circumstances should least impacted reference sites occupy tier 5 and extend into tier 6. This would illustrate a lack of any redeeming reference condition and an alternate approach would be needed to derive numerical biocriteria consistent with CWA goals. Modified and limited reference sites would be expected to represent tier 5 and even into to tier 6, almost by definition, because neither attains the minimum CWA goal. Referring specifically to this standardized framework of reference condition and clearly indicating which practical definition of reference condition is being used to set biocriteria will make biological criteria and the assessments upon which they are based more comparable between the classification regions.

3.3.2 Minnesota Reference Condition

Another important aspect of this framework is that a better understanding of the quality of the applicable regional reference condition will better standardize how numeric biological criteria are established. The relative quality of the regional reference condition is a key variable in determining at what percentile of the reference distribution (i.e., the threshold) of a biological index that represents the minimally acceptable biocriterion for CWA purposes. The actual distribution of empirically measured reference condition also influences how many upper level tiers might be needed and where those biocriteria are set. An example is displayed in Figure 3-7 that depicts the reference site scores for the Minnesota stream and river classification strata. These are the fish and macroinvertebrate IBI scores at minimally to least disturbed reference sites for each fish and macroinvertebrate class. The IBIs were derived and calibrated for each classification strata and the numerical biocriteria derived by the BCG tiers. This framework ensures that the resultant numeric biocriteria are consistent with the goals of the CWA and hence are protective of their designated uses and hedge against unintentional bias that may be introduced by including too many potentially marginal reference sites. The Southern streams and headwaters FIBI GWH biocriterion for fish is above the median reference value (Figure 3-7) and it is doubtful that few if any of those sites represent least impacted reference conditions since the effects of hydromodification and agricultural land use are so extensive and BMPs have not been validated in terms of CWA goal attainment. As such basing the biocriteria thresholds on the median of the BCG tier 4 protects against having the biocriteria determined by what is in this class "best attainable" conditions. In contrast the Northern rivers and streams reflect a preponderance of minimally disturbed conditions as reflected by the position of those FIBI thresholds (Figure 3-7).

3.3.3 Derivation of Numeric Biocriteria for Minnesota Rivers and Streams

An example of how the numeric biological criteria will be structured for Minnesota rivers and streams appears in Table 3-1 and is based on thresholds that correspond to "reference" conditions reflective of Human Disturbance Score (HDS) scores of >61 for headwaters and streams and >45 for large rivers for the General uses. Based on our prior discussion of reference condition this equates to the "bottom" of a least impacted reference condition. Within the Exceptional use an upper tier exceptional biocriterion is being proposed for the Northern Rivers class. The decision about which percentile to select is based on our estimate of the extent of either how "minimally disturbed" of "least impacted" is the prevailing reference condition, with more conservative percentiles (as noted above) being used when that population is comprised predominantly of least impacted and best attainable conditions. In northern classes the 10^{th} percentile of reference sites was used and in southern and statewide classes the 25^{th} percentile was used. Comparison with the BCG indicated that these thresholds most closely matched the median of BCG 4 so this threshold was used to set the General Use (GU) biocriteria values.

For exceptional uses the 75^{th} percentile of IBI scores for reference sites was chosen to be in keeping with the narrative attributes of this tier. This threshold most closely corresponded to the 75^{th} percentile of BCG level 3 and it was used to set biological criteria for the Exceptional Use (EU). Modified Use (MU) criteria were developed by identifying modified "reference" sites

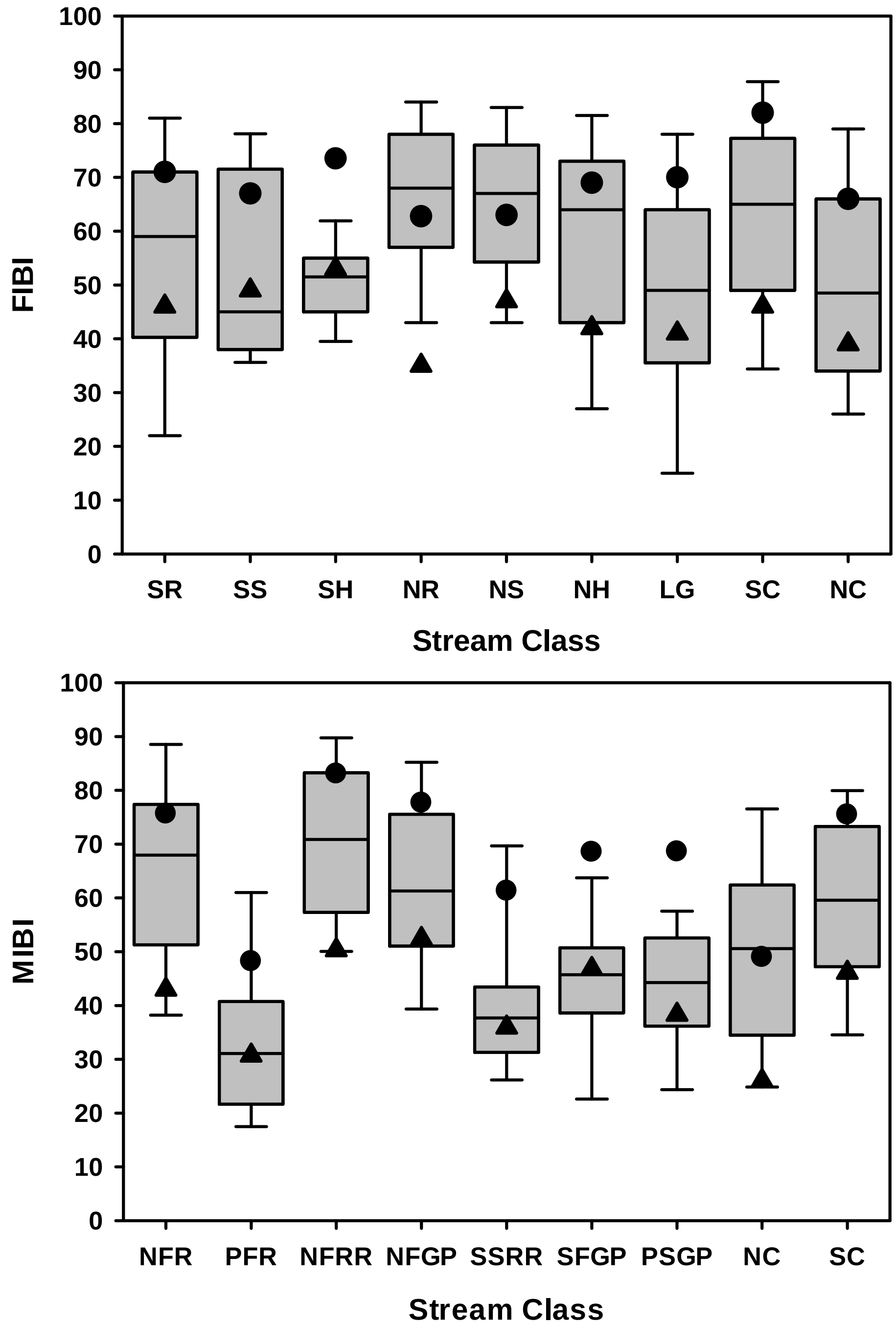


Figure 3-7. Frequency distribution of fish IBI (FIBI; upper) and macroinvertebrate IBI (MIBI; lower) scores at warmwater and cold water (SC and NC) reference sites in Minnesota by classification strata. The General biocriterion (▲) is set at the median of the class-specific BCG tier 4 for all classes. The Exceptional biocriterion (•) is set at the 75th percentile of the class-specific BCG tier 3 for all classes. Symbols: upper and lower bounds of box = 75th and 25th percentiles, middle bar in box = 50th percentile, upper and lower whisker caps = 95th and 5th percentiles; Abbreviations: SR = Southern Rivers, SS = Southern Streams, SH = Southern Headwaters, NR = Northern Rivers, NS = Northern Streams, NH = Northern Headwaters, LG = Low Gradient Streams, SC = Southern Cold water, NC = Northern Cold water, NFR = Northern Forest Rivers, PFR = Prairie Forest Rivers, NFRR = High Gradient Northern Forest Streams, NFGP = Low Gradient Northern Forest Streams, SSRR = High Gradient Southern Streams, SFGP = Low Gradient Southern Forest Streams, PSGP = Low Gradient Prairie Streams, SC = Southern Cold water, NC = Northern Cold water.

that represents the attainable biological condition for these streams. In theory these streams represent the biological condition that is attainable in waters that have been legally modified and which have been subjected to a UAA. To identify these streams, landscape and reach level riparian condition measures were used to select channelized reference streams. Reaches with less than 80% of the riparian disturbed at both the watershed and reach scales were selected. A secondary filter of dissolved oxygen > 4 mg/L and < 12 mg/L was also used to remove reaches that were also impacted by the effects of excessive nutrients. Once these modified "reference" sites were selected, the 25th percentile of IBI scores was determined for each stream class. Nine of the stream classes had very few or no channelized streams and therefore it was determined that development of a Modified Use for these classes was not appropriate. These thresholds were then compared to the BCG and it was determined the reference condition most closely corresponded to the median of BCG level 5. This threshold was used as the Modified Use biocriterion for the classes to which it applies (Table 3-1).

Table 3-1. Draft numeric biocriteria for Minnesota rivers and streams organized by warmwater and cold water ecotypes, stream and river classification strata within each, and the corresponding Exceptional, General, and Modified Uses (NA – not applicable).

Class #	Class Name	EU	GU	MU
	Fish			
1	Southern Rivers	71	46	NA
2	Southern Streams	67	49	33
3	Southern Headwaters	74	53	32
4	Northern Rivers	63	35	NA
5	Northern Streams	63	47	32
6	Northern Headwaters	69	42	22
7	Low Gradient Streams	70	41	15
10	Southern Cold water	82	46	NA
11	Northern Cold water	66	39	NA
	Invertebrates			
1	Northern Forest Rivers	76	43	NA
2	Prairie Forest Rivers	48	31	NA
3	Northern Forest Streams RR	83	51	NA
4	Northern Forest Streams GP	78	49	36
5	Southern Streams RR	61	36	24
6	Southern Forest Streams GP	69	43	28
7	Prairie Streams GP	69	42	21
8	Northern Cold water	49	27	NA
9	Southern Cold water	75	45	NA

3.3.4 Determining Attainment of the TALU-Based Biocriteria

The proposed designated aquatic life use narratives state that attainment will be based primarily on the numeric biocriteria for each use tier and classification stratum. This is consistent with a TALU-based approach in that the biocriteria are the primary response variable while chemical and physical criteria function as indicators of stress and exposure and represent the implementable measures for water quality management. As such, the biocriteria function along the y-axis of the BCG whereas chemical/physical measures function along the x-axis of the BCG. Because this represents a change to the current assessment approach, MPCA may choose to phase biocriteria into the water body assessment process until sufficient assessments are accomplished to determine exactly how to implement the recommended rule language.

The current MPCA process for using biological data is detailed in the *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305b Report and 303d List* (MPCA 2011). This guidance was the first attempt by MPCA to formally incorporate biological assessments into their water body assessment process. Furthermore, biological indicators are essentially treated as a co-factor with chemical/physical indicators which blurs the distinction between the defined roles of these indicators in a TALU-based approach. The current process for determining attainment and non-attainment is written as follows:

> *Overall assessment of whether an AUID adequately supports aquatic life involves the review of the parameter-level evaluations and data quality in conjunction with all available supporting information (flow, habitat, precipitation, etc.) to make an overall use-support determination. For a given AUID, there may be chemistry indicator data, biological indicator data, or both types of data available for assessment. The final assessment takes into consideration the strength of the various indicators and the quality of the data sets and, in addition, looks at upstream and downstream conditions to gain a better understanding of the interactions between the individual AUID and the larger water body and watershed.*
>
> *In general:*
>
> *a) A stream reach is considered to be fully supporting of aquatic life if:*
>
> - *IBI scores for all available assemblages indicate fully supporting conditions, or*
> - *the criteria for both dissolved oxygen and turbidity/t-tube/total suspended solids are adequately met, and*
> - *other lines of evidence considered comprehensively, including upstream/downstream conditions, do not contradict a finding of full support*
>
> *b) A stream reach is considered to be not supporting if:*
>
> - *IBI scores for at least one biological assemblage indicate impairment, or*
> - *one or more water chemistry parameters indicates impairment, and*
> - *other lines of evidence considered comprehensively, including*

upstream/downstream conditions, do not contradict a finding of non-support

c) If the above criteria are not met and the assessment is inconclusive, the result is a determination of insufficient information.

In cases where an assessment unit has been determined to be not supporting based on biological indicators, water-chemistry parameters are added to the list of impairments only when the chemical impairment is clear enough that the AUID would be considered impaired even without the biological evidence.

Additional guidelines are available in MPCA (2011) that clarify the process and outcome decisions for scenarios a through c above. The programmatic implications to the assessment program are discussed in Section 5.0.

For assessing impairments with biological data, the current procedure is to declare an impairment if the biocriterion for either the fish or macroinvertebrate assemblage is exceeded, a practice that we recommend continue. MPCA also considers confidence intervals around the numeric biocriterion in determining an impairment (Figure 3-8), a practice that we concur with.

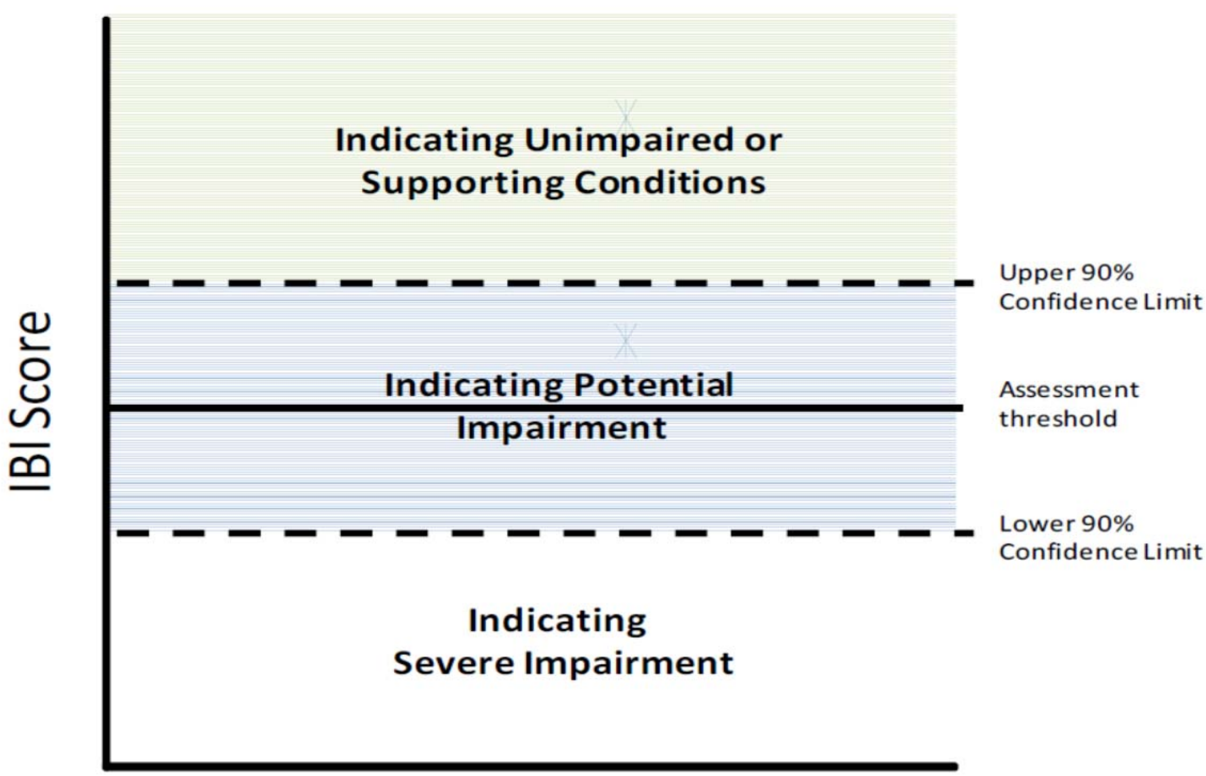


Figure 3-8. General diagram illustrating the characterization of individual biological indicator results (after MPCA 2011).

3.3.5 Biocriteria Application Language

The Minnesota WQS currently provide narrative language for the application of chemical, physical, and biological monitoring data at 7050.0150. As described previously MPCA uses bioassessment results to determine the status of the current general uses primarily for Section 305(b) and 303(d) purposes. Because the application of bioassessment data via a TALU-based approach extends beyond status and impairment listings, application language is recommended that clarifies the options available to water quality management programs in sufficient detail so as to not only be transparent to those programs and external stakeholders, but providing options for findings of attainment and non-attainment. The principles of this language in the Minnesota WQS were described in Section 2.3.6 and should be the basis for the proposed rule language. We feel that this clause is needed to more firmly clarify the roles of biological, chemical, and physical parameters and indicators than it is in the current assessment guidelines. While the potential stratification of certain chemical and physical parameters that result from task 5 of the TALU work plan may help to align chemical/physical and biological results, there will be situations where they do not "agree" hence a consistent and codified approach to how these findings are treated will be necessary.

4. TALU Implementation Strategy

The implementation of a TALU-based approach in Minnesota will most directly impact two major water quality management programs, WQS and M&A. The potential changes to the WQS as described in Section 3.0 are in the form of a revised structure of designated aquatic life uses primarily in the form of an increased number of subcategories of warm and cold water habitats and in "detaching" aquatic life from the current general use framework that combines it with recreational uses. Section 3 already provides the details about the content and substance of the aquatic life uses. What is left now is to refine and finalize the specific rule language and structure within a rule-making proposal.

How TALU affects the current MPCA M&A program is perhaps the more detail laden aspect of TALU adoption and implementation, hence this section is devoted to that issue. TALU implementation is entirely dependent on the state monitoring and assessment program hence an understanding about how TALU might impact the monitoring strategy is an essential next step.

4.1 Minnesota Monitoring Strategy

The MPCA and its partner agencies and organizations conduct numerous surface and groundwater monitoring activities to provide information about the status of the state's water resources and to identify potential or actual threats to the quality of surface and groundwater, choose options for protecting and restoring waters that are impaired, and evaluate the effectiveness of implemented management plans. The goal of the MPCA and its partners is to provide information to assess – and ultimately to restore or protect – the integrity of Minnesota's waters. The MPCA has been developing a watershed approach since 2007 as a key strategy and organizing principle to guide its surface and groundwater quality monitoring activities and many other aspects of the agency's water program (MPCA 2011). Two landmark events that have enabled the MPCA to develop and begin implementing the watershed approach are passage of Minnesota's Clean Water Legacy Act (CWLA) in 2006 and passage of the Clean Water, Land and Legacy Amendment (Amendment) in 2008. The CWLA and the Amendment have provided a structure and a source of revenue that have greatly improved the ability of the MPCA and its partner agencies and organizations to achieve the MPCA's strategic plan vision of clean, sustainable surface and groundwater.

Since preparation of the 2004 – 2014 Water Quality Monitoring Strategy, the MPCA has changed the organizing approach for its water program from the major river basin scale (there are portions of 10 major river basins within the state of Minnesota) to the "major," or eight-digit hydrologic unit code (HUC) level, watershed approach. There are 81 of these major watersheds in Minnesota. The MPCA and its partners began implementing the watershed approach in 2007 following a pilot monitoring study that was conducted in the Snake River Watershed in 2006. The MPCA's watershed approach involves intensively monitoring the streams and lakes within a major watershed and in an unbiased manner to:

- determine the overall health of these water resources;

- identify impaired waters, and,
- identify waters in need of additional protection efforts to prevent impairments.

Follow-up monitoring is then conducted in impaired sub-watersheds to determine the cause(s) of the impairments (i.e. the "stressors" impacting the biological community) and begin identification of pollutant sources and priority management zones. A restoration plan (Total Maximum Daily Load or TMDL) and/or protection strategy and implementation plan is then written for the watershed; following this, partnering agencies and watershed stakeholders can begin BMP improvements based on these efforts. Regulatory efforts continue throughout the process and are adjusted as needed to achieve the clean water goals. A key element of the watershed approach is the goal to assess the condition of Minnesota's waters (all 81 watersheds) via a 10-year cycle that starts over again after the first 10-year cycle is complete. During the second 10-year cycle, the same progression of intensive monitoring to assess current condition and detect any changes, followed by updating of protection and restoration strategies, and then additional implementation efforts, is pursued in each watershed.

MPCA generally categorizes its monitoring activities according to monitoring purpose and how the monitoring data are assessed and used. Monitoring activities are characterized in accordance with one of three categories, as follows:

- Condition monitoring: This type of monitoring is used to identify overall environmental status and trends by examining the condition of individual water bodies or aquifers in terms of their ability to meet established standards and criteria. Condition monitoring may include chemical, physical, or biological measures. The focus of condition monitoring is on understanding the status of the resource, identifying changes over time, and identifying and defining problems at the overall system level. Examples include: the intensive watershed monitoring conducted in Minnesota's major watersheds; probabilistic monitoring conducted at various scales to evaluate the quality of lakes, rivers, and wetlands; and ambient groundwater quality monitoring.

- Problem investigation monitoring: This monitoring involves investigating specific problems or protection concerns to allow for the development of a management approach to protect or improve the resource. Problem investigation monitoring is used to determine the specific causes of impairments to surface water, to evaluate the extent and magnitude of a contaminant plume in groundwater, and to quantify inputs/loads of contaminants to a water body from various sources. It is also used to determine the actions needed to return a resource to a condition that meets standards or goals. Examples include: stressor identification (ID) monitoring in a major watershed that contains impaired waters; monitoring of groundwater and possibly surface water at chemical release sites; and monitoring conducted for Clean Water Partnership and federal CWA Section 319 projects.

- Effectiveness monitoring: This type of monitoring is used to determine the effectiveness of a specific regulatory or voluntary management action taken to improve impaired waters or remediate contaminated groundwater. Effectiveness monitoring allows for the evaluation and refinement of a selected management or remedial action over time to ensure the approach is ultimately successful. Examples of effectiveness monitoring are monitoring conducted following implementation of watershed protection and restoration strategies or BMPs at various scales, such as the subwatershed, watershed, or basin. Also, effluent monitoring that is done to assess the compliance of a facility with a permit, rule or statute (i.e. compliance tracking); in this example, the monitoring data provide information about how regulatory actions applied to a facility affect the facility's contributions to the associated water bodies (not the effect of the facility's contribution on the water body itself).

Formal reviews of the MPCA monitoring and assessment program have been made as part of a detailed engagement with the Region V states by U.S. EPA for TALU development (MBI 2004, MBI 2010). As a result of that process, Minnesota has been exposed to the TALU development and implementation needs of their M&A and bioassessment program through this initiative. This process should utilize the most recent evaluation of the Region V state programs (MBI 2010) which included the most subsequent updates to the critical technical elements reviews, utilizing the latter as a tool to determine specific technical needs and as a tool to enhance a continuous improvement process. Some of these findings spurred the developmental elements that are part of the TALU work plan described in Section 1.

While MPCA has made a commitment to TALU development in their WQS, a similar commitment to TALU implementation M&A will be needed. Currently, the MPCA monitoring strategy emphasizes status monitoring, which is a characteristic of nearly all state programs. It is also a dichotomy in that some states have developed their M&A programs almost exclusively to support status assessments.

The current MPCA monitoring strategy does not specifically address the needs of a TALU-based approach to water quality management. A key challenge is for MPCA to adapt their M&A strategy to include TALU-based monitoring and assessment as a major category. Spatial design is an especially important aspect of TALU implementation since it affects the ability to obtain and apply data to specific streams and rivers and it also has an influence on the awareness and comprehension of multiple stressors. Having said that the MPCA strategy does recognize TALU as an M&A support need as evidenced by the following statement:

> *"The MPCA looks forward to future conversations with EPA as we continue to advance the watershed approach, develop and implement river eutrophication criteria and other new standards, incorporate biological indicators into our monitoring and assessment efforts, and develop and implement the TALU framework for assessing rivers and streams."*

How well the current MPCA watershed design actually supports TALU implementation is being explored as part of the TALU development process by piloting use designation reviews and implementing the newly developed TALU tools in selected watersheds.

4.2 TALU-Based Monitoring and Assessment (M&A)

State monitoring and assessment should be designed and operated to support "day-to-day" water quality management needs in addition to determining statewide status. However, to accomplish both it needs to be implemented such that it can be utilized at the statewide, regional, watershed, and site-specific scales. Besides fulfilling the assessment of status, a sustained TALU-based M&A program "naturally" incorporates strategic support functions and results in improved criteria, methods, tools, and policies. The resulting database it generates is comprised not only of the data, but of the experience gained by producing systematic assessments. It also includes the regular re-sampling of reference sites and the resulting long-term awareness of reference condition. The aggregate database generated by TALU-based M&A allows for comprehensive analysis and interpretation of spatial and temporal trends and tracking the effectiveness of water quality management programs both individually and in the aggregate. The overall program thereby fosters a continuous improvement process through adaptive management because sufficient information is collected at relevant spatial scales and the interpretation of that information is produced to affect management decisions (U.S. EPA 2005). We refer to this as adequate monitoring and assessment (Yoder 1998) the details of which are included herein as Appendix A.

A TALU-based monitoring program is designed and conducted to meet three principal objectives and in the following order:

1) determine if use designations presently assigned to a given water body are appropriate and attainable;
2) determine the extent to which use designations assigned in the state WQS are either attained or not attained; and,
3) determine if any changes in key ambient biological, chemical, or physical indicators have taken place over time, particularly before and after the implementation of point source pollution controls or BMPs.

This sequence and array of objectives is implicitly different than under a non-TALU based approach in one important way – the assessment is used first to *validate the current designated use* as opposed to the usual approach of determining impairment based on the currently assigned use, which in many cases is an assumed "default" use. The problem with this latter approach is that any issues with the currently assigned use will not become apparent until an inaccurate management decision or application triggers a concern over the assigned use. We believe that by addressing the appropriateness of the current use assignment first, everything else automatically "falls into place" thereby eliminating the need for potentially costly and time consuming "after-the-fact" exercises such as TMDL delisting and even more costly use attainability analyses (UAA).

4.2.1 Spatial Design Considerations

Spatial scale is absolutely the most critical aspect of this type of M&A. As the complexity of stressors within a watershed increases, so does the need for increased spatial detail in the sampling design. In addition, TALU assignments can vary from stream to stream within the same watershed as has been shown elsewhere (U.S. EPA 2005, Appendix B, pp. 172-175). Thus a reliance on extrapolation from too few and spatially scattered sampling sites, the statistical integrity of the underlying spatial design notwithstanding, can result in incomplete or even erroneous TALU tier assignments. At the same time it is recognized that not all water bodies will be assessed ahead of certain water quality management actions, thus a prioritization of M&A needs to be integrated into the overall TALU implementation strategy so that the most important and high profile water quality management actions are based on the most accurate WQS. However, by aligning water quality management program schedules within a rotating basin approach to M&A, it should be possible to have most WQS use designation uncertainties resolved *prior to* developing management approaches and plans (e.g., permits, TMDLs, watershed plans, etc.). Ideally, having the management programs aligned with the watershed monitoring approach would be the most efficient approach. However, aligning the monitoring and permitting schedules has been determined to be impractical and instead watershed monitoring to collect the data needed to resolve use designations prior to the review of a permit will need to accommodate the reissuance schedule, even when it is outside of the watershed monitoring schedule.

4.2.2 TALU-Based Assessment Process

The data gathered by systematic TALU-based M&A is processed, evaluated, and synthesized in an assessment report. Each report contains a summary of major findings and recommendations for revisions to stream and river-specific use designations, future monitoring needs, or other actions which may be needed to address existing impairment(s) of designated uses. At the same time, the systematic execution of this type of M&A on a statewide basis builds a long-term database over space and time, creating and sustaining a resource for the development and improvement of tools, criteria, policies, and legislation. In addition TALU-based M&A inherently incorporates a stressor identification process based on having adequate chemical, physical, and biological data in hand when the biological impairments are encountered. Again, this is implicitly broader than status-based M&A that can leave biological impairments incompletely diagnosed or undiagnosed altogether. The compulsion to make as accurate a diagnosis as is feasible of biological impairments revealed by this type of M&A is an assumed part of the biocriteria application language described in Section 2.3.6. Once again, we recognize that this is a departure from current practice where stressor diagnosis is performed as a second year effort. However, we have found that some impairments do not require the same level of diagnosis, hence some situations are amenable to a “short hand” process. Again, this will occur with experience as these assessments are accomplished through time.

4.3 Incorporating M&A Findings into WQS Recommendations

How the monitoring and assessment data and analyses described above are used as an essential part of a TALU process has been generally described via case examples (U.S. EPA 2005) and is available from selected TALU state programs. Use designation reviews and revisions are a direct and routine result of the biological and water quality assessments that are conducted on a stream or river segment and/or watershed basis. Provided that the spatial design is adequate for the meaningful and accurate application of the sampling data to individual streams and stream segments, *the M&A results are the basis for TALU-based use designation* *assignments*. Aquatic life uses are generally designated based on the *demonstrated potential* to attain a particular use tier based on the following sequence (in order of importance):

1) attainment of the numeric biological criteria (if attaining a General use or higher – attainment of the Exceptional biocriteria for both assemblages is required to be designated as EWH); and,

2) if the applicable General use biocriterion is not met, the habitat potential is determined by an analysis of the Minnesota Stream Habitat Assessment (MSHA) habitat attributes which is used to determine the potential to attain the General use at a minimum.

As such this represents a "UAA type" of process even though a UAA is technically not required to designate uses at or above the "CWA minimum" (i.e., one of the General uses in Minnesota).

A TALU-based process is inherently data driven so that the same sequence of decision-making is executed regardless of the relationship of the current use designation to the minimum CWA goal. To designate uses less than General (i.e., Modified or Limited), a UAA ***is required*** and includes the consideration of the factors that essentially preclude General use attainment including the feasibility of restoring the water body. Under a TALU-based approach the following information and knowledge is required:

1) the present attainment status of the water body based on a biological assessment performed in accordance with the requirements of the biocriteria, the Minnesota WQS, and the TALU-based needs for Minnesota (the latter pertains to adequacy of the spatial design);
2) a habitat assessment to evaluate the potential to attain at least the applicable General use; and,
3) a reasonable relationship between the impaired state and the precluding anthropogenic activities or other factors based on an assessment of multiple indicators used in their appropriate indicator roles and a demonstration consistent with 40CFR Part 131.10 [g][1-6].

The above requires that adequately developed tools and processes be available within the State's M&A process in addition to having a TALU framework in the WQS. This represents the "merging of WQS and M&A" that is a signature of the TALU framework.

4.3.1 TALU Management Options Overview

To illustrate the practical options that MPCA will have for making stream or segment-specific TALU assignments based on the results of the M&A process described above, a matrix of TALU management options was developed (Table 4-1). We are assuming here that all Minnesota rivers and streams will have a TALU tier assigned following the adoption of the new designated use tiers. Virtually all rivers and streams will be assigned the most applicable General Use tier as a "default" in the absence of sufficient data. This will be a practical necessity so that other aspects of water quality management that rely on WQS can proceed apace. In practice the

General Use then becomes a default placeholder until an assessment of the "correct" TALU tier can be made.

Table 4-1. Tiered aquatic life use options based on evaluation of default uses currently in the Minnesota WQS and under a new system of tiered aquatic life uses (TALUs).

Current Designated Aquatic Life Use	Monitoring Results	Attains Designated Use?	Management Options Under New TALU-Based Approach
General[3]	**General Use Attainment**	YES	Retain General designation because biocriteria demonstrate attainability.
General	**General Use Non-attainment**	NO	If habitat assessment indicates General is attainable, then retain General use; OR If habitat is impaired & due to 40CFR131[g] factors, change use to Modified or Limited
General	**Exceptional Attainment**	YES	Revise use to Exceptional based on attainment of Exceptional biocriteria by *both* assemblages.
Class 7[4]	**General Use Attainment**	YES	Revise use to General based on attainment of General biocriteria by *both* assemblages.
Class 7	**General Use Non-attainment**	?	If habitat assessment indicates General is attainable, then revise to General use; **OR** -- if habitat is impaired & due to 40CFR131 [g] factors, change use to Modified or Limited[5].

The scenarios in Table 4-1 that start with either the applicable General (equivalent to the current 2A or 2B uses) or the Class 7 designated uses are the only options that can realistically

[3] General – either a General Warmwater or General Cold Water use designation.
[4] Class 7 will remain in place until a site-specific use determination is made.
[5] Limited will be assigned only when Modified is not attainable.

occur. As indicated before, the principal objective of a TALU-based monitoring and assessment program is to determine if the current designated use is appropriate and attainable, which will be either one of the General (2A or 2B) or Class 7 uses in nearly every case. Hence the biological assessment and the attendant habitat assessment tools will be essential in making this determination. If the General Use biocriteria are attained then that is the "best" demonstration that the General Use is attainable at a minimum. If the Exceptional Use biocriteria are attained *by both assemblages,* then that is justification for assigning an Exceptional Use. Both are consistent with the definition of existing use in 40CFR Part 131.1 as:

> *". . . those uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards."*

If the General Use biocriteria are not attained, then the accompanying habitat assessment is used to determine if the habitat quality is capable of supporting the General Use. If habitat is sufficient, then General will be the assigned use. If habitat is not sufficient, then the UAA process is employed to determine if there are precluding factors under the EPA WQS regulations (40CFR Part 131.10[g]) that are essentially "permanent" preclusions to General Use attainment. In this case the options are to either effect proven restoration techniques or assign the Modified or Limited Use designations.

4.3.2 TALU Implementation Process Overview

The preceding description of the generally available TALU management options did not convey all of the important details about how TALU is to be implemented on a water body specific basis in Minnesota. The more detailed implementation process is described herein and focuses on a hierarchy of decision points that are described in Figures 4-1 through 4-3. Figure 4-1 is an overview of the first steps of the implementation process that starts with utilizing the results of the supporting biological assessment.[6] The design and execution of the sampling and analysis must be adequate for supporting the analytical and decision-making tasks that are a part of the TALU implementation process - it is an expected part of any state TALU process. The possible steps herein are consistent with the options described in Table 4-1.

4.3.2.1 Step I: Initial Application of Bioassessment in a TALU Process (Figure 4-1)

The initial decisions in Figure 4-1 focus first on biological status, specifically if the General Use biocriteria are attained or not. The reason for this is that the General Use biocriteria are the minimum condition that meets the baseline goal of the CWA, i.e., "the protection and propagation of fish, shellfish, and wildlife". This benchmark is also important because it determines the point at which a UAA is required even though the entire process that is outlined herein is "UAA like" and requires consideration of the same types of data and analyses. If the General Use biocriteria are fully attained by both assemblages, then this use will apply because meeting this
benchmark of attainability has been directly demonstrated. If biological attainment of the

[6] A biological assessment as used herein includes biological indicators and chemical/physical indicators collected by following the adequate watershed monitoring and assessment approach discussed in Section 4.2.

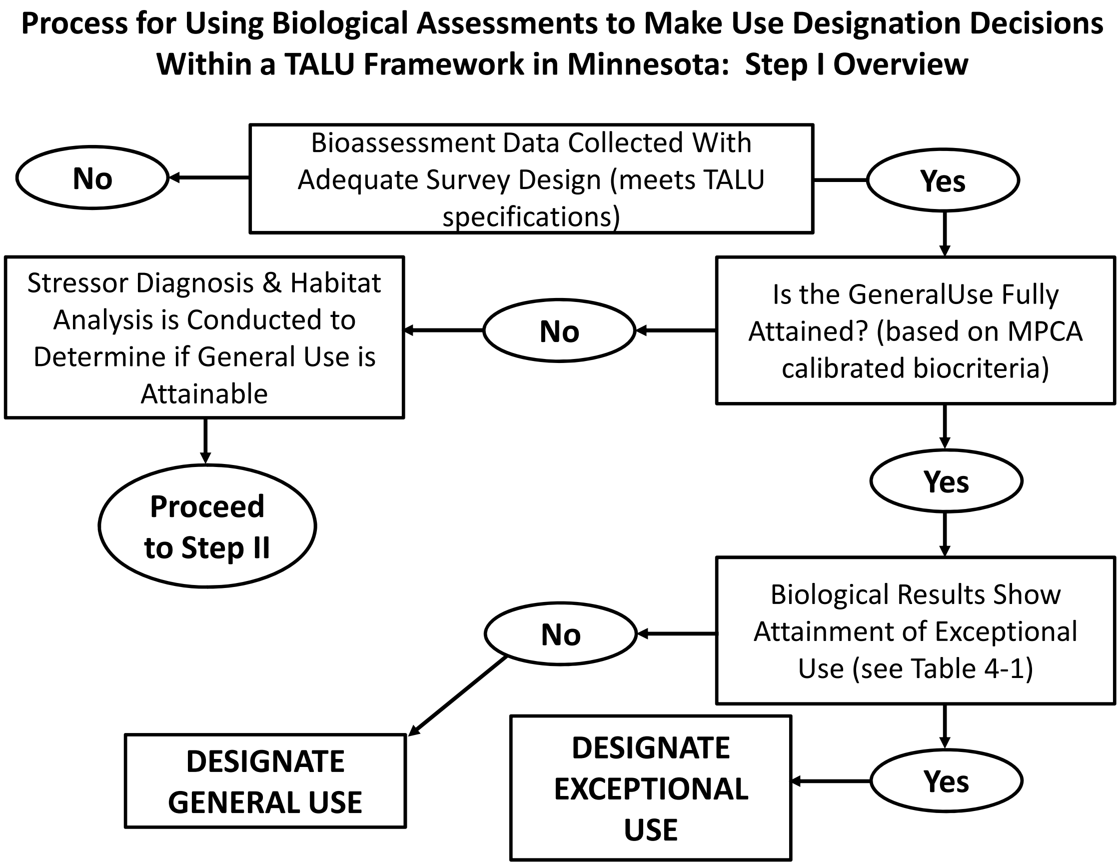


Figure 4-1. Step I: overview of the process for using biological assessments to make use designation decisions in Minnesota based on the proposed TALU framework.

Exceptional Use biocriteria is demonstrated *by both assemblages,* then this use is designated because the attainability of this TALU tier has likewise been demonstrated. Again, each is consistent with the definition of existing use in 40CFR Part 131.3. The Exceptional Use is unique among the TALU tiers in that it requires a showing a biological attainment to be designated as such. Hence it functions as a *preservation use* within a TALU framework, whereas General Use is by comparison a *restoration use.* Hence, attainment of either the General or Exceptional Use biocriteria triggers a straightforward decision to designate those uses (as is also indicated in Table 4-1). Non-attainment of the General Use biocriteria triggers a stressor diagnosis approach that is inherent to a TALU-based program in order to determine if General Use is attainable. This leads to step II -- the process is described in Figure 4-2.

4.3.2.2 Step II: Determining Limitations to General Use Attainment (Figure 4-2)

A finding that the General Use biocriteria are not attained leads to step II (Figure 4-2). The habitat assessment that is conducted as part of the biological assessment is now relied upon to provide the information and analysis that is needed to determine if General Use is indeed attainable. At this point in the process we are simply determining if the attributes of the extant

Process for Using Biological Assessments to Make Use Designation Decisions Within a TALU Framework in Minnesota: Step II

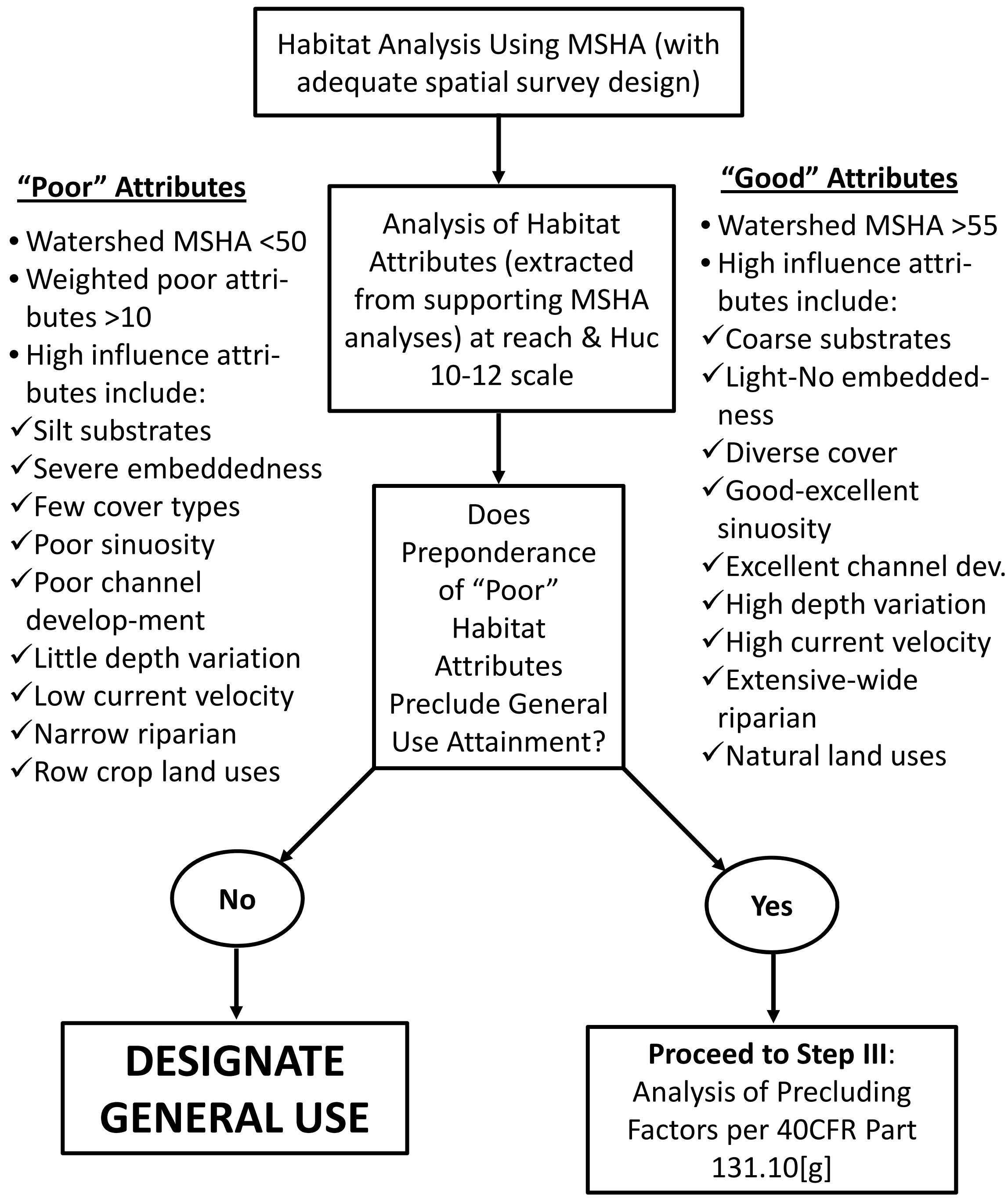


Figure 4-2. Step II: using the analysis of habitat attributes to make decisions about General use attainability.

habitat are sufficient to support biological assemblages consistent with the General Use biocriteria. This requires the use of the supporting analyses of the relationship between MSHA habitat attributes and the biological assemblages that yield sufficiently predictive relationships such that biological attainability can be determined. This descriptive work was accomplished at the stream and river class level utilizing the extant MPCA database and across a sufficiently diverse gradient of habitat quality from very poor to excellent conditions (Rankin and Yoder 2011).

Precedents already exist for this type of process and include the Ohio QHEI analyses by Rankin (1989, 1995). The Minnesota analyses yielded thresholds of MSHA scores that generally correspond to General Use attainment and identified which MSHA attributes provide for a *sufficiently accurate* prediction of General Use attainability. These attributes are expressed as "good" and "poor" attributes (Figure 4-2) the former being comprised of attributes that accumulate to promote biological attainment and the latter having the opposite effect, i.e., those attributes that deter biological assemblages consistent with General Use attainment. The MSHA thresholds and attributes derived for Minnesota (Rankin and Yoder 2011) are used in Figure 4-2. For example, a MSHA score ≥55 is an indication that General Use is attainable, but a score <50 indicates that biological attainment of General Use is less likely. Added to these index thresholds are the occurrence and preponderance of good and poor habitat attributes which help sharpen the decision about General Use attainability. Once this information is analyzed on a reach level basis, a decision about General Use attainability in the absence of direct General Use biological attainment can then be made. If the analysis indicates that habitat is not limiting, then General Use is the resulting decision. However, if the analysis indicates that the habitat attributes are insufficient and therefore limiting then an analysis of the precluding factors consistent with 40CFR Part 131.10[g] is performed (proceed to Step III, Figure 4-3). This process is formally known as a Use Attainability Analysis or UAA.

4.3.2.3 Step III: Use Attainability Analysis (Figure 4-3)

A use that is "lower" than what is recognized as consistent with the CWA, i.e., General Use or higher in Minnesota, can be assigned provided an acceptable UAA is conducted. A UAA is defined as

> *". . . a structured scientific assessment of the factors affecting the attainment of the use which may include physical, chemical, biological, and economic factors as described in §131.10[g]."*

Those criteria are as follows:

40CFR Part 131.10[g]: States may remove a designated use which is not an existing use, as defined in Section 131.3, or establish sub-categories of a use if the State can demonstrate that attaining the designated use is not feasible because:

1) *Naturally occurring pollutant concentrations prevent the attainment of the use; or*

2) *Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met; or*
3) *Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or*
4) *Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use; or*
5) *Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses; or*
6) *Controls more stringent than those required by sections 301(b) and 306 of the Act would result in substantial and widespread economic and social impact.*

Process for Using Biological Assessments to Make Use Designation Decisions Within a TALU Framework in Minnesota: Step III

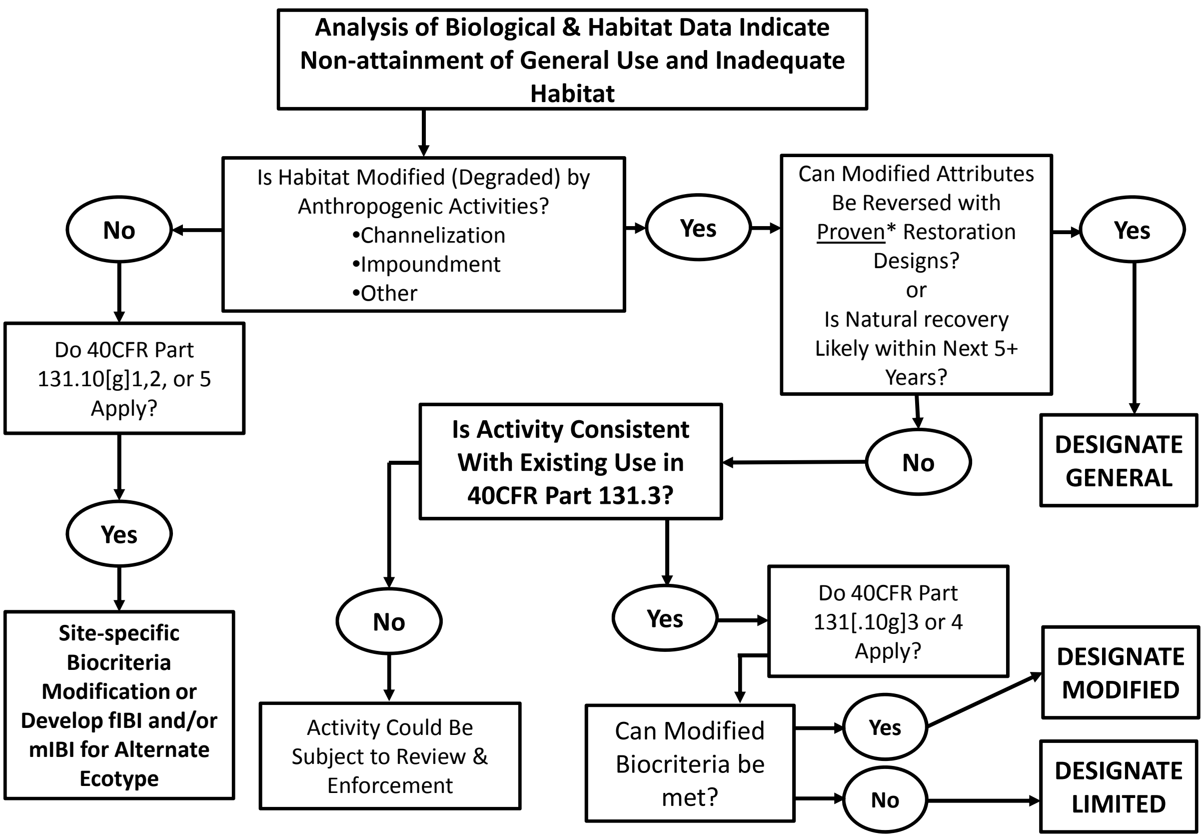


Figure 4-3. Step III: overview of the use attainability analysis parts of the use designation process in Minnesota.

The process arrives at this point because the biological assessment revealed non-attainment of the General Use biological criteria and the analysis of habitat attributes showed habitat to be deficient for supporting biological assemblages consistent with General Use. Since we have already determined that attributes of habitat are insufficient to support General Use, the next task is to determine the “origin” of the deficient habitat, i.e., is it of natural or of anthropogenic (i.e., human action) origin? If it is determined not to be the result of anthropogenic activities, then a determination of whether 40CFR Part 131.10[g][1], [2], or [5] apply is needed. These are considered to be “natural factors” that could preclude attainment of the General Use biological criteria. It would also suggest that either a site-specific modification of the biocriteria is needed or consideration of an alternate ecotype with a distinct biological assessment tool or index is needed. If this phenomenon is encountered on a regional or ecotype basis then the latter option is preferred. In all likelihood the stream and river class-specific development of the biological indices thus far should have “captured” most of these natural factors, but the process is available should something have been overlooked.

We expect almost any habitat caused non-attainment of General Use in Minnesota to be related to anthropogenic habitat impacts that are either of recent or legacy origins. If this is the case then it next needs to be determined if the habitat alterations can be reversed with *proven* restoration designs or if they are of recent enough origin that they are eligible for an enforcement action. By “proven” we are referring to restoration designs that have been shown to restore biological assemblage quality consistent with the General Use biological criteria endpoints and supported by an analysis of restored MSHA attributes. Simply assuming the General Use will be attained because a restoration activity has been undertaken is alone insufficient to satisfy this part of Step III. If there are indeed *proven* designs and these are effectively implemented then General Use could be deemed as attainable. If no restoration actions have been taken or are as yet unproven then the remaining parts of 40CFR Part 131.10[g] will need to be considered.

In Minnesota we expect that the majority of habitat alterations that lead to UAA considerations will most commonly include channelization in support of agricultural row cropping, channelization and other modifications designed to deal with surface runoff in urban settings, and possibly impoundment of riverine habitats by “run-of-river” low head dams (although these are currently not targeted for sampling by MPCA). Each of these has been shown to not only alter habitat such that CWA goals cannot be attained, but also can result in essentially permanent modifications. This is exemplified in 40CFR Part 131.10[g][3] and [4] in that these modifications are due to human actions that are perpetual in their tenure (e.g., [g][3]) and which represent hydrological modifications that cannot be operated in a manner consistent with the General use (e.g., [g][4]). If the actions are consistent with these parts of 40CFR Part 131.10[g] then either the Modified or Limited Uses will be designated. The distinction between Modified and Limited is largely based on the attainability of the Modified biological criteria which are less stringent than the General use biocriteria. A Limited Use biocriteria benchmark equivalent to the 75th percentile of BCG tier 6 is recommended.

4.3.3 Pilot TALU-Based Watershed Assessments

Using the just discussed TALU guidance framework and the technical tools developed to support this process, pilot testing was conducted with MPCA staff using 3 theoretical watersheds as a test of the framework and to determine the limitations of the current spatial monitoring design. The examples include watersheds with a mix of use attainment status (attaining and not attaining), use designation assignment recommendations, monitoring data, and land uses.

4.3.3.1 Agricultural Watershed

In this example there are 4 biological sites in an approximate 25 mile long reach of the primary stream and one location each in two tributaries. The results of applying a TALU framework shows that the General Warmwater Habitat (GWH) subcategory of the General Use suite of uses is the appropriate and attainable aquatic life use in the lower watershed. This is because of the consistent attainment of the General Use biological criteria for this stream class (Figure 4-4). It illustrates the process when biological attainment of at least the General Use occurs (see Fig. 4-1). The example also includes biologically impaired sites (with respect to the GWH biocriteria) that have sufficient habitat to confirm the GWH use where the MSHA indicates sufficient good quality attributes. Hence the restoration goal for these sites is to recover GWH attainment. Two sites in the upper watershed are biologically impaired due to channelization effects on stream habitat. In both cases the MWH use is recommended as the outcome of a UAA. The circumstances and the activities that resulted in the channelization meet the criteria for setting a use lower than the CWA minimum as described in Section 4.3.2. This example also includes unassessed reaches in the upper watershed where the designation will remain at the default use of GWH until sufficient data is collected to show otherwise.

4.3.3.2 Urban Watersheds

The second example is for a watershed predominated by urban land uses (Figure 4-5). In this example there are 3 biological sites on the primary stream and three sites on tributaries. The results indicate non-attainment of the applicable General use biocriteria at all six sites. The two downstream most sites exhibited sufficient habitat to attain the General use hence GWH was retained. At the remaining 4 sites habitat was found to be limiting GWH attainment due to channel modification activities. The Modified Warmwater Habitat (MWH) use is recommended for three of these sites and in accordance with the process in Figures 4-2 and 4-3. At one site flow limitations were such that the Limited use is recommended. The MWH designations were extended upstream only through the channelized reaches thus the unassessed upper portion of the watershed was assigned GWH as a default placeholder.

4.3.3.3 Forested Watershed

The third example is from a predominantly forested watershed with few anthropogenic impacts (Figure 4-6). In this example there are 4 biological sites, 3 on the primary stream and one on a tributary. In this case example the use designation decisions are based on attainment of the General and Exceptional use biocriteria. The downstream most sites attain the Exceptional Warmwater Habitat (EWH) use hence that use was recommended following the process in

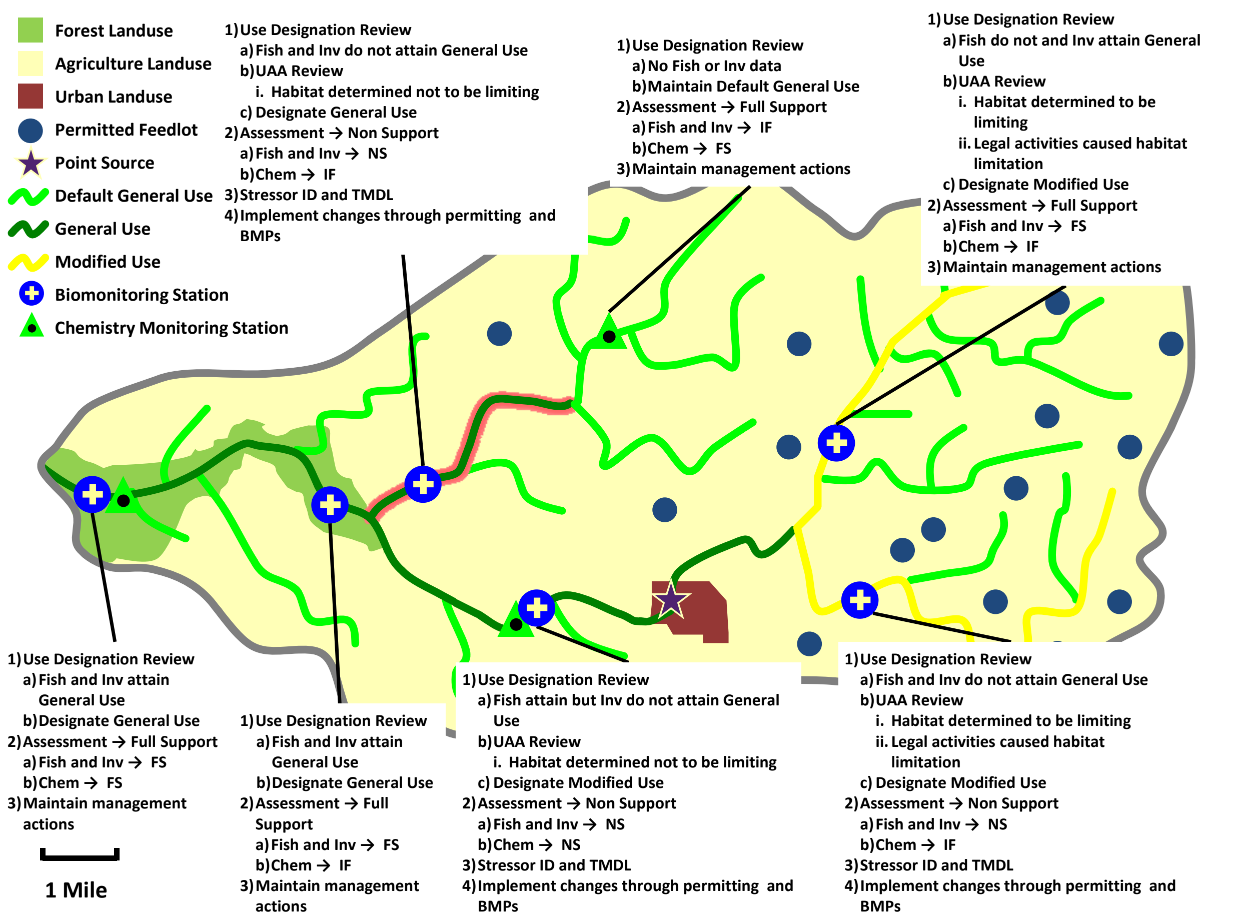


Figure 4-4. Results of applying the MPCA TALU assessment framework in a watershed predominated by agricultural land uses. The result of applying TALU at six sampling locations is described. Sampling sites are indicated by a ✪ symbol.

Figure 4-1. In this case both the fish and macroinvertebrate assemblages met the EWH biocriteria. At the upstream most site fish met the EWH biocriteria, but the macroinvertebrates met GWH, hence the GWH use was retained. The tributary site showed GWH attainment thus confirming that use tier. Several other tributaries were not sampled and are thus considered as unassessed hence the default GWH use was retained.

These three examples generally demonstrate how the designation of the TALU tiers will be conducted as a first step in using bioassessments to first evaluate the appropriateness of the currently assigned aquatic life use, make recommendations for the appropriate TALU-based use, and then conduct the assessment of status based on the recommended TALU tiers.

4.4 Checklist of Technical Tools & Needs

An inventory or checklist of technical tools and needs is discussed here in response to the ongoing development of a TALU-based framework in Minnesota. Some of this has already been accomplished by the evaluation of the Region V state programs (MBI 2004, 2010) and by the

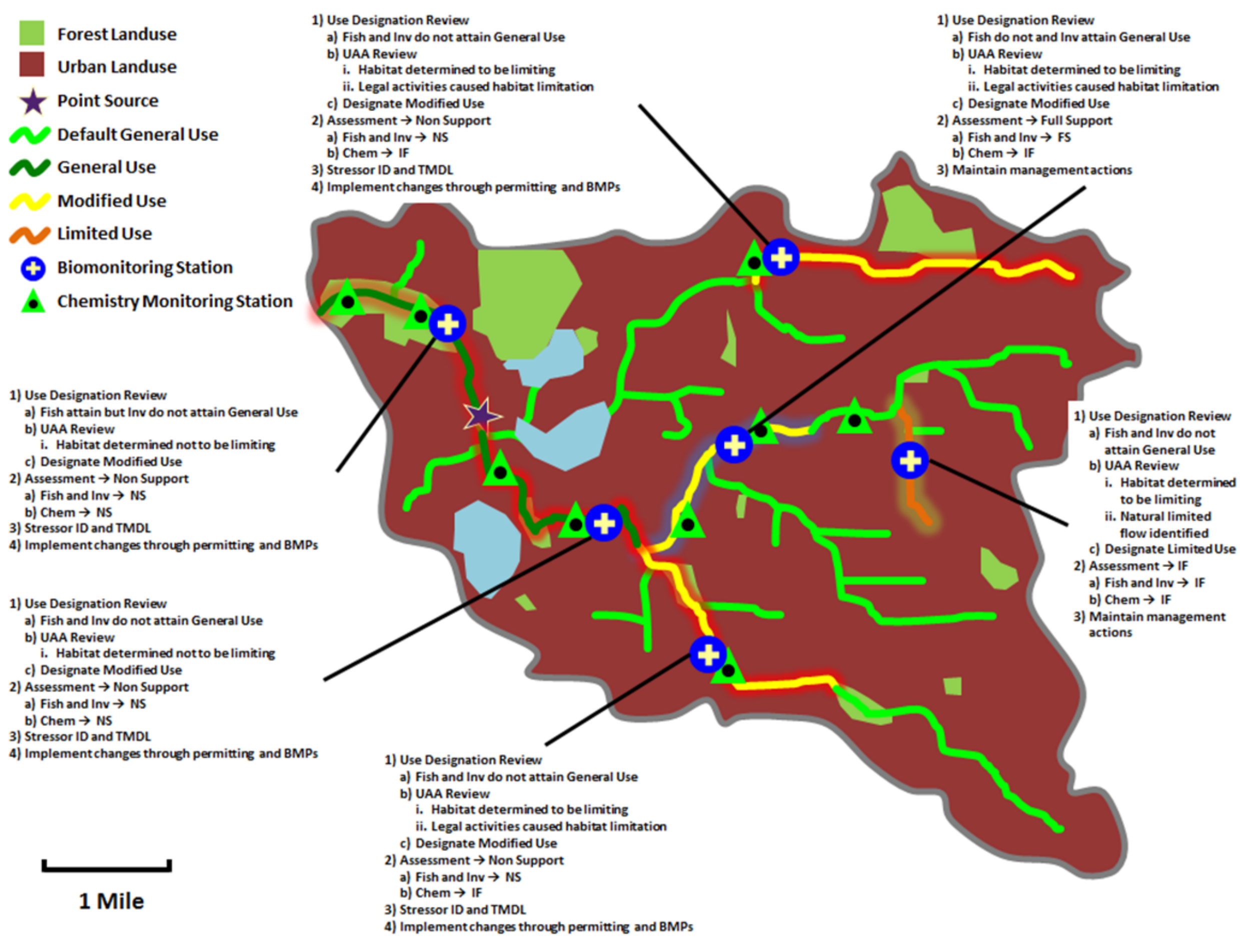


Figure 4-5. Results of applying the MPCA TALU assessment framework to a predominantly urban watershed. The biocriteria attainment status is indicated (GWH Attain) as is the use designation decision for the assessed portion of the streams in the watershed. Sampling sites are indicated by a ✪ symbol.

ongoing critical elements process (Yoder and Barbour 2009; Barbour and Yoder 2008). It should be noted here that the latest critical elements evaluation was based on information as of the 2010 Region V review and that was done as a "desk top" evaluation. A more formal process with the MPCA program needs to be updated to ensure that all developments are captured and understood and in context with the need for a level 4 program to implement a TALU-based approach. The critical elements and state evaluation process is an effective tool for determining the preparedness of a state to implement a TALU-based approach and we recommend that it be updated here to determine if the MPCA is "TALU ready". A mid-level 3 program is needed *at a minimum* to effectively execute a TALU framework and level 4 is the most comprehensive and reliable for that and other purposes including the determination of attainment and non-attainment, stressor identification, and the proper execution of the "UAA type" of process that is the primary driver of the TALU-based approach. The detailed work plan (Appendix A) was developed in part based on prior critical elements reviews conducted in 2002 and 2004 hence that process has influenced the awareness of the technical tools that are needed by MPCA to successfully implement a TALU-based approach.

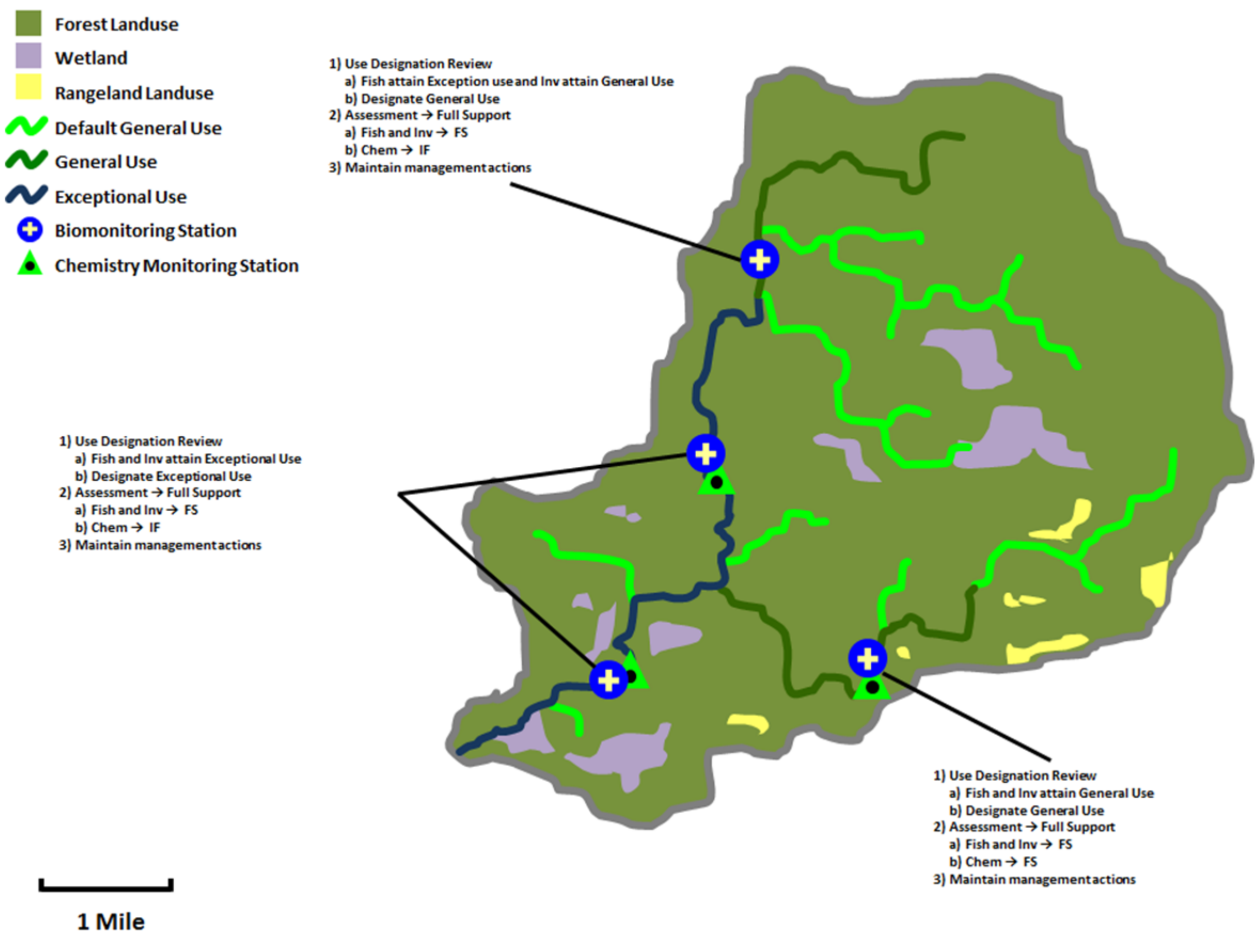


Figure 4-6. Results of applying the MPCA TALU assessment framework to a predominantly forested watershed. The biocriteria attainment status is indicated (EWH Attained and GWH Attained). Sampling sites are indicated by a ✪ symbol.

5. Incorporating TALU into Water Quality Management Programs

The "TALU-based approach" includes TALUs based on numeric biological criteria and implementation via an adequate monitoring and assessment program that includes biological, chemical, and physical measures, parameters, indicators and a process for stressor identification.

WQS are important determinants of both the direction and success of CWA management programs. As the principal custodians of CWA programs, states have the opportunity to determine the structure, content, and technical rigor of their WQS. As part of the state WQS, TALUs are an important component of all three of these aspects. This section focuses on how the adoption of TALUs in the Minnesota WQS might be expected to influence the direction and success of the MPCA CWA management programs.

A traditional view of how WQS affect management programs focuses exclusively on water quality criteria and how changes in these criteria within a "one-size-fits-all" framework will make management goals more or less "stringent". As such the perceptions about adopting a TALU structure in the WQS are "two-dimensional" in that changes in uses have the certain effect of stratifying water quality criteria which then translate directly to more or less stringent management goals and requirements. However, TALU also merges M&A with WQS and their application and as such results in multidimensional effects such that changes in TALU tiers are not necessarily accompanied by corresponding and proportionate changes in the application of water quality criteria. Regional, watershed, reach, and site-specific factors become more important dimensions as they are incorporated into and reflected by M&A results and as such will have a strong bearing on the application of WQS to specific sources and practices. Because a TALU-based approach includes more dimensions and factors than the traditional two-dimensional application of WQS the potential for outcomes that are governed more by regional and watershed level influences are now important considerations. The MPCA biological criteria will be structured into the Minnesota WQS and within the TALU framework. The biological criteria provide an ecologically derived endpoint that directly reflects attainment/non-attainment of designated aquatic life uses. As such, the "starting point" in the application of TALUs is the receiving water body whereas the starting point in traditional water quality management is the regulated activity.

A TALU-based approach when properly developed and implemented is a "modernization" of traditional approaches to setting and implementing WQS. What we term here as the traditional approach to WQS that has emanated from the early 1970s will be significantly modernized by the development and implementation of a TALU-based approach. The incorporation of biological criteria that are in turn defined by the specificity of the TALU tiers represents not only a technical improvement in the measurement of designated aquatic life use attainment, but is an opportunity to address the reality of multiple stressors as opposed to a single parameter or pollutant focused approach. As such it incorporates the concept of pollution[7] into assessments of condition and provides an opportunity to address the key stressors that are the most determinant of biological condition as a result of the accompanying stressor diagnosis aspects of TALU. This in turn better informs water quality management programs about not only which problems to address, but how to better address them from a pre-emptive standpoint. The details about how to develop the designated use language, the biological criteria application language, and the incorporation of biological criteria so that better management outcomes are assured were described in sections 3 and 4.

Figure 5-1. Major State CWA Management Programs and Their Primary Components

Basic Reporting	√ Status √ Trends
TMDLs	√ 303[d] listing √ TMDL dev. √ TMDL effect.
WQS	√ Uses √ UAA √ Criteria √ Antideg.
NPDES	√WQBELs √ Compliance √ Stormwater √ CSO/SSO
Other Permit	√ 401/404 √ State permits
Watersheds	√ NPS mgmt. √ BMP effect. √ Habitat √ Flow √ Priority setting √ Source water

5.1 CWA Management Programs Affected by TALU

WQS ultimately set the goals for management programs through the designation of uses and they provide for the chemical, physical, and biological endpoints that are used to develop management strategies and determine their effectiveness. The major CWA management programs that are part of any state program include basic reporting, WQS, nonpoint source management, watersheds & TMDLs, and permitting. There are important and recognizable components of each of these programs (Figure 5-1) and each are either directly or indirectly affected by the detail in state WQS.

Despite a myriad of attempts over the past 25 years to outline and implement an environmental indicators driven approach to water quality management, the effectiveness of water quality management programs continue to emphasize administrative outputs. These outputs include the quantity and timeliness of activities such as permits issues, backlogs reduced, number of TMDLs, grants awarded, etc. The net result is what we term here as an Administrative Outputs based approach to water quality management in which the goals and measures are based solely on administrative actions (Figure 5-2). In this domain the goal is the performance of a management is judged primarily by attaining administrative accomplishments as measured by programmatic "outputs"[8]. For example, a

[7] The Clean Water Act defines *pollution* as human-induced alteration of waters caused by pollutants as well as non-pollutant agents, such as flow alteration, physical habitat alteration, and introduction of alien taxa [CWA section 502(19)]. *Pollutants* are selected substances that are defined by CWA Section 502(6).

NPDES permitting program is measured by the number of permits issued or re-issued, compliance assistance actions, and the quantity and timing of backlogs. The result of this emphasis is to improve the performance of the program by focusing on the execution of administrative tasks such as efficiency in permit issuance or reductions of backlogs. An environmental indicators approach envisions this shifting this to a resource end "outcomes"[9] based approach (Figure 5-2) where the goal is the attainment of designated uses, which includes aquatic life uses that are a key component of a TALU-based approach. The measures are environmental and include biological, chemical, and physical indicator end-points each being used within their most appropriate role and indicators of stress, exposure, and response (Yoder and Rankin 1998). Under a TALU-based approach this means that the numerical biological criteria are the key response variable which is consistent with how they are defined and codified in the state WQS. Their relationship to other chemical and physical criteria is defined by the biocriteria application language that is a part of the TALU forged modernization of WQS. The overall results of this framework are made manifest when water quality management programs become a means to meeting biological condition goals, not an end in themselves.

States can best execute this approach when administrative program priorities have been sequenced with the monitoring and assessment schedule, usually with the latter being positioned to provide the necessary data and information far enough in advance of developing and then implementing management actions. This sequence especially allows for the designated uses under a TALU-based approach to be reconciled before management

Administrative Output vs. Resource Outcomes Based Management

	ADMINISTRATIVE OUTPUTS BASED	**RESOURCE END OUTCOMES BASED**
Goal:	**Program Performance** (Program execution)	**Environmental Performance** (Attain designated uses)
Measures:	**Administrative Actions** (Lists, Permits, Funding, Rules)	**Indicator End-points** (**Biological**, Chemical, Physical)
Results:	**Improve Programs** (Reduce backlogs, improve timeliness)	**Programs are Tools to Improve the Environment** (Admin. outputs evaluated by environmental end outcomes)

Figure 5-2. Administrative outputs are validated by an environmental based end outcomes approach that is fostered by a TALU framework (after MBI 2004).

[8] An output is a discrete administrative accomplishment such as the issuance of a permit or the completion of a TMDL, i.e., it counts the number of management program products.

[9] An outcome is a direct change in the receiving water body as indicated by a chemical, physical, or biological measurement or indicator. As such an outcome is related to an output by being its end result.

actions are designed and implemented. Too often, inadequacies in "one-size-fits-all" general designated uses are not apparent until the consequence of a management action is realized and perhaps too late to reconcile with a "UAA type" of process that is an embedded part of a TALU-based approach.

5.2 An Information Driven Approach to Water Quality Management

When fully designed and implemented, a TALU-based approach fosters an information driven process for developing and assessing the effectiveness of water quality management programs. While the logistics of such an approach first requires the right information to be available "in time" to affect water quality management programs, how such monitoring and assessment information is sequenced is also an important aspect. U.S. EPA has used Figure 5-3 extensively to illustrate the sequence of having monitoring and assessment information positioned so that it can affect the development and assessment of water quality management programs. While the sequence is essentially correct, this and like examples leave out critical details that are essential components of such a process.

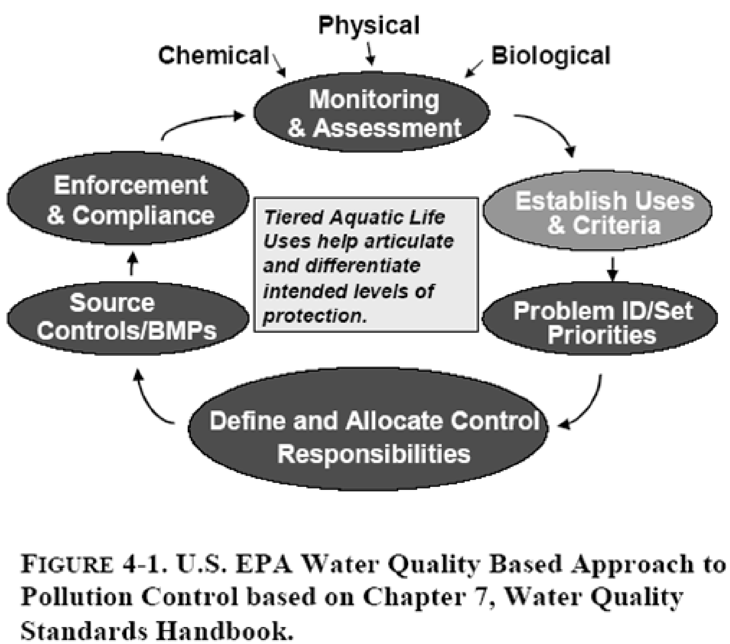


Figure 5-3. The U.S. EPA depiction of how monitoring and assessment fits within a water quality based approach to pollution control and abatement (after U.S. EPA 2005).

5.2.1 Hierarchy of Surface Water Indicators

A carefully conceived ambient monitoring approach, using cost-effective indicators comprised of essential biological, chemical, and physical measures, can ensure that all relevant pollution sources are judged objectively and on the basis of environmental end outcomes. This integrated approach employs a hierarchical continuum that includes administrative and true environmental indicators with the latter arrayed in their "most appropriate roles" as indicators of environmental stress, exposure, and response, respectively (Figure 5-4). This framework was initially described by U.S. EPA (1995a). The framework includes six "levels" of indicators as follows:

Level 1 Actions taken by regulatory agencies (*e.g.,* permitting, enforcement, grants);

Level 2 Responses by the regulated community (*e.g.,* construction of treatment works, pollution prevention);
Level 3 Changes in discharged quantities (*e.g.,* pollutant loadings);
Level 4 Changes in ambient conditions (*e.g.,* water quality, habitat);
Level 5 Changes in uptake and/or assimilation (*e.g.,* tissue contamination, biomarkers, assimilative capacity); and,
Level 6 Changes in health, ecology, or other effects (*e.g.,* ecological condition, pathogenicity).

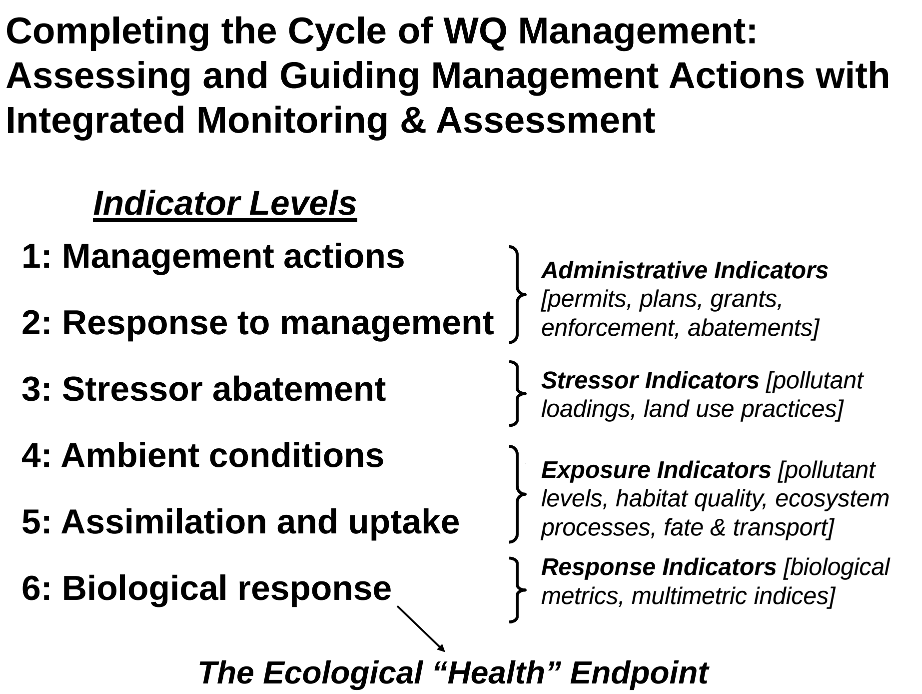


Figure 5-4. Hierarchy of indicators for determining the effectiveness of water quality management and maintaining appropriate relationships and feedback loops between different classes of indicators (modified from U.S. EPA (1995a).

In this process the execution of administrative activities (levels 1 and 2) are followed by changes in pollutant loadings and ambient water quality (levels 3, 4, and 5), all of which lead to measurable environmental "results" (level 6). The process is multi-directional with the level 6 indicators providing feedback about the completeness and accuracy of the process within the preceding hierarchy levels. While the U.S. EPA (1995a,b) hierarchy employs "point source" terminology, it is adaptable to nonpoint sources, other water resource issues, and media other than surface waters. Superimposed on this hierarchy is the concept of stressor, exposure, and response indicators described by Yoder and Rankin (1998).

In order to supply this framework with the necessary biological, chemical, and physical data and assessments an adequate monitoring and assessment program that considers not only what is measured, but the spatial and temporal design of the data collection, the development and completeness of the chemical, physical, and biological indicators, the analytical and interpretive processes used to assemble the data and information into meaningful assessments, and the organizational infrastructure within which it is all accomplished is needed (Yoder 1998). As such, this overall framework includes more than the mere collection of environmental data, but rather emphasizes the development and thoroughness of the assessments that are constructed based on that data. This goes beyond the almost over-emphasized task of assessing statewide status and trends and includes the more detailed task of realizing the integration with water quality management programs on a day-to-day basis and ***at the same scale at which those management actions are applied.*** An important goal for a TALU-based framework is to have the effectiveness of individual water quality management actions and programs determined by environmental *end outcomes* as measured by the information and indicators gained from adequate monitoring and assessment. Inherently embedded in achieving this goal is the adequacy of the essential components of the water quality management infrastructure including WQS. This framework can support any water quality management program where the restoration of designated use attainment is the end goal.

5.2.2 Indicator Discipline – Adherence to Indicator Roles

An important factor in achieving the cost effective approach just described is using chemical, physical, and biological indicators in their most appropriate roles as stressor, exposure, or response indictors. The accurate portrayal of the condition of aquatic resources depends on wider development and use of response indicators and adequate spatial monitoring designs conducted at the same scale of water quality management. Part of the solution to these challenges is to use indicators within their most appropriate roles. The U.S. EPA Environmental Monitoring and Assessment Program (EMAP) first classified indicators as portraying stress, exposure, or response. Yoder and Rankin (1998) further organized the concept defining the most appropriate roles of parameters and measures when used in an adequate monitoring and assessment program. These are categorically described as follows:

Stressor indicators generally include activities and phenomena that impact, but which may or may not degrade or appreciably alter key environmental processes and attributes. These include point and nonpoint source pollutant loadings, land use changes, and other broad-scale influences that most commonly result from anthropogenic activities. Stressor indicators provide the most direct measure of the activities that water quality management attempts to regulate.

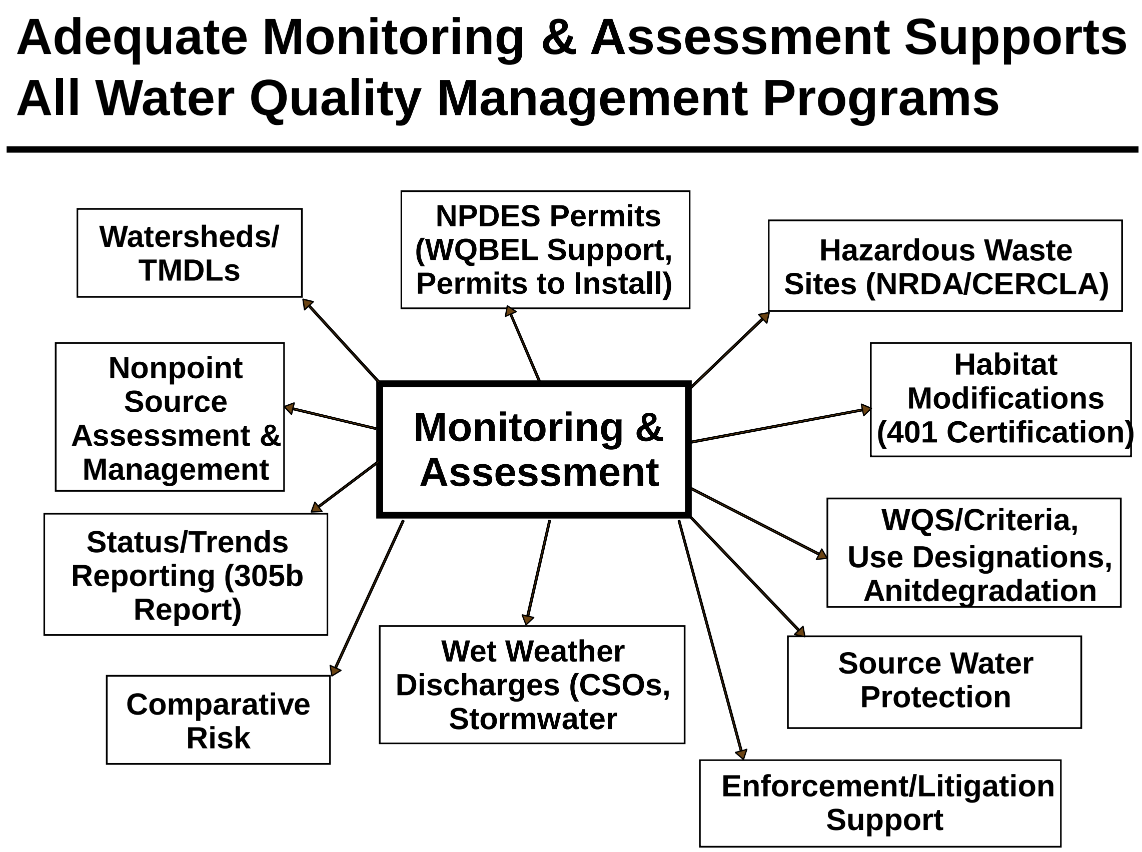
Exposure indicators include chemical-specific, whole effluent toxicity, tissue residues, and biomarkers, each of which suggest or provide evidence of biological exposure to stressor agents. Fecal bacteria also serve as exposure indicators and are used as surrogates for response where direct human response indicators are either lacking or their use would pose an unacceptable risk. These indicators are based on specific measurements that are taken either in the ambient environment or in discharges and effluents, either point or nonpoint source in origin are measures and parameters that reveal the level or degree of an exposure to a potentially deleterious substance or effect that was produced by a stressor event or activity. Chemical water quality parameters and the concentrations at which they occur in the water column fulfill this role. Water quality criteria for toxic substances are developed to indicate chronic, acute, and lethal exposures. Exceedences of these thresholds, either predicted or measured, provide design targets for planning and permitting and assessment thresholds for monitoring and assessment. Fecal bacteria fulfill this role as well, indicating the level of risk posed to humans and other animals by exposure to various levels and durations of potentially harmful pathogens.

Response indicators are measures that most directly relate to an endpoint of concern, i.e., ecological and human health. They are most commonly biological indicators, e.g., aquatic assemblage measures for aquatic life uses and human health for recreational uses and are the most direct measures of the status of designated uses. For aquatic life uses the assemblage and population response parameters that are represented by the biological indices that comprise biological criteria are examples of response indicators. For other designated uses such as recreation and drinking water, symptoms of deleterious effects exhibited by humans would serve as the most direct response indicator, albeit these might prove more difficult to develop and manage. Response indicators represent the synthesis of stress and exposure and are commonly used to represent overall condition or status. The key to implementing a successful indicators and watershed approach that serves as a basis for developing a synthesized "report card" is to ensure that indicators are used within the roles that are the *most appropriate* for each. The inappropriate substitution of stressor and exposure indicators in the surrogate role of response indicators is at the root of the national problem of widely divergent 305(b) and 303(d) statistics reported between the states (NRC 2001). Mapping these indicators to their functional role in monitoring and assessment is best visualized in the hierarchy of indicators depicted in Figure 5-4. This combines their role in a technical sense with their application is a management sense.

5.2.3 Strategic Considerations

Adequate monitoring and assessment is an inherently strategic process. To fully realize its benefits requires an understanding of the multiple uses of information in the management of water resources. A fundamental tenet of adequate monitoring and assessment is that the same set of core resources, methods, standards, data, and information should support multiple program management needs (Figure 5-5). It also requires a commitment to program maintenance and upkeep (i.e., maintenance of adequate resources, facilities, and professionalism) over the long term. Professionalism includes the qualifications of the monitoring and assessment personnel and their ability to carry out all tasks, including data analysis and the sequencing and interpretation of multiple indicators (see Figure 5-4). Indicator usage typically requires specialized expertise in terms of data collection, field observations, laboratory methods, taxonomic practice, and data analysis and interpretation skills. Thus the professional qualification of the personnel who execute and manage a program is a pivotal issue.

Adequate monitoring and assessment provides functional support to individual management programs in two important ways. The first includes "baseline CWA program support" tasks such as determinations of status at multiple scales, UAAs, supporting the regulation and management of specific sources, and providing information to guide watershed planning and restoration programs. The second is that of providing "CWA strategic support" via the systematic accumulation of data, information, knowledge, and experience across various temporal and spatial scales. This includes resources devoted to such tasks as sampling and maintenance of reference sites for determining regional reference condition and developing reference benchmarks for key biological, physical, and chemical indicators and parameters.



program support needs with the same core base of indicators, parameters, and designs.

Many contemporary management needs are not well supported by conventional approaches to water quality criteria and modeling, thus new ways of developing and applying benchmarks and criteria are needed. Developing criteria for nutrients and both clean and contaminated sediments are examples. Other issues such as urbanization and habitat concerns will require landscape and riparian level indicators and objectives. All require robust spatial and temporal datasets. Coupled with this is the need to conduct ongoing applied research and exploratory data analysis with the monitoring program datasets, including the aggregate experience of the program. The ongoing accumulation of data, information, and assessment across different spatial scales provides both the datasets and the assessment experiences. This comprises the strategy for delivering the criteria and benchmarks that will not be delivered by the conventional approach to developing national water quality criteria. Task 5 of the MPCA TALU work plan is an example of this process.

Finally, the recognition that the most important product of adequate monitoring and assessment is the assessment, not just the data, is critical to achieving success. Data by itself has limited usefulness to environmental decision-making unless it is converted to useful information. This means having decision criteria and benchmarks fully integrated into the monitoring and assessment program. It also means adhering to the indicator sequencing and linkage processes that were previously described and most importantly, using indicators within their most appropriate roles. An integrated assessment should serve the needs of multiple programs by the same set of assessments, without the need to generate new or different datasets for each and every management issue.

5.3 How TALU Can Affect Major MPCA Water Quality Management Programs

While we cannot now predict all impacts that the adoption and implementation of TALU will have on MPCA water quality management programs, some general conclusions and descriptions are possible. These are derived in part by knowing how TALU will affect current management processes and also how it has worked where TALUs have been a part of state programs for many years. We will follow the breakdown of major CWA programs as it is depicted in Figure 5-1.

5.3.1 Monitoring and Assessment

Monitoring and assessment is a key component of a TALU approach, but it is also a major CWA program function. States are expected to develop and implement a monitoring strategy that covers the next 10 years of development and implementation. U.S. EPA guidance (U.S. EPA 2003) specified 10 elements that each strategy is to include. MPCA accomplished this recently with their update to the Minnesota Monitoring Strategy (MPCA 2011). The document is both comprehensive and thorough in its attempt to reflect the U.S EPA (2003) guidance. While the strategy describes a stratified approach to the spatial design of surface water monitoring it does not fully describe the TALU specific aspects primarily because it is currently in development. The initial pilot testing described in Section 4 revealed some technical items with monitoring design that includes the following considerations:

1. Spatial density of sampling sites in some watersheds should be improved for assessing the assignment of TALU tiers in selected rivers and streams – this should also improve the delineation of pollution gradients;
2. Having data on both biological assemblages was not available for every site (although it was available at most) – this should be done as a matter of practice given the dual assemblage approach that TALU requires;
3. Chemical/physical data was not able to be paired with every biological site and in some cases this totaled multiple sites in some watersheds – chemical/physical data will need to be paired with biological data and at a sufficient frequency; and,
4. Intensive surveys of specific stream and river segments to assess specific point sources or localized aggregations of impact sources is not included and is only infrequently employed.

These highlight where some modification or supplementation of key aspects of the MPCA monitoring design will be needed and determining this is an important part of the development process and ultimately TALU implementation.

A template for an annual watershed assessment process is depicted in Table 5-1 from the selection of specific watersheds for assessment through detailed study planning, field sampling, data management, data analysis, and reporting are described in their respective sequence.

Table 5-1. Important timelines and milestones in the planning and execution of a watershed assessment process on an annual basis in support of a TALU-based approach.

Timeline	Milestone
December - February: (Months 1-3)	Initial screening of the major hydrologic areas takes place by soliciting input from the various program offices and other stakeholders.
February - March: (Months 3 thru 4)	Final prioritization of issues and definition of specific study areas. Resource allocation takes place and study team assignments are made.
March - May: (Months 4 thru 5)	Study planning takes place and consists of detailed map reconnaissance, review of historical monitoring efforts, and initial sampling site selection by the study team. Final study plans are reviewed and approved.
May - June: (Months 5 thru 6)	Final study plans are used to develop logistics for each field crew. Preparations are made for full-scale field sampling.
June - October: (Months 6 thru 10)	Field sampling takes place with field crews operating somewhat independently on a day-to-day basis, but coordinated by the study plan and the team leader. Study team communication takes place as necessary, especially to resolve unexpected situations.
October - February: (Months 10 thru 14)	Laboratory sample analysis takes place for chemical and biological parameters. Raw data is entered into databases for reduction and analysis. The study team meets to review the information base generated by the field sampling and to coordinate the data analysis and reporting effort.
November - May: (Months 11 thru 17)	Information about indicator levels 3-6 is retrieved, compiled, and used to produce analyses that will support the evaluation of status and trends and causal associations within the study area. Integration of the information (*i.e.,* assessment) is initiated.
May - December: (Months 17 thru 24)	The assessment process is completed by producing working copies of the assessment for review by the study team and a final edit for an internal peer review. Final assessment approved by management for use within and outside of the agency. It is used to support 305b /303d, NPDES permitting, water quality standards (*e.g.,* use designation revisions), and other programs where surface water quality is of concern.

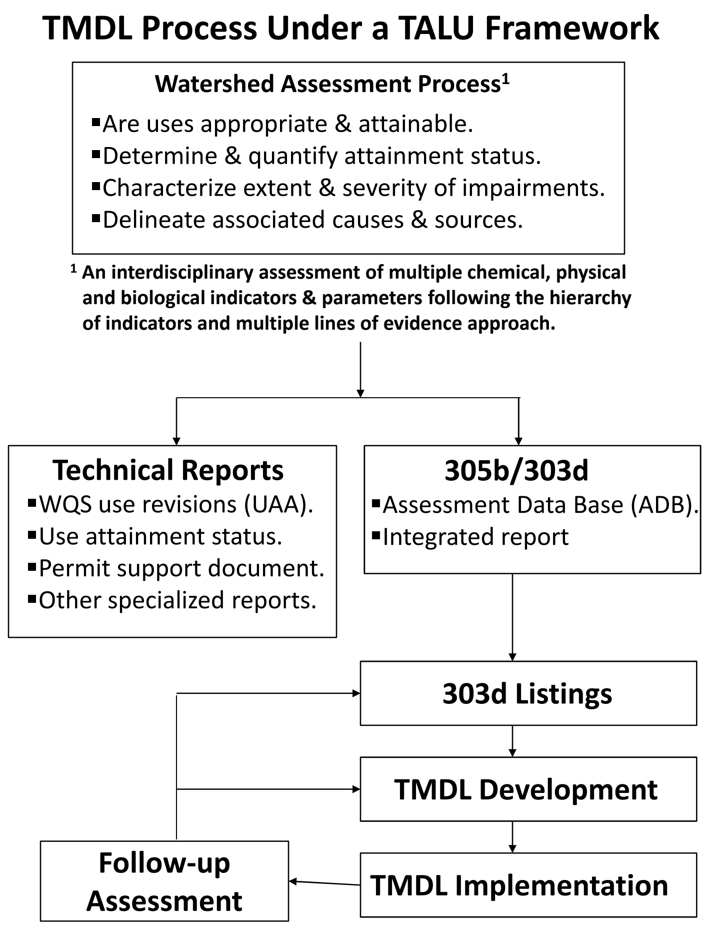


Figure 5-6. Key steps in a TMDL implementation framework within a TALU based framework.

5.3.2 Total Maximum Daily Loads (TMDLs)

The anticipated effect of TALU implementation on TMDLs includes the obvious effect of adding biological assessments to the determination of impairments and the expectation that more and different impairments will be identified (Karr and Yoder 2004). However, the totality of the TALU approach and its influence on the design, conduct, and outcomes of monitoring and assessment will perhaps exert changes in the process of watershed assessment. That process and how it specifically relates to TMDLs is depicted in Figure 5-6. In this approach it is the watershed assessment that is the domain of the TMDL process beginning with the determination of the appropriate and attainable aquatic life uses. This is an essential prerequisite to the determination of impairment under TALU since the attainment/non-attainment biocriteria vary with the use designation tier and within the newly developed stream and river classifications. Instead of using a narrative biocriterion that was applied on a statewide basis, the new biocriteria under the proposed TALU framework are now more detailed and stratified across Minnesota. Hence what may have been considered impaired or not under the former approach may have a different result under the proposed structure of TALUs and biocriteria.

Also included in the watershed assessment process in addition to the use and impairment determinations are the characterization of the severity and extent of impairments and the delineation of causes and sources. While MPCA currently employs a process to delineate stressors associated with findings of impairment via an additional year of investigation, addressing the issue identified in Section 5.3.1 with the inequities of indicator coverage at each site should enable some impairments to be more readily diagnosed with that dataset. This issue certainly bears more detailed examination and pilot testing and it seems plausible to accomplish this in the initial stages of TALU implementation.

The key product of a TALU focused watershed assessment is a technical report that details the WQS use revisions including their location and the basis for any changes to existing assigned uses under the WQS. It also documents use attainment status in a logical array of how stream and river segments occur in the watershed and a summary of the causes and sources that are associated with the observed impairments. The assessment results can be arranged in a manner such that they are directly transferable to the 305b water body inventory (Assessment Database) and the Integrated Report. This information then supports the listing of impaired water bodies as required by the 303d process and the details of the assessment of biological, chemical, and physical data feeds into the development of TMDLs in response to the observed impairments. Ideally, TMDL implementation is followed afterward by follow-up assessments which then provide feedback to the TMDL listing and development process.

5.3.3 Water Quality Standards

While TALUs are a major aspect of state WQS once they are developed and adopted there are other parts of the WQS that can be affected by the TALU approach. This most commonly includes chemical and physical water quality criteria and the nondegredation policy.

5.3.3.1 Refined Water Quality Criteria

Both numeric and narrative water quality criteria can be affected by the adoption of TALUs in the state WQS. This mostly involves the "tiering" of criteria for selected parameters in accordance with the attributes ascribed by the TALU narratives. However, relying on the national criteria development methodology (Stephan et al. 1985) does not necessarily result in the derivation of tiered criteria for the different TALU tiers. The reason for this is that the Stephan et al. (1985) method relies on laboratory data for representative species that actually have data available and this never includes the entirety of an aquatic assemblage. In fact, these databases are usually overrepresented by species that are highly to intermediately tolerant of pollution, seldom including highly intolerant species members of these assemblages. In addition, the differences between TALU tiers are not completely explained by differences in species, but rather by shifts in the relative abundances between the same species. Because the representative species in the Stephan et al. (1985) all count as "equal" contributors, i.e., they are included on a presence/absence basis, the relative abundance influences are not accounted for in the traditional derivation of water quality criteria. Thus the species members of two adjacent TALU tiers may be similar enough that no differences are produced by the conventional method of deriving chemical criteria.

The alternate approach is to develop relationships between the biological criteria endpoints and field measurements of the parameter(s) of interest. Techniques to relate the response of the biological assemblages to single chemical/physical parameters have been developed and used to derive tiered criteria in concert with the adoption of TALUs. These include "wedge plot analysis" and more recently quantile regression (Terrell et al. 1996, Cade and Noon 2003, Bryce et al. 2008, Heiskary et al. 2010). An example using pricewise quantile regression or additive quantile regression smoothing is included in Figure 5-7 which was used as part of an analysis to develop nutrient criteria for rivers in Minnesota (Heiskary et al. 2010). A sufficiently robust spatial and temporal database of paired bioassessment and chemical/physical parameter specific data is needed to accomplish this type of criteria derivation. Furthermore, the full gradient of quality (excellent to very poor) as reflected by both the biological assemblage response and the chemical/physical parameter in question needs to be available. It is for this latter reason that only the most commonly occurring parameters are usually included in this type of process. This would include dissolved oxygen, ammonia-nitrogen, common heavy metals (Cu, Cd, Pb, Zn, Fe), and other parameters such as total suspended solids, total dissolved solids, sulfates, chlorides, and turbidity. This type of analysis is depicted in task 5 of the work plan described in section 1.

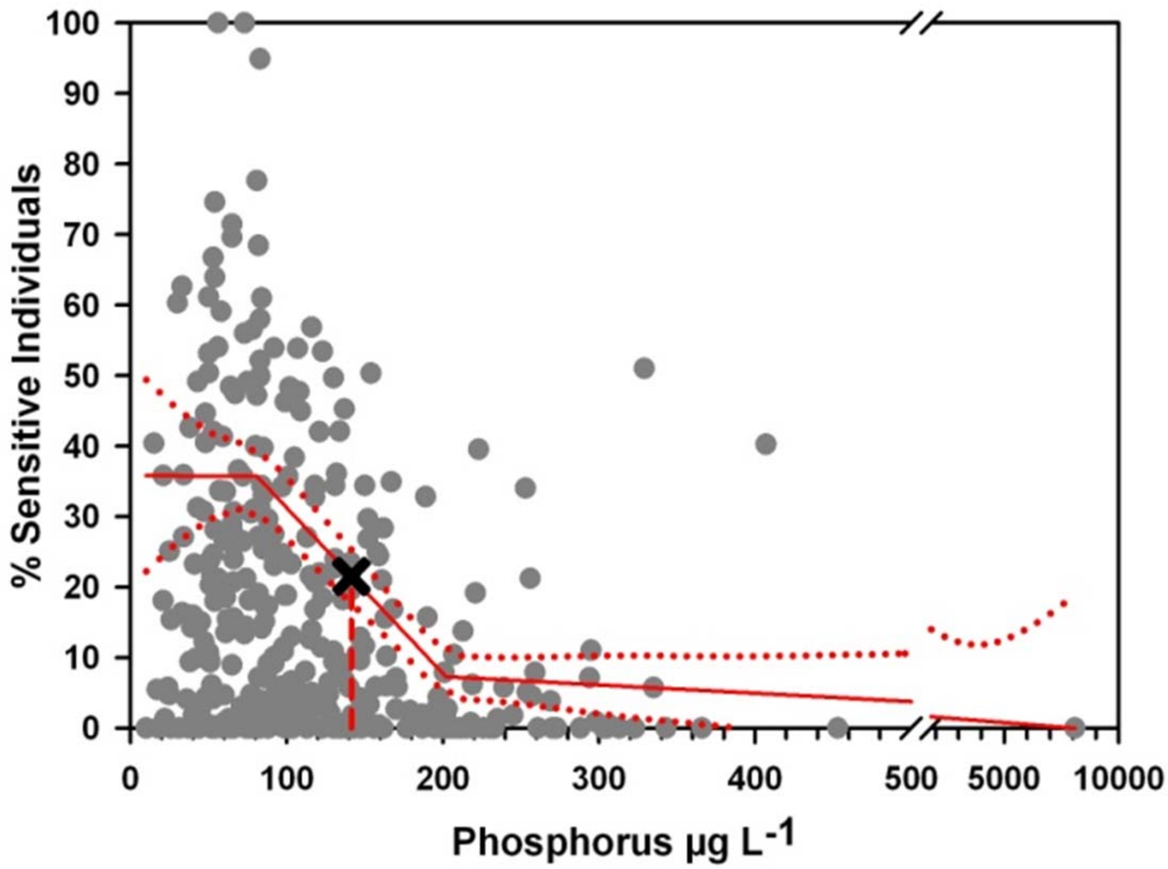


Figure 5-7. Example of 75th percentile additive quantile regression smoothing for percent sensitive fish for the Central Hardwood and Driftless Area ecoregions (solid line = AQRS fit; dotted lines = 90% confidence bands).

5.3.3.2 Antidegradation

TALU is also relevant to antidegradation in particular the assignment of specific water bodies to antidegradation tiers. The same biological data that is used to derive and implement the numeric biocriteria can be used for stratifying the antidegradation tiers while at the same time highlighting the occurrence of unique and sensitive species populations that otherwise may be "obscured" by the biocriteria indices alone.

5.3.3.3 Use Attainability Analysis (UAA)

Section 4.3.2 essentially described in detail a "UAA type" of process for using the results of bioassessment to determine if the currently applicable aquatic life use is both appropriate and attainable. In strict terms a UAA is employed when a use less than a CWA Section 101[a][2] use is being proposed, which in our case would be the Modified Warmwater Habitat (MWH) or Limited Resource Water use tiers (LRW). However, in a TALU-based approach the same data, tools, and stepwise process are used to answer the broader question about the applicability of the currently applicable use as defined by chapter 7050. As was discussed in Section 4.3, the starting point will almost always be class 2B (or class 2A in the case of cold water streams) which is roughly equivalent to the General Warmwater use tier. As such the same process will be used to assign a higher than CWA minimum use as it will to assign a less than CWA minimum use.

5.3.4 NPDES Permitting

The Nation's stream and rivers were grossly polluted by raw and under-treated wastewater discharges from industrial and municipal sources prior to the passage of the Federal Water Pollution Control Act (FWPCA) amendments of 1972. Referred to herein as the CWA it led to the institutionalization of a federal system of discharge permits known as the NPDES. This federal system of permitting developed out of a nearly quarter-century long legislative process that was spurred by an increasing recognition of visibly polluted rivers and streams both by the public and the research community. Pioneering works about the biological effects of water pollution included early studies by Bartsch (1948), Doudoroff and Warren (1951), and a series of studies compiled by the Federal Water Pollution Control Administration (Keup et al. 1967). These and many other investigations raised a keen public awareness about the grossly polluted state of many rivers and streams and spurred the development of legislation aimed at reducing and controlling the adverse impacts on public health, recreation, and aquatic ecosystem health.

The adoption of a TALU-based approach[10] by MPCA presents the opportunity to prioritize and streamline NPDES permit actions using ambient monitoring and assessment information with an emphasis on biological criteria as the key endpoint for determining overall permitting effectiveness. For the purposes of this project, permitting actions include the aggregate of permit development and issuance, compliance, and enforcement. Biological assessment includes the biological, chemical, and physical assessment of receiving waters on a river reach and/or watershed basis with biological criteria serving as the key response variable and as the arbiter of designated aquatic life use attainment. The process is generally illustrated in Figure 5-2 with a TALU-based approach representing the Resource End-Outcomes sequence. The current NPDES program represents the Administrative Outputs sequence with administrative outputs being used as the arbiter of program success.

Presently, the prioritization and effectiveness of NPDES permitting activities in Minnesota is based primarily on administrative processes, indicators, and measures. U.S. EPA and others have acknowledged the potential value of basing permitting and other priorities on ambient monitoring and assessment results *as they can be related to administrative actions*. The framework for a workable process (see Figure 5-4) first emerged out of prior U.S. EPA

[10] The "TALU based approach" includes tiered aquatic life uses (TALU) based on numeric biological criteria and implementation via an adequate monitoring and assessment program that includes biological, chemical, and physical measures, parameters, indicators and a process for stressor identification.

environmental indicators initiatives (U.S. EPA 1990, 1995) and selected pilot projects (Ohio EPA 1997). However, these frameworks have seen neither widespread application nor acceptance by EPA or the states. The lack of a broader and more creative use of ambient monitoring and assessment data and information for these purposes can be attributed to:

1) the lack of a sufficiently developed indicator process in the states;
2) the lack of sufficient and readily available monitoring and assessment data;
3) a cultural adherence to and preference for administrative measures and processes; and,
4) legislative mandates and management directives that reinforce and perpetuate a continued reliance on administrative processes.

In terms of the MPCA program, number 1 is being addressed via the adoption of biological indicators and numeric biocriteria. Number 2 is being addressed via the recommendation to add M&A designs that address specific point sources and in a manner that allows those assessments to serve as the environmental end outcomes in Figure 5-1. Number 3 can be addressed by more fully adopting an environmental end outcomes approach, but only if the right types of M&A data are brought to bear in receiving water assessments. If numbers 1-3 are addressed with MPCA, number 4 becomes a less relevant impediment especially since this new process is not a replacement of administrative measures. Those will continue to be a vital part of the overall NPDES permitting process. One of the first and most important baseline goals of a TALU-based approach is to provide direct support to NPDES permitting, thus the fundamental monitoring design will need to be sufficient for conducting retrospective analyses of the effectiveness of NPDES permitting over the preceding time period. Such an approach should serve as an important "reality check" on some of the administrative process improvements envisioned in the EPA report entitled *"Report on State-EPA Permit Re-engineering and Streamlining"* (October 28, 2002) and subsequent efforts to streamline NPDES permitting.

5.3.4.1 Spatial Survey Design

The key data and information requirements for a TALU-based approach are produced by adherence to the adequate monitoring and assessment framework that was previously described in Section 5.2. This underscores the multiple uses of the same data and indicators provided the spatial M&A design is adequate to the task. As such, multiple assessment issues can be simultaneously addressed by the same survey design. These include ensuring that the designated aquatic life use is appropriate and attainable, determining the severity and extent of impairments, and relating the relevance of sources to the observed impairments. If it is properly developed and executed a TALU-based approach should deliver assessments of specific point sources that fulfill the determination of the environmental effectiveness of NPDES permitting. Specific to this survey design is the recognition of how point source discharges affect the chemical/physical and biological characteristics of a receiving stream or river. Figure 5-8 illustrates a number of important concepts about how point sources of common constituents like oxygen demanding wastes (i.e., as measured by biochemical oxygen demand [BOD]) and ammonia-N react in a downstream direction via the process of pollutant fate and transport. At the same time, and depending on the discharged loadings and resulting instream concentrations, an effect on the dissolved oxygen (D.O.) regime is produced. Finally, the response of the aquatic assemblages can be measured against these chemical gradients and in proximity to the point source of these pollutants. Not only can the severity and extent of any impacts be measured, the type of response can also be visualized with this type of monitoring design. A response to toxicity is suggested by an immediate decline in the biological measures whereas a more D.O. driven response is suggested by a "delayed" response that corresponds to the D.O. "sag" that occurs some distance downstream as the effect of bacterial processing of excess oxygen demanding wastes occurs. The capacity to detect such "pollution gradients" is only possible by having an adequate survey design that employs a longitudinal pollution survey design as depicted in Figure 5-8. The typical "upstream/downstream" designs that have traditionally been used to assess NPDES permitted entities are simply inadequate for this level of characterization.

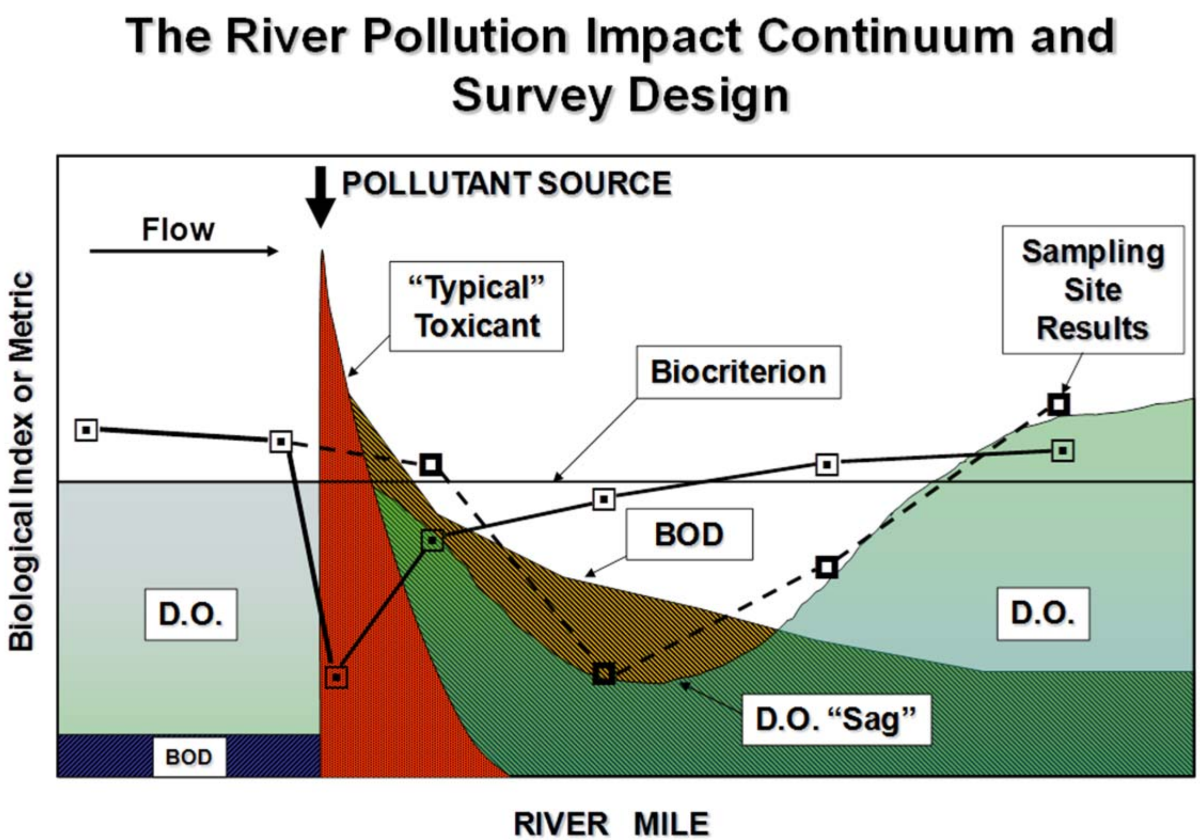


Figure 5-8. The river pollution impact continuum and survey design adapted from the original description of pollution zonation by Bartsch (1948). In addition to how pollutants typically react when discharged in a lotic system, suggested sampling design and two different biological responses are depicted.

Once an impact is characterized a stressor diagnosis process is then applied as part of a TALU-based approach. This consists of assessing multiple lines of evidence that relate to the observed biological impairment. This includes the process depicted in Figure 5-9 as an example of using affiliated tools such as biological response signatures (Simon 2003; Yoder and DeShon 2003; Riva-Murray et al. 2002; Yoder and Rankin 1995b) to categorically classify the type of biological response and then focusing in on key parameters that are either directly contributing or which serve as markers for the type of effluent process that is likely contributing. In addition, using facility information about effluent quality is vital to this diagnosis and includes information about trends in effluent quality and operational issues if any. Frequently, and depending on the type of discharge that is involved, knowledge from similar settings and assessments can be applied in support of the overall diagnosis. This lends support to taking any number of actions with a permit including enforcement, revisiting the water quality based effluent limits (WQBEL), and regulating previously under or unregulated activities.

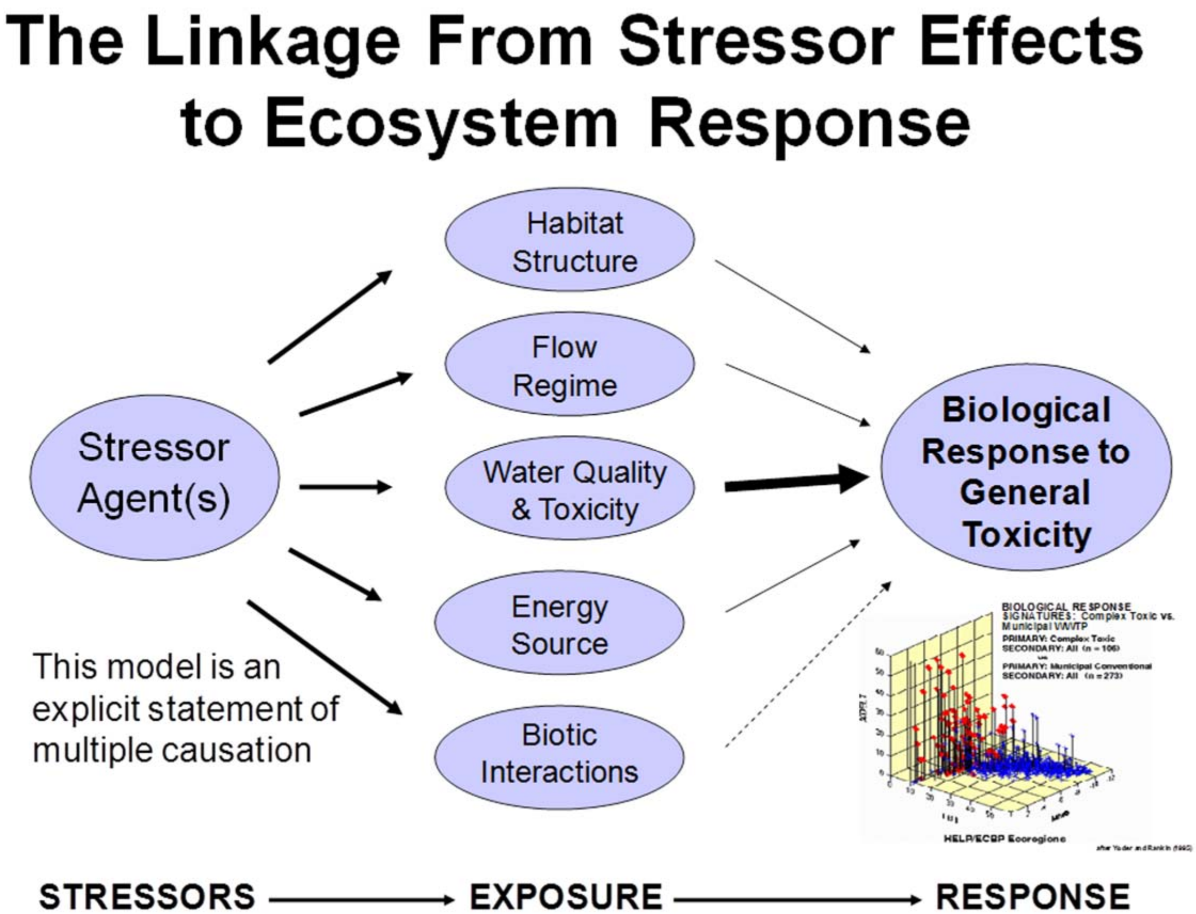


Figure 5-9. The process for relating a biological response indicative of generalized toxicity to the stressor source and via a lines of evidence approach supported by adequate monitoring and assessment data and information.

5.3.4.2 Designated Aquatic Life Use Impacts

Another anticipated impact of a TALU-based approach on NPDES permitting is the designated aquatic life use tier of the receiving stream or river. While this does affect the application of a bioassessment impact analysis by the numerical biocriteria that is applied in an impact assessment as just described, it can also directly affect the derivation of WQBEL if the pollutant specific water quality criteria vary by the different use tiers. However, this will be true only if the water quality criteria are indeed varied by the applicable use tiers.

In addition to the potential effect on WQBELs of differing chemical criteria by use tier is their application to an NPDES permit. A concern that has been expressed in Minnesota and which we have encountered elsewhere is situations where a permit was originally based on a lower tier and the bioassessment documents an upgrade to the current use tier. The assumption is that this automatically makes the WQBELs proportionately more stringent. However, if the biological impact assessment shows that the new use tier biocriteria are attained, then this brings in the biocriteria application language where full attainment is the finding. This could result in the maintenance of existing effluent quality in keeping with the finding of full attainment of the newly proposed use tier. As such, changes in use tiers do not necessarily nor automatically result in more stringent effluent limits. Table 5-2 outlines some general NPDES permit scenarios based on changes to the current designated use under the new TALU-based framework.

Table 5-2. Possible NPDES permit actions based on plausible use change scenarios under the new Minnesota TALU framework.

Current Use Class	New Use Class	Biology	Action
Class 7	Modified/General/Exceptional	Attains	Maintain Permit
Class 7	Modified/General	Does Not Attain	Review Permit[1]
Class 7	Limited Use	Attains	Maintain Permit
Class 2A/2B	Exceptional	Attains	Maintain Permit
Class 7/2B	General CW	Attains	Maintain Permit
Class 7/2B	General CW	Does Not Attain	Review Permit[1]
Class 2A	General WW	Attains	Maintain Permit
Class 2A	General WW	Does Not Attain	Review Permit[1]
Class 2A/2B	Modified	Attains	Maintain Permit
Class 2A/2B	Modified	Does Not Attain	Review Permit[1]
Class 2A/2B	Limited Use	Attains	Maintain Permit

[1] Permit review could result in more stringent effluent limits or if the discharge is not the cause of nonattainment then the effluent limits can be held at current levels.

5.3.4.3 Illustrating Permitting Effectiveness

Provided there is sufficient temporal data accomplished with the preceding M&A designs, bioassessments can be useful to demonstrate the environmental end outcomes of NPDES permitting. This is simply a manifestation of the processes previously described in Figures 5-2 through 5-4. The example in Figure 5-10 illustrates the full success of NPDES permitting over a nearly 30 year period of time for a major metropolitan wastewater treatment plant (WWTP) in Ohio. This especially illustrates the process depicted in Figure 5-4 where the initial actions of issuing and reissuing an NPDES permit (Level 1) coupled with actions taken by the regulated entity to reduce discharged loadings (Levels 2 and 3) improved water quality (Level 4) and assimilative capacity (Level 5) in the receiving river which was followed by an incremental improvement in biological assemblage condition to the full attainment of the designated TALU tier (Level 6). Furthermore, this illustrates an example where the biological improvement was

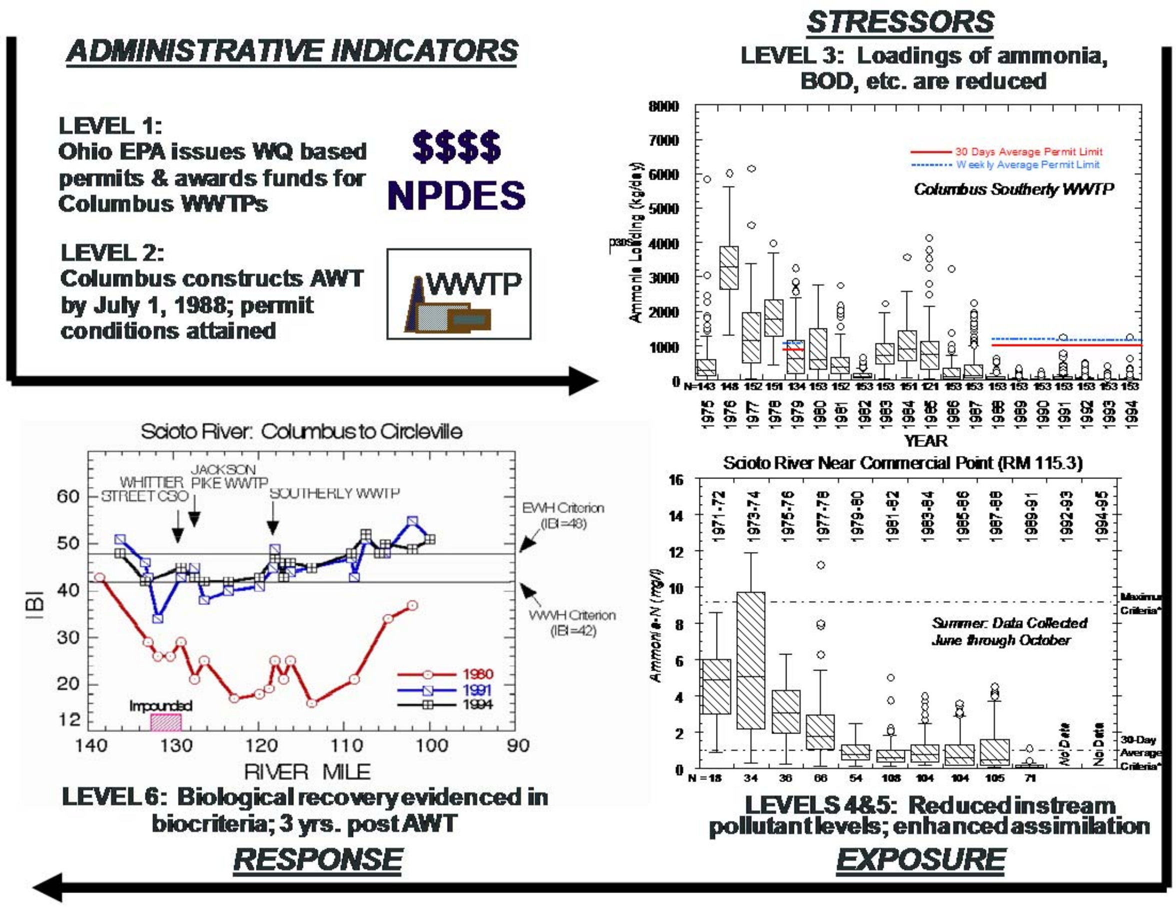


Figure 5-10. Example of using the hierarchy of indicators framework (see Figure 5-4) to demonstrate the sequence of events using level 1 through 6 indicators. This example is for the city of Columbus Southerly WWTP and bioassessment information from the receiving river (Scioto River) collected and assessed by Ohio EPA. It demonstrates a successful environmental outcome of NPDES permitting.

such that an upper TALU tier (Exceptional Warmwater) has been recommended for a portion of the receiving river. This same sequence of improvements in response to WQBELs for municipal WWTPs has been documented in multiple examples and has resulted in a 72% increase in full attainment of the biocriteria in Ohio non-wadeable rivers (Ohio EPA 2010). This level of documentation of full improvement does several things in addition to documenting the aggregate impact of WQBELs at Ohio WWTPs as follows:

1. It provides solid proof that advanced wastewater treatment is both implementable and assures environmental outcomes; and.
2. It provides proof that effluent dominated rivers can meet and exceed CWA goal uses.

The unheralded value of these observations is that the demonstrated successes herein have erased the historical debates about the efficacy of advanced wastewater treatment and the attainment of CWA goal uses in effluent dominated rivers. Prior to the push for WQBELs in the late 1970s and early 1980s, both were seen as barriers to that level of pollution control and at

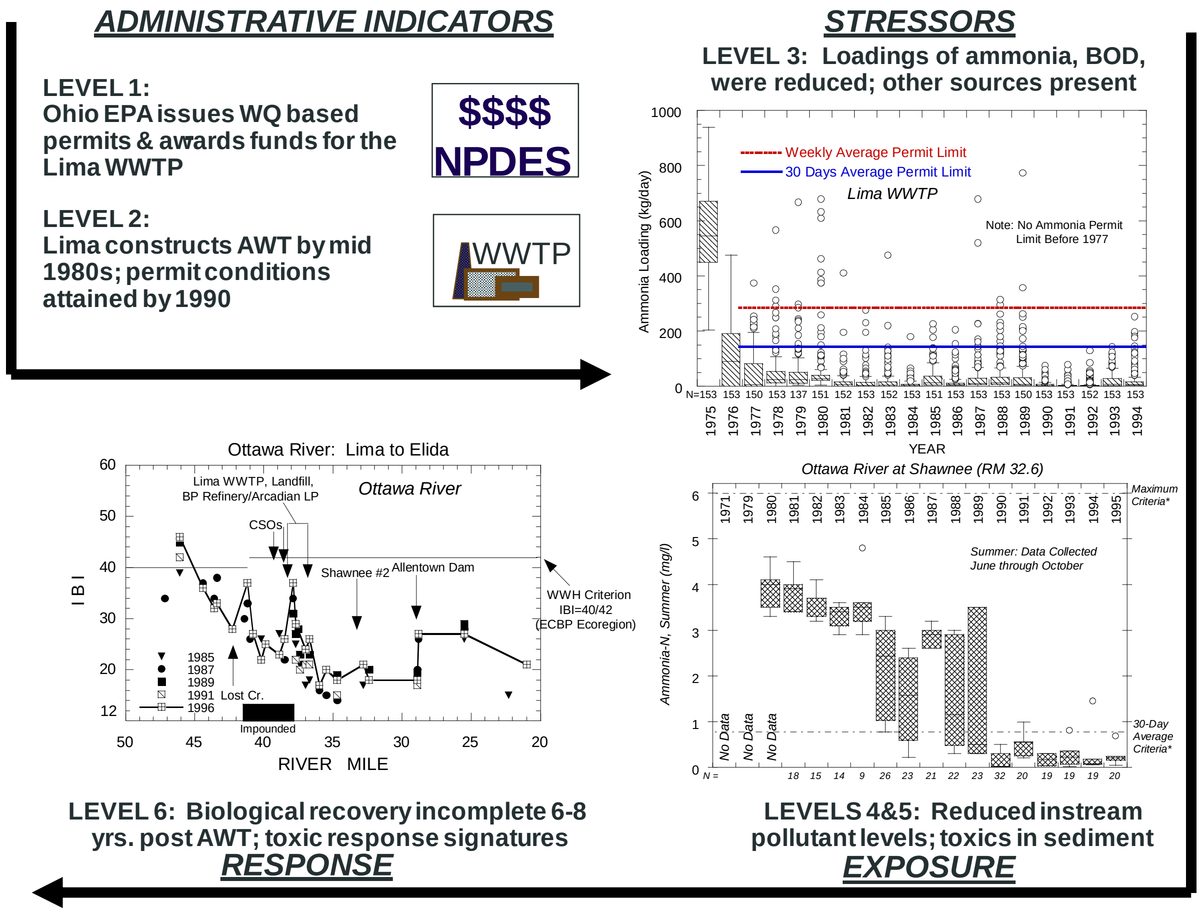


Figure 5-11. Example of using the hierarchy of indicators framework (see Figure 5-4) to demonstrate the sequence of events using level 1 through 6 indicators. This example is for the city of Lima WWTP and bioassessment information from the receiving river (Ottawa River) collected and assessed by Ohio EPA. It demonstrates an unsuccessful environmental outcome of NPDES permitting.

least temporarily resulted in the application of limited uses. Using a long term dataset produced by a sustained TALU-based M&A program illustrates the intangible benefits to a key water quality management program.

While the example in Figure 5-10 illustrates a virtually complete success of water quality based permitting for municipal WWTPs, there are some examples where this “conventional” approach for dealing with steady-state discharges was not completely successful. Figure 5-11 illustrates a municipal setting in Ohio where the same type of permitting and abatement actions were applied to a WWTP. In this case, biological impairment persisted despite attainment of WQBELs at the WWTP. Two adjacent industrial facilities with NPDES permits were suspected of contributing to the non-attainment, but neither was in “significant” noncompliance. The biological response furthermore indicated a toxic response which pointed to contaminants from either or both facilities. The lines of evidence approach (Figure 5-12) that is employed as part of the stressor identification process confirmed the presence of toxic substances in the effluents, water column, and sediments (Yoder and DeShon 2003). The question then became how did and do these substances enter the river if they are not being detected by the required effluent monitoring? Further investigations revealed on site contamination of the soils, legacy landfill disposal sites, and intermittent pulses via stormwater outfalls. As such, it took a lack of the expected biological attainment coupled with the type of biological response and the stressor identification process to guide the process of determining sources of the observed impairments. Preliminary data from Ohio EPA indicates that management interventions aimed at the categorical problems with toxicity have been followed by partial biological recovery, in particular the reduction in deformities, erosions, lesions and tumors (DELT) anomalies on fish which is a key part of the toxic response signature exhibited in the 1980s and 1990s.

Multiple Indicators Matrix: Ottawa River

SEGMENT	DES. USE	RESPONSE INDICATORS				EXPOSURE INDICATORS						STRESSORS				
	Attainment Status	QHEI	IBI	MIwb	ICI	Water Chem.	Sediment Chem.	Toxicity	% DELT	Fish Tiss.	Biomarker	# Dams/ Pools	Urban Indust. Landuse	Cumulative Loads	Spills	CSO SSOs
Ottawa River mainstem (1996)																
Thayer Rd to Sugar St.	FULL-PART	68	Fair-Gooc	Fair-Good	Good	Nitrates	Low	NA	Mod High	Mercury	Low	Moderate	Low	Low	Low	Low
Sugar St. to Lima WWTP dam	**NON**	47	**Poor** to Fair	**Poor** to Fair	**Poor** to M.G.	CBOD TSS D.O.	As,Cr Cd,Cu Ni,Zn	Moderate	**High**	Pesticides	BUN Naph B(a)p	**High**	**High**	Moderate	Moderate	**High**
Lima WWTP dam to Allentown dam	**NON**	72	**Poor**	**Poor** to Fair	Fair to Gooc	Amm. CBOD TSS D.O. Nitrates Phos Chrom PAH Pesticid	As,Cr Cd,Cu Ni,Zn PAH	Moderate	**Very High**	Selenium Pesticides	EROD Naph B(a)p BUN	Moderate	**High**	**High**	**High**	**High**
Allentown dam to Kalida	PARTIAL	69	**Poor** -Fair	Fair-Good	Good -Exc.	TSS	Low	NA	**High**	Pesticides	Low	Low	Low	**High**	Low	Low
Kalida to mouth	FULL	69	Good	Good	Exc.	TSS	Low	NA	**Very High**	Pesticides	Low	Low	Low	**High**	Low	Low

Figure 5-12. A matrix of stressor, exposure, and response indicators for the Ottawa River mainstem based on data collected in 1996 (after Ohio EPA 1998). The darkness of shading indicates the degree of severity in effect expressed by an indicator.

5.3.4.4 Other Types of NPDES Permitting

While the preceding examples were based on NPDES permitting of major point sources, the same principles can be applied to other types of permitting such as stormwater and CAFOs (Combined Animal Feeding Operations). This all applies provided that the design of the M&A is spatially adequate for these tasks, but the same pollution survey design at the watershed or mainstem river segment scale should satisfy the information needs of these applications.

5.3.5 Other Permitting and Review

Other permitting and review functions can also be supported by the TALU-based approach. An example is the review of projects that require a CWA Section 404 permit and a 401 certification by the state WQS agency. A 401 certification indicates that state WQS will be maintained by the subject activity. For rivers and streams these usually include the modification of in channel habitat which is jurisdictional under Section 404 reviews. Given that there is a sufficiently predictable relationship between the MPCA biological criteria endpoints and the MSHA, the effect of any activity subject to review under 404 and 401 will be predictable in terms of meeting and maintaining the Minnesota WQS, the aquatic life designated use in particular. Projects that are predicted to result in an impairment of the biologically based designated use cannot be allowed per the provisions of the existing use clause in the federal water quality regulations (40CFR Part 131). Such activities will need to be modified such that they are compatible with maintenance of the designated use. At the same time it is recognized that not every 404/401 decision will either have or require a review at this level of detail. Operationally this works best when the public notice is jointly reviewed by the 401 and biological monitoring staff. In addition to site-specific reviews, the administration of nationwide permits can also be influenced by the TALU-based approach. Some examples are exempting higher tier uses and antidegradation tiers from the nationwide permit, the effect of which is to require site-specific reviews for these waters.

5.3.6 Watershed Planning and Management

The information from a TALU-based approach is also valuable to watershed planning and management through any number of programs. TALU can affect these in the following ways:

1. The biological data and assessments can communicate about intrinsic condition and quality thus being useful for setting priorities for protection;
2. The biological measures employed in a TALU-based approach can measure incrementally thus providing a way to gauge progress as management programs are applied; and,
3. Indicator units that portray degradation units can be extracted and used in setting priorities for management and restoration projects.

Essential to using TALU-based data and information is the concept of incremental improvement. Incremental improvement is defined here to represent a measurable and technically defensible, positive change in the condition of an impaired water body within which an improvement has been measured, but which does not yet fully meet all applicable WQS. The general principles are defined as follows:

- ***measurement of incremental improvement*** can be accomplished in different ways, provided the measurement method is scientifically sound, appropriately used, and sufficiently sensitive enough to generate data from which signal can be discerned from noise;

- ***measurable parameters and indicators*** of incremental improvement may include biological, chemical, and physical properties or attributes of an aquatic ecosystem that can be used to reliably indicate a change in condition; and,

- ***a positive change in condition*** means a measurable improvement that is related to a reduction in a specific pollutant load, a reduction in total number of impairment causes, a reduction in an accepted non-pollutant measure of degradation, or an increase in an accepted measure of water body condition relevant to designated use support.

The methods, parameters, and tools to implement such an approach are an inherent part of the TALU-based approach and as such it is "ready" to support incremental measurement and comprehension.

A protocol for the documentation of incremental improvements in impaired waters is a major need of watershed management and other surface water protection programs. The evaluation of program success has almost exclusively focused on the full restoration of listed impairments. While this seems a straightforward process based on the removal of all impairment causes and meeting all WQS, it is presently difficult to account for improvements that have occurred as a result of project specific restoration actions, but which do not yet meet all WQS. This can result in the perception that the program seems staked to an "all or nothing" end result with no recognition of any positive movement towards full attainment of WQS. Furthermore, failing to recognize that waters are improving and are on a positive trajectory can lead to erroneous conclusions about the attainability of CWA goals and the viability of certain management practices. Hence, developing ways to measure and display incremental improvement would be beneficial to watershed management programs in a number of different ways. While the TMDL program is the primary water program that is dedicated to the delineation and tracking of the status of impaired surface waters and the progress of their restoration to meet CWA goals, other EPA water programs can also benefit from the measurement of incremental change. The TALU-based framework in development and use now should deliver that capability. Table 5-3 is a listing of the programmatic "clientele" that should benefit from this framework.

The significant challenges in addressing the need for a framework and protocol for measuring incremental change center on the inherently competing concepts of desiring a readily available and tractable process for reporting and the equally important, but frequently overlooked need to have it based on sound data and information (i.e., "credible scientific data"). A TALU-based approach emphasizes the integrity and strength of the underlying data and information upon which the incremental change indicators are founded. One problem with the current situation nationally is that a wide variety of different approaches are essentially homogenized by existing programmatic expressions of designated use attainment. This is commonplace within CWA program reporting and prior examples include state variability in 305[b] reporting from the previous 30 years and the litany of "lists" that have been produced from the same baseline data for a variety of purposes.

Table 5-3. "Clientele" for a framework that includes incremental improvement measurement concepts and methods (after Yoder and Rankin 2008).

Clientele	Reason for Interest
TMDL program managers (primary clientele)	Demonstrate partial recoveries as program results in outcomes potentially earlier and in larger numbers than full recovery (i.e., a recognition that all stressors cannot be remediated in the same time frames).
NPS program managers	Related to qualifying for NPS success stories recognition; also demonstrate more 319 progress and results.
Monitoring program managers	Once documented as partially recovered, help orient limited monitoring funds to measuring waters more likely to have completely recovered. Also documenting incremental improvement is a primary component of post- project effectiveness monitoring.
4b projects (controls other than TMDL are in place)	Demonstrate progress being made within a reasonable time period so as not to revert from 4b to 5/4a process.
EPA Surface Water Strategic Planners and Watershed Managers Forum	Clarify and help defensibility of counting rules on partial restoration measures (W, Y). Also, aid the consideration of possible new measures concerning incremental improvement.
States	Additional consideration in performance partnership agreements & reporting to EPA.
WQS program	Related to determination of highest attainable use for the purpose of designating aquatic life uses; essential in UAA considerations.

A fundamental problem with these past approaches has been the homogenization of technically different baseline inputs in designated use status reporting. Many states base their assessments of status either wholly or partially on chemical/physical parameters and indicators while others employ bioassessment results, yet each is distilled to a common terminology and "currency" expressed as the proportion of a water body unit that partially or fully attains designated aquatic life use support. As has been shown in prior comparability studies (Rankin and Yoder 1990; Rankin 2003; Karr and Yoder 2004) such assessments based on chemical/physical indicators can be substantially different than biologically based assessments, the differences being up to 50% in some cases. In such cases, biological assessment contributed to the avoidance of a type II assessment error that is inherently propagated in chemical/physical assessments, which results in the significant under-reporting of aquatic life use impairments. Current practice in effect obliterates these important differences by effectively homogenizing fundamentally different assessment protocols. There are additional differences in state programs that also contribute to the uncertainty about the reliability of status assessments and these include differences in spatial sampling design and the level of rigor of state M&A programs. These almost certainly contribute to an as yet undocumented degree of variability and uncertainty in consolidated measures of management program effectiveness. An advantage of the TALU-based approach is how it relates baseline chemical, physical, and biological measures and indicators in an integrated assessment process that will result in improved accuracy and consistency in the type of reporting that is to be accomplished by measures SP-11 and SP-12 (aka measures W and Y). This is an important prerequisite to assuring that “credible scientific data” are effectively used in the measurement of incremental change within these reporting frameworks.

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Appendix A: Detailed TALU Work Plan

March 29, 2011

The following are descriptions of the major tasks that are proposed as part of this project. A detailed work plan was developed in cooperation with MPCA and resulted in the following tasks:

Task 1 – Internal and External Stakeholder Meetings

MBI will lead a series of meetings with internal MPCA and external state and local agency and non-governmental stakeholders to coordinate and foster input and support for the principal objectives of this project. These meetings are described as follows:

Task 1a: Initial MPCA Coordination

MBI will participate in meetings and discussions with key MPCA managers and staff to discuss the specific tasks outlined in this detailed work plan and the projected timeline for various subtasks and final delivery of project work products. It includes detailed planning and consultation with MPCA staff in order to determine the key issues that are likely to be of the most interest to internal and external stakeholders. This task also includes the initial development of an implementation plan that communicates how the new biological criteria and WQS will affect their current stakeholder activities. We anticipate one introductory meeting at MPCA and follow-up conference calls as necessary.

Task 1b: Introductory external stakeholder meetings

MBI will lead discussions with stakeholders that include presentations and materials to communicate the scientific and regulatory foundation for biological criteria and TALUs and identifying the potential impacts to stakeholder interests. This task also includes communicating an implementation plan that communicates how the new biological criteria and WQS may affect their current activities. Approximately 7-10 stakeholder meetings are estimated by MPCA to take place mostly in year 1 of the project. As part of this task MBI and its subcontractor will provide on demand technical assistance to MPCA with external stakeholder issues as they arise.

To facilitate discussion and enhance the understanding of the new system MBI will develop a series of presentations to include at a minimum:

- an introduction to biological standards and tiered uses;
- the regulatory background that forms the foundation for biological standards and tiered uses;
- benefits of the new system of biological standards and uses;
- history and outcome of adopting biological standards and TALU by other states; and,
- the proposed Minnesota system of standards and uses.

Task 1c: Follow-up with MPCA Program
This task will involve interacting with the key MPCA staff and managers to foster their understanding about how the new biological criteria and TALUs will affect their principal areas of interest. MBI and Tetratech will apply their experience in this area with other state programs via the EPA national program. We anticipate 1-2 of these meetings at MPCA late in year 1 or during year 2.

Task 1d: Follow-up with external stakeholders
This task will involve conducting follow-up meetings with selected external stakeholders as the project develops and to answer their questions and concerns as the implementation plan, policies, and standards are developed. We anticipate 2-3 follow-up meetings to take place in various Minnesota locations to be determined at a later date.

Task 2 – Exploratory Data Analyses and Indicator Development

MBI will provide technical support that will include exploratory data analysis and summarization and a review of technical tools and products completed by MPCA staff including:

- a review of the statewide IBI for fish and invertebrates as well as the criteria used to define impairment thresholds;
- a review of technical elements and criteria used to define TALU categories;
- assist MPCA staff with calibration of the biological condition gradient for fish and invertebrates;
- data analysis and summarization of large river IBI fish protocols used by the MDNR and MPCA;
- data analysis and summarization of the MPCA qualitative habitat data to identify habitat attributes that are indicative of modified (i.e. less than Clean Water Act interim goal) and exceptional (greater than CWA goal) uses.

Each of these subtasks are further described as follows:

Task 2a – Review statewide indices & biocriteria
This task will involve first understanding the technical basis and characteristics of the MPCA biological indices including their calibration and derivation and spatial patterns across the state. This will next include examining index thresholds including sensitivity analyses for those thresholds. These in turn become the numeric biocriteria for different TALUs and other strata such as stream and river types, cold and warm water, etc.

Task 2b – Review TALU technical elements & criteria
This will include a review of the descriptiveness of the designated use narratives and suggestions for language that better ties the technical process for deriving numerical biological criteria to the designated use narratives.

Task 2c – Calibrate BCG for fish & macroinvertebrates
Calibrating a regionally applicable BCG requires adjustment of the generalized conceptual model (Davies and Jackson, 2006; U.S. EPA, 2005) to regional conditions. This includes components that construct a coherent ecological description of response to stressors in keeping with ecological theory and empirical observation that includes:

- Describe the native aquatic assemblages under natural, undisturbed conditions. The description of natural conditions requires biological knowledge of the region, a natural classification of the assemblages, and, if available, historical descriptions of the habitats and assemblages.
- Identify regional stressors. A description of regionally dominant stressors will help define expectations for biological responses that are likely to occur. This step considers sources of physical and chemical stressors and causes of land use disturbance.
- Assign taxa and other measurements (if available) in the state database to BCG attributes.
- Quantitative description of BCG levels that are the system responses to anthropogenic stressors.

The development process is iterative, and may require several passes through the process to converge on a coherent, locally calibrated BCG that is scientifically defensible.

Task 2d – Large rivers fish IBI data analysis; MPCA/MDNR protocols
This will include examining the data characteristics and methodological properties of the MPCA and MDNR large river fish sampling methods. We can bring the experience of the Region V comparability study to this task. This will include examining key data attributes in addition to the potential impact to the MPCA large river fish IBI.

Task 2e – Analysis of MPCA habitat data; relate to TALUs
An important aspect of a TALU approach is the task of determining if an existing designated use is appropriate and attainable. Key to this process is determining the realistic biological potential of a specific water body or segment. Habitat is a fundamental issue in that it governs the determination of potential for setting appropriate and attainable uses. Therefore a relationship between the indices used to determine attainment and the habitat assessment mechanism must be established in order to develop the required predictive tools and process. MBI proposes to subject the MPCA database to analyses similar to how Ohio EPA developed these relationships.

Task 3 – Develop plan for making transition to TALU

MBI will assist MPCA with the development of a detailed implementation plan for the eventual adoption of biocriteria and TALUs in the Minnesota WQS. Ideally, the implementation TALUs will be sequenced with the annual execution of river and stream assessments and the analysis of that data and information. This will involve anticipating the potential impacts to various stakeholder groups and their activities related to water resource usage. It will also include determining the impact to MPCA obligations such as the Integrated Report and the resulting list of impaired waters under Section 303d.

MBI will develop an implementation plan in the form of a report or reports that will guide stakeholders through the transition into the new system of standards and uses. The implementation plan will include at a minimum:

- identification of processes or procedures that will be impacted by the new system including a description of the process, an explanation of how the process will be affected by the new system and a recommendation of steps necessary to integrate into the new system; and,
- a report that will include a timeline that identifies the sequencing of action items to extend through the rulemaking process.

MBI will work with stakeholders throughout the process to ensure that each recommendation is both necessary and reasonable.

Task 4 – Lead stakeholder TALU implementation meetings

MBI will use the information learned and developed in the preceding tasks to communicate to stakeholders about the implications of the new biological criteria and TALUs. This will consist of 3-5 meetings with selected stakeholder groups.

Task 5 - Exploration and determination of relationships between key biological response variables and environmental stressors

Completion of this task requires that we understand the relationship between key biological response variables and environmental stressors including chemical, physical, hydrology, and watershed land use factors. The development of stressor-response models derived through this type of analysis would support MPCA objectives related to:

- WQS under a TALU framework. (e.g., specific tiered dissolved oxygen criteria derived through analysis of the class specific IBI data)
- Ecological flow modeling (e.g., association between specific biological attributes and hydrologic data will support the development of ecologically sustainable flows).
- Stressor ID to identify the likely stressors affecting the biology at impaired sites and suggest reasonable goals to move the water body back into compliance with CWA objectives.

The analysis phase of this work will consider various analysis techniques to investigate relationships between the stressor and response variables including the percentile method (commonly used by bioassessment programs to derive goal setting criteria), quantile regression, linear regression, logistic regression, species sensitivity distribution, conditional probability analysis, and Threshold Taxa Indicator ANalysis (TITAN). A description of each of these techniques as well as examples of the application of these techniques using field data is found in Cormier, et al (2008) Using Field Data and Weight of Evidence to Develop Water Quality Criteria. Integrated Environment Assessment and Management 4(4), pp 490-504.

Possible stressor variables data sources:

Chemical	Conventional parameters including Nutrients, DO, pH, conductivity. Primary data source is STORET
Physical variables	Stream habitat variables from MPCA quantitative habitat, MSHA, and Rosgen geomorphology variables Data sources include MPCA biological database for habitat data, MPCA and MDNR for geomorphology variables.
Land use	Human disturbance variables including ditching, land use percentages, prevalence of point sources, feedlots, etc. Data source includes MPCA biological database, MDNR, NRRI, etc.
Hydrology	Exploration of flow gauging data including minimum flows and measures of flow variability and timing. Data from Minnesota DNR, MPCA and USGS.

The nature of the stressor-response relationships as well as data limitations will determine when it is reasonable to develop a stressor-response model and which analytical techniques are most appropriate/illustrative for use in developing criteria or benchmarks. Close interaction between MPCA lead biologists and MBI throughout each sub task will maximize the potential benefits associated with the final product. Final products will include reports and associated materials (e.g., statistical coding, data files) for each subtask. The reports will be formatted to allow diagnosis of the cause of an impairment through evaluation of taxa, metrics, and IBI scores for response variables that were tested. When relationships are present graphics will be provided that describes the relationship between the biological measure and the stressor variable. This task also includes an assessment of the adequacy of the existing ambient databases to support such analyses. To complete this task, 2-3 meetings that require travel by MBI personnel are planned to discuss database development and to discuss and review the analyses and products.

Task 5a: Assessment of relationships between chemical and biological data and development of tiered water quality criteria

MPCA staff with consultation from MBI will develop databases with chemical data linked to biological data. The data analysis phase will be led by MBI with consultation from MPCA. Exploratory analyses will identify relationships between biological measures (e.g., indices, metrics, and taxa) and chemical measures. Additional statistical analyses described above will be used to develop models (e.g., regressions) and thresholds between biological and chemical parameters for use in stressor identification and the development of tiered water quality criteria.

The new biological standards and TALU framework will highlight the need to develop tiered water quality criteria for selected pollutants and parameters. This subtask contract will include data analysis of selected chemical parameters, summarization of findings, and recommendations for water quality criteria changes that correspond to the TALU framework.

Task 5b: Assessment of the relationships between physical and biological data
As with sub task 5a, MPCA staff with consultation from MBI will develop databases with biological data linked to biologically relevant physical measures (e.g., stream habitat and geomorphology). The data analysis phase will be led by MBI with consultation from MPCA. Exploratory analyses will identify relationships between biological measures (e.g., indices, metrics, and taxa) and physical measures. Additional statistical analyses will be used to develop models (e.g., regressions) and thresholds between biological and physical parameters for use in stressor identification. The objectives and analytical techniques for subtask 5b are slightly different than those under task 2e.

Task 5c: Exploratory assessment of the relationships between biological data and hydrology
This subtask will be a preliminary assessment of the relationship between flow and biological condition using available flow data (e.g., minimum flows, flow variability and timing). An element of this subtask will be to identify data needs for developing more complete models of the relationship between hydrology and biological condition. Although available flow data may not be sufficient to fully develop the association between specific biological attributes and hydrologic data to support the development of ecologically sustainable flows, this subtask will provide the groundwork to develop these tools.

Tiered Aquatic Life Uses Timeline

Task	2007	2008	2009	2010	2011	2012
1. Regional Framework Analysis						
1a. Literature review						
1b. Statistical analysis and selection of classification system			X			
1c. Calculation of Human Disturbance Score			X			
2. Data Gap Analysis and Sampling						
2a. Identify data gaps	X	X	X	X		
2b. Sample sites to fill data gaps	X	X	X	X		
3. Development of Biological Condition Gradient						
3a. Development of warmwater BCG models			XXX	XXXX		
3b. Development of cold water BCG models				XXX	X	
3c. Examine IBI/BCG relationship				XXXX	XXX	
4. Statewide IBI Development						
4a. Define temperature criteria for cold water streams	X					
4b. Metric selection and calibration – warmwater streams			XX	XX		
4c. Metric selection and calibration – cold water streams				XX	X	
4d. Determine warmwater IBI confidence intervals				X		
4e. Determine cold water IBI confidence intervals					X	
4f. Develop criteria for selection of reference sites				X		
4g. Develop biocriteria for General Use warmwater streams				XX		
4h. Develop biocriteria for General Use cold water streams					XXX	
4i. Assess IBIs				XX	XXXX	
4j. Write IBI development document(s)					XX	XX
5. Tiered Aquatic Life Use Development						
5a. Identify modified use "reference sites"				XX	XX	
5b. Develop biocriteria for modified uses					XXX	
5c. Examine characteristics of exceptional use class waters				XX	XX	
5d. Develop biocriteria for exceptional uses				X	XXX	
5e. Analyze and tier priority chemical criteria					X	XX
5f. Pilot assessment of tiered uses					XX	XX
5g. Write biocriteria development document					XXX	XX
6. Designation and Assessment of TALUs						
6a. Habitat analysis (UAA)				XX	XXXX	
6b. Develop use designation guidance for TALUs (including UAAs)					XXX	
6c. Develop and write assessment guidance for TALUs					XXX	
7. Begin Administrative Rule Process						XX

General Rule Making Timeline

2012	**Establish In-house workgroup to consider and amend proposal**
2013	**Take proposal to stakeholder groups** **Draft rule language** **Solicitation of public opinion in state register** **Define impact to state agencies** **Complete SONAR** **Promulgation of proposed standards in state register**
Summer 2014	**Public hearings, hearing dates in front of ALJ** **Post hearing comment period and response** **Receive ALJ report** **MPCA board**

Water Act (the Act). ''Serve the purposes of the Act'' (as defined in sections 101(a)(2) and 303(c) of the Act) means that water quality standards should, wherever attainable, provide water quality for the protection and propagation of fish, shellfish and wildlife and for recreation in and on the water and take into consideration their use and value of public water supplies, propagation of fish, shellfish, and wildlife, recreation in and on the water, and agricultural, industrial, and other purposes including navigation.

Such standards serve the dual purposes of establishing the water quality goals for a specific water body and serve as the regulatory basis for the establishment of water-quality-based treatment controls and strategies beyond the technology-based levels of treatment required by sections 301(b) and 306 of the Act.

§ 131.3 Definitions.

(a) *The Act* means the Clean Water Act (Pub. L. 92–500, as amended (33 U.S.C. 1251 *et seq.*)).

(b) *Criteria* are elements of State water quality standards, expressed as constituent concentrations, levels, or narrative statements, representing a quality of water that supports a particular use. When criteria are met, water quality will generally protect the designated use.

(c) *Section 304(a) criteria* are developed by EPA under authority of section 304(a) of the Act based on the latest scientific information on the relationship that the effect of a constituent concentration has on particular aquatic species and/or human health. This information is issued periodically to the States as guidance for use in developing criteria.

(d) *Toxic pollutants* are those pollutants listed by the Administrator under section 307(a) of the Act.

(e) *Existing uses* are those uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards.

(f) *Designated uses* are those uses specified in water quality standards for each water body or segment whether or not they are being attained.

(g) *Use attainability analysis* is a structured scientific assessment of the factors affecting the attainment of the use which may include physical, chemical, biological, and economic factors as described in § 131.10(g).

(h) *Water quality limited segment* means any segment where it is known that water quality does not meet applicable water quality standards, and/or is not expected to meet applicable water quality standards, even after the application of the technology-bases effluent limitations required by sections 301(b) and 306 of the Act.

(i) *Water quality standards* are provisions of State or Federal law which consist of a designated use or uses for the waters of the United States and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the Act.

(j) *States* include: The 50 States, the District of Columbia, Guam, the Commonwealth of Puerto Rico, Virgin Islands, American Samoa, the Trust Territory of the Pacific Islands, the Commonwealth of the Northern Mariana Islands, and Indian Tribes that EPA determines to be eligible for purposes of water quality standards program.

(k) *Federal Indian Reservation*, *Indian Reservation*, or *Reservation* means all land within the limits of any Indian reservation under the jurisdiction of the United States Government, notwithstanding the issuance of any patent, and including rights-of-way running through the reservation.''

(l) *Indian Tribe* or *Tribe* means any Indian Tribe, band, group, or community recognized by the Secretary of the Interior and exercising governmental authority over a Federal Indian reservation.

[48 FR 51405, Nov. 8, 1983, as amended at 56 FR 64893, Dec. 12, 1991; 59 FR 64344, Dec. 14, 1994]

§ 131.4 State authority.

(a) States (as defined in § 131.3) are responsible for reviewing, establishing, and revising water quality standards. As recognized by section 510 of the Clean Water Act, States may develop water quality standards more stringent

Minnesota
State Register

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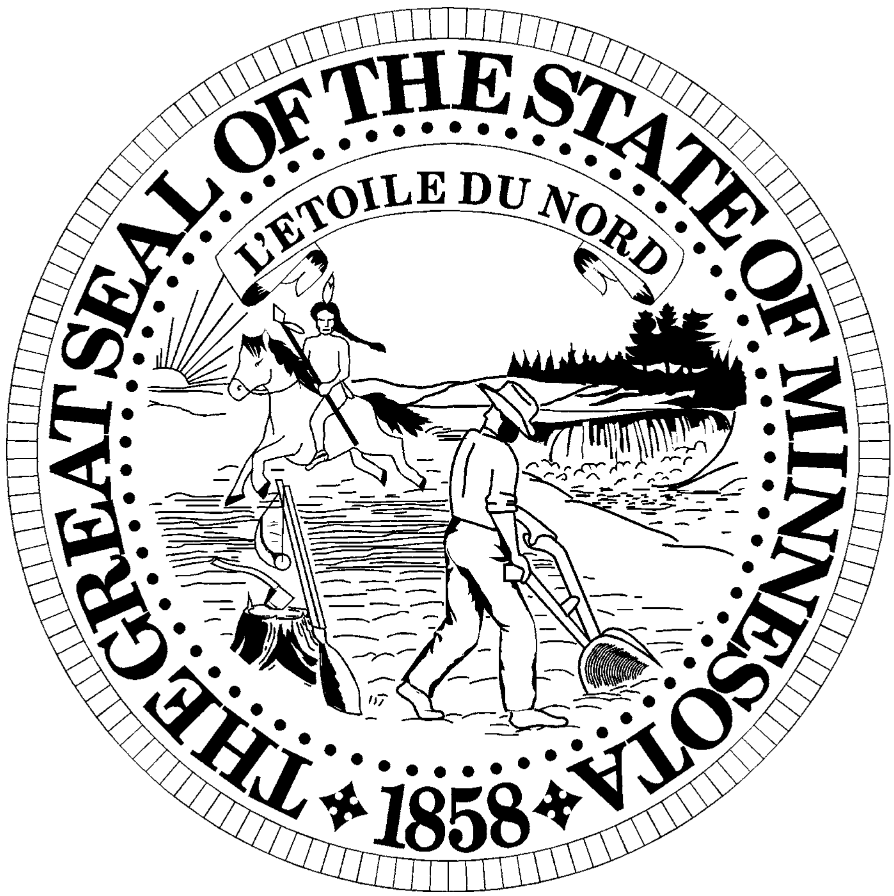

Proposed, Adopted, Emergency, Expedited, Withdrawn, Vetoed Rules; Executive Orders; Appointments; Commissioners' Orders; Revenue Notices; Official Notices; State Grants & Loans; State Contracts; Non-State Public Bids, Contracts and Grants

Monday 16 October 2017

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Pages 437 - 462

Minnesota State Register

Judicial Notice Shall Be Taken of Material Published in the *Minnesota State Register*

The *Minnesota State Register* is the official publication of the State of Minnesota's Executive Branch of government, published weekly to fulfill the legislative mandate set forth in *Minnesota Statutes*, Chapter 14, and *Minnesota Rules*, Chapter 1400. It contains:

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Printing Schedule and Submission Deadlines

Vol. 42 Issue Number	PUBLISH DATE (**BOLDFACE** shows altered publish date)	Deadline for: all Short Rules, Executive and Commissioner's Orders, Revenue and Official Notices, State Grants, Professional-Technical-Consulting Contracts, Non-State Bids and Public Contracts	Deadline for LONG, Complicated Rules (contact the editor to negotiate a deadline)
# 17	Monday 23 October	Noon Tuesday 17 October	Noon Thursday 12 October
# 18	Monday 30 October	Noon Tuesday 24 October	Noon Thursday 19 October
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Minnesota Rules: Amendments and Additions

NOTICE: How to Follow State Agency Rulemaking in the State Register

The State Register is the official source, and only complete listing, for all state agency rulemaking in its various stages. State agencies are required to publish notice of their rulemaking action in the State Register. Published every Monday, the State Register makes it easy to follow and participate in the important rulemaking process. Approximately 80 state agencies have the authority to issue rules. Each agency is assigned specific Minnesota Rule chapter numbers. Every odd-numbered year the Minnesota Rules are published. Supplements are published to update this set of rules. Generally speaking, proposed and adopted exempt rules do not appear in this set because of their short-term nature, but are published in the State Register.

An agency must first solicit Comments on Planned Rules or Comments on Planned Rule Amendments from the public on the subject matter of a possible rulemaking proposal under active consideration within the agency (Minnesota Statutes §§ 14.101). It does this by publishing a notice in the State Register at least 60 days before publication of a notice to adopt or a notice of hearing, or within 60 days of the effective date of any new statutory grant of required rulemaking.

When rules are first drafted, state agencies publish them as Proposed Rules, along with a notice of hearing, or a notice of intent to adopt rules without a hearing in the case of noncontroversial rules. This notice asks for comment on the rules as proposed. Proposed emergency rules, and withdrawn proposed rules, are also published in the State Register. After proposed rules have gone through the comment period, and have been rewritten into their final form, they again appear in the State Register as Adopted Rules. These final adopted rules are not printed in their entirety, but only the changes made since their publication as Proposed Rules. To see the full rule, as adopted and in effect, a person simply needs two issues of the State Register, the issue the rule appeared in as proposed, and later as adopted.

The State Register features partial and cumulative listings of rules in this section on the following schedule: issues #1-13 inclusive; issues #14-25 inclusive (issue #26 cumulative for issues #1-26); issues #27-38 inclusive (issue #39, cumulative for issues #1-39); issues #40-52 inclusive, with final index (#1-52, or 53 in some years). An annual subject matter index for rules was separately printed usually in August, but starting with Volume 19 now appears in the final issue of each volume. For copies or subscriptions to the State Register, contact Minnesota's Bookstore, 660 Olive Street (one block east of I-35E and one block north of University Ave), St. Paul, MN 55155, phone: (612) 297-3000, or toll-free 1-800-657-3757. TTY relay service phone number: (800) 627-3529.

Volume 41 - Minnesota Rules

(Rules Appearing in Vol. 41 Issues #27-52 are in Vol 41, #52 - Monday 26 June 2017)

Volume 42, #16

Monday 3 July - Monday 16 October

Adopted Rules

A rule becomes effective after the requirements of *Minnesota Statutes* §§ 14.05-14.28 have been met and five working days after the rule is published in the *State Register*, unless a later date is required by statutes or specified in the rule. If an adopted rule is identical to its proposed form as previously published, a notice of adoption and a citation to its previous *State Register* publication will be printed. If an adopted rule differs from its proposed form, language which has been deleted will be printed with strikeouts and new language will be underlined. The rule's previous *State Register* publication will be cited.

KEY: Proposed Rules - Underlining indicates additions to existing rule language. ~~Strikeouts~~ indicate deletions from existing rule language. If a proposed rule is totally new, it is designated "all new material." **Adopted Rules** - Underlining indicates additions to proposed rule language. Strikeout indicates deletions from proposed rule language.

Board of Nursing

Adopted Permanent Rules Relating to Advanced Practice Nursing

The rules proposed and published at State Register, Volume 41, Number 46, pages 1309-1322, May 15, 2017 (41 SR 1309), are adopted as proposed.

Pollution Control Agency

Adopted Permanent Rules Relating to Water Quality Standards and Tiered Aquatic Life Uses

The rules proposed and published at State Register, Volume 41, Number 25, pages 659-762, December 19, 2016 (41 SR 659), are adopted with the following modifications:

7050.0150 DETERMINATION OF WATER QUALITY, BIOLOGICAL AND PHYSICAL CONDITIONS, AND COMPLIANCE WITH STANDARDS.

~~Subp. 3a. **Assessment criteria.** The criteria by which water bodies are assessed to determine if beneficial uses are supported, and definitions of the data and information required for that assessment, is in Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List (2014 and as subsequently amended), which is incorporated by reference. The guidance manual is not subject to frequent change and is available at http://www.pca.state.mn.us/lupg1125.~~

Subp. 4. **Definitions.** For the purposes of this chapter and chapter 7053, the following terms have the meanings given them.

S. "Lotic water" means a flowing or moving water body such as a stream, river, or ditch.

~~S.~~ T. "Mixing status" means the frequency of complete mixing of the lake water from surface to bottom, which is determined by whether temperature gradients are established and maintained in the water column during the summer season.

~~T.~~ U. "Measurable increase" or "measurable impact" means a change in trophic status that can be discerned above the normal variability in water quality data using a weight of evidence approach. The change in trophic status does not require a demonstration of statistical significance to be considered measurable. Mathematical models may be used as a tool in the data analysis to help predict changes in trophic status.

~~U.~~ V. "Natural causes" means the multiplicity of factors that determine the physical, chemical, or biological conditions that would exist in a water body in the absence of measurable impacts from human activity or influence.

~~V.~~ W. "Normal aquatic biota" and "normally present" mean a healthy aquatic community expected to be present in the water body in the absence of pollution of the water, consistent with any variability due to natural hydrological, substrate, habitat, or other physical and chemical characteristics. Expected presence is based on comparing the aquatic community in the water body of interest to the aquatic community in representative reference water bodies.

~~W.~~ X. "Nuisance algae bloom" means an excessive population of algae that is characterized by obvious green or blue-green pigmentation in the water, floating mats of algae, reduced light transparency, aesthetic degradation, loss of recreational use, possible harm to the aquatic community, or possible toxicity to animals and humans. Algae blooms are measured through tests for chlorophyll-a, observations of Secchi disk transparency, and observations of impaired recreational and aesthetic conditions by the users of the water body, or any other reliable data that identifies the population of algae in an aquatic community.

~~X.~~ Y. "Periphyton" means algae on the bottom of a water body. In rivers or streams, these forms are typically found attached to logs, rocks, or other substrates, but when dislodged the algae will become part of the seston.

~~Y.~~ Z. "Readily available and reliable data and information" means chemical, biological, and physical data and information determined by the commissioner to meet the quality assurance and quality control requirements in subpart 8, that are not more than ten years old from the time they are used for the assessment. A subset of data in the ten-year period, or data more than ten years old can be used if credible scientific evidence shows that these data are representative of current conditions.

~~Z.~~ AA. "Reference water body" means a water body minimally or least impacted by point or nonpoint sources of pollution that is representative of water bodies of a similar surface water body type and within a geographic region such as an ecoregion or watershed. Reference water bodies are used as a base for comparing the quality of similar water bodies in the same geographic region.

~~AA.~~ BB. "Reservoir" means a body of water in a natural or artificial basin or watercourse where the outlet or flow is artificially controlled by a structure such as a dam. Reservoirs are distinguished from river systems by having a hydraulic residence time of at least 14 days. For purposes of this item, residence time is determined using a flow equal to the $122Q_{10}$ for the months of June through September.

~~BB.~~ CC. "River nutrient region" means the geographic basis for regionalizing the river eutrophication criteria as described in Heiskary, S. and K. Parson, Regionalization of Minnesota's Rivers for Application of River Nutrient Criteria, Minnesota Pollution Control Agency (2013), which is incorporated by reference. The document is not subject to frequent change and is available through the Minitex interlibrary loan system.

~~CC.~~ DD. "Secchi disk" means a tool that is used to measure the transparency of lake water. A Secchi disk is an eight-inch weighted disk on a calibrated rope, either white or with quadrants of black and white. To measure water transparency with a Secchi disk, the disk is viewed from the shaded side of a boat. The depth of the water at the point where the disk reappears upon raising it after it has been lowered beyond visibility is recorded.

~~DD.~~ EE. "Secchi disk transparency" means the transparency of water as measured by a Secchi disk, a Secchi tube, or a transparency tube.

~~EE.~~ FF. "Secchi tube" means a tool that is used to measure the transparency of stream or river water. A Secchi tube is a clear plastic tube, one meter in length and 1-3/4 inch in diameter, with a mini-Secchi disk on a string. To measure water transparency, the tube is filled with water collected from a stream or river and, looking into the tube from the top, the weighted Secchi disk is lowered into the tube by a string until it disappears and then raised until it reappears, allowing the user to raise and lower the disk within the same water sample numerous times. The depth of the water at the midpoint between disappearance and reappearance of the disk is recorded in centimeters, which are marked on the side of the tube. If the Secchi disk is visible when it is lowered to the bottom of the tube, the transparency reading is recorded as "greater than 100 centimeters."

~~FF.~~ GG. "Seston" means particulate matter suspended in water bodies and includes plankton and organic and inorganic matter.

~~GG.~~ HH. "Shallow lake" means an enclosed basin filled or partially filled with standing fresh water with a maximum depth of 15 feet or less or with 80 percent or more of the lake area shallow enough to support emergent and submerged rooted aquatic plants (the littoral zone). It is uncommon for shallow lakes to thermally stratify during the summer. The quality of shallow lakes will permit the propagation and maintenance of a healthy indigenous aquatic community and they will be suitable for boating and other forms of aquatic recreation for which they may be usable. Shallow lakes are differentiated from wetlands and lakes on a case-by-case basis. Wetlands are defined in part 7050.0186, subpart 1a.

~~HH.~~ II. "Summer-average" means a representative average of concentrations or measurements of nutrient enrichment factors, taken over one summer season.

~~II.~~ JJ. "Summer season" means a period annually from June 1 through September 30.

~~JJ.~~ KK. "Transparency tube" means a tool that is used to measure the transparency of stream or river water. A transparency tube is a graduated clear plastic tube, 24 inches or more in length by 1-1/2 inches in diameter, with a stopper at the bottom end. The inside surface of the stopper is painted black and white. To measure water transparency, the tube is filled with water from a surface water; the water is released through a valve at the bottom end until the painted surface of the stopper is just visible through the water column when viewed from the top of the tube. The depth, in centimeters, is noted. More water is released until the screw in the middle of the painted symbol on the stopper is clearly visible; this depth is noted. The two observed depths are averaged to obtain a transparency measurement.

~~KK.~~ LL. "Trophic status or condition" means the productivity of a lake as measured by the phosphorus content, algae abundance, and depth of light penetration.

~~LL.~~ MM. "Use attainability analysis" means a structured scientific assessment of the physical, chemical, biological, and economic factors affecting attainment of the uses of water bodies. A use attainability analysis is required to remove a designated use specified in section 101(a)(2) of the Clean Water Act that is not an existing use. The allowable reasons for removing a designated use are described in Code of Federal Regulations, title 40, section 131.10 (g).

~~MM.~~ NN. "Water body" means a lake, reservoir, wetland, or a geographically defined portion of a river or stream.

~~NN.~~ OO. "Water body type" means a group of water bodies with similar natural physical, chemical, and biological attributes, where the characteristics are similar among water bodies within each type and distinct from water bodies of other types.

7050.0155 PROTECTION OF DOWNSTREAM USES.

All waters must maintain a level of water quality that provides for the attainment and maintenance of the water quality standards of downstream waters, including the waters of another state.

7050.0220 SPECIFIC WATER QUALITY STANDARDS BY ASSOCIATED USE CLASSES.

Subpart 1. **Purpose and scope.** The numeric and narrative water quality standards in this chapter prescribe the qualities or properties of the waters of the state that are necessary for the designated public uses and benefits. If the standards in this chapter are exceeded, it is considered indicative of a polluted condition which is actually or potentially deleterious, harmful, detrimental, or injurious with respect to designated uses or established classes of the waters of the state.

All surface waters are protected for multiple beneficial uses. Numeric water quality standards are tabulated in this part for all uses applicable to four common categories of surface waters, so that all applicable standards for each category are listed together in subparts 3a to 6a. The four categories are:

A. cold water aquatic life and habitat, also protected for drinking water: Classes 1B; 2A, 2Ae, or 2Ag; 3A or 3B; 4A and 4B; and 5 (subpart 3a);

B. cool and warm water aquatic life and habitat, also protected for drinking water: Classes 1B or 1C; 2Bd, 2Bde, 2Bdg, or 2Bdm; 3A or 3B; 4A and 4B; and 5 (subpart 4a);

C. cool and warm water aquatic life and habitat and wetlands: Classes 2B, 2Be, 2Bg, 2Bm, or 2D; 3A, 3B, 3C, or 3D; 4A and 4B or 4C; and 5 (subpart 5a); and

Subp. 3a. **Cold water aquatic life and habitat, drinking water, and associated use classes.** Water quality standards applicable to use Classes 1B; 2A, 2Ae, or 2Ag; 3A or 3b; 4A and 4B; and 5 surface waters. The water quality standards in part 7050.0222, subpart 2, that apply to Class 2A also apply to Classes 2Ae and 2Ag. In addition to the water quality standards in part 7050.0222, subpart 2, the biological criteria defined in part 7050.0222, subpart 2d, apply to Classes 2Ae and 2Ag.

Subp. 4a. **Cool and warm water aquatic life and habitat, drinking water, and associated use classes.** Water quality standards applicable to use Classes 1B or 1C; 2Bd, 2Bde, 2Bdg, or 2Bdm; 3A or 3B; 4A and 4B; and 5 surface waters. The water quality standards in part 7050.0222, subpart 3, that apply to Class 2Bd also apply to Classes 2Bde, 2Bdg, and 2Bdm. In addition to the water quality standards in part 7050.0222, subpart 3, the biological criteria defined in part 7050.0222, subpart 3d, apply to Classes 2Bde, 2Bdg, and 2Bdm.

Subp. 5a. **Cool and warm water aquatic life and habitat and associated use classes.** Water quality standards applicable to use Classes 2B, 2Be, 2Bg, 2Bm, or 2D; 3A, 3B, or 3C; 4A and 4B; and 5 surface waters. See parts 7050.0223, subpart 5; 7050.0224, subpart 4; and 7050.0225, subpart 2, for Class 3D, 4C, and 5 standards applicable to wetlands, respectively. The water quality standards in part 7050.0222, subpart 4, that apply to Class 2B also apply to Classes 2Be, 2Bg, and 2Bm. In addition to the water quality standards in part 7050.0222, subpart 4, the biological criteria defined in part 7050.0222, subpart 4d, apply to Classes 2Be, 2Bg, and 2Bm.

7050.0222 SPECIFIC WATER QUALITY STANDARDS FOR CLASS 2 WATERS OF THE STATE; AQUATIC LIFE AND RECREATION.

Subp. 2c. **Beneficial use definitions for lotic cold water ~~stream and river~~ aquatic life and habitats (Class 2A).**

A. Subitems (1) to ~~(4)~~ (5) apply to the beneficial uses in items B and C:

(2) The attributes of species composition, diversity, and functional organization are measured using:

(a) the ~~fish-based~~ fish IBI as defined in ~~Development of a Fish-based Index of Biological Integrity for Minnesota's Rivers and Streams, Minnesota Pollution Control Agency (2014)~~ Fish Data Collection Protocols for Lotic Waters in Minnesota (2017); or

(b) the macroinvertebrate IBI as defined in ~~Development of a Macroinvertebrate-based Index of Biological Integrity for Minnesota's Rivers and Streams, Minnesota Pollution Control Agency (2014)~~ Macroinvertebrate Data Collection Protocols for Lotic Waters in Minnesota (2017).

(4) The following documents are incorporated by reference and are not subject to frequent change:

(a) Calibration of the Biological Condition Gradient for Streams of Minnesota, Gerritsen et al. (2012). The document is available on the agency's Web site at www.pca.state.mn.us/regulations/minnesota-rulemaking;

(b) ~~Development of a Fish-based Index of Biological Integrity for Minnesota's Rivers and Streams, Minnesota Pollution Control Agency (2014)~~ Fish Data Collection Protocols for Lotic Waters in Minnesota, Minnesota Pollution Control Agency (2017). The document is available on the agency's Web site at www.pca.state.mn.us/regulations/minnesota-rulemaking;

(c) ~~Development of a Macroinvertebrate-based Index of Biological Integrity for Minnesota's Rivers and Streams, Minnesota Pollution Control Agency (2014)~~ Macroinvertebrate Data Collection Protocols for Lotic Waters in

Minnesota, Minnesota Pollution Control Agency (2017). The document is available on the agency's Web site at www.pca.state.mn.us/regulations/minnesota-rulemaking; and

(d) Development of Biological Criteria for Tiered Aquatic Life Uses, Minnesota Pollution Control Agency (2016). The document is available on the agency's Web site at www.pca.state.mn.us/regulations/minnesota-rulemaking.

(5) The beneficial use subclass designators "e" and "g" are added to the Class 2A designator as specific additional designators. The additional subclass designators do not replace the Class 2A designator. All requirements for Class 2A cold water stream and river habitats in parts 7050.0222 and 7052.0100 continue to apply in addition to requirements for Class 2Ae or Class 2Ag cold water stream and river habitats in part 7050.0222. These subclass designators are applied to lotic waters only.

Subp. 2d. **Biological criteria for lotic cold water ~~stream and river~~ aquatic life and habitats (Class 2A).**

Water Body Type	Tier	Class	Assemblage	Biocriterion
Southern cold water streams	Exceptional	2Ae	Fish	82
	General	2Ag	Fish	50
Northern cold water streams	Exceptional	2Ae	Fish	60
	General	2Ag	Fish	35
Northern cold water streams	Exceptional	2Ae	Macroinvertebrates	52
	General	2Ag	Macroinvertebrates	32
Southern cold water streams	Exceptional	2Ae	Macroinvertebrates	72
	General	2Ag	Macroinvertebrates	43

The biological criteria for lotic cold water aquatic life and habitats (Class 2A) are applicable to perennial and intermittent waters that allow for colonization of fish or macroinvertebrates.

Subp. 3c. **Beneficial use definitions for lotic warm or cool water ~~stream and river~~ aquatic life and habitats (Class 2Bd).**

A. Subitems (1) to ~~(4)~~ (5) apply to the beneficial uses in items B to D:

(2) The attributes of species composition, diversity, and functional organization are measured using:

(a) the ~~fish-based~~ fish IBI as defined in ~~Development of a Fish-based Index of Biological Integrity for Minnesota's Rivers and Streams, Minnesota Pollution Control Agency (2014)~~ Fish Data Collection Protocols for Lotic Waters in Minnesota (2017); or

(b) the macroinvertebrate IBI as defined in ~~Development of a Macroinvertebrate-based Index of Biological Integrity for Minnesota's Rivers and Streams, Minnesota Pollution Control Agency (2014)~~ Macroinvertebrate Data Collection Protocols for Lotic Waters in Minnesota (2017).

(4) The following documents are incorporated by reference and are not subject to frequent change:

(a) Calibration of the Biological Condition Gradient for Streams of Minnesota, Gerritsen et al. (2012). The document is available on the agency's Web site at www.pca.state.mn.us/regulations/minnesota-rulemaking;

(b) ~~Development of a Fish-based Index of Biological Integrity for Minnesota's Rivers and Streams, Minnesota Pollution Control Agency (2014)~~ Fish Data Collection Protocols for Lotic Waters in Minnesota, Minnesota Pollution Control Agency (2017). The document is available on the agency's Web site at www.pca.state.mn.us/regulations/minnesota-rulemaking;

(c) ~~Development of a Macroinvertebrate-based Index of Biological Integrity for Minnesota's Rivers and~~

~~Streams, Minnesota Pollution Control Agency (2014)~~ Macroinvertebrate Data Collection Protocols for Lotic Waters in Minnesota, Minnesota Pollution Control Agency (2017). The document is available on the agency's Web site at www.pca.state.mn.us/regulations/minnesota-rulemaking; and

(d) Development of Biological Criteria for Tiered Aquatic Life Uses, Minnesota Pollution Control Agency (2016). The document is available on the agency's Web site at www.pca.state.mn.us/regulations/minnesota-rulemaking.

(5) The beneficial use subclass designators "e," "g," and "m" are added to the Class 2Bd designator as specific additional designators. The additional subclass designators do not replace the Class 2Bd designator. All requirements for Class 2Bd warm or cool water stream and river habitats in parts 7050.0222 and 7052.0100 continue to apply in addition to requirements for Class 2Bde, Class 2Bdg, or Class 2Bdm warm or cool water stream and river habitats in part 7050.0222. These subclass designators are applied to lotic waters only.

D. "Modified cool and warm water aquatic life and habitat, also protected as a source for drinking water" or "Class 2Bdm" is a beneficial use that means waters capable of supporting and maintaining a balanced, integrated, adaptive community of warm or cool water aquatic organisms having a species composition, diversity, and functional organization comparable to the median of biological condition gradient level 5 as established in Calibration of the Biological Condition Gradient for Streams of Minnesota, Gerritsen et al. (2012).

(1) To meet the definition in this item, waters must have been the subject of a use attainability analysis ~~and must have been found to be incapable of supporting and maintaining~~ where it is determined that attainment of the Class 2Bdg beneficial use is not feasible because of human-induced modifications of the physical habitat ~~that preclude the potential for recovery of the fauna~~. These modifications must be the result of direct alteration to the channel, such as drainageway maintenance, bank stabilization, and impoundments.

Subp. 3d. **Biological criteria for lotic warm or cool water ~~stream and river~~ aquatic life and habitats (Class 2Bd).**

Water Body Type	**Tier**	**Class**	**Assemblage**	**Biocriterion**
Southern rivers	Exceptional	2Bde	Fish	71
	General	2Bdg	Fish	49
Southern streams	Exceptional	2Bde	Fish	66
	General	2Bdg	Fish	50
	Modified	2Bdm	Fish	35
Southern headwaters	Exceptional	2Bde	Fish	74
	General	2Bdg	Fish	55
	Modified	2Bdm	Fish	33
Northern rivers	Exceptional	2Bde	Fish	67
	General	2Bdg	Fish	38
Northern streams	Exceptional	2Bde	Fish	61
	General	2Bdg	Fish	47
	Modified	2Bdm	Fish	35
Northern headwaters	Exceptional	2Bde	Fish	68
	General	2Bdg	Fish	42
	Modified	2Bdm	Fish	23
Low gradient	Exceptional	2Bde	Fish	70
	General	2Bdg	Fish	42
	Modified	2Bdm	Fish	15
Northern forest rivers	Exceptional	2Bde	Macroinvertebrates	77
	General	2Bdg	Macroinvertebrates	49

Water Body Type	Tier	Class	Assemblage	Biocriterion
Prairie and southern forest rivers	Exceptional	2Bde	Macroinvertebrates	63
	General	2Bdg	Macroinvertebrates	31
High-gradient northern forest streams	Exceptional	2Bde	Macroinvertebrates	82
	General	2Bdg	Macroinvertebrates	53
Low-gradient northern forest streams	Exceptional	2Bde	Macroinvertebrates	76
	General	2Bdg	Macroinvertebrates	51
	Modified	2Bdm	Macroinvertebrates	37
High-gradient southern streams	Exceptional	2Bde	Macroinvertebrates	62
	General	2Bdg	Macroinvertebrates	37
	Modified	2Bdm	Macroinvertebrates	24
Low-gradient southern forest streams	Exceptional	2Bde	Macroinvertebrates	66
	General	2Bdg	Macroinvertebrates	43
	Modified	2Bdm	Macroinvertebrates	30
Low-gradient prairie streams	Exceptional	2Bde	Macroinvertebrates	69
	General	2Bdg	Macroinvertebrates	41
	Modified	2Bdm	Macroinvertebrates	22

The biological criteria for lotic warm or cool water aquatic life and habitats (Class 2Bd) are applicable to perennial and intermittent waters that allow for colonization of fish or macroinvertebrates.

Subp. 4c. **Beneficial use definitions for lotic warm or cool water ~~stream and river~~ aquatic life and habitats (Class 2B).**

A. Subitems (1) to ~~(4)~~ (5) apply to the beneficial uses in items B to D:

(2) The attributes of species composition, diversity, and functional organization are measured using:

(a) the ~~fish-based~~ fish IBI as defined in ~~Development of a Fish-based Index of Biological Integrity for Minnesota's Rivers and Streams, Minnesota Pollution Control Agency (2014)~~ Fish Data Collection Protocols for Lotic Waters in Minnesota (2017); or

(b) the macroinvertebrate IBI as defined in ~~Development of a Macroinvertebrate-based Index of Biological Integrity for Minnesota's Rivers and Streams, Minnesota Pollution Control Agency (2014)~~ Macroinvertebrate Data Collection Protocols for Lotic Waters in Minnesota (2017).

(4) The following documents are incorporated by reference and are not subject to frequent change:

(a) Calibration of the Biological Condition Gradient for Streams of Minnesota, Gerritsen et al. (2012). The document is available on the agency's Web site at www.pca.state.mn.us/regulations/minnesota-rulemaking;

(b) ~~Development of a Fish-based Index of Biological Integrity for Minnesota's Rivers and Streams, Minnesota Pollution Control Agency (2014)~~ Fish Data Collection Protocols for Lotic Waters in Minnesota, Minnesota Pollution Control Agency (2017). The document is available on the agency's Web site at www.pca.state.mn.us/regulations/minnesota-rulemaking;

(c) ~~Development of a Macroinvertebrate-based Index of Biological Integrity for Minnesota's Rivers and Streams, Minnesota Pollution Control Agency (2014)~~ Macroinvertebrate Data Collection Protocols for Lotic Waters in Minnesota, Minnesota Pollution Control Agency (2017). The document is available on the agency's Web site at www.pca.state.mn.us/regulations/minnesota-rulemaking; and

(d) Development of Biological Criteria for Tiered Aquatic Life Uses, Minnesota Pollution Control Agency (2016). The document is available on the agency's Web site at www.pca.state.mn.us/regulations/minnesota-rulemaking.

(5) The beneficial use subclass designators "e," "g," and "m" are added to the Class 2B designator as specific additional designators. The additional subclass designators do not replace the Class 2B designator. All requirements for Class 2B warm or cool water stream and river habitats in parts 7050.0222 and 7052.0100 continue to apply in addition to requirements for Class 2Be, Class 2Bg, or Class 2Bm warm or cool water stream and river habitats in part 7050.0222. These subclass designators are applied to lotic waters only.

D. "Modified cool and warm water aquatic life and habitat" or "Class 2Bm" is a beneficial use that means waters capable of supporting and maintaining a balanced, integrated, adaptive community of warm or cool water aquatic organisms having a species composition, diversity, and functional organization comparable to the median of biological condition gradient level 5 as established in Calibration of the Biological Condition Gradient for Streams of Minnesota, Gerritsen et al. (2012).

(1) To meet the definition in this item, waters must have been the subject of a use attainability analysis ~~and must have been found to be incapable of supporting and maintaining~~ where it is determined that attainment of the Class 2Bg beneficial use is not feasible because of human-induced modifications of the physical habitat ~~that preclude the potential for recovery of the fauna~~. These modifications must be the result of direct alteration to the channel, such as drainageway maintenance, bank stabilization, and impoundments.

Subp. 4d. **Biological criteria for lotic warm or cool water ~~stream and river~~ aquatic life and habitats (Class 2B).**

Water Body Type	Tier	Class	Assemblage	Biocriterion
Southern rivers	Exceptional	2Be	Fish	71
	General	2Bg	Fish	49
Southern streams	Exceptional	2Be	Fish	66
	General	2Bg	Fish	50
	Modified	2Bm	Fish	35
Southern headwaters	Exceptional	2Be	Fish	74
	General	2Bg	Fish	55
	Modified	2Bm	Fish	33
Northern rivers	Exceptional	2Be	Fish	67
	General	2Bg	Fish	38
Northern streams	Exceptional	2Be	Fish	61
	General	2Bg	Fish	47
	Modified	2Bm	Fish	35
Northern headwaters	Exceptional	2Be	Fish	68
	General	2Bg	Fish	42
	Modified	2Bm	Fish	23
Low gradient	Exceptional	2Be	Fish	70
	General	2Bg	Fish	42
	Modified	2Bm	Fish	15
Northern forest rivers	Exceptional	2Be	Macroinvertebrates	77
	General	2Bg	Macroinvertebrates	49
Prairie and southern forest rivers	Exceptional	2Be	Macroinvertebrates	63
	General	2Bg	Macroinvertebrates	31

Water Body Type	Tier	Class	Assemblage	Biocriterion
High-gradient northern forest streams	Exceptional	2Be	Macroinvertebrates	82
	General	2Bg	Macroinvertebrates	53
Low-gradient northern forest streams	Exceptional	2Be	Macroinvertebrates	76
	General	2Bg	Macroinvertebrates	51
	Modified	2Bm	Macroinvertebrates	37
High-gradient southern streams	Exceptional	2Be	Macroinvertebrates	62
	General	2Bg	Macroinvertebrates	37
	Modified	2Bm	Macroinvertebrates	24
Low-gradient southern forest streams	Exceptional	2Be	Macroinvertebrates	66
	General	2Bg	Macroinvertebrates	43
	Modified	2Bm	Macroinvertebrates	30
Low-gradient prairie streams	Exceptional	2Be	Macroinvertebrates	69
	General	2Bg	Macroinvertebrates	41
	Modified	2Bm	Macroinvertebrates	22

The biological criteria for lotic warm or cool water aquatic life and habitats (Class 2B) are applicable to perennial and intermittent waters that allow for colonization of fish or macroinvertebrates.

7050.0430 UNLISTED WATERS.

Subpart 1. **Statewide surface waters.** Except as provided in subparts 2 and 3, all surface waters of the state that are not listed in part 7050.0470 and that are not wetlands as defined in part 7050.0186, subpart 1a, are hereby classified as Class ~~2Bg~~ 2B, 3C, 4A, 4B, 5, and 6 waters. Unlisted lotic waters are also assigned the beneficial use subclass designator "g" to the Class 2B designator.

7050.0470 CLASSIFICATIONS FOR SURFACE WATERS IN MAJOR DRAINAGE BASINS.

Subpart 1. **Lake Superior Basin.** The water use classifications for the stream reaches within each of the major watersheds in the Lake Superior Basin listed in item A are found in tables entitled "Beneficial Use Designations for Stream Reaches" published on the Web site of the Minnesota Pollution Control Agency at www.pca.state.mn.us/regulations/minnesota-rulemaking. The tables are incorporated by reference and are not subject to frequent change. The date after each watershed listed in item A is the publication date of the applicable table. The water use classifications for the other listed waters in the Lake Superior Basin are as identified in items B to D. See parts 7050.0425 and 7050.0430 for the classifications of waters not listed. Designated use information for water bodies can also be accessed through the agency's Environmental Data Access (http://www.pca.state.mn.us/quick-links/eda-surface-water-data).

Subp. 2. **Lake of the Woods Basin.** The water use classifications for the stream reaches within each of the major watersheds in the Lake of the Woods Basin listed in item A are found in tables entitled "Beneficial Use Designations for Stream Reaches" published on the Web site of the Minnesota Pollution Control Agency at www.pca.state.mn.us/regulations/minnesota-rulemaking. The tables are incorporated by reference and are not subject to frequent change. The date after each watershed listed in item A is the publication date of the applicable table. The water use classifications for the other listed waters in the Lake of the Woods Basin are as identified in items B to D. See parts 7050.0425 and 7050.0430 for the classifications of waters not listed. Designated use information for water bodies can also be accessed through the agency's Environmental Data Access (http://www.pca.state.mn.us/quick-links/eda-surface-water-data).

Subp. 3. **Red River of the North Basin.** The water use classifications for the stream reaches within each of the major watersheds in the Red River of the North Basin listed in item A are found in tables entitled "Beneficial Use Designations for Stream Reaches" published on the Web site of the Minnesota Pollution Control Agency at www.pca.state.mn.us/regulations/minnesota-rulemaking. The tables are incorporated by reference and are not subject to frequent change. The date after each watershed listed in item A is the publication date of the applicable table. The water use classifications for the other listed waters in the Red River of the North Basin are as identified in items B to D. See parts 7050.0425 and 7050.0430 for the classifications of waters not listed. Designated use information for water bodies can also be accessed through the agency's Environmental Data Access (http://www.pca.state.mn.us/quick-links/eda-surface-water-data).

Subp. 4. **Upper Mississippi River Basin (headwaters to the confluence with the St. Croix River).** The water use classifications for the stream reaches within each of the major watersheds in the Upper Mississippi River Basin from the headwaters to the confluence with the St. Croix River listed in item A are found in tables entitled "Beneficial Use Designations for Stream Reaches" published on the Web site of the Minnesota Pollution Control Agency at www.pca.state.mn.us/regulations/minnesota-rulemaking. The tables are incorporated by reference and are not subject to frequent change. The date after each watershed listed in item A is the publication date of the applicable table. The water use classifications for the other listed waters in the Upper Mississippi River Basin from the headwaters to the confluence with the St. Croix River are as identified in items B to D. See parts 7050.0425 and 7050.0430 for the classifications of waters not listed. Designated use information for water bodies can also be accessed through the agency's Environmental Data Access (http://www.pca.state.mn.us/quick-links/eda-surface-water-data).

Subp. 5. **Minnesota River Basin.** The water use classifications for the stream reaches within each of the major watersheds in the Minnesota River Basin listed in item A are found in tables entitled "Beneficial Use Designations for Stream Reaches" published on the Web site of the Minnesota Pollution Control Agency at www.pca.state.mn.us/regulations/minnesota-rulemaking. The tables are incorporated by reference and are not subject to frequent change. The date after each watershed listed in item A is the publication date of the applicable table. The water use classifications for the other listed waters in the Minnesota River Basin are as identified in items B to D. See parts 7050.0425 and 7050.0430 for the classifications of waters not listed. Designated use information for water bodies can also be accessed through the agency's Environmental Data Access (http://www.pca.state.mn.us/quick-links/eda-surface-water-data).

Subp. 6. **Saint Croix River Basin.** The water use classifications for the stream reaches within each of the major watersheds in the Saint Croix River Basin listed in item A are found in tables entitled "Beneficial Use Designations for Stream Reaches" published on the Web site of the Minnesota Pollution Control Agency at www.pca.state.mn.us/regulations/minnesota-rulemaking. The tables are incorporated by reference and are not subject to frequent change. The date after each watershed listed in item A is the publication date of the applicable table. The water use classifications for the other listed waters in the Saint Croix River Basin are as identified in items B to D. See parts 7050.0425 and 7050.0430 for the classifications of waters not listed. Designated use information for water bodies can also be accessed through the agency's Environmental Data Access (http://www.pca.state.mn.us/quick-links/eda-surface-water-data).

Subp. 7. **Lower Mississippi River Basin (from the confluence with the St. Croix River to the Iowa border).** The water use classifications for the stream reaches within each of the major watersheds in the Lower Mississippi River Basin from the confluence with the Saint Croix River to the Iowa border listed in item A are found in tables entitled "Beneficial Use Designations for Stream Reaches" published on the Web site of the Minnesota Pollution Control Agency at www.pca.state.mn.us/regulations/minnesota-rulemaking. The tables are incorporated by reference and are not subject to frequent change. The date after each watershed listed in item A is the publication date of the applicable table. The water use classifications for the other listed waters in the Lower Mississippi River Basin from the confluence with the St. Croix River to the Iowa border are as identified in items B to D. See parts 7050.0425 and 7050.0430 for the classifications of waters not listed. Designated use information for water bodies can also be accessed through the agency's Environmental Data Access (http://www.pca.state.mn.us/quick-links/eda-surface-water-data).

Subp. 8. **Cedar-Des Moines Rivers Basin.** The water use classifications for the stream reaches within each of the major watersheds in the Cedar-Des Moines Rivers Basin listed in item A are found in tables entitled "Beneficial Use Designations for Stream Reaches" published on the Web site of the Minnesota Pollution Control Agency at www.pca.state.mn.us/regulations/minnesota-rulemaking. The tables are incorporated by reference and are not subject to frequent change. The date after each watershed listed in item A is the publication date of the applicable table. The water use classifications for the other listed waters in the Cedar-Des Moines Rivers Basin are as identified in items B to D. See parts 7050.0425 and 7050.0430 for the classifications of waters not listed. Designated use information for water bodies can also be accessed through the agency's Environmental Data Access (http://www.pca.state.mn.us/quick-links/eda-surface-water-data).

Subp. 9. **Missouri River Basin.** The water use classifications for the stream reaches within each of the major watersheds in the Missouri River Basin listed in item A are found in tables entitled "Beneficial Use Designations for Stream Reaches" published on the Web site of the Minnesota Pollution Control Agency at www.pca.state.mn.us/regulations/minnesota-rulemaking. The tables are incorporated by reference and are not subject to frequent change. The date after each watershed listed in item A is the publication date of the applicable table. The water use classifications for the other listed waters in the Missouri River Basin are as identified in items B to D. See parts 7050.0425 and 7050.0430 for the classifications of waters not listed. Designated use information for water bodies can also be accessed through the agency's Environmental Data Access (http://www.pca.state.mn.us/quick-links/eda-surface-water-data).

Official Notices

Pursuant to *Minnesota Statutes* §§ 14.101, an agency must first solicit comments from the public on the subject matter of a possible rulemaking proposal under active consideration within the agency by publishing a notice in the *State Register* at least 60 days before publication of a notice to adopt or a notice of hearing, and within 60 days of the effective date of any new statutory grant of required rulemaking.

The *State Register* also publishes other official notices of state agencies and non-state agencies, including notices of meetings and matters of public interest.

Department of Natural Resources

Lands and Minerals Division

Notice of Hearing on Sale of State Land

NOTICE IS HEREBY GIVEN, that pursuant to *Minnesota Statutes*, section 97A.135, subd. 2a, a hearing will be held by the Department of Natural Resources, at the Norman County Courthouse, Commissioners Room, 16 3rd Avenue East, Ada, Minnesota on **October 26, 2017 at 2:00 p.m.**

The purpose of the hearing is for public input regarding the sale of state land situated in the County of Norman, and described as:

All that part of the North Half of the Northwest Quarter AND the Southwest Quarter of the Northwest Quarter of Section 26, Township 144 North, Range 45 West Norman County, Minnesota, lying southerly and easterly of the following described lines:

Commencing at the northwest corner of said Section 26; thence North 90 degrees 00 minutes East, 2286.42 feet on and along the north line of said Section 26 to the point of beginning; thence South 40 degrees 38 minutes 41 seconds West 1311.59 feet; thence South 33 degrees 58 minutes 29 seconds West of 1694.6 feed to a point on the east-west quarter line of the said Section2 6 and there terminating. Subject to all existing easements.

Minnesota Statutes, section 97A.135, subd. 2a, requires that a public hearing be held before lands within a Wildlife Management Area can be disposed of through sale or exchange. The parcel is designated as part of the Rockwell Wildlife Management Area.

It is proposed that this parcel of land be offered for sale by the Department of Natural Resources in a public sale. This parcel is no longer needed for public purposes. If, after public hearing, the disposal of the land is in the public interest, the Commissioner of Natural Resources may vacate the parcel from Wildlife Management Area designation.

CHAPTER 22

Filling the Gaps in Water Quality Standards: Legal Perspectives on Biocriteria

Robert W. Adler

1.0 INTRODUCTION

Virtually no major aspect of the Clean Water Act (CWA) regulatory scheme has been immune from challenge, as witnessed by the exhaustive, multiparty challenge to EPA's overall permitting system (the National Pollutant Discharge Elimination System, NPDES) (*NRDC v. USEPA* 1988). While biocriteria remain relatively untouched by lawyers and judges thus far, this innocence likely will be lost as biocriteria move from the realm of science to the reality of regulation. Therefore, program managers would be wise to anticipate and to insulate their biocriteria programs from such legal challenges.

To assist in this effort, it is useful to include in this largely scientific compendium some perspective on legal issues relevant to the use of biocriteria. Specifically, this chapter will evaluate the legal basis for the use of biocriteria in water quality standards, as well as the application of those criteria in various CWA programs. Included as well is discussion of various legal issues and problems that may help program managers insulate biocriteria from challenge.

The chapter begins with a brief legal history of water quality standards. Next, it describes the potential legal bases for biocriteria, beginning with the statute and its legislative history, and proceeding to U.S. Environmental Protection Agency (USEPA) regulations and to potentially relevant case law. These legal principles are then used to analyze the various existing and potential applications of biocriteria in clean water programs.

2.0 A BRIEF LEGAL HISTORY OF WATER QUALITY STANDARDS

While used in various forms for decades, the first effort to integrate water quality standards into a comprehensive federal water pollution control program came in Section 5 of the Water Quality Act of 1965, which required states to develop water quality standards for interstate waters. Water quality standards were defined in section 10(c)(1) of the law to include (1) designated uses of waters; (2) numeric or narrative criteria to protect those uses; and (3) an implementation plan.

Narrative criteria are verbal descriptions of water quality, such as "no toxics in toxic amount," "no floatable wastes," or "no putrescible wastes." As such, narrative criteria could address chemical, physical, or biological conditions. Although the use of purely narrative criteria is well accepted (*EDF v. Costle* 1981), cases involving water quality standards reflect the pervasive bias that criteria define numeric limits on chemical pollutants rather than broader definitions of impairment, much less a positive statement describing biological well-being. For example, in 1990 two U.S. Courts of Appeals described water quality criteria as "the maximum concentrations of pollutants that could occur without jeopardizing the

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use" (*NRDC v. USEPA* 1990, Ninth Circuit) and as the "amount of various pollutants" that may be present (*Westvaco v. USEPA* 1990, Fourth Circuit).

In 1972, Congress shifted efforts to control water pollution in general, and point source pollution in particular, away from a focus on receiving water quality in favor of technology-based reductions in pollutant discharges. Under the 1972 CWA, all point sources were subject to "best technology" requirements irrespective of receiving water quality. In theory, these requirements were designed to become increasingly stringent until the ultimate goal of eliminating the discharge of pollutants into receiving waters is achieved (CWA Sections 101(a)(1), 301, 402). Water quality standards, however, retained important functions. States were required to develop water quality standards for intrastate as well as interstate waters; to identify all waters not meeting these standards; to calculate the additional pollutant reductions needed to achieve the standards (known as "total maximum daily loads," or TMDLs); and to impose these requirements through wasteload allocations (WLAs), NPDES permits, and best management practices for nonpoint sources (CWA Sections 208, 302, 303, 402). If a state failed to perform any of these functions, USEPA was obligated to do so instead. Specific requirements are defined further in USEPA regulations (e.g., 40 CFR Parts 130, 131) and guidance (e.g., USEPA 1991f).

States are given the first opportunity to adopt water quality standards (CWA Section 303), reflecting Congress' recognition that biological conditions vary from state to state (*State of Alabama v. USEPA* 1977). However, USEPA maintains critical guidance and oversight functions, and retains the authority to promulgate federal water quality standards for any state that fails to issue standards adequate to achieve the goals and purposes of the act. Under Section 304(a), USEPA issues water quality criteria to guide states in their adoption of enforceable water quality standards. Under Section 303(c), USEPA must review state standards to ensure that they meet the requirements of the act. States are afforded a second chance to address any deficiencies identified by USEPA, but failing such corrections, USEPA is *required* to adopt federal standards under Section 303(d) to ensure full compliance with the law (*Mississippi Commission on Natural Resources v. USEPA* 1980).

The shift to technology-based controls cannot be attributed to a single factor, as the 1972 Senate Report characterized previous water pollution control efforts as "inadequate in every vital aspect" (1972). One major problem, however, was the difficulty, given existing monitoring and modeling techniques, in working backwards from receiving water quality standards to individual discharge requirements. "Regulators had to work backwards from an over-polluted body of water and determine which entities were responsible; proving cause and effect was not always easy" (*NRDC v. USEPA* 1990). In part, the U.S. Supreme Court blamed water quality standards per se: "The problems stemmed from the character of the standards themselves, which focused on the tolerable effects rather than the preventable causes of water pollution..." (*USEPA v. California* 1976).

From the perspective of biocriteria proponents, this critique was insightful and prophetic. Chemical-specific water quality criteria that define "tolerable" amounts of chemical pollution were viewed more as "negative" statements of permissible pollution rather than positive statements of water quality or aquatic ecosystem goals: How much pollution can be allowed without interfering with designated uses? The same is true of whole effluent toxicity (WET) criteria: How much toxicity in effluent and in receiving waters is permissible without impairing uses? Even traditional narrative standards (free from floatables, odors, or other undesirable characteristics) typically are stated as negatives rather than positives. These general rules, of course, are subject to exceptions. For example, does a water quality criterion for dissolved oxygen (DO) establish a positive view of a healthy waterbody or a permissible level of DO reduction?

Biocriteria *could* be viewed in the same way: How much deviation from reference conditions is acceptable without concluding that uses are impaired? More properly, however, biocriteria establish *positive* statements of the desired biological conditions of waterbodies. Rather than defining the "tolerable effects...of pollution," such criteria establish an affirmative statement of desirable ecological attributes. They are aims to achieve, not ills to avoid. It is interesting then, that the Supreme Court in 1992 stated that the purpose of water quality standards is to "establish the desired condition of a waterway" (*Arkansas v. Oklahoma* 1992), and not, as it and other courts had previously, to define tolerable levels of pollution. Given the facts of the *Arkansas* case, it is doubtful that this shift in legal description was intentional; but the new language mirrors the gradual addition of positive goals to a system of water quality standards traditionally stated in negative terms.

Now, USEPA is beginning to view water quality standards as a holistic, affirmative statement of the overall integrity of a waterbody (USEPA 1990a, 1991f). A combination of impermissible negatives

(chemical-specific, condition-specific, and WET) and desired positives (biocriteria) can be used to determine whether uses are attained or impaired, and to guide future assessment and regulatory efforts. While USEPA and state scientists and other water quality officials have been making this shift for about a decade, few hard regulatory requirements have been imposed as a result. Thus, little legal attention has been paid to this trend. As biocriteria evolve from assessment to regulatory tools, this will likely change.

3.0 THE LEGAL BASIS FOR BIOCRITERIA

The objective of the CWA, stated in Section 101(a), is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." Relatedly, "pollution" in Section 502(19) (as distinct from the narrower definition of "pollutant" in Section 502(6)) "means the man-made or man-induced alteration of the chemical, physical, biological, and radiological integrity of water." Logically, then, water quality standards must address biological as well as chemical and physical characteristics of waterbodies (Karr 1990).

During the first two decades of the CWA, however, regulatory agencies paid far more attention to chemical than to biological integrity of the nation's waters (Adler et al. 1993). These omissions were not due to lack of understanding. Over a decade ago, for example, USEPA and the U.S. Fish and Wildlife Service (FWS) commented that "attempts to monitor the condition of the nation's waters have focused only on the physical and chemical characteristics of the water, while the components of the biological communities were largely ignored" (Judy et al. 1984). Similar conclusions had been reached by state and independent researchers even earlier (Karr 1981; Karr and Dudley 1981). In a seminal article published in 1981, Karr and Dudley wrote:

> Water quality is traditionally interpreted as the physical/chemical properties of water, a fact that greatly limits the scope of the goal [of the Act].... A comprehensive evaluation of both physical/chemical and biological data is a better determination of whether or not fishable/swimmable conditions are being achieved. [The authors defined ecosystem integrity as] the capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region. (Karr and Dudley 1981)

As a basic principle of statutory construction, general statements of statutory goals and objectives have no legal force and effect, absent specific operative provisions in the law. However laudable the goals, implementation of specific programs requires adequate statutory authority, especially when the legal obligations of third parties are affected. Support for the issuance and implementation of biocriteria, therefore, should rest on a more rigorous legal analysis. This evaluation will proceed from the operative language of the CWA and relevant legislative history, to USEPA and state regulatory interpretations, to relevant case law (of which there is little at this stage). Two distinct questions will be addressed: first, in Section 3, whether biocriteria issued and applied by the states are legally defensible; and second, in Section 4, whether USEPA has the authority to require states to adopt biocriteria in some form.

3.1 The Clean Water Act and its Legislative History

As noted above, the driving force behind biocriteria is the basic objective of the law to restore and maintain the biological as well as the chemical and physical integrity of the nation's waters. But precise application of this principle requires operative language. This authority stems primarily from Sections 303 and 304, which dictate the manner in which water quality standards are adopted, and Sections 301, 303, and 402, which require that those standards be implemented, and describe how.

Section 303 of the 1972 act recodified and expanded the water quality standards provisions of the 1965 law, but there were no fundamental changes — water quality standards consist of designated uses of waters and water quality criteria based on those uses. "Such standards shall be such as to protect the public health or welfare, enhance the quality of water *and serve the purposes of this Act*" (CWA Section 303(c)(2)(A); emphasis added). The italicized language, while seemingly innocuous, in fact makes fully operative the objectives stated in Section 101. To "serve the purposes of th[e] Act," water quality standards must address chemical, physical, and biological integrity of the nation's waters.

Additional statutory authority to support the use of biocriteria is included in Section 304(a), under which USEPA develops and publishes water quality criteria used by states in developing their water quality standards. Section 304(a) criteria do not have independent legal effect; if a state fails to adopt adequate water quality standards, USEPA must do so through separate rule making under Section 303(c). However, since Congress intended that state water quality standards would be based on the USEPA criteria, logically state water quality standards can be at least as broad as suggested by the wording of Section 304(a). The basic requirements for USEPA criteria are set forth in Subsections 304(a)(1) and (2). In relevant part, Subsection (a)(1) reads:

> The Administrator...shall develop and publish...criteria for water quality accurately reflecting the latest scientific knowledge (A) of the kind and extent of all identifiable effects on health and welfare including, but not limited to, plankton, fish, shellfish, wildlife, plant life, shorelines, beaches, esthetics, and recreation which may be expected from the presence of pollutants in any body of water, including ground water; (B) on the concentration and dispersal of pollutants, or their byproducts, through biological, physical, and chemical processes; and (C) on the effects of pollutants on biological community diversity, productivity, and stability.

The breadth of this language, encompassing "all identifiable effects" on health and welfare, supports USEPA and state authority to issue water quality criteria that address biological as well as chemical impairment. Particularly notable is the authority to address "biological community diversity, productivity, and stability," the very types of metrics used to develop biocriteria. However, Subsection (a)(1) is also notable in its focus on the effects of *pollutants* on the various factors to be addressed, as opposed to broader sources of impairment. In this respect, the distinction between the definitions of "pollutant" and "pollution" in Section 502, discussed above, becomes a two-edged sword, used in this case to slice away at the breadth of Section 304(a)(1). Undoubtedly, challenges to biocriteria that address impairment caused by factors other than the release of chemical pollutants will cite this distinction.

Any doubts raised by this limitation, however, appear to be resolved by the broader context of Subsection (a)(2):

> The Administrator...shall develop and publish...information (A) on the factors necessary to restore and maintain the chemical, physical, and biological integrity of all navigable waters, ground waters, waters of the contiguous zone, and the oceans; (B) on the factors necessary for the protection and propagation of shellfish, fish, and wildlife for classes and categories of receiving waters...(C) on the measurement and classification of water quality; and (D) for the purpose of section 303, on the identification of pollutants suitable for maximum daily load measurement correlated with the achievement of water quality objectives.

[For historical reasons not important to this analysis, part of this language is repeated in Subsection 304(a)(5).]

With the exception of Subsection (D) regarding TMDLs (discussed further in the following section on implementation of biocriteria), this subsection is not limited to effects caused by the release of chemical pollutants, but rather may address effects from any cause of impairment. Stated differently, criteria developed under Section 304(a)(1) could be viewed as criteria to address the effects of *pollutants*, while criteria under Section 304(a)(2) address the broader effects of *pollution*. While in practice USEPA has never made this distinction, as a matter of statutory interpretation the difference is important, and supports USEPA's authority to issue broader biological water quality criteria not necessarily related to releases of specific pollutants. Subsection 304(a)(2) also supports development of biocriteria through its direct incorporation of the requirement to protect chemical, physical, *and* biological integrity.

Indeed, the 1972 Senate Committee Report describes water quality criteria under Section 304(a) in language that is remarkably prescient of the types of biocriteria that have been adopted widely by state agencies only in the past several years:

> Criteria establish the effects of pollutants on health and welfare, including the effects of pollutants on receiving water ecosystems and man, and identify the natural chemical, physical and biological integrity of the Nation's waters. The concentration and dispersal of pollutants and their by-products through biological, physical and chemical processes and any related changes in the diversity, productivity, or stability of receiving waters should be part of the information provided.
>
> The "natural integrity" of the waters may be determined partially by consultation of historical records on species composition, partially from ecological studies in the area or comparable habitats; partially from modeling studies which make estimations of the balanced natural ecosystem based on the information available. (CRS 1972)

USEPA and state authority to issue biological criteria was given an additional boost in the 1987 Water Quality Act, which added Sections 303(c)(2)(B) and 304(a)(8). Section 303(c)(2)(B) was added to force delinquent states to adopt water quality criteria to address priority toxic pollutants present in their waters at levels that might interfere with uses. Numeric criteria were required wherever available. Where such criteria were not available, however, Congress expressly directed that:

> ...such State shall adopt criteria based on biological monitoring or assessment methods consistent with information published pursuant to section 304(a)(8). Nothing in this section shall be construed to limit or delay the use of effluent limitations or other permit conditions based on or involving biological monitoring or assessment methods or previously adopted numerical criteria.

With this language, Congress simultaneously authorized the use of biocriteria prospectively and ratified their previous use. In Section 304(a)(8), Congress directed USEPA to "develop and publish information on methods for establishing and measuring water quality criteria for toxic pollutants on other bases than pollutant-by-pollutant criteria, including biological monitoring and assessment methods."

The breadth of this additional authority will be questioned on two grounds. First, because the provisions were added as part of Congress' program to require states to address toxic priority pollutants, it will be argued that Congress only intended to authorize biological monitoring methods in this limited context. The force of this argument is weakened substantially, however, because in Section 303(c)(2)(B) Congress expressly recognized the validity of previous biocriteria adopted under more general authority. USEPA agrees in its biocriteria guidance document, noting that "[t]hese specific directives do not serve to restrict the use of biological criteria in other settings where they may be helpful" (USEPA 1990a).

Second, substitutes for chemical-specific numeric criteria for toxicants generally used and understood in 1987 were WET testing, not biocriteria. Thus, it may be argued that Congress' use of the term "biological monitoring and assessment" was an unintentionally broad reference to WET. Neither the Conference Report nor the Senate Report (this provision derived from the Senate bill), however, shed additional light on Congress' intended use of these terms. Moreover, Section 304(a)(8) refers to bases other than pollutant-specific criteria, *including* biological monitoring and assessment methods, and grants USEPA broad discretion to explicate the otherwise undefined terms through guidance. Thus, there is no clear evidence that Congress intended to restrict this terminology to any single methodology. Given judicial deference to reasonable USEPA interpretations of ambiguous statutory provisions (*Chevron v. NRDC* 1984), however, USEPA's view that this provision authorizes biocriteria as well as WET criteria is likely to be upheld.

One additional provision of the law merits attention. The CWA establishes only *minimum* federal requirements for state water quality standards and other aspects of state programs (Section 4.0 *infra*). Under Section 510, states are free to establish requirements stricter than those required by the Act (*PCMA v. Watt* 1983; 40 CFR. Section 131.4). However, once state criteria are adopted and approved by USEPA, they become "part of the federal law of pollution control" (*Arkansas v. Oklahoma* 1992). Thus, so long as biocriteria are authorized by state law, they are not prohibited by the CWA; and once approved by USEPA, they become enforceable under federal law as well with respect to any activity that affects receiving waters in the state that issued the standards. An analysis of additional authority for biocriteria in 50 states obviously is beyond the scope of this analysis. As one example, however, in Maine, water quality standards are adopted by statute rather than regulation (Maine Water Pollution Law, Article. 4-A). Thus, Maine's narrative biocriteria are insulated from attack under the CWA itself.

Given the far-reaching implications of the adoption and application of biocriteria, more specific statutory authority is at least desirable. Indeed, entities most likely to feel the regulatory weight of biocriteria undoubtedly will argue that more direct Congressional attention to this issue is essential. But unless and until Congress addresses biocriteria in the next CWA reauthorization, as proposed, for example, in S.1114 introduced by Senators Baucus and Chafee in 1993, legal acceptance of biocriteria will turn on existing statutory language. The manner in which the existing law will be interpreted is guided by USEPA regulations and judicial precedent, discussed in the following two sections.

3.2 USEPA Regulations

USEPA's water quality standards regulations are contained in Title 40, Part 131 of the Code of Federal Regulations (40 CFR Part 131). Related rules governing water quality planning and management are included in 40 CFR Part 130.

Most aspects of the above statutory analysis are supported or paralleled by USEPA regulations. In some respects, however, because many of USEPA's rules predate the development of biocriteria, they contain language that reflects the earlier, narrower view of water quality standards as limits on concentrations of chemical pollutants in waterbodies. While none of this language is fatal to USEPA or state development of biocriteria, especially given the strong statutory support outlined above, USEPA should broaden this language when it revises the relevant regulations.

USEPA regulations confirm that, to "serve the purposes of the Act," water quality standards must address the basic goals set forth in Section 101(a), including "protection and propagation of fish, shellfish and wildlife" (40 CFR. Sections 130.3, 131.2). As shown above, Section 304(a) and its legislative history clarify that Congress intended the definition of a healthy aquatic ecosystem to reflect a balanced, indigenous population of fish, shellfish, and wildlife, based on historical data, reference streams, or modeling based on available data. This matches almost precisely the methods approved by USEPA's biocriteria guidance document (USEPA 1990a).

This interpretation is supported further by USEPA's definition of "use attainability analysis" as a "structured scientific assessment of the factors affecting the attainment of the use which may include physical, chemical, biological, and economic factors..." (40 CFR. Section 131.3(g)). A use attainability analysis is required before water uses can be downgraded below those needed for protection and propagation of fish, shellfish, and wildlife (as well as human contact recreation). Clearly, this requires far more than analysis of chemical water quality.

Moreover, USEPA's water quality standards regulations highlight the desired end goal, protection of designated uses, as the primary concern, as opposed to chemical water quality goals alone. Water quality standards must include uses consistent with Sections 101(a) and 303(c)(2) (40 C F R. Section 131.6(a)), and water quality criteria must be sufficient to protect those uses (40 CFR. Section 131.6(c), 131.11).

USEPA's recognition of use protection as distinct from pure water quality goals is perhaps clearest in the antidegradation rule, which provides that "[e]xisting instream water uses *and* the level of water quality necessary to protect the existing uses shall be maintained and protected" (40 CFR. Section 131.12(a)(1); emphasis added). At least in the context of antidegradation, USEPA recognized that human and ecological use protection involves more than maintenance of chemical water quality, or the dual focus of this rule would be redundant. Of course, application of biocriteria in the antidegradation program will raise interesting questions. For example, what are the antidegradation ramifications where water quality exceeds levels necessary to protect existing uses, but uses do not exist, or vice versa? When permission for additional degradation is requested under the "social and economic" need test for high-quality waters, what degree of biological use impairment will be allowed? One possible strategy is to allow some chemical degradation, where fully justified on social and economic grounds, but only if no biological impairment is shown through the use of biocriteria, which are more sensitive to subtle impairment than traditional indicators of use attainment. These questions are complex, although not unique to biocriteria, and will require additional policy development efforts by USEPA and states.

Finally, USEPA's regulations allow states to adopt water quality criteria for toxic pollutants based on "biomonitoring methods where numerical criteria cannot be established or to supplement numerical criteria" (40 CFR. Section 131.11(b)(2)). As with Section 303(c)(2)(B), which undoubtedly drew its reference to "biomonitoring" from this existing regulation, USEPA was referring largely or exclusively to whole effluent toxicity monitoring. Nonetheless, USEPA recognized even in 1983, when this rule was issued, that water quality standards needed to extend beyond simple numerical chemical criteria to address the full range of impacts to aquatic species and ecosystems.

In other respects, however, USEPA's regulations retain the narrow notion that it is water quality, as opposed to broader notions of ecosystem health, that are primarily at issue. For example, the rules define

water quality criteria as "elements of State water quality standards, expressed as constituent concentrations, levels, or narrative statements, representing a *quality of water* that supports a particular use" (40 CFR. Section 131.3(b); emphasis added). This definition should be expanded to cover biological and physical, as well as chemical integrity of waterbodies.

3.3 Judicial Interpretations

Because biocriteria have been developed only relatively recently, and have been used *primarily* for monitoring and assessment rather than as a permitting tool, there is little judicial precedent on the subject — and to date no federal cases have addressed the validity of biocriteria directly. Other cases on water quality standards in general, however, especially cases dealing with whole effluent toxicity, suggest that the development and implementation of biocriteria will be upheld by federal courts as a legitimate exercise of USEPA's authority to achieve the overall purposes of the CWA.

Courts have recognized for many years that water quality standards are not limited to numeric water quality parameters (*EDF v. Costle* 1981) ("Water quality criteria may be, and often are, totally narrative.") Purely narrative criteria, of course, have serious limitations when the time comes to translate them into regulatory action:

> ...the criteria listed by the states, particularly for toxic pollutants, were often vague narrative or descriptive criteria as opposed to specific numerical criteria. These descriptive criteria were difficult to translate into enforceable limits on discharges from individual polluters. (*NRDC v. USEPA* 1990)

Moreover, until the Supreme Court described water quality standards as affirmative statements of the "desired condition of the waterway" (*Arkansas v. Oklahoma* 1992), courts generally have viewed water quality criteria as statements — whether narrative or numeric — of acceptable levels of pollution. This does not mean, however, that the more recent addition of biological criteria that describe desired affirmative values rather than acceptable negative conditions will be rejected by the courts. Indeed, judicial acceptance of biocriteria is suggested by analogy to cases that have addressed the use of another type of innovative water quality criteria designed to supplement chemical-specific numeric water quality criteria — whole effluent toxicity (WET) criteria.

WET criteria are designed to address the cumulative and synergistic effects of pollutants in a wastestream. This is done by measuring the impact of the entire wastestream — as opposed to a single pollutant — on test organisms such as minnows or daphnia. The more toxic the whole effluent, for example, the more test organisms exposed over a fixed period of time will die (USEPA 1991f). To date, courts have upheld USEPA's innovations in regulating toxicity as opposed to individual chemicals. USEPA's regulatory approval of WET limits was challenged first by various industry groups as part of the multi-party litigation over USEPA's programmatic NPDES regulations (*NRDC v. USEPA* 1988). Industry argued that "toxicity" was not a "pollutant" as defined by the law; therefore, USEPA had no authority to regulate toxicity in NPDES permits. The U.S. Court of Appeals for the District of Columbia, however, summarily rejected this argument:

> While "toxicity" appears to be an attribute of pollutants rather than a pollutant itself, we see no reason why this should preclude the agency from using it as a measure to regulate effluents that are pollutants.

The Court reasoned further that because the statutory definition of "pollutant" includes all "industrial, municipal and agricultural waste" (CWA Section 502(6)), any discharge to which a toxicity limit could be applied "would seem to fall within this broad definition."

More recently, in response to the "toxic hotspots" provisions in Section 304(l) of the 1987 Water Quality Act, the paper industry challenged USEPA's regulation allowing states to translate narrative "no toxics in toxic amounts" criteria into numeric NPDES permit limits through one of three methods. Once again, the U.S. Court of Appeals for the District of Columbia read USEPA's authority expansively, in order to serve the ultimate purposes of the law. Because the court recognized that water quality standards can have no effect on pollution — at least from point sources — unless translated into effluent limits in NPDES permits, it found USEPA's regulation to be a "preeminent example of gap-filling in the interest of a continuous and cohesive regulatory regime" (*API v. USEPA* 1993). This decision appears to resolve any residual doubts about the legality of using WET to interpret and apply narrative water quality standards (i.e., "no toxics in toxic amounts") to complement or address the absence of chemical-specific criteria.

Traditionally, federal courts defer to reasonable administrative agency interpretations of federal statutes, so long as those readings are not foreclosed by the language or legislative history of the statute (*Chevron v. NRDC* 1984). This is true in particular when agencies exercise their technical expertise. There is no reason why these same principles would not apply here. As discussed above, protection of biological as well as chemical and physical integrity is one of the principal goals of the statute; and there is considerable support in the language of the CWA and its legislative history to support the use of biocriteria. In fact, the absence of water quality criteria that address biological integrity leaves a major void in USEPA and state water quality programs. It is likely, then, that federal courts will uphold the development and implementation of biocriteria as another legitimate example of "gap-filling in the interest of a continuous and cohesive regulatory regime."

State courts have not had the opportunity to review the adoption or implementation of biocriteria. In Ohio, which has perhaps the most extensive experience with biocriteria to date (see Yoder and Rankin, Chapter 9), courts have not yet ruled on the validity of biocriteria *per se* or as applied. In one case, a use designation on the Cuyahoga River was challenged, where that designation was based in part on the use of not-yet-promulgated biocriteria (*NEORSD v. Shank* 1991). However, the plaintiffs in this case did not challenge, and the courts did not address, the use of biocriteria in the decision. Ohio's actual adoption of biocriteria has been challenged before the state's Environmental Review Board, but that case has not yet been heard (Yoder and Rankin, Chapter 9).

4.0 USEPA AUTHORITY TO REQUIRE STATE BIOCRITERIA

The previous section discussed the legal authority to support USEPA issuance of biocriteria under Section 304(a), at least in the form of guidance, and state adoption of legally enforceable biocriteria. A separate question, however, is whether USEPA has the authority — or even the duty — to *require* states to adopt biocriteria in some form, or to issue federal biocriteria applicable in a state that fails to do so. Obviously, biocriteria must be adopted as state or federal water quality standards before being used to support regulatory action, as opposed to monitoring and assessment. This legal question is somewhat premature, since thus far USEPA has addressed biocriteria only in the form of guidance. Thus, there is no case law directly on point, and no regulations that apply in more than a general way, and the issue can be addressed only briefly.

As discussed in Section 2.0, under Section 303 of the act, states have the initial role in adopting water quality standards. USEPA issues criteria *guidance* under Section 304(a), but issues enforceable water quality standards only when it finds that the standards in a given state are deficient, and the state fails to correct them. The question, then, is whether USEPA can find state water quality standards deficient for failure to address biological integrity adequately, and issue federal biocriteria if the state fails to do so.

Advocates of states' rights will argue that Congress intended USEPA's role in approving state water quality standards to be narrow. Section 101(b) of the act states:

> the policy of Congress to recognize, preserve, and protect the primary responsibilities and rights of states to prevent, reduce, and eliminate pollution, to plan the development and use (including restoration, preservation, and enhancement) of land and water resources...

Nothing in this statement of policy, however, defines the breadth of USEPA's authority or responsibility in approving state water quality standards. Rather, the controlling statutory language appears in Section 303(c)(3) and (4). Under Section 303(c)(3), state water quality standards may take effect only after USEPA "determines that such standard meets the requirement of th[e] Act." If USEPA finds otherwise, it must inform the state, which has 90 days to correct the deficiency; thereafter, USEPA must issue federal standards under Section 303(c)(4) to do so.

To some extent, this analysis begs the question. Clearly, Section 303(c)(3) gives USEPA the authority to disapprove a specific water quality standard adopted by the state and submitted to USEPA for approval, if that standard inadequately protects state waters. For example, if the state adopts a standard for dissolved

oxygen that will cause harm to resident fish or other species, USEPA may disapprove the standard (*Mississippi Commission on Natural Resources v. Costle* 1980). Courts have given USEPA considerable latitude in making such scientific judgments. Thus, courts have rejected both challenges brought by states arguing that USEPA was too strict (ibid.), and those by environmental groups that USEPA was too lenient (*EDF v. Costle* 1981).

But what if the state simply fails to adopt a standard to address a particular pollutant, or more to the point, to address biological in addition to chemical integrity of its waters? From a policy perspective, it is illogical to assume that states may underprotect their waters by omission but not by commission. Viewed solely from the perspective of chemical pollutants, this would mean that USEPA could disapprove a standard for dissolved oxygen that was too weak, but not the absence of a standard altogether. This view is supported by the language of Section 304(c)(4), which requires USEPA to issue federal water quality standards not only when a revised or new state standard is deemed inadequate (Section 303(c)(4)(A)), but also "in any case where [USEPA] determines that a revised or new standard is necessary to meet the requirements of this Act" (section 303(c)(4)(B)). Thus, Section 303(c)(2)(B), added in 1987 (see Section 3.1 supra), clarified that states may not simply omit criteria for toxic pollutants "the discharge or presence of which in the affected waters could reasonably be expected to interfere with...designated uses..."

There is no logical reason to reach a different conclusion with respect to the adequacy of state water quality standards to protect the biological as well as the chemical integrity of state waters. USEPA's duty is to ensure that state standards meet the requirements of the act. The most fundamental requirement of the act is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. State water quality standards that fail to address biological integrity, therefore, do not meet all of the requirements of the act, and USEPA has both the authority and the duty to fill this gap if the state, on notice, fails to do so.

The fact that USEPA may (or must) insist that states adequately address biological as well as chemical integrity, however, does not necessarily mean that USEPA may dictate the precise manner in which biological integrity is protected. Under the principles discussed above, USEPA may disapprove a state standard only if it does not meet the requirements of the act — not if it fails to do so in the same way as USEPA would choose. For example, with respect to water quality standards for toxic pollutants, USEPA will approve standards based on USEPA criteria, USEPA criteria modified to reflect site-specific circumstances, or criteria based on other "scientifically defensible" methods (40 CFR. Section 131.11). Of the many variations on biocriteria discussed elsewhere in this book, then, states may choose the method(s) best suited to its conditions, or develop its own variations, so long as they are scientifically sound, and so long as USEPA finds them to be adequately protective.

It is likely that some states will continue to resist the adoption and application of biocriteria as defined in this book, just as many states have resisted the adoption and use of WET criteria, and the adoption and application of many chemical-specific standards. Nothing in the CWA mandates state adoption of biocriteria per se. Thus, in principle, states can attempt to prove to USEPA that their other water quality standards, taken as a whole, are sufficient to protect the biological integrity of their waters. This is primarily a scientific rather than a legal judgment. But as evidence continues to mount that biological impairment is detected through biocriteria even when chemical-specific criteria are met, and as the relative focus of water quality programs shifts from chemical releases from point sources to physical and biological impairments caused by polluted runoff, physical habitat alterations, and other nonpoint sources, states will be increasingly hard-pressed to make this case.

5.0 IMPLEMENTATION OF BIOCRITERIA

Having established the legal basis for issuing biocriteria, the next, arguably harder inquiry is for what they may legally be used. Legal challenges are more likely as biocriteria are relied on for harder regulatory purposes, such as the imposition of stricter permit conditions on point sources or more rigorous management practices on nonpoint sources.

In its biocriteria guidance, USEPA lists a range of potential applications of biocriteria, for purposes of the CWA and other federal statutes (USEPA 1990a). These range from monitoring and assessment, to program planning and management, to the imposition of regulatory controls. Curiously (perhaps out of excess caution), USEPA omits reference to NPDES permits under Section 402, the principal legal tool for preventing violation of *any* water quality standards due to point source discharges. Nor does USEPA cite enforcement applications, which have been initiated more recently by USEPA. The legal basis for each of these applications of biocriteria will be addressed in turn.

5.1 Monitoring and Assessment

The various monitoring and assessment provisions of the CWA provide firm support for the use of biocriteria to assess the biological health of waterbodies. In addition to the triad of chemical, physical, and biological integrity established in Section 101(a), discussed earlier, specific monitoring provisions require biological as well as chemical and physical monitoring. Section 305(b) of the law requires each state to monitor and assess its waters every two years, and to report the results to USEPA. In addition to assessing chemical pollutants and their impacts, states must analyze "the extent to which all waters of such State provide for the protection and propagation of a balanced population of shellfish, fish, and wildlife." (CWA Section 305(b)(1)(B)). Similar or identical language appears in a long list of other monitoring provisions in the act, including Sections 303(d) (priority lists of impaired waters), 304(l) (toxic hotspots), 319(a) (nonpoint source assessments), and 320(b) (National Estuary Program assessments). Moreover, USEPA notes that biocriteria can be used to conduct risk assessments under other federal statutes, including the Toxic Substances Control Act; the Resource Conservation and Recovery Act; Superfund; the Federal Insecticide, Fungicide and Rodenticide Act; the National Environmental Policy Act; the Federal Lands Policy and Management Act; the Fish and Wildlife Conservation Act; the Marine Protection, Research and Sanctuaries Act; the Coastal Zone Management Act; and the Fish and Wildlife Coordination Act (USEPA 1990a).

USEPA regulations require state monitoring programs to include physical, chemical and biological data (40 CFR. Section 130.3(b)). Until the advent of biocriteria, however, this requirement had little real meaning. In its official guidelines for the 1994 cycle of state assessments under Section 305(b), USEPA "strongly recommends" that states begin to use biocriteria to supplement existing methods of determining use attainment or impairment, and believes that such use will improve the national consistency of 305(b) reports (USEPA 1993b). Appendix B of the Guidance provides detail on how to translate biocriteria assessments to the 305(b) existing categories of "fully supporting", "partially supporting", and "not supporting" the designated use. To change this recommendation to a requirement, USEPA would either have to amend its existing regulations, or interpret them to require the use of biocriteria to identify impairment.

Identification of a waterbody as "not supporting" or "partially supporting" a designated use has specific legal as well as scientific significance, for example, under CWA Sections 303(c) and (d), 304(l), 319, and 402. As discussed further below, such classification may result in the imposition of additional controls on individual sources of pollution. Thus, the use of biocriteria to supplement existing narrative and chemical-specific criteria will raise two related legal questions.

First, the potential subjects of additional controls may question the validity of classifying a waterbody as impaired under the CWA when all applicable chemical water quality criteria are met. In Ohio's 1988 assessment of 431 sites, for example, impairment was detected using biological but not chemical criteria at 36% of the sites assessed (USEPA 1990a). However, the law clearly is aimed at biological as well as chemical integrity. Moreover, it is hard to quarrel with data showing actual impairment of the biological community as measured by such factors as species abundance, diversity, or community structure. So long as the science is sound and well supported, the findings likely will be upheld in the courts. A more likely (and potentially more fruitful) line of attack, discussed in more detail in the following sections, is what types of controls can be imposed, and on whom, when chemical but not biological criteria are met.

Second, and conversely, parties may challenge a finding of impairment based on the exceedence of chemical criteria when no biological impairment is detected through the use of biocriteria. Obviously, this will be at issue only with respect to chemical criteria adopted to protect the biological use, and not when the criteria protect against human health or other adverse effects. Either the legal ramifications of the finding will be assailed (such as stricter water quality-based effluent limits), or the validity of the chemical criteria will be questioned. Because the chemical-specific criteria were adopted to protect the use, parties will argue that if the criteria are violated but the use is not impaired, the criteria must be unduly conservative (Pifher 1991). Absent adequate explanation of the apparent anomaly, this simple logic may be appealing to some judges.

From an empirical perspective, to date this has not caused a major problem. In the same Ohio results cited above, chemical and biosurvey results agreed 58% of the time, and impairment was indicated by chemical but not biological criteria at only 6% of the sites (USEPA 1990a). Moreover, USEPA has taken the firm position that violation of any one of the three types of water quality criteria — chemical-specific, toxicity, or biological — should be interpreted as suggesting impairment, because each type of standard has strengths and limitations:

> Since each type of criteria...has different sensitivities and purposes, a criterion may fail to detect real impairments when used alone. As a result, these methods should be used together...If any one type of criteria indicates impairment of the surface water, regulatory action can be taken to improve water quality. However, no one type of criteria can be used to confirm attainment of a use if another form of criteria indicates nonattainment. (USEPA 1990a)

A more specific list of the capabilities and limitations of each type of water quality standard appears in USEPA's *Technical Support Document for Water Quality-Based Toxicity Control* (USEPA 1991f). As one example, USEPA notes that "chemical criteria may provide earlier indications of impairment from a bioaccumulative chemical because aquatic communities require exposure over time to incur the full effect" (USEPA 1990a). Since the goal of the law is to *maintain* as well as to restore waterbody integrity (CWA Section 101(a)), that is, to *prevent* adverse effects before they occur, it would be foolhardy (and illegal) to ignore chemical warning signals simply because biological ramifications have not yet appeared. Nonetheless, to guard against potential legal attacks on water quality criteria based on chemistry or toxicity, agencies should be prepared to explain fully the limitations as well as the capabilities of biocriteria. USEPA has evaluated the capabilities and limitations of all three major forms of water quality criteria — chemical-specific, WET, and biocriteria (USEPA 1991f).

5.2 Program Planning and Management

USEPA also suggests that biocriteria be used to guide water quality planning and management (USEPA 1990a). To the extent that biocriteria are used simply to set agency priorities and to develop plans, they are not likely to be challenged. Many of these planning activities, however, have real-world implications for point sources, nonpoint sources and other sources of waterbody impairment.

The 1972 act specifically required states not only to identify impaired waters, but to rank them in order of priority for cleanup and restoration. For example, under Section 303(d) states were to identify any waters for which technology-based effluent limitations on point sources were not strict enough to implement "any water quality standard," and to "establish a priority ranking for such waters, taking into account the severity of the pollution and the uses to be made of such waters" (CWA Section 303(d)(1)(A)). These lists were to drive the state's continuing planning process under Section 303(e). The phrase "any water quality standard" obviously is broad enough to encompass biocriteria, but more important, the relative degree of biological use impairment can be ranked more precisely through numerical biocriteria than through chemical criteria alone. Thus, biocriteria are useful to identify which waters require the most immediate and the most forceful remedial action, and which waters retain biological attributes worthy of protection through antidegradation programs. However, states are not likely to use biocriteria in preparing their lists of priority waters until biocriteria are adopted as part of their water quality standards.

Because the 1972 law set a 1977 deadline for compliance with all water quality standards (CWA Section 301(b)(1)(C)), the notion of "priority lists" under Section 303(d), as opposed to a plan to address all polluted waters, was of questionable validity after 1977. Nevertheless, recognizing the sketchy implementation of these requirements over the law's first 15 years, in 1987 Congress established even more focused assessment requirements, with specific deadlines for implementation.

In section 304(l), for example, states were required to identify all waters not expected to meet minimum statutory uses due to any cause (CWA Section 304(l)(1)(A)(ii)); waters not expected to meet water quality standards for toxic pollutants due to any cause (CWA Section 304(l)(1)(A)(ii)); and waters not expected to meet water quality standards "due entirely or substantially to discharges from point sources of [toxic] pollutants" (CWA Section 303(l)(1)(B)). Waters on at least some of these lists were to be subject to "individual control strategies." USEPA's first limited interpretation of this requirement was rejected by the U.S. Court of Appeals for the Ninth Circuit (*NRDC v. USEPA* 1990). The full scope of the provision has not been finally revisited by USEPA on remand, although USEPA's draft regulation would decline to expand the program (USEPA, 57 Fed. Reg. 33051 et seq. 1992). Because over 17,000 waterbodies were identified in the states' first effort under Section 304(l), with most impairment due largely to nonpoint sources, biocriteria could be used to focus efforts and establish cleanup priorities under this program.

Similarly, impatient with the virtual absence of serious efforts to abate nonpoint source pollution under the planning and management provisions of Section 208, Congress added a new nonpoint source program in 1987 (CWA Section 319). The first step in this program was the identification of waters that would not meet water quality standards without additional nonpoint source controls (CWA Section 319(a)). Biocriteria are particularly useful in identifying impairment from polluted runoff and other nonpoint sources, because many of the impacts from those sources, such as smothering of gravel spawning habitat or alteration of flow velocities and bank morphology due to alteration of hydrology, are not detected through chemical or toxicity tests (USEPA 1990a, 1991f). Moreover, while the existing Section 319 is extremely vague on the question of which waters must be addressed in which sequence, proposals to modify Section 319 would require states to target the most threatened or impaired waters first (Adler et al. 1993). Biocriteria would be useful in identifying and establishing priorities under such a scheme.

Increasingly, a consensus is developing that waterbodies should be restored and protected on a watershed basis. While definitions of this concept vary considerably, the underlying principles are that all sources of impairment of a water should be identified rather than focusing exclusively on individual point sources; and that restoration efforts should focus on physical habitat and biological integrity as well as preventing chemical pollution (Water Quality 2000 1992). Biocriteria can be extremely useful in focusing watershed protection and restoration efforts, because biological assessments can help to pinpoint the location and nature of impairment. Additional efforts are then needed, of course, to isolate causes and identify solutions. USEPA recognizes this utility in the context of the National Estuary Program (CWA Section 320) (USEPA 1990a).

Antidegradation programs, which have been seriously underutilized to date (NWF 1992), also could profit from the use of biocriteria. Waterbodies, or portions thereof, with healthy identified biological communities can be targeted for special protection for purposes of either Tier II or Tier III antidegradation (40 CFR. Section 131.12). Biological assessments are also useful in determining whether antidegradation programs are successful in fully preserving existing uses.

5.3 Permits and Other Regulatory Requirements

The most controversial use of biocriteria, of course, will be to strengthen or to impose new regulatory requirements on individual dischargers. It is here where USEPA or a state agency must be most careful about documenting cause and effect, and to demonstrate why the chosen regulatory action is likely to reduce or eliminate the harm. USEPA's biocriteria guidance document identifies only two programs for which biocriteria may be used for strict regulatory purposes (although by its terms the list is not intended to be exclusive) (USEPA 1990a). Under Section 403(c), USEPA is prohibited from issuing a permit for discharges to ocean and certain near-coastal waters if such discharges will result in degradation of those waters pursuant to guidelines issued by USEPA, which must consider a range of impacts on biota. In this circumstance, of course, biocriteria would have to be used as a predictive tool, for which there is no precedent (USEPA 1991f; however, see Section 2.2.8 in Yoder and Rankin, Chapter 21). Similarly, to determine acceptable sites for the disposal of dredge and fill material under Section 404, biocriteria would have to be used predictively. Since biocriteria are designed to measure status rather than to predict impacts, more likely they will be used in these programs to assess — and perhaps to modify — regulatory decisions made on other grounds.

More controversy, however, is likely to surround the use of biocriteria in NPDES permits, an issue apparently not addressed by USEPA in its existing guidance documents. From a purely legal perspective, in principle there should be no reason why biocriteria — like whole effluent toxicity requirements — cannot be used to support additional requirements in NPDES permits, at least to the extent that detectable harm is caused by the discharge of pollutants from a point source. In practice, however, the use of biocriteria and biological assessments to establish new permit requirements raises interesting and challenging questions.

The language of the statute, USEPA regulations, and relevant case law all suggest that biological water quality criteria can be, or must be, enforced through appropriate NPDES conditions or limitations.

A fundamental requirement of the CWA is that NPDES permits must be designed to ensure compliance with *all* water quality standards. Section 301(b)(1)(C) required effluent limits adequate to meet applicable water quality standards by July 1, 1977. Under Section 302(a), USEPA can require the use of stricter permit requirements where needed to ensure the "protection and propagation of a balanced population of fish, shellfish and wildlife," although permittees can seek to override this requirement based on excessive "social and economic costs." "Effluent limitations" are defined by the statute (CWA Section 502(11)) as "any restriction established by a State or [USEPA] on quantities, rates, and concentrations of chemical, physical, biological, and other constituents..." And if all else fails, Section 402(a)(2) allows the USEPA Administrator to impose in NPDES permits "such other conditions as he deems appropriate." Such "other conditions" are likely to be upheld if they promote the basic goal of the law to protect or restore the biological integrity of a waterbody. Interpreting these provisions, USEPA regulations confirm that NPDES permits *must* ensure compliance with all applicable water quality standards (40 C F R. Sections 122.4, 122.43, and 122.44). Thus, so long as biocriteria are valid elements of water quality standards, as shown in the previous section, they must be enforced in NPDES permits.

The U.S. Supreme Court and lower courts have indicated repeatedly that water quality standards must be enforced through NPDES permits, and in fact, that NPDES permits are the primary means of translating water quality standards into enforceable requirements. "An NPDES permit serves to transform generally applicable effluent limitations and other standards — including those based on water quality — into the obligations of the individual discharger..." (*California v. USEPA* 1981; see also *Trustees for Alaska v. USEPA 1984*; *Arkansas v. Oklahoma* 1992; *NRDC v. USEPA* 1990; *Westvaco Corp. v. USEPA* 1990; *API v. USEPA* 1993).

These principles were used by the U.S. Court of Appeals for the District of Columbia to approve in two separate cases, at least in concept, the application of whole effluent toxicity in NPDES permits (*NRDC v. USEPA* 1988; *API v. USEPA* 1993). Notably, in the first case (the multiparty challenge to USEPA's general NPDES program rules in which industry groups challenged USEPA's toxicity rule), the court refused to address the technical feasibility of applying WET limits in a permit, expressly so that individual permit writers can develop an appropriate record (scientific basis) to support a particular application. The same should be true with respect to biocriteria. In concept, there is no legal reason why NPDES permits cannot be used to implement biocriteria. Judicial review of the technical feasibility and appropriate implementation of that principle, however, should await a specific permit, to enable USEPA or a state agency to develop the appropriate technical record.

Nevertheless, courts have noted that the implementation of water quality criteria that are *not* based on chemical-specific numeric criteria can be difficult as a matter of practice. The Ninth Circuit Court of Appeals, for example, explained that narrative criteria "were difficult to translate into enforceable limits on discharges from individual polluters" (*NRDC v. USEPA* 1990). The harder it is to show a cause-and-effect relationship between a particular discharge and the condition of a waterbody, the more the agency must rely on expert testimony and judgment rather than simple mathematic calculations, as is true for numeric water quality criteria.

The logical question, then, is how a violation of biocriteria (or an indication of impairment based on a biological survey) can be translated into an enforceable requirement of an NPDES permit. Clearly, there is no way to translate biocriteria *directly* into water quality-based effluent limits. A number of results are plausible, however. If the impairment is caused by a pollutant that was not previously detected, for example, the biological assessment may precipitate additional effluent monitoring and appropriate chemical effluent limits, or appropriate new WET limits. The impairment may also result from the timing, as opposed to the raw concentration, of pollutant releases (Courtemanch, Chapter 20). Of course, as the number of sources of impairment of a waterbody increase (point and nonpoint), the more difficult it will be to establish the cause-and-effect relationship needed to use biocriteria to impose specific permit requirements. The full range of potential applications must await actual implementation of biocriteria in NPDES permits.

This does not mean, however, that the use of biocriteria in NPDES permits is unlimited. For example, an NPDES permit will not be required unless there is a release of one or more pollutants from a point source (*NWF v. Gorsuch* 1982). In fact, in finding that dams were not required to have NPDES permits, one court ruled that the fact that dams may cause "pollution" does not necessitate an NPDES permit where there is no addition of "pollutants." States may still implement their water quality standards, of course, for nonpoint sources, including dams, either through their own programs under Section 319, or through water quality certifications issued for federal licenses and permits under section 401. Even under Section

401, however, some courts have rejected conditions based on biological as opposed to purely chemical impairment (Adler et al. 1993). However, in 1994 the U.S. Supreme Court verified that states may use Section 401 to protect designated uses through maintenance of biological habitat, including minimum instream flows (PUD, No. 1 of Jefferson County V. Washington Dept. Ecology, 1994.)

Finally, biocriteria may be useful as well under CWA Section 319, to determine the appropriate best management practices to control nonpoint sources of pollution, and to assess their relative success. Since, as discussed above, traditional chemical water quality criteria do not adequately identify impairment from nonpoint sources, biocriteria will be useful to pinpoint the areas of greatest impairment, potential causes, and appropriate remedial actions.

5.4 Enforcement

Biological assessments based on biocriteria are beginning to be used to support CWA enforcement actions (Yoder and Rankin, Chapters 9 and 17). This application can be useful in a number of ways. First, biological assessments can be used to identify potential violators. If a multisite assessment indicates that impairment occurs below but not above a particular facility, that might be an indication — although probably not sufficient proof without additional evidence — of undetected permit violations (or, as discussed above, that the permit should be strengthened).

Second, biological assessments can be used to prove the harm caused by an identified violation. For example, in determining appropriate administrative or civil penalties, USEPA and federal courts respectively must consider, among other factors, the severity of the violation (CWA Sections 309(d) and 309(g)(3)). Courts have reduced the amount of violations where the plaintiff was not able to show serious harm to the environment (Atlantic States Legal Foundation 1992). Biocriteria could be used not only to demonstrate the degree of impairment downstream of a violator, but also to help prove the likely source of the harm through comparative analysis. Again, more direct independent evidence of cause and effect likely will be needed once harm is detected.

Biocriteria are also potentially useful to determine natural resource damages under CWA Section 311 (or analogous provisions of other statutes, such as Superfund) (*Ohio v. Department of Interior* 1990), or for purposes of criminal penalties which may include fines to account for environmental harm (U.S. Sentencing Commission 1990). Under Section 311, for example, the federal or state governments may collect costs incurred "in the restoration or replacement of natural resources destroyed or damaged as a result of a discharge of oil or a hazardous substance..." Since the cause and extent of damage may be difficult to prove, biological assessments based on biocriteria may be useful additional ammunition. This is particularly true if baseline data are available for the waterbody in question.

Finally, biocriteria could be useful in fashioning and justifying injunctive relief. Since one of the standards for a preliminary or permanent injunction is the balance of harm to the plaintiff and defendant, as well as the public interest, the ability to prove harm may be important either to a prohibitive injunction (to stop polluting), or a mandatory injunction (to remediate past or existing harm).

6.0 CONCLUSION

However well founded the legal basis for biocriteria and their implementation, it is almost certain that they will be challenged in various ways. Already, several avenues of legal attack have been suggested. One legal critic, for example, questioned whether biocriteria are reliable, scientifically repeatable, provide dischargers with adequate notice of acceptable conduct, and can reliably determine cause-and-effect relationships (Pifher 1991).

Therefore, program managers would be wise to anticipate and to insulate their biocriteria programs, from development to implementation, from such legal challenges. Ample authority exists under the CWA to support the development and use of biocriteria for various purposes. Moreover, because existing water quality criteria have not provided adequate protection for biological resources, USEPA and state agencies have a strong policy argument that biocriteria are not only appropriate, but essential, to fulfill the underlying goals of the CWA. The degree to which biocriteria will be upheld turns as well, however, on the sound scientific basis for specific criteria and the application of those criteria. As with most aspects of CWA implementation, good science will ensure good law.

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United States
Environmental Protection
Agency

Summary of Biological Assessment Programs and Biocriteria Development for States, Tribes, Territories, and Interstate Commissions: Streams and Wadeable Rivers

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Office of Environmental Information & Office of Water
U.S. Environmental Protection Agency
Washington, DC 20460

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Cover photo by Wayne Davis, USEPA. This document can be downloaded from EPA's website for Biological Indicators of Watershed Health:

http://www.epa.gov/bioindicators/

Foreword

We are pleased to release the 2002 ***Summary of Biological Assessment Programs and Biocriteria Development for States, Tribes, Territories, and Interstate Commissions: Streams and Wadeable Rivers.*** This summary, a joint project by the Office of Water and the Office of Environmental Information, provides an abundance of technical and programmatic information which illustrates the progress States, Tribes, Territories and Interstate Commissions are making in the utilization of biological assessments and criteria in their water programs.

Biological assessments and criteria are crucial tools for measuring the health of water bodies and for protecting aquatic life. Biological assessments evaluate the condition of a water body using surveys and other direct measurements of aquatic life—aquatic vegetation and algae, fish, insects, crayfish, salamanders, frogs, worms, snails, mussels, etc. Biological criteria are numeric or narrative targets that can be set to define the desired biological condition of a water body and can even be adopted into State and Tribal water quality standards. In combination with other available water quality tools, such as chemical pollutant criteria, the use of biological assessments and criteria give States, Tribes and Interstate Commissions better tools than ever before for restoring and maintaining the quality of our Nation's water bodies.

The progress made by the States, Tribes and Interstate Commissions as reported in this Summary is impressive. Since our previous assessments in 1995 and 1989, significant progress has been made by virtually every State and an increasing number of Tribes and Interstate Commissions. Biological assessments and criteria are in the mainstream of water management programs throughout the Country. More States than ever before are using biological criteria in their water quality programs as definitive standards.

We encourage you to take time to review this Summary to appreciate the progress that is being made. The information in the report is valuable to assess the progress of one program relative to other programs across the country. In addition, it may be possible to learn of new and different ways to employ biological assessments and criteria by better understanding what others have done. This Summary is another example of the value of public access to information and data. EPA firmly believes that analysis of and access to such information is the key to better environmental decision making. And lastly, since every State, Tribe and Interstate Commission reported in the Summary helped assemble the information, we thank you for your help and participation.

Geoffrey Grubbs, Director
Office of Science and Technology

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Development and production of this document, *Summary of Biological Assessment Programs and Biocriteria Development for States, Tribes, Territories, and Interstate Commissions: Streams and Wadeable Rivers*, was coordinated by USEPA's Office of Environmental Information in partnership with the Agency's Biocriteria Team, comprised of members from the Office of Water (Office of Science & Technology, Office of Wetlands, Oceans, and Watersheds) and the Office of Environmental Information. The goal of the project was to obtain the current status of biological assessment programs and biocriteria development for streams and wadeable rivers.

The project team for this document was comprised of members from the USEPA offices listed above as well as members from the Midwest Biodiversity Institute (MBI); the Technology, Planning, and Management Corporation (TPMC); and Tetra Tech, Inc. (Tt). This work was completed under USEPA Contract No. 50-CMAA-900065 to Technology Planning and Management Corporation (TPMC).

The project team extends its most sincere appreciation to all of the State, Tribal, Territorial, and Interstate Basin Commission biological monitoring staffs for their willingness to complete surveys, participate in follow-up interviews, and review numerous interim drafts. Also, we would like to recognize the numerous personnel at EPA headquarters and Regional offices for their time in developing the initial survey and reviewing various drafts. We are particularly grateful to members of EPA's Biocriteria Team, as well as the EPA Regional Biocriteria Coordinators and Regional Indian Program Coordinators, who provided guidance on document structure and the process for gathering information. We also acknowledge the efforts of Brandon Peebles, an EPA intern with the Office of Water's Office of Science and Technology. In addition, the following Tetra Tech staff were essential in the progress and completion of this document: Catherine Cresswell, Brenda Decker, and Kristen Pavlik.

Most of all, we would like to recognize the spirit of collaboration evident throughout the development of this project.

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1. INTRODUCTION

1.1 Bioassessment and Biocriteria in Water Resource Assessment and Management

The Historical Context

During the last half of the 20th century, the terms "environmental protection" and "natural resource management" underwent a profound evolution both conceptually and as applied to decision-making. Two landmark pieces of legislation, the 1948 Federal Water Pollution Control Act (WPCA) and its 1972 amendments contained in the Clean Water Act (CWA), stand out as milestones in this process. Until 1948, water quality management decisions were based primarily on society's economic and public health priorities (Davis 1995). The passage of the 1948 WPCA marked the first time that the *propagation of fish and other aquatic life* was articulated as a stand-alone objective of water resource protection. It was a significant turning point because federal law recognized the importance of protecting waterbodies and aquatic life for their own intrinsic value, not just for their value to human society.

The 1972 Federal Water Pollution Control Act (the Clean Water Act) set far-reaching ideals for restoring the health of our Nation's waters, as outlined in Section 101(a) Declaration of Goals and Policy:

> The objective of this Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. In order to achieve this objective it is hereby declared that, consistent with the provisions of this Act –
>
> 1) it is the national goal that the discharge of pollutants into the navigable waters be eliminated by 1985;
> 2) it is the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish and wildlife and provides for the recreation in and on the water be achieved by July 1, 1983…

Why Bioassessment?

Aquatic life (fish, insects, plants, shellfish, frogs, salamanders, etc.) integrate the cumulative effects of both point source and nonpoint source (NPS) pollution's multiple stressors. Biological assessments, or bioassessments, consisting of surveys and other direct measures of aquatic life, are the most effective way to measure the aggregate impact of these stressors on waterbodies. Bioassessments are an extremely useful tool to evaluate the biological integrity of a waterbody, commonly defined as

> "the ability to support and maintain a balanced, integrated, and adaptive community with a biological diversity, composition, and functional organization comparable to those of natural aquatic ecosystems in the region" (Frey 1977, Karr and Dudley 1981, and Karr et al. 1986).

Because biological communities are affected by all of the environmental factors to which they are exposed over time, bioassessments provide information on perturbations not always revealed by water chemistry measurements or toxicity tests. Thus, they are crucial for determining not only biological health but the *overall* health, or ecological integrity, of a waterbody.

In the mid-1980s, a national workgroup of EPA regional and state agency biologists was convened to provide oversight in the development of technical guidance for biological assessment. The result of the workgroup was the 1989 publication of EPA's Rapid Bioassessment Protocols (RBPs) (USEPA 1989). The RBPs provide a technical framework for using biological assemblage data as a direct indicator of ecological health. The RBPs synthesized existing methods for monitoring fish and benthic macroinvertebrates in streams and wadeable rivers, and presented some innovative ways to assess the biological and physical aspects of streams. The RBP methods were designed to be cost effective, reliable, efficient, applicable nationwide, and easily understood by various stakeholders (USEPA 1999). In addition, the 1990 publication of *Biological Criteria: National Program Guidance for Surface Waters* provided states with an organized approach for addressing their responsibilities as outlined in the CWA (USEPA 1990). In 1992, EPA issued procedures for initiating narrative biological criteria that explained how states and tribes could adopt narrative biocriteria in their water quality standards (USEPA 1992).

Since the 1989 RBPs were published, the use of bioassessments in water resource programs has continued to grow. In 1996, EPA published a guidance document for the development of biocriteria for streams and small rivers (USEPA 1996a). In 1998, EPA produced bioassessment technical guidance for lakes and reservoirs (USEPA 1998a), followed by similar guidance for estuarine and coastal marine waters in 2000 (USEPA 2000) and a series of guidance modules for biological assessments and index development for wetlands in March 2002 (USEPA 2002). The increased use of bioassessment in water monitoring programs nationwide led to the 1999 revision of the original RBPs for streams and wadeable rivers (USEPA 1999). Guidance for large rivers and coral reefs is currently under development.

Over the last 50 years, the science of environmental protection has come a long way both in theory and in practice. As a society, the United States has come to understand that protecting aquatic life is a critical resource management goal in its own right. We have adopted ecological integrity as a barometer of waterbody health. Resource management agencies at the local, state, tribal, and national levels have recognized the importance of biological assessments in the evaluation of water quality and ecological integrity. This evolution has brought us closer to realizing the CWA's goal of restoring and maintaining the physical, chemical, and biological integrity of the Nation's waters.

Current Legal Authority

The CWA and its amendments through 1987 provide the legal authority for the use of biological assessments and criteria in state and tribal water quality programs primarily under the provisions of sections 303 and 304. Under Section 303(c), states are required to have water quality standards that consist of designated uses, criteria to protect those uses, and an antidegradation policy. Also under section 303(c), states are required to review their standards every three years and revise them as needed to achieve the purposes of the Act, including the ecological integrity objective.

Section 303(c)(2)(B), enacted in 1987, requires states to adopt numeric criteria for toxic pollutants for which EPA has published 304(a)(1) criteria if such pollutants interfere with, or may be expected to interfere with, attainment of designated uses. The section further requires that, where numeric 304(a) criteria are not available, states adopt criteria based on biological assessment and monitoring methods consistent with information published by EPA under 304(a)(8).

Section 304(a)(8) directs EPA to develop and publish information on methods for establishing and measuring water quality criteria for toxic pollutants on bases other than pollutant-by-pollutant. This includes biological monitoring and assessment methods that evaluate:

> the effects of pollutants on aquatic community components ("...plankton, fish, shellfish, wildlife, plant life...") and community attributes ("...biological community diversity, productivity, and stability...");
>
> factors necessary "...to restore and maintain the chemical, physical, and biological integrity of all navigable waters..." for "...the protection of fish, shellfish, and wildlife for classes and categories of receiving waters..."
>
> appropriate "...methods for establishing and measuring water quality criteria for toxic pollutants on other bases than pollutant-by-pollutant criteria, including biological monitoring and assessment methods."

The Uses of Bioassessment and Biocriteria in the Clean Water Act

Biocriteria, derived from bioassessment data, are narrative descriptions and numeric values that describe the desired condition for the aquatic life inhabiting waters with a designated aquatic life use. Biocriteria are an effective tool for addressing water quality problems by providing regulatory mechanisms to assess and help protect the biological resources at risk from chemical, physical, or biological impacts. These narrative and/or numeric biocriteria may be formally adopted into water quality standards along with an antidegradation policy intended to protect waters from further deterioration.

As required in the Clean Water Act, states, tribes, and territories report on the quality of their waters through a biennial report referred to as the "305(b) report". USEPA compiles and analyzes this information in the *National Water Quality Inventory Report to Congress*, the primary vehicle for reporting water quality conditions throughout the United States. To assess water quality, states and other jurisdictions compare their monitoring results to the water quality standards they have set for their waters.

Bioassessments help states, tribes, and other entities develop expectations for acceptable biological conditions through a technical process of establishing aquatic life goals, referred to as *aquatic life uses* (ALUs). Designated uses to support aquatic life can cover a broad range of biological conditions; not only do they protect intact communities in a waterbody, but they also can establish restoration goals for compromised ecosystems. Using several types, or tiers, of ALUs allows the allocation of limited resources to waterbodies in proportion to their need for protection.

Although the 305(b) report includes information on the nationwide status of aquatic life use attainment (i.e., state water quality standards), the results reported do not consistently present the information necessary to determine the ecological/biological condition of the Nation's water resources. As currently reported in 305(b) water quality assessments, aquatic life use attainment may be determined solely by chemical parameters and in comparison to chemical water quality criteria. However, since attainment of chemical water quality standards alone may not ensure a healthy biological condition, most states are working to integrate a greater amount of biological information in their aquatic life use attainment determinations (Yoder and Rankin 1995).

Under Section 303(d) of the CWA, a second reporting mechanism requires states, tribes, and territories to provide lists of all impaired waters. These lists are then used to prioritize restoration activities through the development of Total Maximum Daily Loads (TMDLs). TMDLs are calculations of the amount of a pollutant that a waterbody can receive and still meet water quality standards. Bioassessments and biocriteria play a critical role in enabling states, tribes, and territories to develop and implement protection and management strategies needed to fulfill these, and other, requirements of the Clean Water Act, including:

- determining impacts from nonpoint sources [i.e., Section 304(f) "(1) guidelines for identifying and evaluating the nature and extent of nonpoint sources of pollutants, and (2) processes, procedures, and methods to control pollution..."];
- developing lists of waters unable to support "balanced population(s) of shellfish, fish and wildlife..." [(304(l)];
- conducting assessments of lake trophic status and trends, [Sec. 314];
- listings of waters that cannot attain designated uses without nonpoint source controls, [Sec. 319];
- developing management plans and conducting monitoring in estuaries of national significance [Sec. 320];
- determining the impacts and efficacy of NPDES permit controls [Section 402];
- issuing permits for ocean discharges and monitoring ecological effects [Sec. 403(c) and 301(h)(3)]; and,
- determining acceptable sites for disposal of dredge and fill material [Sec. 404].

The 2001 Bioassessment Summary

During 1994-1995, EPA prepared an inventory of state bioassessment programs for streams and wadeable rivers, *Summary of State Biological Assessment Programs for Streams and Rivers* (USEPA

1996b). The purpose of the document was to determine how many states, and in what fashion, were using biological assessments and criteria in water management programs. EPA used the information from that report to evaluate state bioassessment/biocriteria capabilities and their needs for technical support.

During the second half of the 1990s as additional methods, guidance, and information on the use of biological assessments and criteria were issued by EPA, the Office of Water made it a national priority for state and tribal water quality standards programs to adopt biocriteria to better protect aquatic life in all waters where biological assessments methods were available (USEPA 1998b). In 1999, EPA's Office of Water declared the following goals and objectives for the biocriteria program:

- All states/tribes will use bioassessments/biocriteria to evaluate the health of aquatic life in all waterbodies.
- Bioassessment data will be used by all states/tribes to better define aquatic life uses.
- Numeric biocriteria will be adopted in all state/tribal water quality standards to protect aquatic life uses.
- Biocriteria/bioassessments will be used in ongoing regulatory programs.
- Biocriteria/bioassessments will be used to assess the effectiveness of water quality management efforts.
- Bioassessment data and biocriteria will be used to better communicate the health of the Nation's waters.

In the late 1990s, momentum to develop and adopt biocriteria grew, and pressures increased from the Total Maximum Daily Load (TMDL) Program to have well-established biocriteria in water quality standards to support listings of impaired waterbodies. The Office of Water and the Office of Environmental Information determined it would be valuable to re-assess the progress states were making in developing and adopting biological assessments and criteria into their water quality management programs. In 2001, Geoffrey Grubbs, Director of the Office of Water, Office of Science and Technology, stated that the key goal of the biocriteria program should be to accelerate the adoption of biocriteria in state and tribal water quality standards programs to better support regulatory programs. Therefore, in late 2001, the Office of Environmental Information and the Office of Water initiated this effort to update the 1994-95 survey information. This project was also supported by the Office of Wetlands, Oceans, and Watersheds and was coordinated through USEPA Regional Offices.

The goal of the 2001 update was to compile a comprehensive re-assessment of state use of bioassessments and biocriteria for protecting streams and wadeable rivers. The update also illustrates changes and improvements in bioassessment capabilities over the past six years, and serves as an important measure of program advancement and EPA's bioassessment technical transfer efforts. This documentation will enable USEPA to better focus its water quality standards and criteria development and implementation strategy for the next several years, target new program priorities, and assess the present technical support needs of states, tribes, territories, and interstate commissions. EPA will also use this documentation to prepare a summary report card of national progress in adopting biocriteria into water quality standards.

As you will see from this report, the use of biological assessment and criteria for managing the Nation's waterbodies has progressed significantly in the past six years and is equipping states, tribes, territories, interstate commissions, and EPA with a more effective set of monitoring and standards tools for determining and protecting the health of the Nation's waters.

1.2 Introduction to the Process

This project was coordinated by EPA's Office of Environmental Information in partnership with the Agency's Biocriteria Team, composed of members from the Office of Water (Office of Science & Technology, Office of Wetlands, Oceans, and Watersheds) and the Office of Environmental Information. The goal of the project was to obtain the current status of biological assessment programs and biocriteria development for streams and wadeable rivers. The project team also coordinated with EPA Regional Biocriteria Coordinators and Regional Indian Program Coordinators. Because identical information would be solicited from all 50 states, the District of Columbia, US territories, selected tribes, and selected interstate commissions, this project was covered under the Water Quality Standards Program Information Collection Request (ICR No. 0988.07) in compliance with the 1995 Paperwork Reduction Act.

In June 2001, the project team developed a "checklist" of 57 questions covering six different categories (Appendix C contains a blank copy of the checklist):

- contact information (including points of contact for biological programs for other waterbody types – nonwadeable rivers, lakes, reservoirs, estuaries/near coastal marine, and wetlands)
- programmatic elements
- ALU decision making process
- field and lab methods
- data analysis and interpretation
- information management

Throughout the autumn of 2001, email "packets" were distributed to over 75 points of contact in states, tribes, territories, and interstate commissions (provided by EPA Regional offices). These packets consisted of an introductory memo, the checklist, and relevant excerpts from each entity's water quality standards (where applicable). Recipients were asked to complete the checklist and review the standards excerpts for completeness and accuracy. As completed checklists were returned, members of the project team followed-up by phone and email with each entity to clarify, verify, and document information and to fill in gaps where necessary. Contacts from a total of 65 entities responded and provided the information included in this document.

As was done for the 1996 document, the project team created a template "program summary" used to translate and display the information gathered from each entity. The summary pages for each responding entity consist of a narrative program description, documentation and further information, as well as a three page fact sheet. Program summaries for all 65 entities are found in Chapter 3 (there are only 64 actual program summaries because Puerto Rico and the U.S. Virgin Islands are combined into one). The information in the program summaries was organized into several sections as shown below (Appendix D contains a blank program summary coded with the corresponding sections of the original checklist):

Contact Information

Program Description

Documentation and Further Information

Programmatic elements

- Uses of bioassessment within overall water quality program
- Applicable monitoring designs

Stream Miles

- Total miles
- Total perennial miles
- Total miles assessed for biology
  - fully supporting for 305(b)
  - partially/non-supporting for 305(b)
  - listed for 303(d)
  - number of sites sampled
  - number of miles assessed per site

Aquatic Life Use (ALU) Designations and Decision Making

- ALU designation basis
- ALU designations in water quality standards
- Narrative Biocriteria in WQS
- Numeric Biocriteria in WQS
- Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)
- Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU

Reference Site/Condition Development

- Number of reference sites
- Reference site determinations
- Reference site criteria
- Characterization of reference sites within a regional context
- Stream stratification within regional reference conditions
- Additional information

Field and Lab Methods

- Assemblages assessed (no. of samples/year, level of rigor)
- Benthos (sampling gear, habitat selection, subsample size, taxonomy)
- Fish (sampling gear, habitat selection, sample processing, subsample, taxonomy)
- Periphyton (sampling gear, habitat selection, sample processing, taxonomy)
- Habitat assessments
- Quality assurance program elements

Data Analysis and Interpretation

- Data analysis tools and methods
- Multimetric thresholds
  - transforming metrics into unitless scores
  - defining impairment in a multimetric index
- Multivariate thresholds
  - defining impairment in a multivariate index
- Evaluation of performance characteristics
- Biological data
  - Storage
  - Retrieval and analysis

In addition, selected relevant excerpts from state, tribal, territorial and interstate commission water quality standards excerpts were compiled into a separate chapter for inclusion in the document (see Chapter 4: Relevant Excerpts from Water Quality Standards and Biocriteria Language).

In April 2002, a preliminary draft of the document containing the Definition of Terms and Acronyms, Program Summaries, Water Quality Standards and Biocriteria Language, Literature Cited, and List of Contacts was distributed to the full Biocriteria Team for an editorial and technical review. Individual program summaries and water quality excerpts were distributed to the relevant EPA Regional contacts and the point of contact for each responding entity for review and comment. During the summer of 2002, the project team compiled, organized, and incorporated the feedback received from all reviewers.

This document, *Summary of Biological Assessment Programs and Biocriteria Development for States, Tribes, Territories, and Interstate Commissions*: *Streams and Wadeable Rivers*, represents this project's final product. The document's value lies not only in the wealth of information it contains but also in the lessons learned from the process. In the near future, EPA hopes to initiate similar projects to assess the status of bioassessment and biocriteria programs for lakes, reservoirs, estuaries, and wetlands. The effectiveness and efficiency of those efforts will be enhanced by the development of this reference document.

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2. SUMMARY OF FINDINGS

2.1 Summary of Current Biological Assessment Programs and Biocriteria Development

This report summarizes the national breadth of biological monitoring and assessment in stream and wadeable river management programs based on 2001 program information (Table 1). Since this summary pertains to more than just "states," the term "entity" is used to refer to the combination of states, tribes, territories, and interstate commissions. Survey responses were received from 65 entities (50 states, District of Columbia, four territories, six tribes, and four interstate commissions – see Appendix A for a complete list).

Although ranging across a wide spectrum – from initial pilot studies to comprehensive assessment – 57 of the 65 entities have bioassessment programs for streams and wadeable rivers, and two (Puerto Rico and the Nez Perce Tribe) have programs under development. Nearly 440,000 river and stream miles nationwide are assessed using biological data (see Figure 1a for state-by-state percentages). More importantly, as shown in Table 1, 40 entities use bioassessment to help determine aquatic life use support (ALUS) for their 305(b) reporting (Figure 1b), and six states (AK, CA, HI, MT, NV, OK) are developing processes for using biological data to interpret ALU. Thirteen entities, including seven states (AZ, AR, CO, DE, LA, SD, UT) either don't have *comprehensive* statewide bioassessment programs in place, or they don't yet use bioassessment data to determine the condition of their waters.

A total of 29 entities have incorporated narrative biocriteria into their WQS (Figure 2a). The 11 entities (AZ, CO, HI, IL, IN, IA, MD, MT, NV, WA, Pyramid Lake Paiute Tribe) in a developmental phase of adopting narrative biocriteria into their WQS are at various stages in this process. While some may have already developed biocriteria and are working on promulgating the statements into their WQS, others are awaiting state or federal approval, or are in the earlier stages of developing narrative biocriteria to be submitted for review. Although 20 entities do not have narrative biocriteria in their WQS, several of these have incorporated general aquatic life statements. The following five entities – ICPRB, SRBC, Nez Perce Tribe, Oneida Nation of Wisconsin and Passamaquoddy Tribe - Pleasant Point Reservation – do not have federally approved WQS and are not currently working toward that end. Therefore, these entities are not included in any biocriteria counts.[1]

Of the 29 entities with narrative biocriteria incorporated into their WQS, 22 have also developed quantitative implementation procedures or translators, and eight are working to develop them (Figure 2b). These procedures can be found in various documents including WQS, SOPs, 305(b) guidelines, and other agency documents. While numeric procedures are not numeric *biocriteria* per se, they do provide a quantitative basis for assessing attainment of specific designated aquatic life uses and are an important step in biocriteria development.

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[1] While the Oneida Nation does not have federally approved water quality standards, the Tribe is currently using bioassessments to implement their water quality program under tribal law. Inclusion of narrative and numeric biocriteria into the Tribe's WQS is under development.

Table 1. National summary of bioassessment programs for streams and wadeable rivers in 2001

PROGRAMMATIC ELEMENT	NUMBER OF ENTITIES			
	In-place	Under development	None	Not applicable
Use of Bioassessments				
Water resource management	57	2	6	0
Interpret aquatic life use attainment	40	6	13	6[2]
Narrative biocriteria in WQS	29	11	20	5[3]
Narrative biocriteria in WQS with quantitative implementation procedures or translators	22	8	30	5[4]
Numeric biocriteria in WQS	4	11	45	5[4]
Assemblage Used				
Fish	41	0	16	8[4]
Benthic macroinvertebrates	56	1	0	8[5]
Algae (periphyton, diatoms)	20	5	32	8[5]
More than one assemblage	45	5	7	8[5]
Reference Conditions				
Ecoregional	42	2	12	9[5]
Site-specific	19	1	37	8[6]
State-wide or basin-specific	7	1	46	11[6]
Analysis				
Biological metrics	54	1	1	9[7]
Multivariate	22	2	32	9[8]
Assessment				
Multimetric index	41	3	12	9[8]
Habitat assessment	57	0	0	8[3]

[2] DRBC and ICPRB are not regulatory authorities. Nez Perce Tribe, Oneida Nation of Wisconsin, Passamaquoddy Tribe - Pleasant Point Reservation, and Pyramid Lake Paiute Tribe do not have federally approved WQS.

[3] ICPRB, SRBC, Nez Perce Tribe, Oneida Nation of Wisconsin and Passamaquoddy Tribe - Pleasant Point Reservation do not have federally approved WQS and are not currently working toward that end.

[4] The following entities do not use biological assessment methods as a means to assess stream and river water quality: American Samoa (AS), Puerto Rico (PR), U.S. Virgin Islands (USVI), Confederated Tribes of the Colville Reservation, Nez Perce Tribe, Passamaquoddy Tribe - Pleasant Point Reservation, and Seminole Tribe of Florida. The Commonwealth of Northern Mariana Islands (CNMI) has a bioassessment program for marine systems only; bioassessment for freshwater is not applicable.

[5] Virginia did not provide complete reference condition information. American Samoa, CNMI, Puerto Rico, U.S. Virgin Islands, Confederated Tribes of the Colville Reservation, Nez Perce Tribe, Passamaquoddy Tribe - Pleasant Point Reservation, and Seminole Tribe of Florida do not have bioassessment programs.

[6] AS, CNMI, PR, USVI, Confederated Tribes of the Colville Reservation, Nez Perce Tribe, Passamaquoddy Tribe - Pleasant Point Reservation, and Seminole Tribe of Florida do not have bioassessment programs.

[7] Pyramid Lake Paiute Tribe has not yet analyzed or evaluated their biological data. AS, CNMI, PR, USVI, Confederated Tribes of the Colville Reservation, Nez Perce Tribe, Passamaquoddy Tribe - Pleasant Point Reservation, and Seminole Tribe of Florida do not have bioassessment programs.

Four entities (FL, OH, OK, DRBC) have numeric biocriteria incorporated into their WQS (Figure 2c).[8] And of the 11 entities for which numeric biocriteria is categorized as "under development," Maine and Wyoming have developed and incorporated numeric biocriteria into other program documents, such as SOPs and monitoring guidance manuals, and have been using the numeric limits to maintain designated uses.

The three major groups of biological organisms or assemblages monitored as part of comprehensive biological assessment programs are fish, benthic macroinvertebrates, and algae (periphyton). Macroinvertebrates are the most common indicator assemblage used by state water quality agencies and are a part of all but Hawai`i's bioassessment program, where it is currently under development (Figure 3a). The second most common assemblage monitored is fish, followed by periphyton (Figures 3b and 3c). Forty-five entities monitor for at least two assemblages, and another five (AK, HI, NV, UT, WY) currently use one, but are developing the capability of using a second (Figure 3d).

One of the key elements in bioassessment programs is the establishment of reference conditions to help discern human impacts from natural variation. The two types of reference conditions currently used in biological surveys are regional and site-specific. The Ecoregion Concept, a common regionalization approach, recognizes geographic patterns of similarity among ecosystems and the subsequent distribution of biological communities grouped on the basis of environmental variables such as climate, soil type, physiography, and vegetation. Forty-two entities have adopted this method of stream stratification/ characterization in developing reference conditions (Figure 4). Site-specific reference conditions typically consist of condition measurements taken upstream of a point source discharge or from a "paired" watershed. However, their usefulness is limited since they have only site-specific value (USEPA 1999). Only nine entities primarily use this approach to determine reference conditions.

Biological metrics and multivariate analysis are two types of data analysis tools/methods used to reduce a wealth of raw data into workable indicators of biological condition. Nearly all of the entities with bioassessment programs have developed biological metrics. In addition, just under half use multivariate analysis (techniques that look at the pattern of relationships among several variables simultaneously, such as principal components analysis (PCA) and non-metric multidimensional scaling (NMS)). Of the 54 entities that select and calculate biological metrics, 41 aggregate these metrics into a multimetric index (such as fish or macroinvertebrate IBIs) to assess biological condition and water quality, and to discriminate between impaired and unimpaired conditions (Figure 5). Finally, all entities with bioassessment programs also assess the physical habitat quality at their sample sites, usually employing visual based methods (such as QHEI and RBPs) in combination with other measurements.

2.2 Bioassessment Program Success from 1989 to 2001

In 1989, when developing the *Rapid Bioassessment Protocols for Use in Streams and Rivers*, USEPA summarized the bioassessment and biomonitoring capabilities in state regulatory programs (USEPA 1989). While the 1989 summary did not determine the actual use of the bioassessment data for all states, it did provide an estimate based upon past knowledge of state programs and on the documentation gathered during its development.

The *Summary of State Biological Assessment Programs for Streams and Rivers,* based on 1995 data, compiled a more comprehensive assessment of state uses of bioassessments and biocriteria in water management programs (USEPA 1996). The document serves as the baseline for determining changes and improvements in bioassessment capabilities over the past six years. Table 2 presents a summary of the 1989 and 1995 results alongside the 2001 data from Table 1. The incremental change (from 1989 to

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[8] Florida has made substantial progress in developing new multimetric indices for streams (Stream Condition Index and BioRecon), lakes (Lake Condition Index), and wetlands for eventual inclusion in the Florida Administrative Code. When the new indices are adopted as water quality standards, the role of Shannon-Weaver diversity as a numeric standard will be re-evaluated.

Macroinvertebrate biocriteria were developed for DRBC's Special Protection Waters rules issued in 1990, but the criteria were later found to be based upon inconsistent and non-representative methods and have not been used as envisioned during development of the Commission's antidegradation policies. Program redesign recommendations were recently made to improve effectiveness and applicability of the criteria.

1995, and 1995 to 2001) appears in parentheses, and an additional column indicates the net change from 1989 to 2001. For the purposes of comparison, Table 2 only contains program information from the original 52 entities surveyed in 1989 and 1996 (50 states, the District of Columbia, and ORSANCO). Refer to Table 1, Chapter 3, and Appendix A for programmatic information on the additional entities surveyed for this document.

There has been extensive progress in the development and use of biological assessments and criteria as revealed by virtually all measures of the survey as shown in Table 2. All 52 entities contained in this table have incorporated bioassessment in their water resource management programs. This is up over 30% from a count of 37 in 1989. Although the number of states that used bioassessments to determine aquatic life use attainment in 1989 is unknown, these numbers did increase noticeably from 1995 to 2001. And despite the fact that the number of entities with numeric biocriteria in their WQS has only increased by two over the past 12 years, 18 entities have developed and implemented quantitative procedures or translators for use in their water quality management programs (Figure 2b), and sixteen are in the process of developing narrative and/or numeric biocriteria for their standards.

Since 1989, the number of entities sampling at least one of the three major assemblages has steadily grown. Almost every entity surveyed in 1995 now conducts benthic macroinvertebrate assessments (Figure 3a). Even periphyton sampling, which declined from 1989 to 1995, rose sharply from 1995 to 2001. Studies have found that assessing only one assemblage can only achieve roughly 80 to 85% effectiveness at identifying aquatic life use attainment or nonattainment. Thus, since 1995, USEPA has recommended the use of multiple assemblages, especially in larger streams (USEPA 1996). The number of entities using more than one assemblage in 2001 reached 41 (an increase of 15 in just five years); and 20 of these 41 entities sample for at least three, and even four, assemblages, such as phytoplankton, macrophytes and zooplankton (Figure 3d).

One of the major advancements since 1989, and especially since 1995, has been the increased use of regional reference conditions as a basis for making comparisons and detecting use impairment. Only four states were actively using ecoregional reference conditions in 1989, and still only 15 in 1995. However, by 2001, 39 entities characterized reference conditions using a composite or aggregation of least or minimally impaired sites within distinct ecoregions (Figure 4). And conversely, 11 fewer entities used a site-specific approach alone to determine reference conditions.

The number of entities using biological metrics for data analysis increased by eight in 2001, in step with a sharp increase of 39 between 1989 and 1995. Today, all but two of the surveyed entities contained in Table 2 have developed biological metrics.

Finally, for the 2001 survey, we narrowed the definition of what constitutes narrative biocriteria in WQS to exclude general aquatic life statements. We adhered to the definition of narrative biocriteria as “narrative expressions that describe biological integrity of aquatic communities inhabiting waters of a given classification or designated aquatic life use.” We also required entities to clarify how the criteria were operationally defined in their WQS. This examination yielded a count of 28 entities with narrative biocriteria in their WQS, one entity less than was reported in 1995. However, had we used the 1995 definition of narrative biocriteria, these 28 entities would grow to 40, resulting in an increase of 11 between 1995 and 2001.

Refer to Appendix A for a summary of pertinent information for each entity surveyed. This information is captured in greater detail and clarity in the individual program summaries found in Chapter 3.

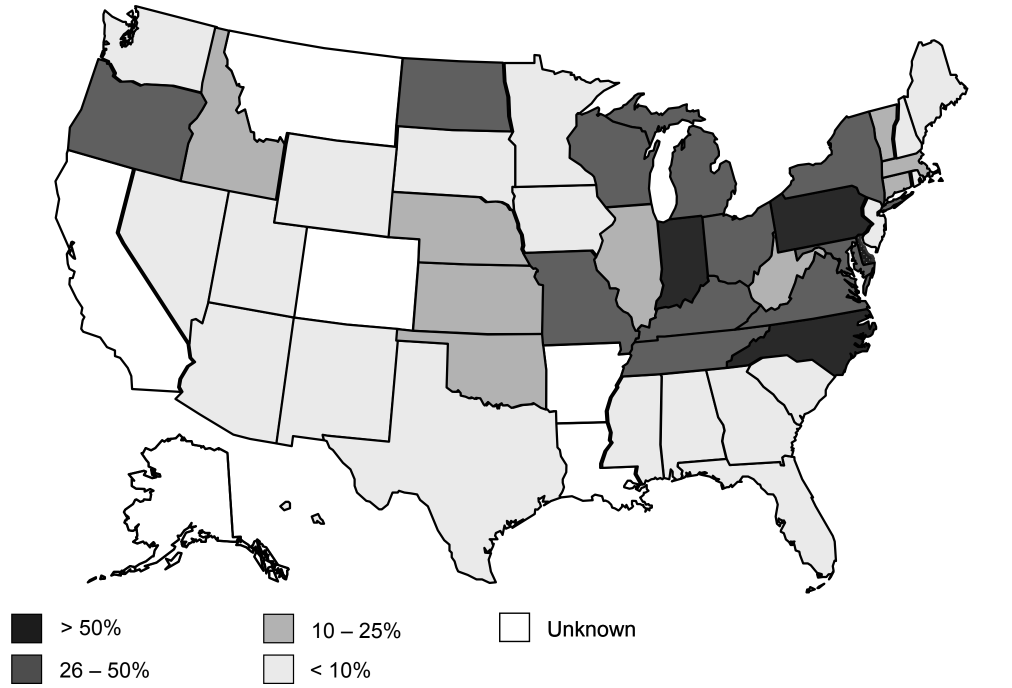
Table 2. National summary of bioassessment programs for streams and wadeable rivers in 1989, 1995, 2001 and the interim change [9]

PROGRAMMATIC ELEMENT	NUMBER OF ENTITIES (see note below)											
	In-place				Under Development				None			
	1989	1995	2001	net change	1989	1995	2001	net change	1989	1995	2001	net change
Use of Bioassessments												
Water resource management	37	41 (+4)	52 (+11)	+11	7	8 (+1)	0(-8)	-3	8	3 (-5)	0(-3)	-8
Interpret aquatic life use attainment	unk	31	39 (+8)	+8	unk	8	6 (-2)	-2	unk	13	7 (-6)	-6
Narrative water quality standard	unk	29	28 (-1)	-1	unk	11	10 (-1)	-1	unk	12	14 (+2)	+2
Numeric water quality standard	1	2 (+1)	3 (+1)	+2	unk	15	10 (-5)	-7	49	35 (-14)	39 (+4)	-8
Organism Group Used												
Fish	23	29 (+6)	37 (+8)	+15	1	5 (+4)	0 (-5)	-1	28	18 (-10)	15 (-3)	-13
Benthic macroinvertebrates	39	44 (+5)	51 (+7)	+12	3	5 (+2)	1 (-4)	-2	10	3 (-7)	0 (-3)	-10
Algae (periphyton, diatoms)	7	4 (-3)	19 (+15)	+12	0	3 (+3)	5 (+2)	+5	45	45 (+0)	28 (-17)	-16
More than one assemblage	24	26 (+2)	41 (+15)	+17	4	10 (+6)	5 (-5)	+1	26	16 (-10)	6 (-10)	-20
Reference Conditions												
Ecoregional	4	15 (+11)	39 (+24)	+35	2	26 (+24)	2 (-24)	0	44	11 (-33)	11[10] (0)	-33
Site-specific	unk	31	19 (-12)	-12	unk	0	1 (+1)	+1	unk	21	32[10] (+11)	+11
State-wide or basin-specific	unk	6	6 (0)	0	unk	0	0	0	unk	46	46[10] (0)	0
Multiple Metrics for Data Analysis												
Biology	3	42 (+39)	50 (+8)	+47	11	6 (-5)	1 (-5)	-10	35	4 (-31)	1 (-3)	-34

NOTE: The same 52 entities were used for each of the years for the most accurate comparison of changes over time.

[9] The incremental change (from 1989 to 1995, and 1995 to 2001) appears in parentheses, and the “net change” column indicates the total change from 1989 to 2001, or 1995 to 2001 where 1989 data is unknown.

[10] The *Ecoregional* and *State-wide or basin-specific* elements are not applicable to New York and Virginia’s programs (Virginia did not complete this section). The *Site-specific* element is not applicable to Utah’s program. For the purposes of comparison, each has been counted as *None* in this table.



*The use of various monitoring designs, i.e. targeted vs. probabilistic, influences the derivation of these numbers.

Figure 1a. Percent of total stream/river miles assessed in each state using bioassessments

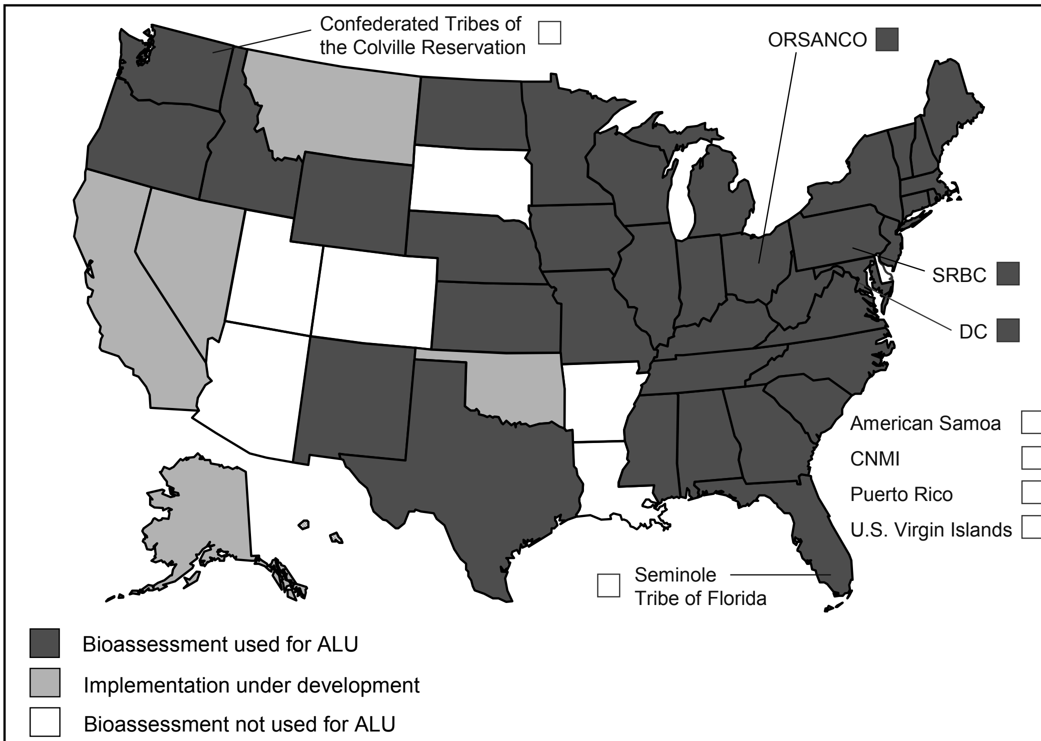


Figure 1b. Use of bioassessment to determine aquatic life use (ALU) for 305(b) reporting

Figure 1. Use of bioassessments to assess water quality

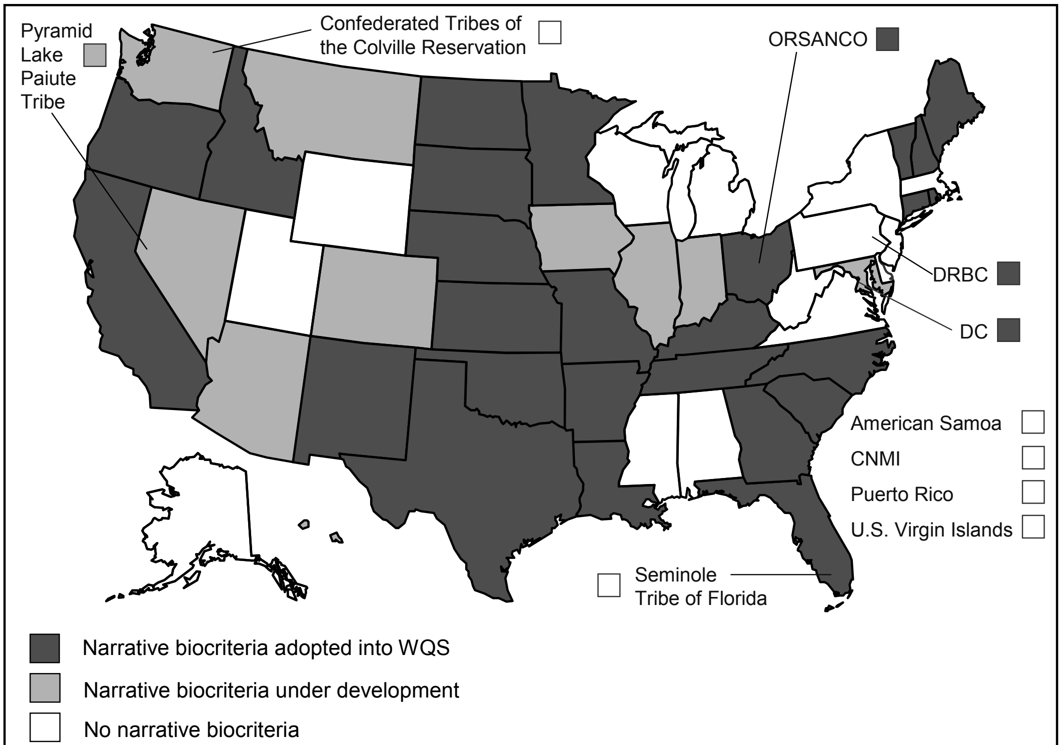


Figure 2a. Narrative biocriteria development

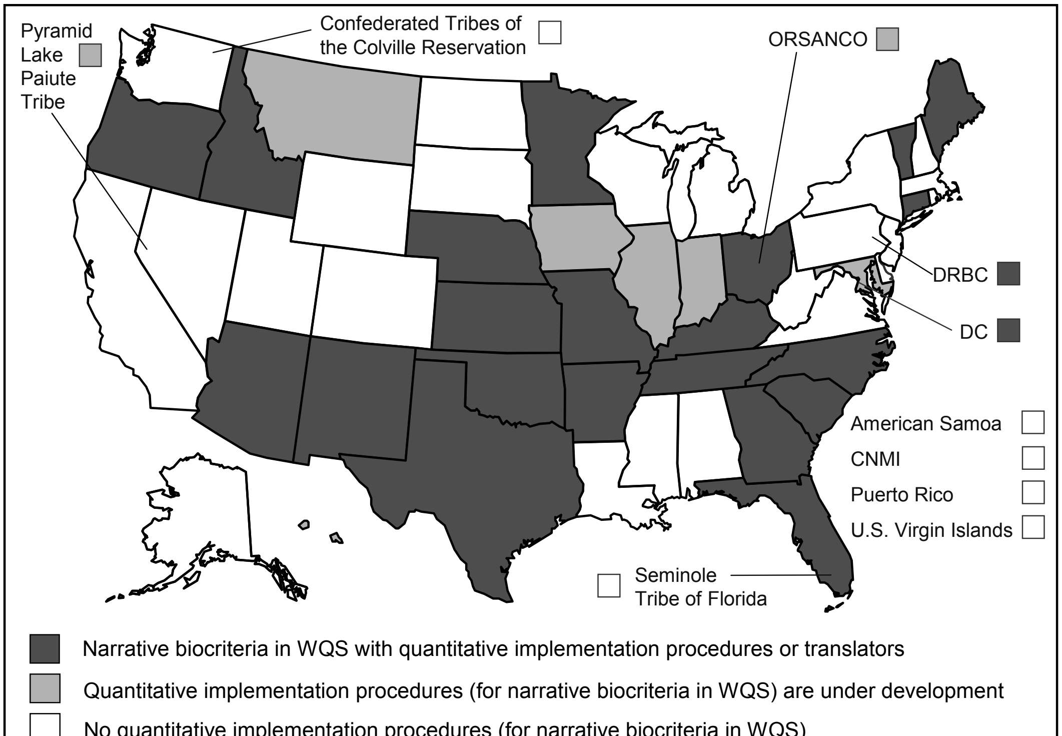


Figure 2b. Narrative biocriteria in WQS with quantitative implementation procedures

Figure 2. Biocriteria development

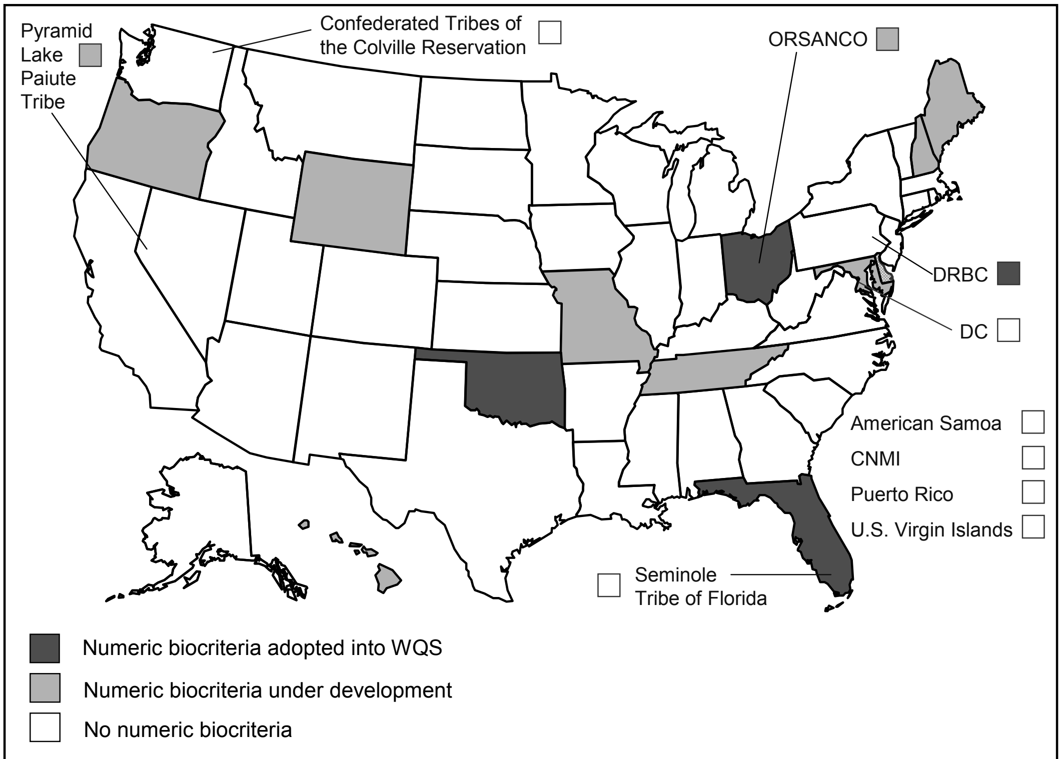


Figure 2c. Numeric biocriteria development

Figure 2 (cont). Biocriteria development

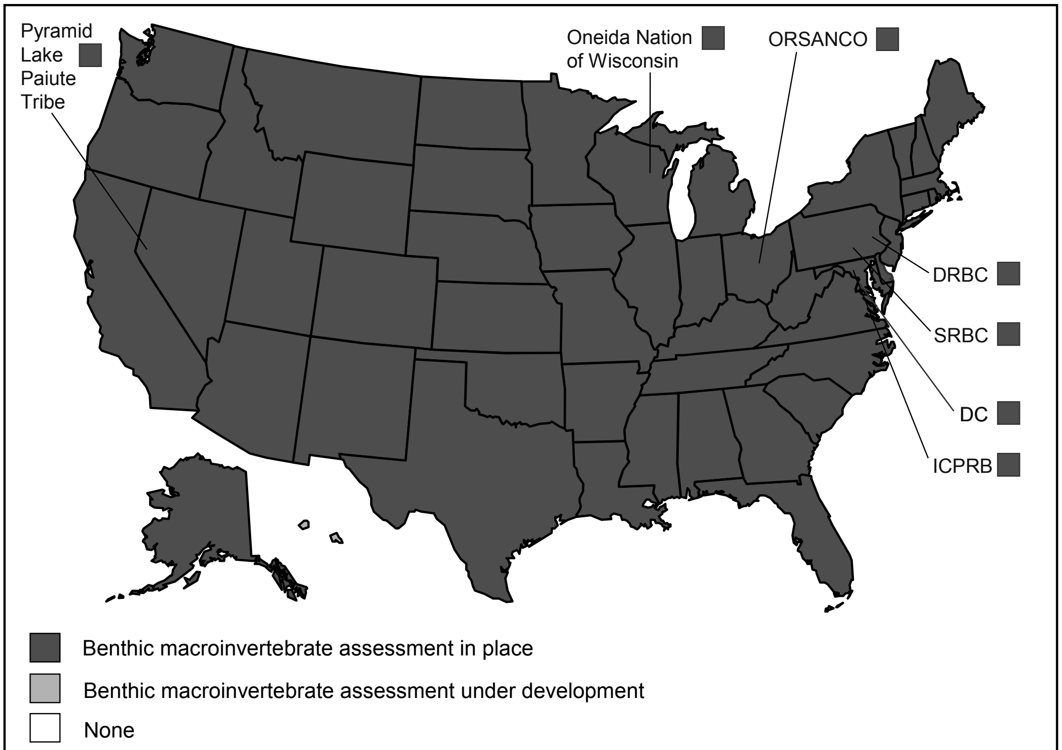


Figure 3a. Benthic macroinvertebrates

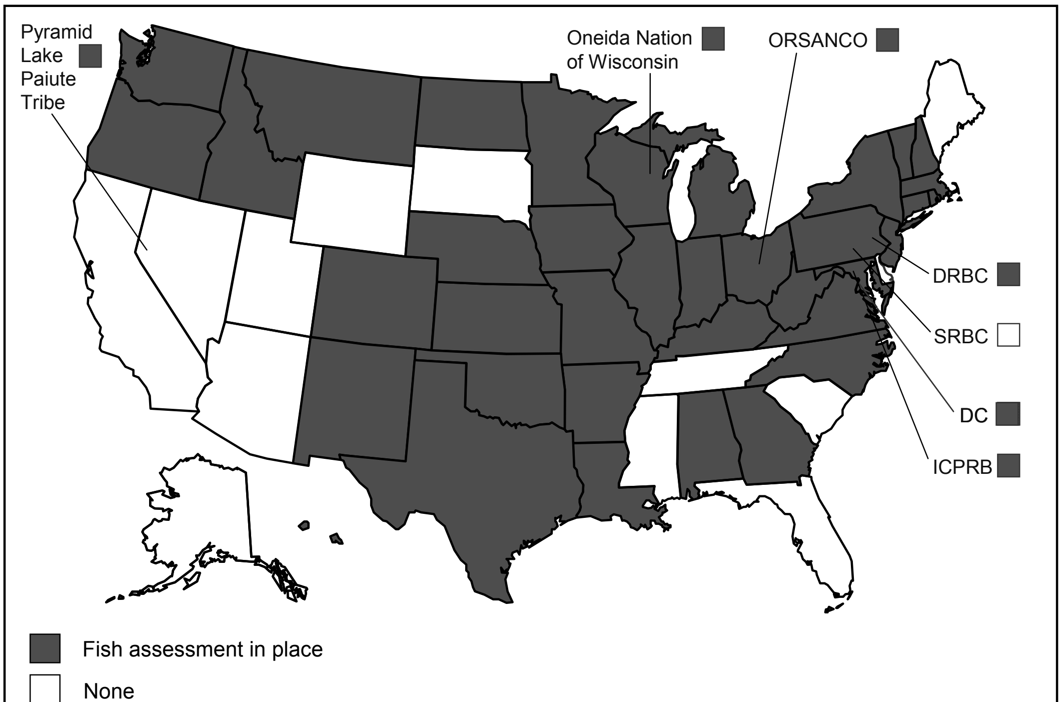
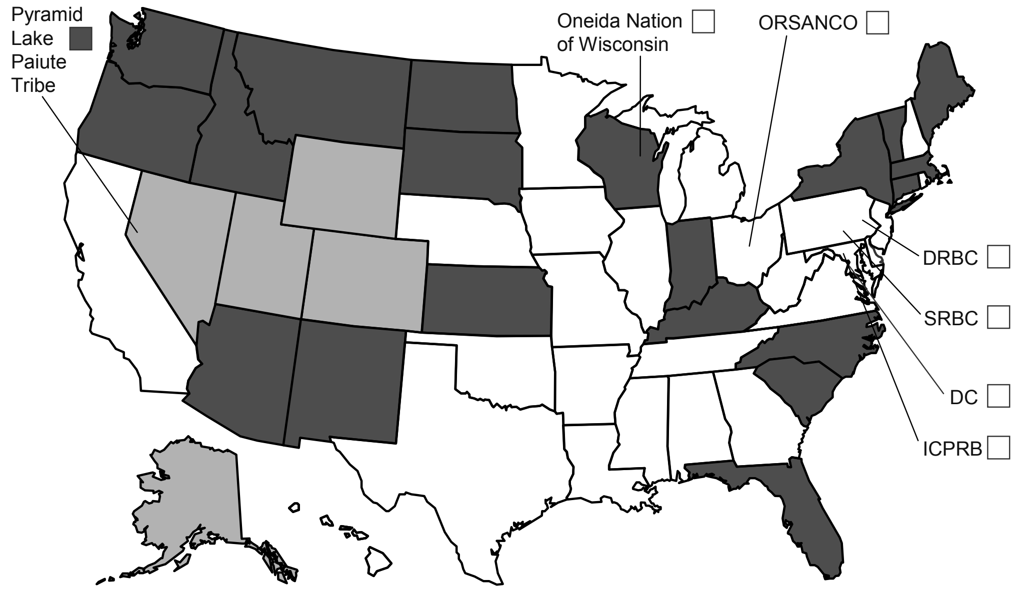


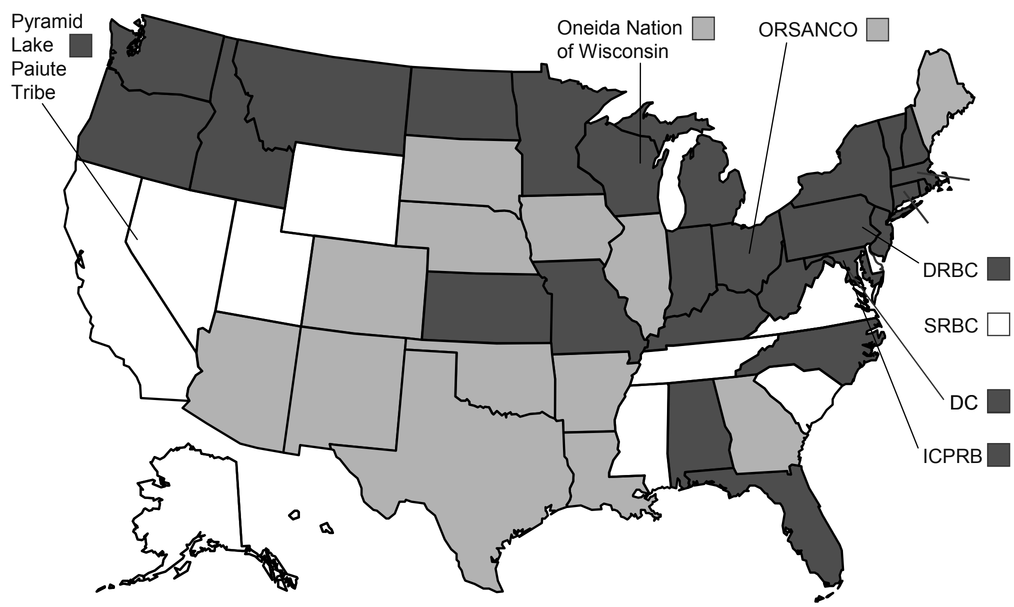
Figure 3b. Fish

Figure 3. Assemblages assessed



Periphyton assessment in place
Periphyton assessment under development
None

Figure 3c. Periphyton



Only one assemblage assessed
Two assemblages assessed
Three or more assemblages assessed

Figure 3d. Number of assemblages assessed

Figure 3 (cont). Assemblages assessed

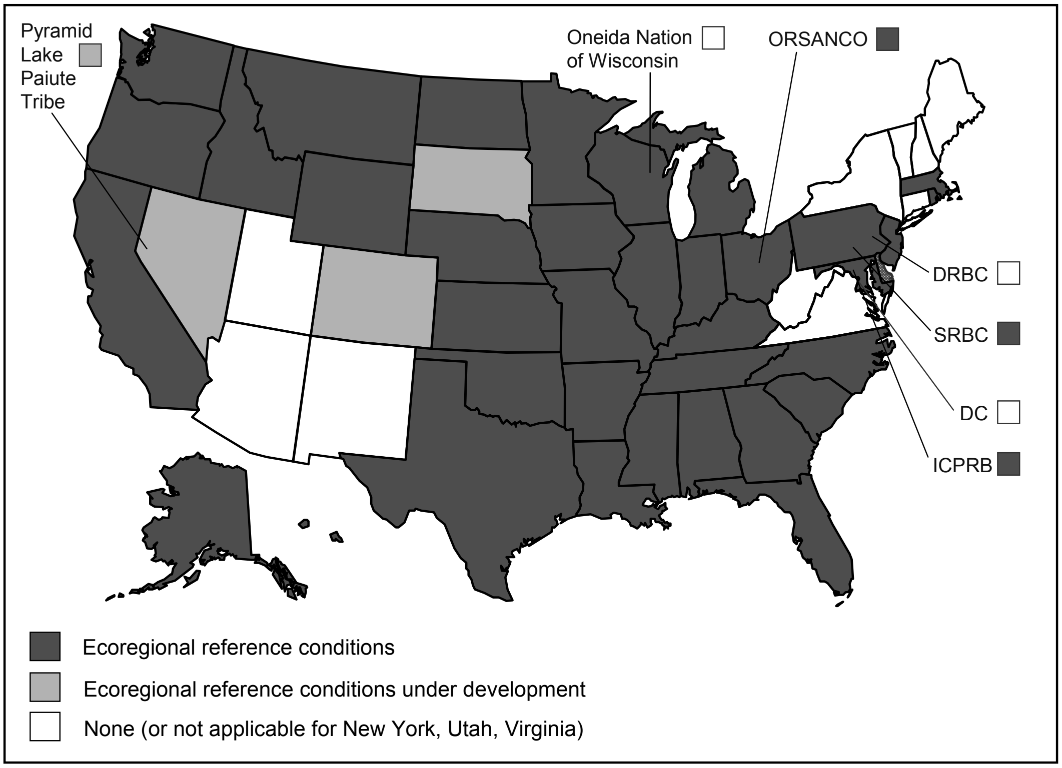


Figure 4. Use of ecoregional reference conditions

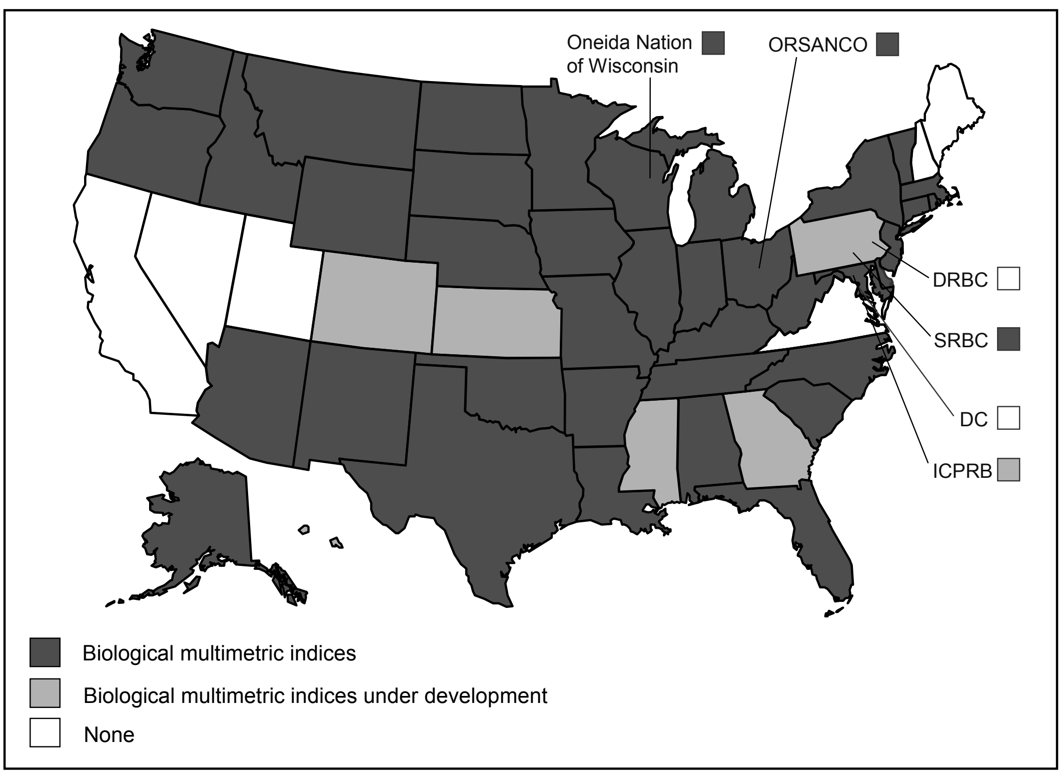


Figure 5. Development of biological multimetric indices

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3. PROGRAM SUMMARIES

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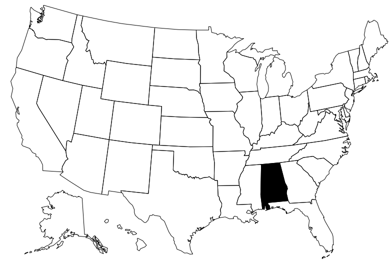
ALABAMA



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ADEM Water Quality homepage:
http://www.adem.state.al.us/WaterDiv/Water%20Quality%20Info/WQMainInfo.htm

Program Description

In the last five years the Alabama Department of Environmental Management (ADEM) has assessed more than 1,100 river and stream locations as a part of six major long-term riverine-focused monitoring programs:

- Nonpoint Source Assessment Program
- Source Assessment Program
- Ecoregion Reference Assessment Program
- Upland Alamap Monitoring and Assessment Program
- Clean Water Act §303(d) Support Assessment/Monitoring Program
- Fixed Ambient Trend Monitoring Program

The Field Operations Division's (FOD) benthic macroinvertebrate assessment program is an integral part of the Department's biological monitoring effort. A Multihabitat Bioassessment Protocol is currently utilized to sample wadeable and nonwadeable streams. All methods utilized are documented in the Department's *Standard Operating Procedures* and *Quality Control Assurance Manual, Volume II* (ADEM 1999).

The Department has developed assessment criteria based on a ten-year ecoregional reference database. These assessments are then used to determine the Aquatic Life Use Designations. These comparisons have aided the Department in evaluating the "best attainable biotic community" within an ecoregion. The Department uses macroinvertebrates and a multi-habitat fish community assessment to evaluate water quality. Periphyton bioassessment methods are currently being tested as a more direct assessment of nutrient enrichment.

Biological integrity and water quality are directly affected by physical habitat. In addition, the assessment of habitat quality is an important step in documenting the adverse impacts of nonpoint source pollution. The Department utilizes the Habitat Assessment Matrices developed by EPA (USEPA 1989) and Barbour and Stribling (1994) in conjunction with physical characteristics and water quality parameters to evaluate and document the habitat quality of each wadeable bioassessment sampling site. More intensive assessment of geomorphological survey methods are currently being implemented (in 2002) to evaluate sedimentation impacts.

Through contracts and cooperative efforts, other agencies have contributed valuable information, time, data, and other resources to the surface and ground water management program. These contributions have included sampling and analysis efforts; flow information; data contribution and management; and GIS development. The Alabama Water Watch (AWW) Program and Association routinely provides quality citizen volunteer monitoring data to ADEM. With so much water to manage and diminishing program funds, the "Alabama Water Watchers" play a key role in identifying waters that need immediate or long-term attention.

Documentation and Further Information

2000 Water Quality Report to Congress, 305(b) Report:
http://www.adem.state.al.us/WaterDiv/Water%20Quality%20Info/305b/WQ305bReport.htm

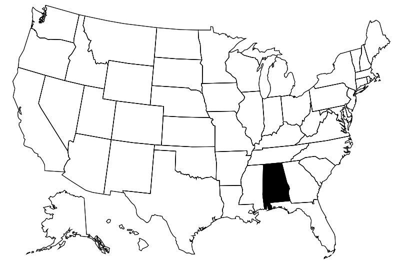
1996, 1998 and 2000 303(d) lists, listing and delisting criteria, and maps of listed waters:
http://www.adem.state.al.us/WaterDiv/Water%20Quality%20Info/303d/WQ303d.htm

ADEM. 1999. *Standard Operating Procedures and Quality Control Assurance Manual Volume II – Freshwater Macroinvertebrate Biological Assessment*. Field Operations Division ADEM, Montgomery, Alabama.

O'Neil, P.E., and T.E. Shepard. 1998. *Standard operating procedure manual for sampling freshwater fish communities and application of the index of biotic integrity for assessing biological condition of flowing, wadeable streams in Alabama*. ADEM Contract No. AGY7042. Geological Survey of Alabama, Tuscaloosa, Alabama.

Barbour, M.T., and J.B. Stribling. 1994. A technique for assessing stream habitat structure. Pages 156-178 in *Conference proceedings, Riparian ecosystems in the humid U.S.: Functions, values, and management.* National Association of Conservation Districts, Washington, D.C. March 15-18, 1993, Atlanta, Georgia.

ALABAMA



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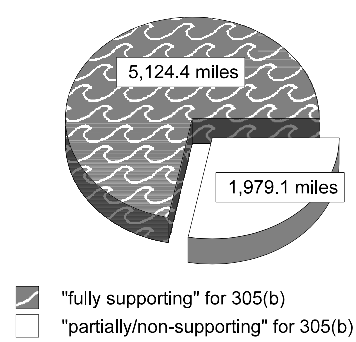
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
		promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects and specific river basins or watersheds)*
	✓	fixed station (i.e., water quality monitoring stations) *(special projects and comprehensive use throughout jurisdiction)*
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
	✓	rotating basin *(special projects and specific river basins or watersheds)*
		other:

Stream Miles

Total miles	**77,274**
Total perennial miles	47,077
Total miles assessed for biology*	**7,103.5**
fully supporting for 305(b)	5,124.4
partially/non-supporting for 305(b)	1,979.1
listed for 303(d)	1,979.1
number of sites sampled *(on an annual basis)*	200
number of miles assessed per site	–

7,103.5 Miles Assessed for Biology



*The above miles are the total river and stream miles assessed for biological *and* other (chemical, physical, etc.) effects. Strictly biological miles are as follows: 2,992.1 *monitored* miles and 5,524 *evaluated* miles were determined as “fully supporting” for 305(b) using bioassessment data. These miles do not include fish tissue monitoring data from streams and rivers.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Fishery Based Uses	
ALU designations in state water quality standards	Three designations: Outstanding Alabama Water, Fish & Wildlife, Limited Warmwater Fishery	
Narrative Biocriteria in WQS	none - A narrative scale of condition is used to support criteria decisions. Draft guidelines, based upon ecoregional reference conditions, are used in the evaluation of aquatic macroinvertebrate community assessments.	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	none	

Reference Site/Condition Development

Number of reference sites	**48 total**	
Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
		professional judgment
		other:
Reference site criteria	Local Soil and Water Conservation District (SWCD) estimates of landuse, animal densities, and sedimentation rates, etc. and departmental databases are used to identify potentially least-impaired sub-watersheds.	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information	✓	reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(100-500 samples/year; multiple seasons, multiple sites - broad coverage for watershed level)*
	✓	fish *(<100 samples/year; multiple seasons, multiple sites - broad coverage for watershed level)*
		periphyton *(currently being tested for assessment of nutrient enrichment)*
	✓	other: phytoplankton *(100-500 samples/year; multiple seasons, multiple sites - broad coverage for watershed level)*

Benthos	
sampling gear	wash bucket, dipnet and kick net (1 meter); 500-600 micron mesh
habitat selection	multihabitat
subsample size	100 per habitat
taxonomy	family and genus
Fish	
sampling gear	backpack electrofisher and seine; 3/16" mesh
habitat selection	pool/glide and riffle/run (cobble)
sample processing	biomass - batch
subsample	none
taxonomy	species
Habitat assessments	visual based; performed both with, and independent of, bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings and training for biologists, sorting and taxonomic proficiency checks, specimen archival

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(aggregate metrics into an index and return single metrics)*
		disturbance gradients
		other:

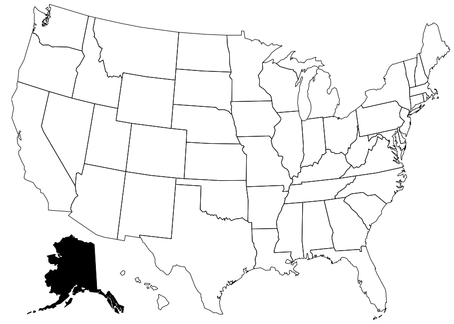
Multimetric thresholds	
transforming metrics into unitless scores	95^{th} percentile of reference population
defining impairment in a multimetric index	The 2000 305(b) report states that sampling results equal to or less than fair/moderately impaired for the macroinvertebrate index and chemical/physical field data indicate an impairment ("excellent, good, fair, poor, very poor" or "unimpaired, slightly impaired, moderately impaired, severely impaired") and will be considered non-support and placed on the 303(d) list.

Evaluation of performance characteristics	✓	repeat sampling *(sampling - multiple crews same site/same day)*
	✓	precision *(sampling, assessment and identification)*
	✓	sensitivity *(sampling and assessment; standard level of identification)*
	✓	bias *(identification - 10% peer review)*
	✓	accuracy *(identification - 10% peer Quality Assurance; lab pick - 100% recheck; field pick - 10% returned to lab for re-check)*

Biological data*	
Storage	Aquatic macroinvertebrate data from 1990 to present are stored in a PACE mainframe database. ADEM has very recently developed an MS Access Fish IBI database and will begin data entry of this information as time allows. Historical macroinvertebrate data are stored in paper files. Fish IBI data are mostly in spreadsheets, but will eventually be included in the Access database.
Retrieval and analysis	Both databases mentioned above include automated metric calculation. The macroinvertebrate database also allows some comparison of taxa lists between stations.

*Additional resources are necessary to develop an in-house biological database module in Oracle that would be compatible with the Oracle Surface Water Quality Database currently under development. The current aquatic macroinvertebrate dataset and the fish community data would be migrated into this database module. STORET will not be used as the primary biological data storage and retrieval system.

ALASKA



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ADEC Division of Air and Water Quality homepage:
http://www.state.ak.us/local/akpages/ENV.CONSERV/dawq/dec_dawq.htm

Program Description

The State of Alaska is in the early stages of using bioassessments in water quality management. The lead agency funding bioassessment work is the Alaska Department of Environmental Conservation (ADEC); with the bulk of the development work done by the University of Alaska (UAA) Environment and Natural Resources Institute (ENRI). To date, bioassessments have not been used for biocriteria. Key accomplishments of Alaska's program include:

- method development and testing, resulting in the Alaska Stream Condition Index
- successful interagency involvement and supplemental funding
- extensive outreach and educational opportunities
- development of regional reference conditions for the Cook Inlet Ecoregion
- stream type differences incorporated into the framework for assessment
- index development incorporating multiple community attributes
- water quality assessments for Cook Inlet Ecoregion
- database development compatible with STORET for the water quality information
- relationship between degradation and habitat quality
- nutrient enrichment issues
- impervious surface areas influences to water quality

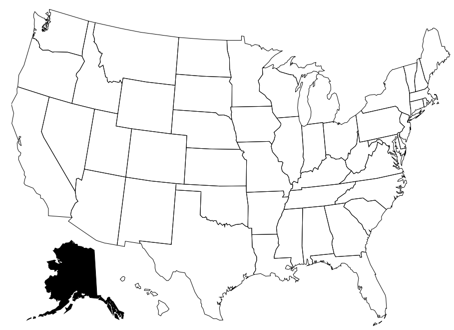
Documentation and Further Information

Alaska's bioassessment program is being developed in conjunction with UAA-ENRI. For consistency and to avoid duplicate information, refer questions on protocols and reference sites to them. Their web site is: http://www.uaa.alaska.edu/enri/bmap

Alaska Stream Condition Index: Biological Index Development for Cook Inlet, Summary 1997 - 2001, August 2001: http://www.uaa.alaska.edu/enri/bmap/pdfs/AK_SCI_2001.pdf

Quality Assurance Project Plan, Alaska Biological Monitoring and Assessment Program, February 2002: http://www.uaa.alaska.edu/enri/bmap/pdfs/ENRI_QAPP_2-02.pdf

ALASKA



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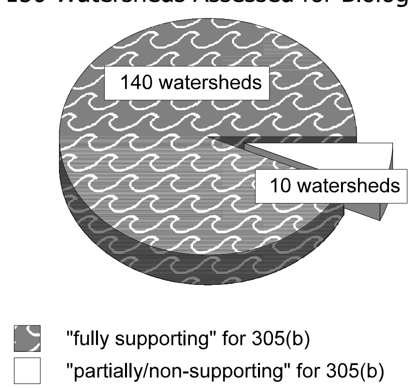
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
		monitoring the effectiveness of BMPs
		ALU determinations/ambient monitoring
		promulgated into state water quality standards as biocriteria
		support of antidegradation
		evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(comprehensive use throughout jurisdiction, special projects and specific river basins or watersheds)*
		fixed station (i.e., water quality monitoring stations)
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
		rotating basin
		other:

Stream Miles

Total miles *(determined using National Hydrography Database)*	**>3 million**
Total perennial miles	unknown
Total watersheds assessed for biology	**150**
watersheds fully supporting for 305(b)	140
watersheds partially/non-supporting for 305(b)	10
watersheds listed for 303(d)	10
number of sites sampled	300
number of miles assessed per site*	10

150 Watersheds Assessed for Biology



*For the purposes of decision making, a 100 meter reach represents approximately 10 stream miles.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Class system (A,B,C)–Every AK stream is designated for ALL uses (including drinking water) unless specifically exempted.	
ALU designations in state water quality standards	One designation in A: 3) aquaculture; One designation in C: 1) growth and propagation of fish, shellfish, other aquatic life, and wildlife	
Narrative Biocriteria in WQS	none	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
		cause and effect determinations
		permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Alaska is just beginning to use bioassessment information to help with assessment/monitoring and in management decisions.	

Reference Site/Condition Development

Number of reference sites	**43 total**	
Reference site determinations	✓	site-specific
		paired watersheds
		regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria	no channelization; no upstream impoundments; no known point-source discharges; DO > 5 ppm; urban land use <15% in catchment; mining or logging in <15% of catchment; forest or natural land use >50% in catchment; riparian buffer width >18m	
Characterization of reference sites within a regional context		historical conditions
		least disturbed sites
		gradient response
		professional judgment
	✓	other: minimally disturbed*
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
	✓	stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information	✓	reference sites linked to ALU
		reference sites/condition referenced in water quality standards
		some reference sites represent acceptable human-induced conditions

*Alaska's reference sites are considered "minimally" disturbed; variation in results is due to natural and environmental influences.

Field and Lab Methods

Assemblages assessed	✓	benthos *(100 to 500 samples/year; single and multiple seasons, multiple sites - broad coverage)*
		fish
	UD	periphyton
		other:

Benthos	
sampling gear	d-frame; 200 - 400 micron mesh
habitat selection	multihabitat
subsample size	300-count target
taxonomy	genus level
Habitat assessments	visual based, hydrogeomorphology; performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan (in progress), periodic meetings and training for biologists, sorting and taxonomic proficiency checks, specimen archival

Data Analysis and Interpretation

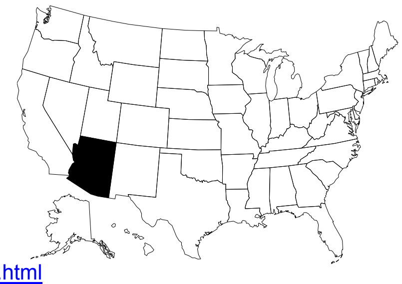
Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	95th percentile of all sites
defining impairment in a multimetric index	first quartile from the 95th percentile

Evaluation of performance characteristics		repeat sampling
	✓	precision *(sampling replicates)*
		sensitivity
		bias
		accuracy

Biological data	
Storage	EDAS
Retrieval and analysis	EDAS

ARIZONA



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ADEQ Water Quality Division homepage: http://www.adeq.state.az.us/environ/water/index.html

Program Description

The Biocriteria Program at the Arizona Department of Environmental Quality (ADEQ) has been sampling benthic macroinvertebrates since 1992. Data has been collected for biocriteria standards development and 305(b) assessment purposes for the past ten years. ADEQ has only one dedicated biocriteria staff person, however six other water quality monitoring staff assist in biological data collection during the spring as part of the ambient watershed monitoring program.

ADEQ does not yet have narrative or numeric biocriteria. However, sampling methods and Indexes of Biological Integrity have been developed with the assistance of USEPA and contractor support. The cold and warm water Indexes of Biological Integrity will be used to support two designated uses, Aquatic and Wildlife (cold water fishery) (A&Wc) and Aquatic and Wildlife (warm water fishery) (A&Ww), which are currently listed in Arizona's surface water quality standards. ADEQ plans to develop a narrative biocriterion for the next triennial review of standards and these indexes will serve as the implementation guidance for such a standard. ADEQ has also developed an approach to using bioassessments plus habitat assessments to implement the narrative bottom deposit standard, which will be proposed during a separate rulemaking on implementation guidance documents for all narrative standards during 2002.

In the water quality standards rules that are currently under review by USEPA, ADEQ has updated definitions for A&Wc and A&Ww based upon "macroinvertebrate regions" identified in Spindler 2001. The 5000' elevation contour marks the threshold for a change in community type from warm to cold, as determined by statistical analysis of empirically derived statewide biological data. These macroinvertebrate regions will be used instead of ecoregions for predicting community types in Arizona. Addition of the elevation range in the A&Wc and A&Ww standards definitions allows Arizona to use the elevation model to better predict the correct A&W use type. Revisions to the "list of surface waters and designated uses" have correspondingly been made in the 2001 standards rule.

ADEQ does not have a biocriteria standard and has subsequently been unable to assess biological integrity in Arizona's 305(b) report or 303(d) list. As a result of a lawsuit, ADEQ is preparing an "impaired waters rule" this year which will specifically outline assessment and listing procedures. Rules for conducting bioassessments will also have to be developed as part of this impaired waters rule, in addition to the surface water quality standard before bioassessments can be fully implemented in our assessment and listing process in Arizona. ADEQ is also partnering with the US Forest Service and Bureau of Land Management to standardize macroinvertebrate sample collection and analysis methods in order to share data on this important ecosystem indicator.

Future program directions include refining narrative bottom deposit standard implementation guidance for rule development, developing narrative biocriterion, starting a diatom bioassessment pilot project, refining reference condition, and developing bioassessments for intermittent streams and large rivers.

Documentation and Further Information

Status of Water Quality In Arizona - Clean Water Act Section 305(b) Report: June 2000:
http://www.adeq.state.az.us/environ/water/assess/305/index.html

Draft Status of Water Quality in Arizona - 2002, Arizona's Integrated 305(b) Assessment and 303(d) Listing Report:
http://www.adeq.state.az.us/environ/water/assess/hsa.html#draft

WQD Biocriteria Program information: http://www.adeq.state.az.us/environ/water/assess/monit.html

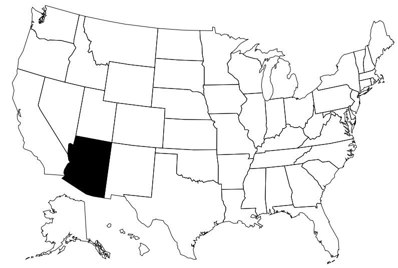
ADEQ. 2001. *DRAFT Quality Assurance Program Plan for the Biocriteria Program. ADEQ*, Phoenix, AZ.

Spindler, P.H. 2001. *DRAFT Narrative bottom deposit standard implementation guidelines for Arizona*. ADEQ, Phoenix, AZ.

Spindler, P.H., 1996. *Using ecoregions for explaining macroinvertebrate community distribution among reference sites in Arizona*, 1992. ADEQ OFR-95-7, Phoenix, AZ.

Other accomplishments include macroinvertebrate community distribution among reference sites in AZ (2001), development of Arizona EDAS biological database (2001), development and testing of a biological index for coldwater streams of AZ (2000), development and testing of a biological index for warmwater streams of AZ (1998), and Macroinvertebrate Photocatalog on CD (1998).

ARIZONA



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Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	UD	nonpoint source assessments
	UD	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	UD	promulgated into state water quality standards as biocriteria
		support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects, specific river basins or watersheds)*
	✓	fixed station (i.e., water quality monitoring stations) *(comprehensive use throughout* jurisdiction)
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
	✓	rotating basin *(specific river basins or watersheds)*
		other:

Stream Miles

Total miles	**127,505**
Total perennial miles	4,980
Total miles assessed for biology*	**0**
fully supporting for 305(b)*	n/a
partially/non-supporting for 305(b)*	n/a
listed for 303(d)*	n/a
number of sites sampled	324
number of miles assessed per site	site specific

*Arizona does not have formal biocriteria and will not be using bioassessments in the 2002 305(b) or 303(d) reports. However, a proposal to use bioassessment plus habitat assessment as the implementation procedure for the narrative bottom deposit standard will be considered during a rulemaking (2002-03), which is separate from the just completed triennial review of standards. The next 305(b) report may include bioassessments in support of the narrative bottom deposit standard, if this implementation procedure is approved.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Warm water vs. Cold Water	
ALU designations in state water quality standards	Aquatic and Wildlife (A&W) cold, A&W warm, A&W-effluent dependent water, A&W-ephemeral (AZ has acute and chronic categories for each except ephemeral in which only acute applies.)	
Narrative Biocriteria in WQS	under development – ADEQ has developed a cold water and warm water Index of Biological Integrity to support these two designated uses, which are currently listed in the surface water quality standards. However ADEQ does not yet have established biocriteria. These indexes will become the implementation guidance for proposed biocriteria in the next triennial review of standards.	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	UD	assessment of aquatic resources
	UD	cause and effect determinations
	UD	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
		watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	none	

Reference Site/Condition Development

Number of reference sites	**89 total**	
Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
		professional judgment
		other:
Reference site criteria	For initial site selection, the following guidelines were used in the early 1990s: a site must be accessible (within a 2-hour walk or 3-4 miles from nearest 4-wheel drive road), > 0.5 km downstream of road crossings, no known discharges upstream, no major impoundments upstream, no channel alterations at the site, and be only minimally impacted by land use activities and nonpoint sources. All of the following criteria must be attained in the field assessment of potential sites for a site to be accepted as reference: site should be truly perennial (indicators: fish, univoltine insects, riparian indicators), site should be free of local land use impacts, site should be free of channel alterations, no violations of pH or dissolved oxygen water quality standards, and habitat assessment index score > 14 using ADEQ's 2001 5-parameter habitat index.	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
	✓	professional judgment
	✓	other: minimally disturbed
Stream stratification within regional reference conditions		ecoregions (or some aggregate)
	✓	elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information	✓	reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

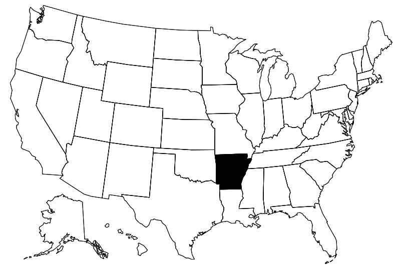
Assemblages assessed	✓	benthos *(<100 samples/year; single season, multiple sites - watershed level)*
		fish
	✓	periphyton *(<100 samples/year; single season, multiple sites - watershed level)*
		other:
Benthos		
sampling gear		d-frame net; 500 micron mesh
habitat selection		riffle/run (cobble)
subsample size		500 - 600 count target
taxonomy		combination level; EPT taxa are identified to genus or species
Periphyton		
sampling gear		**natural substrate**: brushing/scraping device (razor, toothbrush, etc.) **artificial substrate**: microslides or other suitable substratum
habitat selection		riffle/run (cobble); artificial substrate
sample processing		taxonomic identification
taxonomy		diatoms only; identified at species level
Habitat assessments		visual based, quantitative measurements, hydrogeomorphology; performed with bioassessments
Quality assurance program elements		standard operating procedures, quality assurance plan, periodic meetings, training for biologists, sorting and taxonomic proficiency checks, and specimen archival

Data Analysis and Interpretation

Data analysis tools and methods		summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients
		other:
Multimetric thresholds		
transforming metrics into unitless scores		95^{th} percentile of reference population
defining impairment in a multimetric index		25^{th} percentile of reference population
Evaluation of performance characteristics*	✓	repeat sampling *(duplicate samples collected for 10% of sites annually)*
		precision
	✓	sensitivity (*standard level of identification used by lab)*
	✓	bias *(ADEQ uses a standard mesh size, the lab locates small organisms, using a 6-12x dissecting microscope and a Caton tray to randomly obtain fractions of the total sample)*
	✓	accuracy *(any questionable identifications are sent to nationally recognized taxonomic experts for confirmation and a voucher specimen collection is maintained*)
Biological data		
Storage		AZ-EDAS
Retrieval and analysis		Systat, EDAS

*Though multiple performance characteristics are evaluated, ADEQ has not incorporated this information into a QA/QC document.

ARKANSAS



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Program Description

As part of the Water Division of the Arkansas Department of Environmental Quality (ADEQ), the Water Quality Planning Branch has seven biologists/ecologists and two geologists on staff. This branch deals with a variety of issues related to water quality monitoring, standards development, and groundwater and wasteload allocations. The Branch is responsible for conducting water quality surveys, assessing the State's water quality for surface and ground water, and 305(b) reporting. The Branch is also responsible for the development of water quality and biological criteria for water quality use attainability analysis and for water quality standards development. In addition, the Branch is responsible for developing TMDLs (303d) for those waters not meeting water quality standards. Finally, the Branch is responsible for the biomonitoring aspect of the NPDES program.

Biological and habitat monitoring are currently restricted to special project needs associated with synoptic watershed surveys or for the development of additional data to support the establishment of biological criteria. For the 2000 305(b) report, portions of 106 stream segments from 17 planning segments were assessed for aquatic life use support using biological communities. These stream segments were either located above or below a point source discharge, or were part of intensive water quality surveys. Survey objectives were to determine the impacts of the discharge, evaluate the biological community in ecoregional reference streams, determine use attainment in previously listed water bodies of concern or those waters not currently meeting all designated uses.

Macroinvertebrates were collected and evaluated following EPA's *Rapid Bioassessment Protocols (*USEPA 1989). Habitat considerations were used in the evaluation of the macroinvertebrate communities through percent comparability evaluation techniques at all sites. An upstream-downstream comparison of the communities, and a comparison of the community to a least disturbed reference stream were also used to make the assessments. Fish communities were analyzed following EPA's *Technical Support Manual: Waterbody Surveys and Assessments for Conducting Use Attainability Analysis* (USEPA 1983). Direct comparisons were made with ecoregional fish community data outlined in the Department's *Physical, Chemical, and Biological Characteristics of Least-Disturbed Reference Streams in Arkansas' Ecoregions, 1987.* In addition, an upstream-downstream comparison of the communities was made and compared to a least-disturbed reference stream.

Documentation and Further Information

Water Quality Inventory Report 2000, 305(b) Report:
http://www.adeq.state.ar.us/water/pdfs/documents/305(b)_2000.pdf

2002 Proposed 303(d) List: http://www.adeq.state.ar.us/water/pdfs/documents/303(d)_list_proposed_020426.pdf

1998 Arkansas 303(d) List: http://www.adeq.state.ar.us/water/303drprt.htm

Water Quality Standards for Surface Waters, effective Feb.1998, amended January 2001:
http://www.adeq.state.ar.us/regs/files/reg02_final_010917.pdf

Physical, Chemical, and Biological Characteristics of Least-Disturbed Reference Streams in Arkansas' Ecoregions, Volume 1: Data Compilation, and *Volume 2: Data Analysis*. ADEQ Water Division. 1987.

Water Quality Planning Branch, list of publications: http://www.adeq.state.ar.us/water/pdfs/documents/publist.pdf

ARKANSAS

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Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects and specific river basins or watersheds)*
	✓	fixed station (i.e., water quality monitoring stations)
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
	✓	rotating basin
		other:

Stream Miles

Total miles *(determined using RF3 and the National Hydrography Database)*	**87,617**
Total perennial miles	28,408
Total miles assessed for biology*	**245 stream segments**
fully supporting for 305(b)	n/a
partially/non-supporting for 305(b)	n/a
listed for 303(d)	n/a
number of sites sampled *(on an annual basis)*	~450
number of miles assessed per site	–

*Currently, biological monitoring occurs as either 1) part of intensive watershed survey where water quality problems have been previously identified; 2) part of a site specific survey, wasteload allocation; and 3) most recently as part of expanding ecoregion reference stream data. Biological data are not used to list any 303(d) waters.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Single Aquatic Life Use, Fishery Based Uses and Warm Water vs. Cold Water	
ALU designations in state water quality standards	Two designations: Ecologically sensitive waterbodies protecting endangered, threatened, and endemic aquatic species. Fisheries are divided into Trout, Lakes and Reservoirs, and Streams (further subdivided by ecoregion).	
Narrative Biocriteria in WQS	Procedures used to support narrative biocriteria are currently found in the project specific QAPP. Additional methods and SOPs are being developed. NOTE: The development of criteria and standards is ongoing.	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
		monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Currently, baseline data has been collected from numerous locations prior to BMP implementation and NPDES limit changes. Follow-up monitoring has occurred at some locations below point sources. No follow-up monitoring has occurred at nonpoint source locations.	

Reference Site/Condition Development

Number of reference sites	**75 total**	
Reference site determinations	✓	site-specific
	✓	paired watersheds
	✓	regional (aggregate of sites)
	✓	professional judgment
	✓	other: upstream/downstream
Reference site criteria	Water quality and habitat is typical of background ecoregion conditions. Watershed is somewhat undisturbed.	
Characterization of reference sites within a regional context	✓	historical conditions
	✓	least disturbed sites
		gradient response
	✓	professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
	✓	stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
	✓	other: watershed size, habitat, water quality
Additional information	✓	reference sites linked to ALU
	✓	reference sites/condition referenced in water quality standards *(found in ADPC&E 1987 - WQ87-06-01 & 02)*
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(100-500 samples/year; single season, multiple sites - watershed level and broad coverage; multiple seasons, multiple sites)*
	✓	fish *(<100 samples/year; single season, multiple sites - watershed level and broad coverage)*
		periphyton
		other:

Benthos	
sampling gear	D-frame; 200-400 micron mesh
habitat selection	riffle/run (cobble), multihabitat and woody debris
subsample size	100 count
taxonomy	combination - family, genus and species
Fish	
sampling gear	backpack and boat electrofisher, pram unit (tote barge) and seine; 3/16" and 1/4" mesh
habitat selection	pool/glide, riffle/run (cobble), and multihabitat
sample processing	anomalies
subsample	whole samples are sorted and identified to species
taxonomy	species and life stage
Habitat assessments	visual based with limited quantitative measurements and hydrogeomorphology, pebble counts, flows and canopy cover; performed with bioassessments
Quality assurance program elements	quality assurance plan, periodic meetings and training for biologists, sorting and taxonomic proficiency checks, specimen archival, and standard operating procedures (in development stage)

Data Analysis and Interpretation

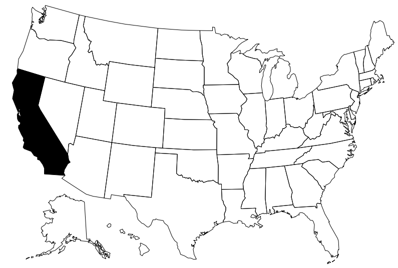
Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
	✓	multivariate analysis
	✓	biological metrics *(aggregate metrics into an index and return single metrics - use endpoint for each single metric)*
	✓	disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	As a percent of either the reference site or based on ecoregion data dependent upon standard deviation units
defining impairment in a multimetric index	As a percent of either the reference site or based on ecoregion data dependent upon standard deviation units
Multivariate thresholds	
defining impairment in a multivariate index	As a percent of either the reference site or based on ecoregion data dependant upon standard deviation units

Evaluation of performance characteristics		repeat sampling
		precision
Not currently evaluated		sensitivity
		bias
		accuracy

Biological data	
Storage	Microsoft databases
Retrieval and analysis	none

CALIFORNIA



Contact Information

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California Aquatic Bioassessment Workgroup homepage: http://www.dfg.ca.gov/cabw/cabwhome.html

Program Description

Historically, the use of bioassessment data in California water regulations and decision-making has not been a high priority. California's tremendous range of ecological diversity and its equally complex history of land and water use have confounded progress towards implementation of a state-wide bioassessment program. The recent organization of California's Surface Water Ambient Monitoring Program (SWAMP) is providing the impetus to implement a better organized and standardized biological assessment and monitoring program throughout the state. Current concerns over hydroaugmentation and use attainability analyses of targeted waterbodies will foster a greater dependence upon bioassessment information in making informed decisions regarding the protection and restoration of California's streams.

Nine regional boards are essentially independent regulatory entities within the California State Water Resources Control Board (SWRCB). Not all regional boards are at the same level of development regarding bioassessment. One of the first management actions advancing bioassessment in CA was in 1993 when the Lahontan Regional Water Quality Control Board (RWQCB 6) required the use of EPA's Rapid Bioassessment Protocols in a fish hatchery permit. Since that time, the use of bioassessment in water resource decision-making has steadily increased. Presently, bioassessment is used by several RWQCBs for a variety of purposes, including to: assess the impacts of human activities on the biological integrity of streams and rivers; evaluate the effectiveness of restoration efforts, BMP implementation, and permit conditions; develop narrative and numeric biocriteria; establish reference conditions; provide baseline data on the benthic macroinvertebrate community in regional streams; determine the biological health of streams relative to land use in specific watersheds; help identify aquatic life stressors and associated development of ecological indicators in agriculturally dominated and effluent dominated waterbodies; and as an additional tool to NPDES and stormwater permitting to supplement the chemical and toxicological information obtained to address chemical standards.

The California Department of Fish and Game's (CA DFG) Water Pollution Control Laboratory and its Aquatic Biological Assessment Laboratory (ABAL) perform macroinvertebrate sampling and identification, fish surveys, physical/habitat surveys, toxicity testing, sedimentation studies, and tissue and water chemistry. Since 1992, the ABAL has conducted projects covering many different applications of biological monitoring throughout California. These projects have demonstrated bioassessment and promoted the effectiveness of bioassessment in the State.

In 1993, ABAL distributed a set of standard protocols for assessing biological and physical conditions of wadeable streams. The California Stream Bioassessment Procedures (CSBP) are regional adaptations of the national USEPA Rapid Bioassessment Protocols. The DFG, in cooperation with the SWRCB and USEPA Region 9, also established the California Aquatic Bioassessment Workgroup (CABW) to provide input and guidance for the development of a state-wide bioassessment program. The Workgroup was formed in 1994 to coordinate scientific and policy-making efforts towards implementing aquatic bioassessment in California. Members of the CABW consist of biologists from universities, consulting firms, industry, and representatives of state and federal agencies responsible for assessing, monitoring and protecting the biological integrity of surface waters. Through its Steering Committee and annual meetings, CABW participants develop objectives and strategies for implementing aquatic bioassessment in California.

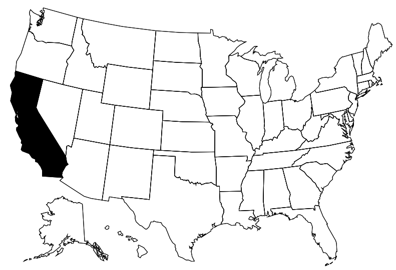
Documentation and Further Information

State Water Resources Control Board. October 2000. *2000 California 305(b) Report on Water Quality*. Sacramento, CA: SWRCB.

Status of Aquatic Bioassessment in California and the Development of a State-wide Bioassessment Program, prepared by the California Department of Fish and Game Aquatic Biological Assessment Laboratory: http://www.dfg.ca.gov/cabw/status.html

California Stream Bioassessment Procedure (CSBP): http://www.dfg.ca.gov/cabw/protocols.html

CALIFORNIA



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email: jharring@ospr.dfg.ca.gov

Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(specific river basins or watersheds)*
	✓	fixed station (i.e., water quality monitoring stations) *(specific river basins or watersheds)*
	✓	probabilistic by stream order/catchment area *(specific river basins or watersheds)*
	✓	probabilistic by ecoregion, or statewide *(specific river basins or watersheds)*
	✓	rotating basin *(comprehensive use throughout jurisdiction)*
		other:

Stream Miles

Total miles	**211,513**
Total perennial miles	64,438
Total miles assessed for biology*	**unknown**
fully supporting for 305(b)	unknown
partially/non-supporting for 305(b)	unknown
listed for 303(d)	unknown
number of sites sampled	unknown
number of miles assessed per site	unknown

*Due to a comprehensive, statewide overhaul of California's database system, SWRCB was unable to break out numbers for stream miles assessed using biology.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis		Fishery Based Uses, Warm Water vs. Cold Water
ALU designations in state water quality standards		Regional Water Quality Boards have a Basin Planning function. Therefore, water quality standards are regionally specific for establishing functional uses, criteria, and implementation plans.
Narrative Biocriteria in WQS		Regional water quality standards contain generic statements for the overarching protection of biological communities with an emphasis on, but not limited to, fisheries. Procedures to support narrative biocriteria are regionally specific.
Numeric Biocriteria in WQS		none
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU		Limited to select studies where biological data are used for management decisions regarding urban development.

Reference Site/Condition Development

Number of reference sites		**~ 200 - 300 total**
Reference site determinations		site-specific
		paired watersheds
		regional (aggregate of sites)
	✓	professional judgment
	✓	other: CA DFG is in the process of developing a more quantitative method of selecting reference sites on a regional basis using GIS land use analyses and quantitative physical habitat measures.
Reference site criteria		under development
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
	✓	other: stream order
Additional information		reference sites linked to ALU
	✓	reference sites/condition referenced in water quality standards *(varies by region)*
	✓	some reference sites represent acceptable human-induced conditions

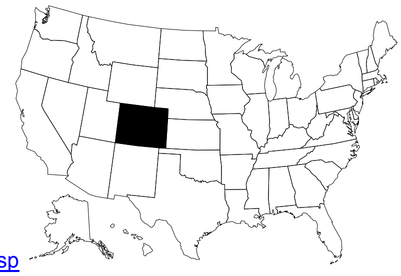
Field and Lab Methods

Assemblages assessed	✓	benthos *(>500 samples/year; varying levels of rigor)*
		fish
		periphyton
		other:
Benthos		
sampling gear		D-frame; 200 - 400 micron mesh (Sierra Nevada Aquatic Research Laboratory), 500 - 600 micron mesh (California Stream Bioassessment Procedure)
habitat selection		riffle/run (cobble)
subsample size		300 - 500 count (Sierra Nevada Aquatic Research Laboratory), 300 count (CSBP)
taxonomy		lowest possible, usually genus or species
Habitat assessments		visual based; performed with bioassessments
Quality assurance program elements		standard operating procedures, sorting and taxonomic proficiency checks

Data Analysis and Interpretation

Data analysis tools and methods		summary tables, illustrative graphs
	✓	parametric ANOVAs
	✓	multivariate analysis
	✓	biological metrics *(return single metrics – use endpoint for each single metric)*
		disturbance gradients
		other:
Multimetric thresholds		
transforming metrics into unitless scores		bar graph distribution function
Multivariate thresholds		
defining impairment in a multivariate index		under development
Evaluation of performance characteristics		repeat sampling
	✓	precision
		sensitivity
		bias
		accuracy
Biological data		
Storage		Central Coast Ambient Monitoring Program (CCAMP) regional database
Retrieval and analysis		CalEDAS

COLORADO



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Program Description

The Monitoring Unit of the Water Quality Control Division, Colorado Department of Public Health and Environment (CDPHE), is responsible for designing studies and collecting chemical, physical, and biological data from a statewide network of sampling stations. Personnel from the Assessment Unit of the Water Quality Control Division evaluate this information, along with data from other agencies. Using a watershed-specific approach, the seven major watersheds within the State of Colorado are assessed sequentially as part of the triennial review of water quality standards and classifications. In addition, specific waterbodies are assessed as part of targeted synoptic studies, site-specific studies, and as required for evaluating waterbodies listed on the State of Colorado's 303(d) list.

Most biological assessments are performed to evaluate aquatic life use classifications and to support standards development. Biological assessments have occasionally been used to determine attainment of aquatic life uses or attainment of provisional sediment standards. However, chemical information from surface water samples is primarily used to assess use support determinations as reported in the State of Colorado's biennial Status of Water Quality report. Biologists in the Monitoring Unit are actively developing biocriteria to more effectively utilize biological information as part of the State of Colorado's water quality standards program. Initially, biocriteria will be developed for benthic macroinvertebrates. Over the last four years, biologists in the Monitoring Unit have collected benthic macroinvertebrate samples from approximately 300 potential reference/least impaired sites from all dominant ecoregions within the State of Colorado. This data is currently being evaluated. Combined with information on physical habitat and water chemistry, this benthic macroinvertebrate data will be used to develop provisional region-specific biocriteria. Once developed, these provisional biocriteria will be evaluated using new benthic macroinvertebrate information, and further refined as needed. It is anticipated that benthic macroinvertebrate biocriteria will be used as an assessment tool to support the water quality standards and classification programs within the State of Colorado. Biocriteria based on fishery information may be developed in the future.

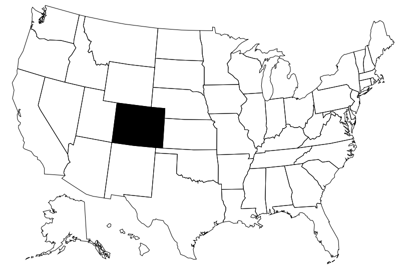
Documentation and Further Information

Colorado's 2002 305(b) report and 1998 303(d) list: http://www.cdphe.state.co.us/op/wqcc/wqresdoc.html

Draft 2001 Unified Assessment Methodology, *Guidance on Data Requirements and Data Interpretation Methods Used in Stream Standards and Classification Proceedings*, July 1993:
http://www.cdphe.state.co.us/wq/Assessment/assessment_practices_and_methods.htm

Water Quality in Colorado 2000: http://www.cdphe.state.co.us/wq/waterqualitybooklet.pdf

COLORADO



Contact Information

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Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	UD	promulgated into state water quality standards as biocriteria
		support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
	✓	other: determine attainment of narrative sediment (clean) standard
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(comprehensive use throughout jurisdiction, specific river basins or watersheds, and special projects)*
	✓	fixed station (i.e., water quality monitoring stations) *(specific river basins or watersheds)*
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
	✓	rotating basin *(comprehensive use throughout jurisdiction)*
		other:

Stream Miles

Total miles *(determined using RF3)*	**107,403**
Total perennial miles	31,415
Total miles assessed for biology*	**n/a**
fully supporting for 305(b)	n/a
partially/non-supporting for 305(b)	n/a
listed for 303(d)	85.1
number of sites sampled *(on an annual basis)*	~70 -100
number of miles assessed per site	–

*Colorado does not use bioassessment in 305(b) assessments with some exceptions. Since Colorado's water quality standards are chemically oriented, the majority of use support determinations are based on chemical data. Bioassessments are conducted as part of the Triennial Standards Review process for Colorado's seven major watersheds; a few are used in the determination of aquatic life use and sediment standards attainment. The majority of CDPHE's work in the field is spent conducting bioassessments in preparation for the review process. During the review process, the Water Quality Control Commission uses biological data to determine the appropriate aquatic life use classification for 636 stream segments. Once classifications are set, all further water quality monitoring and assessment is chemical.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Class System, Warm Water vs. Cold Water	
ALU designations in state water quality standards	Three classifications: Class 1 Cold Water Aquatic Life, Class 1 Warm Water Aquatic Life, Class 2 Cold and Warm Water Aquatic Life	
Narrative Biocriteria in WQS	under development*	
Numeric Biocriteria in WQS	none*	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
		monitoring (e.g., improvements after mitigation)
		watershed based management
Uses of bioassessment/ biocriteria uses in making management decisions regarding restoration of aquatic resources to a designated ALU	Bioassessment endpoints are used as targets in the attainment of the sediment standard (e.g. TMDL development).	

*ALU classifications are defined in Colorado's water quality standards but are not considered to be formal narrative biocriteria in the CO regulatory process. Colorado is presently developing biocriteria through a stakeholder workgroup process.

Reference Site/Condition Development**

Number of reference sites	**300 total potential reference/least impaired sites**	
Reference site determinations	✓	site-specific
		paired watersheds
		regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria	The condition of candidate sites is verified through field evaluation using a "checklist" of stream attributes that include, but are not limited to, measures of riparian condition, Rosgen channel type, land use, basin characteristics, physical habitat, substrate, chemistry, geology, vegetation, and climate.	
Characterization of reference sites within a regional context	✓	historical conditions
	✓	least disturbed sites
		gradient response
	✓	professional judgment
	✓	other: minimally disturbed***
Stream stratification within regional reference conditions	UD	ecoregions (or some aggregate)
		elevation
	✓	stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information	n/a	reference sites linked to ALU
	n/a	reference sites/condition referenced in water quality standards
	n/a	some reference sites represent acceptable human-induced conditions

**Reference condition is used on a limited basis in Colorado. Currently, it is used as a key component in determining sediment deposition impacts to aquatic life and has been used in the first stages of biocriteria development, to locate sampling sites, as part of various EMAP studies underway in CO, and in the development of regional nutrient criteria. The reference condition approach is not developed enough to be an established part of biological assessments or the standards setting process in Colorado. Most, if not all, assessments are conducted on a case-by-case or site-specific basis, and although CO does attempt to characterize the "expected condition" for a particular waterbody, it is not treated as a formal reference condition.

***Sediment guidance suggests 3 tiers for reference conditions like those described in the 1996 EPA technical guidance for biological criteria: 1) minimally disturbed, 2) best available (least disturbed), and 3) none acceptable ("hypothetical explanation"). These can be considered individually and in combination.

Field and Lab Methods*

Assemblages assessed	✓	benthos *(100 - 500 samples/year; single season, multiple sites - watershed level)*
	✓	fish *(<100 samples/year; single season, multiple sites - not at watershed level)*
	UD	periphyton *(<100 samples/year; single season, multiple sites - watershed level)*
		other:

Benthos	
sampling gear	Surber, dipnet; 500 - 600 micron mesh
habitat selection	riffle/run (cobble) or most productive habitat if riffle/run is not available
subsample size	300 count
taxonomy	lowest possible level with positive identification
Fish	
sampling gear	backpack electrofisher
habitat selection	multihabitat
sample processing	length measurement
subsample	none
taxonomy	species
Periphyton	
sampling gear	**natural substrate**: brushing/scraping device (razor, toothbrush, etc), collect by hand
habitat selection	riffle/run (cobble)
sample processing	chlorophyll *a*/ phaeophytin, taxonomic identification
taxonomy	all algae, species level
Habitat assessments	visual based, hydrogeomorphology, pebble counts; performed with bioassessments
Quality assurance program elements	standard operating procedures, periodic meetings and training for biologists, specimen archival

*Field and lab methods reported are those used by the Monitoring Unit of the CDPHE Water Quality Control Division and are patterned after the EPA RBP approach. They do not apply to any of the other agencies collecting biological data in Colorado.

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(return single metrics)*
		disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	impairment thresholds determined on case-by-case basis as part of site-specific analyses
defining impairment in a multimetric index	Colorado is currently exploring possible metrics and indices through a workgroup process.

Evaluation of performance characteristics		repeat sampling
	✓	precision *(replicate samples collected at 10% of sites)*
		sensitivity
		bias
		accuracy

Biological data	
Storage	Currently moving all biological and habitat data into EDAS
Retrieval and analysis	EDAS, Excel, Minitab

CONNECTICUT

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Program Description

The Connecticut Ambient Biological Monitoring Program characterizes water quality by evaluating the biological integrity of resident communities of aquatic organisms. This information is used as the primary indicator to meet reporting requirements for assessment of aquatic life use support and impairment under Sections 305(b) and 303(d) of the Clean Water Act. There are currently about 3.5 full time employees dedicated to biological assessment of rivers. Biological monitoring has been conducted by the CT DEP Bureau of Water Management since the early 1970s and has focused primarily on the benthic invertebrate community of wadeable stream segments. Narrative criteria for benthic invertebrates were incorporated into the CT water quality standards in 1987. Assessments are based on community structure characteristics using techniques intended to minimize the influence of variables such as habitat, seasonality and sampling method. Since 1989, methodology has followed a modified version of the USEPA Rapid Bioassessment Protocol (RBP) III (USEPA 1989).

A total of 302 sites on 153 rivers have been monitored to date (February 2002). Pursuant to the five-year rotating basin monitoring strategy that began in 1996, benthic invertebrate monitoring was conducted at approximately 50 sites each year for the five-year period ending in 2000. Since biological monitoring integrates environmental conditions over an extended time period, each site was sampled only once, primarily during the fall. Spring sampling is conducted on a limited basis for special studies or to supplement fall sampling. Sampling site selection is based on a targeted approach that considers sub-basin size, location of wastewater discharges, land use, and resource value. In addition to the rotating basin schedule, approximately ten regional reference sites located across the State are sampled annually, as well as a limited number of sites to support special projects.

The Bureau of Water Management recognizes the need to obtain a broader perspective of biological integrity by incorporation of fish community assessment data into the biological monitoring process. This has been accomplished to a limited degree by a cooperative working relationship with the CT DEP Division of Inland Fisheries. Fish sampling information obtained by fisheries biologists for purposes consistent with the fisheries management program has been utilized in the form of best professional judgment assessments which CT DEP considers to be generally equivalent to USEPA RBP IV (USEPA 1989). Funds obtained through an EPA 104(b)(3) grant have supported part of a Fisheries Division staff position since 1999. This effort has provided for approximately 24 fish community surveys, roughly equivalent in effort to annual RBP V assessment. This project is intended to support development of fish community structure metrics that will provide a more quantitative approach to the assessment process.

The CT DEP also promotes and directs a monitoring program for volunteers from which usable assessment information is obtained. The details of this program, *A Tiered Approach to Citizen-Based Monitoring of Wadeable Streams and Rivers*, can be obtained from the CT DEP Bureau of Water Management or viewed online at http://dep.state.ct.us/wtr/volunmon/tierapp.pdf

Section 305(b) of the CWA requires that states provide a description of the water quality of all navigable waters within their boundaries. Even with program improvements resulting from the rotating basin approach and incorporation of volunteer data, a complete census of State waters is not possible based on this focused approach to monitoring. To accomplish the goal of comprehensive monitoring, CT DEP is currently utilizing funds and technical assistance from USEPA to conduct a pilot statewide probabilistic monitoring program during 2002-2003. This project will sample the benthic invertebrate, fish, and periphyton communities at approximately 60 randomly selected sites. Through probabilistic monitoring, this statistically valid sample of wadeable streams in Connecticut will provide an estimate of conditions of all wadeable streams in the State. During this two-year period, the rotating basin approach will be suspended. However, limited focused monitoring will continue for reference sites, special projects, intensive surveys and to support TMDL development.

Documentation and Further Information

DRAFT *2002 List of Connecticut Waterbodies Not Meeting Water Quality Standards*, 303(d) list, May 2002: http://dep.state.ct.us/wtr/wq/implist.pdf

Draft Consolidated Assessment and Listing Methodology for 305(b) and 303(d) Reporting, April 2002: http://dep.state.ct.us/wtr/wq/method.pdf

Quality Assurance Project Plan for Ambient Biological Monitoring, March 1996. CT DEP Bureau of Water Management, Planning and Standards Division, CT06106.

Beauchene, M. 2002. *Quality Assurance Project Plan, Ambient Biological Monitoring -- Fish Community Structure*. CT DEP Bureau of Water Management.

Ambient Monitoring Strategy for Rivers and Streams, Rotating Basin Approach. CT DEP 1999.

CONNECTICUT

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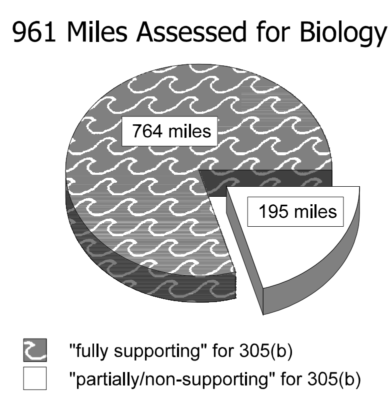
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) (*special projects, specific river basins and watersheds, and comprehensive use throughout jurisdiction)*
	✓	fixed station (i.e., water quality monitoring stations) (*special projects, specific river basins and watersheds, and comprehensive use throughout jurisdiction)*
		probabilistic by stream order/catchment area
	✓	probabilistic by ecoregion, or statewide *(comprehensive use throughout jurisdiction beginning in 2002 and 2003)*
	✓	rotating basin (*comprehensive use throughout jurisdiction)*
		other:

Stream Miles

Total miles *(State based determinations)*	**5,830**
Total perennial miles	5,484
Total miles assessed for biology	**961**
fully supporting for 305(b)	764
partially/non-supporting for 305(b)	195
listed for 303(d)*	n/a
number of sites sampled*	311
number of miles assessed per site*	site specific



*The existing 303(d) doesn't use mileage, although it contains a subset of partially/non-supporting stream miles listed in the 305(b). These numbers will be the same in the next report. Of the 311 sites sampled, 221 were sampled by the state, 30 by contractors and 60 by volunteers. The number of miles assessed per site is site specific and varies according to land use, geomorphology, etc.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Class System (A,B,C)	
ALU designations in state water quality standards	"Fish and Wildlife Habitat" is the only ALU designation, but narrative criteria are provided for "benthic invertebrates which inhabit lotic waters" for classifications AA, A, and B while more general descriptive narrative is provided for C and D.	
Narrative Biocriteria in WQS	Procedures used to support narrative biocriteria located in *SOPs for ambient biological monitoring*	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Bioassessment/biocriteria have been used in specific cases to determine if formerly impaired waters are meeting ALU.	

Reference Site/Condition Development

Number of reference sites	**12 total**	
Reference site determinations	✓	site-specific
		paired watersheds
		regional (aggregate of sites)
		professional judgment
	✓	other: within major drainage basin
Reference site criteria	Least impacted by human influence. Size: ± one stream order or one order of magnitude in drainage area with similar gradient.	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions		ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
	✓	other: major drainage basin, gradient
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(<100 samples/year; single season, multiple sites - watershed level; multiple seasons, multiple sites - broad coverage for watershed level)*
	✓	fish *(<100 samples/year; single season, multiple sites - broad coverage)*
	✓	periphyton *(<100 samples/year; single season, multiple sites - broad coverage)*
	✓	other: phytoplankton and macrophytes *(<100 sample/year; single season, multiple sites - not at watershed level)*

Benthos	
sampling gear	Rectangular kick net, 1.5 ft. wide, 800-900 micron mesh. Surber and multiple plate samplers used prior to 1989. Rock baskets used for special projects.
habitat selection	richest habitat, riffle/run (cobble)
subsample size	200 count
taxonomy	benthic identification is primarily to species
Fish	
sampling gear	backpack electrofisher, pram unit (tote barge)
habitat selection	multihabitat
sample processing	length measurement, anomalies
subsample	none
taxonomy	species
Periphyton	
sampling gear	**natural substrate**: brushing/scraping device (razor, toothbrush, etc.)
habitat selection	riffle/run (cobble)
sample processing	chlorophyll *a*/ phaeophytin; biomass; taxonomic identification; semi-quantitative field-based rapid periphyton survey
taxonomy	all algae, species level if possible
Habitat assessments	visual based; performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings and training for biologists, sorting and taxonomic proficiency checks, specimen archival

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	Use scoring criteria table from 1989 Rapid Bioassessment Protocol (RBP) guidance (Figure 6.3-4). CT DEP recognizes the need to refine scoring criteria and impairment thresholds.
defining impairment in a multimetric index	Use biological condition table from 1989 RBP guidance (Figure 6.3-4): >54% of reference score = non-impaired for purposes of 305(b)/303(d)

Evaluation of performance characteristics	✓	repeat sampling *(duplicate samples at reference sites)*
		precision
		sensitivity
		bias
		accuracy

Biological data	
Storage	Initial sample data is entered into an Excel spreadsheet then transferred to MS Access. Currently working on migration from MS Access to STORET.
Retrieval and analysis	Spreadsheet used for metric calculation. Formerly used SAS. Currently shopping for less expensive statistical package.

DELAWARE

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http://www.dnrec.state.de.us/dnrec2000/Divisions/Water/WaterQuality/WQM.htm

Program Description

Water quality and biological data for Delaware's surface waters are collected under Delaware's Ambient Surface Water Quality Monitoring Program and Biological Monitoring Program within the Delaware Department of Natural Resources and Environmental Control (DNREC). Several active citizen monitoring programs have also been developed throughout Delaware that augment the data collected by DNREC. The purpose of the Ambient Surface Water Quality Monitoring Program is to collect data on the chemical, physical, and biological characteristics of Delaware's surface waters. The information collected under this program is used to:

- Describe general water quality conditions in the State;
- Identify long-term trends in water quality;
- Determine the suitability of Delaware's waters for water supply, recreation, fish and aquatic life, and other uses;
- Monitor achievement of water quality standards;
- Identify and prioritize high quality and degraded waters;
- Support Total Maximum Daily Load Program; and
- Evaluate the overall success of Delaware's water quality management efforts.

DNREC recognizes the need to use its personnel and financial resources efficiently and effectively. To that end, surface water quality monitoring is conducted in a manner that focuses available resources on the Whole Basin Management concept. This program calls for the Department, in partnership with other governmental entities, private interests, and all stakeholders, to focus its resources on specific watersheds and basins (groups of watersheds) within specific time frames. The Whole Basin Management Program in Delaware operates on a 5-year rotating basis. In addition to the planning and preliminary assessment steps, Whole Basin Management will include intensive basin monitoring, comprehensive analyses, management option evaluations, and resource protection strategy development. Public participation and ongoing implementation activities will occur throughout the Whole Basin Management process. This new approach enables DNREC to comprehensively monitor and assess the condition of the State's environment with due consideration to all facets of the ecosystem.

Biological assessment monitoring is one of five major components of Delaware's Surface Water Quality Monitoring Program. The biological monitoring program is a major tool used by the Department to assess the conditions of surface waters. It includes the assessment of indigenous biological communities and physical habitats of streams, ponds, estuaries and wetlands. The goal of the program is to establish numeric biological criteria in State water quality standards to complement both existing chemical criteria and other assessments focused on fish tissue monitoring and bioassay testing. Standard methods have been developed and tested for assessing the biological community and habitat quality of nontidal streams, and draft numeric criteria are under development. Efforts over the next few years will focus on the development of methods for assessing estuaries and ponds and for assessing the quality and quantity of wetlands.

Documentation and Further Information

State of Delaware 2000 Watershed Assessment 305(b) Report and 1998 303(d) List:
http://www.dnrec.state.de.us/water2000/Sections/Watershed/TMDL/305and303.htm

DE Surface Water Quality Standards: http://www.dnrec.state.de.us/water/wqs1999.pdf

State of Delaware Fiscal Year 2000 Surface Water Quality Monitoring Plan:
http://www.dnrec.state.de.us/dnrec2000/Library/Water/swmonpro.pdf

Division of Water Resources 2000 Annual Report: http://www.dnrec.state.de.us/water2000/Public/2000AnnualReport/index.htm

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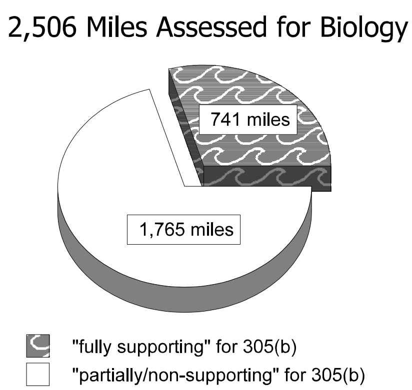
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
		nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
		ALU determinations/ambient monitoring
		promulgated into state water quality standards as biocriteria
		support of antidegradation
		evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects only)*
	✓	fixed station (i.e., water quality monitoring stations) *(specific riverbasins or watersheds)*
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
		rotating basin
	✓	other: probabilistic by specific county *(used comprehensively throughout state)*

Stream Miles

Total miles *(determined using RF3)*	**2,506**
Total perennial miles	1,778
Total miles assessed for biology*	**2,506**
fully supporting for 305(b)*	741
partially/non-supporting for 305(b)*	1,765
listed for 303(d)*	1,173
number of sites sampled *(1991 - 2001)***	195
number of miles assessed per site	–



*All of DE's streams were assessed for the 2000 305(b) Report. These numbers represent the miles assessed for aquatic life support using a combination of physical, chemical, and biological data.

**These sampling stations were EMAP based. Of the 195 total sites sampled, 49 sites have not yet been assessed. Of the 146 sites assessed, 27 are fully supporting and 119 are partially/non-supporting.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Single Aquatic Life Use and Warm Water vs. Cold Water	
ALU designations in state water quality standards	Two designations: 1) Fish, Aquatic Life, and Wildlife; 2) Cold Water Fish	
Narrative Biocriteria in WQS	none - Procedures used to support general aquatic life statements in WQS are those developed by the Mid Atlantic Coastal Streams (MACS) Workgroup.	
Numeric Biocriteria in WQS	Draft numeric criteria are under development.	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
		cause and effect determinations
		permitted discharges
		monitoring (e.g., improvements after mitigation)
		watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Some streams have been placed on the State's 303(d) list for poor biology/habitat.	

Reference Site/Condition Development

Number of reference sites	**13 total**	
Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria	Least impacted, land use, habitat score >110 out of 140, no point source discharge, no known direct discharge from animal feedlots or urban runoff, professional judgment.	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(<100 samples/year; single season, multiple sites - broad coverage)*
		fish
		periphyton
		other:

Benthos	
sampling gear	D-frame and kick net (1 meter); 500-600 micron mesh
habitat selection	riffle/run (cobble) in Piedmont ecoregion, and multihabitat in Coastal Plain ecoregion
subsample size	200 count
taxonomy	genus
Habitat assessments	visual based; performed with bioassessments
Quality assurance program elements	standard operating procedures, periodic meetings and training for biologists, sorting proficiency checks, specimen archival, and a QAPP for biological work is under development

Data Analysis and Interpretation

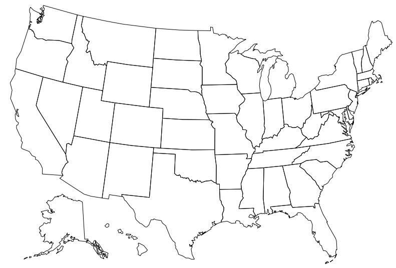
Data analysis tools and methods		summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	95th percentile of all sites
defining impairment in a multimetric index	< 67% of reference is impaired to some degree

Evaluation of performance characteristics	✓	repeat sampling *(replicate samples are collected at every 10 sites by the same team, at the same reach or an adjacent reach)*
		precision
		sensitivity
		bias
		accuracy

Biological data	
Storage	MS Access and Excel
Retrieval and analysis	Excel

DISTRICT OF COLUMBIA



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http://dchealth.dc.gov/services/administration_offices/environmental/services2/water_division/index.shtm

Program Description

The mission of DC's Department of Health (DC DOH), Environmental Health Administration, Water Quality Division is to restore and protect the surface and ground waters of the District of Columbia. The program, established under the authorities of the DC Water Pollution Control Act and the federal Clean Water Act (CWA), has three principal components:

Water Quality Control
The Water Quality Control component fulfills the function of policy planning as well as regulatory control. In addition, it conducts special studies on pollutant fate and transport to identify probable sources and impacts, river/stream sediment and water column quality not covered by ambient monitoring, wet weather nonpoint source runoff quantity and quality, and discharge-related facility inspections. It also tracks permit violations.

Water Quality Monitoring
Water Quality Monitoring functions encompass waterbody assessment; collection of ambient water quality data; periodic fish tissue analysis for parameters of concern such as PCB, chlordane, and DDT; periodic submerged aquatic vegetation survey; and bioassessment of wetlands and river fringes.

Environmental Laboratory
The Environmental Laboratory is charged with the analysis of samples for a variety of chemical parameters.

Documentation and Further Information

District of Columbia 2000 305(b) Report, Executive Summary:
http://dchealth.dc.gov/services/administration_offices/environmental/services2/water_division/pdf/00-305bexsumm.shtm

District of Columbia Water Quality Standards:
http://dchealth.dc.gov/services/administration_offices/environmental/services2/water_division/pdf/WaterQualityStandards.shtm

District of Columbia Water Quality Monitoring Regulations (Chapter 19 of DC Municipal Regulations):
http://dchealth.dc.gov/services/administration_offices/environmental/services2/water_division/pdf/WaterQualityMonitoring.shtm

DISTRICT OF COLUMBIA

Contact Information

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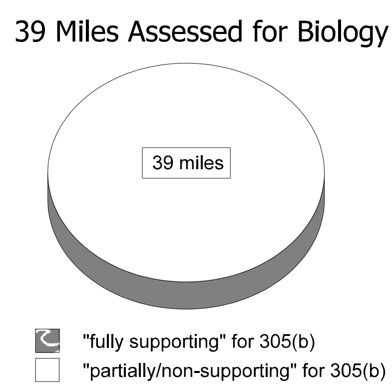
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
		nonpoint source assessments
		monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
		support of antidegradation
		evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects only)*
	✓	fixed station (i.e., water quality monitoring stations) *(comprehensive use throughout jurisdiction)*
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
		rotating basin
		other:

Stream Miles

Total miles *(determined using state based GIS coverage)*	**39**
Total perennial miles	–
Total miles assessed for biology	**39**
fully supporting for 305(b)	0
partially/non-supporting for 305(b)	39
listed for 303(d)	unknown
number of sites sampled	unknown
number of miles assessed per site	unknown



Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Single Aquatic Life Use
ALU designations in state water quality standards	One designation: Protection and propagation of fish, shellfish and wildlife
Narrative Biocriteria in WQS	Formal/informal numeric procedures are used to support narrative biocriteria
Numeric Biocriteria in WQS	none
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	☐ assessment of aquatic resources ☐ cause and effect determinations ☐ permitted discharges ☐ monitoring (e.g., improvements after mitigation) ☐ watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	unknown

Reference Site/Condition Development

Number of reference sites	**2 total**
Reference site determinations	☐ site-specific ☐ paired watershed ☐ regional (aggregate of sites) ✓ professional judgment ☐ other:
Reference site criteria	DC DOH does not have reference site criteria. All streams in DC are contaminated. DC DOH compares streams to reference streams in Prince Georges and Montgomery Counties in Maryland.
Characterization of reference sites within a regional context *Information not provided*	☐ historical conditions ☐ least disturbed sites ☐ gradient response ☐ professional judgment ☐ other:
Stream stratification within regional reference conditions	☐ ecoregions (or some aggregate) ☐ elevation ☐ stream type ☐ multivariate grouping ✓ jurisdictional (i.e., statewide) ☐ other:
Additional information	☐ reference sites linked to ALU ☐ reference sites/condition referenced in water quality standards ✓ some reference sites represent acceptable human-induced conditions

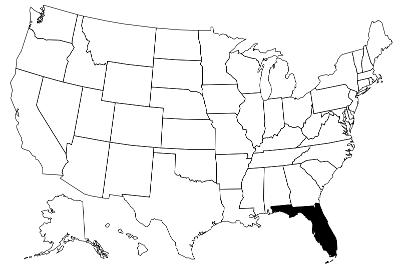
Field and Lab Methods

Assemblages assessed	✓	benthos *(<100 samples/year; single observation, limited sampling)*
	✓	fish *(<100 samples/year; single observation, limited sampling)*
		periphyton
	✓	other: phytoplankton and zooplankton *(<100 samples/year; single observation, limited sampling)*
Benthos		
sampling gear		D-frame, kick net (1 meter); mesh size information not provided
habitat selection		riffle/run (cobble)
subsample size		100 count
taxonomy		family
Fish		
sampling gear		backpack electrofisher
habitat selection		pool/glide, riffle/run (cobble)
sample processing		length measurement, biomass – individual
subsample		none
taxonomy		species
Habitat assessments		hydrogeomorphology; performed with bioassessments
Quality assurance program elements		standard operating procedures, quality assurance plan, periodic meetings and training for biologists

Data Analysis and Interpretation

Data analysis tools and methods		summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics
		disturbance gradients
		other:
Multimetric thresholds		
transforming metrics into unitless scores		*Information not provided*
defining impairment in a multimetric index		*Information not provided*
Multivariate thresholds		
defining impairment in a multivariate index		*Information not provided*
Evaluation of performance characteristics		repeat sampling
		precision
Information not provided		sensitivity
		bias
		accuracy
Biological data		
Storage		paper files only
Retrieval and analysis		data retrieved from paper files

FLORIDA



Contact Information

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FDEP Bioassessment homepage: http://www.dep.state.fl.us/water/bioassess/index.htm

Program Description

Biological sampling has been one component of the Florida Department of Environmental Protection's (FDEP) overall monitoring strategy since the early 1970s. The Bioassessment Program, in its current manifestation, has been in existence since 1992, in response to the need for tools that would detect and characterize the nature and extent of nonpoint source pollution (*sensu* the 319 program). The primary goal of FDEP's bioassessment activities are to determine the biological health, or degree of impairment, in the State's surface waters. The biological assessment results are heavily utilized by a number of FDEP programs for making informed environmental decisions:

- Total Maximum Daily Load (303(d)) program – determining the impairment status of waterbodies for potential inclusion on the 303(d) list
- The National Pollutant Discharge Elimination System (NPDES) program – determining effectiveness of discharge permit limits
- Nonpoint Source Program – targeting areas with nonpoint source problems and determining the effectiveness of Best Management Practices
- Rotating Basin Assessment program – overall assessment of all human activities in a watershed
- Mine Reclamation program – determining the success of mitigation efforts
- FDEP's Division of Waste Management – ensuring that clean up efforts are sufficient to protect aquatic life adjacent to waste clean up sites (e.g., RCRA).

Biological data are used in Florida's 305(b) report as one of the key pieces of Aquatic Life Use Support (ALUS) information for determining if a waterbody meets its designated use. Bioassessment data are also used for establishing the impairment status of a waterbody for 303(d) listing purposes.

After recalibration of bioassessment metrics and indices (currently underway), it is anticipated that Florida's water quality standards (Rule 62.302 Florida Administrative Code) will be revised accordingly. Although the primary target community for the bioassessment program is currently benthic macroinvertebrates, Florida is also working on potential assessment methods that use algal and vascular plant assemblages. While multimetric biological indices are currently complete for streams, rivers, and lakes, it is anticipated that ongoing index development for wetlands and estuaries will be finalized over the next several years.

The most important recent accomplishment of the Bioassessment Program has been the inclusion of the Stream Condition Index, the BioRecon, and Lake Condition Index as impairment indicator tools in Florida's Impaired Waters Rule (IWR), Rule 62-303, FAC. The IWR is a new administrative code that provides detailed specifications for how surface waters are determined to be impaired for Section 303(d) listing. Future challenges include incorporating the bioassessment tools into a Statewide probabilistic survey design, as well as continuing to meet the increasing demands for biological tools and data.

Documentation and Further Information

2000 Florida Water Quality Assessment 305(b) Report: http://www.dep.state.fl.us/water/305b/index.htm

Numerous technical reports are available online at http://www.dep.state.fl.us/labs/reports/index.htm and http://www.dep.state.fl.us/water/bioassess/pubs.htm

For an online collection of FDEP standard operating procedures, go to: http://www.dep.state.fl.us/labs/qa/sops.htm

Surface Water Quality Classifications: http://www.dep.state.fl.us/water/surfacewater/index.htm

FLORIDA

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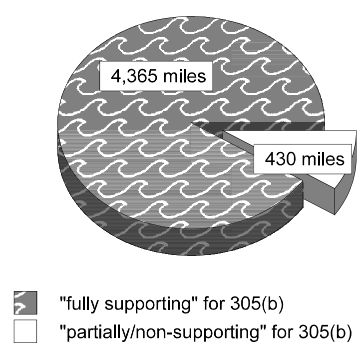
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
	✓	other: biocriteria development
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(comprehensive use throughout jurisdiction)*
		fixed station (i.e., water quality monitoring stations)
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
	✓	rotating basin *(5-year rotation, comprehensive use throughout jurisdiction)*
		other:

Stream Miles

Total miles *(determined using waterbody identification- segment of stream, generally 5 mile increments)*	**51,858**
Total perennial miles	22,993
Total miles assessed for biology	**4,795**
fully supporting for 305(b)	4,365
partially/non-supporting for 305(b)	430
listed for 303(d)	430
number of sites sampled (over 2 years)	959
number of miles assessed per site	5

4,795 Miles Assessed for Biology



Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Single aquatic life use	
ALU designations in state water quality standards	One designation: propagation of a healthy, well balanced fish and wildlife community	
Narrative Biocriteria in WQS	Procedures used to support narrative biocriteria located in FDEP's Standard Operating Procedures	
Numeric Biocriteria in WQS	Numeric biocriteria located in Rule 62-302 Florida Administrative Code – "Shannon-Weaver diversity shall not be reduced more than 25% of background conditions" *	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	TMDLs, restoration/mitigation studies, BMP effectiveness studies, discharge permit renewal	

*Florida has made substantial progress in developing new multimetric indices for streams (Stream Condition Index and BioRecon), lakes (Lake Condition Index), and wetlands for eventual inclusion in the Florida Administrative Code. When the new indices are adopted as water quality standards, the role of Shannon-Weaver diversity as a numeric standard will be re-evaluated.

Reference Site/Condition Development

Number of reference sites	**150 total**	
Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria	least impaired by human activities in a region, optimal habitat, benign land use in watershed, uncontaminated water quality, undisturbed hydrology	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
	✓	gradient response *(for recalibration of existing indexes)*
		professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

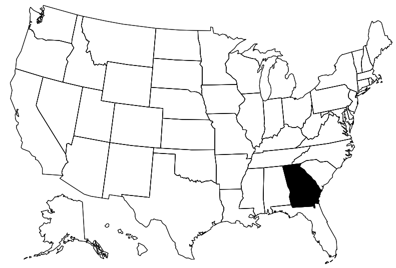
Field and Lab Methods

Assemblages assessed	✓	benthos *(100-500 samples/year; single season, multiple sites - watershed level)*
		fish
	✓	periphyton *(100-500 samples/year; single season, multiple sites - not at watershed level)*
	✓	other: phytoplankton, macrophytes *(100-500 samples/year; single observation, limited sampling)*
Benthos		
sampling gear		d-frame, dipnet (500-600 micron mesh), multiplate (Hester-Dendys)
habitat selection		multihabitat (snags, roots, leaf packs, aquatic vegetation)
subsample size		100-count target
taxonomy		species level (where possible)
Periphyton		
sampling gear		**natural substrate**: brushing/scraping device (razor, toothbrush, etc.), collect by hand **artificial substrate**: periphytometer, microslides or other suitable substratum
habitat selection		multihabitat
sample processing		chlorophyll *a*/phaeophytin, taxonomic identification
taxonomy		all algae, species level (diatoms to variety level)
Habitat assessments		visual based; performed with bioassessments
Quality assurance program elements		standard operating procedures, quality assurance plan, periodic meetings and training for biologists, sorting and taxonomic proficiency checks, specimen archival, habitat assessment tests, sampling field audits, sampling variability studies, performance testing program for bioassessment

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
	✓	disturbance gradients
		other:
Multimetric thresholds		
transforming metrics into unitless scores		25th percentile of reference population
defining impairment in a multimetric index		quadrasection of best score
Evaluation of performance characteristics	✓	repeat sampling *(same team, same reach; different teams in same reach)*
	✓	precision *(coefficient of variation)*
		sensitivity
		bias
	✓	accuracy *(species accumulation)*
Biological data		
Storage		custom Oracle-based program, “S-BIO”
Retrieval and analysis		custom Oracle-based program, “S-BIO”

GEORGIA



Contact Information

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GA DNR Environmental Protection Division: http://www.dnr.state.ga.us/dnr/environ/

Program Description

The Georgia Department of Natural Resources (GA DNR) Environmental Protection Division (EPD) monitoring program integrates physical, chemical, and biological monitoring to provide information for water quality, use attainment assessments, and basin planning. EPD monitors the surface waters of the state to collect baseline and trend data, document existing conditions, study impacts of specific discharges, determine improvements resulting from upgraded water pollution control plants, support enforcement actions, establish wasteload allocations for new and existing facilities, verify water pollution control plant compliance, document water use impairment and reasons for problems causing less than full support of designated water uses, and develop TMDLs. Intensive surveys; lake, coastal, biological, fish tissue, toxic substance, and trend monitoring; and facility compliance sampling are the major monitoring tools used by EPD.

Long-term, trend, and ambient monitoring of streams at strategic locations throughout Georgia, was initiated by EPD during the late 1960s. This work was and continues to be accomplished to a large extent through cooperative agreements with federal, state, and local agencies who collect samples from groups of stations at specific, fixed locations throughout the year.

In 1995, EPD adopted and implemented significant changes to the strategy for trend monitoring in Georgia. The changes were implemented to support the River Basin Management Planning program. The number of fixed stations statewide was reduced in order to focus resources for sampling and analysis in a particular group of basins in any one year in accordance with the basin planning schedule. This approach provides the framework for identifying, assessing, and prioritizing water resource issues, developing implementation strategies, and providing opportunities for targeted, cooperative actions to reduce pollution, enhance aquatic habitat, and provide a dependable water supply.

The Watershed Planning and Monitoring Section of the EPD Water Protection Branch performs the following tasks:

- Conducts monitoring of Georgia streams, rivers, lakes and estuaries for use with wasteload allocations and to determine compliance with water quality standards;
- Develops River Basin Management Plans for river basins in Georgia;
- Conducts water quality modeling for wasteload allocations, water use classifications, and water quality standards in Georgia; and
- Collects samples of facility discharges for laboratory testing of samples.

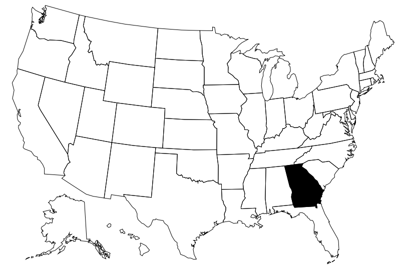
Currently, reference site selection and biocriteria development are being carried out under contract with Columbus State University. The project is in Phase III with projected completion in 2003. The final phase, Phase IV, is projected to be completed in 2004.

Documentation and Further Information

Georgia's 2000 305(b) Report, *Water Quality in Georgia, 1998-1999;* the *Final Georgia 2000 305(b)/303(d) List Documents*, including *Summary of Changes from the 2000 to 2002 305(b)/303(d) List*, can be found under Georgia's Environment, Water Quality in the Table of Contents at the following site:
http://www.dnr.state.ga.us/dnr/environ/

2000. DRAFT *Standard Operating Procedures for Freshwater Macroinvertebrate Biological Assessment*. Georgia Department of Natural Resources, Water Protection Branch, Atlanta, GA.

GEORGIA



Contact Information

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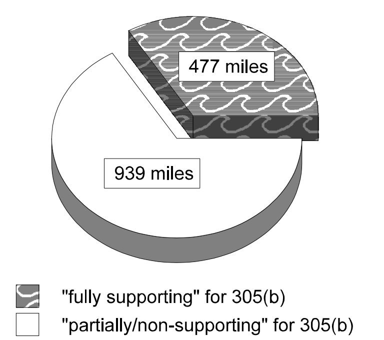
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(specific river basins or watersheds)*
	✓	fixed station (i.e., water quality monitoring stations) *(specific river basins or watersheds, and comprehensive use throughout jurisdiction)*
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
	✓	rotating basin *(comprehensive use throughout jurisdiction)*
		other:

Stream Miles

Total miles *(determined using state based coverage)*	**70,150**
Total perennial miles	44,056
Total miles assessed for biology*	**1,416**
fully supporting for 305(b)	477
partially/non-supporting for 305(b)	939
listed for 303(d)	–
number of sites sampled *(in 2000)*	153
number of miles assessed per site	varies

1,416 Miles Assessed for Biology



*In 2000, 72 stations were sampled and a total of 477 miles were assessed as fully supporting for 305(b) (6.6 miles assessed/station); 75 stations were sampled and a total of 799 miles were assessed as partially supporting (10.7 miles assessed/station); 6 stations were sampled and 140 miles were assessed as not supporting (23.3 miles assessed/station). This results in a total of 153 stations and 1,416 stream miles assessed in 2000 (9.25 miles assessed/station). The stream miles listed above are not divided into those monitored for biology versus chemistry because 305(b) reporting requirements use both types of data. The sampling length per site varies and the length of stream represented by each sample is determined by the surrounding hydrography.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Fishery Based Uses	
ALU designations in state water quality standards	Three designations: Coastal fishing; fishing, propagation of fish, shellfish, game, and other aquatic life; primary and secondary trout waters	
Narrative Biocriteria in WQS	Procedures used to support narrative biocriteria are located in the Environmental Protection Division's SOPs for macroinvertebrates and DNR/Wildlife Resources Division's IBI protocols for fish	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Fish IBI and macroinvertebrate assessments were conducted to evaluate approximately 80 previously 303(d)-listed sites in the last two years. While some sites were removed from the list others, found to be impaired due to (clean) sediment deposition, remained on the list.	

Reference Site/Condition Development

Number of reference sites	**Reference site selection is under development.**	
Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
		professional judgment
		other:
Reference site criteria	Columbus State University is using several criteria for selecting reference sites, including minimum overall habitat score, managed land, urban land, minimum forested riparian zone width, forested riparian zone in catchment, silviculture activity, and point source discharges. Reference sites would be defined as least-disturbed according to these criteria.	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(100-500 samples/year; single season, multiple sites - watershed level)*
	✓	fish *(100-500 samples/year; single season, multiple sites - watershed level)*
		periphyton
		other:
Benthos		
sampling gear		collect by hand and D-frame; 500-600 micron mesh
habitat selection		multihabitat
subsample size		200 count
taxonomy		genus
Fish		
sampling gear		seine, backpack electrofisher, pram unit (tote barge); 3/16" and 1/4" mesh
habitat selection		Sample all habitats within a sample reach that is 35X the mean stream width. Habitat assessments are broken out between riffle/run and glide/pool based on the ecoregion in which the sample is located.
sample processing		biomass – batch, anomalies
subsample		none
taxonomy		species
Habitat assessments		visual based and zig-zag pebble count; performed with bioassessments
Quality assurance program elements		standard operating procedures, quality assurance plan, periodic meetings and training for biologists, sorting and taxonomic proficiency checks

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
	UD	multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients
		other:
Multimetric thresholds		
transforming metrics into unitless scores		under development
defining impairment in a multimetric index		under development
Multivariate thresholds		
defining impairment in a multivariate index		under development
Evaluation of performance characteristics		repeat sampling
		precision
Not currently evaluated		sensitivity
		bias
		accuracy
Biological data		
Storage		EDAS and Excel
Retrieval and analysis		EDAS

HAWAI`I

Contact Information

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Program Description

The primary objective of the Hawai`i State Department of Health (HIDOH) Bioassessment Program is to augment the commonly used physical and chemical water quality assessments performed (during ambient monitoring, use attainability studies, and other investigations) for classification, evaluation and regulation of water bodies. The program primarily utilizes the Hawai`i Stream Bioassessment Protocol (HSBP) 3.01 developed by Mike Kido and the Hawai`i Natural Resources Conservation Service (NRCS) Visual Assessment protocol for characterization of streams. HIDOH currently uses these protocols in conjunction with water quality data to establish TMDLs in the State of Hawai`i. In the future the HSBP and the Hawai`i NRCS protocol will be used in conjunction with physical and chemical water quality data to classify streams and determine exceedances of narrative criteria.

The HSBP includes both habitat and biotic metrics. The general approach of the HSBP is to compare measures of community characteristics and habitat of a study stream to a minimally impacted ecoregional reference condition. An Index of Biotic Integrity, currently focused on fish, composes the biotic portion of the protocol. Much of the basis for evaluation is the presence or absence of native taxa and the introduction of non-native species. Low abundance or low diversity of native fauna suggests diminished biological integrity. The habitat portion of the HSBP includes standard habitat metrics, including bank stability, embeddedness, canopy cover and presence of fine and coarse organic material. The State of Hawai`i will soon be working with USGS to census the macroinvertebrate community in Hawai`i and develop metrics for the Hawai`i Bioassessment Program, which will add a component to measure pollution tolerance. The macroinvertebrate community in Hawai`i is quite different from that of the mainland United States; therefore, the metric may be quite unlike that of any other state.

As a preliminary evaluation of sites and to compliment the HSBP habitat component, the Hawai`i NRCS Visual Assessment protocol is applied. This is a modified version of the national NRCS visual assessment protocol.

The State Water Quality Management Planner, along with a Stream Bioassessment Intern, primarily perform these assessments. Additionally, other scientists from HIDOH, scientists from other local, state and federal agencies, local university students and professors, and skilled community members volunteer their time to help perform these protocols. The time demand of each task is dependent upon the number of aquatic organisms in the stream, the size of the stream, and other local conditions. HIDOH currently sponsors training courses in the protocols to those with a scientific background on a limited basis.

Documentation and Further Information

excerpts from *Hawai`i 2000 305(b) Report*: http://www.hawaii.gov/health/eh/cwb/2000-305b/index.html

Proposed 2001 revisions to *Hawai`i Water Quality Standards, January 2002 Indicators of Environmental Quality Report:* http://www.hawaii.gov/health/eh/epo/wqrev.htm

Hawai`i Stream Bioassessment Protocol, Michael Kido, Version 3.01, January 2001: http://www.state.hi.us/doh/eh/epo/kawa.pdf

HAWAI`I

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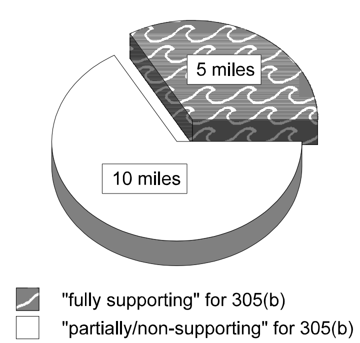
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
		monitoring the effectiveness of BMPs
		ALU determinations/ambient monitoring
	UD	promulgated into state water quality standards as biocriteria
		support of antidegradation
		evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects only)*
		fixed station (i.e., water quality monitoring stations)
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
	✓	rotating basin *(specific river basins or watersheds)*
		other:

Stream Miles

Total miles *(determined using state based coverage)*	**249**
Total perennial miles	249
Total miles assessed for biology	**15**
fully supporting for 305(b)	5
partially/non-supporting for 305(b)	10
listed for 303(d)	10
number of sites sampled *(on an annual basis)*	17
number of miles assessed per site*	<1

15 Miles Assessed for Biology



*Less than 1 mile assessed per site was determined by dividing the 15 total miles assessed for biology by the 17 sites sampled, which equals roughly .88 miles.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Class System (A,B,C)	
ALU designations in state water quality standards	Two designations: 1) Protection of native breeding stock, and 2) Support and propagation of aquatic life	
Narrative Biocriteria in WQS	under development	
Numeric Biocriteria in WQS	under development – Hawai`i is currently proposing to add numeric biocriteria to WQS	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
		cause and effect determinations
		permitted discharges
		monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	none	

Reference Site/Condition Development

Number of reference sites	**3 total**	
Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
		professional judgment
		other:
Reference site criteria	Minimally impacted and most pristine. Always scores near 100% when using the Hawai`i Stream Bioassessment Protocol no matter when and where sampled.	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate) *(the entire State of Hawai`i is one ecoregion)*
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	UD	benthos *(Hawai`i will soon be working with USGS to census the macroinvertebrate community in Hawai`i and develop metrics)*
	✓	fish *(<100 samples/year; single season, multiple sites - watershed level)*
		periphyton
		other:

Fish	
sampling gear	backback electrofisher and snorkel
habitat selection	multihabitat
sample processing	length measurement and biomass - individual
subsample	selected species
taxonomy	species
Habitat assessments	visual based, habitat availability, substrate embeddedness, Fine and Coarse Particulate Organic Matter (FPOM/CPOM) characterization, velocity-depth combinations, channel flow status, channel alteration, bank stability, riparian vegetative zone width, riparian understory coverage, and percent native riparian plant coverage; performed with bioassessments
Quality assurance program elements	standard operating procedures, periodic meetings and training for biologists, and taxonomic proficiency checks

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	under development
defining impairment in a multimetric index	under development*

Evaluation of performance characteristics		repeat sampling
		precision
Not currently evaluated		sensitivity
		bias
		accuracy

Biological data	
Storage	Excel
Retrieval and analysis	Statistica

*The following are the *proposed* impairment thresholds:

	Class 1a (mainly undeveloped, "unimpaired")	**Class 2a (mainly developed, "unimpaired")**
Habitat	greater than or equal to 75% of reference condition	between 50% and 75% of reference condition
Biotic integrity	greater than or equal to 70% of reference condition	between 30% and 70% of reference condition

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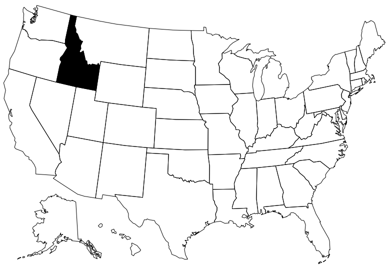

Contact Information

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Program Description

The Idaho surface water program uses biological information extensively to determine use support and impairment. In 1993, the Idaho Department of Environmental Quality (IDEQ) implemented a rapid bioassessment program aimed at integrating biological and chemical monitoring with physical habitat assessment as a way of characterizing water quality and stream integrity. This program, know as the Beneficial Use Reconnaissance Program (BURP), closely follows concepts and methods described in the *Rapid Bioassessment Protocols for Use in Streams and Rivers* (USEPA 1999). The main purpose of BURP is to provide consistency in monitoring, collecting data, and reporting. Specifically, biological along with physical, chemical, and landscape data are used to address the following objectives:

- Determine the degree of beneficial use support of the water body
- Determine the degree of biological integrity using biological information or other measures
- Compile descriptive information about the water body and data used in the assessment.

IDEQ has formal monitoring and assessment methods in place for large rivers and small streams. Methods for lakes and reservoirs are in development. For rivers and streams, there are a total of 8 multimetric indices for benthic macroinvertebrates, periphyton, fish, habitat, and physicochemical measures. Indices are integrated into attaining or non-attaining use support determinations. The integration uses a weight-of-evidence approach combined with individual minimum benchmarks for each assemblage and numeric criteria exceedances.

IDEQ has several plans to improve the current monitoring and assessment program. A draft statewide monitoring strategy will be introduced in July 2002. Future plans include incorporating a probabilistic monitoring design for screening purposes as well as adding methods for other water body types (e.g., wetlands, intermittent streams, springs, etc.). Implementation of these plans is dependent on agency priorities and available resources.

Documentation and Further Information

Idaho's 1998 303(d) List: http://www2.state.id.us/deq/water/1998_303d/303dlist.pdf

Grafe, C.S.et al. 2002. *Water body assessment guidance, 2nd edition*. Idaho Department of Environmental Quality. Boise, Idaho. 113 pp. http://www2.state.id.us/deq/water/surface_water/wbag/WBAG2001.htm

Grafe, C.S. (editor) April 2002. *Idaho small stream ecological assessment framework: an integrated approach*. Idaho Department of Environmental Quality. Boise, Idaho. 304 pp.
http://www2.state.id.us/deq/water/surface_water/wbag/WBAG_AssessmentFramework.htm

Grafe, C.S. (editor). April 2002. *Idaho river ecological assessment framework: an integrated approach*. Idaho Department of Environmental Quality. Boise, Idaho. 222 pp.
http://www2.state.id.us/deq/water/surface_water/wbag/WBAG_AssessmentFramework.htm

Beneficial Use Reconnaissance Program (BURP) 2001 Annual Work Plan for Wadeable (Small) Streams, 2001:
http://www2.state.id.us/deq/water/surface_water/2001_BURP_annual_work_plan_wadeable_streams.pdf

BURP Quality Assurance Plan for Field Data Sheets on Wadeable (Small) Streams, 2001:
http://www2.state.id.us/deq/water/surface_water/BURP_QualityAssurancePlan.pdf

1999 BURP Workplan for Wadeable Streams (Methods Manual):
http://www2.state.id.us/deq/water/surface_water/99_BURP_WORKPLAN.pdf

Streams: 1999 Post-Field Evaluation Summary Report (BURP), 2001:
http://www2.state.id.us/deq/water/surface_water/BURP_streams_Field_Report_99.pdf

Public Involvement and Response to Comment Summary:
http://www2.state.id.us/deq/water/surface_water/wbag/WBAG2001.htm

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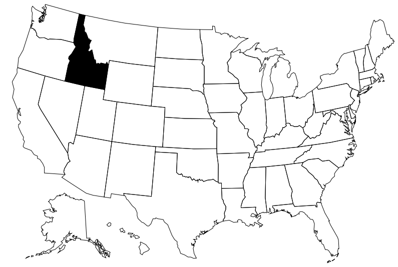

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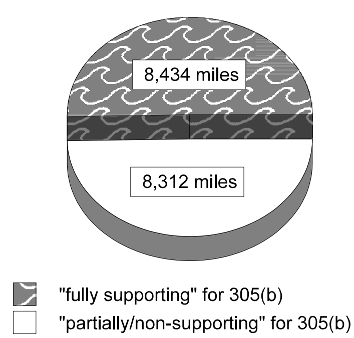
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
		support of antidegradation
		evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects, specific river basins or watersheds, and comprehensive use throughout jurisdiction)*
	✓	fixed station (i.e., water quality monitoring stations) *(special projects only)*
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
		rotating basin
		other:

Stream Miles

Total miles *(determined using the National Hydrography Database)*	**96,200**
Total perennial miles	49,500
Total miles assessed for biology	**16,742**
fully supporting for 305(b)	8,434
partially/non-supporting for 305(b)	8,312
listed for 303(d)	8,312
number of sites sampled	4,500
number of miles assessed per site	~3.5

16,742 Miles Assessed for Biology



Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Warm Water vs. Cold Water	
ALU designations in state water quality standards	Sub-categories are cold water, seasonal cold water, warm water, modified (UAA required), and salmonid spawning.	
Narrative Biocriteria in WQS	IDEQ's "Waterbody Assessment Guidance" and supporting technical reports are used to interpret and implement WQS, including ALU assessment. Although the term "biocriteria" is not used, functional elements are included in the WQS and in implementing ALU designation and support status guidance. Please see: http://www2.state.id.us/adm/adminrules/rules/IDAPA58/58INDEX.HTM	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Used as restoration criteria in CERCLA cleanup monitoring effectiveness plans/consent decrees; bioassessment is required prior to removing 303(d) listed waters Most TMDLs have ALUS biomonitoring as part of implementation; one recent example is the North Fork of the Coeur d'Alene River.	

Reference Site/Condition Development

Number of reference sites	**200 total**	
Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria	Reference site criteria based on nearby road condition, riparian vegetation complexity, channel morphology and complexity, habitat structure complexity, evidence of chemical stressors, substrate heterogeneity, and evidence of point and nonpoint sources. Also, land satellite images are reviewed for evidence of disturbance in the watershed (see IDAPA 58.01.02.003.85).	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
	✓	professional judgment
	✓	other: mostly least disturbed sites, but also minimally disturbed sites in some bioregions
Stream stratification within regional reference conditions		ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
	✓	other: bioregions based on groupings of ecoregions. Some of the indices classify by elevation and stream type.
Additional information	✓	reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(100-500 samples/year; single season, multiple sites - broad coverage)*
	✓	fish *(100-500 samples/year; single season, multiple sites - broad coverage)*
	✓	periphyton *(100-500 samples/year; single season, multiple sites - broad coverage)*
		other:

Benthos	
sampling gear	Surber, Hess, Slack (0.5 meter, in rivers only); 500-600 micron mesh
habitat selection	richest habitat
subsample size	500 count
taxonomy	species
Fish	
sampling gear	backpack electrofisher
habitat selection	multihabitat
sample processing	length measurement, biomass - individual, biomass - batch and anomalies
subsample	none; full sample work-up
taxonomy	species (count and keep voucher specimens for species that are not identified in the field)
Periphyton	
sampling gear	**natural substrate**: brushing/scraping device (razor, toothbrush, etc.)
habitat selection	selected near macroinvertebrate sample
sample processing	taxonomic identification
taxonomy	species level
Habitat assessments	visual based, canopy closure (densiometer), Wolman pebble count, pool complexity (width, depth), stream width/depth, large woody debris; performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings and training for biologists, sorting and taxonomic proficiency checks, specimen archival

Data Analysis and Interpretation*

Data analysis tools and methods	✓	summary tables, illustrative graphs
	✓	parametric ANOVAs
	✓	multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
	✓	disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	Varies by index - a combination of 95th percentile of reference and cumulative distribution function used to scale metrics scores is most frequently used.
defining impairment in a multimetric index	25th percentile of reference population**

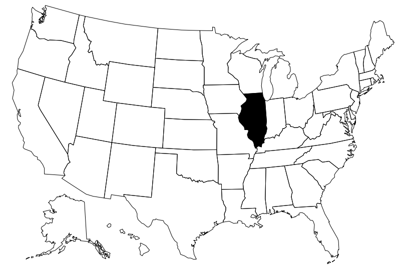
Evaluation of performance characteristics	✓	repeat sampling
	✓	precision *(variability study of reference conditions)*
	✓	sensitivity
	✓	bias
	✓	accuracy

Biological data	
Storage	MS Access, changing to Oracle/Visual Basic indexed to NHD
Retrieval and analysis	Custom interface (Biological Assessment Tool) developed to calculate metrics, indices, and physical and biological summary statistics. Systat is also used.

*Formal methods have been developed for non-wadeable rivers and wadeable streams. Lentic methods are under development. A total of eight multimetric indices for bugs, diatoms, fish, habitat, and physicochemical measures have been developed or adapted for rivers and streams. Indices are integrated into attaining or non-attaining use support determinations.

**Idaho uses a measure of CONDITION, which aggregates 3 different indices - Habitat, Benthos and Fish. Each index is compared to the median of reference condition and is given a score of 1, 2 or 3. All three scores are then combined (averaged). If > or = 2, then fully supporting; if <2, then not supporting.

ILLINOIS



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Program Description

Illinois EPA (IEPA) conducts intensive river basin surveys on a five-year rotational basis in cooperation with the Illinois Department of Natural Resources (IDNR). These surveys are a major source of information for annual 305(b) assessments. Illinois has 33 major river basins within its borders. Stations sampled by IEPA and IDNR are selected on the basis of where intensive data are currently lacking or historical data need updating. Water chemistry and biological (fish and macroinvertebrate) data along with qualitative and quantitative instream habitat information, including stream discharge, are collected to characterize stream segments within the basin, identify water quality conditions, and evaluate aquatic life use impairment. Fish tissue contaminant and sediment chemistry sampling are also conducted to screen for the accumulation of toxic substances.

Illinois' "biological expectations" are based on a regional reference site approach that enables within-region comparisons between the aquatic community at any stream site and the reference expectation. The regional reference site approach is a key component of biocriteria. The approach ensures reasonably attainable biological goals that recognize and account for the unique combination of regional land form, land use, and physical habitat characteristics, which influence the distribution of fish, macroinvertebrates and other aquatic organisms. Illinois is currently developing this framework, which includes refinement of existing biological assessment tools and, where needed, development of new state-of-the-art monitoring approaches.

Illinois EPA is working with IDNR, USEPA, members of the agricultural, industrial, academic and regulated communities, as well as outside contractors, and other interested parties to develop biological criteria for streams and rivers. This approach to biocriteria will enable IEPA to better assess the ecological/environmental quality of Illinois rivers and streams and should allow the Agency to continue to update and refine the stream use designations contained in Illinois' water quality standards.

Documentation and Further Information

Illinois Water Quality Report 2002 (CWA Section 305(b) Report), July 2002, IEPA, Bureau of Water: http://www.epa.state.il.us/water/water-quality/report-2002/305b-2002.pdf

2001 305(b) Summary Report (1999 data), Rivers and Streams: http://www.epa.state.il.us/water/water-quality/report-2001/report-2001.pdf

Condition of Illinois Water Resources - menu of Illinois 305(b) Reports and Assessments, including maps and graphs: http://www.epa.state.il.us/water/water-quality/index.html

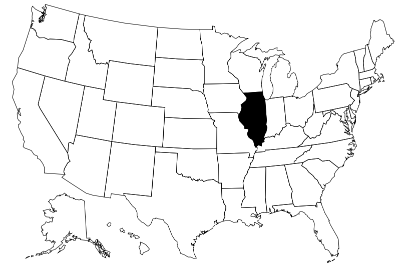
Illinois Targeted Watershed Approach: http://www.epa.state.il.us/water/targeted-watershed/index.html

IEPA Bureau of Water, Surface Water Quality Monitoring and Assessment Programs homepage: http://www.epa.state.il.us/water/surface-water/index.html

IEPA Bureau of Water, River and Stream Monitoring Program homepage, with links to biocriteria development and other relevant information: http://www.epa.state.il.us/water/surface-water/river-stream-mon.html

Hite, R.L. and B.A. Bertrand. 1989. *Biological Stream Characterization (BSC): A Biological Assessment of Illinois Stream Quality*, Special Report No. 13 of the Illinois State Water Plan Task Force. Illinois Environmental Protection Agency.

ILLINOIS



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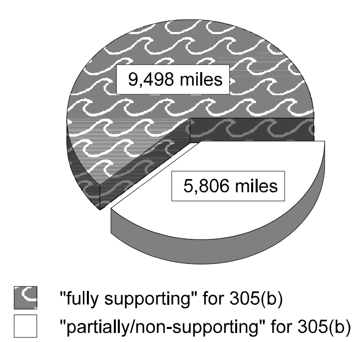
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
		monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	UD	promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects and specific river basins or watersheds)*
	✓	fixed station (i.e., water quality monitoring stations) *(comprehensive use throughout jurisdiction)*
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
	✓	rotating basin *(comprehensive use throughout jurisdiction)*
		other:

Stream Miles

Total miles *(determined using RF3 and existing maps)*	**86,021**
Total perennial miles	30,246
Total miles assessed for biology	**15,304**
fully supporting for 305(b)	9,498
partially/non-supporting for 305(b)	5,806
listed for 303(d)*	–
number of sites sampled	115
number of miles assessed per site**	site specific

15,304 Miles Assessed for Biology



*Total miles listed for 303(d) is a subset of the miles partially/non-supporting for 305(b) and will be determined in the next update.

**10 miles for wadeable sites and 25 miles for non-wadeable sites with some site-specific detailing following the 1997 305(b) guidance.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Single Aquatic Life Use	
ALU designations in state water quality standards	Secondary contact and indigenous aquatic life use waters (IL Title 35, Subtitle C, Chapter I, Part 303.204)	
Narrative Biocriteria in WQS	under development - IEPA has written guidelines and thresholds for fish and invertebrate indices that are not part of the WQS, but are in the 305(b) guidelines (see flowchart). These numeric biological measures are used as decision criteria to determine attainment of ALU.	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Data have been used to make permitting and nonpoint source BMP decisions. Illinois DNR's Biological Stream Characterization (BSC) program is used to determine antidegradation tiers and to influence IDNR natural heritage area designations.	

Reference Site/Condition Development*

Number of reference sites	**120 total**	
Reference site determinations*	✓	site-specific
		paired watersheds
		regional (aggregate of sites)
		professional judgment
	✓	other: watershed measures of physical and chemical disturbance
Reference site criteria	Illinois EPA is in the process of formally defining reference criteria.*	
Characterization of reference sites within a regional context	✓	historical conditions
	✓	least disturbed sites
		gradient response
	✓	professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
	✓	stream type
	✓	multivariate grouping
	✓	jurisdictional (i.e., statewide)
		other:
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

*IEPA currently does not use "reference conditions" for making use-support decisions. Reference conditions were not explicitly defined or used for the present stream IBIs. A not-yet completed reevaluation of Illinois IBIs used reference conditions to develop the new indices. IEPA uses a general concept of least impacted reference condition where there are no data available; no further quantitative development has been done.

Field and Lab Methods

Assemblages assessed	✓	benthos *(100-500 samples/year; single season, multiple sites – not at watershed level)*
	✓	fish *(100-500 samples/year; single season, multiple sites – not at watershed level)*
		periphyton
		other:

Benthos	
sampling gear	collect by hand, dipnet; 500-600 micron mesh
habitat selection	richest habitat, rifle/run (cobble), multihabitat and woody debris
subsample size	300 count and entire sample
taxonomy	combination - order, family, genus and species
Fish	
sampling gear	backpack and boat electrofishers, and seine; 1/4" and 3/8" mesh
habitat selection	pool/glide, riffle/run (cobble) and multihabitat
sample processing	length measurement, biomass - individual and batch
subsample	none
taxonomy	species
Habitat assessments	visual based and quantitative measurements; performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings and training for biologists, sorting and taxonomic proficiency checks

Data Analysis and Interpretation

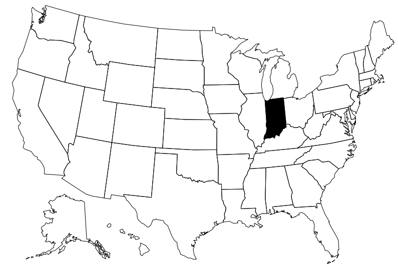
Data analysis tools and methods	✓	summary tables, illustrative graphs
	✓	parametric ANOVAs
	✓	multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
	✓	disturbance gradients
	✓	other: nonparametric statistical tests

Multimetric thresholds	
transforming metrics into unitless scores	Metric values representing least-disturbed conditions statewide are stratified by region; within-region regression of each metric vs. environmental covariate, e.g., stream size and slope, defines benchmark for defining metric-scoring ranges.
defining impairment in a multimetric index	Thresholds are based on the possible index scoring range divided into discrete categories and are not driven by reference sites.

Evaluation of performance characteristics		repeat sampling
		precision
Not currently evaluated		sensitivity
		bias
		accuracy

Biological data	
Storage	IEPA database and spreadsheets
Retrieval and analysis	SAS, Systat, database, spreadsheet, statistical-analysis and statistical-graphics applications, including MS Access, FoxPro, Excel, QuattroPro, Minitab, and Sigma Plot

INDIANA



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Program Description

The Biological Studies Section (BSS) of IDEM's Office of Water Quality conducts studies of fish and macroinvertebrate communities, as well as stream habitats. These data are used to help develop biological criteria to which all other streams can be compared in order to identify impaired streams or watersheds. BSS also conducts fish tissue and sediment sampling to monitor sources of toxic and bioconcentrating substances too low to be detected in other environmental media. Fish tissue data serve as the basis for fish consumption advisories issued to protect the health of people who consume fish caught in Indiana waters. Fish tissue data are also useful for wildlife health risk assessments for fish-eating birds and mammals, and for providing the information needed to develop models for assessing changes in the quality of Indiana ecosystems.

The BSS is responsible for determining the biological integrity of aquatic communities of Indiana streams and lakes. This is accomplished through a variety of field and laboratory studies that involve several different forms of aquatic life. These data are used to determine compliance with the existing narrative biological criteria in Indiana's current water quality standards, to determine the use attainability, and to make correlations to physical and/or chemical impairments which may exist.

The BSS participates in the review of requests for site-specific water quality criteria for waters influenced by NPDES discharges. In the course of its various monitoring and assessment field activities, the staff finds point and nonpoint source-related problems, which are then referred to the appropriate IDEM programs. The Section also cooperates in the monitoring and assessment of the Ohio River in conjunction with the Ohio River Valley Water Sanitation Commission (ORSANCO), and other state and federal agencies.

Lake and reservoir assessments prior to 1989 were conducted by the State and have since been contracted to Indiana University, School of Public and Environmental Affairs. From 1990 through 1995, the State in conjunction with USEPA - Region 5, conducted a statewide ecoregion-based fish community study. Indiana has historically collected macroinvertebrate community samples at a network of fixed stations. In addition the State has been conducting macroinvertebrate community assessments at wadeable stream sites since 1990. Since 1996 the biological assessments for fish and invertebrate community assessments have been conducted using probabilistic sampling on a rotational watershed basis as per Indiana's *Surface Water Quality Monitoring Strategy*. In 2000 the State participated in a study to determine if fish and macroinvertebrate indices could be developed for lakes and reservoirs. Conclusions are still pending.

Documentation and Further Information

Indiana 2001 - 2005 Surface Water Quality Monitoring Strategy:
http://www.in.gov/idem/water/assessbr/016surfwaterqualmonstrat.pdf

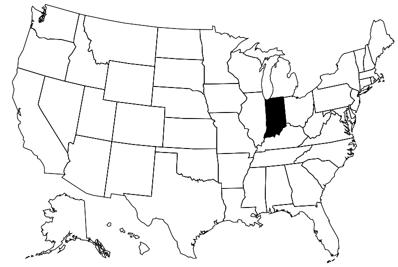
Indiana 303(d) List of Impaired Waterbodies, information and links:
http://www.in.gov/idem/water/planbr/wqs/303d.html

Indiana Water Quality 305(b) Report, general information: http://www.IN.gov/idem/water/planbr/wqs/quality.html

Indiana Water Quality Standards: http://www.state.in.us/legislative/iac/title327.html

IDEM Office of Water Quality's Assessment Branch - Biological Studies Section homepage, with numerous links to relevant fact sheets and reports: http://www.in.gov/idem/water/assessbr/biostud/index.html

INDIANA



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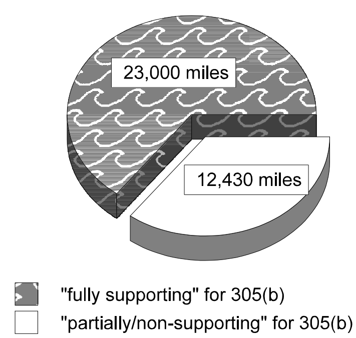
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	UD	promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(specific river basins or watersheds and comprehensive use throughout jurisdiction)*
	✓	fixed station (i.e., water quality monitoring stations) *(specific river basins or watersheds and comprehensive use throughout jurisdiction)*
	✓	probabilistic by stream order/catchment area *(specific river basins or watersheds and comprehensive use throughout jurisdiction)*
	✓	probabilistic by ecoregion, or statewide *(specific river basins or watersheds and comprehensive use throughout jurisdiction)*
	✓	rotating basin *(specific river basins or watersheds and comprehensive use throughout jurisdiction)*
		other:

Stream Miles

Total miles *(determined using RF3 and the National Hydrography Database)*	**35,673**
Total perennial miles	21,094
Total miles assessed for biology	**35,430**
fully supporting for 305(b)	23,000
partially/non-supporting for 305(b)	12,430
listed for 303(d)	unknown
number of sites sampled *(on an annual basis)*	< 200
number of miles assessed per site	site specific

35,430 Miles Assessed for Biology



Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Warm Water vs. Cold Water	
ALU designations in state water quality standards	Two designations: Well balanced warmwater aquatic community and Cold water put-and-take trout waters	
Narrative Biocriteria in WQS	under development - The narrative biocriteria in Indiana have only been proposed and are not formal. They are loosely defined by 327 IAC 2-1-3(a)(2), 327 IAC-2-1-9 (49); and for the Great Lakes waters 327 IAC 2-1.5-5(a)(2) and (3), and 327 IAC 2-1.5-2 (92). IDEM uses informal numeric procedures to support narrative biocriteria (see http://www.in.gov/IDEM/water/planbr/wqs/quality.html).	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
		permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Biological assessment data are used for 305(b)/303(d) purposes and was used for the FY 2000 Unified Watershed Assessment (updated 2001), which was used for the Watershed Restoration Action Strategies.	

Reference Site/Condition Development*

Number of reference sites	**unknown**	
Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria	Deviation from central tendencies on multimetric indices and the qualitative habitat evaluation index (QHEI) is also taken into consideration when evaluating impairment. Field chemistry is measured and probabilistic sites are sampled for broad chemical analysis.	
Characterization of reference sites within a regional context	✓	historical conditions**
	✓	least disturbed sites
	✓	gradient response
		professional judgment
	✓	other: IBI is calibrated on drainage area for headwater streams, wadeable rivers, large rivers and great rivers
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
		stream type
	✓	multivariate grouping
		jurisdictional (i.e., statewide)
	✓	other: 8 digit USGS Hydrologic Unit Codes
Additional information	✓	reference sites linked to ALU *(in a statistical sense)*
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions *(it is understood that all sites have a human-induced condition)*

*IDEM uses a non-typical process for developing reference condition: reference condition is represented by a percentage of the total population of the sites sampled. The number of reference sites in Indiana is not available at this time.

**Reference condition is defined by a historical cross-section of sample sites representing the full gradient of ecological conditions as they existed during statewide or ecoregion specific investigation.

Field and Lab Methods

Assemblages assessed	✓	benthos *(<100 samples/year; single season, multiple sites - broad coverage)*
	✓	fish *(<100 samples/year; single season, multiple sites - broad coverage)*
	✓	periphyton *(<100 samples/year; solely through a pilot contract with USGS)*
	✓	other: phytoplankton and zooplankton *(<100 samples/year; single observation, limited sampling)*

Benthos	
sampling gear	multiplate, dipnet, and kick net (1 meter); 243-600 micron mesh
habitat selection	riffle/run (cobble) and artificial substrate in the absence of riffle/run
subsample size	100 count and proportional/volume
taxonomy	family
Fish	
sampling gear	backpack, boat, longline and pram unit (tote barge) electrofishers; and 1/8" mesh seine
habitat selection	multihabitat
sample processing	enumeration, length measurement, biomass - batch, and anomalies
subsample	none
taxonomy	species
Habitat assessments	visual based; performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings and training for biologists, sorting and taxonomic proficiency checks, specimen archival

Data Analysis and Interpretation

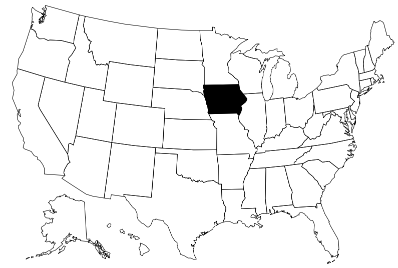
Data analysis tools and methods	✓	summary tables, illustrative graphs
	✓	parametric ANOVAs
	✓	multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
	✓	disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	cumulative distribution function
defining impairment in a multimetric index	cumulative distribution function and use various break points for impairments
Multivariate thresholds	
defining impairment in a multivariate index	significant departure from mean of reference population

Evaluation of performance characteristics	✓	repeat sampling *(watersheds are sampled on 5 yr rotational basis)*
	✓	precision *(Standard Error, 95% Confidence Interval and Relative Percent Difference)*
		sensitivity
		bias
	✓	accuracy *(10% field duplicates, 10% laboratory duplicates)*

Biological data	
Storage	Assessment Information Management System (AIMS), MS Access based utility, and some historical data still in paper files
Retrieval and analysis	Statistica and MINITAB for cluster analysis of large matrices

IOWA



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IDNR Water Quality Bureau: http://www.state.ia.us/dnr/organiza/epd/wtrq/wtrqbur.htm

Program Description

Since 1994, the Iowa Department of Natural Resources (IDNR) and the University Hygienic Laboratory (UHL) have conducted a biological assessment program for Iowa's wadeable streams and rivers. So far, biological sampling has been conducted at 289 stream locations throughout the state. Biological data are collected for a variety of purposes including: ambient monitoring, problem investigation, evaluation of point source and nonpoint source pollution control measures, and TMDL development. The IDNR uses bioassessment information to assess the status of stream aquatic life designated uses for the Section 305(b) report and the Section 303(d) list of impaired waters.

Benthic macroinvertebrates and fish serve as indicators of stream biological integrity. Standardized sampling procedures are used to collect species composition and proportional abundance data from which a suite of biological metrics is calculated. Individual metric values are aggregated to obtain scores for the Benthic Macroinvertebrate Index of Biotic Integrity (BMIBI) and the Fish Index of Biotic Integrity (FIBI). Biological impairment thresholds are based on the statistical distribution of biotic index scores obtained from stream reference site sampling. Currently, the IDNR has identified 96 reference sites that represent least disturbed stream conditions in Iowa's ten ecological regions.

Until 2002, a targeted approach was used to select sampling locations for Iowa's stream biological assessment program. From 1994 through 1998, the program emphasized candidate reference site and test (impacted) site sampling, which provided data for evaluating and calibrating biological data metrics. From 1999-2001, the emphasis shifted toward site-specific problem investigation and follow-up. Beginning in 2002, IDNR and UHL are initiating a probabilistic survey that will provide an unbiased, statistically powerful assessment of Iowa's perennial streams and rivers. The survey design calls for sampling 56 randomly-selected sites per year through 2005. During this period, IDNR and UHL also plan to resample the existing network of reference streams at a rate of 20-25 sites per year.

The IDNR is working toward incorporating narrative and numeric stream biocriteria in Iowa's water quality standards. The bioassessment framework that is currently used for 305(b) assessments can potentially serve as a foundation for biocriteria. The 2002-2005 probabilistic survey will provide useful data from non-wadeable streams and rivers for biocriteria development. Biocriteria development for Iowa's lakes, reservoirs, and wetlands has not been initiated.

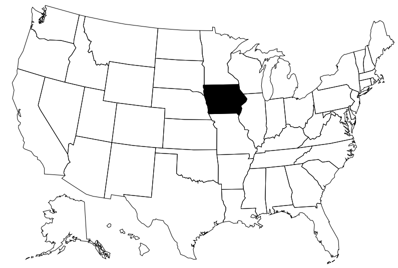
Documentation and Further Information

Water Quality in Iowa During 1998 and 1999 (Iowa's 2000 Section 305(b) report): http://www.state.ia.us/dnr/organiza/epd/wtrq/305b00/index.htm

Final Approved Iowa 1998 303(d) List: http://www.state.ia.us/dnr/organiza/epd/wtresrce/files/303dlist.pdf

Iowa's STORET Database (ambient water quality program dataset): http://wqm.igsb.uiowa.edu/storet/

IOWA



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Programmatic Elements

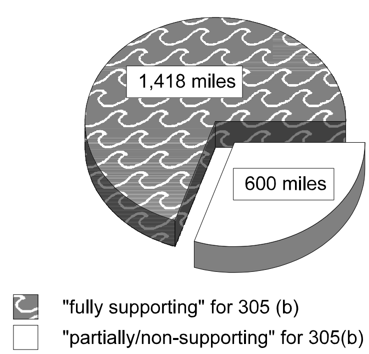
Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	UD	promulgated into state water quality standards as biocriteria
		support of antidegradation
		evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs*	✓	targeted (i.e., sites selected for specific purpose) *(special projects, specific river basins or watersheds, comprehensive use throughout jurisdiction)*
	✓	fixed station (i.e., water quality monitoring stations) *(specific river basins or watersheds)*
		probabilistic by stream order/catchment area
	✓	probabilistic by ecoregion, or statewide *(comprehensive use throughout jurisdiction)*
		rotating basin
		other:

*In 2002, IDNR will initiate a REMAP probabilistic survey of perennial streams and rivers.

Stream Miles

Total miles *(State based determination)*	**71,665**
Total perennial miles	26,630
Total miles assessed for biology*	**2,018**
fully supporting for 305(b)	1,418
partially/non-supporting for 305(b)	600
listed for 303(d)	n/a
number of sites sampled	149
number of miles assessed per site	0.1 - 0.22

2,018 Miles Assessed for Biology



*Stream miles reported are based on Iowa's 2000 305(b) assessment. A 303(d) list was not prepared in 2000.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Class System (A, B, C), Warm Water vs. Cold Water	
ALU designations in state water quality standards	Four designations: B(LR) - limited resource warmwater streams/rivers; B(WW) - significant resource warmwater streams/rivers; B(CW) - coldwater streams; B(LW) - lakes and wetlands	
Narrative Biocriteria in WQS	under development (Iowa's water quality standards include language associated with ALUs but it was not intended to be formal narrative biocriteria. IA is moving toward incorporating narrative biocriteria into the State's water quality standards.)	
Numeric Biocriteria in WQS	none (IA uses thresholds to report data in 305(b) report, but not formal numeric biocriteria.)	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
		permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	303(d) listing, to address point source impacts, and to support TMDL development	

Reference Site/Condition Development

Number of reference sites	**96 total**	
Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria	Regionally representative and least disturbed by human activities, consider impact of livestock waste, wastewater, channel alterations, riparian land use, and quality of instream habitat	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(100 - 500 samples per year; single season, multiple sites - broad coverage)*
	✓	fish *(<100 samples per year; single season, multiple sites - broad coverage)*
		periphyton
		other:

Benthos	
sampling gear	Surber, Hess, multiplate, collect by hand; 500 - 600 micron mesh
habitat selection	riffle/run (cobble), multihabitat, artificial substrate
subsample size	100 count, entire sample
taxonomy	combination - order, family, genus, species
Fish	
sampling gear	backpack electrofisher, pram unit (tote barge); 3/16" mesh
habitat selection	multihabitat
sample processing	anomalies, species abundance
subsample	none
taxonomy	species
Habitat assessments	visual based, quantitative measurements; performed with bioassessments
Quality assurance program elements	standard operating procedures, periodic meetings/training for biologists, taxonomic proficiency checks, specimen archival

Data Analysis and Interpretation

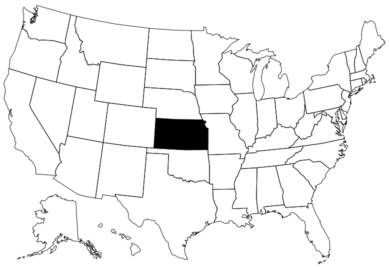
Data analysis tools and methods	✓	summary tables, illustrative graphs
	✓	parametric ANOVAs
	✓	multivariate analysis *(for data exploration only)*
	✓	biological metrics *(aggregate metrics into an index)*
	✓	disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	linear interpolation between optimum (95%) reference population level and the minimum level
defining impairment in a multimetric index	25^{th} percentile of reference population

Evaluation of performance characteristics	✓	repeat sampling
	✓	precision
	✓	sensitivity
		bias
		accuracy

Biological data	
Storage	EDAS (benthic macroinvertebrate data) and MS Access (fish, physical habitat, and water chemistry data)
Retrieval and analysis	STATISTIX (Analytical Software) and Excel

KANSAS



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http://www.kdhe.state.ks.us/befs/index.html

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website: http://www.kdwp.state.ks.us

Program Description

Kansas has maintained a stream biological monitoring program since 1972. Since 1980, the program has remained primarily unchanged. Program data are evaluated and incorporated in five year increments into the 305(b) report and 303(d) list. Data is used to determine aquatic life use support status in combination with chemical water quality data. Further details may be found in the program Quality Management Plan (see documentation below).

Contemporary Program Objectives
The stream biological monitoring program endeavors to provide scientifically defensible information on the quality of flowing waters in Kansas through the analysis of aquatic macroinvertebrate communities. This information is intended for use in:

(1) complying with the water quality monitoring and reporting requirements of 40 CFR 130.4 and sections 106(e)(1), 303(d) and 305(b) of the federal Clean Water Act;

(2) evaluating waterbody compliance with the Kansas surface water quality standards (K.A.R. 28-16-28b *et seq*.);

(3) identifying point and nonpoint sources of pollution contributing most significantly to water use impairments in streams;

(4) documenting spatial and temporal trends in surface water quality resulting from changes in land use patterns, resource management practices, pollutant loadings, and climatological conditions;

(5) developing scientifically defensible environmental standards, wastewater treatment plan permits, and waterbody/watershed pollution control plans; and

(6) evaluating the efficacy of pollution control efforts and waterbody remediation/restoration initiatives implemented by the department and other agencies and organizations.

The Kansas Department of Health and Environment's (KDHE) Bureau of Environmental Field Services is responsible for macroinvertebrate data collection and analysis. The Bureau also analyzes fish community data that are collected by the Kansas Department of Wildlife and Parks (KDWP). KDHE is currently working with the Central Plains Center for BioAssessment (CPCB) at the University of Kansas, to develop both a systematic approach to the identification of reference sites and a regionally standardized approach to habitat assessment.

Documentation and Further Information

Division of Environment Quality Management Plan Part III: Stream Biological Monitoring Program Quality Assurance Management Plan, December 2000: http://www.kdhe.state.ks.us/environment/qmp_2000/download/SBMP_QAMP.pdf

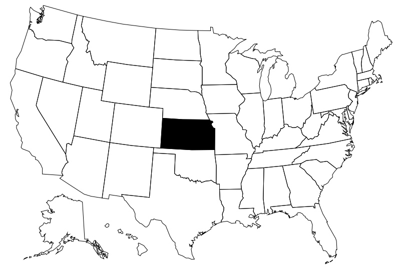
2002 Kansas Water Quality Assessment (305(b) report), April 2002:
http://www.kdhe.state.ks.us/befs/305b_2002/ks305b2002f.pdf

Guidance Document for Use Attainability Analyses, December 2001: http://www.kdhe.state.ks.us/befs/uaas/UAAGuidance.pdf

Draft 2002 303(d) Methodology and List: http://www.kdhe.state.ks.us/tmdl/303d.htm

Kansas State Water Quality Standards: http://www.kdhe.state.ks.us/water/index.html

KANSAS



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Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
		support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
	✓	other: trend analysis
Applicable monitoring designs*	✓	targeted (i.e., sites selected for specific purpose) *(comprehensive use throughout jurisdiction)*
	✓	fixed station (i.e., water quality monitoring stations) *(comprehensive use throughout jurisdiction)*
		probabilistic by stream order/catchment area
	✓	probabilistic by ecoregion, or statewide *(comprehensive use throughout jurisdiction)*
	✓	rotating basin *(comprehensive use throughout jurisdiction)*
	✓	other: rotational sites, statewide *(comprehensive use throughout jurisdiction)*

*KDWP uses a combination of probabilistic design, rotating basin, and fixed sites; KDHE relies primarily on a targeted design, including fixed and rotational sites statewide.

Stream Miles

Total miles *(determined using RF3)*	**134,338**
Total perennial miles	23,731
Total miles assessed for biology*	**23,731**
fully supporting for 305(b)	n/a
partially/non-supporting for 305(b)	n/a
listed for 303(d)	n/a
number of sites sampled	178 targeted over 22 years (KDHE); several hundred probabalistic (KDWP)
number of miles assessed per site	site specific

*Because KDWP uses a probabilistic sampling design, it can be said that all 23,731 perennial stream miles in Kansas are being assessed for biology. KDHE is working with KDWP to incorporate the latter agency's findings into Kansas' 305(b) reports and 303(d) lists. Kansas' 2002 305(b) report is based on four years of ambient stream chemistry data (1998-2001) and only acute aquatic life use support application.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Class System (A,B,C)	
ALU designations in state water quality standards	Three designations: special aquatic life use, expected aquatic life use, restricted aquatic life use	
Narrative Biocriteria in WQS	Procedures used to support narrative biocriteria are located in the most recent 305(b) reports	
Numeric Biocriteria in WQS	none (Numeric biocriteria have not been adopted into the state standards, but are nevertheless used for diagnostic purposes and in 305(b) assessments.)	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
		watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Various point source upgrades and TMDL-related applications	

Reference Site/Condition Development

Number of reference sites	**44 total**	
Reference site determinations*		site-specific
		paired watersheds
		regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria	To date, sites have been selected on the basis of land cover and land use, known hydrological properties and channel characteristics, general absence of confined animal feeding operations, point sources and urban areas, and favorable water quality attributes (low levels of total suspended solids, biochemical oxygen demand, fecal coliform bacteria, total phosphorus, inorganic nitrogen, herbicides, and other contaminants). Rare taxa and historically occurring key species are mainly used for validation purposes. Reference sites, by definition, should also be minimally impacted by anthropogenic phenomena and approach the presettlement condition in terms of hydrology, water quality, available biological habitat, surrounding landscape and watershed attributes, and historically documented plant and animal communities.	
Characterization of reference sites within a regional context	✓	historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
	✓	other: stream size
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

*Currently working with the Central Plains Center for BioAssessment (CPCB) at the University of Kansas to develop a more systematic approach to the identification of reference sites.

Field and Lab Methods

Assemblages assessed	✓	benthos *(100 - 500 samples/year; single season, multiple sites - broad coverage; multiple seasons, select sites)*
	✓	fish *(<100 samples/year; single season, multiple sites - broad coverage by KDWP only)*
	✓	periphyton *(100 - 500 samples/year; multiple seasons, multiple sites - broad coverage for watershed level)**
	✓	other: phytoplankton

Benthos	
sampling gear	collect by hand, D-frame; 500 - 600 micron mesh
habitat selection	richest habitat, riffle/run, multihabitat, woody debris, random sampling by KDWP only
subsample size	entire sample, 100 count minimum
taxonomy	genus/species where practical
Fish	
sampling gear	seine, backpack electrofisher, pram unit (tote barge); 1/8" and 3/16" mesh
habitat selection	multihabitat
sample processing	length measurement, biomass – batch
subsample	batch (generally do not subsample)
taxonomy	species
Periphyton*	
sampling gear	**natural substrate**: suction device, bar clamp sample; **artificial substrate**: periphytometer
habitat selection	wadeable area within stream segment that is designated based on other sampled biota
sample processing	chlorophyll *a*/ phaeophytin, taxonomic identification (limited use)
taxonomy	diatoms only
Habitat assessments	visual based (KDHE), quantitative measurements (KDWP); performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings/training for biologists, sorting and taxonomic proficiency checks, specimen archival, replicate sampling, field audits, and staff certification program

*Periphyton sampling is a new venture for the Kansas Biological Survey and the Central Plains Center for BioAssessment. Whole stream respiration as well as net and gross production via the DO diel cycle method are also determined. Software has been built to support these calculations using large continuous data sets of several weeks to months.

Data Analysis and Interpretation

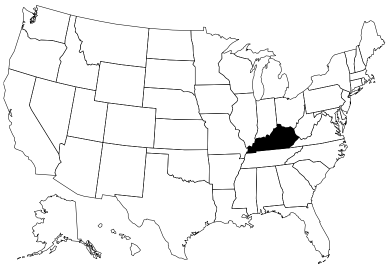
Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(return single metrics)*
		disturbance gradients
	✓	other: regressions, correlations, trends, and other statistical applications

Multimetric thresholds	
transforming metrics into unitless scores	cumulative distribution function
defining impairment in a multimetric index	Kansas returns single metrics but is exploring various indices.

Evaluation of performance characteristics	✓	repeat sampling
	✓	precision
Refer to Quality Management Plan for SOPs and further information.	✓	sensitivity
	✓	bias
	✓	accuracy

Biological data	
Storage	Lotus Notes, Excel
Retrieval and analysis	Minitab, spreadsheet graphics, ArcView, ArcGIS, GARP (pending)

KENTUCKY



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Program Description

A 100 point scale multi-metric index is under development in order to give equal weight to the three assemblages collected (fish, macroinvertebrates and algae). KY Division of Water is also working in conjunction with USEPA/Cincinnati to develop boatable water collection methods for the larger rivers as a first phase of biocriteria and assessment methods for larger rivers. There is a long term goal of establishing response relationships between biological indicators and nutrients in wadeable and boatable waters in order to investigate the feasibility of establishing nutrient criteria in these waters.

The Division of Water has shifted to a watershed approach in assessing stream miles. At this time about two fifths of the stream miles assessed have been entered in the data base, and data from another two fifths are being inputted. The first round of watershed sampling (the last fifth) will be completed in summer 2002. Somewhere between 30,000 to 40,000 actual miles will have been assessed by the time this project is completed.

Probabilistic sampling is also being conducted in all major watersheds. When this is completed, KY Division of Water will be able to estimate the number of stream miles meeting and not meeting designated uses. KY Division of Water was able to carry out this expansion thanks to valuable partnerships with Universities and the Kentucky Department of Fish and Wildlife Resources. These data are used to assess use support for Kentucky's 305(b) Report and for listing streams on the 303(d) list. Biological data can override chemical data if they are contradictory. There is a strong belief that the biological data collected and the collection methods used paint a truer picture of use attainment than chemical data.

Another important application of increased biological knowledge of waters in Kentucky has been the development of biological endpoints for successful stream restoration projects undertaken as a result of environmental damage incidents.

Documentation and Further Information

2000 Kentucky Report to Congress on Water Quality, 305(b) report:
http://water.nr.state.ky.us/wq/305b/2000/2000_305b.htm

1998 303(d) List of Waters for Kentucky, June 1998: http://water.nr.state.ky.us/303d/

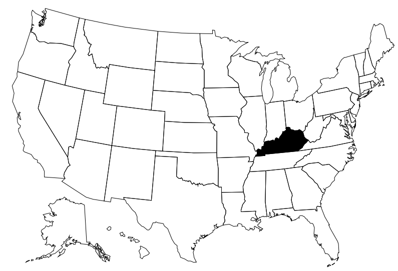
1998-1999 Monitoring Strategy: Kentucky River Basin Management Unit, March 2000:
http://www.uky.edu/WaterResources/Watershed/KRB_AR/PDF_Files/Monitoring%20Report.PDF

For a list and links to more references and documents, conduct a search on the *Kentucky Natural Resources and Environmental Protection Cabinet (NREPC)* publication site:
http://www.kyenvironment.org/nrepc/publications/publications.asp

Kentucky Watershed Management Framework

Other documents include Reference Reach Reports on Algae, Fish and Macroinvertebrates; Division of Water SOP manuals; Consultant reports; USFWS surveys; Kentucky State Nature Preserve Commission surveys; Kentucky Department of Fish and Wildlife Resources surveys; Federal Register notices on Federal T&E listings.

KENTUCKY



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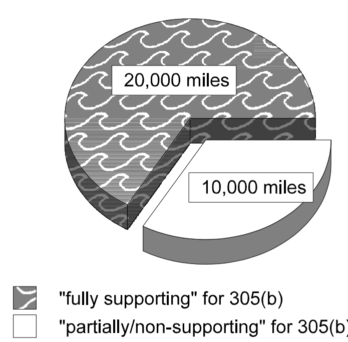
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects only, specific river basins or watersheds, and comprehensive use throughout jurisdiction)*
	✓	fixed station (i.e., water quality monitoring stations) *(comprehensive use throughout jurisdiction)*
		probabilistic by stream order/catchment area
	✓	probabilistic by ecoregion, or statewide *(specific river basins or watersheds)*
	✓	rotating basin *(specific river basins or watersheds)*
		other:

Stream Miles

Total miles *(determined using the National Hydrography Database)*	**89,431**
Total perennial miles	34,334
Total miles assessed for biology*	**~30,000**
fully supporting for 305(b)	~20,000
partially/non-supporting for 305(b)	~10,000
listed for 303(d)	7,500
number of sites sampled	1,750
number of miles assessed per site	–

30,000 Miles Assessed for Biology



*Kentucky has shifted to a basin approach in assessing stream miles. At this time about 2/5ths of the stream miles assessed have been entered in the database, which translates to 10,200 actual miles assessed. There is also data from another 2/5ths that is presently being inputted into the database. The first round of watershed sampling (the last 1/5th) will be completed this summer. 30,000 to 40,000 actual miles will have been assessed upon completion. Probabilistic sampling is also being conducted in all major watersheds. The number of stream miles meeting and not meeting designated uses can be estimated when this is completed.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Warm water vs. Cold water	
ALU designations in state water quality standards	Two designations - Warm water and Cold water	
Narrative Biocriteria in WQS	Numeric procedures used to support narrative biocriteria referenced in KAR 5:030, and in Division publications and SOP manuals.	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Bioassessments have been used to delist streams from the 303(d) list.	

Reference Site/Condition Development

Number of reference sites	**140 total**	
Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
		professional judgment
		other:
Reference site criteria	Minimally impacted from point and nonpoint pollution, natural habitat with high forest density relative to other land uses. Other criteria listed in KY's reference reach report on fish communities. Also depends on ecoregion: habitat score - conductivity (region specific) - nutrients (in some cases).*	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
	✓	other: minimally impacted*
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
		stream type
	✓	multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information		reference sites linked to ALU
	✓	reference sites/condition referenced in water quality standards *(found in 401 KAR 5:030 Section 1(1)(b)4)*
	✓	some reference sites represent acceptable human-induced conditions

*KY tries to use minimally impacted reference sites whenever possible, but least disturbed sites are used to set targeted conditions when there are no minimally impacted sites in a subecoregion.

Field and Lab Methods

Assemblages assessed	✓	benthos *(<100 samples/year; single season, multiple sites - broad coverage)*
	✓	fish *(<100 samples/year; single season, multiple sites - broad coverage)*
	✓	periphyton *(<100 samples/year; single season, multiple sites - broad coverage)*
		other:

Benthos	
sampling gear	D-frame, dipnet, kick net (1 meter), collect by hand; >800 micron mesh
habitat selection	multihabitat
subsample size	entire sample
taxonomy	combination - family, genus, species
Fish	
sampling gear	seine, backback electrofisher, boat electrofisher, pram unit (tote barge), gill nets, trammel nets; 3/16" mesh
habitat selection	multihabitat
sample processing	none
subsample	none
taxonomy	species
Periphyton	
sampling gear	**natural substrate**: suction device, brushing/scraping device (razor, toothbrush, etc.), collect by hand; **artificial substrate**: periphytometer (in non-wadeable waters)
habitat selection	multihabitat
sample processing	taxonomic identification
taxonomy	species
Habitat assessments	visual based; performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings and training for biologists, sorting and taxonomic proficiency checks, specimen archival

Data Analysis and Interpretation

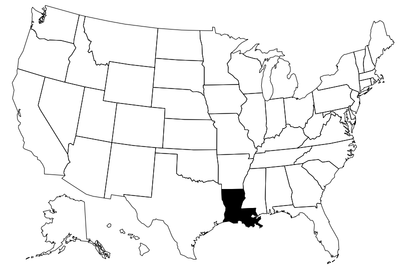
Data analysis tools and methods		summary tables, illustrative graphs
		parametric ANOVAs
	✓	multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	95th percentile of all sites-standard based on a 100 unit scale
defining impairment in a multimetric index	25th percentile of reference population (100 point scale multi-metric index is under development)

Evaluation of performance characteristics	✓	repeat sampling *(annual variability)*
	✓	precision *(repeatability)*
	✓	sensitivity *(Box-Whisker distributions)*
		bias
	✓	accuracy *(% test sites - nonreference, impaired - validation)*

Biological data	
Storage	EDAS
Retrieval and analysis	SAS, Systat, EDAS, Excel, MVSP (Multi-Variate Statistical Package), Statigraphics

LOUISIANA



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Program Description

In Louisiana, bioassessments have been used principally to characterize and delineate reference streams. Bioassessments have also been used for assessing the biological conditions of waterbodies being evaluated for site-specific standards development and use attainability analysis. Bacterial monitoring is conducted for swimming use assessment, Periodic toxicity testing is also conducted. In a very special case, biocriteria were developed for specific wetlands to receive treated disinfected wastewater for wetland restoration.

Further development of bioassessment procedures is dependent on the legal responsibilities and outcome of a consent decree on the Louisiana TMDL program. Any additional development will have to be compatible with TMDL deadlines and deliverables. Since Louisiana does not have biocriteria, there is not a great need for LDEQ to conduct large scale bioassessments to determine criteria attainment. When the concept of biocriteria is adequately thought out and developed for use in state permitting and TMDL programs, then LDEQ will have a larger, more inclusive, bioassessment program. The use and revision of chemical/physical criteria, standards, and assessment procedures are considered the present priority.

The Louisiana Department of Wildlife and Fisheries (LDWF) monitors fishery resources on large rivers and in coastal waters of the state for management purposes and for establishing commercial and recreational regulations on harvest. However, these assessments are not conducted to determine compliance with the Clean Water Act. Environmental agencies are increasing collaboration and coordination with LDWF and are hoping to begin combining monitoring efforts and sharing biological data at a future date.

Documentation and Further Information

State of Louisiana Water Quality Management Plan Water Quality Inventory Section 305(b) 2000:
http://www.deq.state.la.us/planning/305b/2000/index.htm

Dewalt, R. E. 1997. *Fish and macroinvertebrate taxonomic richness, habitat quality, and in-situ water chemistry of ecoregion reference streams in the Western Gulf Coastal Plains and Terrace Upland Ecoregions of Southern Louisiana*. Prepared for the Louisiana Department of Environmental Quality. Baton Rouge, LA. 72 pages.

Dewalt R. E. 1995. *Biological communities of reference streams in the South Central Plains and Upper Mississippi Alluvial Plains ecoregions of Louisiana*. Prepared for the Louisiana Department of Environmental Quality. Baton Rouge, LA. 85 pages.

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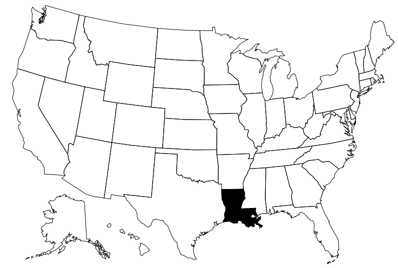

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Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
		nonpoint source assessments
		monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
		support of antidegradation
		evaluation of discharge permit conditions
		TMDL assessment and monitoring
	✓	other: ecoregion reference stream delineation, public education, bacteria assessment for swimming use, occasional toxicity testing, wetlands criteria
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects and specific river basins or watersheds)*
		fixed station (i.e., water quality monitoring stations)
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
		rotating basin
		other:

Stream Miles

Total miles *(State based estimation)*	**66,294**
Total perennial miles	–
Total miles assessed for biology*	**–**
fully supporting for 305(b)	n/a
partially/non-supporting for 305(b)	n/a
listed for 303(d)	n/a
number of sites sampled	–
number of miles assessed per site	–

*Bioassessments are not used for 305(b)/303(d) reporting purposes or biocriteria development. Louisiana's 2000 305(b) report listed 7,228 total river and stream miles assessed using chemical/physical criteria for fish and wildlife propagation and limited aquatic life/wildlife designated uses: 1,118 miles fully supporting and 6,110 miles partially/non-supporting for 305(b).

Aquatic Life Use (ALU) Designations and Decision-Making*

ALU designation basis	Class System (A,B,C)	
ALU designations in state water quality standards	Two designations: 1) Fish and wildlife propagation, 2) Limited aquatic/wildlife (a subcategory of fish and wildlife propagation)	
Narrative Biocriteria in WQS	A qualitative and/or narrative scale of condition that supports narrative biocriteria decisions is found in Louisiana's water quality standards, LAC 33:IX.1111.C and 1113.B.12	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
		cause and effect determinations
		permitted discharges
		monitoring (e.g., improvements after mitigation)
		watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Bioassessments have been used to delineate reference streams, which in turn have been used in management decisions for setting DO criteria across ecoregions.	

*Aquatic life use is assessed using chemical/physical numerical and general criteria. Louisiana does have general (narrative) criteria for biological and aquatic community integrity.

Reference Site/Condition Development

Number of reference sites	**16 total**	
Reference site determinations	✓	site-specific
		paired watersheds
		regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria	Least impacted wadeable streams, determined using best professional judgment ("common sense criteria")	
Characterization of reference sites within a regional context	✓	historical conditions *(when information is available)*
	✓	least disturbed sites
		gradient response
		professional judgment
	✓	other: wadeable streams
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information	✓	reference sites linked to ALU
	✓	reference sites/condition referenced in water quality standards *(found in LAC 33 33:IX.1113.B.12)*
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(<100 samples/year; multiple seasons, multiple sites - broad coverage for watershed level)*
	✓	fish *(<100 samples/year; multiple seasons, multiple sites - broad coverage for watershed level)*
		periphyton
		other:

Benthos	
sampling gear	collect by hand, dipnet, kick net (1 meter); 500-600 micron mesh
habitat selection	multihabitat, woody debris, richest habitat
subsample size	300 count
taxonomy	family and species
Fish	
sampling gear	backpack and boat electrofishers, Rotenone, seine; 1/8" and 1/4" mesh
habitat selection	multihabitat
sample processing	length measurement and anomalies
subsample	none
taxonomy	species
Habitat assessments	visual based; performed with bioassessments (habitat reference conditions found in WQS, LAC 33:IX.1113.B.12.)
Quality assurance program elements	standard operating procedures and quality assurance plan

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
	✓	multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients
	✓	other: nonparametric analysis

Multimetric thresholds	
transforming metrics into unitless scores	cumulative distribution function, North Carolina Biotic Index (NCBI), EPT, fish richness metrics (USEPA 1989)
defining impairment in a multimetric index	cumulative distribution function, NCBI, EPT, fish richness metrics (USEPA 1989)*

Evaluation of performance characteristics *Not currently evaluated*		repeat sampling
		precision
		sensitivity
		bias
		accuracy

Biological data	
Storage	spreadsheets and paper files
Retrieval and analysis	SAS and Excel

*LDEQ has used biological indices and matrices for evaluating wadeable streams in several ecoregions and for determining appropriate reference sites. These indices and matrices have not been adopted into the water quality standards and are not used to assess impairment for 305(b) or regulatory purposes.

MAINE

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Program Description

Biological monitoring is a primary method used by the State of Maine to assess water quality. The Biological Monitoring Program is one of five Sections within the Division of Environmental Assessment. All field, analytical and statistical methods, including the resultant numeric biocriteria have been designed, developed and tested by the MDEP Biomonitoring Program staff and a consulting biostatistician (Dr. Francis Drummond, University of Maine, Orono, Maine). Water quality standards in current use in Maine, including tiered aquatic life uses and statutory definitions of biological terms, were drafted by the Biomonitoring Program and other staff of the Division of Environmental Assessment.

The State of Maine began the process of biological criteria development by incorporating explicit narrative standards for aquatic life uses in the state water quality classification law. Each of three classes, ranging from “natural” (Class A) to minimum state standards (Class C), contains specific language that defines the allowable biological response, taking into consideration other designated uses, and expectations of community response to human activities allowed in that class. The benthic macroinvertebrate community is assessed to determine attainment of standards.

Maine’s numeric biological criteria rely on a three stage decision process. The first stage is a linear discriminant model, utilizing nine metrics to assign an initial classification probability for an unknown site. The second stage linear discriminant model uses 17 additional metrics and indicator taxa, along with probabilities derived in the first stage model, to compute final probabilities of group membership. The output is expressed as a probability of group membership for each of the four water quality classes. The highest class attained, with at least 60% probability, is used as the final model outcome. The third stage uses expert biologist’s judgement to make a final decision about attainment, based on the outcome of the linear discriminant analysis, with adjustments for any known sampling errors, unexplained community structure anomalies or atypical conditions surrounding the sampling event.

The regulatory authority for the Department's numeric biological criteria is derived from the tiered aquatic life use designations that are explicitly defined in the water quality standards law (MRSA Title 38 Article 4-A § 464-465). The Department has draft rules in support of the numeric biocriteria protocol and is expected to go to rule-making as soon as a needed electronic database upgrade is completed. The Biological Monitoring Program provides water quality information for a wide array of programs and initiatives including:

- evaluation of water quality classification attainment and 303(d) listing;
- evaluation of impacts downstream of discharges;
- general, long-term ambient monitoring and trend assessment;
- evaluation of the effects of management activities
- evaluation of the effects of nonpoint source impacts;
- evaluation of impacts from diffuse toxic contamination through the Surface Water Ambient Toxics Program (MDEP 1993)
- evaluation of the impacts of hydropower activities in fulfillment of requirements for the Clean Water Act SEC. 401 water quality certification process.

In addition, the Program is refining methods and criteria to better assess aquatic biological impacts of poor land use practices on stream and wetland systems.

MDEP is funded to do a pilot project using the EPA Stressor Identification protocol applied to an intensively surveyed 303(d) listed urban watershed. To facilitate the development of TMDLs, findings from the SI procedure will be used to better target the assessment approach for a set of five other similarly impacted urban streams.

Documentation and Further Information

State of Maine 305(b) Report, Summer 2000

Biomonitoring Retrospective: Fifteen Year Summary for Maine Rivers and Streams, December 1999: http://www.state.me.us/dep/blwq/docmonitoring/biological/biorep2000.htm

S.P. Davies & L. Tsomides, (1997) "*Methods for Biological Sampling and Analysis of Maine's Inland Waters*", MDEP, revised June 1997: http://www.state.me.us/dep/blwq/docmonitoring/finlmeth.pdf

Relevant biomonitoring materials can be accessed online: http://www.state.me.us/dep/blwq/

MAINE

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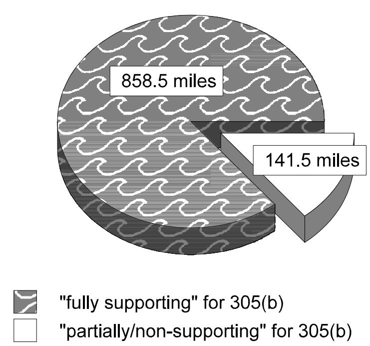
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
	✓	other: hydropower dam licensing, uncontrolled hazardous waste site monitoring
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects only)*
	✓	fixed station (i.e., water quality monitoring stations) *(specific river basins or watersheds)*
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
	✓	rotating basin *(5 yr rotation, specific river basins or watersheds)*
	✓	other: hydropower dam licensing, uncontrolled hazardous waste site monitoring

Stream Miles

Total miles *(determined using state based local GIS coverage)*	**31,672**
Total perennial miles	23,879
Total miles assessed for biology	**1,000***
fully supporting for 305(b)	858.5
partially/non-supporting for 305(b)	141.5
listed for 303(d)	141.5
number of sites sampled *(on an annual basis)*	40
number of miles assessed per site	~5

1,000 Miles Assessed for Biology



*These miles are based on the last five years of monitoring. Stream and river miles are combined, with streams accounting for roughly 80% of the total miles assessed. For program-wide estimation purposes, miles are estimated assuming that each monitored station assesses about 5 miles of river or stream, though this number does vary. The last few years, up to 55 sites have been sampled, but 40 is the average number.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis		Class system (AA, A, B, C)
ALU designations in state water quality standards*		Four designations based on a gradient of biological condition: AA- "as naturally occurs", natural flow regime; A- "as naturally occurs", hydro allowed; B- "no detrimental change"; C- "maintain structure and function, support for salmonids"
Narrative Biocriteria in WQS		Procedures used to support narrative biocriteria located in MDEP WQS.
Numeric Biocriteria in WQS		under development – Draft numeric biocriteria rule in internal agency review, due for promulgation in 2002. (A probabilistic model - linear discriminant analysis - designed using expert judgment and statistical analysis is currently used to determine attainment of conditions described in aquatic life standards. Numeric biocriteria have been used to implement agency policy since 1990.)
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management *(pertains to "small" watersheds)*
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU		Many examples of this have been documented in case studies provided in "Biomonitoring Retrospective: Fifteen year summary for Maine rivers and streams" available in .pdf on website: http://www.state.me.us/dep/blwq/docmonitoring/biological/biorep2000.htm

*Tiered aquatic life uses in Maine Water Quality standards are consistent with the condition gradient describing other applicable WQ standards (dissolved oxygen, bacteria, toxics) for each class.

Reference Site/Condition Development

Number of reference sites		**370 total**
Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria		Minimally disturbed reference site standards are defined by the following criteria – Based on ArcView GIS coverages; by percent of watershed upstream of the sampled station: >90% forested; <5% active logging; <1% cropland, residential or urban.
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
	✓	gradient response
	✓	professional judgment
	✓	other: minimally disturbed**
Stream stratification within regional reference conditions		ecoregions (or some aggregate)
		elevation
		stream type
	✓	multivariate grouping *(4 multivariate groups)*
		jurisdictional (i.e., statewide)
		other:
Additional information	✓	reference sites linked to ALU
	✓	reference sites/condition referenced in water quality standards *(State of Maine. 1985. Maine Laws Ch. 698 §15 - in part. An Act to Amend the Classification System for Maine Waters)*
	✓	some reference sites represent acceptable human-induced conditions

**Minimally disturbed characterization is one component of established reference conditions; they are also divided into different classes and groups with different biological attributes. Maine has a range of streams, from pristine to severely degraded.

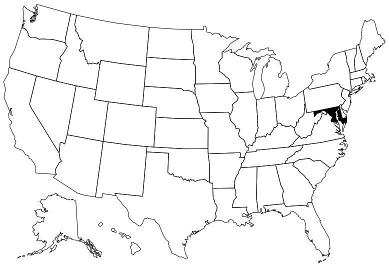
Field and Lab Methods

Assemblages assessed	✓	benthos *(100-500 samples/year; single season, multiple sites - watershed level and broad coverage)*
		fish
	✓	periphyton *(<100 samples/year; single season, multiple sites - broad coverage)*
		other:
Benthos		
sampling gear		rock baskets (500-600 micron mesh)
habitat selection		riffle/run (cobble), artificial substrate
subsample size		entire sample *(if >500 organisms, subsamples are taken proportionately at 25% of sample, then adjusted back to whole sample counts)*
taxonomy		genus, species *(identified to lowest possible level; adjusted to genus in database)*
Periphyton		
sampling gear		**natural substrate**: brushing/scraping device (razor, toothbrush, etc.) **artificial substrate**: periphytometer
habitat selection		open canopy in riffle/run
sample processing		chlorophyll *a*/ phaeophytin; biomass; taxonomic identification
taxonomy		all algae; genus level; species level
Habitat assessments		visual based; performed with bioassessments
Quality assurance program elements		standard operating procedures, quality assurance plan, periodic meetings, training for biologists, sorting proficiency checks, taxonomic proficiency checks, specimen archive

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
	✓	multivariate analysis
	✓	biological metrics *(multiple computed metrics are used as input variables in probabilistic model)*
	✓	disturbance gradients
		other:
Multivariate thresholds		
defining impairment in a multivariate index		Probabilistic model using *a priori* sites defined by expert judgement
Evaluation of performance characteristics	✓	repeat sampling *(long-term annual monitoring sites)*
	✓	precision *(percent accuracy compared to a priori class)*
		sensitivity
	✓	bias *(in relation to stream size, latitude/longitude, velocity, eco-region)*
	✓	accuracy *(percent accuracy compared to a priori class; a priori reference sites compared to land use - selected reference sites)*
Biological data		
Storage		STORET; Oracle/Visual Basic relational database (with linkage to ARCINFO spatial database with point coverage for all monitoring stations)
Retrieval and analysis		Core linear discriminant models statistical routines are run and reported from within the Oracle database; spatial analysis in ArcView and ARCINFO; routine queries run in MS Access, Systat or Excel

MARYLAND



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MD DNR Maryland Streams homepage: http://www.dnr.state.md.us/streams/index.html

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Program Description

The Maryland Biological Stream Survey (MBSS) is a program of the Maryland Department of Natural Resources (MD DNR) and is intended to provide statistically unbiased estimates of the condition of first through third-order (wadeable) non-tidal streams and rivers of Maryland on a local (e.g., drainage basin or county) as well as a statewide scale. The survey is based on a probabilistic stream sampling approach where random selections are made from all streams in the state that can physically be sampled. The approach supports statistically valid population estimation of variables of interest (e.g., largemouth bass densities, miles of streams with degraded physical habitat, miles of streams with poor Index of Biotic Integrity scores, etc.). When repeated, the Survey will also provide a basis for assessing future changes in ecological condition of flowing waters of the state. At present, plans are to repeat the Survey at regular intervals and expand the approach to larger streams and tidal creeks.

Benthic macroinvertebrates and water quality samples are collected during the spring index period from March through early May, while fish, herpetofauna, *in situ* stream chemistry, and physical habitat sampling are conducted during the low flow period in the summer, from June through September.

Data collected from each sample site are used to develop statewide and basin-specific estimates of totals, means (or averages), proportions, and percentiles for the parameters of interest. The amount of variability (or margin of error) associated with any estimate of a total, mean, proportion, or percentile is determined by calculating a standard error, a statistic that measures the reliability of an estimate. A standard error also provides a statistical basis for deciding if the observed changes in any parameter of interest over time or space are significantly different or simply due to chance alone.

Documentation and Further Information

2000 Maryland Section 305(b) Water Quality Report, with *Appendix E, Assessment Methodology*:
http://dnrweb.dnr.state.md.us/download/bays/MD2000_305b.pdf

DRAFT 2002 Integrated 303(d) List: http://www.mde.state.md.us/tmdl/2002_303dlist/index.html

From the Mountains to the Sea: The State of Maryland's Freshwater Streams, December 1999:
http://www.dnr.state.md.us/streams/pubs/md-streams.pdf

Maryland Biological Stream Survey (MBSS) Sampling Manual, February 2000:
http://www.dnr.state.md.us/streams/pubs/2000samp_manual.pdf

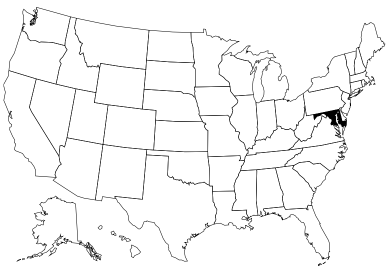
MBSS Laboratory Methods for Benthic Macroinvertebrate Processing and Taxonomy, November 2000:
http://www.dnr.state.md.us/streams/pubs/ea00-6_lab_man.pdf

Refinement and Validation of a Fish Index of Biotic Integrity (IBI) for Maryland Streams, October 2000:
http://www.dnr.state.md.us/streams/pubs/ea00-2_fibi.pdf

Development of a Benthic Index of Biological Integrity for Maryland Streams, December 1998:
http://www.dnr.state.md.us/streams/pubs/1998_Benthic%20IBI.pdf

For more documents and publications, go to: http://www.dnr.state.md.us/streams/mbss/mbss_pubs.html or
http://www.dnr.state.md.us/streams/pubs/pub_list.html

MARYLAND



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Programmatic Elements

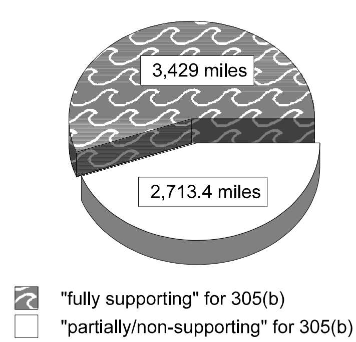
Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs *(LIMITED)*
	✓	ALU determinations/ambient monitoring *(LIMITED)*
	UD	promulgated into state water quality standards as biocriteria *(through MDE)*
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions *(LIMITED)*
	✓	TMDL assessment and monitoring *(MDE using MBSS data)*
	✓	other: target restoration costs and locations; areas for preservation; track trends in stream conditions; identify relationships between stressors and biota; predict future conditions based on land use changes
Applicable monitoring designs*	✓	targeted *(small portion - special projects and specific river basins or watersheds)*
	✓	fixed station (i.e., water quality monitoring stations) *(sentinel site network, best of the best streams in the state, comprehensive use throughout jurisdiction)*
	✓	probabilistic by stream order/catchment area *(comprehensive use throughout jurisdiction)*
	✓	probabilistic by ecoregion, or statewide *(comprehensive use throughout jurisdiction)*
	✓	rotating basin *(comprehensive use throughout jurisdiction)*
		other:

*The largest portion of sampling effort is for probabilistic sampling with watershed as primary strata.

Stream Miles

Total miles *(determined using National Hydrography Database)*	**17,000**
Total perennial miles	12,343
Total miles assessed for biology**	**6,142**
fully supporting for 305(b)	3,429.0
partially/non-supporting for 305(b)	2,713.4
listed for 303(d)**	178 actual listings
number of sites sampled *(from 1995-1997)*	1,000
number of miles assessed per site	–

6,142 Miles Assessed for Biology



**The miles listed above were extracted from Maryland's 2000 305(b) Report, which stated, "The assessment of non-tidal rivers and streams is based on monitoring data, including ambient water quality monitoring programs and other water quality data collected by [various agencies and programs]." The above miles are categorized as "monitored" in the 2000 305(b). However, the MBSS method only applies to *wadeable* nontidal streams, thus some portion of the total assessed stream and river miles listed above were not assessed using this method. The 178 sites listed for 303(d) were pulled from the DRAFT 2002 303(d) Report. These miles do not include streams larger than 4th order or with tidal flow.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Single Aquatic Life Use, Fishery Based Uses, Warm Water vs. Cold Water	
ALU designations in state water quality standards	Seven uses: I: support of fish & aquatic life and recreation; I-P: adds drinking water supply to Use I; II: shellfish harvesting; III: natural trout; III-P: adds drinking water supply; IV: recreational trout (put and take); IV-P: adds drinking water.	
Narrative Biocriteria in WQS	Narrative regulations and formal/informal numeric procedures specifically addressing biocriteria applications are under development.	
Numeric Biocriteria in WQS	none - documented quantitative method applied	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges *(RARELY)*
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Threatened and Endangered species listings are being revised based on MBSS fish population data; cost estimates for habitat restoration in MD streams are being finalized in support of Chesapeake Bay 2000 Agreement action items; MBSS data integral to developing restoration priority ranking for MD watersheds; also used by The Nature Conservancy to develop highest priority watersheds for land acquisition and other preservation activities	

Reference Site/Condition Development

Number of reference sites	**152 total**	
Reference site determinations		site-specific
		paired watersheds
		regional (aggregate of sites)
		professional judgment
	✓	other: use combination of *a priori* physical and chemical criteria applied to randomly selected sites - these represent the best remaining sites in Maryland
Reference site criteria	Must meet *a priori* chemical and physical criteria (criteria found in MBSS IBI documents for fish and benthos)	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
	✓	other: reference sites stratified by stream order
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(100-500 samples/year; single season, multiple sites - watershed level)*
	✓	fish *(100-500 samples/year; single season, multiple sites - watershed level)*
		periphyton
	✓	other: macrophytes and amphibians/reptiles (*presence/absence only) (100-500 samples/year; single season, multiple sites - watershed level*)

Benthos	
sampling gear	D-frame; 500-600 micron mesh
habitat selection	multihabitat, focus on most productive habitat - riffles
subsample size	100 count
taxonomy	genus (family level taxonomy for volunteer Stream Waders Program)
Fish	
sampling gear	backpack electrofisher, barge shocker sometimes used on larger streams, herpetile search also conducted by hand; 1/4" mesh
habitat selection	whatever is in the 75 meter segment
sample processing	length measurement and biomass – batch (gamefish only); anomalies (unusual types or prevalence noted)
subsample	none
taxonomy	species
Habitat assessments	visual based, quantitative measurements, buffer width and vegetation size category, linear and areal extent of eroded banks; performed with bioassessments
Quality assurance program elements	standard operating procedures; quality assurance plan; periodic meetings/ training for biologists; sorting and taxonomic proficiency checks; specimen archival; double entry of data; range checks; peer review of reports; certification program for bioassessment

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
	✓	parametric ANOVAs
	✓	multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
	✓	disturbance gradients
	✓	other: various, depending on needs

Multimetric thresholds*	
transforming metrics into unitless scores	50th percentile of reference population
defining impairment in a multimetric index	10th percentile used as threshold between metric scores of 3 and 1; confidence intervals used to evaluate sample results for attainment decisions
Multivariate thresholds	
defining impairment in a multivariate index	For development of IBI; not current analysis

Evaluation of performance characteristics	✓	repeat sampling *(see IBI documents plus interim biocriteria document produced by MDE)*
	✓	precision *(replicate sample/same team, same reach)*
	✓	sensitivity *(classification efficiency)*
		bias
	✓	accuracy *(classification efficiency)*
	✓	other: re-sort in laboratory

Biological data	
Storage	MS Access, SAS primarily, but also use spreadsheets for some applications (data dictionaries are produced for external users - see MBSS publications page)
Retrieval and analysis	SAS, Excel, Quattro pro, ARC View

*Fish and Benthic IBIs are also combined into a "Combined Biological Index."

MASSACHUSETTS

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Program Description

Biological monitoring techniques are an important component of the watershed-based surface water quality monitoring and assessment program administered by the Massachusetts Department of Environmental Protection (MADEP). The goals of this program are to assess whether the surface waters of Massachusetts are of sufficient quality and quantity to support their multiple uses, and to report those findings in watershed assessment reports, the 305(b) Summary of Water Quality Report and the 303(d) List of Impaired Waters. Monitoring is also used to identify causes and sources of water use impairments as the first step toward developing water quality and quantity management strategies.

MADEP biologists assess the condition of resident macroinvertebrate, fish and algal communities in streams to provide a direct measure of the ecological response to the cumulative effects of pollutant loadings and habitat degradation. These bioassessments, coupled with water quality data and other relevant information, form the basis for determining the aquatic life use-support status, as defined in the *Massachusetts Surface Water Quality Standards*.

Rapid bioassessment protocols (RBPs), based on those developed by the USEPA, are used to monitor the integrity of the benthic macroinvertebrate community. A targeted sampling design is employed whereby sites are selected for upstream/downstream comparisons, comparisons against a regional or surrogate reference, or for long-term trend monitoring. Based on scoring of several metrics, four categories of impairment are discerned by the RBP analysis (non-impaired, slightly impaired, moderately impaired, and severely impaired). Approximately 50-75 sites are assessed each year in accordance with a rotating watershed monitoring scheme.

The analysis of the structure of the finfish community as a measure of biological integrity is another component of the water quality monitoring program. MADEP utilizes a standardized method based on RBP V (USEPA 1989) to improve data comparability among wadeable sampling sites. The fish collection procedures involve sampling habitats in relative proportion to their local availability. A representative 100-meter stream reach is selected to include the primary physical habitat characteristics of the stream (i.e., riffle, run, and pool habitats). Electrofishing is the preferred method for obtaining a representative sample of the fish community at each sampling site. Fish (except young-of-the-year) collected within the study reach are identified to species, counted, and examined for external anomalies, (i.e., deformities, eroded fins, lesions, and tumors). Aquatic life use-support status is derived from a knowledge of the environmental requirements (e.g., water temperature and clarity, dissolved oxygen content) and relative tolerance to water pollution of the species collected.

Algae represent a third community that may be assessed. The analysis of the attached algae or periphyton community in shallow streams, or the phytoplankton in deeper rivers and lakes employs an indicator species approach whereby inferences on water quality conditions are drawn from an understanding of the environmental preferences and tolerances of the species present. Because the algal community typically exhibits dramatic temporal shifts in species composition throughout a single growing season, results from a single sampling event are generally not indicative of historical conditions. For this reason the information gained from the algal community assessment is more useful as a supplement to the assessments of other communities that serve to integrate conditions over a longer time period.

In addition to the community analyses described above, MADEP also collects some fish to be assayed for the presence of toxic contaminants in their tissues. The goal of this monitoring element is primarily to provide data for the assessment of the risk to human consumers associated with the consumption of freshwater finfish. In the past fish collection efforts were generally restricted to waterbodies where wastewater discharge data or previous water quality studies indicated potential toxic contamination problems. More recently, concerns about mercury contamination from both local and far-field sources have led to a broader survey of waterbodies throughout Massachusetts. In both cases, nonetheless, the analyses have been restricted to edible fish fillets.

Documentation and Further Information

Commonwealth of Massachusetts Summary of Water Quality 2000

Massachusetts Surface Water Quality Standards, May 1997: http://www.state.ma.us/dep/bwp/iww/files/314004.pdf

For a list of online resources, go to: http://www.state.ma.us/dep/brp/wm/wmpubs.htm#other

Jessup, B.K., J. Gerritsen, M.T. Barbour, and R. Haynes. 2001. *Analysis and Interpretation of Pilot Study Data as an Initial Step in the Development of Biological Criteria for Streams and Small Rivers in Massachusetts*. Prepared by Tetra Tech, Inc., for Massachusetts Department of Environmental Protection, Worcester, MA.

MASSACHUSETTS

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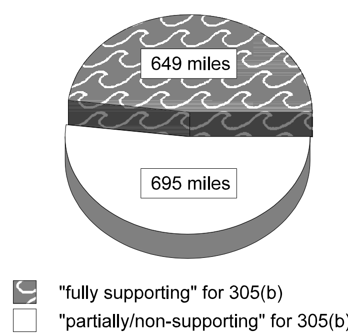
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
		monitoring the effectiveness of BMPs
	✓	ALU determinations, ambient monitoring
		promulgated into state water quality standards as biocriteria
		support of antidegradation
	✓	evaluation of discharge permit conditions
		TMDL assessment and monitoring
	✓	other: development of numeric biocriteria
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(specific river basins or watersheds)*
		fixed station (i.e., water quality monitoring stations)
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
	✓	rotating basin *(specific river basins or watersheds)*
		other:

Stream Miles

Total miles *(determined using a state based program)*	**8,229**
Total perennial miles	7,133
Total miles assessed for biology	**1,344**
fully supporting for 305(b)	649
partially/non-supporting for 305(b)	695
listed for 303(d)	695
number of sites sampled *(on an annual basis)**	~100
number of miles assessed per site*	site specific

1,344 Miles Assessed for Biology



*The number of sites sampled varies annually, as does the number of miles assessed per site.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Warm water vs. Cold water	
ALU designations in state water quality standards	Three designations: 1. General Aquatic Life Support 2. Cold Water/Warm Water Fishery 3. Shellfish Harvesting	
Narrative Biocriteria in WQS	none - General aquatic life statement found in WQS; informal process in place to translate RBP metrics to level of use support.	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
		cause and effect determinations
	✓	permitted discharges
		monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Information discussed in water quality assessment reports along with recommendations for management, restoration and further monitoring.	

Reference Site/Condition Development

Number of reference sites	**5 - 10 total** *(on an annual basis)**	
Reference site determinations	✓	site-specific
	✓	paired watersheds
	✓	regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria	Least impacted by known point discharges; least impacted by riparian zone land uses; habitat qualities comparable to test sites. For regional reference sites MADEP attempts to locate the least-disturbed sites by conducting extensive reconnaissance throughout the watershed and selecting sites that do not appear to have point or nonpoint sources of pollution upstream from them. Reference sites that represent the various sub-ecoregions that exist in Massachusetts are gradually being identified. This process is not yet complete, however.	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
	✓	other: MADEP is working on identifying reference sites to represent various sub-ecoregions
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

*MADEP does not have a fixed set of reference stations situated throughout the state. Rather, during the rotating basin schedule MADEP reconnaissances new reference sites depending upon where the sampling will take place. Therefore the number of reference sites may vary from year to year.

Field and Lab Methods

Assemblages assessed	✓	benthos *(<100 samples/year; single season, multiple sites - watershed level)*
	✓	fish *(<100 samples/year; single season, multiple sites - watershed level)*
	✓	periphyton *(<100 samples/year; single season, multiple sites - some at watershed level)*
	✓	other: macrophytes *(<100 samples/year; single season, multiple sites - not at watershed level)*

Benthos	
sampling gear	multi-plate, rock baskets, collect by hand, single-pole kick-net (45 cm, rectangular, 500-600 micron mesh)
habitat selection	riffle/run (cobble)
subsample size	100 count
taxonomy	combination--genus, species
Fish	
sampling gear	backpack electrofisher, boat electrofisher, seine; 1/8", 3/16" and 1/4" mesh
habitat selection	multihabitat
sample processing	length measurement, biomass - individual, anomalies
subsample	all species, 25 individuals of each
taxonomy	sub-species
Periphyton	
sampling gear	**natural substrate**: suction device, brushing/scraping device (razor, toothbrush, etc.), collect by hand; **artificial substrate**: microslides or other suitable substratum
habitat selection	richest habitat, riffle/run (cobble), multihabitat, artificial substrate
sample processing	chlorophyll *a*/ phaeophytin, biomass, taxonomic identification
taxonomy	genus level for soft-bodied algae when possible; diatoms are not cleared
Habitat assessments	visual based; performed with bioassessments
Quality assurance program elements	standard operating procedures; quality assurance plan; periodic meetings, training for biologists; limited taxonomic proficiency checks; specimen archival

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients
		other:

Multimetric thresholds*	
transforming metrics into unitless scores	Follow 1989 EPA RBP guidelines (Figure 6.3-4)
defining impairment in a multimetric index	Follow 1989 EPA RBP guidelines: anything <83% of reference is impaired/impacted

Evaluation of performance characteristics		repeat sampling
	✓	precision *(duplicate sampling)*
		sensitivity
		bias
		accuracy

Biological data	
Storage	MS Access 2000
Retrieval and analysis	MS Access 2000 - benthos database customized from EDAS

*Everything is determined relative to the reference sites; however some parts of this have been refined, including the similarity index thresholds, and MADEP hopes to use biocriteria data to further modify thresholds. MADEP has also evaluated a model community at order level as a substitute for similarity indices (see Novak & Bode, 1992).

MICHIGAN

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MDEQ Water homepage: http://www.michigan.gov/deq/1,1607,7-135-3313---,00.html

Program Description

In 1997, the Michigan Department of Environmental Quality (MDEQ) completed a report entitled, *A Strategic Environmental Quality Monitoring Program for Michigan's Surface Waters* (Strategy). This Strategy describes the monitoring activities necessary for a comprehensive assessment of water quality in Michigan's surface waters. One component of the Strategy is expanded and improved monitoring of biological integrity and physical habitat.

This program element includes all monitoring conducted for fish and benthic invertebrate community structure, nuisance aquatic plants, algae, and slimes, and assessment of physical habitat. The MDEQ's goal in conducting watershed surveys is to assess 80 percent of the stream and river miles in Michigan over a five-year period.

Enhanced biological integrity and physical habitat monitoring is consistent with existing MDEQ programs and activities. MDEQ uses the existing five-year basin units defined by the NPDES permitting program, which includes 45 watershed units based on drainage to the four Great Lakes. Monitoring activities in each watershed include not only biological integrity, but also fish and wildlife contaminant studies, water chemistry, and sediment chemistry. Integrating the enhanced biological monitoring with the other activities, within the framework of the five-year permitting cycle, will ensure that the monitoring is closely linked with other MDEQ programs and contributes to resource management decisions. Specific objectives of biological integrity and physical habitat monitoring are to:

1. Determine whether waters of the state are attaining standards for aquatic life.
2. Assess the biological integrity of the waters of the state.
3. Determine the extent to which sedimentation in surface waters is impacting indigenous aquatic life.
4. Determine whether the biological integrity of surface waters is changing with time.
5. Assess the effectiveness of BMPs and other restoration efforts in protecting and/or restoring biological integrity and physical habitat.
6. Evaluate the overall effectiveness of MDEQ programs in protecting the biological integrity of surface waters.
7. Identify waters that are high quality, as well as those that are not meeting standards.
8. Identify the waters of the state that are impacted by nuisance aquatic plants, algae, and bacterial slimes.

Rapid, qualitative biological assessments of wadeable streams and rivers are conducted using the Great Lakes and Environmental Assessment Section Procedure 51, which compares fish and benthic invertebrate communities at a site to the communities that are expected at an un-impacted, or reference, site. This is a key tool used by MDEQ to determine whether waterbodies are attaining Michigan WQS. Because Procedure 51 is meant to be a qualitative, rapid assessment tool, the MDEQ established a contract with the Great Lakes Environmental Center to develop a statistically valid sample design and procedure for detection of trends using benthic macroinvertebrates. This project is scheduled for completion in January 2003.

All biological community data are entered into MDEQ's MS Access database. Biological and habitat data collected as part of the five-year watershed surveys are summarized in watershed reports. The list of these reports is stored in a database that will be accessible to the public via the MDEQ Surface Water Quality Division's website.

Documentation and Further Information

Michigan Water Quality Report (Year 2000 305(b) Report):
http://www.michigan.gov/deq/1,1607,7-135-3313_3686_3728-12711--,00.html

CWA Section 303(d) List: Michigan Submittal for Year 2002:
http://www.deq.state.mi.us/documents/deq-swq-gleas-303_d_Rpt2002b.pdf

Michigan's WQS, revised April 1999: http://www.deq.state.mi.us/documents/deq-swq-gleas-305b2002Appl.doc

MDEQ Biosurveys website:
http://www.michigan.gov/deq/0,1607,7-135-3313_3686_3728-32369--,00.html

MICHIGAN

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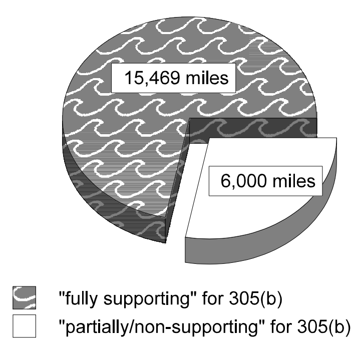
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
		promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects only)*
		fixed station (i.e., water quality monitoring stations)
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
	✓	rotating basin *(specific river basins or watersheds and comprehensive use throughout jurisdiction)*
		other:

Stream Miles

Total miles *(determined using RF3)*	**49,141**
Total perennial miles	27,873
Total miles assessed for biology	**21,469**
fully supporting for 305(b)	15,469
partially/non-supporting for 305(b)	6,000
listed for 303(d)	2,600
number of sites sampled	3,500
number of miles assessed per site	–

21,469 Miles Assessed for Biology



Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Warm Water vs. Cold Water	
ALU designations in state water quality standards	Three designations: coldwater fisheries, warmwater fisheries, and other indigenous aquatic life and wildlife (per Rule 100 of Michigan's WQS). Coldwater fishery includes any of the following: trout, salmon, whitefish, cisco. Warmwater fishery includes fish species that thrive in relatively warmwater, including any of the following: bass, pike, walleye, panfish.	
Narrative Biocriteria in WQS	none*	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	TMDL listing and delisting decisions	

*Michigan does not have narrative biocriteria, per se. However, MI does have tiered ALU designations and numeric procedures (the Gleas Procedure #51) to implement WQS, evaluate nonpoint source impacts, and assess designated uses. According to MDEQ's *Qualitative and Biological Biological Survey Protocols for Wadeable Streams and Rivers* (Procedure #51), "The development of these biological and habitat survey protocols was a result of the increasing demand for a more vigorous and standardized evaluation of nonpoint source impacts. The nature and diversity of the causes of nonpoint pollution created a need for greater refinement and sophistication of the Surface Water Quality Division's standard biological survey procedures in order to assess the degree and causes of these biological impacts."

Reference Site/Condition Development

Number of reference sites	**200 total**	
Reference site determinations	✓	site-specific
		paired watersheds
		regional (aggregate of sites)
		professional judgment
		other:
Reference site criteria	excellent biota present	
Characterization of reference sites within a regional context *Not applicable*		historical conditions
		least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(>500 samples/year; single season, multiple sites - watershed level)*
	✓	fish *(<100 samples/year; single season, multiple sites - watershed level)*
		periphyton
		other:

Benthos	
sampling gear	D-frame and dipnet; 800-900 micron mesh
habitat selection	multihabitat
subsample size	100 count
taxonomy	combination - family, genus
Fish	
sampling gear	backpack electrofisher and pram unit (tote barge)
habitat selection	multihabitat
sample processing	length measurement and anomalies
subsample	none
taxonomy	species
Habitat assessments	visual based; performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings and training for biologists, specimen archival

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	Two standard deviations from excellent condition
defining impairment in a multimetric index	Two standard deviations from excellent condition

Evaluation of performance characteristics	✓	repeat sampling
	✓	precision *(repeat sampling by teams during round robins over the years)*
		sensitivity
		bias
		accuracy

Biological data	
Storage	MS Access database, spreadsheets
Retrieval and analysis	SAS, Systat and Statistica

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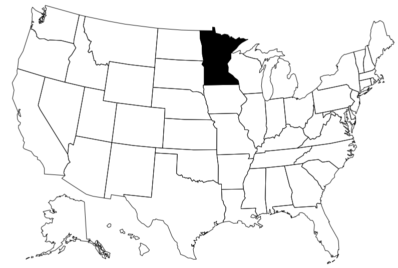

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Program Description

The Minnesota Pollution Control Agency (MPCA) Biological Assessment Unit, located in the Environmental Standards and Analysis Section, performs many functions integral to water quality decision-making. Among these, the Unit:

- Develops biological measures of ecological integrity for streams and wetlands.
- Collects and analyzes biological monitoring data.
- Builds a biological monitoring system that includes streams in the 10 major river basins.
- Lays the groundwork for the development of biological indicators for lakes and large rivers.
- Determines biological impairments of rivers and streams for use in TMDL studies
- Coordinates creation of TMDL listing.

Documentation and Further Information

2000 Minnesota Water Quality: Surface Water Section, Years 1998 - 1999 305(b) Report:
http://www.pca.state.mn.us/publications/reports/305bfinalreport-2000.pdf

Stream Assessment Methods for Use Support: http://www.pca.state.mn.us/water/basins/method98.pdf

MPCA Water Quality Criteria - Aquatic Life Use Support in Rivers and Streams:
http://www.pca.state.mn.us/water/basins/rivkey98.pdf

Minnesota Lake Water Quality Assessment Data: 2000: http://www.pca.state.mn.us/water/pubs/lwqar.pdf

MPCA Environmental Outcomes Division website: http://www.pca.state.mn.us/about/eod.html

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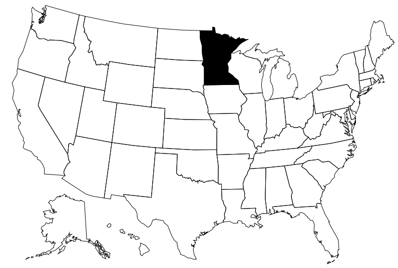

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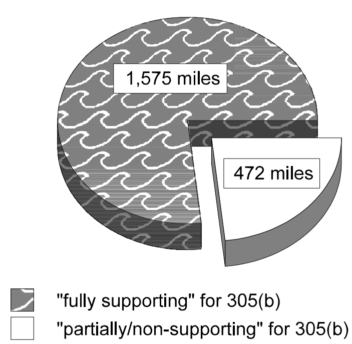
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
		monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
		support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(in specific river basins or watersheds for biocriteria development, problem investigation, and effectiveness monitoring)*
		fixed station (i.e., water quality monitoring stations)
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
	✓	rotating basin *(in specific river basins or watersheds for condition monitoring and biocriteria development)*
	✓	other: probabilistic by major basin

Stream Miles

Total miles *(determined using National Hydrography Database)*	**91,944**
Total perennial miles	32,985
Total miles assessed for biology*	2,047
fully supporting for 305(b)	1,575
partially/non-supporting for 305(b)	472
listed for 303(d)	785
number of sites sampled *(on an annual basis)*	100
number of miles assessed per site	depends on segment length

2,047 Miles Assessed for Biology



*The discrepancy between 305(b) and 303(d) miles is due to a change in methods related to the threshold level of impairment. The numbers for 303(d) reflect the information from the latest proposed 303(d) list using the new threshold levels. The 305(b) miles will reflect the old threshold levels until the next 305(b) assessments occur.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Class System (1,2,3), Fishery Based Uses and Warm Water vs. Cold Water	
ALU designations in state water quality standards	Aquatic life and recreation, Class 2. 4 subclasses: 2A, cold water (salmonid) fishery; 2B cool & warm water fishery; 2C, "indigenous" fishery; 2D, wetlands	
Narrative Biocriteria in WQS	Numeric procedures to implement narrative biocriteria are in separate Guidance documents, not part of the water quality standards.	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
		cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Bioassessment information is being used in the TMDL process and to support decisions regarding permitted discharges.	

Reference Site/Condition Development

Number of reference sites	**35 total**	
Reference site determinations*		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria	Reference sites are defined as minimally disturbed reaches/areas within a specific geographic region, within a given aquatic classification framework. The criteria used to define reference sites are based on biology, landuse, and habitat and are adjusted by region (basin, ecoregion, etc).	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
	✓	other:**
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
	✓	stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
	✓	other: At this time MPCA is using major river basin as a framework. This could change once a statewide database is developed.
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

*Candidate reference sites are initially selected using GIS coverages including landuse, point source, ditching, and feedlot. After the biological sampling has occurred, reference sites are chosen using the biological, habitat, and GIS based information.

**There are regions within Minnesota where *minimally impacted* reference sites will eventually be identified. MPCA has not had the opportunity to develop biological criteria for these areas yet, but is planning to do so within the next five to ten years.

Field and Lab Methods

Assemblages assessed	✓	benthos *(100-500 samples/year; single season, multiple sites - watershed level)*
	✓	fish *(100-500 samples/year; single season, multiple sites - watershed level)*
		periphyton
	✓	other: macrophytes *(<100 samples/year; single season multiple sites – not at watershed level)*

Benthos	
sampling gear	D-frame; 500-600 micron mesh
habitat selection	multihabitat
subsample size	300 count
taxonomy	genus
Fish	
sampling gear	backpack and boat electrofishers, and pram unit (tote barge)
habitat selection	multihabitat
sample processing	length measurement, biomass - batch and anomalies
subsample	none
taxonomy	species
Habitat assessments	quantitative measurements; performed with bioassessments
Quality assurance program elements	standard operating procedures, periodic meetings and training for biologists, sorting and taxonomic proficiency checks, specimen archival

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
	✓	disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	95^{th} percentile of all sites
defining impairment in a multimetric index	The percentile of the reference population will vary by major basin because of wide variability between basins regarding the level of human disturbance.

Evaluation of performance characteristics	✓	repeat sampling *(10% of all sites are repeated during a season)*
	✓	precision (*A multiyear study, currently 5 years long, is being conducted to evaluate the precision of IBI scores over a long term period. This work is taking place at reference sites and degraded sites - ten sites total.)*
	✓	sensitivity *(sensitivity has been examined by evaluating IBI scores against gradients of disturbance)*
		bias
	✓	accuracy *(accuracy has been informally examined by comparison of IBI scores to expected results from a landuse/habitat rating score)*

Biological data	
Storage	database (details not provided)
Retrieval and analysis	Systat

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Program Description

The Mississippi Department of Environmental Quality (MDEQ) has a Surface Water Monitoring Program (SWMP), which:

- Meets the requirements of Section 106 of CWA,
- Monitors, assesses and reports overall status and trends of surface water quality state-wide,
- Identifies impaired waterbodies and determines causes and sources of impairment,
- Determines effectiveness and supports monitoring and assessment activities of other Surface Water Division (SWD) Programs,
- Addresses surface water quality issues and economic development interests of public concern, and
- Determines better ways of monitoring and assessing surface waters.

Biological data collection, assessment and reporting are an integral component of MDEQ's SWMP and have been for many years. In addition, biological data are a primary assessment component of MDEQ's 305(b) and 303(d) reporting processes. Specifically, macroinvertebrate assessment results are used in the process of determining aquatic life use support and for identifying impaired waterbodies. Macroinvertebrate data are also used to complement other environmental data throughout the TMDL process, including stressor identification and TMDL implementation monitoring. A probabilistic survey design is planned for incorporation into MDEQ's ongoing ambient monitoring network in the future. This approach is intended to produce a more accurate, scientifically defensible and comprehensive assessment of biological condition throughout the state. This will result in collection of biological data at a combination of fixed and random stations each year in conjunction with MS DEQ's Basin Management Approach.

In 2001, MDEQ redesigned its biological monitoring and assessment program to include more rigorous training; field sampling; laboratory sorting, subsampling, and taxonomy; analytical methods; and documentation. It included a comprehensive QA Project Plan with detailed standard operating procedures (SOPs), revision of data entry and database management procedures, and documentation of data quality characteristics throughout the entire assessment process. Approximately 450 wadeable stream sites were sampled statewide with the exception of the MS River Alluvial Plain during a winter index period for benthic macroinvertebrates, physical habitat quality, substrate particle size distribution, and selected field and analytical chemistry. Using GIS, the drainage area for the each site was delineated and land use characterized. For five bioregions, reference conditions were developed based on the concept of "best attainable" conditions, and a multimetric index of biological integrity calibrated, the Mississippi Benthic Index of Stream Quality (M-BISQ).

Documentation and Further Information

State of Mississippi Water Quality Assessment 2002 Section 305(b) Report, Big Black River Basin Supplement: http://www.deq.state.ms.us Click: OPC then Surface Water then 305(b)

State of Mississippi 2002 List of Waterbodies, 303(d) Report: http://www.deq.state.ms.us Click: TMDLs

State of Mississippi Water Quality Criteria for Intrastate, Interstate and Coastal Waters, October 2002: http://www.deq.state.ms.us Click: MDEQ Regulations then By Type then Water then WPC-1

Quality Assurance Project Plan for 303(d) List Assessment and Calibration of the Index of Biological Integrity for Wadeable Streams in Mississippi.

Development and Application of the Mississippi Benthic Index of Stream Quality (M-BISQ).

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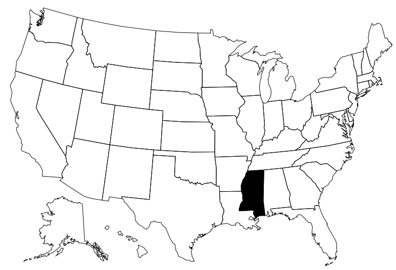

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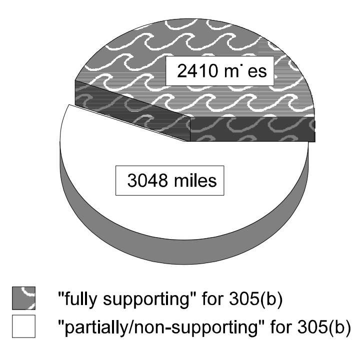
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
		promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(comprehensive use throughout jurisdiction)*
	✓	fixed station (i.e., water quality monitoring stations) *(comprehensive use throughout jurisdiction)*
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
	✓	rotating basin *(comprehensive use throughout jurisdiction)*
		other:

Stream Miles

Total miles *(determined using RF3)*	**84,003**
Total perennial miles	26,454
Total miles assessed for biology	**5,458**
fully attaining ALUS for 305(b)	2,410
not fully attaining ALUS for 305(b)	3,048
listed for 303(d)	3,048
number of sites sampled	455
number of miles assessed per site	~12

5,458 Miles Assessed for Biology



*MDEQ implemented a new biological assessment program (started in fall, 2001). Miles assessed for biology and 305(b)/303(d) numbers reflect this change and vary significantly from previous assessments.

NOTE: All information contained in this summary refers to procedures adopted under the *new* bioassessment program.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Single Aquatic Life Use
ALU designations in state water quality standards	One designation: Fish and Wildlife (biological data are only assessed for fish and wildlife classification)
Narrative Biocriteria in WQS	Presently, there are no written informal/formal numeric procedures to support narrative biocriteria decisions. Available procedures support a general aquatic life standard.
Numeric Biocriteria in WQS	none

Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management

Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	none

Reference Site/Condition Development

Number of reference sites	**83 total**

Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
		professional judgment
		other:

Reference site criteria	Surrounding landuse, physical habitat, substrate particle size, water chemistry, biology, and historical information.

Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions		ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
	✓	other: bioregion
Additional information	✓	reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(100-500 samples/year; single season, multiple sites - broad coverage)*
		fish
		periphyton
		other:

Benthos	
sampling gear	D-frame net (800 x 900 micron mesh) for wadeable streams
habitat selection	multihabitat
subsample size	200 count
taxonomy	genus
Habitat assessments	visual based habitat assessment and modified Wolman Pebble Count; performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings and training for biologists, field and laboratory performance audits, sorting and taxonomic proficiency checks, specimen archival

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
	✓	multivariate analysis*
	✓	biological metrics *(aggregate metrics into an index)*
	✓	disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	95th percentile of all sites
defining impairment in a multimetric index	25th percentile of reference condition

Evaluation of performance characteristics**	✓	repeat sampling *(different team, same reach; same team, adjacent reach)*
	✓	precision *(repeat & duplicate field samples, repeat sorting, taxonomic & data checks)*
	✓	sensitivity *(disturbance gradient for reference & degraded streams)*
	✓	bias *(repeat, duplicate samples)*
	✓	accuracy (discrimination efficiency)

Biological data	
Storage	EDAS
Retrieval and analysis	Systat, Statistica and EDAS

* Multivariate analysis is being used to *develop* the new index, but the subsequent analysis of biological data will be multimetric.
**Additional evaluation procedures of performance characteristics include: field (biological, habitat and chemistry repeats), lab (pickate rechecks, QC checks), taxonomy (two taxonomists and a third party for precision; reference collection), data entry QC, and metric calculation QC checks.

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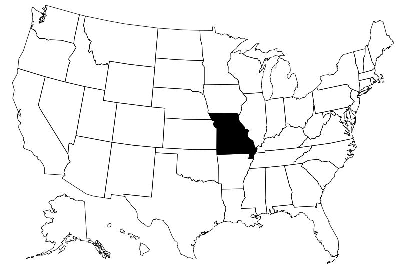

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Program Description

The overall aquatic biological assessment program for Missouri streams and wadeable rivers is a multi-agency collaborative effort between the Missouri Department of Conservation (MDC), the Missouri Department of Natural Resources (MDNR), The University of Missouri-Columbia, and the USEPA. The overall program involves a Resource Assessment and Monitoring Program, biological criteria development, monitoring of targeted sites to determine compliance with the designated use of aquatic life protection in the standards, monitoring for 303(d) purposes, and the development of a stream classification system framework.

The Resource Assessment and Monitoring Program is committed to sampling 120 sites per year beginning in 2002. These sites are a combination of targeted reference sites and randomly selected sites. The MDC is responsible for fish sampling, physical habitat assessment, and water quality contaminant sampling (to be analyzed by the USEPA). The MDNR is responsible for sampling macroinvertebrates at 30% of the sites. For the remainder of the sites, samples are collected by MDC and analyzed by the University of Missouri-Columbia. The Resource Assessment and Monitoring Program operates on a five year cycle with statewide random sites collected for one year and random sites in priority watersheds collected for four years. Data will be used to report on the status of Missouri's streams and wadeable rivers.

The MDNR initiated biological criteria development for wadeable, perennial streams in 1992. Numeric biocriteria for one trophic level (macroinvertebrate communities) were completed in February 2002. This effort also involved the cooperation of the University of Missouri-Columbia, School of Natural Resources and the Missouri Resource Assessment Partnership. Future biological criteria efforts will add an additional trophic level (fish communities) to wadeable, perennial streams and will initiate a low level effort to develop numeric criteria for other size ranges of streams and rivers. The numeric criteria and associated components have been used to evaluate compliance with the designated use of aquatic life protection as well as in the assessment of biological communities for 303(d) purposes.

The Missouri Resource Assessment Partnership is an interagency partnership that provides expertise in geographic information systems, remote sensing, and natural resource management. Since 1997, the Missouri Resource Assessment Partnership has been in the process of developing a hierarchical classification framework for Missouri's stream resources. This framework is expected to provide the foundation for biological study designs in the Resource Assessment and Monitoring Program, biological criteria, and targeted studies concerning the designated use of aquatic life protection and 303(d) purposes.

Documentation and Further Information

Methodology for the 2002 303(d) list, 1998 303(d) list, and Missouri's Water Quality Standards and criteria are all available on the MDNR Water Pollution Control Program homepage: http://www.dnr.state.mo.us/deq/wpcp/homewpcp.htm

Fischer, S.A. 2002. *Resource Assessment and Monitoring Program: Standard Operating Procedures - fish sampling*. Missouri Department of Conservation, Columbia, MO.

Sarver, R., S. Harlan, C. Rabeni, and S. Sowa. 2001. *Draft Report - Biological Criteria for Wadeable/Perennial Streams of Missouri*. Prepared by Missouri Department of Natural Resources, Air and Land Protection Division, Environmental Services Program.

Also available through MDNR: *Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure* (2001); *Stream Habitat Assessment Project Procedure* (2000); Macroinvertebrate Levels of Taxonomy SOP/FSS/209 (1998); *Biological Criteria for Streams of Missouri* - A Final Report to the MO Department of Natural Resources, University of Missouri, Cooperative Fish and Wildlife Unit; *Quality Control Procedures for Data Processing* (2001) MDNR/WQMS/214.

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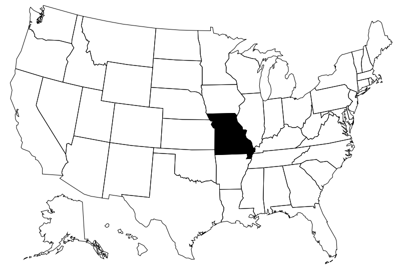

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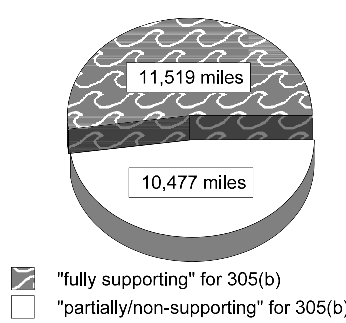
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
		support of antidegradation
	✓	evaluation of discharge permit conditions *(MDNR only)*
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(comprehensive use throughout jurisdiction by MDNR)*
		fixed station (i.e., water quality monitoring stations)
	✓	probabilistic by stream order/catchment area *(comprehensive use throughout jurisdiction and in specific river basins or watersheds by MDC)*
	✓	probabilistic by ecoregion, or statewide *(comprehensive use throughout jurisdiction and in specific river basins or watersheds by MDC)*
	✓	rotating basin *(used in specific rivers basins or watersheds by MDNR)*
	✓	other: reference site monitoring

Stream Miles

Total miles *(estimated using National Hydrography Database)*	**52,194**
Total perennial miles	22,194
Total miles assessed for biology*	**21,996**
fully supporting for 305(b)	11,519
partially/non-supporting for 305(b)	10,477
listed for 303(d)	n/a
number of sites sampled *(on an annual basis)*	200
number of miles assessed per site	site specific *(MDC)* 0.25 *(MDNR)*

21,996 Miles Assessed for Biology



*Miles assessed for aquatic life as reported in Missouri's draft 2002 305(b) Water Quality Report are based on biological, chemical, physical and toxicological data. The status and number of stream miles assessed exclusively for biology is not readily available.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Warm Water vs. Cold Water	
ALU designations in state water quality standards	Four designations: General Warm Water Aquatic Life, Limited Warm Water Aquatic Life, Cool Water Fisheries, and Cold Water Fisheries	
Narrative Biocriteria in WQS	Procedures used to support narrative biocriteria located in SOPs and draft biocriteria document for wadeable/perennial streams housed at MDNR/Air and Land Protection Division, Environmental Services Program	
Numeric Biocriteria in WQS	under development (Numeric biocriteria for macroinvertebrate communities in wadeable, perennial streams will be completed sometime in 2002. These criteria are intended for inclusion in the water quality standards during the next triennial WQS review.)	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
		monitoring (e.g., improvements after mitigation)
		watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	none	

Reference Site/Condition Development

Number of reference sites	**62 total**	
Reference site determinations	✓	site-specific *(MDC)*
		paired watersheds
	✓	regional (aggregate of sites)
	✓	professional judgment *(MDC)*
	✓	other: Missouri Ecologic Drainage Units/VST layer *(MDC)*
Reference site criteria	Representative of ecoregion and stream size, and in natural condition with respect to habitat, water quality, biological integrity and diversity, watershed land use and riparian conditions Disturbed habitat = <75% comparable to reference *(MDNR)* MDC uses R-EMAP terminology: perennial flow, relatively high heterogeneity of substrate materials, natural channel morphology, natural hydrograph, natural water color	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
	✓	other: minimally disturbed in the Ozarks
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
	✓	stream type *(MDNR)*
		multivariate grouping
		jurisdictional (i.e., statewide)
	✓	other: MDC is attempting to put reference sites into each of Missouri's 17 Ecologic Drainage Units.
Additional information	✓	reference sites linked to ALU
	✓	reference sites/condition referenced in water quality standards *(Sarver et al. 2001)*
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(100 - 500 samples per year; single season, multiple sites - broad coverage by MDC; multiple seasons, multiple sites - broad coverage for watershed level by MDNR)*
	✓	fish *(100 - 500 samples per year; single season, multiple sites - broad coverage by MDC only)*
		periphyton
		other:

Benthos	
sampling gear	kick net, 500 micron mesh nitex bag
habitat selection	multihabitat
subsample size	900 for glide/pool streams, 1200 for riffle/pool streams
taxonomy	genus, species
Fish	
sampling gear	backpack electrofisher, pram unit (tote barge), and seines; 3/16" mesh for 12' net and 1/4" mesh for 30' net
habitat selection	multihabitat
sample processing	biomass - batch
subsample	batch
taxonomy	species
Habitat assessments	visual based, quantitative measurements *(MDC)*, stream width and discharge *(MDNR)*; performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings and training for biologists, sorting and taxonomic proficiency checks, specimen archival, MDNR data entry QC, certification program for bioassessment within MDC

Data Analysis and Interpretation

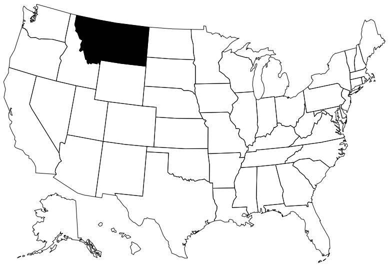
Data analysis tools and methods	✓	summary tables, illustrative graphs
	✓	parametric ANOVAs
	✓	multivariate analysis
	✓	biological metrics *(aggregate metrics into index)*
		disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	25th percentile of reference population *(MDNR)*; some based on log 10 mean wetted width, mean proportion of reference sites, or specific percentiles *(MDC)*
defining impairment in a multimetric index	cumulative score equivalent to 81% of reference condition *(MDNR)*
Multivariate thresholds	
defining impairment in a multivariate index	significant departure from mean of reference population *(MDC)*, threshold not used by MDNR for criteria but as supporting information only

Evaluation of performance characteristics	✓	repeat sampling *(multiple seasons and years by MDNR, annual revisits by MDC)*
	✓	precision *(10% duplicates within reach by MDNR)*
	✓	sensitivity *(evaluated in MDNR pilot project)*
	✓	bias *(MDNR eliminated redundant metrics during pilot project, multiple techniques used by MDC)*
		accuracy

Biological data	
Storage	STORET *(MDC)*, MS Access
Retrieval and analysis	SAS *(MDC)*, Programming in Visual Basics for MS Access and Sigmastat *(MDNR)*

MONTANA



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http://www.deq.state.mt.us/wqinfo/MDM/WQMonitoring_Assessment.asp

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Program Description

The Montana Department of Environmental Quality (DEQ) strongly encourages the use of biological data for making ALUS determinations (more than 90% of MT's 303(d) assessments include biological data). It is very difficult to acquire sufficient credible data in Montana without having biological data; thus the incorporation of bioassessment in DEQ's monitoring program is very important.

DEQ is in the second year of collecting macroinvertebrate and periphyton data from fixed station sites that are located on major streams throughout Montana. The primary objective is to determine status and trends. In 2002, the Department initiated an effort to develop vegetation assessment tools for assessing the biological conditions of riparian areas and wetlands and is also looking at amphibians. In the past, wetland macroinvertebrate and diatom communities have been assessed.

DEQ collaborates with a number of agencies and organizations. The Montana Bureau of Land Management has helped fund DEQ's statewide biological monitoring efforts. USGS is collecting chemistry data at most fixed station sites. The Department is also working closely with the wetlands program, universities and the Montana Natural Heritage Program to assess riparian zones. For 303(d) purposes DEQ has collaborated with conservation districts, the Natural Resource Conservation Service, USFS, and USEPA, among others.

In 2000 DEQ developed a new listing methodology that strongly encourages the use of biological data to assess waters for 303(d) purposes. The Department was required to use this methodology for all waters that were previously listed as impaired, but were unfortunately not required to use the new listing methodology for streams that were previously listed as fully supporting ALU. Montana DEQ is also currently forming workgroups to begin the process of developing a state-wide water quality database that can be accessed by federal and state agencies in Montana.

Some challenges include achieving access to private lands and assessing prairie streams that are located in eastern Montana. In the future DEQ intends to develop and implement a random study design to assess the biological condition of smaller order streams.

Documentation and Further Information

Year 2001 305(b) Report Database and Year 2000 303(d) List Database:
http://nris.state.mt.us/scripts/esrimap.dll?name=TMDL&Cmd=INST

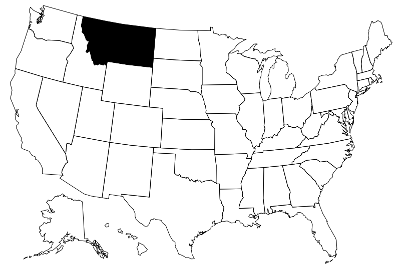
DRAFT 2002 Montana 303(d) List: http://nris.state.mt.us/scripts/esrimap.dll?name=TMDL2002&Cmd=INST

Montana's *Water Quality Standards and Classifications*: http://www.deq.state.mt.us/wqinfo/Standards/Index.asp

Water Quality Monitoring Standard Operating Procedures: http://www.deq.state.mt.us/ppa/mdm/SOP/sop.asp

Montana Natural Heritage Program homepage: http://nhp.nris.state.mt.us/

MONTANA



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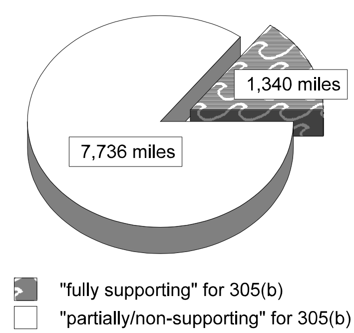
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	UD	promulgated into state water quality standards as biocriteria
		support of antidegradation
		evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects only)*
	✓	fixed station (i.e., water quality monitoring stations) *(comprehensive throughout jurisdiction)*
	✓	probabilistic by stream order/catchment area *(special projects only)*
	✓	probabilistic by ecoregion, or statewide *(special projects only)*
		rotating basin
		other:

Stream Miles

Total miles *(determined using RF3)*	**176,750**
Total perennial miles	53,221
Total miles assessed for biology*	**9,076**
fully supporting for 305(b)**	1,340
partially/non-supporting for 305(b)**	7,736
listed for 303(d)	7,736
number of sites sampled *(USGS sites)*	~40
number of miles assessed per site	–

9,076 Miles Assessed for Biology



*MT DEQ collects biological data as part of a joint project with USGS to assess 38 sites that are located near the mouth of major streams and rivers. Aside from this, Montana does not have a state biological monitoring program but it is currently under development.

**71% of the waters that were assessed as fully supporting ALU used biological data; 94% of the waters where ALUS was determined to be impaired used biological data.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis		Class System (A,B,C), Warm Water vs. Cold Water
ALU designations in state water quality standards		Although there are 9 classifications (A, B, C and subdivided), Class A-Closed is suitable for growth and propagation of fishes and associated aquatic life (among other uses) and Classes A-1, B-1, B-2, B-3, C-1 AND C-2 must have water quality suitable for growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers (among other uses).
Narrative Biocriteria in WQS		under development (Brief biocriteria language without formal numeric translation mechanism located in WQS. Informal numeric procedures located in guidance document for 303(d) listing purposes complying with WQS.)
Numeric Biocriteria in WQS		none
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
		permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU		TMDL targets

Reference Site/Condition Development

Number of reference sites		**~50 total (potential reference sites)***
Reference site determinations	✓	site-specific
		paired watersheds
	✓	regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria		specific criteria under development; currently using best professional judgment to determine "least impaired" considering geomorphology, habitat, landuse, biology, and chemistry
Characterization of reference sites within a regional context	✓	historical conditions
	✓	least disturbed sites
		gradient response
	✓	professional judgment
	✓	other: some sites are minimally disturbed**
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
	✓	elevation
	✓	stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information	✓	reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

*In 2001, Montana DEQ began the process of locating reference sites using GIS and sampled ~30 potential reference sites using EMAP methods. A similar effort was made in 1990 when ~38 sites were sampled. In total, Montana has assessed ~50 potential reference sites.

**Montana's regional reference sites are characterized as least disturbed. These sites are used to describe the best potential for a stream given the historical land use. However, many least disturbed reference sites are actually *minimally* disturbed, especially those sites that are located in the Rocky Mountain Ecoregion. In this case the best potential for a stream is near natural condition. These streams are often located in roadless areas, wilderness areas or National Parks.

Field and Lab Methods

Assemblages assessed	✓	benthos *(100 - 500 samples per year; single season, multiple sites - broad coverage)*
	✓	fish *(<100 samples per year; single season, multiple sites - broad coverage)*
	✓	periphyton *(100 - 500 samples per year; single season, multiple sites - broad coverage)*
	✓	other: macrophytes *(<100 samples per year; single season, multiple sites - watershed level)*

Benthos	
sampling gear	Hess, D-frame, kick net (1m); 500 - 600 and >800 micron mesh sizes
habitat selection	richest habitat, riffle/run (cobble), multihabitat, woody debris
subsample size	300-500 count
taxonomy	combination - lowest feasible
Fish	
sampling gear	backpack and boat electrofishers, seine; 1/4" mesh
habitat selection	multihabitat
sample processing	length measurement, anomalies
subsample	none
taxonomy	species
Periphyton	
sampling gear	**natural substrate**: suction device, brushing/scraping device
habitat selection	riffle/run (cobble), multihabitat
sample processing	chlorophyll *a* / phaeophytin, biomass, taxonomic identification
taxonomy	diatoms (mainly species level), all algae (genus and species)
Habitat assessments	visual based, quantitative measurements, hydrogeomorphology, pebble counts; performed with and independent of bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings and training for biologists, sorting and taxonomic proficiency checks, specimen archival

Data Analysis and Interpretation

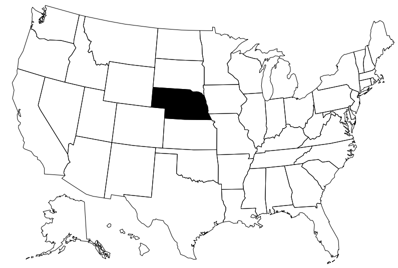
Data analysis tools and methods	✓	summary tables, illustrative graphs
	✓	parametric ANOVAs
	✓	multivariate analysis
	✓	biological metrics *(aggregate metrics into an index and return single metrics)*
	✓	disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	cumulative distribution function
defining impairment in a multimetric index	75% of reference condition
Multivariate thresholds	
defining impairment in a multivariate index	significant departure from mean of reference population

Evaluation of performance characteristics	✓	repeat sampling *(duplicates)*
	✓	precision *(splits with USGS and EMAP for bioassessments)*
		sensitivity
	✓	bias *(comparison of different methods)*
		accuracy

Biological data	
Storage	developing use of MS Access and Excel
Retrieval and analysis	Systat, Statmost

NEBRASKA



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Program Description

Nebraska's biological monitoring program was started in 1985 with semi-quantitative methods for collecting fish and macroinvertebrates. The original purpose was to determine naturally occurring biological delineations within the state and to classify streams based on biological characteristics. In 1997, collection methods were changed to the REMAP methodology because the Nebraska Department of Environmental Quality (NDEQ) felt that more quantitative approaches were needed to summarize the data.

NDEQ's program for adapting the metrics to the standards and fine tuning the metrics has been slowed by data management and computer programming problems. NDEQ has a small staff and time constraints have affected this program. NDEQ is experiencing problems with the reference site concept. Since many of the streams have a "sameness" throughout a large area of the state, Nebraska lacks solid reference sites for the ecoregions and stream classes. Except for a few places, it seems most streams are heavily affected by agricultural use. NDEQ has a lot of data, but is having trouble analyzing it.

Due to concerns about the accuracy of the existing biological indices, NDEQ has chosen to reassess past biological data and redefine its indices. Five streams are currently listed on Nebraska's 303(d) list due to biodiversity impacts. Only about 20% of Nebraska's total stream miles are currently assessed for biology in the 305(b) report. These streams are known to be fully supporting (17%) or not supporting (3%).

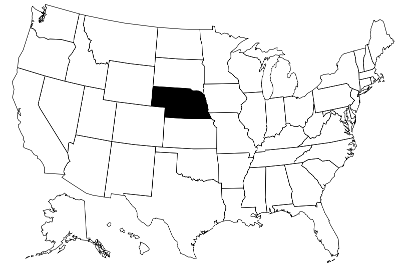
Nebraska agrees with the reference site concept but needs to determine if appropriate reference sites exist in Nebraska. NDEQ is currently evaluating macroinvertebrate and fish data to locate both excellent and severely impaired sites in order to determine the appropriate habitat conditions that correspond to both extremes. Reference site criteria have not yet been finalized.

Documentation and Further Information

Nebraska DRAFT 2000 305(b) report

DRAFT 2002 303(d) report, 2001, *Comprehensive Study of Water Quality Monitoring*, and Title 117 - Nebraska's Surface Water Quality Standards are available online at http://www.ndeq.state.ne.us

NEBRASKA



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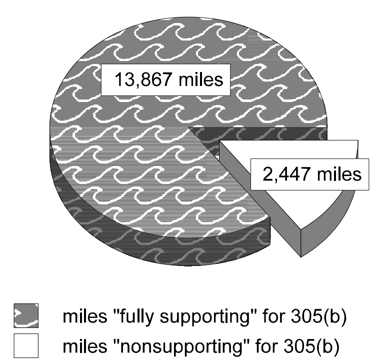
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
		support of antidegradation
		evaluation of discharge permit conditions
		TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) (*specific river basins or watersheds*)
	✓	fixed station (i.e., water quality monitoring stations) (*comprehensive use throughout jurisdiction*)
		probabilistic by stream order/catchment area
	✓	probabilistic by ecoregion, or statewide (*comprehensive use throughout jurisdiction*)
	✓	rotating basin (*comprehensive use throughout jurisdiction*)
		other:

Stream Miles

Total miles *(determined using RF3)*	**81,573**
Total perennial miles	16,090
Total miles assessed for biology*	**16,314**
fully supporting for 305(b)	13,867
non-supporting for 305(b)	2,447
listed for 303(d)	0
number of sites sampled *(on an annual basis)*	40
number of miles assessed per site	site specific

16,314 Miles Assessed for Biology



*The 16,314 stream miles assessed for biology are the streams known to be only very high fully supporting (13,867) and very low non-supporting (2,447).

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis		Class system (A, B, C), Fishery Based Uses, Warm Water vs. Cold Water
ALU designations in state water quality standards		Four designations: Warmwater A, Warmwater B, Coldwater A, Coldwater B
Narrative Biocriteria in WQS		Procedures used to support narrative biocriteria located in various reports, e.g., biological classification, 305(b), bioassessment procedures
Numeric Biocriteria in WQS		none
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
		permitted discharges
		monitoring (e.g., improvements after mitigation)
		watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU		none

Reference Site/Condition Development*

Number of reference sites		**38 total**
Reference site determinations	✓	site-specific
		paired watersheds
	✓	regional (aggregate of sites)
	✓	professional judgment
		other:
Reference Site Criteria		No waste water treatment plants, other point sources, or concentrated animal feeding operations (CAFOs); good instream habitat, riparian habitat, land use and cover, physical and chemical parameters, biological metrics, and faunal assemblages; no altered hydrologic regimes; representativeness. At a minumum, sites need to be in the top 10 to 20 percent of all sites sampled in the ecoregion, with little disturbance and no spills or discharges within sites area.
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
	✓	other: regionally representative, reasonably attainable
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate) *(there are three ecoregions and six strata with roughly five reference sites in each)*
		elevation
	✓	stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information	✓	reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

*Reference site criteria have not been finalized. These responses are based on NDEQ's current efforts to evaluate reference sites and condition.

Field and Lab Methods

Assemblages assessed	✓	benthos *(<100 samples/year, single season, multiple sites - broad coverage)*
	✓	fish *(<100 samples/year, single season, multiple sites - broad coverage)*
		periphyton
		other:

Benthos	
sampling gear	surber, multiplate, collect by hand, D-frame, dipnet; 200 - 400 micron mesh
habitat selection	multihabitat, artificial substrate, woody debris
subsample size	300 count, entire sample
taxonomy	genus, species
Fish	
sampling gear	backpack electrofisher, boat electrofisher, pram unit (tote barge), seine; 1/4" mesh
habitat selection	pool/glide, riffle/run (cobble), multihabitat
sample processing	length measurement (gamefish only), anomalies
subsample	batch
taxonomy	species
Habitat assessments	visual based, quantitative measurements; performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, taxonomic proficiency checks and specimen archival

Data Analysis and Interpretation*

Data analysis tools and methods	✓	summary tables, illustrative graphs
	✓	parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients
		other:

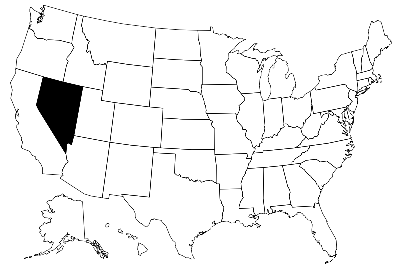
Multimetric thresholds	
transforming metrics into unitless scores	95^{th} percentile of reference population, dependent upon approach
defining impairment in a multimetric index	25^{th} percentile of reference population

Evaluation of performance characteristics	✓	repeat sampling *(revisit sites)*
		precision
		sensitivity
		bias
		accuracy

Biological data	
Storage	STORET, Excel and MS Access spreadsheets
Retrieval and analysis	SAS, Minitab

*NDEQ is testing different indices for validity and, as mentioned earlier, is still exploring reference criteria. Responses are based on NDEQ's current evaluation efforts, which include several changes in the way past biological data were evaluated. Data analysis procedures may change before metrics, indices, and reference sites are finalized.

NEVADA



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Program Description

Nevada began its Bioassessment Program in the year 2000 and has continued to collect biological information on an annual basis. Although the program is in its infancy, the State plans to continue collecting biological data for ambient monitoring and to assist in defining reference conditions and sites. There are seven primary water basins in Nevada and the State has collected biological data annually on four of these basins covering approximately 600 river miles. It is expected the State will continue to collect at these river basins, in addition to new basins and several lakes, until a valid biological baseline has been established over the next four to five years. After such time, the State is expected to switch to an alternating site or basin ambient bioassessment monitoring program.

The program primarily consists of macroinvertebrate collection, physical habitat evaluations, and physical measurements of slope, velocity, flow, dissolved oxygen, specific conductivity, pH, temperature, substrate composition, canopy cover, and width and depth of the sampling area. Periphyton, plankton, and/or chlorophyll sampling is conducted when necessary to assist in defining problem areas. Water chemistry data is collected at sites where the water chemistry is currently unknown. The data will eventually be used in 305(b) and 303(d) reports in addition to basin assessments of stream health. Some NPDES dischargers in the State are voluntarily collecting macroinvertebrates to assess impact to the aquatic environment.

Reference site criteria are currently being defined based on available information. The State expects to use chemical data, habitat assessments, physical measurements, professional knowledge and degrees of human impact to define the conditions and sites. Where reference sites are unavailable, the State expects to use modeling and/or least disturbed sites to evaluate conditions. It is anticipated to take several years for reference sites to be selected.

An independent biological laboratory conducts identification of macroinvertebrates. QA/QC of macroinvertebrate identification consists of approximately 15% of the samples being analyzed by two distinct biological laboratories. Data collected will be stored annually in the Ecological Data Application System (EDAS). Analysis and evaluation of the bioassessment data will be developed as the program progresses and based on the most accurate methods. Reference sites, where appropriate, will be used as a baseline for analysis.

Nevada recently hosted its first bioassessment conference in the State. The conference resulted in the formation of a State Bioassessment Committee consisting of agencies, tribes, and industry. The primary goal of the committee is to evaluate and coordinate protocols, methodologies and sampling in the State. Nevada also participates in the National Aquatic Life Use (ALUS) work group based out of USEPA Headquarters in Washington, D.C. The State is also planning to host an Arid West Aquatic Life Use Workgroup in conjunction with other arid states, tribal entities and USEPA in the next year.

Documentation and Further Information

Nevada's 305(b) report, September 2000: http://ndep.state.nv.us/bwqp/305b1998.pdf

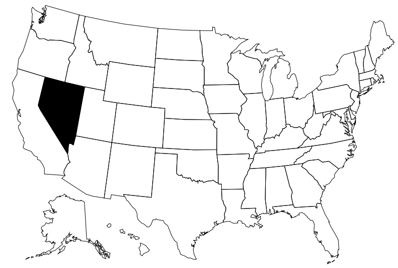
DRAFT Nevada's 2002 303(d) Impaired Waters List, June 2002: http://ndep.state.nv.us/bwqp/303list.pdf

Nevada's 1998 303(d) List, April 1998: http://ndep.state.nv.us/bwqp/nv303d98.pdf

Draft Continuing Planning Process, December 2001: http://ndep.state.nv.us/bwqp/cppdraft.pdf

Water Quality Standards, narrative and numeric: http://ndep.state.nv.us/bwqp/stdsw.htm

NEVADA



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Programmatic Elements

Uses of bioassessment within overall water quality program*	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
		promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
	✓	other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects, specific river basins or watersheds, and comprehensive use throughout jurisdiction)*
	✓	fixed station *(i.e., water quality monitoring stations) (special projects, specific river basins or watersheds, and comprehensive use throughout jurisdiction)*
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
	✓	rotating basin *(specific river basins or watersheds and comprehensive use throughout jurisdiction)*
		other:

*Bioassessment information will eventually be used in 303(d) and 305(b) reports.

Stream Miles

Total miles *(determined using River Reaches and calculated using GIS coverages.)*	**143,578**
Total perennial miles	14,988
Total miles assessed for biology**	**602**
fully supporting for 305(b)	0
partially/non-supporting for 305(b)	0
listed for 303(d)	0
number of sites sampled	50-60
number of miles assessed per site	–

**602 miles were assessed per year for 2000 and 2001 by the state (NDEP) and 97 miles were also assessed by others (Dischargers). The state estimates 900 river miles to be assessed in 2002. Since mileage is estimated and Nevada's 2001 data set has not been analyzed, the State has not used biology for 305(b)/303(d); therefore "0" is reported. However, it will be used in the future.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Class System (A,B,C), Fishery Based Uses and Warm Water vs. Cold Water	
ALU designations in state water quality standards	Propagation of aquatic life and the levels of warm water and cold water fisheries.	
Narrative Biocriteria in WQS	under development	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
		permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Truckee River Restoration projects include the lahontan cutthroat trout.	

Reference Site/Condition Development*

Number of reference sites	**0 total**	
Reference site determinations	✓	site-specific
	✓	paired watersheds
	✓	regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria	This is under development. NDEP expects to use chemical, habitat, physical measurements and least human impact. Where reference sites are unavailable modeling and/or metrics will be used to evaluate conditions.	
Characterization of reference sites within a regional context	✓	historical conditions
	✓	least disturbed sites
		gradient response
	✓	professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
	✓	elevation
	✓	stream type
	✓	multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions *(for fishery based uses)*

*Nevada is in the process of developing reference sites. This section has been completed based on the criteria that will be considered during development.

Field and Lab Methods

Assemblages assessed	✓	benthos *(<100 samples/year, single season, multiple sites - broad coverage)*
		fish
	UD	periphyton *(<100 samples/year, single season, multiple sites - watershed level)*
		other:

Benthos	
sampling gear	kick net (1 m); 500-600 micron mesh
habitat selection	riffle/run (cobble) *(when unavailable, use vegetation and sediment)*
subsample size	500 count
taxonomy	combination--family, genus, species
Periphyton	
sampling gear	**natural substrate**: brushing/scraping device (razor, toothbrush, etc.) Periphyton will be routinely collected and analyzed by a professional lab beginning in 2002. Chlorophyll analysis is performed at some stations.
habitat selection	n/a
sample processing	chlorophyll *a*/ phaeophytin and taxonomic identification
taxonomy	genus level for soft-bodied algae when possible; diatoms are not cleared
Habitat assessments	quantitative measurements (some sites) and visual based; performed with bioassessments; riffle slope, flow, average width and depth of flow, riffle velocity, canopy cover, some vegetation (grass, scrubs, trees) coverage along riparian zone, reach length, conductivity, temperature and dissolved oxygen
Quality assurance program elements	Quality assurance program elements are currently being developed (i.e., standard operating procedures, quality assurance plan, taxonomic proficiency checks, specimen archival).

Data Analysis and Interpretation*

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
	✓	multivariate analysis
	UD	biological metrics *(NDEP has not yet developed metrics but analysis tools and methods will be developed based on the most accurate method)*
	✓	disturbance gradients
		other:
Evaluation of performance characteristics	✓	repeat sampling *(ideally, 5 years worth of data will be collected at each site to determine the variability)*
		precision
		sensitivity
		bias
		accuracy

Biological data	
Storage	EDAS (being developed)
Retrieval and analysis	EDAS (being developed)

*Analysis tools and methods will be developed more fully in the future.

NEW HAMPSHIRE

Contact Information

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NHDES Watershed Management Bureau, *Biomonitoring Program*:
http://www.des.state.nh.us/wmb/biomonitoring/

Program Description

The New Hampshire Department of Environmental Services (NHDES) has been gathering biological data in wadeable streams and rivers since 1995. The primary goal of this effort is the development of numeric biological criteria in support of the current narrative standard. Biological communities assessed for this purpose are fish and macroinvertebrates. Since the program's inception, the protocols for collecting data have remained fairly consistent. The fish are collected with a backpack electro-shocker for 150 meters, with efforts to include all habitats typical of the stream type. Macroinvertebrate sampling is done by rock baskets deployed for 8 weeks and retrieved in the fall. A visual habitat assessment is also conducted at each station using USEPA's Rapid Bioassessment Protocols for high or low gradient streams, whichever is appropriate.

Since the program's beginnings, over 200 stations have been assessed. These stations are captured in an ArcView coverage that includes watershed delineations specific to the biological sampling station. Efforts are currently underway to determine the degree of human activity in each of the watersheds by evaluating parameters such as land use, population, hazardous waste sites and road density. This type of scoring will help to determine reference quality/least impacted sites.

The Biomonitoring Program is also investigating the need to classify the wadeable streams in New Hampshire. The state is small but very diverse, with low coastal systems and high mountainous regions. It is not yet clear whether it will be necessary to establish unique biological criteria for different regions of the state.

In the past, biomonitoring information has been used for 305(b) reporting and also for 303(d) listing. The Watershed Management Bureau, which is responsible for producing these reports, is currently evaluating the assessment and listing methodologies, using USEPA's CALM guidance. In 2002-2003 the Biomonitoring Program will be testing a probabilistic sampling design for site selection. This type of sampling will allow for greater confidence in statements of statewide water quality, and continue to provide useful data for biocriteria development.

Information about New Hampshire's Biomonitoring Program, including sampling protocols, can be found at http://www.des.state.nh.us/wmb/biomonitoring/.

Documentation and Further Information

State of New Hampshire 2000 Section 305(b) Water Quality Report:
http://www.des.state.nh.us/wmb/2000-305b.pdf

NHDES Biomonitoring Program Protocols, January 2002:
http://www.des.state.nh.us/wmb/biomonitoring/protocols.pdf

New Hampshire Biomonitoring Program general information: http://www.des.state.nh.us/wmb/biomonitoring/sites

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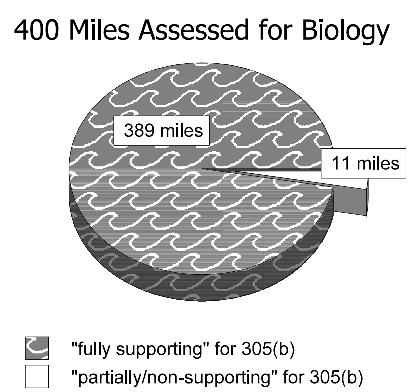
Programmatic Elements

Use of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
		support of antidegradation
	✓	evaluation of discharge permit conditions
		TMDL assessment and monitoring
	✓	other: Ecological Risk Assessments
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects and specific river basins or watersheds)*
	✓	fixed station (i.e., water quality monitoring stations) *(special projects only)*
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
		rotating basin
		other:

Stream Miles

Total miles *(State based determination)*	**10,881**
Total perennial miles	8,636
Total miles assessed for biology	**400**
fully supporting for 305(b)	389
partially/non-supporting for 305(b)	11
listed for 303(d)	0
number of sites sampled *(on an annual basis)*	130
number of miles assessed per site*	~3



*NHDES will be doing random sampling in the future. For now, 150 meters are assessed and extrapolated to a broader area, roughly three miles per site, though this number does vary.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Class system (A, B, C)	
ALU designations in state water quality standards	One designation: Fishable	
Narrative Biocriteria in WQS	There aren't any written formal/informal numeric procedures to support narrative biocriteria decisions yet because they are very subjective. Presently, data is being analyzed using New York's metrics.	
Numeric Biocriteria in WQS	under development	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
		cause and effect determinations
	✓	permitted discharges
		monitoring (e.g., improvements after mitigation)
		watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	none	

Reference Site/Condition Development

Number of reference sites	**40 total**	
Reference site determinations	✓	site-specific
		paired watersheds
		regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria	Generally use best professional judgment. Least disturbed sites are determined following some stratification of characteristics (ArcView coverage, hazardous waste sites, etc.) – it is very visual.	
Characterization of reference sites within a regional context *Not applicable**		historical conditions
		least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions *Not applicable**		ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

*Regional reference sites not used.

Field and Lab Methods

Assemblages assessed	✓	benthos *(<100 samples/year; single season, multiple sites - broad coverage)*
	✓	fish *(<100 samples/year; single season, multiple sites - broad coverage)*
		periphyton
	✓	other: amphibians/reptiles *(<100 samples/year; single season, multiple sites - broad coverage)*

Benthos	
sampling gear	D-frame, kick net (1 meter), multiplate, rock baskets; 500-600 micron mesh
habitat selection	multihabitat, artificial substrate
subsample size	100 count
taxonomy	genus, lowest reasonable taxa
Fish	
sampling gear	backpack electrofisher
habitat selection	multihabitat
sample processing	anomalies
subsample	none
taxonomy	species
Habitat assessments	visual based; performed with bioassessments
Quality assurance program elements	standard operating procedures; quality assurance plan; periodic meetings, training for biologists; sorting and taxonomic proficiency checks; specimen archival; certification program for bioassessment (Biologists must have a certificate of completion of USFWS Electrofishing Course)

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(return single metrics - use endpoint for each single metric)*
		disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	under development - Presently, only the raw score is tracked – there is no scale of comparison with the reference site yet.

Evaluation of performance characteristics		repeat sampling
		precision
Information not provided		sensitivity
		bias
		accuracy

Biological data	
Storage	EDAS
Retrieval and analysis	EDAS

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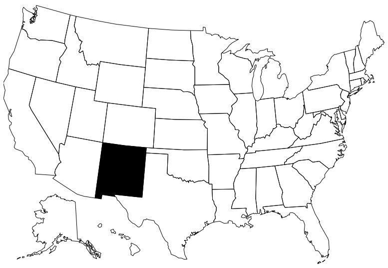

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NMED Surface Water Quality Bureau: http://www.nmenv.state.nm.us/swqb/swqb.html

Program Description

Starting in 1998 the New Mexico Environment Department's (NMED) Surface Water Quality Bureau (SWQB) had a goal of monitoring all watersheds in the state on a 5-year cycle. NMED has recently begun to survey fish populations to supplement the data from the NM Department of Game and Fish. NMED uses RBP collection methods and is currently working on assessment methods suitable for the depauperate fish population of New Mexico. The SWQB coordinates with the NM Department of Game and Fish to obtain the most current fishery assessments in the watersheds.

The benefits of this approach are:

- It provides a systematic, detailed review of water quality data and allows for a more efficient use of valuable monitoring resources;
- It provides information at a scale where implementation of corrective activities is feasible;
- With an established order of rotation and predictable sampling in each basin, it is easier to coordinate efforts with other programs and water quality entities, and program efficiency is enhanced and the basis for management decisions is improved.

Documentation and Further Information

Water Quality and Water Pollution Control in New Mexico, 2000 305(b):
http://www.nmenv.state.nm.us/swqb/305b_2000.html

State of New Mexico Standards for Interstate and Intrastate Surface Waters, December 16, 2001:
http://www.nmenv.state.nm.us/NMED_regs/swqb/20_6_4_nmac.html

Surface Water Quality Bureau Library: http://www.nmenv.state.nm.us/swqb/links.html#WPS_Library

For a list of and links to *Reports and Publications*, go to:
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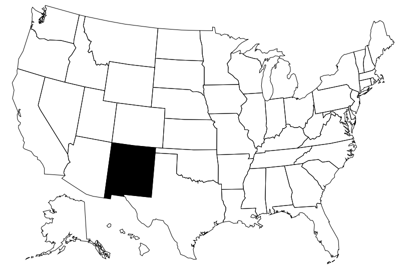

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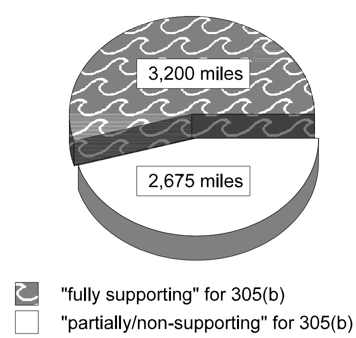
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
		support of antidegradation
		evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects only)*
	✓	fixed station (i.e., water quality monitoring stations) *(comprehensive use throughout jurisdiction)*
		probabilistic by stream order/catchment area
	✓	probabilistic by ecoregion, or statewide *(special projects only)*
	✓	rotating basin *(comprehensive use throughout jurisdiction)*
		other:

Stream Miles

Total miles *(State based determination)*	**110,741**
Total perennial miles	8,682
Total miles assessed for biology	**5,875**
fully supporting for 305(b)	3,200
partially/non-supporting for 305(b)*	2,675
listed for 303(d)*	–
number of sites sampled *(on an annual basis)*	30
number of miles assessed per site	–

5,875 Miles Assessed for Biology



*A total of 3,080 miles are partially/non-supporting when miles with "impacts observed" are included. NMED is currently working on a 303(d) list.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Fishery Based Uses and Warm Water vs. Cold Water	
ALU designations in state water quality standards	Five designations: Coldwater Fishery, High Quality Coldwater Fishery, Limited Warmwater Fishery, Marginal Coldwater Fishery, and Warmwater Fishery	
Narrative Biocriteria in WQS	none	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
		permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	none	

Reference Site/Condition Development

Number of reference sites	**200 total**	
Reference site determinations		site-specific
		paired watersheds
		regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria	The least disturbed sites are picked according to best professional judgment (based on chemistry, quantitative habitat measurements, visual indicators, etc). There are plans to shift to RIVPACS as biocriteria are developed during the next few years.	
Characterization of reference sites within a regional context *Not applicable*		historical conditions
		least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions		ecoregions (or some aggregate)
	✓	elevation *(preliminary ecoregions are based on elevation and other habitat parameters)*
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(30 samples/year; single season, multiple sites - watershed level)*
	✓	fish *(30 samples/year; single season, multiple sites - watershed level)*
	✓	periphyton* *(9 samples/year; single observation, limited sampling)*
	✓	other: phytoplankton *(9 samples/year; single observation, limited sampling)*

Benthos	
sampling gear	Hess, D-frame, kick net (1 meter); 500-600 micron mesh
habitat selection	riffle/run (cobble)
subsample size	300 count
taxonomy	combination (it depends on the family--some to genus, some to species level)
Fish	
sampling gear	backpack and bank electrofisher; 1/4" mesh
habitat selection	multihabitat
sample processing	length measurement and anomalies
subsample	batch
taxonomy	species
Periphyton*	
sampling gear	**natural substrate:** collect by hand; **artificial substrate:** periphytometer
habitat selection	richest habitat and multihabitat
sample processing	taxonomic identification
taxonomy	diatoms only
Habitat assessments**	visual based, hydrogeomorphology; and the RBP assessment is conducted with the bioassessment. NMDE may also conduct a Rosgen type hydrogeomorphological assessment, including pebble counts, independently of the bioassessment.
Quality assurance program elements	standard operating procedures, quality assurance plan, sorting proficiency checks and specimen archival

*Periphyton is collected primarily from lakes. It is only collected from streams in response to a specific problem or when looking at a certain impairment – sampling is very minimal (<10).

**Up to this point bioassessments have been conducted as described in the EPA's RBP. These methods are just now starting to be refined for regional applicability.

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	95th percentile of reference population
defining impairment in a multimetric index	95th percentile of reference population

Evaluation of performance characteristics *Not currently evaluated*		repeat sampling
		precision
		sensitivity
		bias
		accuracy

Biological data	
Storage	Just recently started using MS Access. All historic data (1977 - 1999) are in STORET
Retrieval and analysis	In the process of moving from STORET to MS Access; some data are also in Excel

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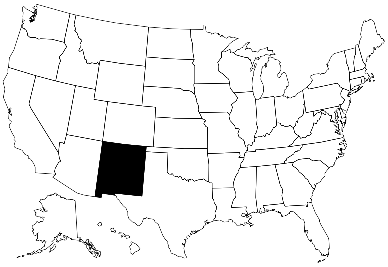

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- It provides a systematic, detailed review of water quality data and allows for a more efficient use of valuable monitoring resources;
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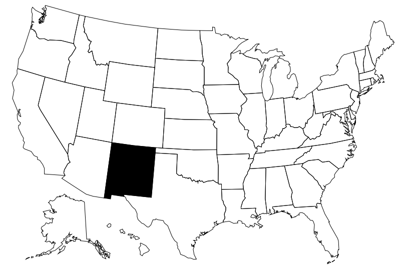

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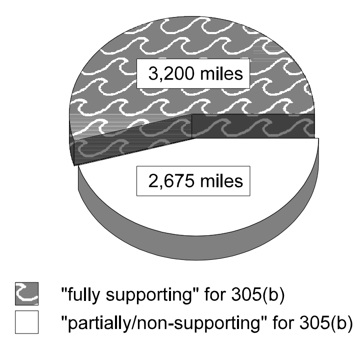
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
		support of antidegradation
		evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects only)*
	✓	fixed station (i.e., water quality monitoring stations) *(comprehensive use throughout jurisdiction)*
		probabilistic by stream order/catchment area
	✓	probabilistic by ecoregion, or statewide *(special projects only)*
	✓	rotating basin *(comprehensive use throughout jurisdiction)*
		other:

Stream Miles

Total miles *(State based determination)*	**110,741**
Total perennial miles	8,682
Total miles assessed for biology	**5,875**
fully supporting for 305(b)	3,200
partially/non-supporting for 305(b)*	2,675
listed for 303(d)*	–
number of sites sampled *(on an annual basis)*	30
number of miles assessed per site	–

5,875 Miles Assessed for Biology



*A total of 3,080 miles are partially/non-supporting when miles with "impacts observed" are included. NMED is currently working on a 303(d) list.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Fishery Based Uses and Warm Water vs. Cold Water	
ALU designations in state water quality standards	Five designations: Coldwater Fishery, High Quality Coldwater Fishery, Limited Warmwater Fishery, Marginal Coldwater Fishery, and Warmwater Fishery	
Narrative Biocriteria in WQS	none	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
		permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	none	

Reference Site/Condition Development

Number of reference sites	**200 total**	
Reference site determinations		site-specific
		paired watersheds
		regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria	The least disturbed sites are picked according to best professional judgment (based on chemistry, quantitative habitat measurements, visual indicators, etc). There are plans to shift to RIVPACS as biocriteria are developed during the next few years.	
Characterization of reference sites within a regional context *Not applicable*		historical conditions
		least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions		ecoregions (or some aggregate)
	✓	elevation *(preliminary ecoregions are based on elevation and other habitat parameters)*
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(30 samples/year; single season, multiple sites - watershed level)*
	✓	fish *(30 samples/year; single season, multiple sites - watershed level)*
	✓	periphyton* *(9 samples/year; single observation, limited sampling)*
	✓	other: phytoplankton *(9 samples/year; single observation, limited sampling)*

Benthos	
sampling gear	Hess, D-frame, kick net (1 meter); 500-600 micron mesh
habitat selection	riffle/run (cobble)
subsample size	300 count
taxonomy	combination (it depends on the family--some to genus, some to species level)
Fish	
sampling gear	backpack and bank electrofisher; 1/4" mesh
habitat selection	multihabitat
sample processing	length measurement and anomalies
subsample	batch
taxonomy	species
Periphyton*	
sampling gear	**natural substrate:** collect by hand; **artificial substrate:** periphytometer
habitat selection	richest habitat and multihabitat
sample processing	taxonomic identification
taxonomy	diatoms only
Habitat assessments**	visual based, hydrogeomorphology; and the RBP assessment is conducted with the bioassessment. NMDE may also conduct a Rosgen type hydrogeomorphological assessment, including pebble counts, independently of the bioassessment.
Quality assurance program elements	standard operating procedures, quality assurance plan, sorting proficiency checks and specimen archival

*Periphyton is collected primarily from lakes. It is only collected from streams in response to a specific problem or when looking at a certain impairment – sampling is very minimal (<10).

**Up to this point bioassessments have been conducted as described in the EPA's RBP. These methods are just now starting to be refined for regional applicability.

Data Analysis and Interpretation

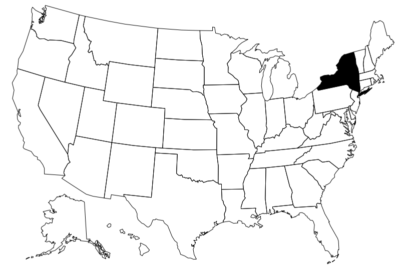
Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	95th percentile of reference population
defining impairment in a multimetric index	95th percentile of reference population

Evaluation of performance characteristics		repeat sampling
		precision
Not currently evaluated		sensitivity
		bias
		accuracy

Biological data	
Storage	Just recently started using MS Access. All historic data (1977 - 1999) are in STORET
Retrieval and analysis	In the process of moving from STORET to MS Access; some data are also in Excel

NEW YORK



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Program Description

The Stream Biomonitoring Unit of the New York State Department of Environmental Conservation (NYSDEC) was formed in 1972. The primary objective of the Unit is to assess the water quality of streams and rivers in New York State using aquatic invertebrate communities. Secondary objectives include taxonomic investigations, invertebrate tissue analysis, and public outreach. The unit presently consists of five biologists: Robert Bode, Margaret Novak, Lawrence Abele, Diana Heitzman, and Alexander Smith.

The Stream Biomonitoring Unit is part of the ambient surface water monitoring team at NYSDEC. Water quality is assessed to determine the level of designated use support and the primary factors causing the impacts. In addition to community assessments, invertebrates are collected for tissue analysis to determine if elevated levels exist for metals, pesticides, PCBs, or PAHs. Biological monitoring using benthic invertebrate communities is the primary monitoring tool for the initial screening phase within the watersheds, providing a coverage of 150-200 streams each year. Additionally, biomonitoring is used to conduct multi-site intensive surveys on approximately 10 streams each year to provide baseline data and trend monitoring data or to trackdown sources of xenobiotic substances.

Assessments based on macroinvertebrate sampling are used extensively in 305(b) reports and the Priority Water List, and to a lesser extent in 303(d) reports. Assessments generally do not directly address the designated uses of drinking, swimming, or fishing, contained in the State water quality standards, although they provide sound basis for determination of aquatic life support (reported in 305b) and relate secondarily to the designated use of fish propagation and survival. Biocriteria are addressed by the Biological Impairment Criteria, which are used to define impairment by exceedances of metrics measured upstream and downstream of a discharge. The primary assessment method using benthic macroinvertebrates is based on a multimetric scale divided into four levels of impairment, ranging from non-impacted to severely impacted. Although nearly all the collection of biological data remains within the Unit, many studies are conducted in cooperation with other New York State agencies (NYS Museum), federal agencies (USGS, USEPA), neighboring states (Vermont, Massachusetts, New Jersey), and non-governmental organizations (Hudson Basin River Watch, Trout Unlimited, Nature Conservancy).

Accomplishments

- publication of a manual for the identification of larvae of Chironomidae (1980)
- development of methods for the Rapid Biological Assessment of streams (1983)
- establishment of biological impairment criteria (1990)
- publication of Percent Model Affinity, a community analysis technique (1992)
- documentation of 20-year trends in water quality in New York State (1993)
- development of Impact Source Determination, a pollution identification method (1995)

Future program directions and challenges

- continuing long-term trend monitoring
- providing maximum biomonitoring coverage of streams in New York State
- integrating more assessments with diatom and fish data
- developing invertebrate identification aids using digital photography and the NYSDEC website
- capturing biodiversity information outside of the subsampling process

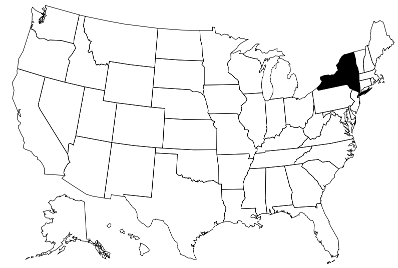
Documentation and Further Information

New York State Water Quality 2000, 305(b) Report, October 2000: http://www.dec.state.ny.us/website/dow/305b00.pdf

Draft 2002 Section 303(d) list: http://www.dec.state.ny.us/website/dow/303dcalm.pdf

Bode, R. W., M.A. Novak, and L.E. Abele, 1996. Quality assurance work plan for biological stream monitoring in New York State. New York State Department of Environmental Conservation Technical Report, 89 pages.

NEW YORK



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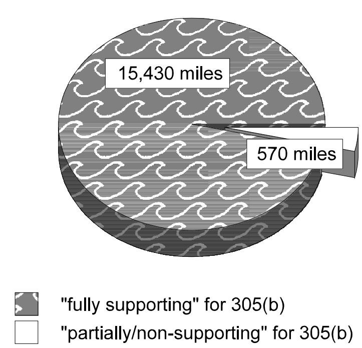
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
		promulgated into state water quality standards as biocriteria
		support of antidegradation
		evaluation of discharge permit conditions
		TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(comprehensive use throughout jurisdiction)*
	✓	fixed station (i.e., water quality monitoring stations) *(comprehensive use throughout jurisdiction)*
	✓	probabilistic by stream order/catchment area *(special projects only)*
		probabilistic by ecoregion, or statewide
	✓	rotating basin *(comprehensive use throughout jurisdiction)*
		other:

Stream Miles

Total miles *(determined using a state based program)*	**52,337**
Total perennial miles	46,266
Total miles assessed for biology*	**16,000**
fully supporting for 305(b)	15,430
partially/non-supporting for 305(b)	570
listed for 303(d)	484
number of sites sampled	800
number of miles assessed per site	20

16,000 Miles Assessed for Biology



*These numbers represent primarily stream miles (roughly 85-90%), but there are some river miles included due to program overlap in metrics, etc. It would be very difficult to separate the data for these two waterbody types. Also, there is a discrepancy between 305(b) partially/non-supporting and 303(d) stream miles because the 1998 303(d) list did not include all impaired waters, just impaired waters suitable for TMDLs. Also, the 305(b) and 303(d) lists, up until now, have been developed independent of each other.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Fishery Based Uses	
ALU designations in state water quality standards	One designation: Fish propagation and survival	
Narrative Biocriteria in WQS	none - New York does have *biological impairment criteria* (see footnote), but these are not found in the water quality standards.	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
		permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to their designated ALU	none	

Reference Site/Condition Development

Number of reference sites	**not applicable***	
Reference site determinations	✓	site-specific
		paired watersheds
		regional (aggregate of sites)
		professional judgment
		other:
Reference site criteria	For application of biological impairment criteria, reference sites are control sites located upstream of a suspected source of impairment.	
Characterization of reference sites within a regional context *Not applicable**		historical conditions
		least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions *Not applicable**		ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
		some reference sites represent acceptable human-induced conditions

*Reference sites are used in the following manner only: NYSDEC's reference sites are merely site-specific "control" sites, used strictly used for rating the water quality near a suspected source of impairment. This is done by collecting water samples at the source of impairment and upstream of the source, and then *biological impairment criteria* are applied for rating purposes. For example, if more than eight species are lost between the two samples, then the impairment criteria have been exceeded and the stream section would be considered significantly impaired. Thus the biological impairment criteria define how much change is allowed from upstream to downstream.

Field and Lab Methods

Assemblages assessed	✓	benthos *(100-500 samples/year; single season, multiple sites - watershed level)*
	✓	fish *(<100 samples/year; single season, multiple sites - not at watershed level)*
	✓	periphyton *(<100 samples/year; single season, multiple sites - not at watershed level)*
		other:

Benthos	
sampling gear	multiplate, Ponar grab sampler, dipnet; >800 micron mesh
habitat selection	riffle/run (cobble)
subsample size	100 count
taxonomy	genus, species, combination
Fish	
sampling gear	backpack electrofisher, 1/4" mesh
habitat selection	pool/glide, riffle/run (cobble)
sample processing	counts only
subsample	100 count
taxonomy	species
Periphyton	
sampling gear	**natural substrate**: suction device, brushing/scraping device (razor, toothbrush, etc.), from macrophyte surfaces; **artificial substrate**: collect by hand (multihabitat) using a knife blade and eyedropper
habitat selection	multihabitat
sample processing	taxonomic identification
taxonomy	diatoms only, species
Habitat assessments	quantitative measurements; performed with bioassessments
Quality assurance program elements	standard operating procedures; quality assurance plan; periodic meetings, training for biologists; sorting proficiency checks; taxonomic proficiency checks; specimen archival

*Water quality assessments using benthos are based on a multimetric scale divided into 4 levels of impairment ranging from non-impacted to severely impacted (see below). NYSDEC's bioassessment program had periphyton monitoring capabilities in 1999 and 2000, but this has since been dropped and it is not clear if the sampling will be continued. Fish sampling is conducted by another Division within NYSDEC for a limited number of sites per year.

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(aggregate metrics into an index and return single metrics)*
		disturbance gradients
	✓	other: Impact Source Determination using cluster analysis

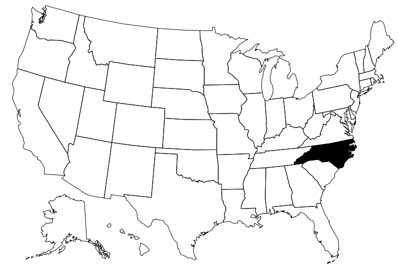
Multimetric thresholds	
transforming metrics into unitless scores	transformed into 4 impact categories, using approximately 25th, 50th, and 75th percentiles of database
defining impairment in a multimetric index	transformed into 4 impact categories using approximately 25th, 50th, and 75th percentiles**

Evaluation of performance characteristics	✓	repeat sampling *(sampling same site in different flow regime years)*
	✓	precision *(QA checks on subsampling)*
	✓	sensitivity *(comparisons with diatom sampling, fish sampling)*
	✓	bias *(replicate sampling to test for sampler differences)*
	✓	accuracy *(comparisons with toxicity testing, chemical sampling)*

Biological data	
Storage	data are entered in Excel spreadsheets, then transferred to FoxPro
Retrieval and analysis	In-house programs in FoxPro

**The impairment threshold is not defined using reference sites. Instead, NYSDEC creates impact categories using all of the data from the sites: everything >75th percentile is considered non-impacted/good.

NORTH CAROLINA



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Program Description

Benthic Macroinvertebrates
The Biological Assessment Unit of NCDENR uses aquatic macroinvertebrates as one type of indicator of biological integrity in streams and rivers. A swamp-sampling method is under development with sampling occurring in winter/early spring. North Carolina biologists first began collecting data in the late 1970s, and began using consistent sampling in 1983. Collection methods include a standard qualitative method (applicable for most between-site and/or between-date comparisons and used for all evaluations of impaired streams - those on the state 303(d) list), and the EPT method (an abbreviated version of the regular qualitative technique used to quickly determine between-site differences in water quality). Benthic samples are processed on site at each location. Another collection method is used for swamp streams. The boat sampling technique for nonwadeable freshwater rivers is an adaptation of the standard qualitative method.

Bioclassification criteria have been developed that are based on the number of intolerant EPT taxa present and the relative pollution tolerance of each taxa, as summarized in a Biotic Index for standard evaluation (EPT uses taxa richness only). Stream and river reaches are then given a final bioclassification of either Excellent, Good, Good/Fair, Fair or Poor. These bioclassifications, which have been developed for major ecoregions, are used to assess the various impacts of both point source discharges and nonpoint source runoff.

Beginning in 1991, the benthos summer sampling effort was directed toward specific river basins in given years based on the NPDES permitting schedule. This basin-wide monitoring is generally conducted three years prior to the year of permit renewal for the basin. This allows biological data to be incorporated in basin assessment, and subsequently into the management plan for each basin. Benthos data, by sub-basin, is incorporated into an Environmental Sciences Branch assessment report that also includes a review of pertinent data and information from other sources.

Between 110 and 130 wadeable sites are sampled for benthos each year during basinwide monitoring, and additional sites are sampled for special studies. The resulting information is used to document both spatial and temporal changes in water quality and to complement water chemistry analyses, fish community data, and habitat evaluations. In addition to assessing the effects of water pollution, biological information is also used to define High Quality or Outstanding Resource Waters, support enforcement of stream standards, and measure improvements associated with management actions. The results of biological investigations have been an integral part of North Carolina's basinwide monitoring program. Benthos data is the primary source for use support determinations.

Fish Community
To the public, the condition of the fishery is one of the most meaningful indicators of ecological integrity. Fish occupy the upper levels of the aquatic food web and are both directly and indirectly affected by chemical and physical changes in the environment. The Biological Assessment Unit employs a standard method for assessing streams' biological integrity by examining the structure and health of fish communities. This assessment incorporates information about species richness and composition, trophic composition, fish abundance, and fish condition. Criteria for the 12 metrics used in the North Carolina Index of Biological Integrity (NCIBI) are based on reference site data collected from groupings of river basins with similar fauna. The reference site sampling began in 1999, and fish community samples are now given a bioclassification similar to the benthos sites. Approximately 90 basinwide fish sites are sampled annually. Fish community data are used in the same ways as benthos data.

Use Support
North Carolina has moved toward assessing use support for each use class. Benthos and fish data are used for the evaluation of aquatic life standards. Biological data are typically given more weight than chemical data for use support. Sites with data from more than one trophic level are evaluated on a site specific basis for use support.

Documentation and Further Information

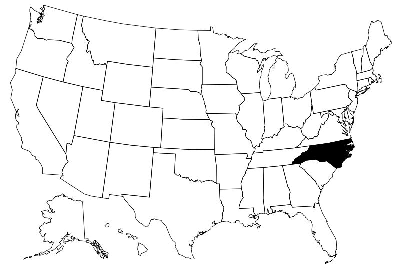
North Carolina 2000 305(b) Report: http://h2o.enr.state.nc.us/bepu/download.html

SOPs Biological Monitoring, Stream Fish Community Assessment & Fish Tissue:
http://www.esb.enr.state.nc.us/BAUwww/IBI%20Methods%202001.pdf

SOPs for Benthic Macroinvertebrates: http://www.esb.enr.state.nc.us/BAUwww/benthossop.pdf

Benthic Macroinvertebrate Sampling and Narrative Criteria: http://www.esb.enr.state.nc.us/BAUwww/benthosdata.pdf

NORTH CAROLINA



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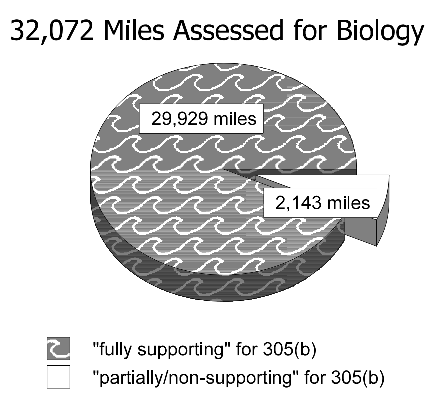
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
	✓	other: 303(d) listing
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(comprehensive use throughout jurisdiction)*
	✓	fixed station (i.e., water quality monitoring stations) *(comprehensive use throughout jurisdiction)*
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
	✓	rotating basin *(comprehensive use throughout jurisdiction)*
		other:

Stream Miles

Total miles *(State based determinations)*	**37,672**
Total perennial miles	–
Total miles assessed for biology*	**32,072**
fully supporting for 305(b)	29,929
partially/non-supporting for 305(b)	2,143
listed for 303(d)	2,143
number of sites sampled *(on an annual basis)***	350
number of miles assessed per site	91.6



*Presently, biological sites are not separated from chemical for reporting purposes. However, Aquatic Life usages will be based primarily on biological assessment in the future. The 303(d) list is due before all assessments were completed (roughly 99% of partially/non supporting waters for 305(b) list). Thus, the number of miles assessed using biological data can't be confirmed because so many sources of information are used to make use support assessments. It can be assumed that using the current methodology of breaking out use support ratings by category (i.e., aquatic life), all the waters assessed in this category could be added up into miles. However, this method has only been applied to 6 of the 17 basins in North Carolina. NCDENR may have these numbers in the next few years.

**Best professional estimate of the number of sites sampled since the program's inception is 5000 benthos, 600 fish and 4000 phytoplankton samples (this is very good coverage of sites within river basins for mainstem and major tributaries).

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Class System (A,B,C)	
ALU designations in state water quality standards	"Aquatic life propagation and maintenance of biological integrity..." applies as a best usage for Class C and Class WS-I waters.	
Narrative Biocriteria in WQS	Procedures used to support narrative biocriteria located in SOPs for biological assessment	
Numeric Biocriteria in WQS	none (Located in SOPs for biological assessment but not in water quality standards.)	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Biological data have been used to pinpoint degraded areas and to validate improvement after management activities have been completed.	

Reference Site/Condition Development

Number of reference sites	**300 total**	
Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
		professional judgment
		other:
Reference site criteria	Must achieve an excellent bioclassification or meet certain land use criteria (percent forest, no major dischargers, etc). Benthos reference sites: EPT criteria and biotic index criteria; fish reference sites: IBI criteria.	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
	✓	elevation
	✓	stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information	✓	reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(100-500 samples/year; multiple seasons, multiple sites – broad coverage for watershed level)*
	✓	fish *(<100 samples/year; multiple seasons, multiple sites – broad coverage for watershed level)*
	✓	periphyton, *(<100 samples/year; single observation, limited sampling)*
	✓	other: phytoplankton *(>500 samples/year; multiple seasons, multiple sites – broad coverage for watershed level)* and macrophytes *(<100 samples/year; single observation, limited sampling*)

Benthos	
sampling gear	collect by hand, sandbag, fine-mesh samplers made with net between PVC pipe joins, dipnet, kick net (1 meter); 200-400 micron mesh
habitat selection	multihabitat
subsample size	entire sample, aimed at >10 organisms/taxon (from qualitative field picking)
taxonomy	genus, species
Fish	
sampling gear	backpack electrofisher, boat electrofisher, seine; 1/8" mesh
habitat selection	multihabitat
sample processing	length measurement, anomalies
subsample	none
taxonomy	species, subspecies
Periphyton	
sampling gear	**natural substrate**: brushing/scraping device (razor, toothbrush, etc.), collect by hand; **artificial substrate**: collect by hand, bring rock back to lab
habitat selection	richest habitat
sample processing	taxonomic identification
taxonomy	diatoms only, species level
Habitat assessments	visual based, performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings and training for biologists, taxonomic proficiency checks, specimen archival, certification program for bioassessment

Data Analysis and Interpretation

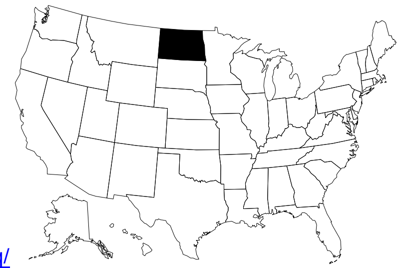
Data analysis tools and methods	✓	summary tables, illustrative graphs
	✓	parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(aggregate metrics into an index and return single metrics - use endpoint for each single metric)*
	✓	disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	reference data set used to set bounds for metrics - percent will vary with metric
defining impairment in a multimetric index	reference data set used to set bounds for metrics - percent will vary with metric

Evaluation of performance characteristics	✓	repeat sampling *(seasonal, multiyear data)*
	✓	precision *(to look for subtle differences in water quality)*
	✓	sensitivity *(different teams sample the same site)*
	✓	bias *(overlap sites with different crews)*
	✓	accuracy *(compare bioassessments with chemical & toxicity data)*

Biological data	
Storage	Fourth Dimension used for benthos data, MS Access used for fish and phytoplankton data
Retrieval and analysis	In house database

NORTH DAKOTA



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Program Description

The primary goal of North Dakota's biological monitoring and assessment program is to develop a set of scientifically defensible ecological indicators that can be used to assess the extent to which the state's rivers and streams are meeting their designated aquatic life uses. Once developed, these indicators can also be used to set restoration goals when developing total maximum daily loads (TMDLs) and/or Section 319 nonpoint source pollution project implementation plans.

The North Dakota Department of Health (NDHD) initiated its biological monitoring and assessment program in 1993 and 1994 as part of an interagency project to develop a multimetric index of biological integrity (IBI) for fish in the Lake Agassiz Plain ecoregion, Red River of the North Basin. In addition to the Department of Health, other agencies involved in the project were the Minnesota Pollution Control Agency, Minnesota Department of Natural Resources, EPA Region V, and the USGS – Red River National Water Quality Assessment (NAWQA) project team. The project resulted in a 12 metric IBI for fish which distinguished among headwater, moderate, and large sized rivers.

Since 1995, NDHD has conducted biological monitoring in each of the state's four major river basins. The Department's biological monitoring and assessment efforts continued in the Red River of the North Basin in 1995 and 1996. In addition to fish, the Department began sampling macroinvertebrates in 1995. In 1997 and 1998, monitoring and assessment efforts were expanded to the Souris River and James River basins, respectively, and in 1999 and 2000 the Department sampled the Missouri River Basin. In addition to fish and macroinvertebrate samples collected at each site, NDHD also conducted a habitat assessment following EPA's Rapid Bioassessment Protocol.

Preliminary multimetric IBIs have been developed for fish and macroinvertebrates in the Red River Basin and for fish in the Souris River Basin. These IBIs have been used to assess aquatic life use support for the 2000 Section 305(b) report. As these IBIs are refined and as additional IBIs are developed for the remaining river basins, it is the Department's intent to include these biological assessments in future Section 305(b) reports as well as in the development of Section 303(d) TMDL lists.

NDHD is currently collaborating with North Dakota State University and EPA Region VIII in a two year pilot project to evaluate the response of the benthic periphyton community to varying summer growing season nutrient levels with the goal of developing regional nutrient criteria. Based on the results of this pilot project, NDHD may include periphyton in future biological monitoring and assessment activities, especially in relation to nutrient enrichment and eutrophication.

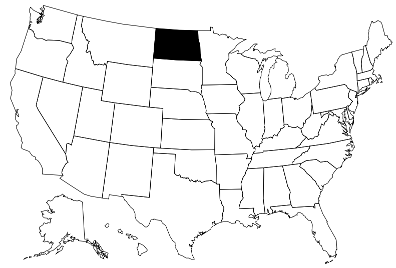
The Department is also a collaborator with EPA in the EMAP Western Pilot Project. The EMAP Western Pilot is currently in the third year of a four year project. By collaborating in this 12 state project, the Department hopes to integrate EMAP sampling design as well as EMAP sampling protocols into future biological monitoring and assessment projects. When NDHD's commitment to this project is completed in 2004, it's the Department's plan to begin its rotating basin monitoring program with the Red River Basin.

Documentation and Further Information

North Dakota Water Quality Assessment 1998 - 1999, 2000 305(b) Report:
http://www.health.state.nd.us/ndhd/environ/wq/2000_305b/2000_305b.pdf

For links to numerous NDHD surface water quality/management publications, including *Standards of Quality for Waters of the State, Chapter 33-16-02* and *North Dakota Unified Watershed Assessment, FY1999*, go to:
http://www.health.state.nd.us/ndhd/environ/wq/

NORTH DAKOTA



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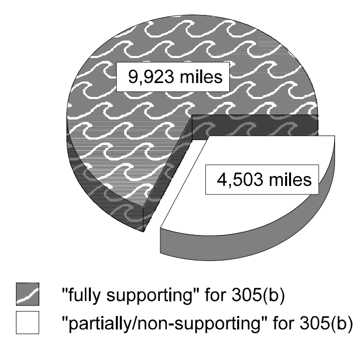
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
		support of antidegradation
		evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects only)*
		fixed station (i.e., water quality monitoring stations)
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
	✓	rotating basin *(specific river basins or watersheds)*
		other:

Stream Miles

Total miles *(determined using RF3)*	**54,427**
Total perennial miles	unknown
Total miles assessed for biology*	**14,426**
fully supporting for 305(b)	9,923
partially/non-supporting for 305(b)	4,503
listed for 303(d)	–
number of sites sampled *(on an annual basis)***	150
number of miles assessed per site	–

14,426 Miles Assessed for Biology



*Both stream and river miles were assessed for biological, chemical and physical effects. As reported in ND's 2000 305(b) report, approximately 68.8 percent (9,923 miles) of rivers and streams assessed for this report fully support the beneficial use designated as aquatic life. The remaining 31.2 percent of rivers and streams (4,503 miles) either partially supporting or did not support their aquatic life uses.

**According to ND's 2000 305(b) report, "In 1997, 1998, and 1999, the department focused its intensive basin survey efforts on the Souris River Basin, the James River Basin, and the Lake Sakakawea subbasin, respectively. In addition to chemical monitoring, biological monitoring was conducted at approximately 50 sites in each basin each year."

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Single Aquatic Life Use	
ALU designations in state water quality standards	North Dakota has several classes described (Class I, Ia, II, and III) but the ALU is basically the same for all classes.	
Narrative Biocriteria in WQS	A narrative biological goal is contained in ND's water quality standards. There are no formal/informal numeric procedures used to support narrative biocriteria.	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
		permitted discharges
		monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Nonpoint source project implementation plans	

Reference Site/Condition Development

Number of reference sites	**~75 total**	
Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
		professional judgment
		other:
Reference site criteria	Reference sites are the best sites of the whole population sampled, determined by habitat condition of sites and fish IBI.	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
	✓	stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
	✓	other: river basin
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(100 - 500 samples/year; single season, multiple sites - watershed level)*
	✓	fish *(<100 samples/year; single season, multiple sites - watershed level)*
	✓	periphyton *(<100 samples/year; multiple seasons, multiple sites - broad coverage for watershed level)*
		other:

Benthos	
sampling gear	D-frame; 500-600 micron mesh
habitat selection	multihabitat
subsample size	300 count
taxonomy	lowest practical, usually genus
Fish	
sampling gear	boat and longline electrofishers, pram unit (tote barge)
habitat selection	multihabitat
sample processing	length measurement, biomass - batch, anomalies
subsample	none
taxonomy	species
Periphyton	
sampling gear	**natural substrate**: suction device
habitat selection	riffle/run (cobble)
sample processing	taxonomic identification
taxonomy	diatoms only
Habitat assessments	visual based and hydrogeomorphology; performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan and specimen archival

Data Analysis and Interpretation

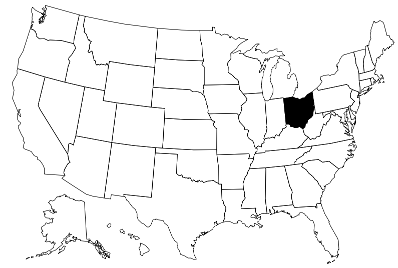
Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(multimetric index under development)*
	✓	disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	95^{th} percentile of all sites
defining impairment in a multimetric index	"power analysis"

Evaluation of performance characteristics	✓	repeat sampling *(replicate sampling within and among years)*
		precision
		sensitivity
		bias
		accuracy

Biological data	
Storage	Fish and habitat assessment data are in an MS Access 97 database maintained by the Department. Macroinvertebrate data are in EDAS.
Retrieval and analysis	Macroinvertebrate data are analyzed by EDAS, and plots generated by SAS. Fish data are analyzed with queries developed in-house.

OHIO



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OHEPA Division of Surface Water,Statewide Biological and Water Quality Monitoring and Assessment homepage: http://www.epa.state.oh.us/dsw/bioassess/ohstrat.html

Program Description

The Ohio EPA has been sampling biological communities in Ohio streams and rivers with standardized sampling protocols since the mid 1970s. Biological criteria was incorporated into the Ohio water quality standards (WQS; Ohio Administrative Code 3745-1) regulations in February 1990 (effective May 1990). These criteria consist of numeric values for the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb), both of which are based on fish assemblage data, and the Invertebrate Community Index (ICI), which is based on macroinvertebrate assemblage data. Criteria for each index are specified for each of Ohio's five ecoregions (as described by Omernik 1987), and are further organized by organism group, index, site type, and aquatic life use designation. These criteria, along with the existing chemical and whole effluent toxicity evaluation methods and criteria, figure prominently in the monitoring and assessment of Ohio's surface water resources.

Ohio EPA employs biological, chemical, and physical monitoring and assessment techniques in biosurveys in order to meet three major objectives: 1) determine the extent to which use designations assigned in the Ohio WQS are either attained or not attained; 2) determine if use designations assigned to a given waterbody are appropriate and attainable; and 3) determine if any changes in key ambient biological, chemical, or physical indicators have taken place over time, particularly before and after the implementation of point source pollution controls or best management practices. Biosurvey data are processed, evaluated, and synthesized in a biological and water quality report. Each biological and water quality study contains a summary of major findings and recommendations for revisions to WQS, future monitoring needs, or other actions that may be needed to resolve existing impairment of designated uses. While the principal focus of a biosurvey is on the status of aquatic life uses, the status of other uses such as recreation and water supply, as well as human health concerns, are also addressed.

Documentation and Further Information

Year 2000 Ohio Water Resource Inventory, 305(b) Report: http://www.epa.state.oh.us/dsw/documents/Ohio305B2000.pdf

FWPCA Section 303(d) TMDL Priority List for FFY 1999-2000: http://www.epa.state.oh.us/dsw/tmdl/303dnotc.html

The State of the Aquatic Ecosystem: Ohio Rivers and Streams, 1998 Status: http://www.epa.state.oh.us/dsw/documents/fs8mas98.pdf

The Role of Biological Criteria in Water Quality Monitoring, Assessment, and Regulation, 1995: http://www.epa.state.oh.us/dsw/documents/instbusl.pdf

Using Biological Criteria to Validate Applications of Water Quality Criteria: Dissolved and Total Recoverable Metals, February 1997: http://www.epa.state.oh.us/dsw/documents/gli_bio.pdf

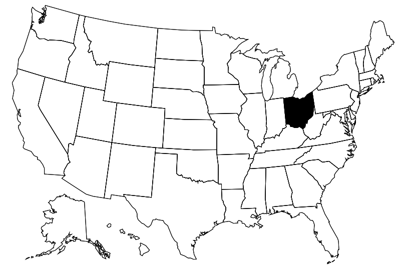
Rankin, E.T. 1989. *The qualitative habitat evaluation index (QHEI): rationale, methods, and application*. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, Ohio.

Biological and Water Quality Reports, list of documents: http://www.epa.state.oh.us/dsw/document_index/psdindx.html

Biocriteria manuals are currently only available as hard copies upon emailed or written request. Information on obtaining copies can be found at http://www.epa.state.oh.us/dsw/document_index/printdoc.html. The biocriteria manuals are titled as follows:

> Ohio Environmental Protection Agency. 1987a. *Biological criteria for the protection of aquatic life: Volume I. The role of biological data in water quality assessment*. Division of Water Quality Monitoring & Assessment, Surface Water Section, Columbus, Ohio.
>
> Ohio Environmental Protection Agency. 1987b. *Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters*. Division of Water Quality Monitoring & Assessment, Surface Water Section, Columbus, Ohio.
>
> Ohio Environmental Protection Agency. 1989b. *Addendum to Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters*. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, Ohio.
>
> Ohio Environmental Protection Agency. 1989c. *Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities*. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, Ohio.

OHIO



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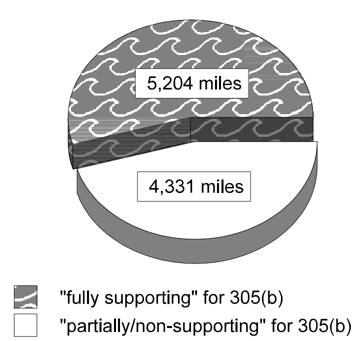
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALUS determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects, specific river basins or watersheds, and comprehensive use throughout jurisdiction)*
	✓	fixed station (i.e., water quality monitoring stations) *(specific river basins or watersheds)*
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
	✓	rotating basin *(special projects, specific river basins or watersheds, and comprehensive use throughout jurisdiction)*
	✓	other: geometric design *(specific river basins or watersheds and comprehensive use throughout jurisdiction)*

Stream Miles

Total miles *(based on the USEPA RF3 map of perennial stream miles as determined for Ohio)*	**29,113**
Total perennial miles	29,113
Total miles assessed for biology	**9,535**
fully supporting for 305(b)	5,204
partially/non-supporting for 305(b)	4,331
listed for 303(d)*	2,052
number of sites sampled *(1999-2000)*	1,100
number of miles assessed per site *(1999-2000)*	2.5

9,535 Miles Assessed for Biology



*The 2,052 miles are from Ohio's 1998 303(d) list, which is based on the 1996 305(b) statistics and includes data collected through 1994. OHEPA has recently taken a different approach to assessment and listing that will be reflected in upcoming 303(d) listings. The Agency now discourages the use of attainment statistics based on monitored stream miles in favor of a watershed level approach that provides an indication of the attainment status of watersheds in total (in essence, a measure of square miles of watersheds fully, partially, or not supporting ALU).

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Class System (A,B,C) - Tiered	
ALU designations in state water quality standards	Seven designations: Warmwater Habitat, Exceptional Warmwater Habitat, Coldwater Habitat, Modified Warmwater Habitat, Seasonal Salmonid, Limited Warmwater Habitat (being phased out), Limited Resource Water	
Narrative Biocriteria in WQS	Procedures used to support narrative biocriteria located in Ohio WQS, http://www.epa.state.oh.us/dsw/rules/3745-1.html	
Numeric Biocriteria in WQS	Also found in Ohio WQS, see above link	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	There are many instances where bioassessments documented before and after conditions based on POTW improvements. Biosurvey data and biocriteria thresholds are the primary arbiters in the determination of aquatic life use attainment status; results are used to determine 305(b) aquatic life use attainment statistics and to drive the 303(d) listing/delisting and TMDL development process.	

Reference Site/Condition Development

Number of reference sites	**500 total** (including modified reference sites)	
Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
		professional judgment
		other:
Reference site criteria*	Representative of best watershed conditions within an ecoregion given the background activities prevalent in society.	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information	✓	reference sites linked to ALU
	✓	reference sites/condition referenced in water quality standards *(listed in Biocriteria Manuals, which are referenced in WQS)*
	✓	some reference sites represent acceptable human-induced conditions

*All reference sites were originally screened to eliminate sites with evidence of substantial human disturbance. This was accomplished by examining maps of human population density and current and past land uses, compiling a watershed disturbance ranking, and noting the size and location of point source discharges. Additional site-specific factors considered in the selection of a reference site included (1) the amount, if any, of stream channel modification, (2) the condition of the vegetative riparian buffer zone, (3) water volume, (4) channel morphology characteristics, (5) substrate character and condition, (6) presence of obvious color/odor problems, (7) amount of instream woody debris, and (8) the general representativeness of the site within the ecoregion.

Field and Lab Methods

Assemblages assessed	✓	benthos *(100-500 samples/year; single season, multiple sites - broad coverage)*
	✓	fish *(100-500 samples/year; single season, multiple sites - broad coverage)*
		periphyton
		other:

Benthos	
sampling gear	collect by hand, multiplate: 200-400 micron mesh
habitat selection	multihabitat and artificial substrate
subsample size	entire sample (presort with subsampling)
taxonomy	combination (lowest practical with current knowledge)
Fish	
sampling gear	backpack electrofisher (in small streams only), boat electrofisher, pram unit (tote barge), and longline method using electrofishing unit and 100 meter line
habitat selection	multihabitat
sample processing	biomass - individual and batch, anomalies
subsample	batch (for weight only)
taxonomy	species
Habitat assessments	visual based; performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings and training for biologists, taxonomic proficiency checks, specimen archival, and a certification program for bioassessment has been developed for the OHEPA Voluntary Action Program (i.e., Brownfields Redevelopment)

Data Analysis and Interpretation

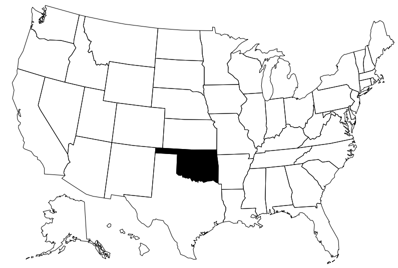
Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	95th percentile of reference population
defining impairment in a multimetric index	25th percentile of reference population (ecoregion Warmwater Habitat and Modified Warmwater Habitat); 75th percentile of reference population (statewide Exceptional Warmwater Habitat); EPA RBP Guidelines

Evaluation of performance characteristics	✓	repeat sampling *(many sites - including reference sites - with multiple-year collections to track temporal variability)*
	✓	precision *(multiple samples occasionally collected from the same site on the same date, especially at potential litigation sites)*
	✓	sensitivity *(studies have been done to determine the possible range of variation in index scores at a given sampling location on a given sampling date)*
		bias
		accuracy

Biological data	
Storage	In initial stages of modernization and migration to MS Access
Retrieval and analysis	Custom programs to calculate indices, other summarized data, 305(b) statistics, etc.

OKLAHOMA



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Program Description

The Oklahoma Water Resources Board (OWRB) has many monitoring programs. In 1998, the State Legislature directed the OWRB to oversee certain state water quality monitoring activities to determine compliance with Oklahoma's Water Quality Standards (OWQS). Specifically, the OWRB was charged with coordinating all monitoring under a standing cooperative agreement with the USGS, conducting a Comprehensive Beneficial Use Monitoring Program (BUMP), and developing Use Support Assessment Protocols (USAPS) to ensure the consistent data interpretation of beneficial use support. The overall goal of BUMP is to document beneficial use impairments, identify impairment sources (if possible), detect water quality trends, provide needed information for the OWQS and facilitate the prioritization of pollution control activities. River and stream monitoring is one of five key elements of BUMP.

So far, OWRB's biological monitoring is related only to special projects, such as biocriteria development or the occasional fish tissue study. However, BUMP is a developing program and there is intent to expand biological monitoring in the near future. Presently, there are fixed and rotating stations at which chemistry and flow information may be collected. The OWRB is currently monitoring almost 200 sites on a monthly basis. These sites are segregated into two discrete types of monitoring activities. The first monitoring activity is focuses on fixed station monitoring on rivers and streams. In general, at least one sample station is located in each of 67 watersheds. Following consultation with other appropriate state environmental agencies, the OWRB originally identified 84 fixed sites; that number has now grown to 100. The second component of river and stream monitoring focuses on water quality sampling stations whose location will rotate on an annual basis. Stations and identified monitoring parameters were based upon Oklahoma's 303(d) list and the monitoring requirements of other state environmental agencies. Monitoring parameters are specific for each stream segment.

Oklahoma DEQ's fish monitoring program has been discontinued but provided a wealth of information concerning statewide fish distribution. Improvements in Oklahoma's water quality monitoring programs are being developed and implemented in order to provide more consistent and reliable information related to the condition of aquatic resources (including quality habitat alteration, and impacts of polluted runoff and point source discharges). Unfortunately, much of the monitoring information in Oklahoma is fragmentary and incompatible because it is collected through programs that are designed and conducted for differing objectives.

Documentation and Further Information

The State of Oklahoma Water Quality Assessment Report, 2000 Edition, November 2000:
http://www.deq.state.ok.us/WQDnew/305b_303d/2000_305b_Report_Final.pdf

Status of Water Quality Monitoring in Oklahoma, 2000 Final Report to the Oklahoma Legislature:
www.owrb.state.ok.us/reports/OkWqStatus2000.pdf

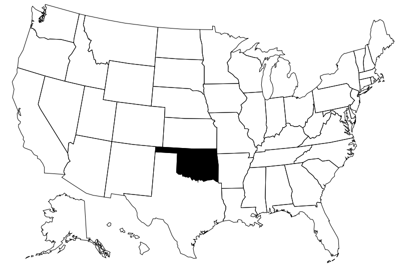
Oklahoma Water Resources Board, Chapter 46 of Implementation of Oklahoma's WQS, effective August 2001:
http://www.owrb.state.ok.us/rules/Chap46.pdf

SOP for Field Sampling Efforts of the OK Water Resources Board Beneficial Use Monitoring Program, June 2001:
http://www.owrb.state.ok.us/reports/BUMP_SOPFY-01.pdf

Oklahoma's Nonpoint Source Management Program and Nonpoint Source Assessment Report, FINAL DRAFT:
http://www.okcc.state.ok.us/Divisions/Water_Quality/Reports/REPORT078.pdf

Conduct your own "Biological Monitoring" search for additional documents using: http://www.soonersearch.odl.state.ok.us/

OKLAHOMA



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Programmatic Elements

Uses of bioassessment within overall water quality program*		problem identification (screening)
		nonpoint source assessments
		monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
		support of antidegradation
		evaluation of discharge permit conditions
		TMDL assessment and monitoring
		other:
Applicable monitoring designs		targeted (i.e., sites selected for specific purpose)
		fixed station (i.e., water quality monitoring stations)
		probabilistic by stream order/catchment area
	✓	probabilistic by ecoregion, or statewide *(comprehensive use throughout jurisdiction)*
		rotating basin
		other:

*Several possibilities exist, but currently only use-support decisions and use assignments are done with bioassessments.

Stream Miles

Total miles *(State based determination - waterbody identifications)*	**78,778**
Total perennial miles	22,386
Total miles assessed for biology	**13,313**
fully supporting for 305(b)**	–
partially/non-supporting for 305(b)**	–
listed for 303(d)**	–
number of sites sampled	3,391
number of miles assessed per site	~4 (site specific)

**Much of Oklahoma's efforts are still in the development stages. The new 305(b) and 303(d) are not complete and there have been significant changes in protocol since last completed; thus the data from past reports are no longer relevant. The new 305(b) and 303(d) reports should be complete sometime in 2002.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	ALU subcategories	
ALU designations in state water quality standards	Habitat Limited Aquatic Community (least restrictive), Warm Water A.C., Cool Water A.C. (most restrictive), Trout Fishery (anti-degradation limitation)	
Narrative Biocriteria in WQS	Formal/informal numeric procedures used to support narrative biocriteria exist for specific ecoregions only.	
Numeric Biocriteria in WQS	Only for specific ecoregions; biological use-support thresholds found in 785:46-15 (WQS implementation).	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
		cause and effect determinations
		permitted discharges
		monitoring (e.g., improvements after mitigation)
		watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	none	

Reference Site/Condition Development

Number of reference sites	**66 - 132 total** (will increase as number of ecoregions are completed)	
Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
		professional judgment
	✓	other: least impacted, no point sources
Reference site criteria	Reference sites are defined by the least impacted version of a stream type in a particular ecoregion. Specific criteria is under development.	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
	✓	stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information	✓	reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(<100 samples/year; single observation, limited sampling*)
	✓	fish *(<100 samples/year; single observation, limited sampling*)
		periphyton
		other:

Benthos	
sampling gear	dipnet, kick net (1 meter); 500-600 micron mesh
habitat selection	riffle/run (cobble) and woody debris
subsample size	100 count
taxonomy	genus
Fish	
sampling gear	backpack electrofisher, seine; 1/4" mesh
habitat selection	all habitats contained within the "representative" reach of 200 - 400 meters
sample processing	anomalies and taxonomic identification
subsample	none
taxonomy	species
Habitat assessments	quantitative measurements; performed independent of bioassessments (see *Oklahoma Water Resource Board Technical Report 99-3* for more information)
Quality assurance program elements	standard operating procedures, quality assurance plan, taxonomic proficiency checks and specimen archival

Data Analysis and Interpretation

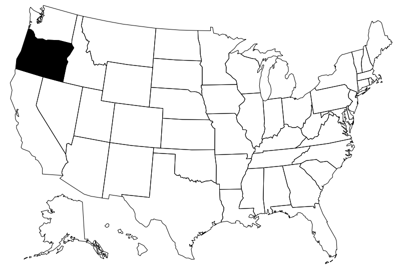
Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	cumulative distribution function (ecoregion dependent)
defining impairment in a multimetric index	cumulative distribution function (ecoregion dependent)

Evaluation of performance characteristics	✓	repeat sampling *(site validation collections and habitat assessments)*
		precision
		sensitivity
		bias
		accuracy

Biological data	
Storage	MS Access and/or Excel formats
Retrieval and analysis	application dependent, spreadsheet driven (no large statistical treatment yet); in the process of pulling existing data from other agencies to help develop a program

OREGON



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ORDEQ Water Quality Program homepage: http://www.deq.state.or.us/wq/

Program Description

Oregon DEQ (ORDEQ) has a history of using biological data in water quality assessments. Since the early 1990's the biomonitoring program has grown from two full time staff to nine current permanent staff, and over 15 during the summer field season. The principle objectives of the biomonitoring program are to:

- Assess the status of stream conditions and fish and macroinvertebrate assemblages across the state,
- Identify trends in stream conditions and biological assemblages,
- Identify the primary chemical and physical parameters impairing biological assemblages,
- Assess the effectiveness of restoration projects and management activities designed to improve stream conditions, and
- Help standardize protocols for biological assessments throughout the state and region

Increased concern over nonpoint sources of pollution and the listing of numerous salmon species as threatened or endangered has focused more attention on the importance of biological information in the State. In 1991 Oregon DEQ adopted narrative biocriteria into state water quality standards. ORDEQ is currently developing numeric biocriteria and expects to have numeric standards adopted by 2004.

Most biological data are collected using a probabilistic sampling design. A reference site network is also being developed and sampled. ORDEQ has worked closely with EPA and other state agencies in developing its monitoring strategy. Over 400 sites have been sampled for biological, chemical and physical parameters (approximately 150 sites per year). Currently biological data are incorporated into the State's 305(b) report and 303(d) list. Other biological data are used in NPDES permit assessments, CWA Section 401 permit applications, and beneficial use assessments.

Maintaining a commitment to long-term funding is one of the primary challenges of any state monitoring effort. Data management and data quality are also key issues that require ongoing efforts to maintain an effective program. Finally, integrating biological data into the overall water quality program (i.e. TMDLs) is an ongoing challenge and an area for improvement in the future. To view current ORDEQ biomonitoring technical reports, go to: http://www.deq.state.or.us/lab/Biomon/bio_rpt.htm

Documentation and Further Information

Oregon's 2000 Water Quality Status Assessment Report, Section 305(b) Report:
http://www.deq.state.or.us/wq/305bRpt/305bReport00a.pdf

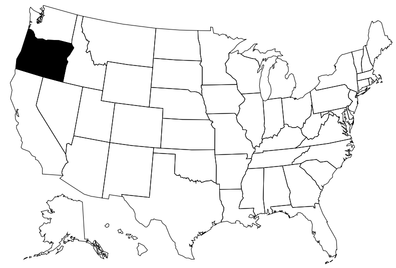
ORDEQ Water Quality Limited Streams 303(d) List information (including Listing Criteria, etc.):
http://www.deq.state.or.us/wq/303dlist/303dpage.htm

Oregon Water Quality Standards homepage: http://www.deq.state.or.us/wq/standards/wqstdshome.htm

Quality Assurance Guidelines:
http://www.deq.state.or.us/lab/qa/NPDES%20and%20WPCF%20Self-Monitoring%20Laboratories.pdf

Mrazik, S. 1999. *Reference site selection: a six step approach for selecting reference sites for biomonitoring and stream evaluation studies*. Oregon Department of Environmental Quality, Biomonitoring Section.

OREGON



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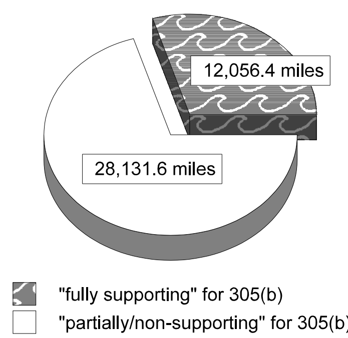
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
		support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
	✓	other: 401 permits and restoration effectiveness monitoring
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects only)*
		fixed station (i.e., water quality monitoring stations)
	✓	probabilistic by stream order/catchment area *(specific river basins or watersheds)*
	✓	probabilistic by ecoregion, or statewide *(comprehensive use throughout jurisdiction)*
		rotating basin
		other:

Stream Miles

Total miles *(determined using RF3 and National Hydrography Database)*	**114,823**
Total perennial miles	51,695
Total miles assessed for biology*	**40,188**
fully supporting for 305(b)	12,056.4
partially/non-supporting for 305(b)	28,131.6
listed for 303(d)**	unknown
number of sites sampled *(on an annual basis)****	150+
number of miles assessed per site	–

40,188 Miles Assessed for Biology



*Most of the biological monitoring is based on a probabilistic sampling design in order to calculate the total stream miles represented by the data.

**ORDEQ is in the process of drafting a new 303(d) list (as of March 2002). If ORDEQ were to provide data based on past 303(d) lists, the number of miles listed would be considerably smaller than the 28,131 miles that are "partially/non-supporting" for 305(b) because 303(d) lists are *not* based on a probabilistic sampling design.

***Over 400 total sites have been sampled.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Fishery Based Uses	
ALU designations in state water quality standards	Four designations: Salmonid Passage; Salmonid rearing; Salmonid spawning; Protection of resident fish and aquatic life	
Narrative Biocriteria in WQS	applied using a numeric approach found in 303(d) listing criteria, http://www.deq.state.or.us/wq/303dlist/303dpage.htm	
Numeric Biocriteria in WQS	under development	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
		watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	The best example is a stream restoration project in Eastern Oregon that is trying to restore habitat and water quality to support salmonid spawning and rearing. Bioassessment data have been an ongoing part of this project's evaluation.	

Reference Site/Condition Development

Number of reference sites	**200 total**	
Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
	✓	professional judgment
	✓	other: see criteria below
Reference site criteria	Reference sites must fall into the lowest level of human disturbance based on a set of GIS information and field results including land use, road density and habitat (GIS data and best professional judgment are used to identify 5th field watersheds with minimal human disturbance). Once potential watersheds have been identified, stream monitoring sites are randomly selected from within those watersheds. Field reconnaissance confirms if they are suitable reference sites.	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
	✓	other: minimally disturbed*
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
	✓	elevation
	✓	stream type
	✓	multivariate grouping
		jurisdictional (i.e., statewide)
	✓	other: gradient; latitude and longitude; conductivity; watershed area
Additional information		reference sites linked to ALU
	✓	reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

*Oregon has three classes of reference sites: A - Sites with no human disturbance. These sites represent "natural" conditions and are generally found in wilderness areas or very remote regions of the state, B - Sites with minimal human disturbance. These sites represent conditions expected to occur without or with very minimal human activity, and C - Sites with human disturbance that measurably alters stream conditions. These are the best available (least disturbed) sites.

Field and Lab Methods

Assemblages assessed	✓	benthos *(100-500 samples/year; single season, multiple sites - broad coverage)*
	✓	fish *(100-500 samples/year; single season, multiple sites - broad coverage)*
	✓	periphyton *(<100 samples/year; single season, multiple sites - watershed level) NOTE: ORDEQ samples periphyton for some projects, but not at the majority of sites.*
	✓	other: amphibians and reptiles *(100-500 samples/year; single season, multiple sites - broad coverage)*

Benthos	
sampling gear	D-frame; 500-600 micron mesh
habitat selection	riffle/run (cobble)
subsample size	500 count
taxonomy	combination - typically genus/species. A regional (multistate) taxonomy workgroup meets to set taxonomic level standards.
Fish/Amphibians	
sampling gear	backpack electrofisher
habitat selection	multihabitat
sample processing	length measurement and anomalies
subsample	none
taxonomy	species
Periphyton	
sampling gear	**natural substrate**: brushing/scraping device (razor/toothbrush, etc.)
habitat selection	riffle/run (cobble)
sample processing	taxonomic identification
taxonomy	all algae
Habitat assessments	quantitative measurements; performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings and training for biologists, and specimen archival

Data Analysis and Interpretation

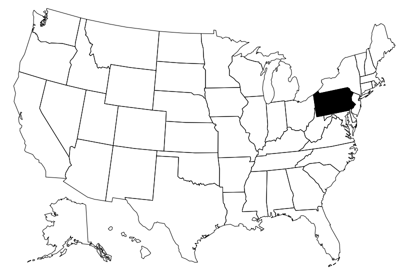
Data analysis tools and methods	✓	summary tables, illustrative graphs
	✓	parametric ANOVAs
	✓	multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
	✓	disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	25^{th} percentile of reference population
defining impairment in a multimetric index	Cumulative distribution function
Multivariate thresholds	
defining impairment in a multivariate index	Significant departure from mean of reference population

Evaluation of performance characteristics	✓	repeat sampling *(a minimum of 10% of sites are sampled twice each field season)*
	✓	precision *(Signal-to-noise analysis)*
	✓	sensitivity *(Multivariate model sensitivity checked by rerunning model on subset of reference sites)*
		bias
		accuracy

Biological data	
Storage	Data are stored in an agency database using MS Access. Macroinvertebrate data are also being stored in a regional database (multi-agency and multi-state).
Retrieval and analysis	SAS and Statistica

PENNSYLVANIA



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http://www.dep.state.pa.us/dep/deputate/watermgt/watermgt.htm

Program Description

The basics of Pennsylvania's current water quality monitoring program began in the late 1960s and has included elements of bioassessment in some form since its inception. The primary objectives of the water quality monitoring program are to define surface water quality status and trends and to evaluate compliance with discharge permit limits.

The State of Pennsylvania uses biological assessments in several program areas. The Statewide Surface Water Assessment Program (SSWAP), started in 1997, was developed to assess all 83,000 miles of streams in the state. The first comprehensive statewide assessment is scheduled for completion by 2007. After five seasons, approximately two thirds of Pennsylvania's surface waters have been assessed. Assessments are based on an evaluation of the instream habitat and macroinvertebrate community composition. All assessed streams are determined to be either impaired or unimpaired and a source and cause is listed for the former. These data are compiled into an MS Access database and GIS stream layer that is updated yearly and submitted to USEPA as part of the 305(b) report. Impaired reaches are placed on the 303(d) list and scheduled for follow-up TMDLs. Due to increasing complexities in the TMDL program, the assessment field methodology will be refined and enhanced in order to satisfy data needs for TMDL development.

Pennsylvania's Antidegradation Program also uses biological assessments based on a modified version of USEPA's Rapid Bioassessment Protocols (RBP) methodology to define aquatic life use designations of candidate streams. Biological samples are collected, subsampled, identified, and selected metrics are generated and analyzed. Candidate streams are compared to reference streams to determine if they qualify for designation as High Quality or Exceptional Value Waters. To alleviate the problem of site-specific reference site variability, staff biologists are currently working to develop a set of regionalized Reference Condition scores that can be compared to candidate streams.

Biological assessments are also an important component of the Surface Water Quality Monitoring Network (WQN). Biological samples are collected at 26 fixed stations three times per year (spring, summer, and fall) and once a year (summer) at 123 additional stations using the same RBP methodology referenced above. These data, in conjunction with bimonthly water chemistry samples, are used to monitor long-term trends in water quality on the major streams in the Commonwealth.

Fish are collected at approximately 35 WQN stations each year. Fillets from these fish are analyzed for contaminants such as heavy metals and pesticides. This tissue analysis is used to generate consumption advisories for fish living in any contaminated surface waters.

In order to more effectively meet its water quality objectives, Pennsylvania has fostered several cooperative bioassessment partnerships. Through contracts with the PA DEP, the Pennsylvania Fish and Boat Commission (PFBC), Susquehanna River Basin Commission (SRBC), and Interstate Commission on the Potomac River Basin (ICPRB) assist with SSWAP assessments. The Department plans to contract with the USGS to collect WQN samples. There are also cooperative efforts with citizen monitoring groups for water quality monitoring data collection and 305(b) reporting purposes.

While Pennsylvania's bioassessment efforts have increased in recent years (Statewide Surface Waters Assessment program), additional bioassessment challenges are being tackled. Department biologists are currently working to develop fish-based bioassessment methodologies for larger streams, refine lake assessments for 303(d) reporting purposes, and bioassessments of specialized habitats; such as limestone, glide/pool dominated, and non-wadeable waters.

Documentation and Further Information

Commonwealth of Pennsylvania 2000 Water Quality Assessment 305(b) Report:
http://www.dep.state.pa.us/dep/deputate/watermgt/Wqp/WQStandards/305_wq2000_narr.htm

Commonwealth of Pennsylvania 2001 305(b) UPDATE:
http://www.dep.state.pa.us/dep/deputate/watermgt/Wqp/WQStandards/305_wq2001_narr.htm

DRAFT 2002 Section 303(d) Report, List of Impaired Waterbodies, June 2002:
http://www.dep.state.pa.us/dep/deputate/watermgt/Wqp/WQStandards/303d-Report.htm

Pennsylvania's Surface Water Quality Monitoring Network (WQN), revised 2001:
http://www.dep.state.pa.us/dep/deputate/watermgt/wqp/wqstandards/Facts/BK0636-1.pdf

Water Quality Assessment and Standards Fact Sheets:
http://www.dep.state.pa.us/dep/deputate/watermgt/wqp/wqstandards/Facts/Pubs-c.htm

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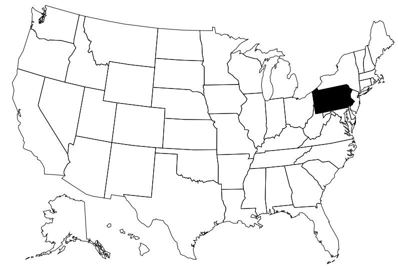

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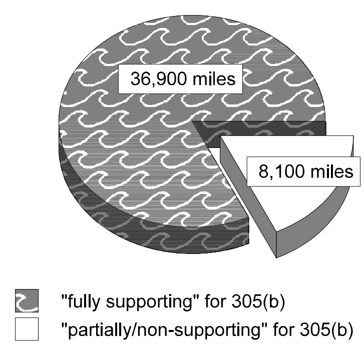
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
		promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects only)*
	✓	fixed station (i.e., water quality monitoring stations) *(comprehensive use throughout jurisdiction)*
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
	✓	rotating basin *(special projects only)*
		other:

Stream Miles

Total miles *(determined using 1/24,000 scale streams GIS coverage)*	**83,000**
Total perennial miles	–
Total miles assessed for biology	**45,000**
fully supporting for 305(b)	36,900
partially/non-supporting for 305(b)	8,100
listed for 303(d)	8,100
number of sites sampled	7,435
number of miles assessed per site*	–

45,000 Miles Assessed for Biology



*Stations are placed at the mouths of major tributaries and on mainstems; towns are bracketed (upstream/downstream) depending on landuse observed while in field.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Fishery Based Uses	
ALU designations in state water quality standards	Four designations: Cold water fishes, Warm water fishes, Migratory fishes, Trout stocking	
Narrative Biocriteria in WQS	none - Antidegradation protocols used to support general aquatic life standard are under development, not statutory - found in Chapter 93 of Statutory Code.	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	none	

Reference Site/Condition Development

Number of reference sites	**~100 total**	
Reference site determinations		site-specific
	✓	paired watersheds
	✓	regional (aggregate of sites)
		professional judgment
		other:
Reference site criteria	Based on stream classification in the antidegradation program, land use, and habitat: primarily forested, no water quality criteria violations, excellent habitat, and minimal siltation.	
Characterization of reference sites within a regional context		historical conditions
		least disturbed sites
		gradient response
		professional judgment
	✓	other: minimally disturbed
Stream stratification within regional reference conditions		ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
	✓	other: drainage area, land use, use designations, gradient, size and other regionalization other than ecoregion
Additional information	✓	reference sites linked to ALU
		reference sites/condition referenced in water quality standards
		some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(100-500 samples/year; multiple seasons, multiple sites - broad coverage for watershed level)*
	✓	fish* *(<100 samples/year; single season, multiple sites - not at watershed level)*
		periphyton
	✓	other: phytoplankton *(<100 samples/year; single season, multiple sites - not at watershed level)*

Benthos	
sampling gear	multiplate, D-frame and kick net (1 meter); >800 micron mesh
habitat selection	riffle/run (cobble)
subsample size	100 count
taxonomy	genus
Fish*	
sampling gear	backpack and boat electrofishers
habitat selection	multihabitat
sample processing	length measurement and anomalies
subsample	none
taxonomy	species
Habitat assessments	visual based; performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings and training for biologists, taxonomic proficiency checks, specimen archival

*Pennsylvania Fish & Boat Commission provides fish data to PA DEP. For more information, contact Rick Spear, PA Fish & Boat Commission, 450 Robinson Lane, Bellefonte, PA 16823, Phone: 814/359-5233, e-mail: rspear@state.pa.us.

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
	✓	parametric ANOVAs
	✓	multivariate analysis
	✓	biological metrics *(return single metrics - use endpoint for each single metric)*
	✓	disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	Still in the process of evaluating the best approach (considering 75th and 95th percentile of reference population and cumulative distribution function)
defining impairment in a multimetric index	Still in the process of evaluating the best approach (considering 75th and 95th percentile of reference population and cumulative distribution function)
Multivariate thresholds	
defining impairment in a multivariate index	In the process of evaluating the best approach

Evaluation of performance characteristics	✓	repeat sampling *(two or three separate samples in the same riffle)*
		precision
		sensitivity
		bias
		accuracy

Biological data	
Storage	MS Access
Retrieval and analysis	SAS

RHODE ISLAND

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RIDEM Office of Water Resources homepage:
http://www.state.ri.us/dem/programs/benviron/water/index.htm

Program Description

The importance of biological assessments in the evaluation of water quality has long been recognized in Rhode Island. Biological assessments are used to supplement physical and chemical water quality monitoring data. More specifically, the biological data can be used to identify long-term trends in water quality which reflect water pollution abatement efforts and/or needs. The Rhode Island Department of Environmental Management (RIDEM), Office of Water Resources (OWR) has two types of biological monitoring programs. Multiple plate artificial substrates have been used to evaluate the biological community in deep rivers since 1974. In addition, EPA's Rapid Bioassessment Protocol (RBP) (USEPA 1989) has been used since 1991 for the assessment of the biological integrity of various shallow river sites in the state.

Artificial Substrate Monitoring
The Fullner multiple-plate artificial substrate with 14 plates has been used by the Office of Water Resources for over 20 years to assess instream biological communities. Stations selected for this biological monitoring include those used for USGS trend chemical sampling to more closely relate chemical and biological data. This method has the advantage of providing a uniform sampling habitat for each station, thus reducing the problem caused by varying types of river bottom and depth. Macroinvertebrates collected on the artificial substrates are classified according to their tolerance of pollutants.

Rapid Bioassessment Protocol Monitoring
RBP monitoring involves an integrated assessment, comparing habitat (physical structure, flow regime) and biological measures with defined reference site conditions. Since 1992, a network of 45 stream riffle-area sites have been surveyed by Roger Williams University in cooperation with and contracted by RIDEM. Each site is visited during the spring-summer season and macroinvertebrates are sampled (minimum 100 organisms per site visit where feasible). Data are analyzed using RBP I and II protocols, which include varying degrees of field and laboratory organism identification.

The streams sampled within the state range from first order to fifth order. Eight of the streams are considered to be first order, eighteen second order, twelve third order, four fourth order and three are of the fifth order. Lower order streams are quite dependent upon the immediate characteristics of the watershed. In other words, runoff is a direct-affect component versus one of many components within a higher order stream. It is important to note that the 1993, 1995 and 1997 sampling events took place during drought conditions, which may have resulted in fewer riffles, lower dilution and lack of runoff. This probably affected the types of organisms collected and resulted in an altered picture of the stations based from that seen in other years. This information was taken into account during the evaluation of the biological assessments.

Initial bioassessment work involved establishing and field testing the RBPs in Rhode Island streams and rivers. In addition, refinement of the protocol over the past 4 years has established the presence of two sub-ecoregions within the state: coastal areas and inland areas. Incorporation of the presence of these two sub-ecoregions into selection of reference sites and application of the protocols will continue. The habitat/physical parameters and biological metrics of each station were compared to those of the selected reference station and given an overall bioassessment score.

Documentation and Further Information

The State of the State's Waters Rhode Island Section 305(b) Report, September 2000:
http://www.state.ri.us/dem/pubs/305b/index.htm

State of Rhode Island 2000 303(d) List of Impaired Waters, November 2000: http://www.state.ri.us/dem/pubs/303d/303d00.pdf

Water Quality Regulations (including WQS), amended June 2000:
http://www.state.ri.us/dem/pubs/regs/REGS/WATER/h20qlty.pdf

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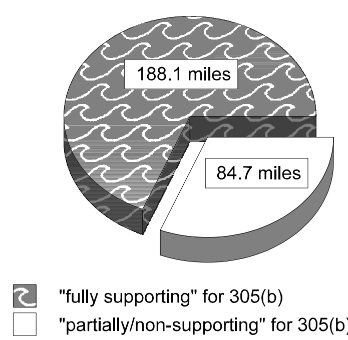
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
		support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(specific river basins or watersheds and comprehensive use throughout jurisdiction)*
	✓	fixed station (i.e., water quality monitoring stations) *(specific river basins or watersheds and comprehensive use throughout jurisdiction)*
		probabilistic by stream order/catchment area
	✓	probabilistic by ecoregion, or statewide *(comprehensive use throughout jurisdiction)*
		rotating basin
		other:

Stream Miles

Total miles *(determined using state based GIS coverage)*	**1,498**
Total perennial miles	979
Total miles assessed for biology*	**272.8**
fully supporting for 305(b)*	188.1
partially/non-supporting for 305(b)*	84.7
listed for 303(d)*	78.5
number of sites sampled *(on an annual basis)***	~62
number of miles assessed per site	site specific

272.8 Miles Assessed for Biology



*These numbers represent the miles assessed for ALUS using biology or a combination of biological and chemical data. The miles listed for 303(d) were taken from the RI draft 2002 303(d) list for biodiversity impairments.

**Roughly 62 sites are monitored on an annual basis, though this number does vary (10 = artificial substrate; 45 - 50 = RBP). Fifty-five additional sites were sampled in 2000 as part of a random sampling design for the EPA.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Single Aquatic Life Use and Class System (A,B,C)	
ALU designations in state water quality standards	One designation: fish and wildlife habitat	
Narrative Biocriteria in WQS	No formal/informal numeric procedures are used to support narrative biocriteria; however, there is a qualitative and/or narrative scale of condition.	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Super-fund sites and Rhode Island Pollutant Elimination Discharge System (RIPDES) permit toxic elimination	

Reference Site/Condition Development

Number of reference sites	**2 total**	
Reference site determinations	✓	site-specific
		paired watersheds
		regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria	Minimally impaired/disturbed (best reference site in New England) – natural conditions, bank erosion, land use, etc. High Quality unimpaired condition for RBP or site-specific for special site studies.	
Characterization of reference sites within a regional context	✓	historical conditions
		least disturbed sites
		gradient response
		professional judgment
	✓	other: minimally disturbed*
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information	✓	reference sites linked to ALU
		reference sites/condition referenced in water quality standards
		some reference sites represent acceptable human-induced conditions

*Rhode Island's reference sites are considered minimally disturbed. The Wood River reference site (most widely used) will likely remain minimally disturbed because its watershed is largely contained within State Park boundaries. RI allows for about a 20% variation from that target for compliance. However, special watershed projects may be asking an upstream or downstream question and, therefore, may be required to find a least disturbed site within the unique segment for comparison.

Field and Lab Methods

Assemblages assessed	✓	benthos *(<100 samples/year; single season, multiple sites - broad coverage)*
	✓	fish *(sampled once in conjunction with USEPA: < 100 samples; single observation)*
		periphyton
	✓	other: macrophytes *(<100 samples/year; single season, multiple sites - broad coverage)*

Benthos	
sampling gear	collect by hand, multiplate, D-frame; 200-400 micron mesh
habitat selection	riffle/run (cobble), artificial substrate
subsample size	100 count
taxonomy	combination
Habitat assessments	visual based; performed with bioassessments
Quality assurance program elements	standard operating procedures, periodic meetings and training for biologists, taxonomic proficiency checks, and specimen archival

Data Analysis and Interpretation

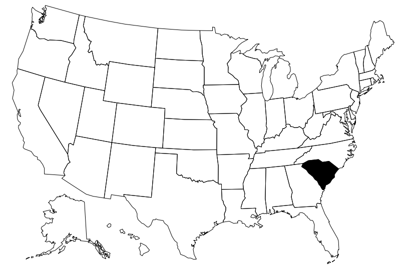
Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	25th percentile of reference population
defining impairment in a multimetric index	75th percentile of reference population - standard random sampling design, EPT index, RBPs

Evaluation of performance characteristics	✓	repeat sampling
		precision
		sensitivity
	✓	bias
		accuracy

Biological data	
Storage	databases, spreadsheets
Retrieval and analysis	EDAS

SOUTH CAROLINA



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SC DHEC Bureau of Water homepage: http://www.scdhec.net/water/

Program Description

Biologists at the South Carolina Department of Health and Environmental Control use aquatic macroinvertebrates as bioindicators to make assessments of water quality. The program began in the early 1970s with the first technical report printed in 1972. Currently, flowing streams and rivers are the primary waterbodies that are assessed. South Carolina's monitoring efforts can be divided into two categories: ambient monitoring and special studies. Both fixed sites and randomly selected sites are chosen each year for the ambient monitoring work. Fixed sites are sampled once every five years on a rotating basin schedule. Special studies usually involve a point source discharge or a nonpoint source perturbation such as a logging operation. Upstream and downstream sites are selected for sampling when conducting special studies. Agency staff may carry out the special studies or they may be required by the industry as part of a permit or consent order. In the latter case, state certified consultants conduct the studies with the resulting reports reviewed by agency scientists.

South Carolina's program is modeled after that of North Carolina's, which was developed in the 1970s and 1980s. A timed qualitative multihabitat approach is taken for sampling macroinvertebrates. Organisms are picked in the field and returned to the laboratory for identification to the lowest practical taxonomic level – usually genus or species. Two metrics are calculated to produce an assessment: the EPT Index, and the NC Biotic Index. These two metrics are standardized on a scale of 1 to 5 and averaged to produce a final score. The Bioclassification of the stream is based on this score. The numeric criteria developed in SC are dependant on the ecoregion within which the stream is located. There are separate criteria for the mountains, piedmont, and coastal plain regions of the state. For special studies, impact is determined by the change in the bioclassification score from the upstream control site to the downstream test site. A rigorous quality control/quality assurance program has been developed and implemented for sampling, identification of organisms, and data entry.

Documentation and Further Information

The 2002 Section 305(b) Water Quality Assessment Report for South Carolina, March 2000:
http://www.scdhec.net/eqc/water/pubs/305b.pdf

State of South Carolina 303(d) List for 2000, EPA approved in May 2000:
http://www.scdhec.net/eqc/water/pubs/303d2000.pdf (for the DRAFT 2002 303(d) List and 1998 303(d) List, go to http://www.scdhec.net/eqc/water/html/tmdl.html#303d)

The Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. 2001. SC DHEC.

State of South Carolina Monitoring Strategy for Calendar Year 2002, January 2002:
http://www.scdhec.net/eqc/water/pubs/strategy.pdf

Antidegradation Implementation for Water Quality in South Carolina, July 1998:
http://www.scdhec.net/eqc/water/pubs/antideg.pdf

Watershed Water Quality Management Strategy Program Description: http://www.scdhec.net/water/shed/prog.html

For a list of and links to additional SC DHEC *Bureau of Water* water quality publications, go to
http://www.scdhec.net/eqc/admin/html/eqcpubs.html#wqreports

DRAFT July 1998. *Standard Operating Procedures and Quality Control Procedures for Macroinvertebrate Sampling*. Technical Report No. 004-98. Prepared by South Carolina Bureau of Water, Division of Water Monitoring, Assessment and Protection, Aquatic Biology Section.

SOUTH CAROLINA

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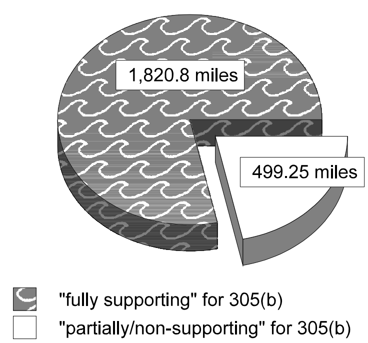
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(comprehensive use throughout jurisdiction)*
	✓	fixed station (i.e., water quality monitoring stations) *(comprehensive use throughout jurisdiction)*
	✓	probabilistic by stream order/catchment area *(comprehensive use throughout jurisdiction)*
	✓	probabilistic by ecoregion, or statewide *(comprehensive use throughout jurisdiction)*
	✓	rotating basin *(specific river basins or watersheds)*
		other:

Stream Miles

Total miles *(determined using RF3)*	**35,461**
Total perennial miles	25,729
Total miles assessed for biology*	**2,320**
fully supporting for 305(b)	1,820.8
partially/non-supporting for 305(b)	499.25
listed for 303(d)	499.25
number of sites sampled *(on an annual basis)*	80
number of miles assessed per site	–

2,320 Miles Assessed for Biology



*These miles, listed in the 2000 205(b) report, were assessed based on a combination of physical/chemical **and** biological/habitat data. The following subset of the 2,320 total combined miles contains stream miles assessed based **solely** on biological/habitat: 678.6 total miles assessed, 563.98 miles “fully supporting” for 305(b), and 114.6 miles “partially/non-supporting” for 305(b) and listed for 303(d).

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Class System (A,B,C) and Warm Water vs. Cold Water	
ALU designations in state water quality standards	Three designations: Freshwater, Trout - 3 types, Saltwater	
Narrative Biocriteria in WQS	Procedures used to support narrative biocriteria are not included in SC water quality standards, but are available in the monitoring program SOP.	
Numeric Biocriteria in WQS	none (South Carolina has limited numeric biociteria/indices used to evaluate ALU, which are not included in state water quality standards – see monitoring program SOP.)	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Biocriteria can affect permitting decisions if a watershed is listed on the 303(d) list for biological impacts.	

Reference Site/Condition Development

Number of reference sites	**30 total**	
Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
		professional judgment
		other:
Reference site criteria	The best sites are selected from a habitat and organismal point of view. Faunal characteristics and land use data from GIS are also considered (see newly-amended R.61-68.F.I.d. for more information).	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
	✓	stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information	✓	reference sites linked to ALU
	✓	reference sites/condition referenced in water quality standards *(found in R61-68.F.I.d.)*
	✓	some reference sites represent acceptable human-induced conditions

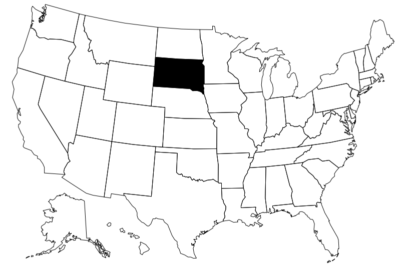
Field and Lab Methods

Assemblages assessed	✓	benthos *(100-500 samples/year; multiple seasons, multiple sites – broad coverage for watershed level)*
		fish
		periphyton
		other:
Benthos		
sampling gear		collect by hand, brass sieve, D-frame, kick net (1 meter); 500-600 micron mesh
habitat selection		multihabitat
subsample size		entire sample
taxonomy		combination and species when possible
Habitat assessments		visual based; performed with bioassessments
Quality assurance program elements		standard operating procedures, quality assurance plan, periodic meetings and training for biologists, taxonomic and sampling proficiency checks, specimen archival, data entry checks, certification program for bioassessment

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients
		other:
Multimetric thresholds		
transforming metrics into unitless scores		cumulative distribution function
defining impairment in a multimetric index		cumulative distribution function - follow guidelines outlined in following document: Lenat. 1993. *A biotic index for the southeastern United States, derivation and list of tolerance values, with criteria for assigning water quality ratings*. Journal of the North American Benthological Society. 12:279-290
Evaluation of performance characteristics		repeat sampling
	✓	precision *(replicate sampling of same stream, 10% each year)*
		sensitivity
		bias
	✓	accuracy *(compare faunal results with land use data and discharge presence or absence)*
Biological data		
Storage		MS FoxPro for Windows and Excel
Retrieval and analysis		FoxPro

SOUTH DAKOTA



Contact Information

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SD DENR Surface Water Quality website:
http://www.state.sd.us/denr/DES/Surfacewater/surfwprg.htm

Program Description

Currently, the South Dakota Department of Environment and Natural Resources (SD DENR) Water Resources Assistance Program (WRAP) collects biological data in addition to chemical and physical parameters for TMDL assessments. These bioassessments are useful in determining the impact of contaminants as well as detecting chronic water quality impairments that may not be discovered by ambient chemical and physical grab samples. Of the 9,937 total stream miles, approximately 4 miles have been biologically assessed (60 sites assessed; 150 meters per site). SD DENR has not yet established biological criteria for use in water quality standards.

The Water Resource Assistance Program evaluates benthic macroinvertebrate community structure in streams using both the EMAP protocol and USEPA's Rapid Bioassessment Protocols (RBPs) in conjunction with assessments of stream habitats. All biological samples are identified to the lowest possible level of taxonomic resolution. Biological data are entered into the STORET database and are summarized using multimetric indices and descriptive statistics. SD DENR intends to use the biological data to identify potential reference sites for determining the condition of water quality and the integrity of the biological community. WRAP is beginning to sample periphyton communities to determine if they are a better biological indicator of water quality.

Documentation and Further Information

Stueven, E., A. Wittmuss, and R.L. Smith. 2000. *Standard Operating Procedures for Field Samplers. Revision 4.0, January 2000*. South Dakota Department of Environment and Natural Resources, Water Resource Assistance Program. Pierre, SD.

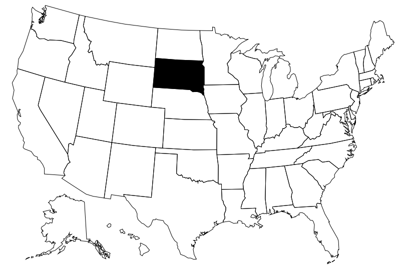
Ecoregion Targeting of Impaired Lakes in South Dakota (May 2000)

The 2000 South Dakota Report to Congress, 305(b) Water Quality Assessment, http://www.state.sd.us/denr/Documents/SD_2000_305b.pdf

The 1998 South Dakota 303(d) Waterbody List and Supporting Documentation, http://www.state.sd.us/denr/303(d)/98sd303d.pdf

South Dakota Surface Water Quality Standards, http://legis.state.sd.us/rules/rules/7451.htm

SOUTH DAKOTA



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Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
		support of antidegradation
		evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects, specific river basins or watersheds)*
		fixed station (i.e., water quality monitoring stations)
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
		rotating basin
		other:

Stream Miles

Total miles *(determined using RF3, National Hydrography Database, and state based determination)*	**9,937**
Total perennial miles	1,932
Total miles assessed for biology*	**3.73**
fully supporting for 305(b)	n/a
partially/non-supporting for 305(b)	n/a
listed for 303(d)	n/a
number of sites sampled *(on an annual basis)*	~60
number of miles assessed per site	~.093 *(150 meters)*

*South Dakota reports only chemical data in 305(b) reports and 303(d) listings. Currently, biological data is only collected during TMDL assessments. South Dakota's DENR plans to use the biological data to locate reference sites and conditions based on ecoregions as well as to establish biocriteria.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Warm Water vs. Cold Water	
ALU designations in state water quality standards	Five designations: Cold Water Permanent, Cold Water Marginal, Warm Water Permanent, Warm Water Semi-Permanent, Warm Water Marginal	
Narrative Biocriteria in WQS	No formal/informal numeric procedures exist to support narrative biocriteria	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
		cause and effect determinations
		permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	none	

Reference Site/Condition Development*

Number of reference sites	**~31 total**	
Reference site determinations *Under development*		site-specific
		paired watersheds
		regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria	Under development. Criteria used for defining reference sites include: EMAP protocol, habitat, chemical, and aquatic life.	
Characterization of reference sites within a regional context *Under development*		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions *Under development*	✓	ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information *Under development*		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

*The responses above characterize how reference sites will most likely be determined in the future. Twenty-seven sites have been assessed in South Dakota as reference for the EMAP data set. South Dakota's DENR samples ~4 sites as reference and will be working on establishing formal reference sites and criteria for streams and rivers. Lake reference sites and criteria have already been developed.

Field and Lab Methods

Assemblages assessed	✓	benthos *(100 - 500 samples/year; single season, multiple sites - not at watershed level)*
		fish
	✓	periphyton *(<100 samples/year; single season, multiple sites - not at watershed level)*
		other:

Benthos	
sampling gear	D-frame, multiplate, rock baskets; 500 - 600 micron mesh
habitat selection	multihabitat
subsample size	300 count
taxonomy	combination
Periphyton	
sampling gear	**natural substrate**: brushing/scraping device (razor, toothbrush, etc.) **artificial substrate**: microslides or other suitable substratum
habitat selection	multihabitat
sample processing	chlorophyll *a* / phaeophytin, taxonomic identification
taxonomy	species level
Habitat assessments	visual based, quantitative measurements, hydrogeomorphology; performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings and training for biologists, taxonomic proficiency checks, specimen archival

Data Analysis and Interpretation

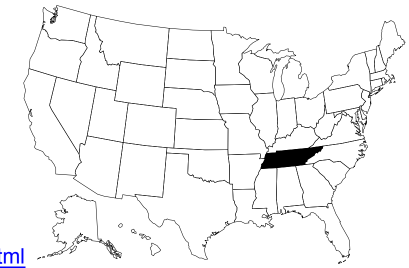
Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(multimetric index under development)*
		disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	25^{th} percentile of reference population, natural breaks
defining impairment in a multimetric index	25^{th} percentile of reference population

Evaluation of performance characteristics *Not currently evaluated*		repeat sampling
		precision
		sensitivity
		bias
		accuracy

Biological data	
Storage	STORET
Retrieval and analysis	Statistica, EDAS

TENNESSEE



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TDEC Division of Water Pollution Control: http://www.state.tn.us/environment/wpc/index.html

Program Description

The Tennessee Department of Environment and Conservation's (TDEC) Division of Water Pollution Control (WPC), has an extensive bioassessment program. Benthic macroinvertebrate surveys are one of the primary tools used in assessing surface waters in the state. Biological data are instrumental in determining use-support and generating both the 305(b) and 303(d) reports. In-stream macroinvertebrate monitoring is included in many NPDES permits. Bioassessments are also used in the anti-degradation evaluation process. Biological data are used to measure improvements in water quality resulting from clean-up and habitat restoration efforts. Over 2,100 macroinvertebrate surveys have been conducted by TDEC since 1996.

TDEC has eight field offices each with at least two benthic biologist positions. In addition, there is a central laboratory facility in the Department of Health with seven aquatic biologists under contract to TDEC. These nine offices conduct the majority of macroinvertebrate stream surveys. Data from other agencies including the Tennessee Valley Authority (TVA), US Army Corps of Engineers (USACE), and USGS are also incorporated into the program.

In 1995, TDEC initiated an ecoregion delineation project resulting in the identification of 25 ecological subregions. Ninety-eight reference streams were targeted for monitoring. The macroinvertebrate community in these streams was sampled seasonally for three years and on a five-year cycle by watershed starting in 1999. These data were used to develop regional numeric biocriteria that have been proposed for inclusion in the 2002 triennial review of water quality standards. The proposed numeric criteria are already being used to help interpret narrative criteria. In addition, reference stream data were used to develop guidelines for biological reconnaissance as a screening tool during watershed assessments.

Future goals of the bioassessment program include:

- Continue to monitor ecoregional reference streams and locate additional streams to further refine biocriteria and better identify reference condition.
- Conduct additional bioassessments as means to increase TDEC's percentage of assessed streams for national reporting purposes.
- Develop a macroinvertebrate tolerance index specific to Tennessee.
- Develop biocriteria for large rivers, wetlands and reservoirs.
- Continue to use benthic data as a measure of improvement in water quality.

Documentation and Further Information

Arnwine, D.H. and G. M. Denton. 2001. *Development of Regionally-Based Interpretations of Tennessee's Existing Biological Integrity Criteria*. Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville. TN

Arnwine D.H. and G. M. Denton. 2001. *Habitat of Least Impacted Streams in Tennessee*, Tennessee Department of Environment and Conservation, Division of Water Pollution Control, Nashville, TN

Arnwine, D.H., J.I. Broach, L.K. Cartwright and G.M. Denton. 2000. *Tennessee Ecoregion Project*. Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, TN.

Denton, G.M., A.D. Vann, and S.H. Wang. 2000.*The status of Water Quality in Tennessee: Year 2000 305(b) Report*. Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, TN.

Griffith, G.E., J.M. Omernik and S. Azevedo. 1997. *Ecoregions of Tennessee*. EPA/600/R-97/022. NHREEL, Western Ecological Division, U.S. Environmental Protection Agency, Corvalis, Oregon.

Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys. 2002. Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville. TN.

DRAFT Year 2002 303(d) List, July 2002: http://www.state.tn.us/environment/wpc/2002303ddraft.pdf

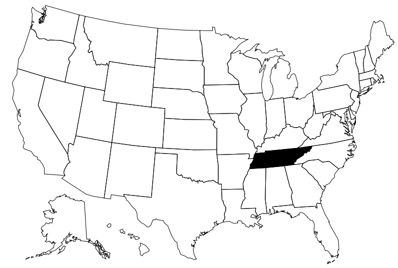
TDEC General Water Quality Criteria, rev. October 1999: http://www.state.tn.us/sos/rules/1200/1200-04/1200-04-03.pdf

TDEC Use Classifications for Surface Waters, rev. October 1999: http://www.state.tn.us/sos/rules/1200/1200-04/1200-04-04.pdf

2001 Triennial Review of Water Quality Standards, Staff Proposal: http://www.state.tn.us/environment/wpc/tr_wqs.pdf

Other TDEC publications, including 305(b) reports, can be found online at: http://www.state.tn.us/environment/wpc/publicat.htm

TENNESSEE



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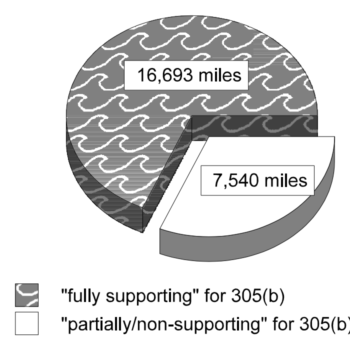
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(comprehensive use throughout jurisdiction)*
	✓	fixed station (i.e., water quality monitoring stations) *(comprehensive use throughout jurisdiction)*
		probabilistic by stream order/catchment area
	✓	probabilistic by ecoregion, or statewide *(special projects only)*
	✓	rotating basin *(comprehensive use throughout jurisdiction)*
		other:

Stream Miles

Total miles *(Determined using RF3)*	**60,187**
Total perennial miles	–
Total miles assessed for biology	**24,233**
fully supporting for 305(b)	16,693
partially/non-supporting for 305(b)*	7,540
listed for 303(d)*	14,333
number of sites sampled	2,202
number of miles assessed per site	–

24,233 Miles Assessed for Biology



*The stream miles "partially/non-supporting" for 305(b) are significantly less than the stream miles listed for 303(d) because the last 303(d) list was revised in 1998 while the 305(b) reflects assessments through 2000. The 2002 draft 303(d) and 305(b) reports are in agreement.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Single Aquatic Life Use
ALU designations in state water quality standards	One designation: Fish and Aquatic Life
Narrative Biocriteria in WQS	Formal/informal numeric procedures used to support narrative biocriteria are found in the *Development of Regionally-Based Numeric Interpretations of Tennessee's Narrative Biological Integrity Criterion* (see documentation).
Numeric Biocriteria in WQS	under development (Tennessee water quality standards will be changed in 2002 to reflect proposed numeric criteria for 15 bioregions. Numeric biocriteria, proposed for inclusion in the new WQS are as follows, "Multimetric index using 7 metrics - TR, EPT, %EPT, %OC, NCBI, %DOM and % Clingers*. Scoring criteria is based on 25% of reference condition. Reference condition is based on ecoregion reference data at the 90th percentile. Ecoregions have been grouped into 15 bioregions. Expected index score is calibrated to each bioregion and by season where appropriate.")

Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU		Nonpoint source section, field offices - office by office use, not systematic/statewide use

*TR = total richness; EPT = Ephemeroptera (mayflies), Plecoptera (stoneflies), Trichoptera (caddisflies); OC = Orthocladiinae of Chironomidae; NCBI = North Carolina Biotic Index; DOM = dominant taxa.

Reference Site/Condition Development

Number of reference sites		**98 total**
Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
		professional judgment
		other:
Reference site criteria		Reference database of chemical, habitat and biometrics based on monitoring of regional reference sites since 1996. Reference sites must fall within 90th percentile for chemical, biological and habitat parameters compared to existing reference database. Disturbed sites are those under 75% comparable to reference condition for biological and habitat, above the 90th percentile (reference) for nutrients (and show impaired biology), or exceed numeric criteria for other specified parameters.
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information	✓	reference sites linked to ALU
	UD	reference sites/condition referenced in water quality standards *(WQS under revision)*
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(100-500 samples/year; single season, multiple sites - watershed level)*
		fish
		periphyton
		other:

Benthos	
sampling gear	dipnet and kick net (1 meter); 500 - 600 micron mesh
habitat selection	riffle/run used for biocriteria in high gradient streams; rooted bank used for biocriteria in low gradient streams (Note that four jab multihabitat bioreconnaissances are used for general water quality assessments, not comparable to biocriteria)
subsample size	200 count
taxonomy	genus
Habitat assessments	visual based; performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings and training for biologists, sorting and taxonomic proficiency checks, specimen archival

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
	✓	parametric ANOVAs
	✓	multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	90th or 10th percentile of reference population depending on direction of metric
defining impairment in a multimetric index	25% of 90th (or 10th) percentile of reference population
Multivariate thresholds	
defining impairment in a multivariate index	Used for development of initial criteria, not for current assessments

Evaluation of performance characteristics	✓	repeat sampling *(replicate samples at 10% of reference sites by different teams)*
	✓	precision *(two samples collected at 10% of sites by two teams)*
	✓	sensitivity *(standard level of identification, compare metric scores to known impacts)*
	✓	bias *(compared different sample/habitat types)*
	✓	accuracy *(10% of samples QC for taxonomy and sorting efficiency)*

Biological data	
Storage	MS Access; semi-quantitative samples (taxa lists and metric scores) are stored in EDAS database and bioreconnaissance results are stored in Water Quality Database (taxa lists are in paper files). The eventual goal is for data to be sent to STORET. Assessment results are stored in an Assessment Database.
Retrieval and analysis	EDAS, Statview, and multivariate statistical package

TEXAS

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Program Description

Since the late 1980s, biological assessments have been employed for use attainability analyses (UAAs) and the development of an index of biological integrity (IBI) for rivers and streams. A tidal streams IBI is in the preliminary stages of development. Recently, a new emphasis has been placed on bioassessments relative to 303(d) listed waterbodies. For the most part, the new data have not been fully evaluated and work is continuing to expand in this area. Also, for the first time, the draft 2002 Water Quality Inventory includes bioassessments to determine the support of aquatic life uses.

The Texas Parks and Wildlife Department (TPWD) has been a major provider of fish community data for many of the UAAs and the development of the IBI. Other providers include various river authorities in the state.

***NOTE: On September 1, 2002, the Texas Natural Resources Conservation Commission (TNRCC) formally changed its name and began doing business as the Texas Commission on Environmental Quality (TCEQ).**

Documentation and Further Information

Draft 2002 Texas Water Quality Monitoring and Assessment Report (Integrated 305(b) report and 303(d) list):
http://www.tnrcc.state.tx.us/water/quality/02_twqmar/index.html

Texas Water Quality Inventory (SFR-050/00), includes *Volume I: Surface Water, Groundwater and Finished Drinking Water Assessments and Water Quality Management Programs:*
http://www.tnrcc.state.tx.us/admin/topdoc/sfr/050_00/050_00.html#1

Revisions to the Texas Surface Water Quality Standards and Implementation Procedures:
http://www.tnrcc.state.tx.us/permitting/waterperm/wqstand/revisions.html

Surface Water Quality Monitoring Procedures Manual (Chapter 7: Biological Sampling Procedures and Chapter 8: Stream Habitat Assessment Procedures), August 1999, GI-252:
http://www.tnrcc.state.tx.us/admin/topdoc/gi/252.html

Monitoring and Receiving Water Assessment Procedures Manuals:
http://www.tnrcc.state.tx.us/water/quality/data/wqm/index.html#manuals

Surface Water Quality Monitoring Program information:
http://www.tnrcc.state.tx.us/water/quality/data/wqm/index.html

Leppo, E.W., M.T. Barbour, and J. Gerritsen. 2001. *An evaluation of the stream habitat assessment approach used by TNRCC*. Prepared for: Texas Natural Resource and Conservation Commission, Austin, Texas and USEPA Region 6, Dallas, Texas.

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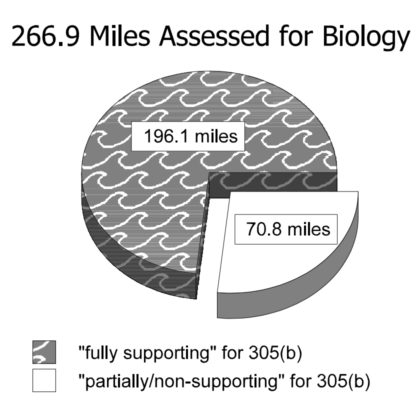
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
		nonpoint source assessments
		monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
		support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects, specific river basins or watersheds, and comprehensive use throughout jurisdiction)*
	✓	fixed station (i.e., water quality monitoring stations) *(specific river basins or watersheds and comprehensive use throughout jurisdiction)*
		probabilistic by stream order/catchment area
	✓	probabilistic by ecoregion, or statewide *(special projects only)*
		rotating basin
		other:

Stream Miles

Total miles *(State based determination)*	**191,228**
Total perennial miles	40,194
Total miles assessed for biology*	**266.9**
fully supporting for 305(b)	196.1
partially/non-supporting for 305(b)	70.8
listed for 303(d)	–
number of sites sampled *(on an annual basis)**	30
number of miles assessed per site	–



*68,611.78 total miles were surveyed and 63,102.68 total miles were assessed. Of these, 266.9 miles were assessed using biology. 30 sites were surveyed and 16 sites were assessed.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Class System (A,B,C)	
ALU designations in state water quality standards	Five designations: Exceptional, High, Intermediate, Limited, and Oyster waters	
Narrative Biocriteria in WQS	Procedures used to support narrative biocriteria located in the *Water Quality Standards Implementation Procedures Receiving Water Assessment Procedures Manual* (see documentation)	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
		watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Trinity River Segment 0805 was elevated from a limited aquatic life use to a high aquatic life use designation. EPA Region 6 considers Texas' high and exceptional aquatic life use designations as meeting the 101(a) goals of the Clean Water Act.	

Reference Site/Condition Development

Number of reference sites	**72 total**	
Reference site determinations	✓	site-specific
	✓	paired watersheds
	✓	regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria	no point source discharge, land use patterns, limited human impact, least disturbed sites determined using best professional judgment	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information	✓	reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(<100 samples/year; multiple seasons, multiple sites – broad coverage for watershed level)*
	✓	fish *(<100 samples/year; multiple seasons, multiple sites – broad coverage for watershed level)*
		periphyton
		other:

Benthos	
sampling gear	surber, multiplate, lopping shears for collecting woody debris, D-frame, kick net; 500-600 micron mesh
habitat selection	riffle/run (cobble), artificial substrate and woody debris
subsample size	100 count and entire sample
taxonomy	combination
Fish	
sampling gear	backpack and boat electrofisher, trawl and gill net (particularly for tidal streams), seine; 1/8", 3/16" and 1/4" mesh
habitat selection	multihabitat
sample processing	length measurement, batch, anomalies
subsample	none
taxonomy	species
Habitat assessments	quantitative measurements; performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings and training for biologists, taxonomic proficiency checks, specimen archival

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
	✓	parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	95^{th} percentile of reference population
defining impairment in a multimetric index	50^{th} percentile of reference population (follow EPA RBP guidelines)

Evaluation of performance characteristics		repeat sampling
		precision
Not currently evaluated		sensitivity
		bias
		accuracy

Biological data	
Storage	TCEQ's TRACS database and hard copies; STORET is under development
Retrieval and analysis	At this time, the hard copies are primarily used for evaluation of biological data. Spreadsheets are also used.

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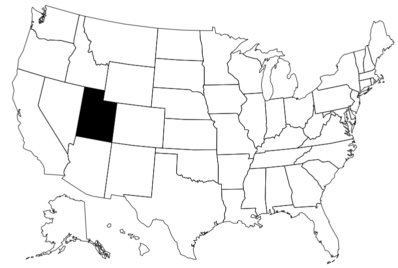

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Program Description

Prior to 2001, The Utah Division of Water Quality (DWQ) Biological Assessment program was limited to benthic macroinvertebrate data collected at 18 long-term monitoring sites. They have been sampled since 1978 with the exception of about five years in which the allocation of the 18 samples were used to supplement water chemistry and physical data collected in the five-year basin rotation monitoring plan. These samples were collected to ascertain long-term water quality and to be used in determining trends. In addition, benthic macroinvertebrate samples were collected at 16 Nonpoint Source Project sites to assess the effects of BMP implementation. These data have been incorporated into several NPS reports to determine what improvements in water quality have occurred. Data collected from the 18 long-term monitoring sites and the NPS projects have been used in making beneficial use assessments (305(b)) and listing waters on the 303(d) list.

In 2001, the DWQ reviewed its bio-monitoring program and decided that a major effort was needed to improve and develop new components of its water quality assessment program. During this review, an inventory of benthic macroinvertebrate data collected by DWQ, the U.S. Bureau of Land Management (BLM), and the U.S. Forest Service (USFS) was completed. Upon completion of this review, the DWQ contacted the BLM and USFS and requested all of the benthic macroinvertebrate data that they had collected from 1990 through 1997 be sent to DWQ for entering into STORED. These data, along with DWQ's, were entered into STORET. Data collected since 1997 have been stored electronically and a program to electronically transfer these data into STORET is being developed. These data will be evaluated as to their usefulness in establishing reference sites and the development of metrics to be used in assessing beneficial use support.

In 2001, the DWQ negotiated an agreement to complete the E-MAP sampling for EPA within the State. Experience obtained from this work would allow environmental scientists (field and staff) to learn and evaluate the methods used in the E-MAP protocol. This experience could then be used to develop a bioassessment protocol for assessing waters within the State.

Concurrent with doing the E-MAP work, the Division decided to commit additional resources to develop reference sites for bioassess-ment work. It was decided that the DWQ would select and try to sample up to 60 potential reference sites during the next 2-3 years. Water chemistry, fish, benthic macroinvertebrate, periphyton, and physical habitat data will be collected at these sites. The selection of sites were based upon the different ecoregions within the state and the need for low elevation, low-gradient stream reference sites.

DWQ is also assisting the EPA Corvallis Lab in reviewing and selecting reference sites that were initially selected using GIS techniques. Approximately 100 sites were initially selected and the number has been reduced to 20 sites. The DWQ is assisting in sampling these sites. Information obtained from this program will be evaluated and possibly incorporated into the Division's bio-assessment program.

The DWQ has committed to developing a set of reference sites and metrics that can be used to ensure that the waters of the State are assessed in a scientifically sound and standard method. Work is also going on to evaluate other assessment methods such as RIVPACS in assessing beneficial use support.

Documentation and Further Information

Utah Water Quality Assessment Report to Congress, September 2000 and Year 2000 Water Quality Inventory, 305(b) Assessment: http://www.waterquality.utah.gov/2000_305b_fact.pdf

Utah Division of Water Quality's 2000 Water Quality Monitoring Program::
http://www.waterquality.utah.gov/monitoring/complete_monitor_plan_2000.pdf

Utah's 2000 303(d) List of Waters, October 2000: http://www.waterquality.utah.gov/documents/approved_2000_303d.pdf

DRAFT, Utah's 2002 303(d) List of Waters: http://www.waterquality.utah.gov/documents/2002303dinternet.pdf

Quality Assurance and Standard Operating Procedures Manual. Utah Department of Environmental Quality, Division of Water Quality. 1993. Utah Department of Environmental Quality, Salt Lake City, UT.

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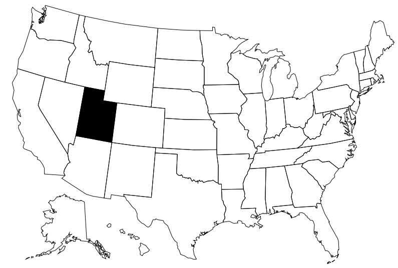

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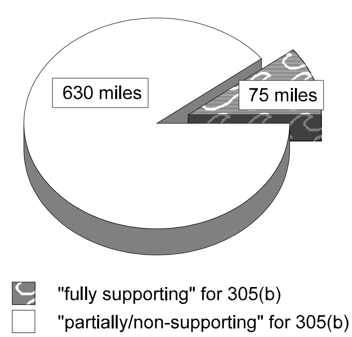
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
		promulgated into state water quality standards as biocriteria
		support of antidegradation
		evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects, specific river basins or watersheds and comprehensive use throughout jurisdiction)*
	✓	fixed station (i.e., water quality monitoring stations) *(special projects, specific river basins or watersheds and comprehensive use throughout jurisdiction)*
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
	✓	rotating basin *(specific river basins or watersheds and comprehensive use throughout jurisdiction)*
		other:

Stream Miles

Total miles *(determined using the National Hydrography database and state based determination)*	**85,916**
Total perennial miles	14,000+
Total miles assessed for biology*	**705**
fully supporting for 305(b)	75
partially/non-supporting for 305(b)	630
listed for 303(d)	300
number of sites sampled *(on an annual basis)*	~56
number of miles assessed per site	12.6

705 Miles Assessed for Biology



*Biological data were used along with water chemistry data to assess the above listed miles. The biological assessment was done using benthic macroinvertebrates and used a weight-of-evidence assessment because reference sites were not used. Diversity indices, the Biotic Condition Index, and the number of sediment and nutrient tolerant taxa were used to determine beneficial use support when the pollution indicator value for total phosphorus was exceeded.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Class System (A,B,C)	
ALU designations in state water quality standards	Five designations*	
Narrative Biocriteria in WQS	none - Procedures used to support general aquatic life statement in WQS are not standardized, but are primarily based on best professional judgment using some metrics.	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
		cause and effect determinations
		permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Used primarily in assessing 319 nonpoint source projects including assessment, implementation of BMPs, and evaluation of water quality	

*The designations are as follows: 3A - cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food web. 3B - warm water species of game fish and other warm water aquatic life, including the necessary aquatic organisms in their food web. 3C - Nongame fish and other aquatic life including the necessary aquatic organisms in their food chain. 3D - Waterfowl, shore birds and other water-oriented wildlife not included in Classes 3A, 3B, or 3C, including the necessary aquatic organisms in their food chain. 3E - Severely habitat-limited waters.

Reference Site/Condition Development**

Number of reference sites	**not applicable**	
Reference site determinations		site-specific
		paired watersheds
		regional (aggregate of sites)
		professional judgment
		other:
Reference site criteria		
Characterization of reference sites within a regional context		historical conditions
		least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions		ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
		some reference sites represent acceptable human-induced conditions

**Utah is currently working with the EMAP to develop reference sites.

Field and Lab Methods

Assemblages assessed	✓	benthos *(<100 samples/year; multiple seasons, multiple sites – broad coverage for watershed level)*
		fish
	UD	periphyton *(A periphyton program is under development and will be used primarily in nutrient-impacted streams. Dr. Sam Rushforth, at Utah Valley State College, is assisting in the development of this program.)*
		other:

Benthos	
sampling gear	rock baskets and Hess; 200-400 micron mesh
habitat selection	riffle/run (cobble) and artificial substrate
subsample size	300 count
taxonomy	combination
Habitat assessments	quantitative measurements, and a few nonpoint source project sites have pebble counts, channel profiles and riparian condition evaluated on a very limited basis; performed with bioassessments
Quality assurance program elements	standard operating procedures and quality assurance plan

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(return single metrics - use endpoint for each single metric)*
		disturbance gradients
	✓	other: some tolerance information is used in the evaluation

Multimetric thresholds*	
transforming metrics into unitless scores	BCI Methods described by USFS are used to differentiate higher quality waters, less discriminating in impaired waters.

Evaluation of performance* characteristics *Not currently evaluated*		repeat sampling
		precision
		sensitivity
		bias
		accuracy

Biological data**	
Storage	Data are currently being loaded into STORET
Retrieval and analysis	SAS (metrics are calculated by the contracting laboratory using spreadsheets or another computer program–language not known)

*EPA is currently having a contractor review benthic macroinvertebrate data to determine what metrics might apply to various regions of the State. Any metrics presently being used are those produced by the contracting laboratory and best professional judgement is used in the interpretation. No metric sensitivity analyses, regional biases, or other evaluations have been done to this point.

**EPA's Assessment Database is being used to store and retrieve assessment information for Utah's 305(b) report. Some indexing of waterbodies still needs to be done, but this should be completed during fiscal year 2002.

VERMONT

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Program Description

The Water Quality Division of the Vermont Department of Environmental Conservation (VTDEC) has been conducting aquatic biological health assessments since the early 1970's. In 1982, the Biomonitoring and Aquatic Studies Section (BASS) was created with a focus on river and stream biological monitoring. BASS is currently staffed by five full-time aquatic biologists who participate in VTDEC water quality management programs at all levels. This "top to bottom" involvement by biologists has been critical to the extensive acceptance and use of biological assessment data within a wide variety of Departmental programs. The primary objectives of ambient monitoring activities are: 1) monitor long-term trends in water quality as revealed in changes over time to ambient aquatic biological communities; 2) evaluate potential impacts from point and nonpoint permitted direct and indirect discharges, development projects, nonpoint sources, and spills on aquatic biological communities; 3) establish a reference database that would facilitate the generation of Vermont-specific biological criteria for water quality classification and use attainment determinations; 4) support VTDEC permitting and water quality management programs requiring biological assessment data; 5) conduct special studies to assess emerging water quality and environmental management issues. Further information about VTDEC BASS is available at: http://www.anr.state.vt.us/dec/waterq/bass.htm.

Since 1985, the Department has used standardized methods for sampling fish and macroinvertebrate communities, evaluating physical habitat, processing samples, and analyzing and evaluating data. The program has led to the development of two Vermont-specific fish community Indexes of Biotic Integrity (IBI) and selected macroinvertebrate metrics. Guidelines have been developed for determining water quality classification attainment by using both macroinvertebrate community biological integrity metrics and the fish community IBI. Approximately 75-125 sites per year are assessed using fish and/or macroinvertebrate assemblages. Alkalinity, pH, conductivity, temperature and such measurements as substrate composition (pebble counts), embeddedness, canopy cover, percent and type of periphyton cover, and approximate velocity are routinely monitored. From 1985 to 2001, approximately 1,500 stream assessments were completed using macroinvertebrate and/or fish from more than 900 wadeable stream reaches. This monitoring effort is subject to a USEPA-approved quality assurance project plan. Data from the project are summarized and stored in an electronic database.

Biological data are used extensively to determine aquatic life use support and impairment. A significant proportion of Vermont's 303(d) list is made up of reaches with impaired aquatic life use determined through bioassessment. The development of biological criteria supported by the Vermont Water Quality Standards has provided a vehicle for enforceable implementation of biocriteria. Biological assessment data are used extensively in virtually all VTDEC water quality management programs, including RCRA, NPDES, CERCLA, watershed planning, 401 certification, aquatic nuisance control permitting, and 305(b). In addition to wadeable stream monitoring, BASS conducts a variety of special studies and assessment in other aquatic habitats, and is in the process of evaluating biocriteria for vernal pools and ponded waters.

VTDEC participates in collaborations with other agencies and organizations including: USEPA; USFWS; USFS; USGS; academic institutions; neighboring states; private consultants; special interest groups; and volunteer monitors. Staff also participate in public outreach activities as resources allow.

Biological criteria are the current performance standards for a large number of 303(d) waterbodies throughout the state. Future demand for biological assessments from VTDEC management programs will increase as the 303(d)/TMDL process advances and watershed planning initiatives expand statewide. The greatest challenge facing the biomonitoring program will be maintaining adequate staff resources to continue assessing 303(d) restoration management actions, providing support to watershed plan development, and providing support to various management programs within VTDEC and the Agency of Natural Resources.

Documentation and Further Information

Vermont 2000 Water Quality and Assessment, 305(b) Report

Vermont Water Quality Methodology, April 2001

Wadeable Stream Biocriteria Development for Fish and Macroinvertebrate Assemblages in Vermont Streams and Rivers

July 2, 2000 Vermont Water Quality Standards: http://www.state.vt.us/wtrboard/july2000wqs.htm

Fish Sampling and Metrics homepage: http://www.anr.state.vt.us/dec/waterq/bassfish.htm

Macroinvertebrate Sampling, Processing and Metrics homepage: http://www.anr.state.vt.us/dec/waterq/bassmacro.htm

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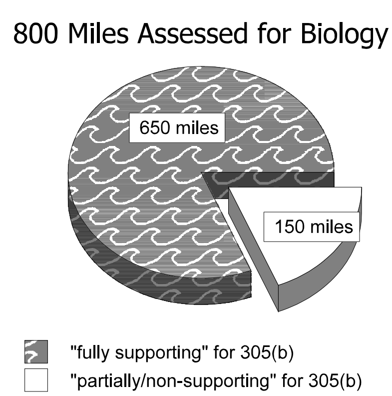
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
	✓	other: bioassessments used for all aquatic life use support evaluations
Applicable monitoring designs*	✓	targeted (i.e., sites selected for specific purpose) *(comprehensive use throughout jurisdiction)*
	✓	fixed station (i.e., water quality monitoring stations) *(comprehensive use throughout jurisdiction)*
	✓	probabilistic by stream order/catchment area *(special projects only)*
		probabilistic by ecoregion, or statewide
	✓	rotating basin *(specific river basins or watersheds)*
		other:

*The majority of biological sampling conducted by VTDEC is targeted and in the context of rotating basin elements. Fixed station and special projects are also significant elements. Some monitoring required by discharge permits or basin plans related to TMDL's is done by consultants. Consultants generating biological monitoring data for aquatic life use support determinations consistent with Vermont Water Quality Standards or for compliance with discharge permit limitations are required to meet QA/QC requirements and submit to QA oversight by VTDEC biologists.

Stream Miles

Total miles *(State based determination)*	**7,099**
Total perennial miles	7,099
Total miles assessed for biology*	**~800**
fully supporting for 305(b)	~650
partially/non-supporting for 305(b)	~150
listed for 303(d)	~150
number of sites sampled *(total number with available biological monitoring data)*	1,193
number of miles assessed per site	–



*The latest 305(b) report was used to estimate some of these numbers. 305(b) reports total stream miles assessed by "evaluation" and "monitoring". The majority of VTDEC sites that are "monitored" are monitored for biology. The total miles reported as assessed in the last "statewide" assessment report in 2000 was 5,261, with 4,411 miles "evaluated" and 850 miles "monitored". Roughly 800 of the 850 miles "monitored" were monitored using biology (similarly with use support categories).

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Class System (A,B,C)	
ALU designations in state water quality standards	Three designations related to changes from reference condition: minimal, minor, and moderate change from the reference condition.	
Narrative Biocriteria in WQS	VTDEC procedures used to support narrative biocriteria are independent of WQS.	
Numeric Biocriteria in WQS	none (Numeric biocriteria are currently found in VTDEC procedural documents.)	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Used extensively throughout management programs including: NPDES, 305(b), 303(d), basin planning, point and nonpoint source management, aquatic nuisance control, RCRA, CERCLA.	

Reference Site/Condition Development

Number of reference sites	**150 total**	
Reference site determinations	✓	site-specific
		paired watersheds
	✓	regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria	Reference sites are defined using the best professional judgment of biologists based on the level of human activity and potential for that activity to affect the aquatic resource. There are no quantitative criteria, but general considerations may include: very good riparian condition at site; predominantly forested watershed; outside the influence of assessed activity; least disturbed condition.	
Characterization of reference sites within a regional context	✓	historical conditions
		least disturbed sites
		gradient response
	✓	professional judgment
	✓	other: minimally disturbed*
Stream stratification within regional reference conditions		ecoregions (or some aggregate)
		elevation
	✓	stream type
	✓	multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information	✓	reference sites linked to ALU
	✓	reference sites/condition referenced in water quality standards
		some reference sites represent acceptable human-induced conditions

*This language is included in the definition of reference condition in the Vermont Water Quality Standards, effective July 2, 2000.

Field and Lab Methods

Assemblages assessed	✓	benthos *(100-500 samples/year; single season, multiple sites - broad coverage)*
	✓	fish *(<100 samples/year; single season, multiple sites - broad coverage)*
	✓	periphyton *(Periphyton and algae in rivers and streams are sampled qualitatively for descriptive purposes only. Some indirect discharge permits require quantitative periphyton and macroinvertebrate sampling with artificial substrates in order to determine compliance with permit conditions. Compliance criteria are independent of WQS.)*

Benthos	
sampling gear	rock baskets, kick net (18x9 rectangular net, 500 micron mesh)
habitat selection	riffle/run (cobble) and woody debris (varies according to stream category)
subsample size	must be minimum 300 animals AND 25% of sample.
taxonomy	lowest possible taxon - genus, species and combination (specified level in SOPs and C185)
Fish	
sampling gear	backpack electrofisher
habitat selection	multihabitat
sample processing	length measurement and anomalies
subsample	none
taxonomy	species
Habitat assessments	visual based and hydrogeomorphology - performed with and independent of bioassessments; pebble counts currently implemented quite extensively in conjunction with bioassessments
Quality assurance program elements	standard operating procedures; quality assurance plan; periodic meetings and training for biologists; sorting and taxonomic proficiency checks; specimen archival; sending voucher specimens to experts for identification confirmation

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
	✓	parametric ANOVAs
	✓	multivariate analysis
	✓	biological metrics *(aggregate metrics into an index and return single metrics - use endpoint for each single metric)*
		disturbance gradients
		other:

Multimetric thresholds*	
transforming metrics into unitless scores	Combination of reference distribution, impaired site distribution, and best professional judgement; do not use unitless scores.
defining impairment in a multimetric index	Cumulative distribution function
Multivariate thresholds*	
defining impairment in a multivariate index	Significant departure from mean of reference population

Evaluation of performance characteristics	✓	repeat sampling *(long term fixed station sampling)*
	✓	precision *(field replication)*
		sensitivity
		bias
	✓	accuracy *(sample processing and analysis QA)*

Biological data	
Storage	Data are stored and managed in MS Access data base. Various programs used to analyze sub-sets include: Excel, Sigma-Plot/Stat and PC-ORD
Retrieval and analysis	MS Access database calculates metrics and generates event summary reports. Data can be moved from Access to other programs for project-specific analyses. Commonly used programs include: Excel, Sigma-Plot/Stat, PC-ORD

*Benthos data are used to generate individual metrics, which are considered individually. Fish assemblage data are used to generate metrics for a multimetric Index of Biotic Integrity. Water Quality Standard thresholds (deviations from the reference condition) are based on BPJ evaluations of metric distribution patterns in both reference and non-reference sites.

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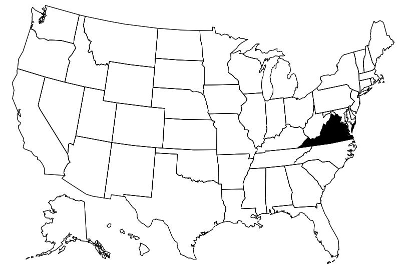

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Program Description

The Virginia Department of Environmental Quality (DEQ) Biological Monitoring Program (BMP) utilizes the study of bottom dwelling macroinvertebrate communities to determine overall water quality. Changes in water quality generally alter the kinds and numbers of these animals living in streams or other waterbodies. Like physical and chemical water quality monitoring data, biological monitoring data are used to assess water quality for support of aquatic life designated use and the Clean Water Act "fishable and swimmable" goals.

The BMP is composed of 150 to 170 stations that are examined annually during the spring and fall. Qualitative and semiquantitative biological monitoring has been conducted by the agency since the early 1970s. The USEPA Rapid Bioassessment Protocol (RBP) II was employed beginning in the fall of 1990 to utilize standardized and repeatable methodology. The RBPs produce water quality ratings of nonimpaired, slightly impaired, moderately impaired and severely impaired instead of the former ratings of good, fair and poor.

Currently, there are approximately 70 organizations throughout the Commonwealth with active citizen water quality monitoring programs. Biological parameters measured by citizen monitors often include benthic macroinvertebrates, fecal coliform bacteria, and/or chlorophyll *a*. A statewide organization, the Izaak Walton League of America Virginia Save Our Streams Program (IWLA VA SOS), took the lead in establishing relations with DEQ and the Department of Conservation and Recreation (DCR) to develop a statewide citizen monitoring program. IWLA VA SOS has a benthic macroinvertebrate citizen monitoring protocol that is widely used by many affiliate organizations. In 2000, VA SOS completed a two-year study, funded by DEQ, evaluating this protocol and developing a new protocol to more closely correlate with professional methods developed by EPA and used by DEQ.

Documentation and Further Information

Water Quality Assessment and Impaired Waters Report (combined 2002 305b and 303d), July 2002:
http://www.deq.state.va.us/water/305b.html

2000 Water Quality Assessment 305(b) Report: http://www.deq.state.va.us/water/00-305b.html

Water Quality Assessment Guidance Manual for 2002, 305(b) and 303(d) reports, July 2002:
http://www.deq.state.va.us/pdf/water/wqassessguide.pdf

2001 Ambient Water Quality Monitoring Plan:
http://www.deq.state.va.us/water/my01rpt.html

Watershed Maps of *Virginia Impaired Water Segments, 303(d) TMDL Priority List*:
http://www.deq.state.va.us/watermaps/

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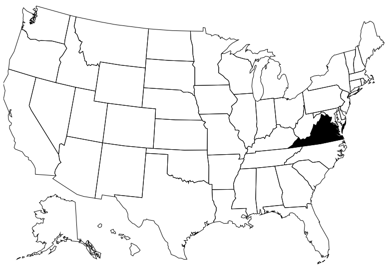

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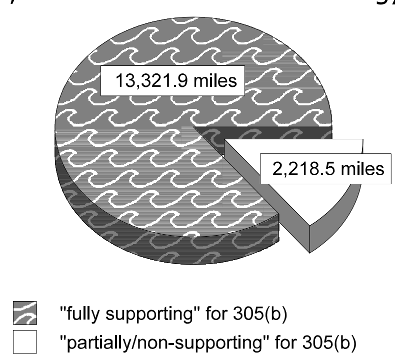
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
		monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
		promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects only)*
	✓	fixed station (i.e., water quality monitoring stations) *(comprehensive use throughout jurisdiction)*
		probabilistic by stream order/catchment area
	✓	probabilistic by ecoregion, or statewide *(comprehensive use throughout jurisdiction)*
		rotating basin
		other:

Stream Miles

Total miles *(determined using the National Hydrography Database)*	**50,329**
Total perennial miles	50,329
Total miles assessed for biology*	**15,540.4**
fully supporting for 305(b)*	13,321.9
partially/non-supporting for 305(b)*	2,218.5
listed for 303(d)*	2,218.5
number of sites sampled *(on an annual basis)**	150 -170
number of miles assessed per site	–

15,540.4 Miles Assessed for Biology



*The numbers listed above were extracted from Virginia's 2002 combined 305(b)/303(d) report and represent stream and river miles assessed (evaluated and monitored) for aquatic life using chemical, physical and biological parameters. However, of the 2,218.5 total miles partially/non-supporting for 305(b), 661.4 miles were determined to be impaired based solely on biological (benthic) data.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis		Single Aquatic Life Use
ALU designations in state water quality standards		Three designations (apply to all State waters): recreational uses, e.g., swimming and boating; the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; and the production of marketable resources, e.g. fish and shellfish.
Narrative Biocriteria in WQS		none - Virginia has no formal/informal numeric procedures to support general aquatic life statement found in WQS
Numeric Biocriteria in WQS		none
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria) *Information not provided*		assessment of aquatic resources
		cause and effect determinations
		permitted discharges
		monitoring (e.g., improvements after mitigation)
		watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU		Several TMDLs are addressing ALUS restoration because of poor bioassessment scores.

Reference Site/Condition Development

Number of reference sites		**information not provided**
Reference site determinations	✓	site-specific
	✓	paired watersheds
		regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria		No reference site criteria. Reference sites are defined as best available, least impaired.
Characterization of reference sites within a regional context *Information not provided*		historical conditions
		least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions *Information not provided*		ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(300-400 samples/year; multiple seasons, multiple sites – broad coverage for watershed level)*
		fish
		periphyton
		other:

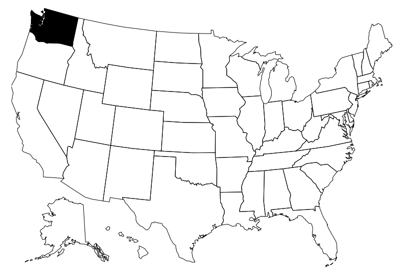
Benthos	
sampling gear	D-frame, kick net (1 meter); 500-600 micron mesh
habitat selection	richest habitat and riffle/run (cobble)
subsample size	100 count
taxonomy	family
Habitat assessments	visual based; performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings and training for biologists, specimen archival

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
		biological metrics
		disturbance gradients
		other:
Evaluation of performance characteristics		repeat sampling
		precision
Information not provided		sensitivity
		bias
		accuracy

Biological data	
Storage	EDAS
Retrieval and analysis	EDAS

WASHINGTON



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Stream Biological Monitoring website:
http://www.ecy.wa.gov/programs/eap/fw_benth/fwb_intr.html

Program Description

Washington State's Biological Monitoring Program has been operated by the Washington Department of Ecology since 1993. The program has served as a focal point for technical assistance and as a reference for data comparison. Its primary objectives are: 1) to continually describe the spatial and temporal features of biotic communities in wadeable streams, 2) describe and then validate biological expectations for appropriate spatial classifications (e.g., ecoregions), 3) develop guidance and criteria that evaluate human-induced disturbance in biological communities, and 4) expand where biological information is used in water quality and resource management. Although field data collection methodology has remained consistent, data storage and analytical products have improved in their capacity and sophistication.

The Freshwater Monitoring Unit within the Department of Ecology has engaged in biological monitoring activities for more than twelve years and has made its information available online for public use. The primary objectives in continuing to develop this program are to: 1) proceed with calibration of ten biometrics that will be based on reference conditions within each of eight ecoregions, 2) continue assistance in development of RIVPACS (River Invertebrate Prediction and Classification System) models for western and eastern Washington streams with researchers at Utah State University (Dr. C. Hawkins), and 3) locate and visit additional reference sites outside of the ranges currently being monitored.

Interpretive tools developed from these efforts are being placed into the ALUS framework under development by the USEPA (contact Susan Jackson). WA is able to use the knowledge and tools developed through former biological monitoring efforts to create a meaningful matrix of expectations as diagramed by ALUS so that incremental improvements in stream quality, based on biological signatures, can be tracked. The first step toward adoption of biocriteria will be the construction of a guidance that outlines analytical products and biological expectations for streams within each ecoregion of Washington State. Biological evaluation tools such as RIVPACS scores, biometric scores, index scores, and indicator taxa are currently being assembled for inclusion in the guidance.

Biological information is currently being included in the 303(d) listing process to directly evaluate impairment. WA has amassed an adequate data bank for describing reference conditions that serves as an effective and defensible means for comparison. The Freshwater Monitoring Unit issued a report titled "Condition of Freshwaters in Washington State for the Year 2000" that evaluates data from water quality monitoring, biological monitoring, lakes monitoring, and nuisance aquatic plant monitoring. This report was intended as a template for future reviews of environmental information, like the 305(b) report, and will eventually satisfy reporting content of the current required data summaries as well as new guidance like CALM (Consolidated Assessment and Listing Methodology).

Many of the water quality problems of interest to the Department of Ecology's Regional Offices are related to habitat destruction due to human influence. This is one of the areas in which collaborative work with volunteer monitoring groups, local governments, state agencies, tribes, and other federal agencies is promoted.

One important partnership has been with the USEPA and the Environmental Monitoring and Assessment Program (EMAP). The Department of Ecology has engaged both EMAP and R-EMAP (Regional Environmental Monitoring and Assessment Program) since 1994. The acquisition of both knowledge and equipment in operating this program has provided impetus to implement the probabilistic monitoring design in the Ambient River and Stream Water Quality Monitoring Program. WA is working with the Colville Tribe in expanding the description of reference conditions for northeastern Washington and with the Yakima Tribe, county, and federal agencies in evaluating the effects of floodplain gravel mining along the Yakima River. WA is especially encouraged by several volunteer monitoring groups, like Streamkeepers of Clallam County, whose organizers have assembled teams of personnel that generate useful biological, chemical, and flow data.

Documentation and Further Information

2000 Washington State Water Quality Assessment - Section 305(b) Report: http://www.ecy.wa.gov/pubs/0010058.pdf

DRAFT 2002 303(d) List of Impaired and Threatened Waters, May 2002:
http://www.ecy.wa.gov/programs/wq/303d/2002-revised/listpolicydraftfinal7.pdf

Condition of Freshwaters in Washington State for the Year 2000: http://www.ecy.wa.gov/pubs/0103025.pdf

Water Quality Standards for Surface Waters of the State of Washington: http://www.ecy.wa.gov/pubs/wac173201a.pdf

For a comprehensive list of Stream Biological Monitoring Publications available online and/or by mail, go to:
http://www.ecy.wa.gov/programs/eap/fw_benth/fwb_pubs.html

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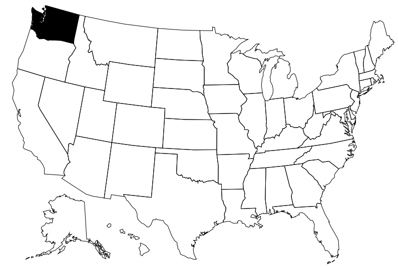

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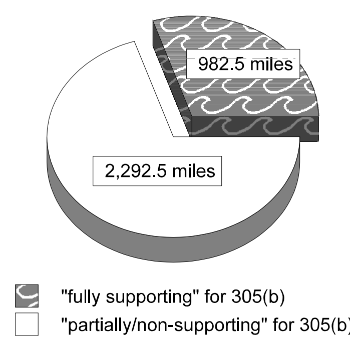
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
		ALU determinations/ambient monitoring
	UD	promulgated into state water quality standards as biocriteria
		support of antidegradation
		evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(specific river basins or watersheds)*
	✓	fixed station (i.e., water quality monitoring stations) *(comprehensive use throughout jurisdiction)*
	✓	probabilistic by stream order/catchment area *(stream order as subset of ecoregion sampling)*
	✓	probabilistic by ecoregion, or statewide *(special projects and comprehensive use throughout jurisdiction)*
	✓	rotating basin *(specific river basins or watersheds)*
		other:

Stream Miles

Total miles *(State based determination)*	**73,886**
Total perennial miles	39,483
Total miles assessed for biology*	**3,275**
fully supporting for 305(b)**	982.5
partially/non-supporting for 305(b)**	2,292.5
listed for 303(d)	0
number of sites sampled	655
number of miles assessed per site	5

3,275 Miles Assessed for Biology



*Approximately 10% of the State's perennial streams are assessed for biology. The 3,275 total miles assessed for biology is an estimate derived from multiplying 655 sites by the 5 miles assessed per site.

**The “fully supporting” and “partially/non-supporting” for 305(b) stream mile estimates are based on an old assessment policy estimation process. WA most recently used EPA's National Hydrography Data Layer to create the stream segment breaks but the new data has not been generated yet.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Class System (A,B,C)
ALU designations in state water quality standards	The Water Class system currently in use contains four categories: Class AA, Class A, Class B, and Class C. Class AA (extraordinary) freshwaters shall markedly and uniformly exceed the requirements for all or substantially all uses. Class A (excellent) freshwaters shall meet or exceed the requirements for all or substantially all uses. Class B (good) freshwaters shall meet or exceed requirements for most uses. Class C (fair) freshwaters shall meet or exceed the requirements of selected and essential uses.
Narrative Biocriteria in WQS*	under development
Numeric Biocriteria in WQS	none

Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU		none

*Water Classes AA, A, and B include a characteristic use designation called "Wildlife Habitat." This characteristic use designates waters of the state used by, or that directly or indirectly provide food support to fish, other aquatic life, and wildlife for any life history stage or activity. The term "biological assessment" is defined in Washington's water quality standards and is intended to be used to evaluate the condition of "Wildlife Habitat."

Reference Site/Condition Development

Number of reference sites		**187 total**
Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria		1) Least-disturbed sites that show little or no signs of human impact, 2) Relatively-unimpacted sites that show some signs of historical human influence but are at an advanced successional stage
Characterization of reference sites within a regional context	✓	historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
	✓	other: minimally disturbed (see "relatively-unimpacted" reference site criteria)
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
	✓	stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(100-500 samples/year; single season, multiple sites - watershed level and broad coverage)*
	✓	fish *(100-500 samples/year; single season, multiple sites - watershed level and broad coverage)*
	✓	periphyton *(<100 samples/year; single season, multiple sites - watershed level and broad coverage)*
	✓	other: macrophytes and waterfowl *(<100 samples/year; single season, multiple sites - watershed level and broad coverage)*

Benthos	
sampling gear	Surber, D-frame; 500-600 micron mesh
habitat selection	riffle/run (cobble); pool habitat may also be assessed if physical and/or chemical degradation has occurred and can be detected through a biotic response
subsample size	500 count
taxonomy	family, genus, and species
Fish	
sampling gear	backpack electrofisher; 7 millimeter mesh
habitat selection	multihabitat
sample processing	length measurement, anomalies
subsample	none - all specimens are examined and counted
taxonomy	species, life stage
Periphyton	
sampling gear	**natural substrate:** brushing/scraping device (razor, toothbrush, etc.); **artificial substrate:** collect by hand
habitat selection	multihabitat
sample processing	taxonomic identification
taxonomy	genus
Habitat assessments	visual based, quantitative measurements and hydrogeomorphology; performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings and training for biologists, sorting and taxonomic proficiency checks, specimen archival

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
	✓	multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients

Multimetric thresholds	
transforming metrics into unitless scores	25^{th} percentile of reference population
defining impairment in a multimetric index	25^{th} percentile of reference population
Multivariate thresholds	
defining impairment in a multivariate index	Significant departure from mean of reference population

Evaluation of performance characteristics	✓	repeat sampling *(multi-year sampling at gradient of sites)*
	✓	precision *(multi-year sampling at reference sites)*
		sensitivity
		bias
		accuracy

Biological data	
Storage	All biological (including habitat and chemistry) information is stored in MS Access
Retrieval and analysis	SAS, Systat, CANOCO, Primer, Cornell Ecology Programs, and Calibrate

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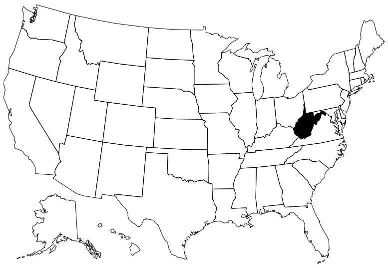

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WV DNR Wildlife Resources Section homepage: http://www.dnr.state.wv.us/wvwildlife/default.htm

Program Description

The West Virginia Department of Environmental Protection (WV DEP) implemented the Watershed Assessment Program in 1996. This program was designed to systematically measure the water quality and biological health of the state's rivers and streams. The program has four major components: 1) Random or Probabilistic Sampling; 2) Pre-TMDL sampling; 3) Ambient WQ Monitoring; and 4) "Regular Assessments."

Benthic macroinvertebrates are collected at the "random sites," regular WAP (Watershed Assessment Program) sites, and selected Pre-TMDL sites. The program utilizes a rectangular dip net, compositing samples from two square meters and identifying a 200 organism sub-sample. WV DEP identified the "bugs" in-house to family level the first three years of the program. In 1999, WV DEP contracted out the identification work and switched to genus level identification. In 2000, a macroinvertebrate index was developed for West Virginia with support from EPA's biocriteria development program. This index provides a means to establish an impairment threshold that is based on a set of minimally disturbed reference sites.

The "Regular Assessments" were the majority of WV DEP's workload in the program's first year and continue to be a major portion of efforts. These consisted of sampling as many streams as possible (considering personnel limitations) in watersheds that were scheduled for assessment according to a 5 year cycle (5-7 watersheds per year). These assessments included the collection of water quality, habitat and macroinvertebrate data. All streams previously listed as impaired were targeted for assessment, as were a portion of all "unassessed" and "partially impaired" streams.

In 1997, the Watershed Assessment Program added a probabilistic sampling component. The first 5-year cycle was completed in 2001. The first cycle consisted of sampling 30-35 sites in each of the major watersheds (8-digit HUCs) in the state, sampling all sites in a watershed in a single year. The next 5 year cycle begins in 2002 and will have a different sampling strategy. The same effort, 150 sites, will be spread across the state each year instead of just the 5-7 watersheds being assessed that year. This will allow a summary of the condition of the state's streams to be completed every year instead of having to wait for the end of the 5-year cycle. This strategy also eliminates the problem of comparing watersheds sampled in different years that may have had drastically different climactic conditions (i.e. drought versus flood).

Periphyton will be collected at all of the random sites starting in 2002. The results of these collections will hopefully aid in the development of nutrient criteria. Streams with known eutrification problems and some of WV DEP's established reference sites may be sampled as well.

The Division of Natural Resources (DNR) is the fish and game agency of West Virginia. As part of its duties, statewide fishery surveys are conducted annually to monitor game and nongame fish populations. These surveys are not probability based as they are usually performed on target streams with ongoing programs (e.g., stockings) or due to crisis management reasons. The WV DNR has no regulatory authority relative to the state's water quality standards, but we are sometimes involved in a fish advisory capacity. The WV DNR is developing a fish Index of Biotic Integrity via a cooperative agreement with the USEPA. The IBI is being developed somewhat independently from the WQS that are utilized by WV DEP. Someday it may be used in the 305(b) program by a collaboration of agencies.

Documentation and Further Information

WV DEP Division of Water Resources list of publications, including direct links to *West Virginia Water Quality Status Assessment 305(b) Report 2000* and other 305(b) reports, multiple 303(d) listings, *West Virginia's Monitoring Strategy*, and *A Stream Condition Index for West Virginia Wadeable Streams*, 2000: http://www.dep.state.wv.us/item.cfm?ssid=11&ss1id=192

Smithson, J. 2001. Watershed assessment program. SOP. WV DEP Division of Water Resources.

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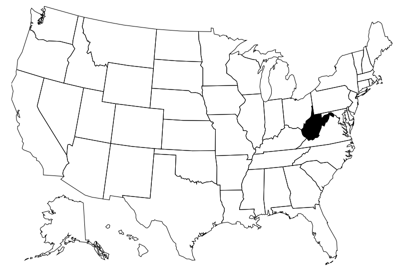

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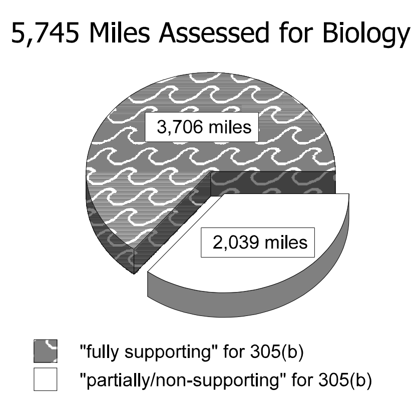
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
		promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(comprehensive use throughout jurisdiction)*
	✓	fixed station (i.e., water quality monitoring stations) *(comprehensive use throughout jurisdiction)*
		probabilistic by stream order/catchment area
	✓	probabilistic by ecoregion, or statewide *(comprehensive use throughout jurisdiction)*
	✓	rotating basin *(comprehensive use throughout jurisdiction)*
		other:

Stream Miles

Total miles *(determined using RF3 augmented with all named streams on 1:24,000 topographic map)*	**32,278**
Total perennial miles	21,114
Total miles assessed for biology	**5,745**
fully supporting for 305(b)	3,706
partially/non-supporting for 305(b)	2,039
listed for 303(d)	1,315
number of sites sampled	60-90
number of miles assessed per site	–



Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Single Aquatic Life Use	
ALU designations in state water quality standards	Two designations: warmwater and coldwater	
Narrative Biocriteria in WQS	none - Internal program procedures used to support general aquatic life standard	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Watershed restoration action strategies as part of the 319 grant program.	

Reference Site/Condition Development

Number of reference sites	**~105 total**	
Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria	The following selection criteria are used to select reference sites: (* Indicates criterion that can be determined in the field.) 1. D.O. > 5.0mg/l* 2. pH between 6.0 and 9.0* 3. Conductivity < 500 µS /cm* 4. Fecal coliform < 800 colony/100ml 5. No violations of State WQ Standards 6. No obvious sources of nonpoint pollution* 7. Epifaunal substrate / available cover score >10* 8. Channel alteration score >10* 9. Sediment deposition score >10 * 10. Bank vegetative protection score >5* 11. Undisturbed vegetation zone width score >5* 12. Total habitat score > or = 130 points* 13. Evaluation of anthropogenic activities and disturbances* 14. No known point source discharges upstream and within view of assessment site (completed after 1-13 are met)	
Characterization of reference sites within a regional context		historical conditions
		least disturbed sites
		gradient response
		professional judgment
	✓	other: minimally disturbed**
Stream stratification within a regional reference conditions		ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
	✓	jurisdictional (i.e., statewide)
		other:
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions *(minimal)*

**WV reference sites are best described as *minimally disturbed* sites. They have to meet each of the 14 criteria mentioned above; thus there are some areas with no sites that WV DEP is comfortable calling reference.

Field and Lab Methods

Assemblages assessed	✓	benthos *(>500 samples/year, single season, multiple sites - watershed level)*
	✓	fish* *(<100 samples/year; single observation, limited sampling)*
		periphyton
		other:

Benthos	
sampling gear	D-frame, dipnet, collect by hand; 500-600 micron mesh
habitat selection	riffle/run (cobble)
subsample size	200 count
taxonomy	family, genus
Fish*	
sampling gear	seine, backpack and boat electrofishers, electric seine; 1/8" and 3/16" mesh
habitat selection	multihabitat
sample processing	length measurement, biomass - individual
subsample	none
taxonomy	species
Habitat assessments	visual based, quantitative measurements, riffle stability index; performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings, training for biologists, sorting proficiency checks, sorting and taxonomic proficiency checks, specimen archival

*West Virginia Division of Natural Resources is the fish and game agency of West Virginia. WV DNR duties include statewide annual fishery surveys to monitor game and nongame fish populations. These surveys are not probability based as they are ususally performed on target streams due to ongoing programs (eg. stockings) or crisis management reasons. The WV DNR has no regulatory authority relative to the state's water quality standards, but are sometimes involved in a fish advisory capacity. The WV DNR is developing a fish Index of Biotic Integrity via a cooperative agreement with the USEPA. It is being developed somewhat independently from the quality standards that are utilized by WV DEP, and may someday be used in the 305(b) program by a collaboration of agencies.

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	95th percentile of total population
defining impairment in a multimetric index	5th percentile of reference sites

Evaluation of performance characteristics*	✓	repeat sampling
	✓	precision
	✓	sensitivity
	✓	bias
	✓	accuracy

Biological data	
Storage	WAPBAS (similar to EDAS)
Retrieval and analysis	WAPBAS (similar to EDAS)

***Described in *A Stream Condition Index for West Virginia Wadeable Streams* (see documentation and further information)

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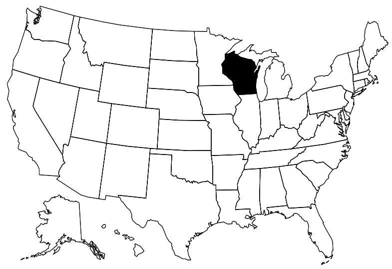

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email: talbom@dnr.state.wi.us and masnar@dnr.state.wi.us
WI DNR Division of Water homepage: http://www.dnr.state.wi.us/environmentprotect/water.html

Program Description

Historically, much of the water resource assessment work done by the Wisconsin Department of Natural Resources (WDNR) has focused on the evaluation of degraded watersheds or water resources with high public profile. As a result, there is a lack of data on the overall quality of Wisconsin's water resources. In addition, monitoring techniques often varied among assessment sites and over time thus making it difficult to compare data across the state or from different time periods. To address these concerns, WDNR initiated a new program in 1999, called Baseline Monitoring. Standardized assessment techniques for aquatic habitat, macroinvertebrates and fish have been developed and are being applied throughout the state. The elements of this new program are contained in a draft report on Wisconsin's Surface Water Monitoring Strategy.

The overall goals of the baseline monitoring strategy are to answer the following questions:

1. What are the use expectations for Wisconsin's water resources?
2. Are the state's waters meeting their use potential?
3. What factors are preventing the state's water resources from meeting their potential?
4. What are the statewide status and trends in the quality of Wisconsin's surface waters?

To achieve the goals of the program, the following specific set of monitoring objectives were established:

- Determine the designated attainable uses of each waterbody. Stream and lake habitat information and fisheries data collected during baseline assessments will be compared with biological criteria obtained from "least-impacted" regional reference waters to determine the water's use classification.
- Determine the level of use attainment of each waterbody. Stream habitat and fisheries data collected during baseline assessment monitoring will allow the WDNR to determine if designated uses are being attained. More emphasis is being placed on biological monitoring to determine if designated uses are being met.
- Determine why some waterbodies are not attaining their designated uses. Physical, chemical and biological data collected during baseline assessment monitoring will provide at least some of the information required to achieve this objective.

For stream biological monitoring, WDNR collects information on riparian and in-stream habitat data, aquatic insects and fish species. The aquatic insects are identified and the numbers of fish are determined using standardized collection protocols. Lake monitoring involves collecting trophic state data and fish community data using the standardized protocols.

WDNR will begin using a stratified-random sampling approach to achieve adequate coverage of the state’s 55,000 miles of streams. This sampling design allows the WDNR to sample a variety of streams and lakes across the state and also provides the Department with the ability to evaluate the quality of water resources that have not been sampled. The WDNR collects over 400 aquatic invertebrate samples per year. However, under the baseline monitoring that was initiated last year, the WDNR is now annually assessing about 600 stream sites. In the future, maps showing the location of biological sampling sites will be available.

Documentation and Further Information

Wisconsin Water Quality Report to Congress, 2000 305(b): http://www.dnr.state.wi.us/org/water/wm/watersummary/WQ.pdf

Wisconsin’s Unified Watershed Assessment: http://www.dnr.state.wi.us/org/water/wm/watersummary/uwa/index.htm#intro

Water Quality Standards for Wisconsin Surface Waters, revised February 1998:
http://www.legis.state.wi.us/rsb/code/nr/nr102.pdf

Wisconsin DNR Fisheries and Habitat Biological Database: http://infotrek.er.usgs.gov/wdnr_bio/

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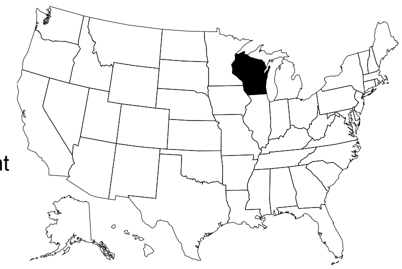

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Phone 608/267-7662 ■ Fax 608/267-2800
email: talbom@dnr.state.wi.us and masnar@dnr.state.wi.us

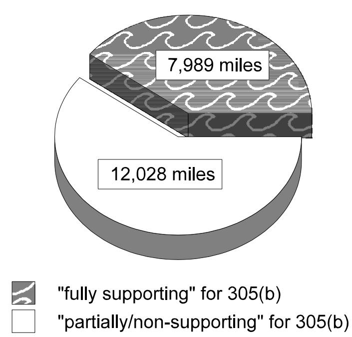
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
		promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
	✓	other: fishery assessments, FERC re-licensing, decisions, etc.
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects only)*
	✓	fixed station (i.e., water quality monitoring stations) *(specific river basins or watersheds)*
		probabilistic by stream order/catchment area
	✓	probabilistic by ecoregion, or statewide *(comprehensive use throughout jurisdiction)*
		rotating basin
		other:

Stream Miles

Total miles*	**55,000**
Total perennial miles	32,000
Total miles assessed for biology**	**24,422**
fully supporting for 305(b)	7,989
partially/non-supporting for 305(b)	12,028
listed for 303(d)	–
number of sites sampled *(on an annual basis)*	600
number of miles assessed per site**	5

24,422 Miles Assessed for Biology



*Surface water resources for Wisconsin have been quantified using GIS. A 1:24,000 scale hydrography GIS database was developed by digitizing surface waters shown on USGS 7.5 minute quadrangle maps.

**The miles assessed for biology include fish consumption and aquatic life use. Of the 12,394 miles fully supporting for 305(b), 4,405 miles are threatened. Each site sampled represents 5 miles of stream for baseline surveys, based on research conducted by WDNR.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Fishery Based Uses and Warm Water vs. Coldwater	
ALU designations in state water quality standards	Five designations: 1) Coldwater – Salmonids & some sculpin species, 2) Warm Water Fish & Aquatic Life – game fish and some important forage species, 3) Warm Water Forage Fish – forage fish communities intolerant to low dissolved oxygen, 4) Limited Forage Fish – forage fish communities tolerant of low dissolved oxygen, 5) Limited Aquatic Life – communities with non-fish species (invertebrates, etc.) that are tolerant of low dissolved oxygen.	
Narrative Biocriteria in WQS	Wisconsin does not have narrative biocriteria per se. It does have narrative criteria that are applied to protect against harm to human, wildlife and fish and aquatic life communities. Please see below.*	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
	✓	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Wisconsin's bioassessment program is still evolving, but has been used regularly to make water quality management decisions that range from fishery management issues (bag limits, habitat restoration projects) to FERC license operating conditions to assessing potential vs. actual fish & aquatic life uses of surface waters.	

***Acute Narrative Criterion**: NR 102.04(1)(d) (d) Substances in concentrations or combinations which are toxic or harmful to humans shall not be present in amounts found to be of public health significance, nor shall substances be present in amounts which are acutely harmful to animal, plant or aquatic life.
Chronic Narrative Criterion: NR 102.04(4)(d) (d) Other substances. Unauthorized concentrations of substances are not permitted that alone or in combination with other materials present are toxic to fish or other aquatic life. Surface waters shall meet the acute and chronic criteria as set forth in or developed pursuant to ss. NR 105.05 and 105.06. Surface waters shall meet the criteria which correspond to the appropriate fish and aquatic life subcategory for the surface water, except as provided in s. NR 104.02(3).

Reference Site/Condition Development

Number of reference sites	**100 total**	
Reference site determinations	✓	site-specific
		paired watershed
	✓	regional (aggregate of sites)
		professional judgment
		other:
Reference site criteria	Reference sites are defined by 1) BPJ using biota, 2) Upper quartile of biota index scores within two years, and 3) will eventually be supplemented with *a priori* land use. Also, a fish IBI is currently used, and habitat, water chemistry and macroinvertebrates will be incorporated within two years.	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
	✓	professional judgment
	✓	other: will eventually use *a priori* GIS land use data
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
	✓	stream type *(temperature, gradient, stream order)*
		multivariate grouping
		jurisdictional (i.e., statewide)
	✓	other: will assess strata with multivariate analysis
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(>500 samples/year; single season, multiple sites - broad coverage)*
	✓	fish *(>500 samples/year; single season, multiple sites - broad coverage)*
	✓	periphyton *(<100 samples/year; single observation, limited sampling)*
		other:

Benthos	
sampling gear	Surber, Hess, D-frame (all limited use); 500 - 600 micron mesh
habitat selection	riffle/run (cobble)
subsample size	minimum of 125, but typically 200 - 300 organisms
taxonomy	lowest taxa-level possible - usually genus, sometimes combination
Fish	
sampling gear	backpack and boat electrofisher, pram unit (tote barge); 1/4" mesh
habitat selection	multihabitat
sample processing	length measurement, biomass- individual (gamefish), biomass- batch (non-game), anomalies
subsample	selected species
taxonomy	species
Periphyton	
sampling gear	**natural substrate**: brushing/scraping device (razor, toothbrush, etc.) **artificial substrate**: rock, rip-rap, bridge concrete
habitat selection	richest habitat
sample processing	chlorophyll *a*/ phaeophytin and taxonomic identification
taxonomy	diatoms only
Habitat assessments	quantitative measurements; performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings, training for biologists, sorting and taxonomic proficiency checks, specimen archival

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
	✓	parametric ANOVAs
	✓	multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)**
	✓	disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	25th percentile of reference population
defining impairment in a multimetric index	25th percentile of reference population

Evaluation of performance characteristics	✓	repeat sampling
	✓	precision *(repeat sampling of assessment sites is conducted)*
	✓	sensitivity *(multiple streams along various stressor gradients have been assessed to document metric sensitivity to the stressor of concern)*
	✓	bias *(Stream habitat assessment crews assess the same site to document crew experience bias. Least-impacted streams of differing size/stream order are sampled to document macroinvertebrate metric bias among streams of varying order)*
	✓	accuracy *(multiple least-impacted streams are sampled to document metric accuracy)*

Biological data	
Storage	A database has been developed in concert with USGS. It is not currently compatible with STORET. The database can be viewed at: http://www.infotrek.er.usgs.gov/wdnr_bio/
Retrieval and analysis	SAS, Systat, and Statistica. Also, an ORACLE-based data management system is being developed to store data and provide routine report summaries and metric calculations.

*Multimetric indexes for habitat and fish have been developed, and a multimetric index for macroinvertebrates is being developed.

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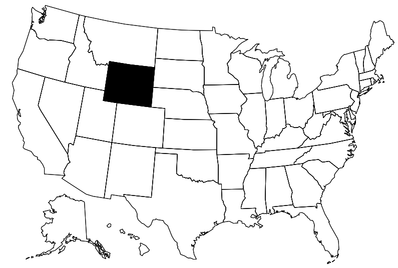

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Program Description

The primary objective of bioassessments conducted by the Wyoming Department of Environmental Quality (WYDEQ) is to assess the support of aquatic life for 303(d) listing and 305(b) reporting, using macroinvertebrates as the primary indicator. The program has been in existence since 1993, when it was initiated in the form of the Reference Stream Project (RSP). The primary goal of the RSP was to collect baseline biological data at least-impacted (reference) streams in each ecoregion of Wyoming as a benchmark for assessing biological and water quality conditions of other streams across the State. In 1998, the focus shifted from collecting reference stream data to using RSP data as a benchmark to assess biological conditions of other Wyoming streams as part of the Beneficial Use Reconnaissance Program (BURP). BURP uses a comprehensive approach (chemical, physical, and biological components) to assess water quality conditions of Wyoming streams. Today, the RSP is still ongoing, but at a much smaller scale.

Several other organizations have been or will be important sources of bioassessment data in Wyoming. The Wyoming Association of Conservation Districts (WACD) has been very involved in collecting biological data at streams across Wyoming. With proper guidance, local Conservation Districts (CDs) can elect to assume some of WYDEQ's bioassessment responsibilities, with the data being used for 303(d) and 305(b). Many CDs have welcomed the opportunity to collect bioassessment data.

The USGS also has been a very important source of biological data. Wyoming has contracted the USGS-Wyoming District to carry out the Environmental Monitoring and Assessment Program (EMAP) monitoring in Wyoming. Approximately 50 randomly selected sites will be assessed over the four year contract, with the end goal being an unbiased estimate of water quality conditions in the State. The USGS also conducted an assessment of the Yellowstone River Basin of Wyoming and Montana as part of the National Water-Quality Assessment Program (NAWQA). The considerable amount of biological data generated from these studies is being evaluated for comparability with WYDEQ data to explore the usefulness of these data for 305(b) purposes. In addition, joint-funding agreements are in place with the USGS that allow for enhanced biological monitoring of streams in areas affected by coal bed methane development.

The Wyoming Game and Fish Department (WGFD) is an important source of fish data. WYDEQ has chosen not to sample fish communities as part of bioassessments, but uses WGFD data for determining support of fisheries uses, as well as in classifying streams for assignment of uses and designating appropriate water quality standards associated with those uses.

Wyoming has made significant strides in recent years in the development of multimetric biocriteria. Work will continue toward refining the existing numeric criteria and narrative aquatic life standard, and toward the eventual implementation of numeric aquatic life standards. Implementation of numeric standards is sure to be a challenging effort. The physical heterogeneity of Wyoming (e.g., climate, landscape, land use, and geology) poses significant scientific challenges. Political considerations are also likely to pose challenges.

Currently, WY is exploring the use of predictive models for assessing biological conditions of streams, as well as the addition of periphyton as an additional biological indicator to supplement macroinvertebrate data and WGFD fish data used in bioassessments. Periphyton samples have been collected at a limited number of long-term reference stations in the past, and the use of periphyton data will expand in coming years.

Documentation and Further Information

Wyoming's 2000 305(b) State Water Quality Assessment Report and *2000 303(d) Report*: http://deq.state.wy.us/wqd/watershed/01452-doc.pdf

Wyoming Surface Water Quality Standards: http://deq.state.wy.us/wqd/index.asp?pageid=52#Stand

Manual of SOPs for Sample Collection and Analysis: http://deq.state.wy.us/wqd/watershed/10574-doc.pdf

WYDEQ Water Quality Division Five-Year Comprehensive Monitoring Plan, 2001 Update, October 2001: http://deq.state.wy.us/wqd/watershed/12806-doc.pdf

Jessup, B.K. and J.B. Stribling. 2000. *Testing the Wyoming stream integrity index*. Prepared by Tetra Tech, Inc., Owings Mills, Maryland, for USEPA Region 8, Denver, CO.

Gerritsen, J; Jessup, B.K.; King, K.; Smith, J. and Stribling, J.B. 2000. *Development of Biological Criteria for Wyoming Streams and their Use in the TMDL Process.* Prepared by Tetra Tech, Inc., Owings Mills, Maryland, for USEPA Region 8, Denver, CO.

Data can be found online at http://wy.water.usgs.gov/ and http://www.wrds.uwyo.edu/

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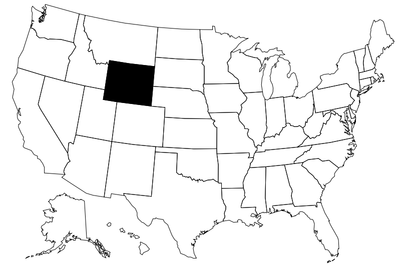

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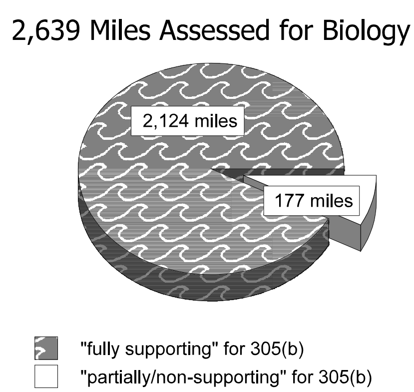
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
		promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
	✓	other: UAAs and site-specific standards
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(specific river basins or watersheds)*
	✓	fixed station (i.e., water quality monitoring stations) *(specific river basins or watersheds)*
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
	✓	rotating basin *(specific river basins or watersheds)*
		other:

Stream Miles

Total miles *(determined using RF3, 2000 and National Hydrography Datatbase, 2001)*	**113,422**
Total perennial miles	32,520
Total miles assessed for biology*	**2,639**
fully supporting for 305(b)	2,124
partially/non-supporting for 305(b)	177
listed for 303(d)	177
extent fully supporting, but threatened	388
number of sites sampled	700+
number of miles assessed per site	3.25



*Since a Weight-of-Evidence approach is used in use support decisions, the numbers provided reflect waterbody reach extent where some type of biological data were used in the assessment.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Class System (A,B,C), Fishery Based Uses and Warm Water vs. Cold Water
ALU designations in state water quality standards	Game Fish (Warm Water and Cold Water Game Fish), Non-game Fish and Aquatic Life Other than Fish
Narrative Biocriteria in WQS	Formal/informal numeric procedures exist to support ALU decisions.
Numeric Biocriteria in WQS	under development (Numeric biocriteria are in use but are still being refined and are not yet incorporated in WY's water quality standards.)

Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
		permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management

Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Trend analysis in watershed improvement projects and following degradation resulting from construction projects and spills.

Reference Site/Condition Development

Number of reference sites	**140** based on field investigation checklist **90** based on quantitative physical and chemical filters

Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
	✓	professional judgment *(Best Professional Judgment based on landscape and field investigation coupled with select water chemical and physical filters)*
		other:

Reference site criteria	Site is identified by the field investigation to be "reference quality" based on analysis of a 27 item checklist of reach and watershed characteristics plus select ecoregion specific quantitative physical and chemical filters.

Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
	✓	professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(100-500 samples/year; single season, multiple sites – not at watershed level)*
		fish
	UD	periphyton
		other:
Benthos		
sampling gear		Surber, dipnet; 500-600 micron mesh
habitat selection		riffle/run (cobble)
subsample size		500 count
taxonomy		combination--genus, species
Periphyton		
sampling gear		**natural substrate:** brushing/scraping device (razor, toothbrush, etc.)
habitat selection		riffle/run (cobble)
sample processing		WYDEQ's periphyton program is under development. Samples have been collected, but analysis protocols are yet to be developed.
taxonomy		under development
Habitat assessments		visual based, quantitative measurements, hydrogeomorphology, pebble counts (Wolman), streambank stability (Bauer and Burton - EPA910/R-93-017), pool quality (Bauer and Burton); performed with bioassessments
Quality assurance program elements		standard operating procedures, quality assurance plan, periodic meetings and training for biologists, taxonomic proficiency checks, specimen archival

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
	UD	multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients
		other:
Multimetric thresholds		
transforming metrics into unitless scores		95th percentile of reference population
defining impairment in a multimetric index		25th percentile of reference population
Evaluation of performance characteristics	✓	repeat sampling *(select sites are sampled annually to document annual variability)*
	✓	precision *(side-by-side sampling at 10% of stations; Data Quality Objectives for density and number of taxa)*
		sensitivity
		bias
		accuracy
Biological data		
Storage		STORET, EDAS, and internal spreadsheets
Retrieval and analysis		EDAS

AMERICAN SAMOA

Contact Information

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Program Description

American (Amerika) Samoa is a group of six Polynesian islands in the South Pacific. Located fourteen degrees below the equator, it is the United States' southern-most territory.

The American Samoa Environmental Protection Agency (ASEPA) develops and implements programs that protect environmental and public health from harmful impacts on air and water quality. USEPA works in partnership with ASEPA and provides funding and technical assistance to carry out environmental programs. ASEPA activities include water quality monitoring, inspecting facilities and new developments for compliance with environmental regulations, preparing responses to hazardous material releases, advocating practices that decrease and prevent pollution, and educating the public on environmental issues and practices.

American Samoa does not have a biological assessment program in place, and has no immediate plans for implementing a bioassessment program. The American Samoa Water Quality Standards contain no numeric biocriteria. Wording in standards that states that Fresh Surface Water and Wetlands "shall be protected to support the propagation of indigenous aquatic and terrestrial life" may be considered narrative criteria.

Documentation and Further Information

Personal communication (email), Edna Buchan, 11/26/2001.

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Commonwealth of Northern Mariana Islands (CNMI)

Contact Information

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Program Description

NOTE: Since few freshwater sources exist on the islands, all information in this program summary refers to CNMI's marine environments (CNMI has only two or three, very small, perennial streams. CNMI's dynamic tropical marine system requires different approaches and techniques than are used by the states to develop biocriteria.)

The objective of CNMI's Marine Monitoring Program is to monitor CNMI's reefs, lagoon, and reef flats with regards to benthic communities, macroinvertebrate and fish abundances, and water quality. In addition, CNMI has a biodiversity list of all organisms encountered in CNMI and a reference collection. CNMI Water Quality Standards clearly state that benthic communities can not be altered due to a discharge (Section 7.12 (d)). Any significant changes would be changes from 1) previous conditions at the same site or 2) changes from a similar reference site. The goal is to gather as much baseline data in as many different areas as possible to use for comparisons. Last year, a "State of the Reef Report" was completed which comprises all of the results from monitoring efforts.

In 2001, the focus was on assessments of nearshore coral reef systems surrounding Saipan and Rota. The 2000/2001 *State of the Reef Reports* were produced summarizing past and present coral reef data for Saipan and Rota. Though it would be impossible to survey the entire coral reef system around CNMI with current resources, there are approximately 20 sites established for intensive data collection on a yearly basis. The goal is to continue to enhance CNMI's interagency marine monitoring group composed of Coastal Resources Management, Division of Fish and Wildlife, and Division of Environmental Quality. Assessments of existing and additional sites on Rota, Saipan, Tinian, and other Northern Islands will be conducted and included in the next Reef Report (2002). Data will be used for future assessments of natural disasters, potential anthropogenic disturbances/development, and overall biological health.

In 2002, the entire Saipan Lagoon, covering several watersheds, will also be surveyed to assess and understand how upland runoff (nonpoint source pollution) may be affecting this valuable resource. The entire lagoon will be divided into habitats and quantitative and qualitative data from each habitat will be gathered. Once completed, existing aerial photographs will be scanned and remote sensing techniques will delineate the habitats found. The end result will be used to examine correlations between water quality, drainage areas, other areas of concern, and the lagoon habitat. This project is also required by the Army Corps of Engineers in order to proceed with a master drainage plan for areas associated with Saipan's Lagoon. Lagoon survey work is currently a joint project between NOAA's Coastal Resource Management Program and DEQ. Hopefully, the Division of Fish and Wildlife will be involved in this project in 2002 as well.

CNMI's reef monitoring program is based on site selection. Sites that have "concerns" or "disturbances" are selected, as well as several reference sites. There are many more habitats in the nearshore coral reef communities around CNMI than are found in the Saipan Lagoon, hence the difference in methods. Also, weather conditions prohibit surveys on windward sides of the islands most of the year. All of this data is very useful for understanding baseline water quality conditions, and these data are used for assessment when and if projects are proposed that involve a discharge.

CNMI's program can not follow the same type of biocriteria monitoring program implemented in any of the U.S. states. There is a very dynamic tropical marine system surrounding CNMI which warrants the use of techniques different than those used by our State counterparts.

Documentation and Further Information

Commonwealth of Northern Mariana Islands Water Quality Assessment Report 305(b), April 2000

Commonwealth of Northern Mariana Islands Water Quality Assessment Report 305(b), 2002
(Interested parties can contact Peter Houk, CNMI DEQ, or EPA Region 9 for a copy of either report)

CNMI *State of the Reef Report*, 2000

CNMI *Nonpoint Source and Marine Monitoring Program* information: http://www.deq.gov.mp/NPS/default.htm

Commonwealth of Northern Mariana Islands

Contact Information

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Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
	✓	evaluation of discharge permit conditions
		TMDL assessment and monitoring
	✓	other: public information and awareness
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects only)*
	✓	fixed station (i.e., water quality monitoring stations) *(comprehensive use throughout jurisdiction)*
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
		rotating basin
		other:

Stream Miles* **(pertains to coral reef monitoring)**	
Total miles	**–**
Total perennial miles	–
Total miles assessed for biology	**n/a**
fully supporting for 305(b)	n/a
partially/non-supporting for 305(b)	n/a
listed for 303(d)	n/a
number of sites sampled on the reef *(on an annual basis)*	20
number of miles assessed per site	site specific

*The above section is not applicable to CNMI's monitoring program since no stream monitoring is conducted. For lagoon surveys, CNMI plans to intensively survey and create habitat maps for the entire Saipan Lagoon system. This covers several watersheds. CNMI's outer reef monitoring program is based on site selection - sites that have "concerns" or "disturbances," as well as several reference sites. There are many more habitats in the nearshore coral reef communities around CNMI than are found in the Saipan Lagoon, hence the difference in methods. Also, weather conditions prohibit surveys on windward sides of the islands most of the year. All of these data are very useful for understanding baseline water quality conditions, and these data are used for assessment when and if projects are proposed that involve a discharge.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Class System (A,B,C)
ALU designations in state water quality standards	AA - top quality marine, A - marine non-recreational 1 - surface water (runoff mainly, no rivers) highest quality, 2 - surface water non-recreational
Narrative Biocriteria in WQS	Formal/informal numeric procedures used to support narrative biocriteria are determined by the best available data.
Numeric Biocriteria in WQS	none (Numeric biocriteria are located in yearly reports on monitoring activities. Each site differs with respect to benthic communities and CNMI's WQS uses the term "shall not differ substantially from those where similar conditions exist.")

Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
		cause and effect determinations
		permitted discharges
		monitoring (e.g., improvements after mitigation)
		watershed based management

Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	A ponding basin was established on Rota Island in response to CNMI DEQ's monitoring results. There are also other small projects similar to this. DEQ is collecting baseline data with the intention of using it to assess BMPs and aid future decision-making.

Reference Site/Condition Development

Number of reference sites	**5 total**	
Reference site determinations	✓	site-specific
		paired watersheds
		regional (aggregate of sites)
	✓	professional judgment
	✓	other: based on benthic community composition
Reference site criteria	Reference sites are chosen based on similar geological/physical features (slope, substrate, etc.). They are sites similar in community composition that are not subjected to the discharge in question. There are usually several on each island in CNMI.	
Characterization of reference sites within a regional context *Not applicable**		historical conditions
		least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions *Not applicable*		ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information	✓	reference sites linked to ALU *(in some cases)*
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions *(in some cases)*

*Characterization of reference sites does not apply because CNMI uses a degree of community change based on reference versus test sites.

Field and Lab Methods*

Assemblages assessed	✓	benthos *(<100 samples/year; single season, multiple sites - broad coverage)*
	✓	fish *(<100 samples/year; single season, multiple sites - broad coverage)*
		periphyton
	✓	other: waterfowl *(100-500 samples/year; multiple seasons, multiple sites - broad coverage for watershed level)*

Benthos*	
sampling gear	Transect lines, underwater photo equipment, hammer, measuring tapes, diving gear, underwater slates/pencils
taxonomy	genus and species
Fish*	
sampling gear	speargun, reference books
taxonomy	species
Habitat assessments	quantitative measurements, benthic coverage estimates of major benthos, basic water quality parameter measurements, abundances of fish and macroinvertebrates, and biodiversity of all organisms present; performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings and training for biologists, and specimen archival

*Following is a summary of biological sampling methods used in the reef – see CNMI's *State of the Reef Report* for details

- Three 50 meter transect lines are secured parallel to the shoreline (laid end-to-end, 150m total length), and marked with a sediment trap holder and re-bar driven securely into the reef.
- For benthics, an underwater camera is used to take still photographs of .5-m quadrats placed at all even numbers along the transect line. For each photo the bottom right corner of the quadrat is aligned with the corresponding transect line distance.
- Coral communities are examined using the point-quarter method described by Randall et al., (1988). A dive knife is haphazardly tossed 16 times along the three transects. For each toss the distance to the nearest living coral colony is noted for each of four quadrants, as well as the diameter and taxonomic name.
- Fish abundance is determined by a single observer swimming along the transect lines recording data. Counts of all fishes within 5 meters of each side of the transect line are recorded. Fishes are identified to the family level.
- All macroinvertebrates within 2 meters of each side of the transect line are counted. These data were presented as abundances per (100-m^2) of reef on each of three transects. Macroinvertebrates are either identified to genus or grouped by life form, depending on abundances.
- Sediment traps provide sedimentation rate data from sites where sedimentation is a concern.
- Water samples are taken for chemistry.

Data Analysis and Interpretation

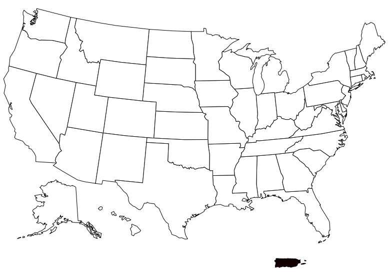
Data analysis tools and methods	✓	summary tables, illustrative graphs
	✓	parametric ANOVAs
	✓	multivariate analysis
		biological metrics
		disturbance gradients
	✓	other: distribution analysis and cluster analysis

Multivariate thresholds	
defining impairment in a multivariate index	5th percentile of reference population (Pvalue of .05 is cut off)

Evaluation of performance characteristics	✓	repeat sampling
		precision
		sensitivity
		bias
		accuracy

Biological data	
Storage	MS Access, Excel, Word, Arcview GIS and Photo documentation
Retrieval and analysis	Excel

PUERTO RICO and the U.S. VIRGIN ISLANDS



Contact Information

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Program Description

Puerto Rico is presently evaluating Rapid Bioassessment Protocols (RBPs) for mountain streams. According to the Water Monitoring Plan for fiscal year 2002, the Puerto Rico Environmental Quality Board (PREQB), in coordination with EPA Region II, will continue to work on the development of biological indicators for stream monitoring. PREQB is responsible for current monitoring activities which include ambient water quality monitoring, intensive water quality studies, and 305(b) reporting. The 2000 Cycle 305(b) Report doesn't include any biological information (aside from limited wetland loss data). The EPA (ORD Coastal 2000 Program) conducted an EMAP study on the estuaries of Puerto Rico, which included benthic macroinvertebrate sampling.

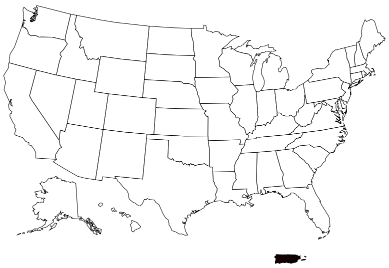
The *U.S. Virgin Islands 2000 Water Quality Assessment* reported that there are "no perennial streams on any of the islands; intermittent streams can only be seen after heavy rainfall. The absence of large freshwater resources and perennial streams means that *guts* (watercourses) form the basis for watershed management in the territory." Also, the Virgin Islands primarily assess coastal waters and estuaries, but "no monitoring for biological effects is conducted for lack of baseline standards for Virgin Islands conditions. According to the Virgin Islands multi-year monitoring strategy, the Department of Planning and Natural Resources (DPNR) will explore options for implementing a biological component of the Ambient Monitoring Program. This may include developing a partnership with NOAA or another agency with similar monitoring objectives."

Documentation and Further Information

Goals and Progress of Statewide Water Quality Management Planning: Puerto Rico 1998-1999, 2000 Cycle 305(b) Report. Puerto Rico Environmental Quality Board. November 2000.

2000 Water Quality Assessment for the United States Virgin Islands, 2000 305(b) Report. Department of Planning and Natural Resources, Division of Environmental Protection (DPNR/DEP). April 2001.

PUERTO RICO and the U.S. VIRGIN ISLANDS



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Programmatic Elements

Uses of bioassessment within overall water quality program *Not currently used*		problem identification (screening)
		nonpoint source assessments
		monitoring the effectiveness of BMPs
		ALU determinations/ambient monitoring
		promulgated into state water quality standards as biocriteria
		support of antidegradation
		evaluation of discharge permit conditions
		TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects only)*
	✓	fixed station (i.e., water quality monitoring stations) *(special projects only)*
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
		rotating basin
		other:

Stream Miles

NOTE: *These stream and river miles apply only to Puerto Rico. The U.S. Virgin Islands reports no stream miles.*

Total miles *(determined using RF3)*	**5,394.2**
Total perennial miles	–
Total miles assessed for biology*	**0**
fully supporting for 305(b)	n/a
partially/non-supporting for 305(b)	n/a
listed for 303(d)	n/a
number of sites sampled	n/a
number of miles assessed per site	n/a

*Specific biological studies have been conducted, but there are no ongoing projects. However, Puerto Rico does conduct other regular chemical and physical monitoring. According to PR's 2000 305(b) report, during the 1998 - 1999 monitoring cycle there were 5,394 total assessed miles; 4,297 evaluated segments; and 1,096 monitored segments. Of the 1,096.7 river miles monitored for Aquatic Life Use, 222.4 miles were determined to be fully supporting, 16.8 miles were partially supporting, and 857.5 miles were non-supporting.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Class System (A,B,C)	
ALU designations in state water quality standards	Standards list definitions for the following: pelagic and planktonic species, propagation and preservation of desirable species.	
Narrative Biocriteria in WQS	none (Puerto Rico and the U.S. Virgin Islands have no biocriteria. According to Puerto Rico's 2000 305(b) report, there were expectations of achieving/developing some, but no monitoring strategy has been submitted as of yet.)	
Numeric Biocriteria in WQS	none	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria) *Not currently used*	☐	assessment of aquatic resources
	☐	cause and effect determinations
	☐	permitted discharges
	☐	monitoring (e.g., improvements after mitigation)
	☐	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	none	

Reference Site/Condition Development*

Number of reference sites	**none**	
Reference site determinations	☐	site-specific
	☐	paired watersheds
	☐	regional (aggregate of sites)
	☐	professional judgment
	☐	other:
Reference site criteria		
Characterization of reference sites within a regional context	☐	historical conditions
	☐	least disturbed sites
	☐	gradient response
	☐	professional judgment
	☐	other:
Stream stratification within regional reference conditions	☐	ecoregions (or some aggregate)
	☐	elevation
	☐	stream type
	☐	multivariate grouping
	☐	jurisdictional (i.e., statewide)
	☐	other:
Additional information	☐	reference sites linked to ALU
	☐	reference sites/condition referenced in water quality standards
	☐	some reference sites represent acceptable human-induced conditions

*This section is not applicable – no biological monitoring is conducted in Puerto Rico or the U.S. Virgin Islands, thus neither territory has reference sites.

Field and Lab Methods*

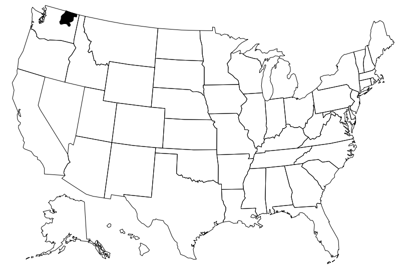
Assemblages assessed	☐	benthos
	☐	fish
	☐	periphyton
	☐	other:
Habitat assessments	not applicable	
Quality assurance program elements	not applicable	

Data Analysis and Interpretation*

Data analysis tools and methods	☐	summary tables, illustrative graphs
	☐	parametric ANOVAs
	☐	multivariate analysis
	☐	biological metrics
	☐	disturbance gradients
	☐	other:
Evaluation of performance characteristics	☐	repeat sampling
	☐	precision
	☐	sensitivity
	☐	bias
	☐	accuracy
Biological data		
Storage	not applicable	
Retrieval and analysis	not applicable	

*These sections are not applicable since no biological monitoring is conducted in Puerto Rico or the U.S. Virgin Islands.

CONFEDERATED TRIBES OF THE COLVILLE RESERVATION



Contact Information

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Program Description

The Colville Indian Reservation land base covers 1.4 million acres or 2,100 square acres located in North Central Washington, primarily in Okanogan and Ferry counties. The Reservation consists of tribally owned lands held in federal trust status for the Confederated Tribes, land owned by individual Colville tribal members (most of which is held in federal trust status), and land owned by others (described as fee property and taxable by counties). Colville Reservation lands are diverse with natural resources including standing timber, streams, rivers, lakes, minerals, varied terrain, native plants and wildlife.

Although the Confederated Tribes of the Colville Reservation do have federally approved water quality standards, the Tribes' Office of Environmental Trust doesn't use biological assessment methods as a means to assess water quality. In 2001, the Tribes gave permission to the State of Washington Department of Ecology to conduct some biological assessments on the reservation, but the results of those surveys are not yet complete. The primary obstacle to conducting bioassessment has been cost. The water quality monitoring program is reevaluated every year, and it is possible the Tribes may implement biological monitoring in the future.

Documentation and Further Information

Personal Communication (email), Gary Passmore, 11/28/2001.

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NEZ PERCE TRIBE

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Program Description

The Nez Perce Reservation is located in North Central Idaho. The Tribal Department of Natural Resources consists of the Land Services, Cultural Resources, Wildlife Resources, Forest Resources, Water Resources, and Environmental Restoration and Waste Management Programs. These programs focus on delivering resource management services on the Reservation and participating in the planning and decisions of land management activities affecting the Nez Perce Treaty area. The programs provide protection of reserved treaty-rights in all areas to their best abilities. Department administration is structured to facilitate an interdisciplinary approach in meeting these needs.

Currently the Tribe is collecting baseline chemical and physical habitat data on Reservation waterbodies and will, eventually, be establishing its own water quality standards for the reservation area. The Nez Perce Tribe may soon promulgate the standards USEPA is developing for Indian country, with the idea of refining them from narrative standards to both chemical and biological criteria. The Tribe has used the State of Idaho Beneficial Use Assessment Procedure (BURP) for reservation water bodies in 1997, 1998 and 1999 and would like to adopt its own protocols for beneficial use assessment.

The Tribe recently obtained funds to begin the EMAP bioassessment procedure for the reservation. This will be accomplished through participation in the EMAP Western Pilot and methods will be developed based on EMAP protocols.

Documentation and Further Information

Personal Communication (email), Ann Storrar, 10/01/2001.

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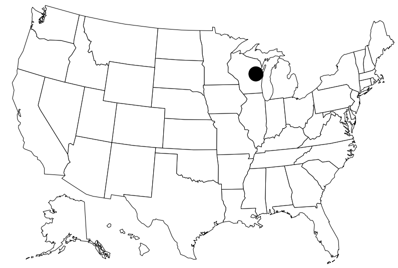
ONEIDA NATION OF WISCONSIN



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Program Description

Objectives
The Oneida Tribe's current and future uses of information gathered using bioassessment include protection, restoration, assessing impacts, monitoring changes, as well as driving policy and promoting knowledge and appreciation of aquatic resources.

Background
Although there had been some invertebrate and fish surveys performed on the Reservation over the last twenty years or so, the development of a formal biological monitoring program was initiated in 2000. Tri-annual fishery surveys at established monitoring sites have been performed since 1997. In 1999, the Tribe began sampling invertebrate communities and immediately began using the findings as tools. An onsite aquatic invertebrate taxonomy laboratory was also established in 1999 and equipped with scopes, literature, drying oven, hood, etc. In 2000, qualitative sampling of invertebrates was performed at five stream sites and a quantitative study of one lake was initiated to determine the effectiveness of BMPs in the surrounding basin. In the meantime, SOPs were developed for qualitative and quantitative methods for lakes and wadeable streams and metrics were researched and tested. Contracts were set up for the picking and sorting of invertebrate samples (UW-Superior) and for toxicity testing (Environmental Consulting and Testing) of certain waterbodies. In 2001, quantitative samples were collected at three stream sites and the lake, as well as three more sites being sampled qualitatively. Stream types have not been formalized, but four reference sites have been established:

1. **Thornberry Creek** (at forest Drive), a first order cold water system, exhibiting "pristine" conditions during 1999 and 2000.
2. **Trout Creek** (at County FF), a 3rd order cold water system, exhibiting "good" to "very good" conditions.
3. **Oneida Creek** (at VanBoxtel Road), a 3rd order cool water system, exhibiting "good" conditions in 2000. A very rare fingernet caddisfly, *Wormaldia moesta*, known to occur only in "small, cold, rapid streams" has been collected at this site.
4. **Duck Creek** (at Seminary Road), a 4th order warm water system, the largest stream on the Reservation. The water quality and invertebrate community represent "good" conditions. The same stream is in "poor" condition before entering the Reservation from the south near the Town of Freedom.

The streams at these sites represent the reference conditions for all stream types on the Reservation. In 2002, qualitative or quantitative sampling will be conducted at approximately 30 invertebrate sites and mid-summer fish IBIs will be conducted at eleven sites.

Setting/Land Use
The entire Reservation, covering approximately 64,500 acres, is in the Southeastern Wisconsin Till Plains ecoregion (Omernick 1987). At this time, the main sources of impairment are sedimentation (construction and agriculture) and nutrients (agriculture, suburban lawns, golf courses). The Reservation straddles the boundary of Brown and Outagamie Counties and includes all or portions of the City of Green Bay, Villages of Ashwaubenon and Howard, and the Towns of Hobart, Oneida and Pittsfield. Eleven additional municipalities rest within the watersheds flowing through the Reservation. All surface waters within the Oneida Reservation drain to the Great Lakes Basin (Lake Michigan). There are four separate surface water drainages, bearing numerous tributaries:
1) Duck Creek River – Fish Creek, Oneida Creek, Trout Creek, Lancaster Brook, Beaver Dam Creek, Silver Creek (*Lower Green Bay Basin*); 2) South Branch of the Suamico River (*Upper Green Bay Basin*); 3) Ashwaubenon Creek – North Branch, South Branch, Hemlock Creeks (*Fox River Basin*); and 4) Dutchman Creek (*Fox River Basin*)

Land use percentages surrounding the sites will be mapped this summer (2002), and the first formal biomonitoring report is being produced.

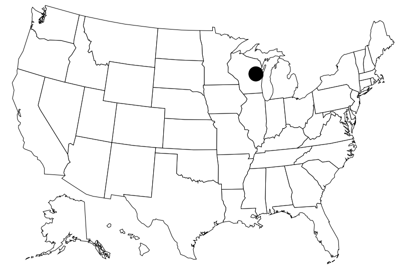
Metrics and Biocriteria Development
While the Oneida Nation does not have federally approved water quality standards, the Tribe is implementing a water quality program with bioassessment surveys under tribal law. The inclusion of biocriteria into the Tribe's WQS has been delayed due to urgent water resource issues that have come up, rather than lack of information. The appropriate metrics to accurately predict responses in benthic invertebrate communities for the area are fairly well proven at this time. The metrics currently being used (for streams) are the Hilsenhoff Biotic Index (HBI), Taxa Richness, dominance, percent clingers and in some cases Ephemeroptera, Plecoptera and Trichoptera (EPT) and E, P and T taken separately. The most common impacts are due to sedimentation and organic loading. Because of the limited number and type of streams within the Reservation, it is believed that the appropriate reference sites to represent all of the stream types have been selected. A final designation of these has not been made, nor are biocriteria being submitted for inclusion in the WQS until there is a chance to conduct more sampling of test sites to compare with the reference sites.

Documentation and Further Information

Personal communication (letter), James L. Snitgen, 1/2002.

Hard copies of documents including the Oneida Nation's WQS; SOPs for the Qualitative Sampling (#BI002) and Quantitative Sampling (#BI003) of Streams for Benthic Invertebrates; Annual Water Resources Report (future reports will contain fish and macroinvertebrate data)

ONEIDA NATION OF WISCONSIN



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Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
		promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
		evaluation of discharge permit conditions
		TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose)
	✓	fixed station (i.e., water quality monitoring stations)
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
		rotating basin
		other:

Stream Miles

Total miles	**233**
Total perennial miles	–
Total miles assessed for biology	–
fully supporting for 305(b)	n/a
partially/non-supporting for 305(b)	n/a
listed for 303(d)	n/a
number of sites sampled *(in summer 2002)*	41
number of miles assessed per site	~0.02 miles (25 meters)

Aquatic Life Use (ALU) Designations and Decision-Making*

ALU designation basis	Warm Water vs. Cold Water	
ALU designations in state water quality standards	Two designations: cold water ecosystems, warm water ecosystems	
Narrative Biocriteria in WQS	Inclusion of narrative and numeric biocriteria into the Tribe's WQS is under development, as is nutrient criteria. Tribal WQS include biological and water quality language but this does not constitute formal biocriteria.	
Numeric Biocriteria in WQS	see above	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
		permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Macroinvertebrate community data were used to designate one stream as a cold water resource. RBPs were conducted following a stormwater spill.	

*Water quality standards were federally approved in 1996 and then rescinded following a lawsuit.

Reference Site/Condition Development

Number of reference sites	**4 total**	
Reference site determinations		site-specific
		paired watershed
		regional (aggregate of sites)
	✓	professional judgment *(Qualitative data gathered initially on candidate reference sites. Most "pristine" of each stream type used as reference--still in early stages of determining all necessary reference sites)*
		other:
Reference site criteria	water quality, benthic invertebrate community (Hilsenhoff Biotic Index), land use, physical habitat, geomorphology, qualitative benthos investigations	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions		ecoregions (or some aggregate)
		elevation
	✓	stream type *(all within Reservation/all in same ecoregion)*
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information	UD	reference sites linked to ALU
	UD	reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods*

Assemblages assessed	✓	benthos *(<100 samples per year; single season, multiple sites - broad coverage)*
	✓	fish *(<100 samples per year; multiple seasons, multiple sites - broad coverage for watershed level)*
		periphyton
		other:

Benthos	
sampling gear	Surber, D-frame, collect by hand; 500 micron mesh
habitat selection	riffle/run (cobble)
subsample size	300 count
taxonomy	species
Fish	
sampling gear	backpack electrofisher; 1/4" mesh
habitat selection	previously established monitoring sites and/or sites suitable for long term monitoring
sample processing	biomass - individual (identify and count)
subsample	none
taxonomy	species
Habitat assessments	visual based, quantitative measurements; performed with bioassessments
Quality assurance program elements	standard operating procedures, periodic meetings and training for biologists, sorting and taxonomic proficiency checks, specimen archival

*The Oneida Nation has sampled fish for four years and began a macroinvertebrate program in 2001 using the RBP habitat rating score sheet. The Tribe's first herpetile survey is planned for summer 2002 to collect baseline data on two riverways and three wetlands. Oneida also plans to begin using macrophytes as indicators in wetlands.

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
	✓	parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(aggregate metrics into an index and return single metrics)*
		disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	information not provided
defining impairment in a multimetric index	information not provided

Evaluation of performance characteristics	✓	repeat sampling
	✓	precision (replicates)
		sensitivity
		bias
		accuracy

Biological data	
Storage	Macroinvertebrate data in Corel Quattro Pro; fish data in MS Access
Retrieval and analysis	information not provided

PASSAMAQUODDY TRIBE, PLEASANT POINT RESERVATION

Contact Information

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Program Description

The Passamaquoddy Tribe at Pleasant Point is located in coastal Maine, near the border of New Brunswick. The Tribe's Environmental Department is responsible for the health of the natural resources under Tribal Management. This responsibility begins by assessing and mapping these resources and related risks, then developing programs to insure that these natural resources are protected. While the Passamaquoddy Tribe does not have federally approved water quality standards, it is implementing a water quality program with limited bioassessment surveys under tribal law. Current water quality work includes testing salt water for fecal coliform and phytoplankton in a cooperative arrangement with the Maine Department of Marine Resources (DMR) and the Cobscook Bay Resource Center. This work provides the DMR with information to manage closure of clam flats.

Documentation and Further Information

Personal communication (email), Deirdre Whitehead, 11/30/2001.

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PYRAMID LAKE PAIUTE TRIBE

Contact Information

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Program Description

The Pyramid Lake Paiute Tribe's Reservation is located thirty five miles northeast of Reno, Nevada in a remote desert area situated in the counties of Washoe, Lyon, and Storey. The area of the reservation contains 475,000 acres or 742.2 square miles.

The Environmental Department of the Pyramid Lake Paiute Tribe (PLPT) has been conducting bioassessments on waterbodies within the reservation border since 1975. An ecological study on Pyramid Lake was conducted from 1975 through 1977. A comprehensive bioassessment study was conducted on the lower Truckee River during the summer of 1981. In 1989, a regular Rapid Bioassessment (RBA) program was established for the Truckee River, following the first EPA bioassessment training in Reno, Nevada.

PLPT is in the process of establishing standardized protocols for assessing the biological and physical conditions of wadeable streams within the exterior boundaries of the Pyramid Lake Paiute Indian Reservation. The Tribe will use protocols outlined in EPA's Rapid Bioassessment Protocols (USEPA 1989). There are plans to incorporate the bench sheets and protocols as outlined by the California Department of Fish and Game (CA DFG) Water Pollution Control Laboratory in their *California Stream Bioassessment Procedure* (May 1999). These technical documents describe RBA in more detail. Updating and developing aquatic/riparian RBA techniques is an ongoing process.

The PLPT RBA program will ensure that the information generated can be compatible with the National or State EPA bioassessment program, to produce high quality and reliable assessments of stream habitat and water quality. A professional aquatic biologist/entomologist will act as the project team leader, backed by an interdisciplinary team of two to four biologists and/or technicians.

Fish and benthic macroinvertebrates (BMIs) will be identified to the lowest taxonomic level possible (genus/species). The presence or absence of fish and BMIs are proven indicators of an impaired or healthy aquatic system. Bioassessments can be used to detect impairments to aquatic communities from point and nonpoint sources of pollution and for assessing ambient biological condition. The upper third of riffles will be targeted for collecting biological samples because they are the richest habitat for BMIs in wadeable streams. The Tribe's goal is to protect an endangered lake sucker called a "Cui-ui" (*Chasmistes cujus*), and the threatened Lahontan Cutthroat Trout.

In summer 2001, the Tribe initiated a RBA program for springs and wetlands. A wetland specialist will act as team leader, looking at amphibians, wildlife, BMIs, birds, plants, and water chemistry for each waterbody as indicators of an impaired or healthy aquatic system.

In the future, PLPT plans to explore numeric biocriteria for BMIs on the Truckee River. The Tribe will also begin gathering baseline data on the five streams that surround Pyramid Lake. The Tribe's water quality standards are currently undergoing review by EPA.

Documentation and Further Information

Personal communication (letter), Dan Mosely, 2001.

The following PLPT department homepages are under development (July 2002):
Environmental Department: http://plpt.nsn.us/modules.php?name=Sections&sop=listarticles&secid=21
Water Resources Department: http://plpt.nsn.us/modules.php?name=Sections&sop=listarticles&secid=20

PYRAMID LAKE PAIUTE TRIBE

Contact Information

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Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	UD	monitoring the effectiveness of BMPs
	UD	ALU determinations/ambient monitoring *(to be developed)*
	UD	promulgated into tribal water quality standards as narrative biocriteria
	UD	support of antidegradation
		evaluation of discharge permit conditions
	UD	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(specific river basins or watersheds)*
	✓	fixed station (i.e., water quality monitoring stations)
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
		rotating basin
		other:

Stream Miles

Total miles	–
Total perennial miles	–
Total miles assessed for biology	**31+**
fully supporting for 305(b)	–
partially/non-supporting for 305(b)	–
listed for 303(d)	–
number of sites sampled*	13 to 15
number of miles assessed per site	–

*Eight to ten sites are sampled on the Truckee River, covering 31 miles. Five sites on five streams surrounding Pyramid Lake are also sampled.

Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	Fishery Based Uses	
ALU designations in state water quality standards	under development	
Narrative Biocriteria in WQS	under development (Narrative biocriteria are incorporated into Pyramid Lake's water quality standards, but are currently awaiting approval by EPA Region 9. No formal/informal numeric procedures are used to support narrative biocriteria.)	
Numeric Biocriteria in WQS	under development (The Pyramid Lake Paiute Tribe will be developing "scientifically defensible" numeric biocriteria for the Lower Truckee River over the next several years.)	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	UD	cause and effect determinations
	UD	permitted discharges
	UD	monitoring (e.g., improvements after mitigation)
	UD	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	presently none - to be developed	

Reference Site/Condition Development*

Number of reference sites	**under development**	
Reference site determinations		site-specific
		paired watersheds
		regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria	Based on historical data, what the best conditions should be for that site. On Truckee River, the Tribe has been using reference "conditions" based on bioassessment data from 1981 to present.	
Characterization of reference sites within a regional context	✓	historical conditions
		least disturbed sites
		gradient response
	✓	professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
	✓	elevation
	✓	stream type
		multivariate grouping
	✓	jurisdictional *(within Tribe's boundaries)*
		other:
Additional information	UD	reference sites linked to ALU
		reference sites/condition referenced in water quality standards
		some reference sites represent acceptable human-induced conditions

*Reference site use is currently under development.

Field and Lab Methods

Assemblages assessed*	✓	benthos *(<100 samples/year [3 replicates per riffle site]; single season, multiple sites - not at watershed level*)
	✓	fish
	✓	periphyton
		other:

Benthos	
sampling gear	surber (used 1981 through 2000), kicknet (started in 2001) - 9" x 18" rectangle 500 micron mesh
habitat selection	richest habitat - upper third of riffle
subsample size	entire sample
taxonomy	genus and species
Fish	
sampling gear	seine (multiple gill nets), backpack and boat electrofisher
habitat selection	pool/glide
sample processing	length measurement, biomass - individual, anomalies
subsample	study specific
taxonomy	species
Periphyton	
sampling gear	**natural substrate**: brushing/scraping device (razor, toothbrush, etc.) **artificial substrate**: collect by hand
habitat selection	multihabitat
sample processing	chlorophyll *a*/ phaeophytin, biomass, taxonomic identification
taxonomy	all algae; species level; genus level for soft-bodied algae when possible; diatoms are not cleared
Habitat assessments	visual based and quantitative measurements; performed with bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings and training for biologist, sorting and taxonomic proficiency checks, specimen archival

*Tribal Fisheries conducts fish bioassessments and a Tribal Wetlands staff member conducts amphibian biostudies. Periphyton sampling is conducted on tribal land by the Desert Research Institute.

Data Analysis and Interpretation**

Data analysis tools and methods		summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
		biological metrics
		disturbance gradients
		other:
Evaluation of performance characteristics		repeat sampling
		precision
		sensitivity
		bias
		accuracy

Biological data	
Storage	Quattro Pro and paper files
Retrieval and analysis	EDAS (under development)

**Data have not yet been analyzed or evaluated. Pyramid Lake Paiute Tribe is just beginning to sort/identify the 2001 benthic macroinvertebrate collections.

SEMINOLE TRIBE of FLORIDA

Contact Information

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Program Description

The reservations that comprise the Seminole Tribe of Florida begin around Tampa and extend into the southern tip of the state. The Tribe's Water Resource Management Department is responsible for protecting the land and water systems within the Reservation while ensuring a sustainable economic and cultural future for the Tribe. USEPA has delegated to the Tribe the authority to implement the Clean Water Act within the Tribe's jurisdiction. As part of that program, the Tribe implemented a sophisticated monitoring program, adopted federally approved water quality standards for the Big Cypress reservation, and is developing standards for the other reservations.

The Tribe has developed other programs, as well, including spill prevention plans for above ground storage tanks and removal programs for underground storage tank facilities. The Tribe actively participates in a number of task forces, working groups, and commissions regarding the restoration of the South Florida ecosystem. The Tribe spends considerable resources supporting the overall design and implementation of South Florida's environmental restoration.

Currently the Tribe does not use biocriteria in any of its water quality monitoring programs. However, the Tribe is involved in a research project conducted by Florida Atlantic University that includes development of biocriteria (primarily for variations in hydroperiod and the effects of restoration), using vegetation and fish as bioindicators.

Documentation and Further Information

Personal communication (email), Bill Dunson, 12/4/2001.

Working Drafts – Bioindicators for wetland change; Presentation on use of data in conducting rapid wetland assessments

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Delaware River Basin Commission (DRBC)

Interstate compact: PA, NJ, NY, DE

Contact Information

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Program Description

The objectives of the Commission's biological monitoring program are presently focused upon the 200-mile long non-tidal Delaware River corridor:

1. Protection of high quality aquatic life uses in Water Quality Zones 1A through 1E of the Delaware River, from Hancock, New York to Trenton, New Jersey
2. Development of anti-degradation biological criteria based upon existing water quality
3. Definition of longitudinal changes in benthic community structure along the Delaware River corridor, to support decisions to maintain or improve water quality where necessary

DRBC and the National Park Service (NPS) have operated the Scenic Rivers Monitoring Program since the early 1980s. The Commission has never used biological criteria for 305(b) assessments or determinations of impairment, other than reports arising from fish-tissue toxics analysis and inference of aquatic life use attainment based upon water chemistry. Macroinvertebrate biocriteria were developed for DRBC's Special Protection Waters rules issued in 1990, but the criteria were later found to be based upon inconsistent and non-representative methods, and have not been used as envisioned during development of the Commission's anti-degradation policies.

With the launch of DRBC's Lower Delaware Monitoring Program in 1999, declaration of most of the non-tidal Delaware River as Wild and Scenic in 2000, and major efforts to update DRBC's comprehensive plan and water quality standards (applicable to most of the Delaware River), interest in DRBC's biomonitoring program was renewed. Meetings with state and local partners resulted in the decision that the Commission would bear the primary responsibility for biological monitoring of the Delaware River, while each state would regulate and monitor tributaries. With technical support and advice from NJDEP, PADEP, USGS, USEPA Region 3, NPS, and the Academy of Natural Sciences, DRBC set out to define goals, objectives, and methods for improving its biological assessment program for the river.

DRBC investigated large-river bioassessment methods and decided to wait for issuance of EPA's large-rivers guidance before launching large-scale monitoring in difficult habitats such as pools, rapids, and upper-estuarine reaches. In 2001, DRBC initiated an annual benthic survey in 2001 of wadeable riffle, run, and island margin habitats, to develop a benthic index of biological integrity for the non-tidal river. The annual August/September low-flow survey is narrowly defined to eliminate spatial and temporal variability, enabling site-to-site, reach-to-reach, and year-to-year comparison of results. By 2005, DRBC hopes to have enough data to create a low-flow benthic IBI (B-IBI) for wadeable portions of the Delaware River, and to apply the B-IBI to future 305(b) assessments and protection of existing water quality.

The Commission would like to monitor other assemblages in order to gain a more complete picture of the ecological integrity of the Delaware River, and to measure progress toward objectives defined by the Commission's comprehensive plan. DRBC is investigating methods to assess submerged aquatic vegetation, periphyton, fish, mussels, plankton, invasive exotic species, and ecological characterization of over 50 unique microhabitats observed in the river. These investigations have been scheduled on a rotating basis as special studies, though they are not used in use support and/or impairment determinations.

Within the next year, DRBC and the NPS will begin planning for tributary Boundary Control Point biomonitoring. DRBC will establish locations and methods to define existing water quality and create biological targets at each location for antidegradation purposes. With the river survey in progress, this is an appropriate next step in improving biomonitoring coverage and implementing antidegradation policies. DRBC is also moving away from doing taxonomy in-house due to a lack of both time and work space. The identification work from the annual river survey will likely be contracted out sometime in the near future.

Documentation and Further Information

Delaware River & Bay Water Quality Assessment, 2000 305(b) report: http://www.state.nj.us/drbc/2K305b_text.PDF

DRBC Annual Report 2000: http://www.state.nj.us/drbc/ar2000.htm

DRBC Quality Assurance Project Plan 2001 Update: http://www.state.nj.us/drbc/QAplanLDEL01.PDF

DRBC Publications homepage: http://www.state.nj.us/drbc/public.htm

2001 Biomonitoring Work Plan (contains numerous citations, including three reports on DRBC's 3-year bioassessment study, issued by the Academy of Natural Sciences, Patrick Environmental Research Center with recommendations on how best to proceed with update of biocriteria and implementation of antidegradation as mandated in DRBC's Water Quality Standards)

Delaware River Basin Commission (DRBC)

Interstate compact: PA, NJ, NY, DE

Contact Information

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email: rlimbeck@drbc.state.nj.us

Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
		monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
	✓	support of antidegradation
		evaluation of discharge permit conditions
		TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects and specific river basins or watersheds)*
	✓	fixed station (i.e., water quality monitoring stations) *(specific river basins or watersheds)*
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
		rotating basin
		other:

Stream Miles

Total miles* *(total miles of mainstem segment only, not including tributaries; determined using RF3 - Interstate river corridor is well-defined by river reaches, not watershed based)*	**200**
Total perennial miles	unknown
Total miles assessed for biology	**200**
fully supporting for 305(b)**	n/a
partially/non-supporting for 305(b)**	n/a
listed for 303(d)**	n/a
number of sites sampled *(on an annual basis)*	23
number of miles assessed per site***	~8.7

*DRBC is an Interstate Compact encompassing river miles in four states: Pennsylvania, New Jersey, New York and Delaware, and has not determined the number of total stream miles in the Basin. The Delaware River Basin watershed encompasses 13,539 square miles. Bioassessment and biocriteria activities are concentrated on a 200-mile non-tidal segment of the Delaware River and tributary boundary control points.

**Biocriteria are not currently used for the 305(b) report. Biocriteria were developed years ago, but the extent of their application is unknown.

***The number of miles assessed per site (~8.7) is very rough. DRBC's goal is to sample approximately 10 additional sites, thus reducing this number.

Aquatic Life Use (ALU) Designations and Decision-Making*

ALU designation basis	Single Aquatic Life Use and Fishery Based Uses	
ALU designations in state water quality standards	Two designations: The fishery-based designation is general, narrative, and defined by river zone. The single aquatic life use designation is macroinvertebrate criteria within DRBC's Special Protection Waters areas, and is defined for antidegradation purposes.	
Narrative Biocriteria in WQS	See definition of Existing Water Quality in Special Protection Waters (found in the 2001 workplan) for procedures used to support narrative biocriteria.*	
Numeric Biocriteria in WQS	See DRBC's *Administraive Manual – Part III, Water Quality Regulations*, Section 3.10.3 Stream Quality Objectives, Section A. Antidegradation of Waters, Table 1.*	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
		permitted discharges
		monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	DRBC/NPS attempted to use existing criteria to define perceived problem areas. The existing criteria, as defined, could not distinguish anthropogenic versus natural measurable change. Program redesign is necessary.	

*Application of the existing system has been unsuccessful thus far due to the low priority given to biomonitoring. Program redesign recommendations were recently made to improve effectiveness and applicability of the criteria. Criteria for the entire non-tidal river are currently being updated, and a best-habitat based benthic IBI that might eventually be applied to future 305(b) assessments and the protection of existing water quality is under development. Additional data will be required, as well as a clear definition of how the criteria will be applied to the 305(b) process. Separate criteria will be required for the river, the tributaries, and for different levels of application and interpretation.

Reference Site/Condition Development

Number of reference sites	**23 total**	
Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
		professional judgment
	✓	other: aggregate sites in each river reach were used to define existing water quality for antidegradation purposes.**
Reference site criteria	In known high-quality waters numeric definition of Existing Water Quality provides a reference for comparison. Measurable Change determines departure from the reference condition.	
Characterization of reference sites within a regional context	✓	historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions *UD - tributaries are assessed according to methods used by states to facilitate comparability and data sharing*		ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information	✓	reference sites linked to ALU *(not well linked)*
	✓	reference sites/condition referenced in water quality standards *(found in water quality standards)*
	✓	some reference sites represent acceptable human-induced conditions *(exceptional water quality was defined under 1980's New York City reservoir operations & dischargers)*

**The program's purpose is to protect the high quality of the river; therefore all sites sampled could be theoretically considered reference sites (the same sites are continually sampled each year and findings are compared to the original samples' data to determine if the quality has changed).

Field and Lab Methods

Assemblages assessed	✓	benthos *(<100 samples/year; single season, multiple sites)*
	✓	fish* *(<100 samples/year; single season, multiple sites)*
		periphyton
	✓	other: macrophytes *(<100 samples/year; single season, multiple sites)*

Benthos	
sampling gear	Surber, Hess, D-frame (500 - 600 micron mesh), BFN = Big-River Frame Net (custom rectangular net, bottom frame area .37 square meters, for Delaware River to 3ft deep, 4 fps, 500 micron mesh)
habitat selection	richest habitat, riffle/run (cobble), multihabitat
subsample size	tributaries - entire sample; river - 200 count
taxonomy	tributaries - family; river - genus
Habitat assessments	visual based, hydrogeomorphology, pebble counts, Pfankuch Flow characterization, Simon Channel Evolution Status; mostly performed with bioassessments, some performed independent of bioassessments
Quality assurance program elements	standard operating procedures, quality assurance plan, periodic meetings and training for biologists, sorting and taxonomic proficiency checks, specimen archival

*Some fish tissue data are collected as part of DRBC's monitoring program, but the work is contracted out to NJDEP and the Academy of Natural Sciences in Philadelphia. DRBC also makes use of PADEP, PA Fish and Boat Commission, and USGS NAWQA study data in water quality assessments.

The Delaware Estuary Program recently assembled an interstate committee to standardize fish advisories in interstate waters. DRBC has had trouble in the past with making use attainment calls based upon state fish advisories. Each state sampled different areas, species, and used different criteria. Conflicts among the different states' data arose when DRBC tried to pull everything together for the Delaware River assessment. DRBC's focus upon interstate coordination and cooperation to improve the process has subsequently increased.

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(return single metrics - use endpoint for each single metric)*
		disturbance gradients
		other:
Multimetric thresholds		
transforming metrics into unitless scores		95th percentile of all sites
Evaluation of performance characteristics**	✓	repeat sampling
	✓	precision
	✓	sensitivity
	✓	bias
	✓	accuracy

Biological data	
Storage	STORET, SAS, MS Access and Excel
Retrieval and analysis	SAS

**See reports issued by the Academy of Natural Sciences (ANS) for an evaluation. ANS identified problems with performance characteristics depending on the level of data interpretation. A redesign of the program is necessary, including refinement of the biocriteria, and field and laboratory practices.

Interstate Commission on the Potomac River Basin (ICPRB)

Interstate compact: VA, WV, MD, PA, DC

Contact Information

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Program Description

ICPRB has no water/land ownership, management or regulatory authority, and therefore has set no water quality standards. However, since the Commission's creation in 1940, ICPRB often assists the basin states (Virginia, Maryland, West Virginia and Pennsylvania), the District of Columbia, and the federal government on such formulations. As part of this assistance, ICPRB conducts stream bioassessments, both fish and benthic, consults with the jurisdictions regarding current and proposed biocriteria and water quality standards, and works with the jurisdictions' data to better understand and characterize the environmental conditions of the Potomac River watershed and associated land usages.

ICPRB is currently working to integrate data from many sources (Virginia, Maryland, West Virginia, Pennsylvania, the District of Columbia, various federal and local governments, and nongovernmental sources) into a single reference watershed analysis. In addition to benthic and fish monitoring in streams and wadeable rivers, ICPRB is doing shad and herring restoration work in non-wadeable rivers. The stream data collected downstream of reservoirs, influences reservoir management decisions. The Commission also analyzes estuary data collected by other entities and works on Chesapeake Bay water quality issues.

Documentation and Further Information

Potomac Basin Water Quality Assessment home (with links to District of Columbia, Maryland, Pennsylvania, Virginia and West Virginia 305(b) and 303(d) information): http://www.potomacriver.org/wqassess.htm

Map of 303(d)-Listed Waters in the Potomac Basin: http://www.potomacriver.org/wq303d.htm

Virginia DEQ Water Quality Assessment Guidance Manual for 2002, 305(b) Water Quality Report and 303(d) Impaired Waters List, amended July 2002: http://www.deq.state.va.us/pdf/water/wqassessguide.pdf

2000 Maryland Section 305(b) Water Quality Report, with *Appendix E, Assessment Methodology*, August 2000: http://dnrweb.dnr.state.md.us/download/bays/MD2000_305b.pdf

Commonwealth of Pennsylvania 2000 Water Quality Assessment 305(b) Report: http://www.dep.state.pa.us/dep/deputate/watermgt/Wqp/WQStandards/305_wq2000_narr.htm

For a link to *West Virginia Water Quality Status Assessment 2000 305(b) Report for the period 1997-1999,* go to: http://www.dep.state.wv.us/item.cfm?ssid=11&ss1id=192

For a list of ICPRB publications and ordering information, go to: http://www.potomacriver.org/publications.htm

Interstate Commission on the Potomac River Basin (ICPRB)

Interstate compact: VA, WV, MD, PA, DC

Contact Information

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Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
	✓	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
		promulgated into state water quality standards as biocriteria
		support of antidegradation
		evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects and specific river basins or watersheds)*
		fixed station (i.e., water quality monitoring stations)
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
	✓	rotating basin *(special projects and specific river basins or watersheds)*
		other:

Stream Miles

Total miles* *(total miles of Potomac River mainstem, not including tributaries)*	**383**
Total perennial miles	–
Total miles assessed for biology**	**n/a**
fully supporting for 305(b)	n/a
partially/non-supporting for 305(b)	n/a
listed for 303(d)	n/a
number of sites sampled*	~1,300
number of miles assessed per site	–

*The Potomac River drainage area includes 14,670 square miles in the following jurisdictions: Maryland, Virginia, West Virginia, Pennsylvania and the District of Columbia.

**ICPRB is not a regulatory authority, but assists the states in the Potomac River Basin (ICPRB doesn't develop own criteria, etc.). The Commission looks at the basin as a whole, across state lines, and thus has no way of producing an accurate estimate of miles assessed. Although ICPRB works with the data from roughly 1,300 sampling stations, sampling is only conducted at several hundred of those stations – these include the samples collected and provided to Pennsylvania's Potomac Watershed Program. The rest of the stations are sampled by various state agencies who supply ICPRB with data to analyze and use for management decisions.

Aquatic Life Use (ALU) Designations and Decision-Making*

ALU designation basis	n/a	
ALU designations in state water quality standards	n/a	
Narrative Biocriteria in WQS	n/a	
Numeric Biocriteria in WQS	n/a	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	n/a	cause and effect determinations
	n/a	permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	Not applicable for ICPRB, but member jurisdictions in the Potomac basin use data in various ways.	

*ICPRB does not define aquatic life uses, but uses those designated by member jurisdictions: Virginia, Maryland, West Virginia, Pennsylvania, and the District of Columbia.

Reference Site/Condition Development**

Number of reference sites	**under development**	
Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
		professional judgment
		other:
Reference site criteria	Under development. Each member jurisdiction has its own reference site criteria. ICPRB is working to establish regional reference sites using the "common elements" of the various jurisdictions' habitat evaluations and water quality information. The criteria will be based on water quality data and habitat parameters, and possibly macroinvertebrate data as well. The reference sites will be the least disturbed sites based on these parameters.	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
	✓	gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
	✓	jurisdictional (i.e., statewide)
		other:
Additional information	n/a	reference sites linked to ALU
	n/a	reference sites/condition referenced in water quality standards
		some reference sites represent acceptable human-induced conditions

**Reference sites are presently defined by statistical category (example: 95^{th} percentile), but ICPRB would prefer to establish hypothetical reference conditions.

Field and Lab Methods

Assemblages assessed	✓	benthos *(<100 samples/year; multiple seasons, multiple sites – broad coverage for watershed level)*
	✓	fish *(<100 samples/year; multiple seasons, multiple sites – broad coverage for watershed level)*
		periphyton
	✓	other: phytoplankton and zooplankton *(<100 samples/year; multiple seasons, multiple sites – broad coverage for watershed level)*

Benthos	
sampling gear	kick net (1 meter); 200-400 micron mesh
habitat selection	riffle/run (cobble)
subsample size	entire sample
taxonomy	family
Fish	
sampling gear	backpack electrofisher, seine; 1/4" mesh
habitat selection	multihabitat
sample processing	length measurement and anomalies
subsample	selected species, batch
taxonomy	species
Habitat assessments	visual based; performed with bioassessments
Quality assurance program elements	ICPRB follows QA protocols according to each state's requirements. Elements include periodic meetings and training for biologists, taxonomic proficiency checks, and a certification program for bioassessment.

Data Analysis and Interpretation*

Data analysis tools and methods	✓	summary tables, illustrative graphs
	✓	parametric ANOVAs
	✓	multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients
		other:

Multimetric thresholds	
transforming metrics into unitless scores	Current emphasis is on the 95th percentile of all sites (reference and stressed) and a quadrisection of the range. Presently testing various published methods of establishing scoring thresholds in each jurisdiction.
defining impairment in a multimetric index	Consistent thresholds are currently being assembled from impairment criteria applied by member states.

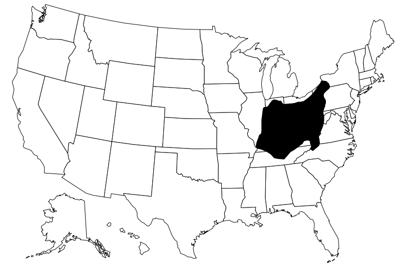
Evaluation of performance characteristics		repeat sampling
		precision
Not currently evaluated		sensitivity
		bias
		accuracy

Biological data	
Storage	Raw data and documentation are obtained from state and federal agencies in varying formats (hardcopy, disc, downloadable ftp files). Data are stored and analyzed using a custom-developed MS Access database similar to EDAS.
Retrieval and analysis	Various statistical software applications are being evaluated; i.e. S-PLUS, Total Access Statistics, et al.

*The objective of the *Basinwide Assessments* program is to integrate and analyze monitoring data from member states' nontidal rivers and streams. While states' data cannot be compared directly, most apply a similar data analysis approach. ICPRB is adapting this analysis framework by selecting and normalizing consistent criteria from the various approaches to define reference and stressed conditions. Invertebrate communities at these sites will be measured and compared. Candidate metrics are also being screened for assessment accuracy and redundancy to select core metrics.

Ohio River Valley Water Sanitation Commission (ORSANCO)

Interstate compact: NY, VA, PA, WV, OH, KY, IN, IL



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Program Description

The strategic objective of ORSANCO's Biological Program is to conduct biological monitoring of the Ohio River in order to determine the extent to which the objective of Article 1 of the Compact "..that the Ohio River be capable of maintaining fish and other aquatic life" is met. Tasks conducted in support of this strategic objective include: 1) Developing techniques for biological monitoring of large rivers in general, and the Ohio River in particular, and 2) Utilizing biological monitoring, assessment, and criteria to characterize the condition of the river. ORSANCO is currently developing numeric biological criteria and plans to integrate biological methods into overall monitoring and assessment efforts.

ORSANCO has been collecting biological data from the Ohio River since 1957 with the initiation of a lockchamber rotenone sampling program, which continues to this day. This method has provided the Commission with a 45-year look at fish community changes within the Ohio River.

ORSANCO is collecting biological data from the Ohio River on behalf of the eight states of the Commission (NY, VA, PA, WV, OH, KY, IN, and IL). These states rely on the Commission to develop appropriate methods, conduct sampling, develop assessment indices and eventually incorporate biological information into all assessment strategies. The states are also relying on ORSANCO to assist them in conducting similar programs on the large Ohio River tributaries within each state.

The Commission uses biological data in a report to each of the states which the states then use for their 305(b) report and 303(d) listings. The Commission is currently in the process of developing numeric biological criteria. Discussions are underway to determine whether the Commission should proceed with referencing biological criteria in Pollution Control Standards for the Ohio River, or incorporating said criteria as 'hard numbers' or codified criteria. ORSANCO will proceed at the recommendation of the states.

ORSANCO is also expanding its programs, including biological efforts, into the tributaries and reaches of the basin. In the very near future, ORSANCO will be working with the states to conduct biological sampling on larger, navigable, tributaries to test methods, develop indices, and eventually expand the coverage of biocriteria. The tributary work will be important in determining how to transition from great rivers to large rivers, in terms of monitoring and assessment, and will enable researchers to make that transition seamlessly.

Documentation and Further Information

ORSANCO 1998 305(b) Fact Sheet for the Ohio River

ORSANCO Water Quality Protection, *Biological Program* homepage: http://www.orsanco.org/watqual/aquatic/biological.htm

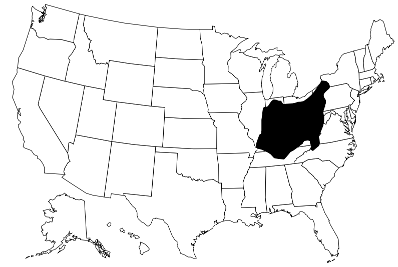
2000 Kentucky Report to Congress on Water Quality, 305(b) report, November 2000: http://water.nr.state.ky.us/wq/305b/2000/2000_305b.htm

1998 Kentucky Report to Congress on Water Quality, 305(b) report, January 1999 (sites sampled by ORSANCO found in *Table 2*): http://water.nr.state.ky.us/305b/

For a list of publications (including QA/QC documents, monitoring and assessment strategies, data summaries, etc.), go to: http://www.orsanco.org/rivinfo/pubs/pubs.htm

Ohio River Valley Water Sanitation Commission (ORSANCO)

Interstate compact: NY, VA, PA, WV, OH, KY, IN, IL



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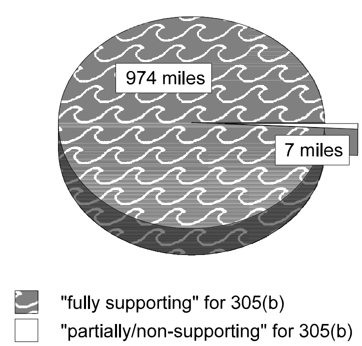
Programmatic Elements

Uses of bioassessment within overall water quality program*	✓	problem identification (screening)
	UD	nonpoint source assessments
	UD	monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
	✓	promulgated into state water quality standards as biocriteria
	UD	support of antidegradation
	UD	evaluation of discharge permit conditions
	UD	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects only)*
	✓	fixed station (i.e., water quality monitoring stations) *(special projects only)*
	UD	probabilistic by stream order/catchment area
	UD	probabilistic by ecoregion, or statewide
		rotating basin
		other:

Stream Miles

Total miles *(total miles of mainstem only, not including tributaries)*	**981**
Total perennial miles	–
Total miles assessed for biology*	**981**
fully supporting for 305(b)*	974
partially/non-supporting for 305(b)*	7
listed for 303(d)*	55
number of sites sampled *(on an annual basis)*	>1,000
number of miles assessed per site	0.5

981 Miles Assessed for Biology



*The Ohio River flows through or borders six states: Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia. It encompasses 203,940 square miles, but ORSANCO only conducts biological monitoring on the mainstem of the Ohio River, which is 981 miles long. ORSANCO produces a 305(b) report exclusively for the Ohio River, and this document is referenced by different states for use in their own 305(b) reports. Fifty-five Ohio River miles are listed on Kentucky's 303(d) list, but this number is based on a past report and the Kentucky Division of Water feels that there is not enough biological data to delist those miles quite yet.

Aquatic Life Use (ALU) Designations and Decision-Making*

ALU designation basis	Single Aquatic Life Use
ALU designations in state water quality standards	One designation: Warmwater Aquatic Life – other categories are under development
Narrative Biocriteria in WQS*	Formal/informal numeric procedures used to support narrative biocriteria are under development.
Numeric Biocriteria in WQS*	under development (to be included or referenced by standards)

Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)	✓	assessment of aquatic resources
	✓	cause and effect determinations
		permitted discharges
	✓	monitoring (e.g., improvements after mitigation)
	✓	watershed based management

Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	This is currently unknown because numeric biocriteria are just being proposed for the water quality standards.

*ORSANCO's water quality standards are the adopted standards that serve as recommendations to states for incorporation into their own standards. ORSANCO is entering review this year (starting with a fish biocriteria proposal); ALU designations and numeric biocriteria are expected to be completed sometime before 2004.

Reference Site/Condition Development

Number of reference sites		**400 total**
Reference site determinations	✓	site-specific
		paired watersheds
	✓	regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria		Least impacted sites are sites out of the immediate influence of human impact. Specifically, one kilometer below discharges or major tributaries as well as free from other obvious disturbance. Least impacted sites are used as a surrogate for reference sites.
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)**
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information	✓	reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

**Plans are underway to develop a tiered aquatic life use approach with expectations based on river reach (ecoregion surrogate) and habitat type.

Field and Lab Methods

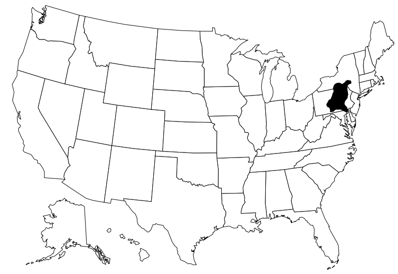
Assemblages assessed	✓	benthos *(100-500 samples/year; multiple seasons, multiple sites – broad coverage for watershed level)*
	✓	fish *(100-500 samples/year; multiple seasons, multiple sites – broad coverage for watershed level)*
		periphyton
		other:
Benthos		
sampling gear	multiplate; standard #30 sieve	
habitat selection	multihabitat	
subsample size	entire sample	
taxonomy	lowest possible level	
Fish		
sampling gear	boat electrofisher; 1/4" mesh	
habitat selection	multihabitat	
sample processing	length measurement, biomass - individual, anomalies	
subsample	none	
taxonomy	species and subspecies	
Habitat assessments	ORSANCO has developed a habitat assessment approach and habitat index for the Ohio River. The index is based on substrate composition (broad categories), depth and cover estimates; these are performed with bioassessments.	
Quality assurance program elements	standard operating procedures, periodic meetings and training for biologists, sorting and taxonomic proficiency checks, specimen archival. There are plans to develop a certification program for bioassessment.	

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
	✓	parametric ANOVAs
	✓	multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
	✓	disturbance gradients
		other:
Multimetric thresholds		
transforming metrics into unitless scores	25th percentile of reference population	
defining impairment in a multimetric index	25th percentile of reference population	
Evaluation of performance characteristics	✓	repeat sampling *(look at site variability)*
		precision
	✓	sensitivity *(look at metrics and index performance)*
		bias
		accuracy
Biological data		
Storage	MS Access	
Retrieval and analysis	Statistica	

Susquehanna River Basin Commission (SRBC)

Interstate compact: NY, PA, MD



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Program Description

The Susquehanna River Basin Commission (SRBC) is the governing agency established to protect and wisely manage the water resources of the Susquehanna River Basin. The Susquehanna River starts in Cooperstown, NY and flows 444 miles to Havre de Grace, MD, where the river meets the Chesapeake Bay. The watershed encompasses parts of New York, Pennsylvania, and Maryland. Currently, SRBC implements several programs assessing the biological condition of streams and rivers, including the Subbasin Survey and Interstate Water Quality Monitoring Network (ISWQN) Programs.

Six subbasins exist in the Susquehanna River Basin: the Chemung, Upper Susquehanna, Middle Susquehanna, West Branch Susquehanna, Juniata, and Lower Susquehanna. SRBC samples each subbasin on a rotating schedule, assessing each approximately every ten years. The assessment evaluates the chemical, biological, and habitat conditions of streams, identifies major sources of pollution, documents changes in stream quality over time, and identifies areas for more intensive study. This program was initiated in 1982 and was refined in 1998 to include a more intensive second year of sampling to address specific local concerns, such as restoration and protection. Year 1 includes collection of macroinvertebrate samples and physical habitat information using Rapid Bioassessment Protocol (RBP) III, water quality collection, and flow measurement in a single-sampling event during baseflow conditions. Year 2 of the program can include a variety of projects, such as more intensive bimonthly water quality sampling to provide information to watershed groups for protection and restoration efforts. All data collected during SRBC's subbasin surveys are used in reporting to the USEPA under Section 305(b) of the Clean Water Act.

The ISWQN program, initiated in 1986, includes periodic collection of water quality and biological samples, as well as physical habitat assessments of interstate streams. Water quality data are collected quarterly and are used to assess compliance with water quality standards, characterize stream quality and seasonal variations, build a database for assessing water quality trends, and identify areas for restoration and protection. SRBC staff collect macroinvertebrate and physical habitat information annually from 51 sites on interstate streams along the New York-Pennsylvania and Pennsylvania-Maryland borders using RBP III methods. Water samples and flow information are collected at 19 sites quarterly and 30 sites yearly. Water quality data also are used to determine the existence and magnitude of trends for selected parameters. All data collected during SRBC's interstate streams surveys are used in 305(b) reporting to USEPA.

Currently, SRBC is initiating a pilot project to determine proper methods of assessing the biological conditions, using benthic macroinvertebrate populations, of the large rivers in the Susquehanna River Basin. The pilot project will take place on the Susquehanna River between Windsor, NY and Sayre, PA, during late summer 2002. Three separate methodologies will be tested: RBP III, artificial substrate samplers, and a diver operated dome (suction) sampler. A habitat assessment will be performed and water quality samples will also be taken at each site. Data will be used to select and calculate metrics for a benthic Index of Biotic Integrity to assess the biological conditions of the large rivers in the Susquehanna River Basin and will be included in 305(b) reporting.

Documentation and Further Information

2000 Susquehanna River Basin Commission 305(b) Narrative

The 1998 Susquehanna River Basin Water Quality Assessment 305(b) Report: http://www.srbc.net/docs/305bReport_201.pdf

Report Announcement - *2002 Susquehanna River Basin Water Quality Assessment 305(b) Report*, Publication No. 220: http://www.srbc.net/docs/summary_may02.PDF

Report Announcement - *Water Quality of Interstate Streams in the Susquehanna River Basin*, Publication No. 211: http://www.srbc.net/pub211summary.pdf

Assessment of Interstate Streams in the Susquehanna River Basin: 1997-1998, Monitoring Report #12, June 1999: http://www.srbc.net/docs/iswq97-98.pdf

Upper Susquehanna Subbasin: A Water Quality and Biological Assessment, 1999: http://www.srbc.net/docs/pub203.pdf

Susquehanna River Basin Commission (SRBC)

Interstate compact: NY, PA, MD

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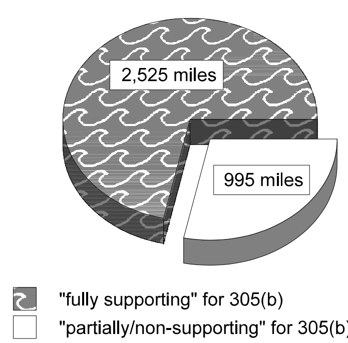
Programmatic Elements

Uses of bioassessment within overall water quality program	✓	problem identification (screening)
	✓	nonpoint source assessments
		monitoring the effectiveness of BMPs
	✓	ALU determinations/ambient monitoring
		promulgated into state water quality standards as biocriteria
		support of antidegradation
		evaluation of discharge permit conditions
	✓	TMDL assessment and monitoring
		other:
Applicable monitoring designs	✓	targeted (i.e., sites selected for specific purpose) *(special projects only)*
	✓	fixed station (i.e., water quality monitoring stations) *(specific river basins or watersheds)*
		probabilistic by stream order/catchment area
		probabilistic by ecoregion, or statewide
	✓	rotating basin *(comprehensive use throughout jurisdiction)*
		other:

Stream Miles

Total miles*	**31,193**
Total perennial miles	–
Total miles assessed for biology	**3,520**
fully supporting for 305(b)**	2,525
partially/non-supporting for 305(b)**	995
listed for 303(d)	n/a
number of sites sampled *(on an annual basis)*	317
number of miles assessed per site	11

3,520 Miles Assessed for Biology



*Stream mile estimate is based on the 1993 EPA document, *Total Waters Estimates for United States Streams and Lakes: Total Waters Database and Reporting Program*. Monitoring Branch Assessment and Watershed Protection Division, Office of Wetlands, Oceans, and Watersheds, Office of Water, Washington, D.C.

**305(b) reporting is for SRBC benefit, USEPA requirements (contracts), and to provide more samples for states to use in their official 305(b) and 303(d) listings.

Aquatic Life Use (ALU) Designations and Decision-Making*

ALU designation basis		
ALU designations in state water quality standards		
Narrative Biocriteria in WQS		
Numeric Biocriteria in WQS		
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria)		assessment of aquatic resources
		cause and effect determinations
		permitted discharges
		monitoring (e.g., improvements after mitigation)
		watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU		

*This section is not applicable to SRBC's biological monitoring program. SRBC does not define aquatic life uses, but utilizes those designated by member jurisdictions: Maryland, New York, and Pennsylvania.

Reference Site/Condition Development

Number of reference sites	**total number varies according to project**	
Reference site determinations		site-specific
		paired watersheds
	✓	regional (aggregate of sites)
	✓	professional judgment
		other:
Reference site criteria	Habitat disturbance, best available conditions of the biological and chemical components	
Characterization of reference sites within a regional context		historical conditions
	✓	least disturbed sites
		gradient response
		professional judgment
		other:
Stream stratification within regional reference conditions	✓	ecoregions (or some aggregate)
		elevation
		stream type
		multivariate grouping
		jurisdictional (i.e., statewide)
		other:
Additional information		reference sites linked to ALU
		reference sites/condition referenced in water quality standards
	✓	some reference sites represent acceptable human-induced conditions

Field and Lab Methods

Assemblages assessed	✓	benthos *(100-500 samples/year; single season, multiple sites - broad coverage)*
		fish
		periphyton
		other:
Benthos		
sampling gear		D-frame, kick net (1 meter); 500-600 micron mesh
habitat selection		riffle/run (cobble)
subsample size		100 count
taxonomy		genus
Habitat assessments		visual based; performed with bioassessments
Quality assurance program elements		standard operating procedures, quality assurance plan, periodic meetings and training for biologists, sorting and taxonomic proficiency checks, specimen archival

Data Analysis and Interpretation

Data analysis tools and methods	✓	summary tables, illustrative graphs
		parametric ANOVAs
		multivariate analysis
	✓	biological metrics *(aggregate metrics into an index)*
		disturbance gradients
		other:
Multimetric thresholds		
transforming metrics into unitless scores		varies according to metric used: RBP 1989 methods. Always try to use 6 metrics for each project, but the metrics chosen vary depending on the project
defining impairment in a multimetric index		varies according to metric used: >81% non impaired, though this could vary slightly depending on the project
Evaluation of performance characteristics		repeat sampling
		precision
Not currently evaluated		sensitivity
		bias
		accuracy
Biological data		
Storage		Excel spreadsheets for internal projects; SRBC is currently working on entering data into STORET.
Retrieval and analysis		Excel spreadsheets for internal projects; working on finding a good statistical package that fits needs

4. RELEVANT EXCERPTS FROM WATER QUALITY STANDARDS AND BIOCRITERIA LANGUAGE

This section of the report contains excerpts from the approved water quality standards of states, tribes, territories, and interstate commissions. These excerpts may contain any or all of the following: designated uses as related to aquatic life uses, narrative and/or numeric biocriteria, and any other specific sections that are relevant to the entity's protection and propagation of aquatic life. It is important to note that this chapter is not intended to be a compendium of the entire water quality standard for each state, tribe and territory, but rather to highlight specific language within the standard that describes the use of biology and biological assessments to develop relevant criteria that assess water quality and protect aquatic life.

STATES

Alabama

SOURCE: Alabama Department of Environmental Management, Water Division - Water Quality Program, Chapter 335, Division 6, Volume 1, Chapter 10, Water Quality Criteria: September 7, 2000.
http://www.adem.state.al.us/Regulations/Regulations/regulations.htm

335-6-10-.03 Water Use Classifications.

1. Outstanding Alabama Water
3. Swimming and Other Whole Body Water-Contact Sports
5. Fish and Wildlife
6. Limited Warmwater Fishery
7. Agricultural and Industrial Water Supply

335-6-10-.04 Antidegradation Policy.

(1) The purpose and intent of the water quality standards is to conserve the waters of the State of Alabama and to protect, maintain and improve the quality thereof for public water supplies, for the propagation of wildlife, fish and aquatic life, and for domestic, agricultural, industrial, recreational and other legitimate beneficial uses; and to provide for the prevention, abatement and control of new or existing water pollution.

(4) Where high quality waters constitute an outstanding National resource, such as waters of national and state parks and wildlife refuges and waters of exceptional recreational or ecological significance, that water quality shall be maintained and protected.

(5) Developments constituting a new or increased source of thermal pollution shall assure that such release will not impair the propagation of a balanced indigenous population of fish and aquatic life.

335-6-10-.06 Minimum Conditions Applicable to All State Waters. The following minimum conditions are applicable to all State waters, at all places and at all times, regardless of their uses:

(c) State waters shall be free from substances attributable to sewage, industrial wastes or other wastes in concentrations or combinations which are toxic or harmful to human, animal or aquatic life to the extent commensurate with the designated usage of such waters.

335-6-10-.09 Specific Water Quality Criteria.

(1) OUTSTANDING ALABAMA WATER

(a) Best usage of waters: activities consistent with the natural characteristics of the waters.

(b) Conditions related to best usage:

1. High quality waters that constitute an outstanding Alabama resource, such as waters of state parks and wildlife refuges and waters of exceptional recreational or ecological significance, may be considered for classification as an Outstanding Alabama Water (OAW).

(3) SWIMMING AND OTHER WHOLE BODY WATER-CONTACT SPORTS

(b) Conditions related to best usage: ... The quality of waters will also be suitable for the propagation of fish, wildlife and aquatic life. The quality of salt waters and estuarine waters to which this classification is assigned will be suitable for the propagation and harvesting of shrimp and crabs.

(5) FISH AND WILDLIFE

(a) Best usage of waters: fishing, propagation of fish, aquatic life, and wildlife...

(b) Conditions related to best usage: the waters will be suitable for fish, aquatic life and wildlife propagation. The quality of salt and estuarine waters to which this classification is assigned will also be suitable for the propagation of shrimp and crabs.

(e) Specific criteria:

3. Temperature:

(ii) The maximum temperature in streams, lakes, and reservoirs in the Tennessee and Cahaba River Basins, and for that portion of the Tallapoosa River Basin from the tailrace of Thurlow Dam at Tallassee downstream to the junction of the Coosa and Tallapoosa Rivers which has been designated by the Alabama Department of Conservation and Natural Resources as supporting smallmouth bass, sauger, or walleye, shall not exceed 86° F.

(vi) In all waters the normal daily and seasonal temperature variations that were present before the addition of artificial heat shall be maintained, and there shall be no thermal block to the migration of aquatic organisms.

(vii) Thermal permit limitations in NPDES permits may be less stringent than those required by subparagraphs (i)-(iv) hereof when a showing by the discharger has been made pursuant to Section 316 of the Federal Water Pollution Control Act (FWPCA), 33 U.S.C. §1251 et seq. or pursuant to a study of an equal or more stringent nature required by the State of Alabama authorized by Title 22, Section 22-22-9(c), Code of Alabama, 1975, that such limitations will assure the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife, in and on the body of water to which the discharge is made. Any such demonstration shall take into account the interaction of the thermal discharge component with other pollutants discharged.

4. Dissolved oxygen:

(i) For a diversified warm water biota, including game fish, daily dissolved oxygen concentrations shall not be less than 5 mg/l at all times; except under extreme conditions due to natural causes, it may range between 5 mg/l and 4 mg/l, provided that the water quality is favorable in all other parameters. The normal seasonal and daily fluctuations shall be maintained above these levels. In no event shall the dissolved oxygen level be less than 4 mg/l due to discharges from existing hydroelectric generation impoundments. All new hydroelectric generation impoundments, including addition of new hydroelectric generation units to existing impoundments, shall be designed so that the discharge will contain at least 5 mg/l dissolved oxygen where practicable and technologically possible. The Environmental Protection Agency, in cooperation with the State of Alabama and parties responsible for impoundments, shall develop a program to improve the design of existing facilities.

(iv) In the application of dissolved oxygen criteria referred to above, dissolved oxygen shall be measured at a depth of 5 feet in waters 10 feet or greater in depth; and for those waters less than 10 feet in depth, dissolved oxygen criteria will be applied at mid-depth.

5. Toxic substances attributable to sewage, industrial wastes, or other wastes: only such amounts, whether alone or in combination with other substances, as will not exhibit acute toxicity or chronic toxicity, as demonstrated by effluent toxicity testing or by application of numeric criteria given in Rule 335-6-10-.07, to fish and aquatic life, including shrimp and crabs in estuarine or salt waters or the propagation thereof.

6. Taste, odor, and color-producing substances attributable to sewage, industrial wastes, or other wastes: only such amounts, whether alone or in combination with other substances, as will not exhibit acute toxicity or chronic toxicity, as demonstrated by effluent toxicity testing or by application of numeric criteria given in Rule 335-6-10-.07, to fish and aquatic life, including shrimp and crabs in estuarine and salt waters or adversely affect the propagation thereof; impair the palatability or marketability of fish and wildlife or shrimp and crabs in estuarine and salt waters; or unreasonably affect the aesthetic value of waters for any use under this classification.

(6) LIMITED WARMWATER FISHERY
 (a) The (a) The provisions of the Fish and Wildlife water use classification at Rule 335-6-10-.09(5) shall apply to the Limited Warmwater Fishery water use classification, except as noted below. Unless alternative criteria for a given parameter are provided in paragraph (e) below, the applicable Fish and Wildlife criteria at paragraph 10-.09(5)(e) shall apply year-round. At the time the Department proposes to assign the Limited Warmwater Fishery classification to a specific waterbody, the Department may apply criteria from other classifications within this chapter if necessary to protect a documented, legitimate existing use.

(7) AGRICULTURAL AND INDUSTRIAL WATER SUPPLY
 (b) Conditions related to best usage:
 (i) The waters, except for natural impurities which may be present therein, will be suitable for ... fish survival...

335-6-10-.10 Special Designations.
(1) OUTSTANDING NATIONAL RESOURCE WATER
 (a) Designation:
 1. High quality waters that constitute an outstanding National resource, such as waters of national and state parks and wildlife refuges and waters of exceptional recreational or ecological significance, may be considered for designation as an Outstanding National Resource Water (ONRW). For waters designated as ONRW, existing water quality shall be maintained and protected.

Alaska

SOURCE: Alaska Administrative Code: Chapter 70, Title 18, amended as of May 27, 1999: http://www.state.ak.us/local/akpages/ENV.CONSERV/title18/70wqs.pdf

18 AAC 70.020. PROTECTED WATER USE CLASSES AND SUBCLASSES; WATER QUALITY CRITERIA; WATER QUALITY STANDARDS TABLE.
(a) Classes and subclasses of use of the state's water protected by criteria set out under (b) of this section are:
 (1) fresh water
 (A) aquaculture
 (C) growth and propagation of fish, shellfish, other aquatic life, and wildlife; and
 (2) marine water
 (C) growth and propagation of fish, shellfish, other aquatic life, and wildlife; and
 (D) harvesting for consumption of raw mollusks or other raw aquatic life.

Arizona

SOURCE: Arizona Administrative Code, Title 18, Environmental Quality, Chapter 11. Department of Environmental Quality, Article 1. Water Quality Standards for Surface Waters, amended effective March 8, 2002: http://www.sosaz.com/public_services/Title_18/18-11.htm

R18-11-101. Definitions
The terms of this Article shall have the following meanings:

7. “Aquatic and wildlife (cold water)” means the use of a surface water by animals, plants, or other cold-water organisms, generally occurring at elevations greater than 5000 feet, for habitation, growth, or propagation.

8. "Aquatic and wildlife (effluent dependent water)" means the use of an effluent dependent water by animals, plants, or other organisms for habitation, growth, or propagation.

9. "Aquatic and wildlife (ephemeral)" means the use of an ephemeral water by animals, plants, or other organisms, excluding fish, for habitation, growth, or propagation.

10. “Aquatic and wildlife (warm water)” means the use of a surface water by animals, plants, or other warm-water organisms, generally occurring at elevations less than 5000 feet, for habitation, growth, or propagation.

22. “Ephemeral water” means a surface water that has a channel that is at all times above the water table and that flows only in direct response to precipitation.

26. "Fish consumption" means the use of a surface water by humans for harvesting aquatic organisms for consumption. Harvestable aquatic organisms include, but are not limited to, fish, clams, turtles, crayfish, and frogs.

44. "Unique water" means a surface water which has been classified as an outstanding state resource water by the Director under R18-11-112.

<u>R18-11-108. Narrative Water Quality Standards</u>

A. A surface water shall be free from pollutants in amounts or combinations that:
   1. Settle to form bottom deposits that inhibit or prohibit the habitation, growth, or propagation of aquatic life or that impair recreational uses;
   5. Are toxic to humans, animals, plants, or other organisms;
   6. Cause the growth of algae or aquatic plants that inhibit or prohibit the habitation, growth, or propagation of other aquatic life or that impair recreational uses;

<u>R18-11-112. Unique Waters</u>

D. The Director may classify a surface water as a unique water upon finding that the surface water is an outstanding state resource water based upon the following criteria:
   a. The surface water is a perennial water;
   b. The surface water is in a free-flowing condition. For purposes of this subsection, “in a free-flowing condition” means that a surface water does not have an impoundment, diversion, channelization, rip-rapping or other bank armor, or another hydrological modification within the reach nominated for unique water classification;
   c. The surface water has good water quality. For purposes of this subsection, “good water quality” means that the surface water has water quality that meets or exceeds applicable surface water quality standards. A surface water that is listed as impaired under § 303(d) of the Clean Water Act [33 U.S.C. § 1313] is ineligible for unique waters classification; and
   d. The surface water meets one or both of the following conditions:
   e. The surface water is of exceptional recreational or ecological significance because of its unique attributes, including but not limited to, attributes related to the geology, flora, fauna, water quality, aesthetic values, or the wilderness characteristics of the surface water.
   f. Threatened or endangered species are known to be associated with the surface water and the existing water quality is essential to the maintenance and propagation of a threatened or endangered species or the surface water provides critical habitat for a threatened or endangered species. Endangered or threatened species are identified in “Endangered and Threatened Wildlife and Plants,” 50 CFR § 17.11 and § 17.12 (revised as of October 1, 2000) which is incorporated by reference and on file with the Department and the Office of the Secretary of State. This incorporation by reference contains no future editions or amendments.

Arkansas

SOURCE: Arkansas Pollution Control and Ecology Commission Regulation 2**,** Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas, October 28, 2002, Chapter 3 Water Body Uses, http://www.adeq.state.ar.us/regs/files/reg02_final_021028.pdf

Section 2.302 Designated Uses
The designated uses are defined as follows:

A. Extraordinary Resource Waters - This beneficial use is a combination of the chemical, physical and biological characteristics of a waterbody and its watershed which is characterized by scenic beauty, aesthetics, scientific values, broad scope recreation potential and intangible social values.

B. Ecologically Sensitive Waterbody - This beneficial use identifies segments known to provide habitat within the existing range of threatened, endangered or endemic species of aquatic or semi-aquatic life forms.

C. Natural and Scenic Waterways - This beneficial use identifies segments which have been legislatively adopted into a state or federal system.

F. Fisheries - This beneficial use provides for the protection and propagation of fish, shellfish and other forms of aquatic life. It is further subdivided into the following subcategories:

(1) Trout - water which is suitable for the growth and survival of trout (Family: Salmonidae).

(2) Lakes and Reservoirs - water which is suitable for the protection and propagation of fish and other forms of aquatic life adapted to impounded waters. Generally characterized by a dominance of sunfishes such as bluegill or similar species, black basses and crappie. May include substantial populations of catfishes such as channel, blue and flathead catfish and commercial fishes including carp, buffalo and suckers. Forage fishes are normally shad or various species of minnows. Unique populations of walleye, striped bass and/or trout may also exist.

(3) Streams - water which is suitable for the protection and propagation of fish and other forms of aquatic life adapted to flowing water systems whether or not the flow is perennial.

(a) Ozark Highlands Ecoregion - Streams supporting diverse communities of indigenous or adapted species of fish and other forms of aquatic life. Fish communities are characterized by a preponderance of sensitive species and normally dominated by a diverse minnow community followed by sunfishes and darters. The community may be generally characterized by the following fishes:

Key Species	Indicator Species
Duskystripe shiner	Banded sculpin
Northern hogsucker	Ozark madtom
Slender madtom	Southern redbelly dace
"Rock" basses	Whitetail shiner
Rainbow and/or Orangethroat darters	Ozark minnow
Smallmouth bass	

(b) Boston Mountains Ecoregion - Streams supporting diverse communities of indigenous or adapted species of fish and other forms of aquatic life. Fish communities are characterized by a major proportion of sensitive species; a diverse, often darter-dominated community exists but with nearly equal proportions of minnows and sunfishes. The community may be generally characterized by the following fishes:

Key Species	Indicator Species
Bigeye shiner	Shadow bass
Black redhorse	Wedgespot shiner

Key Species	Indicator Species
Slender madtom	Longnose darter
Longear sunfish	Fantail darter
Greenside darter	
Smallmouth bass	

(c) Arkansas River Valley Ecoregion - Streams supporting diverse communities of indigenous or adapted species of fish and other forms of aquatic life. Fish communities are characterized by a substantial proportion of sensitive species; a sunfish- and minnow-dominated community exists but with substantial proportions of darters and catfishes (particularly madtoms). The community may be generally characterized by the following fishes:

Key Species	Indicator Species
Bluntnose minnow	Orangespotted sunfish
Golden redhorse	Blacksidedarter
Yellow bullhead	Madtoms
Longear sunfish	
Redfin darter	
Spotted bass	

(d) Ouachita Mountains Ecoregion - Streams supporting diverse communities of indigenous or adapted species of fish and other forms of aquatic life. The fish community is characterized by a major proportion of sensitive species; a minnow-sunfish-dominated community exists, followed by darters. The community may be generally characterized by the following fishes:

Key Species	Indicator Species
Bigeye shiner	Shadow bass
Northern hogsucker	Gravel chub
Freckled madtom	Northern studfish
Longear sunfish	Striped shiner
Orangebelly darter	
Smallmouth bass	

(e) Typical Gulf Coastal Ecoregion - Streams supporting diverse communities of indigenous or adapted species of fish and other forms of aquatic life. Fish communities are characterized by a limited proportion of sensitive species; sunfishes are distinctly dominant followed by darters and minnows. The community may be generally characterized by the following fishes:

Key Species	Indicator Species
Redfin shiner	Pirate perch
Spotted sucker	Warmouth
Yellow bullhead	Spotted sunfish
Flier	Dusky darter

Key Species	Indicator Species
Slough darter	Creek chubsucker
Grass pickerel	Banded pygmy sunfish

(f) Springwater-influenced Gulf Coastal Ecoregion -Streams supporting diverse communities of indigenous or adapted species of fish and other forms of aquatic life. Fish communities are characterized by a substantial proportion of sensitive species; sunfishes normally dominate the community and are followed by darters and minnows. The community may be generally characterized by the following fishes:

Key Species	Indicator Species
Redfin shiner	Pirate perch
Blacktail redhorse	Golden redhorse
Freckled madtom	Spotted bass
Longear sunfish	Scaly sand darter
Creole darter	Striped shiner
Grass pickerel	Banded pygmy sunfish

(g) Least-altered Delta Ecoregion - Streams supporting diverse communities of indigenous or adapted species of fish and other forms of aquatic life. Fish communities are characterized by an insignificant proportion of sensitive species; sunfishes are distinctly dominant followed by minnows. The community may be generally characterized by the following fishes:

Key Species	Indicator Species
Ribbon shiner	Pugnose minnow
Smallmouth buffalo	Mosquitofish
Yellow bullhead	Pirate perch
Bluegill	Tadpole madtom
Bluntnose darter	Banded pygmy sunfish
Largemouth bass	

(h) Channel-altered Delta Ecoregion- Streams supporting diverse communities of indigenous or adapted species of fish and other forms of aquatic life. Fish communities are characterized by an absence of sensitive species; sunfishes and minnows dominate the population followed by catfishes. The community may be generally characterized by the following fishes:

Key Species	Indicator Species
Blacktail shiner	Mosquitofish
Drum	Gizzard shad
Carp	Emerald shiner
Channel catfish	
Green sunfish	
Spotted gar	

California*

*This language has not been reviewed for accuracy by state/tribal agency.

SOURCE: California Ocean Plan, Water Quality Control Plan for Ocean Waters of California, State Water Resources Control Resolution No. 90-27, Approval of the Amendment to the Water Quality Control Plan For Ocean Waters of California, effective March 22, 1990.
http://www.epa.gov/ost/standards/wqslibrary

Chapter II WATER QUALITY OBJECTIVES

E. Biological Characteristics

1. Marine communities, including vertebrate, invertebrate, and plant species, shall not be degraded.

Chapter III GENERAL REQUIREMENTS FOR MANAGEMENT OF WASTE* DISCHARGE TO THE OCEAN*

A. Waste management systems that discharge to the ocean must be designed and operated in a manner that will maintain the indigenous marine life and a healthy and diverse marine community.

B. Waste discharged to the ocean must be essentially free of:

2. Settleable material or substances that may form sediments which will degrade benthic communities or other aquatic life.
3. Substances which will accumulate to toxic levels in marine waters, sediments or biota.
4. Substances that significantly decrease the natural light to benthic communities and other marine life.

D. Location of waste discharges must be determined after a detailed assessment of the oceanographic characteristics and current patterns to assure that:

2. Natural water quality conditions are not altered in areas designated as being of special biological significance or areas that existing marine laboratories use as a source of seawater.

Chapter V DISCHARGE PROHIBITIONS

B. Areas of Special Biological Significance--Waste shall not be discharged to areas designated as being of special biological significance. Discharges shall be located a sufficient distance from such designated areas to assure maintenance or natural water quality conditions in these areas.

Region I (North Coast)

Source: Water Quality Control Plan for the North Coast Region, North Coast Regional Water Quality Control Board, Section 6 - Surveillance and Monitoring, Section 6-1.00, amended May 23, 1996. http://www.epa.gov/ost/standards/wqslibrary/ca/ca_9_north_coast.pdf

STATEWIDE MONITORING PROGRAMS

State Mussel Watch Program

The California State Mussel Watch (SMW) Program is a long-term monitoring program administered by the State Water Board. Actual sampling and analysis are performed by the Department of Fish and Game. SMW provides the State Water Board and the six coastal regional water boards with an indication of geographical and temporal (year-to-year) trends in toxic pollutants along the California coast. Mussels (the common bay mussel, Myilus edulis, and the California mussel, M. californianus) have been shown to be efficient bioaccumulators of many toxic substances in their water environment. Further, the sedentary nature of mussels, whether native or transplanted, permits a time integrated sampling of toxic pollutants at one location. The merits of employing mussels as water quality indicators are well established in the scientific literature, previous SMW reports, and other scientific publications. The North Coast Region will continue to participate in existing SMW monitoring and the development of freshwater applications. The North Coast Region has been involved in developing freshwater applications of SMW methodology, using freshwater clams, Corbicula sp. The North Coast Region has required that some discharges be monitored using these techniques. There are current plans to expand the use of these organisms as indicators in sensitive areas. In the North Coast Region sampling under the SMW program has led to the detection and mitigation of controllable releases of toxic substances. Sampling priorities are directed toward areas of immediate concern.

Region II (San Francisco Bay Basin)

Source: Chapter 2, Beneficial Uses, Water Quality Control Plan, Region 2, California Regional Water Quality Control Board, San Francisco Bay Region, June 21, 1995:

http://www.epa.gov/ost/standards/wqslibrary/ca/ca_9_san_francisco.pdf

Definitions of Beneficial Uses
(ASBS) Areas of Special Biological Significance
Areas designated by the State Water Resources Control Board.
These include marine life refuges, ecological reserves, and designated areas where the preservation and enhancement of natural resources requires special protection, in these areas, alteration of natural water quality is undesirable. The areas that have been designated as ASBS in this region are depicted in Figure 2-1. The State Ocean Plan (see Chapter 5) requires wastes to be discharged at a suffitionfor cient distance from these areas to assure maintenance of natural water quality conditions

(COLD) COLD FRESHWATER HABITAT
Uses of water that support cold water ecosysterns,including, but not limited to preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

Cold freshwater habitats generally support trout and may support the anadromous salmon and steelhead fisheries as well. Cold water habitats are commonly well-oxygenated. Life within these waters is relatively intolerant to environmental stresses. Often, soft waters feed cold water habitat These waters render fish more susceptible to toxic metals, such as copper, because of their lower buffering capacity.

(EST) ESTUARINE HABITAT
Uses of water that support estuarine ecosysterns, including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds), and the propagation, sustenance, and migration of estuarine organisms.

Estuarine habitat provides an essential and unique habitat that serves to acclimate anadromous fishes (salmon, striped bass) migrating into fresh or marine water conditions. The protection of estuarine habitat is contingent upon (1) the maintenance of adequate Delta outflow to provide mixing and salinity control; and (2) provisions to protect wildlife habitat associated with marshlands and essential to the Bay periphery (i.e., prevention of fill activities). Estuarine habitat is generally associated with moderate seasonal fluctuations in dissolved oxygen, pH, and temperature and with a wide range in turbidity.

(MAR) MARINE HABITAT
Uses of water that support marine ecosysterns, including, but not limited to, preservation or enhancement of marine habitats, vegetation such as kelp, fish, shellfish, or wildlife (e.g., marine mammals, shorebirds).

In many cases, the protection of marine habitat will be accomplished by measures that protect wildlife habitat generally, but more stringent criteria may be necessary for waterfowl marshes and other habitat, such as those for shellfish and marine fishes. Some marine habitats, such as important intertidal zones and kelp beds, may require special protection.

(MIGR) FISH MIGRATION
Uses of water that support habitats necessary for migration, acclimatization between fresh water and salt water, and protection of aquatic organisms that are temporary inhabitants of waters within the region.

The water quality provisions acceptable to cold water fish generally protect anadromous fis*h* as well. However, particular attention must be paid to maintaining zones of passage. Any barrier to migration or free movement of migratory fish is harmful. Natural tidal movement in estuaries and unimpeded river flows are necessary to sustain migratory fish and their offspring. A water quality barrier, whether thermal, physical, or chemical, can destroy the integrity of the migration mute and lead to the rapid decline of dependent fisheries. Water quality may vary through a zone of passage as a result of natural or human-induced activities. Fresh water entering estuaries may float on the surface of the denser salt water or hug one shore as a result of density differences related to water temperature, salinity, or suspended matter.

(RARE) PRESERVATION OF RARE AND ENDANGERED SPECIES
Uses of waters that support habitats necessary for the survival and successful maintenance of plant or animal species established under state and/or federal law as rare, threatened, or endangered.

The water quality criteria to be achieved that would encourage development and protection of rare and endangered species should be the same as those for protection of fish and wildlife habitats generally. However, where rare or endangered species exist, special control requirements may be necessary to assure attainment and maintenance of particular quality criteria, which may vary slightly with the environmental needs of each particular species. Criteria for species using areas of special biological significance should likewise be derived from the general criteria for the habitat types involved, with special management diligence given where required.

<u>(SPWN) FISH SPAWNING</u>
Uses of water that support high quality aquatic habitats suitable for reproduction and early deteiopment of fish.

Dissolved oxygen levels in spawning areas should ideally approach saturation levels. Free movement of water is essential to maintain well-oxygenated conditions around eggs deposited in sediments. Water temperature, size distribution and organic content of sediments, water depth, and current velocity are also important determinants of spawning area adequacy.

<u>(WARM) WARM FRESHWATER HABITAT</u>
Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

The warm freshwater habitats supporting bass, bluegill, perch, and other panfish are generally lakes and reservoirs, although some minor streams will serve this purpose where stream flow is sufficient to sustain the fishery. The habitat is also important to a variety of nonfish species, such as flogs, crayfish, and insects, which provide food for fish and small mammals. This habitat is less sensitive to environmental changes, but more diverse than the cold freshwater habitat and natural fluctuations in temperature, dissolved oxygen, pH, and turbidity are usually greater.

<u>WII.D) WILDLIFE HABITAT</u>
Uses of waters that support wildllife habitats, including, but not limited to, the preservation and enhancement of vegetation and prey species used by wildlife, such as waterfowl.

The two most important types of wildlife habitat are riparian and wetland habitats. These habitats can be threatened by development, erosion, and sedimentation, as well as by poor water quality. The water quality requirements of wildlife pertain to the water directly ingested, the aquatic habitat itself, and the effect of water quality on the production of food materials. Waterfowl habitat is particularly sensitive to changes in water quality. Dissolved oxygen, pH, alkalinity, salinity, turbidity, settleable matter, oil, toxicants, and specific disease organisms are water quality characteristics particularly important to waterfowl habitat. Dissolved oxygen is needed in waterfowl habitats to suppress development of botulism organisms; botulism has killed millions of waterfowl. It is particularly important to mainrain adequate circulation and aerobic conditions in shallow fringe areas of ponds or reservoirs where botulism has caused problems.

Region III (Central Coast)
Source: Water Quality Control Plan -Regional Water Quality Control Board 3 (Central Coast), California Regional Water Quality Control Board, Chapter 6: Surveillance And Monitoring, pg. VI-2, September 8, 1991: http://www.epa.gov/ost/standards/wqslibrary/ca/ca_9_wqcp.pdf

III.A.1. TOXIC SUBSTANCE MONITORING
The Toxic Substances Monitoring (TSM) portion of the Primary Network has been integrated with other Primary Network Monitoring. Streams and lakes were ranked according to various criteria established to indicate their importance to the State in terms of water quality. From this process, the water bodies ranked Priority 1, or highest priority, were included in the Primary Network; routine chemical and biological water monitoring is performed by DWR and/or the USGS; and toxic substances monitoring of resident organisms is performed by the Department of Fish and Game. The objectives of the Primary Network TSM program are:

1. To develop statewide baseline data and to demonstrate trends in the occurrence of toxic elements and organic substances in the aquatic biota,

Region IV (Los Angeles)
Source: Water Quality Control Plan Los Angeles - Region Basin Plan for the Coastal Watersheds of Los

Angeles and Ventura Counties, Chapter 6: Surveillance And Monitoring, approved February 23, 1995: http://www.epa.gov/ost/standards/wqslibrary/ca/ca_9_los_angeles.pdf

Biological Criteria
Biological criteria are narrative (and sometimes numeric) expressions that describe the biological integrity of aquatic communities (EPA, 1991). Biological criteria supplement other water quality objectives (physical, chemical, toxicity) by providing a direct measure of aquatic communities at risk from human activities. These criteria can also provide evidence of streams with exceptional water quality. Baseline data must be collected from both reference and impacted streams in the Region. Regular monitoring of these areas can then provide a continual assessment of instream impacts. Over 30 of the 50 states have developed, or are developing, biological criteria programs. Although there is not a current biological criteria program in the Region, Regional Board staff are planning to begin conducting baseline surveys in the coming years. Although **there is not a current** biological criteria program in the Region, Regional Board staff are planning to begin conducting baseline surveys in the coming years.

Colorado

SOURCE: Colorado Department of Public Health and Environment, Department Regulations, Water Quality Control Commission, Surface Water Quality Classifications & Standards, Regulation 31- Basic Standards & Methodologies for Surface Water, amended effective October 30, 2001: http://www.cdphe.state.co.us/op/regs/100231.pdf and http://www.cdphe.state.co.us/wq/wqhom.html

31.5 DEFINITIONS

(8) "COLD WATER BIOTA" means aquatic life, including trout, normally found in waters where the summer temperature does not often exceed 20° C.

(32) "WARM WATER BIOTA" means aquatic life normally found in waters where the summer temperature frequently exceeds 20° C.

31.11 BASIC STANDARDS APPLICABLE TO SURFACE WATERS OF THE STATE
All surface waters of the state are subject to the following basic standards; however, discharge of substances regulated by permits which are within those permit limitations shall not be a basis for enforcement proceedings under these basic standards:

(1) Except where authorized by permits, BMP's, 401 certifications, or plans of operation approved by the Division or other applicable agencies, state surface waters shall be free from substances attributable to human-caused point source or nonpoint source discharge in amounts, concentrations or combinations which:

(a) for all surface waters of the state except wetlands;
(v) are harmful to the beneficial uses or toxic to humans, animals, plants, or aquatic life; or
(vi) produce a predominance of undesirable aquatic life;

(b) for surface waters in wetlands;
(ii) are toxic to humans, animals, plants, or aquatic life of the wetland.

31.13 STATE USE CLASSIFICATIONS

(c) Aquatic Life
These surface waters presently support aquatic life uses as described below, or such uses may reasonably be expected in the future due to the suitability of present conditions, or the waters are intended to become suitable for such uses as a goal:
(i) Class I - Cold Water Aquatic Life
These are waters that (1) currently are capable of sustaining a wide variety of cold water biota, including sensitive species, or (2) could sustain such biota but for correctable water quality conditions. Waters shall be considered capable of sustaining such biota where physical habitat, water flows or levels, and water quality conditions result in no substantial impairment of the

abundance and diversity of species.

(ii) Class 1 - Warm Water Aquatic Life
These are waters that (1) currently are capable of sustaining a wide variety of warm water biota, including sensitive species, or (2) could sustain such biota but for correctable water quality conditions. Waters shall be considered capable of sustaining such biota where physical habitat, water flows or levels, and water quality conditions result in no substantial impairment of the abundance and diversity of species.

(iii) Class 2- Cold and Warm Water Aquatic Life
These are waters that are not capable of sustaining a wide variety of cold or warm water biota, including sensitive species, due to physical habitat, water flows or levels, or uncorrectable water quality conditions that result in substantial impairment of the abundance and diversity of species.

(e) Wetlands
(v) The Commission may adopt a "wetlands" classification based on the functions of the wetlands in question. Wetland functions that may warrant site-specific protection include ground water recharge or discharge, flood flow alteration, sediment stabilization, sediment or other pollutant retention, nutrient removal or transformation, biological diversity or uniqueness, wildlife diversity or abundance, aquatic life diversity or abundance, and recreation.

Connecticut

SOURCE: Connecticut Water Quality Standards Sections II and III, effective April 9, 1997: http://dep.state.ct.us/wtr/wqsinfo.htm and http://dep.state.ct.us/wtr/wqs.pdf

NARRATIVE BIOCRITERIA

Surface waters and sediments shall be free from chemical constituents in concentrations or combinations which will or can reasonably be expected to result in acute or chronic toxicity to aquatic organisms or impair the biological integrity of aquatic or marine ecosystems outside of any allocated zone of influence or which will or can reasonably be expected to bioconcentrate or bioaccumulate in tissues of fish, shellfish and other aquatic organisms to levels which will impair the health of aquatic organisms or wildlife or result in unacceptable tastes, odors or health risks to human consumers of aquatic life. In determining consistency with this Standard, the Commissioner shall at a minimum consider the specific number criteria listed in Appendix D and any other information she or he deems relevant.

Benthic invertebrate criteria may be utilized where appropriate for assessment of biological integrity of surface waters. The criteria apply to the fauna of erosional or riffle habitats in flowing waters which are not subject to tidal influences.

III. SURFACE WATER CLASSIFICATIONS
INLAND SURFACE WATERS
CLASS AA

Designated Use - Existing or proposed drinking water supply; fish and wildlife habitat; recreational use; agricultural, industrial supply and other purposes, (recreational uses may be restricted).

CRITERIA

Parameter	Standard
13. Benthic Invertebrates which inhabit lotic waters	A wide variety of macroinvertebrate taxa should normally be present and all functional feeding groups should normally be well represented. Presence and productivity of aquatic species is not limited except by natural conditions, permitted flow regulation or irreversible cultural impacts. Water quality shall be sufficient to sustain a diverse macroinvertebrate community of indigenous species. Taxa within the Orders Plecoptera (stoneflies), Ephemeroptera (mayflies), Coleoptera (beetles) and Trichoptera (caddisflies) should be well represented.

INLAND SURFACE WATERS
CLASS A
Designated Uses - Potential drinking water supply; fish and wildlife habitat; recreational use; agricultural, industrial supply and other legitimate uses, including navigation.

CRITERIA

Parameter	Standard
13. Benthic Invertebrates which inhabit lotic waters	A wide variety of macroinvertebrate taxa should normally be present and all functional feeding groups should normally be well represented. Presence and productivity of aquatic species is not limited except by natural conditions, permitted flow regulation or irreversible cultural impacts. Water quality shall be sufficient to sustain a diverse macroinvertebrate community of indigenous species. Taxa within the Orders Plecoptera (stoneflies), Ephemeroptera (mayflies), Coleoptera (beetles) and Trichoptera (caddisflies) should be well represented.

INLAND SURFACE WATERS
CLASS B
Designated Use - Recreational use; fish and wildlife habitat; agricultural and industrial supply and other legitimate uses including navigation.

CRITERIA

Parameter	Standard
13. Benthic Invertebrates which inhabit lotic waters	Water quality shall be sufficient to sustain a diverse macroinvertebrate community of indigenous species. All functional feeding groups and a wide variety of macroinvertebrate taxa shall be present, however one or more may be disproportionate in abundance. Waters which currently support a high quality aquatic community shall be maintained at that high quality. Presence and productivity of taxa within the Orders Plecoptera (stoneflies), Ephemeroptera (mayflies); and pollution intolerant Coleoptera (beetles) and Trichoptera (caddis-flies) may be limited due to cultural activities. Macroinvertebrate communities in waters impaired by cultural activities shall be restored to the extent practical through implementation of the department's procedures for control of pollutant discharges to surface waters and through Best Management Practices for non-point sources of pollution.

INLAND SURFACE WATERS
CLASS C
Present water quality conditions preclude the full attainment of one or more designated uses for Class B waters some or all of the time. One or more Water Quality Criteria for Class B waters are not being consistently achieved. Class C waters may be suitable for certain fish and wildlife habitat, certain recreational activities, industrial use and other legitimate uses, including navigation.

INLAND SURFACE WATERS
CLASS D
Present water quality conditions persistently preclude the attainment of one or more designated uses for Class B waters. One or more Water Quality Criteria for Class B waters are not being achieved most or all of the time. Class D waters may be suitable for bathing or other recreational purposes, certain fish and wildlife habitat, industrial or other legitimate uses, including navigation.

Delaware

SOURCE: State of Delaware Surface Water Quality Standards as amended, August 11, 1999, Department of Natural Resources and Environmental Control: http://www.dnrec.state.de.us/water/wqs1999.pdf

Section 1: Intent

1.1. It is the policy of the Department to maintain within its jurisdiction surface waters of the State of satisfactory quality consistent with public health and public recreation purposes, the propagation and protection of fish and aquatic life, and other beneficial uses of the water.

Section 2: Definitions

Cold water fish use: Protection of fish species (such as from the family Salmonidae) and other flora and fauna indigenous to a cold water habitat.

Fish, aquatic life and wildlife: All animal and plant life found in Delaware, either indigenous or migratory, regardless of life stage or economic importance.

Section 3: Antidegradation Policy

3.1. Existing instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected. Degradation of water quality in such a manner that results in reduced number, quality, or river or stream mileage of existing uses shall be prohibited. Degradation shall be defined for the purposes of this section as a statistically significant reduction, accounting for natural variations, in biological, chemical, or habitat quality as measured or predicted using appropriate assessment protocols.

3.2. Where the quality of the waters exceeds levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water, that quality shall be maintained and protected. In the case of waters of exceptional recreational or ecological significance, existing quality shall be maintained or enhanced...

3.3. Where high quality waters constitute an outstanding National resource, such as waters of National parks and wildlife refuges, existing quality shall be maintained and protected.

Section 4: General Stream Criteria

4.1. All surface waters of the State (except as detailed in Sections 8 and 12) shall meet the following minimum criteria:

(a) Waters shall be free from substances that are attributable to wastes of industrial, municipal, agricultural or other human-induced origin. Examples include but are not limited to the following:

(iii) Any pollutants, including those of a thermal, toxic, corrosive, bacteriological, radiological, or other nature, that may interfere with attainment and maintenance of designated uses of the water, may impart undesirable odors, tastes, or colors to the water or to aquatic life found therein, may endanger public health, or may result in dominance of nuisance species.

District of Columbia*

*This language has not been reviewed for accuracy by state/tribal agency.

SOURCE: Chapter 11, Water Quality Standards of Title 21 of the District of Columbia Municipal Regulations (Notice of Final Rulemaking, January 21, 2000): http://dchealth.dc.gov/services/administration_offices/environmental/services2/water_division/pdf/WaterQualityStandards.shtm

1101.1 For the purposes of water quality standards, the surface waters of the District shall be classified on the basis of their (i) current uses, and (ii) future uses to which the waters will be restored. The categories of beneficial uses for the surface waters of the District shall be as follows:

Categories of Uses Which Determine Water Quality Standards	Classes of Water
Protection & propagation of fish, shellfish and wildlife	...C...

1102.3 TIER III: Where High Quality Waters constitute an outstanding National resource, such as waters of the National and District parks and wildlife refuges and waters of exceptional recreational or ecological significance, those waters shall be designated Outstanding National Resource Waters (ONRW) and the water quality in the ONRW shall be maintained, protected and designated as below:

(a) New point and nonpoint source discharges, treated or otherwise, shall be prohibited in these segments;

(b) Increases in loadings or new pollutants from existing point and nonpoint source discharges shall be prohibited in these segments;

(c) Short-term degradation of the water quality shall be allowed after opportunity for public participation and addressing their comments, if any. However, all practical means of minimizing such degradation shall be implemented; and

(d) Designation of ONRWs shall be adopted after full satisfaction of the intergovernmental coordination of the District's agencies and public participation.

1102.4 SPECIAL WATERS OF THE DISTRICT OF COLUMBIA (SWDC): Any segment or segments of the surface waters of the District which are of water quality better than needed for the current use or have scenic or aesthetic importance shall be designated as Special Waters of the District of Columbia (SWDC)...

1103 WETLANDS

1103.1 In a wetland, the numerical and the narrative criteria shall be applied to the column of water above the wetland in accordance with the designated use.

1103.2 Wetlands with rooted vascular aquatic vegetation, except those specifically constructed or created as waste water treatment devices and except as provided in D. C. Code subsection 6-923(d) and subsection 6-926(a)(3), shall be protected from significant adverse hydrologic modifications, excessive sedimentation, deposition of toxic substances in toxic amounts, nutrient imbalances, and other adverse anthropogenic impacts.

1104 STANDARDS

1104.1 The surface waters of the District shall be free from substances in amounts or combinations that do any of one the following:

(d) cause injury to, are toxic to, or produce adverse physiological or behavioral changes in humans, plants or animals
(e) Produce undesirable or nuisance aquatic life or result in the dominance of nuisance species; or
(f) Impair the biological community that naturally occurs in the waters or depends on the waters for its survival and propagation

1104.5 Class C streams shall be maintained to support aquatic life and shall not be placed in pipes.

Florida

SOURCE: Florida Administrative Code, Chapter 62-302 Surface Water Quality Standards, effective December 26, 1996: http://www.dep.state.fl.us/water/surfacewater/rules.htm and http://www8.myflorida.com/environment/learn/science/laboratories/index.html

62-302.200 Definitions.
(10)"Exceptional Ecological Significance" shall mean that a water body is a part of an ecosystem of unusual value. The exceptional significance may be in unusual species, productivity, diversity, ecological

relationships, ambient water quality, scientific or educational interest, or in other aspects of the ecosystem's setting or processes.

(15)"Nuisance Species" shall mean species of flora or fauna whose noxious characteristics or presence in sufficient number, biomass, or areal extent may reasonably be expected to prevent, or unreasonably interfere with, a designated use of those waters.

(16)"Nursery Area of Indigenous Aquatic Life" shall mean any bed of the following aquatic plants, either in monoculture or mixed: Halodule wrightii, Halophila spp., Potamogeton spp. (pondweed), Ruppia maritima (widgeon-grass), Sagittaria spp. (arrowhead), Syringodium filiforme (manatee-grass), Thalassia testudinum (turtle grass), or Vallisneria spp. (eel-grass), or any area used by the early-life stages, larvae and post-larvae, of aquatic life during the period of rapid growth and development into the juvenile states.

(17)"Outstanding Florida Waters" shall mean waters designated by the Environmental Regulation Commission as worthy of special protection because of their natural attributes.

(18)"Outstanding National Resource Waters" shall mean waters designated by the Environmental Regulation Commission that are of such exceptional recreational or ecological significance that water quality should be maintained and protected under all circumstances, other than temporary lowering and the lowering allowed under Section 316 of the Federal Clean Water Act.

(22)"Propagation" shall mean reproduction sufficient to maintain the species' role in its respective ecological community.

(24)"Shannon-Weaver Diversity Index" shall mean: negative summation (from i=1 to s) of (n i /N) log 2 (n i /N) where s is the number of species in a sample, N is the total number of individuals in a sample, and n i is the total number of individuals in species i.

(25)"Special Waters" shall mean water bodies designated in accordance with Section 62-302.700, F.A.C., by the Environmental Regulation Commission for inclusion in the Special Waters Category of Outstanding Florida Waters, as contained in Section 62-302.700, F.A.C. A Special Water may include all or part of any water body.

62-302.400 Classification of Surface Waters, Usage, Reclassification, Classified Waters.

(1) All surface waters of the State have been classified according to designated uses as follows:
CLASS III Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife

(4) Water quality classifications are arranged in order of the degree of protection required, with Class I water having generally the most stringent water quality criteria and Class V the least. However, Class I, II, and III surface waters share water quality criteria established to protect recreation and the propagation and maintenance of a healthy, well-balanced population of fish and wildlife.

Excerpt from 62-302.530, Criteria for Surface Water Quality Classifications

Parameter	Units	Class I: Potable Water Supply	Class II: Shellfish Propagation or Harvesting	Class III: Recreation, Propagation and Maintenance of a Health, Well-balanced Population of Fish and Wildlife		Class IV: Agricultural Water Supplies	Class V: Navigation, Utility, and Industrial Use
				Predominantly Fresh Waters	Predominantly Marine Waters		
11) Biological Integrity	Percent reduction of Shannon-Weaver Diversity Index	The Index for benthic macro-invertebrates shall not be reduced less than 75% of background levels measured using organisms retained by a U. S. Standard No. 30 sieve and collected and composited from a minimum of three Hester-Dendy type artificial substrate samplers of 0.10 to 0.15 m2 area each, incubated for a period of four weeks.	The Index for benthic macro-invertebrates shall not be reduced to less than 75% of established background levels as measured using organisms retained by a U. S. Standard No. 30 sieve and collected and composited from a minimum of three natural substrate samples, taken with Ponar type samplers with minimum sampling area of 225 cm2.	The Index for benthic macro-invertebrates shall not be reduced to less than 75% of established background levels as measured using organisms retained by a U. S. Standard No. 30 sieve and collected and composited from a minimum of three Hester-Dendy type artificial substrate samplers of 0.10 to 0.15 m2 area each, incubated for a period of four weeks.	The Index for benthic macro-invertebrates shall not be reduced to less than 75% of established background levels as measured using organisms retained by a U. S. Standard No. 30 sieve and collected and composited from a minimum of three natural substrate samples, taken with Ponar type samplers with minimum sampling area of 225 cm2.		

62-302.800 Site Specific Alternative Criteria.

(2) The affirmative demonstration required by this section shall mean a documented showing that the proposed alternative criteria would exist due to natural background conditions or man-induced conditions which cannot be controlled or abated. Such demonstration shall be based upon relevant factors which include:

(c) A description of the historical and existing biology, including variations, which may be affected by the parameter of concern. Conditions in similar water bodies may be used for comparison.

Georgia

SOURCE: Rules of Georgia Department of Natural Resources, Environmental Protection Division, Chapter 391-3-6, Water Quality Control, revised October 2001: http://www.dnr.state.ga.us/dnr/environ/rules_files/exist_files/391-3-6.pdf and http://www.dnr.state.ga.us/dnr/environ

(2) Water Quality Enhancement:

(a) The purposes and intent of the State in establishing Water Quality Standards are to provide enhancement of water quality and prevention of pollution; to protect the public health or welfare in accordance with the public interest for drinking water supplies, conservation of fish, wildlife and other beneficial aquatic life, and agricultural, industrial, recreational, and other reasonable and necessary uses and to maintain and improve the biological integrity of the waters of the State.

391-3-6.03 Water Use Classifications and Water Quality Standards

(3) Definitions:

(b) "Biological integrity" is functionally defined as the condition of the aquatic community inhabiting least impaired waterbodies of a specified habitat measured by community structure and function.

(4) Water Use Classifications. Water use classifications for which the criteria of this Paragraph are applicable are as follows:
  (c) Fishing, Propagation of Fish, Shellfish, Game and Other Aquatic Life
  (d) Wild River
  (e) Scenic River
  (f) Coastal Fishing

(6) Specific Criteria for Classified Water Usage. In addition to the general criteria, the following criteria are deemed necessary and shall be required for the specific water usage as shown:
  (a) Drinking Water Supplies: Those waters approved as a source for public drinking water systems permitted or to be permitted by the Environmental Protection Division. Waters classified for drinking water supplies will also support the fishing use and any other use requiring water of a lower quality.
  (c) Fishing: Propagation of Fish, Shellfish, Game and Other Aquatic Life; secondary contact recreation in and on the water; or for any other use requiring water of a lower quality.
  (d) Wild River: For all waters designated in 391-3-6-.03(13) as "Wild River," there shall be no alteration of natural water quality from any source.
  (e) Scenic River: For all waters designated in 391-3-6-.03(13) as "Scenic River," there shall be no alteration of natural water quality from any source.
  (f) Coastal Fishing: This classification will be applicable to specific sites when so designated by the Environmental Protection Division. For waters designated as "Coastal Fishing", site specific criteria for dissolved oxygen will be assigned and detailed by footnote in Section 391-3-6.03(13), "Specific Water Use Classifications." All other criteria and uses for the fishing use classification will apply for coastal fishing.

(15) Trout Streams. Streams designated as Primary Trout Waters are waters supporting a self-sustaining population of Rainbow, Brown or Brook Trout. Streams designated as Secondary Trout Streams are those with no evidence of natural trout reproduction, but are capable of supporting trout throughout the year...

Hawai`i

SOURCE: Source: Hawai`i Administrative Rules Title 11, Department of Health Chapter 54, Water Quality Standards, April 17, 2000:
http://www.hawaii.gov/health/rules/11-54.pdf and
http://www.epa.gov/waterscience/standards/wqslibrary/hi/hawaii_9_wqs.pdf

§11-54-01 Definitions. As used in this chapter:
- "Amphidromous" means aquatic life that migrate to and from the sea, but not specifically for reproductive purposes. Amphidromous aquatic life in Hawai'ian streams are confined to fresh waters as adults, but their larval stages are partially or entirely spent in the ocean as part of the zooplankton.
- "Anchialine pools" means coastal bodies of standing waters that have no surface connections to the ocean but display both tidal fluctuations and salinity ranges characteristic of fresh and brackish waters, indicating the presence of subsurface connections to the watertable and ocean. Anchialine pools are located in porous substrata (recent lava or limestone) and often contain a distinctive assemblage of native aquatic life. Deeper anchialine pools may display salinity stratification, and some shallow pools may contain standing water only on the highest tides.
- "Aquatic life" means "any type or species of mammal, fish, amphibian, reptile, mollusk, crustacean, arthropod, invertebrate, coral, or other animal that inhabits the freshwater or marine environment and includes any part, product, egg, or offspring thereof; or freshwater or marine plants, including seeds, roots, products, and other parts thereof".
- "Estuaries" means characteristically brackish coastal waters in well-defined basins with a continuous or seasonal surface connection to the ocean that allows entry of marine fauna. Estuaries may be either natural or developed.
- "Introduced aquatic life" means those species of aquatic organisms that are not native to a given area or water body and whose populations were established (deliberately or accidentally) by human activity. "Introduced" organisms are also referred to as "alien" or "exotic".

- "Low wetlands" means freshwater wetlands located below 100 m (330 ft) elevation that may be natural or artificial in origin and are usually found near coasts or in valley termini. Low wetlands are maintained by either stream, well, or ditch influent water, or by exposure of the natural water table. Low wetlands include, but are not limited to, natural lowland marshes, riparian wetlands, littoral zones of standing waters (including lakes, reservoirs, ponds and fishponds) and agricultural wetlands such as taro lo'i.
- "Native aquatic life" means those species or higher taxa of aquatic organisms that occur naturally in a given area or water body and whose populations were not established as a result of human activity.
- "Natural estuaries" means volumes of brackish coastal waters in well-defined basins of natural origin, found mainly at the mouths of streams or rivers. Natural estuaries can be either stream-fed (drowned stream mouths fed by perennial stream runoff) or spring-fed (nearshore basins with subterranean fresh water sources). Stream-fed estuaries serve as important migratory pathways for larval and juvenile amphidromous stream fauna.
- "Natural freshwater lakes" means standing water that is always fresh, in well-defined natural basins, with a surface area usually greater than 0.1 ha (0.25 acres), and in which rooted emergent hydrophytes, if present, occupy no more than 30% of the surface area. Natural freshwater lakes in Hawai‘i occur at high, intermediate, and low elevations. Lowland freshwater lakes characteristically lack a natural oceanic connection (surface or subsurface) of a magnitude sufficient to cause demonstrable tidal fluctuations.

§11-54-03 Classification of water uses.

(a) The following use categories classify inland and marine waters for purposes of applying the standards set forth in this chapter, and for the selection or definition of appropriate quality parameters and uses to be protected in these waters. Storm water discharge into State waters shall be allowed provided it meets the requirements specified in this section and the basic water quality criteria specified in section 11-54-04.

(b) Inland waters.

(1) Class 1. It is the objective of class 1 waters that these waters remain in their natural state as nearly as possible with an absolute minimum of pollution from any human-caused source. To the extent possible, the wilderness character of these areas shall be protected. Waste discharge into these waters is prohibited. Any conduct which results in a demonstrable increase in levels of point or nonpoint source contamination in class 1 waters is prohibited.

(a) Class 1.a. The uses to be protected in class 1.a waters are scientific and educational purposes, protection of native breeding stock, baseline references from which human-caused changes can be measured, compatible recreation, aesthetic enjoyment, and other nondegrading uses which are compatible with the protection of the ecosystems associated with waters of this class;

(b) Class 1.b. The uses to be protected in class 1.b waters are domestic water supplies, food processing, protection of native breeding stock, the support and propagation of aquatic life...

(2) Class 2. The objective of class 2 waters is to protect their use for recreational purposes, the support and propagation of aquatic life, agricultural and industrial water supplies, shipping, and navigation. The uses to be protected in this class of waters are all uses compatible with the protection and propagation of fish, shellfish, and wildlife, and with recreation in and on these waters. These waters shall not act as receiving waters for any discharge which has not received the best degree of treatment or control compatible with the criteria established for this class...

(c) Marine waters.

(1) Class AA. It is the objective of class AA waters that these waters remain in their natural pristine state as nearly as possible with an absolute minimum of pollution or alteration of water quality from any human-caused source or actions. To the extent practicable, the wilderness character of these areas shall be protected. No zones of mixing shall be permitted in this class:

(a) Within a defined reef area, in waters of a depth less than 18 meters (ten fathoms); or

(b) In waters up to a distance of 300 meters (one thousand feet) off shore if there is no defined reef area and if the depth is greater than 18 meters (ten fathoms). The uses to be protected in this class of waters are oceanographic research, the support and propagation of shellfish and other marine life, conservation of coral reefs and wilderness areas, compatible recreation, and aesthetic enjoyment. The classification of any water area as Class AA shall not preclude other uses of the waters compatible with these objectives and in conformance with the criteria applicable to them;

(2) Class A. It is the objective of class A waters that their use for recreational purposes and aesthetic

enjoyment be protected. Any other use shall be permitted as long as it is compatible with the protection and propagation of fish, shellfish, and wildlife, and with recreation in and on these waters. These waters shall not act as receiving waters for any discharge which has not received the best degree of treatment or control compatible with the criteria established for this class.

(d) Marine bottom ecosystems.

(1) Class I. It is the objective of class I marine bottom ecosystems that they remain as nearly as possible in their natural pristine state with an absolute minimum of pollution from any human-induced source. Uses of marine bottom ecosystems in this class are passive human uses without intervention or alteration, allowing the perpetuation and preservation of the marine bottom in a most natural state, such as for nonconsumptive scientific research (demonstration, observation or monitoring only), nonconsumptive education, aesthetic enjoyment, passive activities, and preservation;

(2) Class II. It is the objective of class II marine bottom ecosystems that their use for protection including propagation of fish, shellfish, and wildlife, and for recreational purposes not be limited in any way. The uses to be protected in this class of marine bottom ecosystems are all uses compatible with the protection and propagation of fish, shellfish, and wildlife, and with recreation.

§11-54-05.2 Inland water criteria.

(b) Specific criteria for streams.

(2) Bottom criteria for streams:

(e) The director shall prescribe the appropriate parameters, measures, and criteria for monitoring stream bottom biological communities including their habitat, which may be affected by proposed actions. Permanent benchmark stations may be required where necessary for monitoring purposes. The water quality criteria for this subsection shall be deemed to be met if time series surveys of benchmark stations indicate no relative changes in the relevant biological communities, as noted by biological community indicators or by indicator organisms which may be applicable to the specific site.

Idaho

SOURCE: Source: Rules of the Department of Environmental Quality, IDAPA 58.01.02, Water Quality Standards and Wastewater Treatment Requirements, amended April 5, 2000:
http://www2.state.id.us/adm/adminrules/rules/idapa58/0102.pdf and
http://www2.state.id.us/adm/adminrules/rules/idapa58/58index.htm

3. Definitions

04. Beneficial Use. Any of the various uses which may be made of the water of Idaho, including, but not limited to, domestic water supplies, industrial water supplies, agricultural water supplies, navigation, recreation in and on the water, wildlife habitat, and aesthetics. The beneficial use is dependent upon actual use, the ability of the water to support a non-existing use either now or in the future, and its likelihood of being used in a given manner. The use of water for the purpose of wastewater dilution or as a receiving water for a waste treatment facility effluent is not a beneficial use. (8-24-94)

05. Aquatic Species. Any plant or animal that lives at least part of its life in the water column or benthic portion of waters of the state. (8-24-94)

11. Biological Monitoring or Biomonitoring. The use of a biological entity as a detector and its response as a measure to determine environmental conditions. Toxicity tests and biological surveys, including habitat monitoring, are common biomonitoring methods.

23. Desirable Species. Species indigenous to the area or those introduced by the Idaho Department of Fish and Game.

71. Outstanding Resource Water (ORW). A high quality water, such as water of national and state parks and wildlife refuges and water of exceptional recreational or ecological significance, which has been designated by the legislature and subsequently listed in this chapter. ORW constitutes an outstanding national or state resource that requires protection from point and nonpoint source activities that may lower water quality. (3-20-97)

85. Reference Stream Or Condition. A water body which represents the minimum conditions necessary to fully support the applicable designated beneficial uses as further specified in these rules, or natural conditions with few impacts from human activities and which are representative of the highest level of support attainable in the basin. In highly mineralized areas or in the absence of such reference streams or water bodies, the Director, in consultation with the basin advisory group and the technical advisors to it, may define appropriate hypothetical reference conditions or may use monitoring data specific to the site in question to determine conditions in which the beneficial uses are fully supported.

87. Resident Species. Those species that commonly occur in a site including those that occur only seasonally or intermittently. This includes the species, genera, families, orders, classes, and phyla that: (8-24-94)

a. Are usually present at the site; (8-24-94)
b. Are present only seasonally due to migration; (8-24-94)
c. Are present intermittently because they periodically return or extend their ranges into the site; (8-24-94)
d. Were present at the site in the past but are not currently due to degraded conditions, and are expected to be present at the site when conditions improve; and (8-24-94)
e. Are present in nearby bodies of water but are not currently present at the site due to degraded conditions, and are expected to be present at the site when conditions improve. (8-24-94)

111. Unique Ecological Significance. The attribute of any stream or water body which is inhabited or supports an endangered or threatened species of plant or animal or a species of special concern identified by the Idaho Department of Fish and Game, which provides anadromous fish passage, or which provides spawning or rearing habitat for anadromous or desirable species of lake dwelling fishes.

53. BENEFICIAL USE SUPPORT STATUS.

In determining whether a water body fully supports designated and existing beneficial uses, the Department shall determine whether all of the applicable water quality standards are being achieved, including any criteria developed pursuant to these rules, and whether a healthy, balanced biological community is present. The Department shall utilize biological and aquatic habitat parameters listed below and in the current version of the "Water Body Assessment Guidance", as published by the Idaho Department of Environmental Quality, as a guide to assist in the assessment of beneficial use status. Revisions to this guidance will made after notice and an opportunity for public comment. These parameters are not to be considered or treated as individual water quality criteria or otherwise interpreted or applied as water quality standards. (4-5-00)

01. Aquatic Habitat Parameters. These parameters may include, but are not limited to, stream width, stream depth, stream shade, measurements of sediment impacts, bank stability, water flows, and other physical characteristics of the stream that affect habitat for fish, macroinvertebrates or other aquatic life; and (3-20-97)

02. Biological Parameters. These parameters may include, but are not limited to, evaluation of aquatic macroinvertebrates including Ephemeroptera, Plecoptera and Trichoptera (EPT), Hilsenhoff Biotic Index, measures of functional feeding groups, and the variety and number of fish or other aquatic life to determine biologicalcommunity diversity and functionality.

100. SURFACE WATER USE DESIGNATIONS.

01. Aquatic Life. (7-1-93)

a. Cold water (COLD): water quality appropriate for the protection and maintenance of a viable aquatic life community for cold water species. (4-5-00)
b. Salmonid spawning: waters which provide or could provide a habitat for active self-propagating populations of salmonid fishes. (7-1-93)
c. Seasonal cold water (SC): water quality appropriate for the protection and maintenance of a viable aquatic life community of cool and cold water species, where cold water aquatic life may be absent

during, or tolerant of , seasonally warm temperatures. (4-5-00)

d. Warm water (WARM): water quality appropriate for the protection and maintenance of a viable aquatic life community for warm water species. (4-5-00)

e. Modified (MOD): water quality appropriate for an aquatic life community that is limited due to one (1) or more conditions set forth in 40 CFR 131.10(g) which preclude attainment of reference streams or conditions.

04. Wildlife Habitats. Water quality appropriate for wildlife habitats. This use applies to all surface waters of the state. (4-5-00)

Illinois

SOURCE: Title 35: Environmental Protection, Subtitle C: Water Pollution, Chapter I: Pollution Control Board, Part 302 and 303 Water Quality Standards, amended August 26, 1999:
http://www.ipcb.state.il.us/Title_35/Subtitles/C/302.pdf and
http://www.ipcb.state.il.us/Title_35/Subtitles/C/303.pdf

Section 302.102 Allowed Mixing, Mixing Zones and ZIDs

(b) The portion, volume and area of any receiving waters within which mixing is allowed pursuant to subsection (a) shall be limited by the following:

2) Mixing is not allowed in waters which include a tributary stream entrance if such mixing occludes the tributary mouth or otherwise restricts the movement of aquatic life into or out of the tributary.

3) Mixing is not allowed in waters containing mussel beds, endangered species habitat, fish spawning areas, areas of important aquatic life habitat, or any other natural features vital to the well being of aquatic life in such a manner that the maintenance of aquatic life in the body of water as a whole would be adversely affected.

6) Mixing must allow for a zone of passage for aquatic life in which water quality standards are met.

SUBPART E:
Section 302.501 Scope, Applicability, and Definitions
"Resident or indigenous species" means species that currently live a substantial portion of their life cycle, or reproduce, in a given body of water, or that are native species whose historical range includes a given body of water.

"Target species" is a species to be protected by the criterion.

"Target species value" is the criterion value for the target species.

"Trophic level" means a functional classification of taxa within a community that is based on feeding relationships. For example, aquatic green plants and herbivores comprise the first and second trophic levels in a food chain.

SUBPART B: Nonspecific Water Use Designations:
Section 303.204 Secondary Contact and Indigenous Aquatic Life Waters
Waters which are required to meet the secondary contact and indigenous aquatic life standards of Subpart D, Part 302, are not required to meet the general use standards or the public and food processing water supply standards of Subparts B and C, Part 302.

Indiana

SOURCE: Indiana Administrative Code, Title 327 Water Pollution Control Board, Article 2: Water Quality Standards, Updated April 1, 2002: http://www.ai.org/legislative/iac/title327.html

Indiana Water Quality Standards for the Non-Great Lakes Basin Portions of Indiana

327 IAC 2-1-3 Surface water use designations; multiple uses

Sec. 3. (a) The following water uses are designated by the water pollution control board:

(1) Surface waters of the state are designated for full-body contact recreation as provided in section 6(d) of this rule.

(2) All waters, except as described in subdivision (5), will be capable of supporting a well-balanced, warm water aquatic community and, where natural temperatures will permit, will be capable of supporting put-and-take trout fishing. All waters capable of supporting the natural reproduction of trout as of February 17, 1977, shall be so maintained.

(3) All waters which are used for public or industrial water supply must meet the standards for those uses at the points where the water is withdrawn. This use designation and its corresponding water quality standards are not to be construed as imposing a user restriction on those exercising or desiring to exercise the use.

(4) All waters which are used for agricultural purposes must, as a minimum, meet the standards established in section 6(a) of this rule.

(5) All waters in which naturally poor physical characteristics (including lack of sufficient flow), naturally poor chemical quality, or irreversible man-induced conditions, which came into existence prior to January 1, 1983, and having been established by use attainability analysis, public comment period, and hearing may qualify to be classified for limited use and must be evaluated for restoration and upgrading at teach triennial review of this rule. Specific waters of the state designated for limited use are listed in section 11(a) of this rule.

(6) All waters which provide unusual aquatic habitat, which are an integral feature of an area of exceptional natural beauty or character, or which support unique assemblages of aquatic organisms may be classified for exceptional use. Specific waters of the state designated for exceptional use are listed in section 11(b) of this rule.

(b) Where multiple uses have been designated for a body of water, the most protective of all simultaneously applicable standards will apply. *(Water Pollution Control Board; 327 IAC 2-1-3; filed Sep 24, 1987, 3:00 p.m.: 11 IR 580; filed Feb 1, 1990, 4:30 p.m.: 13 IR 1019; filed Jan 14, 1997, 12:00 p.m.: 20 IR 1348)*

327 IAC 2-1-6 Minimum surface water quality standards

Sec. 6. (a) The following are minimum water quality conditions:

(1) All waters at all times and at all places, including the mixing zone, shall meet the minimum conditions of being free from substances, materials, floating debris, oil, or scum attributable to municipal, industrial, agricultural, and other land use practices, or other discharges:

(A) that will settle to form putrescent or otherwise objectionable deposits;

(B) that are in amounts sufficient to be unsightly or deleterious;

(C) that produce color, visible oil sheen, odor, or other conditions in such degree as to create a nuisance;

(D) which are in amounts sufficient to be acutely toxic to, or to otherwise severely injure or kill aquatic life, other animals, plants, or humans:

(i) to assure protection of aquatic life, concentrations of toxic substances shall not exceed the final acute value (FAV = 2 (AAC)) in the undiluted discharge or the acute aquatic criterion (AAC) outside the zone of initial dilution or, if applicable, the zone of discharge-induced mixing:

(AA) for certain substances, the AAC are established and set forth in Table 1 (which table4 incorporates Table 2); and (BB) for substances for which an AAC is not specified in Table 1, or if a different AAC can be scientifically justified based on new toxicological data or site-specific conditions concerning water quality characteristics or species present, an AAC can be calculated by the commissioner using the procedures in section 8.2 of this rule; and

(ii) this clause shall not apply to the chemical control of plants and animals when that control is performed in compliance with approval conditions specified by the Indiana Department of Natural Resources as provided by IC 14-2-1; and

(E) which are in concentrations or combinations that will cause or contribute to the growth of aquatic plants or algae to such degree as to create a nuisance, be unsightly, or otherwise impair the designated uses.

(2) At all times, all waters outside of mixing zones shall be free of substances in concentrations which on the basis of available scientific data are believed to be sufficient to injure, be chronically toxic to, or be carcinogenic, mutagenic, or teratogenic to humans, animals, aquatic life, or plants. To assure protection against the adverse effects identified in this subdivision, the following requirements are established:

The Great Lakes Basin is covered by its own regulation which follows:

327 IAC 2-1.5-5: GLI Water Use Designations

327 IAC 2-1.5-5 Surface water use designations; multiple uses

Sec. 5. (a) The following water uses are designated by the board:

(1) All surface waters of the state within the Great Lakes system are designated for full-body contact recreation.

(2) All surface waters, except as described in subdivision (7), shall be capable of supporting a well-balanced, warm water aquatic community.

(3) Where natural temperatures will permit, surface waters shall be capable of supporting put-and-take trout fishing. All waters capable of supporting the natural reproduction of trout shall be so maintained. The following waters are designated as salmonid waters and shall be capable of supporting a salmonid fishery:
   (A) Trail Creek and its tributaries downstream to Lake Michigan.
   (B) East Branch of the Little Calumet River and its tributaries downstream to Lake Michigan via Burns Ditch.
   (C) Salt Creek above its confluence with the Little Calumet River.
   (D) Kintzele Ditch (Black Ditch) from Beverly Drive downstream to Lake Michigan.
   (E) The Galena River and its tributaries in LaPorte County.
   (F) The St. Joseph River and its tributaries in St. Joseph County from the Twin Branch Dam in Mishawaka downstream to the Indiana/Michigan state line.
   (G) The Indiana portion of the open waters of Lake Michigan.
   (H) Those waters designated by the Indiana department of natural resources for put-and-take trout fishing.

(4) All surface waters used for public water supply are designated as a public water supply. This use designation and its corresponding water quality criteria are not to be construed as imposing a user restriction on those exercising or desiring to exercise the use.

(5) All surface waters used for industrial water supply are designated as an industrial water supply. This use designation and its corresponding water quality criteria are not to be construed as imposing a user restriction on those exercising or desiring to exercise the use.

(6) All surface waters used for agricultural purposes are designated as an agricultural use water.

(7) Limited use waters are designated under section 19(a) of this rule pursuant to section 18 of this rule. All waters that are designated as a limited use water under section 19(a) of this rule must be evaluated for restoration and upgrading at each triennial review of this rule.

(8) Outstanding state resource waters are designated under section 19(b) of this rule pursuant to section 18 of this rule.

(b) Where multiple uses have been designated for a body of water, the most protective of all simultaneously applicable standards will apply. (Water Pollution Control Board; 327 IAC 2-1.5-5; filed Jan 14, 1997, 12:00 p.m.: 20 IR 1369)

327 IAC 2-1.5-8 Minimum surface water quality criteria

Sec. 8. (a) All surface water quality criteria in this section, except those provided in subsection (b)(1), will cease to be applicable when the stream flows are less than the applicable stream design flow for the particular criterion as determined under 327 IAC 5-2-11.4. (b) The following are minimum water quality conditions:

(1) All waters within the Great Lakes system at all times and at all places, including waters within the mixing zone, shall meet the minimum conditions of being free from substances, materials, floating

debris, oil, or scum attributable to municipal, industrial, agricultural, and other land use practices, or other discharges that do any of the following:
(A) Will settle to form putrescent or otherwise objectionable deposits.
(B) Are in amounts sufficient to be unsightly or deleterious.
(C) Produce color, visible oil sheen, odor, or other conditions in such degree as to create a nuisance.
(D) Are in concentrations or combinations that will cause or contribute to the growth of aquatic plants or algae to such degree as to create a nuisance, be unsightly, or otherwise impair the designated uses.
(E) Are in amounts sufficient to be acutely toxic to, or to otherwise severely injure or kill aquatic life, other animals, plants, or humans. To assure protection of aquatic life, the waters shall meet the following requirements:
   (i) Concentrations of toxic substances shall not exceed the CMC outside the zone of initial dilution or the final acute value (FAV = 2 (CMC)) in the undiluted discharge unless, for a discharge to a receiving stream or Lake Michigan, an alternate mixing zone demonstration is conducted and approved in accordance with 327 IAC 5-2-11.4(b)(4), in which case, the CMC shall be met outside the discharge-induced mixing zone:

(2) At all times, all waters outside of the applicable mixing zones determined in accordance with 327 IAC 5-2-11.4(c) through 327 IAC 5-2-11.4(f) shall be free of substances in concentrations, that, on the basis of available scientific data, are believed to be sufficient to injure, be chronically toxic to, or be carcinogenic, mutagenic...

Iowa

SOURCE: Iowa Administrative Code, Environmental Protection Rule 567, Chapter 61, Water Quality Standards, October 18, 2000:
http://www.state.ia.us/government/dnr/organiza/epd/prgrmdsc/wtrqual/spqual.htm
http://www.state.ia.us/epd/prgrmdsc/wtrqual/sum.htm and
http://www.state.ia.us/dnr/organiza/epd/wtrq/wtrqbor.htm

Class "B" Waters: Waters which are designated as Class "B" are to be protected for wildlife, fish, aquatic and semi-aquatic life and secondary contact water uses. Class "B" waters are divided into the following categories:

- Class "B" (CW) (cold water aquatic life): streams or lakes that support trout and associated aquatic communities
- Class "B" (WW) (significant resource warm water): lakes or rivers which support warm water game fish and associated aquatic communities, including sensitive species
- Class "B" (LR) (limited resource warm water): streams which support limited aquatic life populations primarily composed of minnows and other nongame fish species
- Class "B" (LW) (lakes and wetlands): artificial impoundments and natural lakes with lake-like conditions that support warm water game fish and associated aquatic communities

High Quality (HQ) waters: Waters with exceptionally better quality than specified by Iowa water quality criteria and with exceptional recreational and ecological importance. Special protection is warranted to maintain the unusual, unique or outstanding physical, chemical, or biological characteristics that these waters possess.

High Quality Resource (HQR) waters: Waters of substantial recreational or ecological significance that possess unusual, outstanding or unique physical, chemical or biological characteristics that enhance the beneficial uses and warrant special protection.

Kansas

SOURCE: Kansas Register, Notice/Regulations, Administrative Regulations, Kansas Department of Health and Environment, Water Pollution Control, Chapter 28-1, Volume 20, Number 33, August 16, 2001:

http://www.kdhe.state.ks.us/water/index.html#Proposed%20Regulations%20and%20 and
http://www.kdhe.state.ks.us/environment/qmp_2000/SBMP_QAMP.pdf

Article 16. Surface Water Quality Standards

28-16-28b. Definitions.

(h) ''Bioassessment methods and procedures'' means the use of biological methods of assessing surface water quality including, but not limited to, field investigations of aquatic organisms and laboratory or field aquatic toxicity tests.

(k) ''Biota'' means the animal and plant life of a given geographical region.

(v) ''Ecological integrity'' means the natural or unimpaired structure and functioning of an aquatic or terrestrial ecosystem.

(oo) ''Outstanding natural resource water'' means any of the surface waters or surface water segments of exceptional recreational or ecological significance identified in the surface water register, as defined in K.A.R. 28-16-28b(uu), and afforded the highest level of water quality protection under the antidegradation provisions of K.A.R. 28-16-28c(a) and the mixing zone provisions of K.A.R. 28-16-28c(b).

(ddd) ''Surface waters'' means all of the following:

(1) Streams, including rivers, creeks, brooks, sloughs, draws, arroyos, canals, springs, seeps, and cavern streams, and any alluvial aquifers associated with these surface waters;

(2) lakes, including oxbow lakes and other natural lakes and man-made reservoirs, lakes, and ponds; and

(3) wetlands, including water bodies meeting the technical definition for jurisdictional wetlands given in the corps of engineers wetlands delineation manual,'' as published in January 1987, which is hereby adopted by reference.

28-16-28d. Surface water use designation and classification.

(a) Designated uses of surface waters are defined as follows.

(2) ''Aquatic life support use'' means the use of surface water for the maintenance of the ecological integrity of streams, lakes and wetlands, including the sustained growth and propagation of native aquatic life, indigenous or migratory semi-aquatic life, or terrestrial wildlife directly or indirectly dependent on surface water for survival.

(A) ''Special aquatic life use waters'' means either surface waters that contain combinations of habitat types and indigenous biota not found commonly in the state or surface waters that contain representative populations of threatened or endangered species.

(B) ''Expected aquatic life use waters'' means surface waters containing habitat types and indigenous biota commonly found or expected in the state.

(C) ''Restricted aquatic life use waters'' means surface waters containing indigenous biota limited in abundance diversity by the physical quality or availability of habitat, due to natural deficiencies or artificial modifications, compared to more suitable habitats in adjacent waters.

28-16-28e. Surface water quality criteria.

(a) Criteria development guidance. The development of surface water quality criteria for substances not listed in these standards shall be guided by water quality criteria published by the United States environmental protection agency. If the department finds that the criteria listed in this regulation are underprotective or overprotective for given surface water segment, appropriate site-specific criteria may be developed and applied by the department, in accordance with K.A.R. 28-16-28f(f), using bioassessment methods or other related scientific procedures...

(c) Criteria for designated uses of surface waters. The numeric criteria in tables 1a, 1b, 1c, 1d, and 1e shall not apply if the critical low flow is less than 0.03 cubic meters per second for waters designated as expected aquatic life use waters and restricted aquatic life use waters, unless studies conducted or approved by the department show that water present during periods of no flow, or flow below critical low flow, provides important refuges for aquatic life and permits biological recolonization of intermittently flowing segments. The numeric criteria in tables 1a, 1b, 1c, 1d, and 1e shall not apply if the critical low flow is less than 0.003 cubic meters per second for waters designated as special aquatic life use waters, unless studies conducted or approved by the department show that water present during periods of no flow, or flow below critical low flow, provides important refuges for aquatic life and permits biological recolonization of intermittently flowing segments. The following critieria shall apply to all classified surface waters for the indicated designated uses.

Kentucky

SOURCE: Title 401, Chapter 5, Kentucky Administrative Regulations (KAR), effective December 8, 1999: http://www.lrc.state.ky.us/kar/401/005/026.htm

401 KAR 5:002. Definitions for 401 KAR Chapter 5.
Section 1. Definitions.

(8) "Adversely affect" or "adversely change" means, for purposes of 401 KAR 5:026 through 5:031, to alter or change the community structure or function, to reduce the number or proportion of sensitive species, or to increase the number or proportion of pollution tolerant aquatic species so that aquatic life use support or aquatic habitat is impaired.

(54) "Cold water aquatic habitat" or "CAH" means surface waters and associated substrate that will support indigenous aquatic life or self-sustaining or reproducing trout populations on a year-round basis.

(124) "Impairment" means, for the purpose of 401 KAR 5:026 through 5:031, a detrimental impact to a surface water that prevents attainment of a designated use.

(127) "Indigenous aquatic life" means naturally occurring aquatic organisms including but not limited to bacteria, fungi, algae, aquatic insects, other aquatic invertebrates, reptiles, amphibians, and fishes. Under some natural conditions one (1) or more of the above groups may be absent from a surface water.

(233) "Productive aquatic community" means an assemblage of indigenous aquatic life capable of reproduction and growth.

(236) "Propagation" means the continuance of a species by successful spawning, hatching, and development or natural generation in the natural environment, as opposed to the maintenance of the species by artificial culture and stocking.

(250) "Representative important species" means species which are representative, in terms of their biological needs, of a balanced, indigenous community of shellfish, fish, and wildlife in the body of water into which a discharge of heat is made.

(317) "Warm water aquatic habitat" or "WAH" means any surface water and associated substrate capable of supporting indigenous warm water aquatic life.

401 KAR 5:026.Designation of uses of surface waters.
Section 1. Scope of Designation.

(2) Designated uses are:
  (a) Warm water aquatic habitat;
  (b) Cold water aquatic habitat;
  (f) Outstanding state resource water.

(4) Outstanding state resource waters may have unique water quality characteristics that shall be protected by additional criteria established in 401 KAR 5:031, Section 7.

401 KAR 5:029.General provisions.
Section 3. Documentation for Redesignations.

(3) Documentation to support the redesignation of a surface water of the Commonwealth shall be:
  (g) An assessment of the existing and potential aquatic life habitat in the surface waters under consideration and the adjacent upstream surface waters. The existing aquatic life shall be

documented and livestock and natural wildlife dependence on the surface water shall be assessed. The occurrence of individuals or populations, indices of diversity and well-being, and abundance of species of any unique native biota shall be documented;

401 KAR 5:030. Antidegradation policy implementation methodology.

Section 1. Implementation of Antidegradation Policy..

(1) Categorization. Surface waters shall be placed into one (1) of three (3) categories:
- (a) Outstanding national resource waters:
- (b) Exceptional waters:
  1. Surface water designated as a Kentucky Wild River, unless it is categorized as an outstanding national resource water;
  2. Outstanding state resource water that does not support a federally threatened or endangered aquatic species;
  3. Surface water that fully supports all applicable designated uses and contains:
     - a. A fish community that is rated "excellent" by the use of the Index of Biotic Integrity included in "Methods for Assessing Biological Integrity of Surface Waters", incorporated by reference in Section 4 of this administration regulation; or
     - b. A macroinvertebrate community that is rated "excellent" by the Macroinvertebrate Bioassessment Index included in "A Macroinvertebrate Bioassessment Index for Streams of the Interior Plateau Ecoregion in Kentucky", incorporated by reference in Section 4 of this administrative regulation; and
  4. Water in the cabinet's reference reach network.

401 KAR 5:031.Surface water standards.

Section 2. Minimum Criteria Applicable to All Surface Waters.

(1) The following minimum water quality criteria are applicable to all surface waters including mixing zones, with the exception that toxicity to aquatic life in mixing zones shall be subject to the provisions of 401 KAR 5:029, Section 4. Surface waters shall not be aesthetically or otherwise degraded by substances that:
- (d) Injure, are chronically or acutely toxic to or produce adverse physiological or behavioral responses in humans, animals, fish and other aquatic life;
- (e) Produce undesirable aquatic life or result in the dominance of nuisance species;

Section 4. Aquatic Life.

(1) Warm water aquatic habitat. The following parameters and associated criteria shall apply for the protection of productive warm water aquatic communities, fowl, animal wildlife, arboreous growth, agricultural, and industrial uses:
- (a) Natural alkalinity as CaCO3 shall not be reduced by more than twenty-five (25) percent. If natural alkalinity is below twenty (20) mg/l CaCO3, there shall not be a reduction below the natural level. Alkalinity shall not be reduced or increased to a degree which may adversely affect the aquatic community.
- (c) Flow shall not be altered to a degree which will adversely affect the aquatic community.
- (d) Temperature shall not exceed thirty-one and seven-tenths (31.7) degrees Celsius (eighty-nine (89) degrees Fahrenheit).
  2. The cabinet may determine allowable surface water temperatures on a site-specific basis utilizing available data which shall be based on the effects of temperature on the aquatic biota which utilize specific surface waters of the Commonwealth and which may be affected by person-induced temperature changes. Effects on downstream uses will also be considered in determining site-specific temperatures...
  3. A successful demonstration concerning thermal discharge limits carried out under Section 316(a) of the Clean Water Act shall constitute compliance with the temperature requirements of this subsection. A successful demonstration assures the protection and propagation of a balanced indigenous population of shellfish, fish and wildlife in or on the water into which the discharge is made.
- (f) Solids.
  1. Total dissolved solids. Total dissolved solids shall not be changed to the extent that the indigenous aquatic community is adversely affected.
  2. Total suspended solids. Total suspended solids shall not be changed to the extent that the

indigenous aquatic community is adversely affected.

3. Settleable solids. The addition of settleable solids that may alter the stream bottom so as to adversely affect productive aquatic communities is prohibited.

Louisiana

SOURCE: Louisiana Administrative Code, Title 33: Environmental Regulatory Code, Part IX, Water Quality, March 20, 2001: http://www.deq.state.la.us/planning/regs/title33/33v09.pdf

Chapter 11. Surface Water Quality Standards
§1101. Introduction

A. The purpose of this Chapter is to establish surface water quality standards which will:
   1. provide for the protection and preservation of the abundant natural resources of Louisiana's many and varied aquatic ecosystems;

§1105. Definitions

Biological and Aquatic Community Integrity—the condition of the aquatic community inhabiting a specified habitat as measured by community structure and function.

Biological Succession—the gradual and orderly process of ecosystem or community development brought about by changes in species populations that culminates in the production of a climax characteristic of a particular geographic region.

Fresh Warmwater Biota—those aquatic life species whose populations typically inhabit waters with warm temperatures (seasonal averages above 20 o C, 68 o F) and low salinities (less than 2 parts per thousand,‰), including but not limited to, black basses and freshwater sunfish and catfish and characteristic freshwater aquatic invertebrates and wildlife.

Marine Water Biota—those aquatic life species whose populations typically inhabit waters with salinities equal to or greater than 2 parts per thousand (‰) including but not limited to characteristic fishes, invertebrates and wildlife of coastal waters and the Gulf of Mexico.

§1109. Policy

B. Water Use
   1. It is the policy of the state of Louisiana that all state waters should be protected for recreational uses and for the preservation and propagation of desirable species of aquatic biota and indigenous species of wildlife...
   2. In applying this policy, the terms "recreational uses" and "desirable species of aquatic biota" will be given common sense applications. Recreational uses will be classified as either "primary contact" or "secondary contact." "Desirable species of aquatic biota" refers to a diverse and naturally occurring range of aquatic biota and not to species that exist in the area in question in disproportionate numbers as a result of wastewater discharges. Desirable species of fish, shellfish and other invertebrates, wildlife, and other aquatic biota will be specified as "fresh warmwater" or "marine water" species. All future designations of water uses and their associated criteria must, at a minimum, adhere to these classifications, except as provided in LAC 33:IX.1109.B.3 and C. will be viewed as a problem to be solved, not as an impediment to categorizing water bodies or assigning designated uses...

§1111. Water Use Designations

C. Fish and Wildlife Propagation. Fish and wildlife propagation includes the use of water for aquatic habitat, food, resting, reproduction, cover, and/or travel corridors for any indigenous wildlife and aquatic life species associated with the aquatic environment. This use also includes the maintenance of water quality at a level that prevents damage to indigenous wildlife and aquatic life species associated with the aquatic environment and contamination of aquatic biota consumed by humans. The subcategory of "limited aquatic life and wildlife use" recognizes the natural variability of aquatic habitats, community requirements, and local environmental conditions. Limited aquatic life and wildlife use may be designated for water bodies having habitat that is uniform in structure and morphology with most of the regionally expected aquatic species absent, low species diversity and richness, and/or a severely imbalanced trophic structure. Aquatic life able to survive and/or propagate in such water bodies include species tolerant of severe or variable environmental conditions. Water bodies that might qualify for the limited aquatic life and wildlife use subcategory include intermittent streams and man-made water bodies with characteristics including, but not limited to, irreversible hydrologic modification, anthropogenically and irreversibly degraded water quality, uniform channel morphology, lack of channel structure, uniform substrate, lack of riparian structure, and similar characteristics making the available habitat for aquatic life and wildlife suboptimal. Limited aquatic life and wildlife use will be denoted in Table 3 (LAC 33:IX.1123) as an "L."

E. Oyster Propagation. Oyster propagation is the use of water to maintain biological systems that support economically important species of oysters, clams, mussels, or other mollusks so that their productivity is preserved and the health of human consumers of these species is protected.
This use shall apply only to those water bodies named in the Numerical Criteria and Designated Uses Table and not to their tributaries or distributaries unless so specified.

G. Outstanding Natural Resource Waters. Outstanding natural resource waters include water bodies designated for preservation, protection, reclamation, or enhancement of wilderness, aesthetic qualities, and ecological regimes, such as those designated under the Louisiana Natural and Scenic Rivers System or those designated by the department as waters of ecological significance. Characteristics of outstanding natural resource waters include, but are not limited to, highly diverse or unique instream and/or riparian habitat, high species diversity, balanced trophic structure, unique species, or similar qualities. This use designation applies only to the water bodies specifically identified in Table 3 (LAC 33:IX.1123) and not to their tributaries or distributaries unless so specified.

§1113. Criteria

B. General Criteria.
   12. Biological and Aquatic Community Integrity. The biological and community structure and function in state waters shall be maintained, protected, and restored except where not attainable and feasible as defined in LAC 33:IX.1109.B.3. This is the ideal condition of the aquatic community inhabiting the unimpaired water bodies of a specified habitat and region as measured by community structure and function. The biological integrity will be guided by the fish and wildlife propagation use designated for that particular water body. Fish and wildlife propagation uses are defined in LAC 33:IX.1111.C. The condition of these aquatic communities shall be determined from the measures of physical, chemical, and biological characteristics of each surface water body type, according to its designated use (LAC 33:IX.1123). Reference site conditions will represent naturally attainable conditions. These sites should be the least impacted and most representative of water body types. Such reference sites or segments of water bodies shall be those observed to support the greatest variety and abundance of aquatic life in the region as is expected to be or has been recorded during past surveys in natural settings essentially undisturbed by human impacts, development, or discharges. This condition shall be determined by consistent sampling and reliable measures of selected, indicative communities of animals and/or invertebrates as established by the department and may be used in conjunction with acceptable chemical, physical, and microbial water quality measurements and records as deemed for this purpose.

Maine

SOURCE: Title 38, Section 464, Maine Revised Statutes, 1999:
http://janus.state.me.us/legis/statutes/38/title38sec464.html and http://www.state.me.us/dep/blwq

38 MRSA Section 464. Classification of Maine waters:

1. **Findings; objectives; purpose.**...The Legislature declares that it is the State's objective to restore and maintain the chemical, physical and biological integrity of the State's waters and to preserve certain pristine state waters. The Legislature further declares that in order to achieve this objective the State's goals are:
   C. That water quality be sufficient to provide for the protection and propagation of fish, shellfish and wildlife and provide for recreation in and on the water.

4. **General provisions.** The classification system for surface waters established by this article shall be subject to the following provisions.
   F. The antidegradation policy of the State is governed by the following provisions.
      (1) ...Determinations of what constitutes an existing in-stream water use on a particular water body must be made on a case-by-case basis by the department. In making its determination of uses to be protected and maintained, the department shall consider designated uses for that water body and:
         (a) Aquatic, estuarine and marine life present in the water body;
         (b) Wildlife that utilize the water body;
         (c) Habitat, including significant wetlands, within a water body supporting existing populations of wildlife or aquatic, estuarine or marine life, or plant life that is maintained by the water body;
         (d) Any other evidence that, for divisions (a), (b) and (c), demonstrates their ecological significance because of their role or importance in the functioning of the ecosystem or their rarity and, for division (d), demonstrates its historical or social significance.
      (1-A) The department may only issue a waste discharge license pursuant to section 414-A, or approve a water quality certification pursuant to the United States Clean Water Act, Section 401, Public Law 92-500, as amended, when the department finds that:
         (a) The existing in-stream use involves use of the water body by a population of plant life, wildlife, or aquatic, estuarine or marine life, or as aquatic, estuarine, marine, wildlife, or plant habitat, and the applicant has demonstrated that the proposed activity would not have a significant impact on the existing use. For purpose of this division, significant impact means:
            (i) Impairing the viability of the existing population, including significant impairment to growth and reproduction or an alteration of the habitat which impairs viability of the existing population; or

         The department shall determine what constitutes a population of a particular species based upon the degree of geographic and reproductive isolation from other individuals of the same species.

6. **Implementation of biological water quality criteria.** The implementation of water quality criteria pertaining to the protection of the resident biological community shall be governed by the provisions of this subsection.
   A. At any time during the term of a valid wastewater discharge license that was issued prior to the effective date of this article, the board may modify that license in accordance with section 341-D, subsection 3 if the discharger is not in compliance with the water quality criteria pertaining to the protection of the resident biological community. When a discharge license is modified under this subsection, the board shall establish a reasonable schedule to bring the discharge into compliance with the water quality criteria pertaining to the protection of the resident biological community.
   B. When a discharge license is issued after the effective date of this article and before the effective date of the rules adopted pursuant to subsection 5, the department shall establish a reasonable schedule to bring the discharge into compliance with the water quality criteria pertaining to the protection of the resident biological community.

38 MRSA § 465. Standards for classification of fresh surface waters

The department shall have 4 standards for the classification of fresh surface waters which are not classified as great ponds.

1. Class AA waters. Class AA shall be the highest classification and shall be applied to waters which are outstanding natural resources and which should be preserved because of their ecological, social, scenic or recreational importance.
   A. Class AA waters shall be of such quality that they are suitable... as habitat for fish and other aquatic life. The habitat shall be characterized as free flowing and natural.
   B. The aquatic life, dissolved oxygen and bacteria content of Class AA waters shall be as naturally occurs.

2. Class A waters. Class A shall be the 2nd highest classification.
   A. Class A waters shall be of such quality that they are suitable...as habitat for fish and other aquatic life.

The habitat shall be characterized as natural.
   B. ...The aquatic life and bacteria content of Class A waters shall be as naturally occurs.

3. Class B waters. Class B shall be the 3rd highest classification.
   A. Class B waters shall be of such quality that they are suitable... as habitat for fish and other aquatic life. The habitat shall be characterized as unimpaired.
   B. The dissolved oxygen content of Class B waters shall be not less than 7 parts per million or 75% of saturation, whichever is higher, except that for the period from October 1st to May 14th, in order to ensure spawning and egg incubation of indigenous fish species...
   C. Discharges to Class B waters shall not cause adverse impact to aquatic life in that the receiving waters shall be of sufficient quality to support all aquatic species indigenous to the receiving water without detrimental changes in the resident biological community.

4. Class C waters. Class C shall be the 4th highest classification.
   A. Class C waters shall be of such quality that they are suitable...as a habitat for fish and other aquatic life.
   B. The dissolved oxygen content of Class C water may be not less than 5 parts per million or 60% of saturation, whichever is higher, except that in identified salmonid spawning areas where water quality is sufficient to ensure spawning, egg incubation and survival of early life stages, that water quality sufficient for these purposes must be maintained...
   C. Discharges to Class C waters may cause some changes to aquatic life, provided that the receiving waters shall be of sufficient quality to support all species of fish indigenous to the receiving waters and maintain the structure and function of the resident biological community.

38 MRSA § 466. Definitions: http://janus.state.me.us/legis/statutes/38/title38sec466.html

1. **Aquatic life.** "Aquatic life" means any plants or animals which live at least part of their life cycle in fresh water.

2. **As naturally occurs.** "As naturally occurs" means conditions with essentially the same physical, chemical and biological characteristics as found in situations with similar habitats free of measurable effects of human activity.

3. **Community function.** "Community function" means mechanisms of uptake, storage and transfer of life-sustaining materials available to a biological community which determines the efficiency of use and the amount of export of the materials from the community.

4. **Community structure.** "Community structure" means the organization of a biological community based on numbers of individuals within different taxonomic groups and the proportion each taxonomic group represents of the total community.

10. **Resident biological community.** "Resident biological community" means aquatic life expected to exist in a habitat which is free from the influence of the discharge of any pollutant. This shall be established by accepted biomonitoring techniques.

11. **Unimpaired.** "Unimpaired" means without a diminished capacity to support aquatic life.

12. **Without detrimental changes in the resident biological community.** "Without detrimental changes in the resident biological community" means no significant loss of species or excessive dominance by any species or group of species attributable to human activity.

Maryland

SOURCE: Code of Maryland Regulations, Title 26, Department of the Environment, Subtitle 08 Water Pollution, Subpart 26.0.02, November 6, 1995: COMAR 26.08.02.01, Surface Water Quality Protection and 26.08.02.02, Designated Uses: https://constmail.gov.state.md.us/comar/26/26.08.02.01.htm and https://constmail.gov.state.md.us/comar/26/26.08.02.02.htm

.01 Surface Water Quality Protection

A. Purpose. To protect surface water quality, this State shall adopt water quality standards to:
   (1) Protect public health or welfare;
   (2) Enhance the quality of water;
   (3) Protect aquatic resources; and
   (4) Serve the purposes of the Federal Act.

B. Water Quality Standards.
   (2) Water quality standards shall, wherever attainable, provide water quality for the designated uses of:
      (b) Fishing;
      (c) Propagation of fish, other aquatic life, and wildlife...

.02 Designated Uses

A. General.
   (1) Waters of this State shall, wherever attainable, be protected for the basic uses of water contact recreation, fishing, protection of aquatic life and wildlife, and agricultural and industrial water supply as identified in Use I.

B. Specific Designated Uses.
   (1) Use I: Water Contact Recreation, and Protection of Aquatic Life. This use designation includes waters which are suitable for:
      (c) Fishing;
      (d) The growth and propagation of fish (other than trout), other aquatic life, and wildlife;

   (2) Use I-P: Water Contact Recreation, Protection of Aquatic Life, and Public Water Supply. This use designation includes:
      (a) All uses identified for Use I....

   (3) Use II: Shellfish Harvesting Waters. This use designation includes waters where:
      (a) Shellfish are propagated, stored, or gathered for marketing purposes; and
      (b) There are actual or potential areas for the harvesting of oysters, softshell clams, hardshell clams, and brackish water clams.

   (4) Use III: Natural Trout Waters. This use designation includes waters which have the potential for or are:
      (a) Suitable for the growth and propagation of trout; and
      (b) Capable of supporting self-sustaining trout populations and their associated food organisms.

   (5) Use III-P: Natural Trout Waters and Public Water Supply. This use designation includes:
      (a) All uses identified for Use III waters; and...

   (6) Use IV: Recreational Trout Waters. This use designation includes cold or warm waters which have the potential for or are:
      (a) Capable of holding or supporting adult trout for put-and-take fishing; and
      (b) Managed as a special fishery by periodic stocking and seasonal catching.

   (7) Use IV-P: Recreational Trout Waters and Public Water Supply. This use designation includes:
      (a) All uses identified for Use IV waters; and...

Massachusetts

SOURCE: 314 CMR 4.00: Massachusetts Surface Water Quality Standards, effective May 12, 2000: http://www.state.ma.us/dep/bwp/iww/files/314cmr4.htm

4.02: Definitions

Aquatic Life - A native, naturally diverse, community of aquatic flora and fauna.

<u>Cold Water Fishery</u> - Waters in which the maximum mean monthly temperature generally does not exceed 68°F (20°C) and, when other ecological factors are favorable (such as habitat), are capable of supporting a year-round population of cold water stenothermal aquatic life such as trout (*salmonidae*).

<u>Vernal Pool</u> - A waterbody that has been certified by the Massachusetts Division of Fisheries and Wildlife as a vernal pool.

<u>Warm Water Fishery</u> - Waters in which the maximum mean monthly temperature generally exceeds 68°F (20°C) during the summer months and are not capable of sustaining a year-round population of cold water stenothermal aquatic life.

<u>4.05 Classes and Criteria</u>

(3) Inland Water Classes:

(a) Class A - These waters are designated as a source of public water supply. To the extent compatible with this use they shall be an excellent habitat for fish, other aquatic life and wildlife, and suitable for primary secondary contact recreation. These waters shall have excellent aesthetic value. These waters are designated for protection as Outstanding Resource Waters under 314 CMR 4.04(3).

1. Dissolved Oxygen -
   a. Shall not be less than six mg/l unless background conditions are lower;
   b. natural seasonal and daily variations above this level shall be maintained; levels shall not be lowered below 75% of saturation due to a discharge; and
   c. site-specific criteria may apply where back-ground levels are lower than specified levels or to the hypolimnion of stratified lakes where the Department determines that designated uses are not impaired.
2. Temperature -
   a. Shall not exceed 68°F (20°C) in cold water fisheries, nor 83°F (28.3°C) in warm water fisheries, and the rise in temperature due to a discharge shall not exceed 1.5°F (0.8°C); and
   b. natural seasonal and daily variations shall be maintained. There shall be no changes from background conditions that would impair any use assigned to this Class, including site-specific limits necessary to protect normal species diversity, successful migration, reproductive functions or growth of aquatic organisms.
5. Solids - These waters shall be free from floating, suspended and settleable solids in concentrations or combinations that would impair any use assigned to this class, that would cause aesthetically objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom.

(b) Class B - These waters are designated as a habitat for fish, other aquatic life, and wildlife, and for primary and secondary contact recreation. Where designated they shall be suitable as a source of public water supply with appropriate treatment. They shall be suitable for irrigation and other agricultural uses and for compatible industrial cooling and process uses. These waters shall have consistently good aesthetic value.

1. Dissolved Oxygen
   a. Shall not be less than 6.0 mg/l in cold water fisheries nor less than 5.0 mg/l in warm water fisheries unless background conditions are lower;
   b. natural seasonal and daily variations above these levels shall be maintained; levels shall not be lowered below 75% of saturation in cold water fisheries nor 60% of saturation in warm water fisheries due to a discharge; and
   c. site-specific criteria may apply where background levels are lower than specified levels, to the hypolimnion of stratified lakes or where the Department determines that designated uses are not impaired.
2. Temperature -
   a. Shall not exceed 68°F (20°C) in cold water fisheries nor 83°F (28.3°C) in warm water fisheries, and the rise in temperature due to a discharge shall not exceed 3°F (1.7°C) in rivers and streams designated as cold water fisheries nor 5°F (2.8°C) in rivers and streams designated as warm water fisheries (based on the minimum expected flow for the month); in lakes and ponds the rise shall not exceed 3°F (1.7°C) in the epilimnion (based on the monthly average of maximum daily temperature); and
   b. natural seasonal and daily variations shall be maintained. There shall be no changes from

background conditions that would impair any use assigned to this Class, including site-specific limits necessary to protect normal species diversity, successful migration, reproductive functions or growth of aquatic organisms.

5. Solids - These waters shall be free from floating, suspended and settleable solids in concentrations and combinations that would impair any use assigned to this Class, that would cause aesthetically objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom.

(c) Class C - These waters are designated as a habitat for fish, other aquatic life and wildlife, and for secondary contact recreation. These waters shall be suitable for the irrigation of crops used for consumption after cooking and for compatible industrial cooling and process uses. These waters shall have good aesthetic value.

1. Dissolved Oxygen -
    a. Shall not be less than 5.0 mg/l at least 16 hours of any 24-hour period and not less than 3.0 mg/l at any time unless background conditions are lower;
    b. natural seasonal and daily variations above these levels shall be maintained; levels shall not be lowered below 50% of saturation due to a discharge; and (c) site-specific criteria may apply where background levels are lower than specified levels, or to the hypolimnion of stratified lakes where the Department determines that designated uses are not impaired.
2. Temperature -
    a. Shall not exceed 85˚F (29.4˚C) nor shall the rise due to a discharge exceed 5F (2.8˚C); and
    b. Natural seasonal and daily variations shall be maintained. There shall be no changes from background conditions that would impair any use assigned to this Class, including the site-specific limits necessary to protect normal species diversity, successful migration, reproductive functions or growth of aquatic organisms.
5. Solids - These waters shall be free from floating, suspended and settleable solids in concentrations and combinations that would impair any use assigned to this Class, that would cause aesthetically objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom.

Michigan*

*This language has not been reviewed for accuracy by state/tribal agency.

SOURCE: Department of Environmental Quality Environmental Response Division General Rules, Part 4. Water Quality Standards: http://www.deq.state.mi.us/documents/deq-swq-gleas-305b2002AppI.doc

R 323.1043 Definitions; A to L

Rule 43

(b) "Acceptable wildlife endpoints" means subchronic and chronic endpoints that affect reproductive or developmental success, organismal viability, or growth or any other endpoint that is, or is directly related to, a parameter that influences population dynamics.

(d) "Adverse effect" means any deleterious effect to organisms due to exposure to a substance. The term includes effects that are or may become debilitating, harmful, or toxic to the normal functions of the organism. The term does not include nonharmful effects such as tissue discoloration alone or the induction of enzymes involved in the metabolism of the substance.

(f) "Anadromous salmonids" means trout and salmon that ascend streams to spawn.

(r) "Coldwater fishery" means waterbodies that contain fish species which thrive in relatively cold water, including any of the following:
- (i) Trout.
- (ii) Salmon.
- (iii) Whitefish.
- (iv) Cisco.

(x) "Designated use" means a use of the surface waters of the state as established by these rules, including use for any of the following:
- (i) Industrial, agricultural, and public water supply.
- (ii) Recreation.

(iii) Warmwater and coldwater fisheries, other aquatic life, and wildlife.
(iv) Navigation.

(hh) "Fisheries, other aquatic life, and wildlife use" means the use of the surface waters of the state by fish, other aquatic life, and wildlife for any life history stage or activity and the protection of fish for human consumption.

R 323.1044 Definitions; M to W.
Rule 44.

(c) "Natural water temperature" means the temperature of a body of water without an influence from an artificial source or a temperature as otherwise determined by the department.

(dd) "Warmwater fishery" means a waterbody that contains fish species which thrive in relatively warm water, including any of the following:
(i) Bass.
(ii) Pike.
(iii) Walleye.
(iv) Panfish.

Minnesota

SOURCE: Minnesota Rules, Chapter 7050, Minnesota Pollution Control Agency Waters of the State, October 11, 2000: http://www.revisor.leg.state.mn.us/arule/7050/

7050.0150 Determination of Water Quality Condition and Compliance,
The intent of the state is to protect and maintain surface waters in a condition which allows for the maintenance of all existing beneficial uses. The condition of a surface water body is determined by its physical, chemical, and biological qualities.

The biological quality of any given surface water body shall be assessed by comparison to the biological integrity of a reference condition or conditions which best represents the most natural condition for that surface water body type within a geographic region. The biological quality shall be determined by reliable measures of indicative communities of fauna and flora.

7050.0200 Water Use Classifications for Waters of the State:
Subpart. 3. Class 2 waters, aquatic life and recreation. Aquatic life and recreation includes all waters of the state which do or may support fish, other aquatic life, bathing, boating, or other recreational purposes, and where quality control is or may be necessary to protect aquatic or terrestrial life or their habitats, or the public health, safety, or welfare.

Subp. 5. Class 4 waters, agriculture and wildlife. Agriculture and wildlife includes all waters of the state which are or may be used for any agriculture purposes, including stock watering and irrigation, or by waterfowl or other wildlife, and for which quality control is or may be necessary to protect terrestrial life and its habitat or the public health, safety, or welfare.

Subp. 8. Class 7 waters, limited resource value waters. Limited resource value waters include surface waters of the state which have been subject to a use attainability analysis and have been found to have limited value as a water resource... The agency, in cooperation and agreement with the Department of Natural Resources with respect to determination of fisheries values and potential, shall use this information to determine the extent to which the waters of the state demonstrate:

A. the existing and potential faunal and floral communities are severely limited by natural conditions as exhibited by poor water quality characteristics, lack of habitat, or lack of water; or
B. the quality of the resource has been significantly altered by human activity and the effect is essentially irreversible; and
C. there are limited recreational opportunities (such as fishing, swimming, wading, or boating) in and on the water resource...

7050.0222 SPECIFIC STANDARDS OF QUALITY AND PURITY FOR CLASS 2 WATERS OF THE STATE; AQUATIC LIFE AND RECREATION.

Subp. 2. Class 2A waters; aquatic life and recreation. The quality of Class 2A surface waters shall be such as to permit the propagation and maintenance of a healthy community of cold water sport or commercial fish and associated aquatic life, and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable. This class of surface waters is also protected as a source of drinking water...

Subp. 3. Class 2Bd waters. The quality of Class 2Bd surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable. This class of surface waters are also protected as a source of drinking water...

Subp. 4. Class 2B waters. The quality of Class 2B surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life, and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable. This class of surface water is not protected as a source of drinking water...

Subp. 5. Class 2C waters. The quality of Class 2C surface waters shall be such as to permit the propagation and maintenance of a healthy community of indigenous fish and associated aquatic life, and their habitats. These waters shall be suitable for boating and other forms of aquatic recreation for which the waters may be usable...

Subp. 6. Class 2D waters. The quality of Class 2D wetlands shall be such as to permit the propagation and maintenance of a healthy community of aquatic and terrestrial species indigenous to wetlands, and their habitats. Wetlands also add to the biological diversity of the landscape. These waters shall be suitable for boating and other forms of aquatic recreation for which the wetland may be usable...

Mississippi

SOURCE: State of Mississippi Water Quality Criteria for Intrastate, Interstate and Coastal Waters, Adopted November 16, 1995: http://www.deq.state.ms.us/newweb/opchome.nsf/pages/SurfaceWaterfiles/$file/wqc.pdf

SECTION III. SPECIFIC WATER QUALITY CRITERIA

4. FISH AND WILDLIFE:
Waters in this classification are intended for fishing and for propagation of fish, aquatic life, and wildlife. Waters that meet the Fish and Wildlife Criteria shall also be suitable for secondary contact recreation. Secondary contact recreation is defined as incidental contact with the water, including wading and occasional swimming.

5. EPHEMERAL STREAM:
Waters in this classification do not support a fisheries resource and are not usable for human consumption or aquatic life. Ephemeral streams normally are natural watercourses, including natural watercourses that have been modified by channelization or manmade drainage ditches, that without the influent of point source discharges flow only in direct response to precipitation or irrigation return-water discharge in the immediate vicinity and whose channels are normally above the groundwater table. These streams may contain a transient population of aquatic life during the portion of the year when there is suitable habitat for fish survival. Normally, aquatic habitat in these streams is not adequate to support a reproductive cycle for fish and other aquatic life. Wetlands are excluded from this classification.

Waters in this classification shall be protective of wildlife and humans which may come in contact with the waters. Waters contained in ephemeral streams shall also allow maintenance of the standards applicable to all downstream waters.

Missouri

SOURCE: Missouri Rules of Department of Natural Resources Division 20—Clean Water Commission Chapter 7—Water Quality, August 31, 2000:
http://www.epa.gov/waterscience/standards/wqslibrary/mo/mo_7_wqs.pdf;
http://mosl.sos.state.mo.us/csr/10csr/10c20-7a.pdf and www.dnr.state.mo.us/water

10 CSR 20-7.031 Water Quality Standards:

(1) Definitions.

(C) Beneficial water uses...

2. Livestock and wildlife watering—Maintenance of conditions to support health in livestock and wildlife.
3. Cold-water fishery—Waters in which naturally occurring water quality and habitat conditions allow the maintenance of a naturally reproducing or stocked trout fishery and other naturally reproducing populations of recreationally important fish species.
4. Cool-water fishery—Waters in which naturally occurring water quality and habitat conditions allow the maintenance of a sensitive, high-quality sport fishery (including smallmouth bass and rock bass) and other naturally reproducing populations of recreationally important fish species.
5. Protection of aquatic life (General warm-water fishery)—Waters in which naturally occurring water quality and habitat conditions allow the maintenance of a wide variety of warm-water biota, including naturally reproducing populations of recreationally important fish species...
6. Protection of aquatic life (Limited warm-water fishery)—Waters in which natural water quality and/or habitat conditions prevent the maintenance of naturally reproducing populations of recreationally important fish species.
13. Habitat for resident and migratory wildlife species, including rare and endangered species—Waters that provide essential breeding, nesting, feeding and predator escape habitats for wildlife including water-fowl, birds, mammals, fish, amphibians and reptiles.

(D) Biocriteria—Numeric values or narrative expressions that describe the reference biological integrity of aquatic communities inhabiting waters that have been designated for aquatic-life protection.

(G) Ecoregion—A major region within the logical, hydrological, chemical and biological characteristics.

(O) Outstanding national resource waters—Waters which have outstanding national recreational and ecological significance.

(R) Reference stream reaches—Stream reaches determined by the department to be the best available representatives of ecoregion waters in a natural condition, with respect to habitat, water quality, biological integrity and diversity, watershed land use and riparian conditions.

(4) Specific Criteria

(Q) Biocriteria. The biological integrity of waters, as measured by lists or numeric diversity indices of benthic invertebrates, fish, algae or other appropriate biological indicators, shall not be significantly different from reference waters. Waters shall be compared with reference waters of similar size within an ecoregion.

Montana

SOURCE: Administrative Rules of Montana, Rule 17, Chapter 30, Water Quality, Subchapter 6, Surface Water Quality Standards and Procedures, June 30, 1996:
http://www.deq.state.mt.us/dir/Legal/Chapters/CH30-06.pdf and www.deq.state.mt.us

17.30.601 POLICY

(1) The following standards are adopted to conserve water by protecting, maintaining, and improving the quality and potability of water for public water supplies, wildlife, fish and aquatic life, agriculture, industry,

recreation, and other beneficial uses.

17.30.602 DEFINITIONS

(10)"Ephemeral stream" means a stream or part of a stream which flows only in direct response to precipitation in the immediate watershed or in response to the melting of a cover of snow and ice and whose channel bottom is always above the local water table.

(13)"Intermittent stream" means a stream or reach of a stream that is below the local water table for at least some part of the year, and obtains its flow from both surface runoff and groundwater discharge.

(17)"Naturally occurring" means conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil and water conservation practices have been applied. Conditions resulting from the reasonable operation of dams in existence as of July 1, 1971 are natural.

17.30.621 A-CLOSED CLASSIFICATION STANDARDS

(1) Waters classified A-Closed are suitable for drinking, culinary, and food processing purposes after simple disinfection. Water quality is suitable for swimming, recreation, growth, and propagation of fishes and associated aquatic life...

(3) No person may violate the following specific water quality standards for waters classified A-Closed:

   (f) No increases are allowed above naturally occurring concentrations of sediment, settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.

17.30.622-17.30.627 CLASSIFICATION STANDARDS

A-1, B-1, B-2, B-3, C-1, and C-2 classification standards state that water quality must be suitable for...growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers....[and other uses as assigned for each class]. [The following condition applies to these classifications:]

(3) No person may violate the following specific water quality standards for waters classified A-1:

   (f) No increases are allowed above naturally occurring concentrations of sediment, settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.

17.30.628 I CLASSIFICATION STANDARDS

(1) The goal of the state of Montana is to have these waters fully support the following uses: drinking, culinary, and food processing purposes after conventional treatment; bathing, swimming, and recreation; growth and propagation of fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply...

17.30.629 C-3 CLASSIFICATION STANDARDS

(1) Waters classified C-3 are suitable for bathing, swimming and recreation, growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers...

Nebraska

SOURCE: Title 117 - Nebraska Surface Water Quality Standards, Nebraska Department of Environmental Quality, Chapter 4: Standards for Water Quality, August 22, 2000: http://www.deq.state.ne.us/

001 It is the public policy of the State of Nebraska to protect and improve the quality of surface water for human consumption, wildlife, fish and other aquatic life, industry, recreation, and other productive, beneficial uses.

The beneficial uses defined by these standards are:

- Aquatic Life
   - Coldwater (Class A and B)

Warmwater (Class A and B)

003.01G Biological Criteria. Any human activity causing water pollution which would significantly degrade the biological integrity of a body of water or significantly impact or displace an identified "key species" shall not be allowed except as specified in Chapter 2.

003.01G1 Key Species. Key species are identified endangered, threatened, sensitive, or recreationally-important aquatic species. Key species are designated by stream segment (Chapter 5). The following list defines the aquatic species considered by the Department to be key species.

COMMON NAME	**SCIENTIFIC NAME**
Endangered Species:	
Pallid sturgeon	*Scaphirhynchus albus*
Topeka shiner	*Notropis topeka*
Threatened Species:	
Lake sturgeon	*Acipenser fulvescens*
Northern redbelly dace	*Phoxinus eos*
Pearl dace	*Semotilus margarita*
Finescale dace	*Phoxinus neogaeus*
Blacknose shiner	*Notropis heterolepis*
Sensitive Species:	
Lake chub	*Couesius plumbeus*
Brook stickleback	*Culea inconstans*
Iowa darter	*Etheostoma exile*
Johnny darter	*Etheostoma nigrum*
Orangethroat darter	*Etheostoma spectabile*
Blacknose dace	*Rhinichthys atratulus*
Grass pickerel	*Esox americanus*
Pumpkinseed	*Lepomis gibbosus*
Golden shiner	*Notemigonus crysoleucas*
Common shiner	*Notropis cornutus*

COMMON NAME	SCIENTIFIC NAME
Recreationally-Important Species:	
Shovelnose sturgeon	*Scaphirhynchus platorynchus*
Paddlefish	*Polyodon spathula*
Brook trout	*Salvelinus fontinalis*
Brown trout	*Salmo trutta*
Rainbow trout	*Oncorhynchus mykiss*
Northern pike	*Esox lucius*
Muskellunge	*Esox masquinongy*
Blue catfish	*Ictalurus furcatus*
Channel catfish	*Ictalurus punctatus*
Flathead catfish	*Pylodictis olivaris*
Striped bass	*Morone saxatilis*
White bass	*Morone chrysops*
Rock bass	*Ambloplites rupestris*
Largemouth bass	*Micropterus salmoides*
Smallmouth bass	*Micropterus dolomieui*
Spotted bass	*Micropterus punctulatus*
Redear sunfish	*Lepomis microlophus*
Bluegill	*Lepomis macrochirus*
Black crappie	*Pomoxis nigromaculatus*
White crappie	*Pomoxis annularis*
Yellow perch	*Perca flavescens*
Sauger	*Stizostedion canadense*
Walleye	*Stizostedion vitreum vitreum*

[1] Endangered, threatened, and recreationally-important aquatic species are not included.

003.02 Site-Specific Criteria for Aquatic Life.

003.02A1 The following are acceptable conditions for developing site-specific criteria.

003.02A1a Resident species of a water body are more or less sensitive than those species used to develop a water quality criterion.

003.02A1a(1) Natural adaptive processes have enabled a viable, balanced aquatic community to exist in waters where natural background levels of a chemical exceed the criterion (e.g., resident species have evolved a genetically-based greater resistance to high concentrations of a chemical).

003.02A1a(2) The composition of aquatic species in a water body is different from those used in deriving a criterion (e.g., most of the species considered among the most sensitive, such as salmonids or the cladoceran, Daphnia magna, which were used in developing a criterion, are absent from a water body).

003.02A3 Site-specific criteria shall protect all life stages of resident species year-round (or seasonally for seasonally dependent criteria) and prevent acute and chronic toxicity in all parts of a water body...

Nevada

SOURCE: Nevada Administrative Code, Chapter 445A, Standards for Water Quality, September 2000: http://www.ndep.state.nv.us/nac/445a119.pdf

NAC 445A.119 Criteria for water quality for designated beneficial uses. The water quality criteria for designated beneficial uses for the various waters of the state are in the following table.

[NOTE: In this section of NV's standards, the table titled *Water Quality Criteria for Designated Beneficial Uses* includes Aquatic Life with the following levels: Warmwater: propagation and put and take and Coldwater:

propagation and put and take.]

NAC 445A.122 Standards applicable to beneficial uses.
1. The following standards are intended to protect both existing and designated beneficial uses and must not be used to prohibit the use of the water as authorized under Title 48 of NRS:
   (c) Aquatic life. The water must be suitable as a habitat for fish and other aquatic life existing in a body of water. This does not preclude the reestablishment of other fish or aquatic life.
   (h) Propagation of wildlife. The water must be suitable for the propagation of wildlife and waterfowl without treatment.
   (i) Waters of extraordinary ecological or aesthetic value. The unique ecological or aesthetic value of the water must be maintained.

NAC 445A.124 Class A waters: Description; beneficial uses; quality standards.
1. Class A waters include waters or portions of waters located in areas of little human habitation, no industrial development or intensive agriculture and where the watershed is relatively undisturbed by man's activity.
2. The beneficial uses of class A waters are... aquatic life, propagation of wildlife, irrigation, watering of livestock, recreation including contact with the water and recreation not involving contact with the water.

NAC 445A.125 Class B waters: Description; beneficial uses; quality standards.
1. Class B waters include waters or portions of waters which are located in areas of light or moderate human habitation, little industrial development, light-to-moderate agricultural development and where the watershed is only moderately influenced by man's activity.
2. The beneficial uses of class B water are ...aquatic life and propagation of wildlife, recreation involving contact with the water...

NAC 445A.126 Class C waters: Description; beneficial uses; quality standards.
1. Class C waters include waters or portions of waters which are located in areas of moderate-to-urban human habitation, where industrial development is present in moderate amounts, agricultural practices are intensive and where the watershed is considerably altered by man's activity.
2. The beneficial uses of class C water are ... aquatic life, propagation of wildlife...

NAC 445A.127 Class D waters: Description; beneficial uses; quality standards.
1. Class D waters include waters or portions of waters located in areas of urban development, highly industrialized or intensively used for agriculture or a combination of all the above and where effluent sources include a multiplicity of waste discharges from the highly altered watershed.
2. The beneficial uses of class D waters are ... aquatic life, propagation of wildlife...

New Hampshire

SOURCE: New Hampshire Code of Administrative Rules Chapter Env-Ws 1700 Surface Water Quality Regulations, December 10, 1999: http://www.des.state.nh.us/wmb/Env-Ws1700.pdf

PART Env-Ws 1702 DEFINITIONS
Env-Ws 1702.04 "Benthic community" mean the community of plants and animals that live on, over, or in the substrate of the surface water.

Env-Ws 1702.07 "Biological integrity" means the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of similar natural habitats of a region.

Env-Ws 1702.08 "Biota" means species of plants or animals occurring in surface waters.

PART Env-Ws 1703 WATER QUALITY STANDARDS
Env-Ws 1703.01 Water Use Classifications.
   (b) All surface waters shall be restored to meet the water quality criteria for their designated classification

including existing and designated uses, and to maintain the chemical, physical, and biological integrity of surface waters.

(c) All surface waters shall provide, wherever attainable, for the protection and propagation of fish, shellfish and wildlife, and for recreation in and on the surface waters.

Env-Ws 1703.19 Biological and Aquatic Community Integrity.

(a) The surface waters shall support and maintain a balanced, integrated, and adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of similar natural habitats of a region.

(b) Differences from naturally occurring conditions shall be limited to non-detrimental differences in community structure and function.

PART Env-Ws 1707 MIXING ZONES

Env-Ws 1707.02 Minimum Criteria. Mixing zones shall be subject to site specific criteria that, as a minimum:

(b) Do not interfere with biological communities or populations of indigenous species;

(f) Do not impinge upon spawning grounds and/or nursery areas of any indigenous aquatic species;

(g) Do not result in the mortality of any plants, animals, humans, or aquatic life within the mixing zone.

New Jersey

SOURCE: New Jersey Administrative Code 7:9-B (Chapter 9B. Surface Water Quality Standards), as amended May 18, 1998: http://www.state.nj.us/dep/watershedmgt/swqs/98swqs_web.pdf

7:9B-1.4 Definitions

"Anadromous fish" means fish that spend most of their life in saline waters and migrate to fresh waters to spawn.

"Aquatic substrata" means soil material and associated biota underlying the water.

"Biota" means the animal and plant life of an ecosystem; flora and fauna collectively.

"Diadromous fish" means fish that spend most of their life in one type of water, either fresh or saline, and migrate to the other type to spawn.

"FW1" means those fresh waters, as designated in N.J.A.C. 7:9B-1.15(h) Table 6, that are to be maintained in their natural state of quality (set aside for posterity) and not subjected to any man-made wastewater discharges or increases in runoff from anthropogenic activities. These waters are set aside for posterity because of their clarity, color, scenic setting, other characteristic of aesthetic value, unique ecological significance, exceptional recreational significance, exceptional water supply significance, or exceptional fisheries resource(s).

"FW2" means the general surface water classification applied to those fresh waters that are not designated as FW1 or Pinelands Waters.

"Important species" means species that are commercially valuable (for example, within the top 10 species landed, by dollar value); recreationally valuable; threatened or endangered; critical to the organization and/or maintenance of the ecosystem; or other species necessary in the food web for the well-being of the species identified in this definition.

"Measurable changes" means changes measured or determined by a biological, chemical, physical, or analytical method, conducted in accordance with USEPA approved methods as identified in 40 C.F.R. 136 or other analytical methods (for example, mathematical models, ecological indices) approved by the Department, that might adversely impact a water use (including, but not limited to, aesthetics).

"Natural water quality" means the water quality that would exist in a waterway or a waterbody without the addition of water or waterborne substances from artificial origin.

"Outstanding National Resource Waters" means high quality waters that constitute an outstanding national resource (for example, waters of National/State Parks and Wildlife Refuges and waters of exceptional recreational or ecological significance) as designated in N.J.A.C. 7:9B-1.15(i).

"SC" means the general surface water classification applied to coastal saline waters.

"SE" means the general surface water classification applied to saline waters of estuaries.

"Trout maintenance waters" means waters designated at N.J.A.C. 7:9B-1.15(b) through (g) for the support of trout throughout the year.

"Trout production waters" means waters designated at N.J.A.C. 7:9B-1.15(b) through (g) for use by trout for spawning or nursery purposes during their first summer.

7:9B-1.5 Statements of policy

(a) General policies are as follows:

2. Water is vital to life and comprises an invaluable natural resource which is not to be abused by any segment of the State's population or economy. It is the policy of the State to restore, maintain and enhance the chemical, physical and biological integrity of its waters, to protect the public health, to safeguard the aquatic biota, protect scenic and ecological values, and to enhance the domestic, municipal, recreational, industrial, agricultural and other reasonable uses of the State's waters.
3. Toxic substances in waters of the State shall not be at levels that are toxic to humans or the aquatic biota, or that bioaccumulate in the aquatic biota so as to render them unfit for human consumption.

(f) Bioassay and biomonitoring policies are as follows:

1. Bioassay test species selection criteria follow:
   - i. The objective of the Department is to use test species for toxicity testing bioassays that are representative of the more sensitive aquatic biota from the different trophic levels of the waters in question.
   - ii. Test species need not be indigenous to, nor occur in the waters in question.
   - iii. When the bioassay test protocol being utilized falls under the scope of N.J.A.C. 7:18 the Department shall designate the approved representative species considered to be the most sensitive to the discharge.

2. Acute definitive bioassay tests, in accordance with N.J.A.C. 7:18, will normally be utilized in determining the toxicity of a discharge to the aquatic biota.
3. The Department, in order to further characterize the toxicity of a discharge, may allow or require the use of other procedures including, but not limited to:
   - iii. Measures of the structure and function of the aquatic community in the receiving waters.

7:9B-1.12 Designated uses of FW1, PL, FW2, SE1, SE2, SE3, and SC waters

(a) In all FW1 waters the designated uses are:

1. Set aside for posterity to represent the natural aquatic environment and its associated biota;
3. Maintenance, migration and propagation of the natural and established aquatic biota...

(b) In all PL waters the designated uses are:

2. Maintenance, migration and propagation of the natural and established biota indigenous to this unique ecological system;...

(c) In all FW2 waters the designated uses are:

1. Maintenance, migration and propagation of the natural and established biota...

(d) In all SE1 waters the designated uses are:

2. Maintenance, migration and propagation of the natural and established biota....

(e) In all SE2 waters the designated uses are:

1. Maintenance, migration and propagation of the natural and established biota;
2. Migration of diadromous fish;
3. Maintenance of wildlife;...

(f) In all SE3 waters the designated uses are:
   2. Maintenance and migration of fish populations;
   3. Migration of diadromous fish;
   4. Maintenance of wildlife;...

(g) In all SC waters the designated uses are:
   1. Maintenance, migration and propagation of the natural and established biota;...

New Mexico

SOURCE: State of New Mexico Standards For Interstate And Intrastate Surface Waters, Title 20 Environmental Protection, Chapter 6 Water Quality, Standards For Interstate And Intrastate Surface Waters (20.6.4.12 New Mexico Administrative Code), New Mexico Water Quality Control Commission, December 16, 2001: http://www.nmenv.state.nm.us/NMED_regs/swqb/20_6_4_nmac.html#12 and http://www.nmenv.state.nm.us

20.6.4.7 DEFINITIONS:

I. "Coldwater fishery" means a surface water of the State where the water temperature and other characteristics are suitable for the support or propagation or both of coldwater fishes.

U. "High quality coldwater fishery" means a perennial surface water of the State in a minimally disturbed condition which has considerable aesthetic value and is a superior coldwater fishery habitat. A surface water of the State to be so categorized must have water quality, stream bed characteristics, and other attributes of habitat sufficient to protect and maintain a propagating coldwater fishery.

BB. "Limited warmwater fishery" means a surface water of the State where intermittent flow may severely limit the ability of the reach to sustain a natural fish population on a continuous annual basis; or a surface water of the State where historical data indicate that water temperature may routinely exceed 32.2˚C (90˚F).

DD. "Marginal coldwater fishery" means a surface water of the State known to support a coldwater fish population during at least some portion of the year, even though historical data indicate that the maximum temperature in the surface water of the State may exceed 20˚C (68˚F).

XX. "Warmwater fishery" means a surface water of the State where the water temperature and other characteristics are suitable for the support or propagation or both of warmwater fishes.

CCC. "Wetlands" means those areas which are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soft conditions in New Mexico. Constructed wetlands used for wastewater treatment purposes are not included in this definition.

DDD. "Wildlife habitat" means a surface water of the State used by plants and animals not considered as pathogens, vectors for pathogens or intermediate hosts for pathogens for humans or domesticated livestock and plants.

20.6.4.12. GENERAL STANDARDS.

A. Bottom Deposits: Surface waters of the State shall be free of water contaminants from other than natural causes that will settle and damage or impair the normal growth, function, or reproduction of aquatic life or significantly alter the physical or chemical properties of the bottom.

20.6.4.14. USE ATTAINABILITY ANALYSIS.

D. Physical, chemical and biological evaluations of surface waters of the State other than lakes and reservoirs for purposes of use attainability analyses or equivalent studies shall be conducted according to the procedures outlined in the "Technical Support Manual: Waterbody Surveys and Assessments for Conducting Use Attainability Analyses," ...
E. Physical, chemical and biological evaluations of lakes and reservoirs for purposes of use attainability analyses or equivalent studies shall be conducted according to the procedures outlined in the "Technical Support Manual' Waterbody Surveys and Assessments for Conducting Use Attainability Analyses, Volume III: Lake Systems,"...
F. A use attainability analysis or equivalent study should include any applicable information concerning the following:
   5. A physical and biological evaluation of the surface water of the State to be reviewed to identify any factors unrelated to water quality which impair attainment of designated uses and to determine which designated uses are feasible to attain in such surface water of the State given existing physical limitations,
   7. An evaluation of the aquatic and terrestrial biota utilizing the surface water of the State to determine resident species and which species could potentially exist in such water if physical and chemical factors impairing a designated use are corrected.

New York

SOURCE: Official Compilation of Codes, Rules, and Regulations of the State of New York, Title 6, Environmental Conservation Rules and Regulations, Chapter X, Division of Water Resources, Part 701, Classifications-Surface Waters and Groundwaters, amended March 1998:
http://www.dec.state.ny.us/website/regs/701.htm

§ 701.2 Class N fresh surface waters.

(a) The best usages of Class N waters are the enjoyment of water in its natural condition and, where compatible, as a source of water for drinking or culinary purposes, bathing, fishing, fish propagation, and recreation.

§ 701.3 Class AA-Special (AA-S) fresh surface waters.

(a) The best usages of Class AA-S waters are: a source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. The waters shall be suitable for fish propagation and survival.

§ 701.4 Class A-Special (A-S) fresh surface waters.

(a) The best usages of Class A-S waters are: a source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. The waters shall be suitable for fish propagation and survival.

§ 701.5 Class AA fresh surface waters.

(a) The best usages of Class AA waters are: a source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. The waters shall be suitable for fish propagation and survival.

§ 701.6 Class A fresh surface waters.

(a) The best usages of Class A waters are: a source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. The waters shall be suitable for fish propagation and survival.

§ 701.7 Class B fresh surface waters.

The best usages of Class B waters are primary and secondary contact recreation and fishing. These waters shall be suitable for fish propagation and survival.

§ 701.8 Class C fresh surface waters.
The best usage of Class C waters is fishing. These waters shall be suitable for fish propagation and survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes.

§ 701.9 Class D fresh surface waters.
The best usage of Class D waters is fishing. Due to such natural conditions as intermittency of flow, water conditions not conducive to propagation of game fishery, or stream bed conditions, the waters will not support fish propagation. These waters shall be suitable for fish survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes.

North Carolina

SOURCE: North Carolina Administrative Code, Title 15A Environment and Natural Resources, Subchapter 2B Surface Water Standards: Monitoring, January 1, 2002:
http://h2o.enr.state.nc.us/admin/rules/rb010102.pdf and www.esb.enr.state.nc.us

15A NCAC 02B .0101 General Procedures
(e) The following are supplemental classifications:
- (1) Trout waters (Tr): freshwaters protected for natural trout propagation and survival of stocked trout.
- (2) Swamp waters (Sw): waters which have low velocities and other natural characteristics which are different from adjacent streams.
- (4) Outstanding Resource Waters (ORW): unique and special waters of exceptional state or national recreational or ecological significance which require special protection to maintain existing uses.
- (5) High Quality Waters (HQW): waters which are rated as excellent based on biological and physical/chemical characteristics through Division monitoring or special studies, native and special native trout waters (and their tributaries) designated by the Wildlife Resources Commission, primary nursery areas (PNA) designated by the Marine Fisheries Commission and other functional nursery areas designated by the Marine Fisheries Commission, all water supply watersheds which are either classified as WS-I or WS-II or those for which a formal petition for reclassification as WS-I or WS-II has been received from the appropriate local government and accepted by the Division of Water Quality and all Class SA waters.
- (7) Unique wetland (UWL): wetlands of exceptional state or national ecological significance which require special protection to maintain existing uses. These wetlands may include wetlands that have been documented to the satisfaction of the Commission as habitat essential for the conservation of state or federally listed threatened or endangered species.

15A NCAC 02B.0202 Definitions

- (11) Biological integrity means the ability of an aquatic ecosystem to support and maintain a balanced and indigenous community of organisms having species composition, diversity, population densities and functional organization similar to that of reference conditions.

15A NCAC 02B .0211 Fresh Surface Water Quality Standards for Class C Waters
- (1) Best Usage of Waters. Aquatic life propagation and maintenance of biological integrity (including fishing, and fish), wildlife, secondary recreation, agriculture and any other usage except for primary recreation or as a source of water supply for drinking, culinary or food processing purposes;
- (2) Conditions Related to Best Usage. The waters shall be suitable for aquatic life propagation and maintenance of biological integrity, wildlife, secondary recreation, and agriculture; sources of water pollution which preclude any of these uses on either a short-term or long-term basis shall be considered to be violating a water quality standard;

15A NCAC 02B .0212, .0214-.0216, .0218-.0219 Fresh Surface Water Quality Standards for Class WS-I -WS-V and Class B Waters
...Water quality standards applicable to Class C waters as described in Rule .0211 of this Section also apply to Class WS-I waters [and other uses as assigned for each class].

15A NCAC 02B .0220 TIDAL SALT WATER QUALITY STANDARDS FOR CLASS SC WATERS
General. The water quality standards for all tidal salt waters are the basic standards applicable to Class SC waters. Additional and more stringent standards applicable to other specific tidal salt water classifications are specified in Rules .0221 and .0222 of this Section.

(1) Best Usage of Waters. Aquatic life propagation and maintenance of biological integrity (including fishing, fish and functioning PNAs [Primary Nursery Areas]), wildlife, secondary recreation, and any other usage except primary recreation or shellfishing for market purposes.
(2) Conditions Related to Best Usage. The waters shall be suitable for aquatic life propagation and maintenance of biological integrity, wildlife, and secondary recreation; Any source of water pollution which precludes any of these uses, including their functioning as PNAs, on either a short-term or a long-term basis shall be considered to be violating a water quality standard.

15A NCAC 02B .0221 Tidal Salt Water Quality Standards for Class SA Waters
The following water quality standards apply to surface waters that are used for shellfishing for market purposes and are classified SA. Water quality standards applicable to Class SC waters as described in Rule .0220 of this Section also apply to Class SA waters.

(1) Best Usage of Waters. Shellfishing for market purposes and any other usage specified by the "SB" or "SC" classification...

15A NCAC 02B .0222 Tidal Salt Water Quality Standards for Class SB Waters
The following water quality standards apply to surface waters that are used for primary recreation, including frequent or organized swimming, and are classified SB. Water quality standards applicable to Class SC waters [as] described in Rule .0220 of this Section also apply to SB waters...

15A NCAC 02B .0225 Outstanding Resource Waters
(a) General In addition to the existing classifications, the Commission may classify unique and special surface waters of the state as outstanding resource waters (ORW) upon finding that such waters are of exceptional state or national recreational or ecological significance and that the waters have exceptional water quality while meeting the following conditions:
    (1) that the water quality is rated as excellent based on physical, chemical or biological information...
(b) Outstanding Resource Values. In order to be classified as ORW, a water body must exhibit one or more of the following values or uses to demonstrate it is of exceptional state or national recreational or ecological significance:
    (1) there are outstanding fish (or commercially important aquatic species) habitat and fisheries;
    (5) the waters are of special ecological or scientific significance such as habitat for rare or endangered species or as areas for research and education.

North Dakota

SOURCE: Standards of Water Quality for State of North Dakota, Rule 33-16-02, North Dakota State Department of Health and Consolidated Laboratories, June 1, 2001:
http://www.epa.gov/ost/standards/wqslibrary/

33-16-02-08. General water quality standards.
2. **Narrative Biological Goal**
    a. Goal. The biological condition of surface waters shall be similar to that of sites or waterbodies determined by the department to be regional reference sites.
    b. Definitions:
        (1) “Assemblage” means an association of aquatic organisms of similar taxonomic classification living in the same area. Examples of assemblages include, but are not limited to, fish, macroinvertebrates, algae, and vascular plants.
        (2) “Aquatic organism”means any plant or animal which lives at least part of its life cycle in water.
        (3) “Biological condition” means the taxonomic composition, richness, and functional organization of an assemblage of aquatic organisms at a site or within a water body.
        (4) “Functional organization” means the number of species or abundance of organisms within an assemblage which perform the same or similar ecological functions.

(5) “Metric” means an expression of biological community composition, richness, or function which displays a predictable, measurable change in value along a gradient of pollution or other anthropogenic disturbance.
(6) “Regional reference sites” are sites or water bodies which are determined by the department to be representative of sites or water bodies of similar type (e.g., hydrology and ecoregion) and are least impaired with respect to habitat, water quality, watershed land use, and riparian and biological condition.
(7) “Richness” means the absolute number of taxa in an assemblage at a site or within a water body.
(8) “Taxonomic composition” means the identity and abundance of species or taxonomic groupings within an assemblage at a site or within a water body.

c. Implementation. The intent of the state in adopting a narrative biological goal is solely to provide an additional assessment method that can be used to identify impaired surface waters. Regulatory or enforcement actions based solely on a narrative biological goal, such as the development and enforcement of North Dakota pollutant discharge elimination system permit limits, are not authorized. However, adequate and representative biological assessment information may be used in combination with other information to assist in determining whether designated uses are attained and to assist in determining whether new or revised chemical-specific permit limitations may be needed. Implementation will be based on the comparison of current biological conditions at a particular site to the biological conditions deemed attainable based on regional reference sites. In implementing a narrative biological goal, biological condition may be expressed through an index composed of multiple metrics or through appropriate statistical procedures.

33-20-02-09. Surface water classifications, mixing zones, and numeric standards.

1. **Classifications**...

a. Class I streams. The quality of the waters in this class shall be suitable for the propagation and/or protection of resident fish species and other aquatic biota and for swimming, boating, and other water recreation. The quality of the waters shall be for irrigation, stock watering, and wildlife without injurious effects. After treatment consisting of coagulation, settling, filtration, and chlorination, or equivalent treatment processes, the water quality shall meet the bacteriological, physical, and chemical requirements of the department for municipal or domestic use.
b. Class IA streams. The quality of the waters in this class shall be the same as the quality of class I streams, except that treatment for municipal use may also require softening to meet the requirements of the department.
c. Class II streams. The quality of the waters in this class shall be the same as the quality of class I streams, except that additional treatment may be required to meet the drinking water requirements of the department. Streams in this classification may be intermittent in nature which would make these waters of limited value for beneficial uses such as municipal water, fish life, or irrigation.
d. Class III streams. The quality of the waters in this class shall be suitable for agricultural and industrial uses such as stock watering, irrigation, washing, and cooling. These streams have low average flows and, generally, prolonged periods of no flow. They are of limited seasonal value for immersion recreation, fish life, and aquatic biota. The quality of these waters must be maintained to protect recreation, fish, and aquatic biota.

Ohio

SOURCE: Ohio Administrative Code, Chapter 3745-1-07 Water use designations and statewide criteria, February 22, 2002: http://www.epa.state.oh.us/dsw/rules/01-07.pdf

(A) Water quality standards contain two distinct elements: designated uses; and numerical or narrative criteria designed to protect and measure attainment of the uses.
(1) Each water body in the state is assigned one or more aquatic life habitat use designations. Each water body may be assigned one or more water supply use designations and/or one recreational use designation. These use designations are defined in paragraph (B) of this rule. Water bodies are assigned use designations in rules 3745-1-08 to 3745-1-32 of the Administrative Code. In addition, a water body may be assigned designations as described in the antidegradation rule (rule 3745-1-05 of the Administrative Code).

(6) Biological criteria presented in table 7-14 of this rule provide a direct measure of attainment of the warmwater habitat, exceptional warmwater habitat and modified warmwater habitat aquatic life uses. Biological criteria and the exceptions to chemical-specific or whole-effluent criteria allowed by this paragraph do not apply to any other use designations.

(a) Demonstrated attainment of the applicable biological criteria in a water body will take precedence over the application of selected chemical-specific aquatic life or whole-effluent criteria associated with these uses when the director, upon considering appropriately detailed chemical, physical and biological data, finds that one or more chemical-specific or whole-effluent criteria are inappropriate. In such cases the options which exist include:

(i) The director may develop, or a discharger may provide for the director's approval, a justification for a site-specific water quality criterion according to methods described in "Water Quality Standards Handbook, 1983, U.S. EPA Office of Water";

(ii) The director may proceed with establishing water quality based effluent limits consistent with attainment of the designated use.

(b) Demonstrated nonattainment of the applicable biological criteria in a water body with concomitant evidence that the associated chemical-specific aquatic life criteria and whole-effluent criteria are met will cause the director to seek and establish, if possible, the cause of the nonattainment of the designated use. The director shall evaluate the existing designated use and, where not attainable, propose to change the designated use. Where the designated use is attainable and the cause of the nonattainment has been established, the director shall, wherever necessary and appropriate, implement regulatory controls or make other recommendations regarding water resource management to restore the designated use...

(B) Use designations are defined as follows:

(1) Aquatic life habitat

(a) "Warmwater" - these are waters capable of supporting and maintaining a balanced, integrated, adaptive community of warmwater aquatic organisms having a species composition, diversity, and functional organization comparable to the twenty-fifth percentile of the identified reference sites within each of the following ecoregions: the interior plateau ecoregion, the Erie/Ontario lake plains ecoregion, the western Allegheny plateau ecoregion and the eastern corn belt plains ecoregion. For the Huron/Erie lake plains ecoregion, the comparable species composition, diversity and functional organization are based upon the ninetieth percentile of all sites within the ecoregion. For all ecoregions, the attributes of species composition, diversity and functional organization will be measured using the index of biotic integrity, the modified index of well-being and the invertebrate community index as defined in "Biological Criteria for the Protection of Aquatic Life: Volume II, Users Manual for Biological Field Assessment of Ohio Surface Waters," as cited in paragraph (B) of rule 3745-1-03 of the Administrative Code. In addition to those water body segments designated in rules 3745-1-08 to 3745-1-32 of the Administrative Code, all upground storage reservoirs are designated warmwater habitats. Attainment of this use designation (except for upground storage reservoirs) is based on the criteria in table 7-14 of this rule. A temporary variance to the criteria associated with this use designation may be granted as described in paragraph (F) of rule 3745-1-01 of the Administrative Code.

(b) "Limited warmwater" - these are waters that were temporarily designated in the 1978 water quality standards as not meeting specific warmwater habitat criteria. Criteria for the support of this use designation are the same as the criteria for the support of the use designation warmwater habitat. However, individual criteria are varied on a case-by-case basis and supersede the criteria for warmwater habitat where applicable. Any exceptions from warmwater habitat criteria apply only to specific criteria during specified time periods and/or flow conditions. The adjusted criteria and conditions for specified stream segments are denoted as comments in rules 3745-1-08 to 3745-1-30 of the Administrative Code. Stream segments currently designated limited warmwater habitats will undergo use attainability analyses and will be redesignated other aquatic life habitats. No additional stream segments will be designated limited warmwater habitats.

(c) "Exceptional warmwater" - these are waters capable of supporting and maintaining an exceptional or unusual community of warmwater aquatic organisms having a species composition, diversity, and functional organization comparable to the seventy-fifth percentile of the identified reference sites on a statewide basis. The attributes of species composition, diversity and functional organization will be measured using the index of biotic integrity, the modified index of well-being and the invertebrate community index as defined in "Biological Criteria for the Protection of

Aquatic Life: Volume II, Users Manual for Biological Field Assessment of Ohio Surface Waters," as cited in paragraph (B) of rule 3745-1-03 of the Administrative Code. In addition to those water body segments designated in rules 3745-1-08 to 3745-1-32 of the Administrative Code, all lakes and reservoirs, except upground storage reservoirs, are designated exceptional warmwater habitats. Attainment of this use designation (except for lakes and reservoirs) is based on the criteria in table 7-14 of this rule. A temporary variance to the criteria associated with this use designation may be granted as described in paragraph (F) of rule 3745-1-01 of the Administrative Code.

(d) "Modified warmwater" - these are waters that have been the subject of a use attainability analysis and have been found to be incapable of supporting and maintaining a balanced, integrated, adaptive community of warmwater organisms due to irretrievable modifications of the physical habitat. Such modifications are of a long-lasting duration (i.e., twenty years or longer) and may include the following examples: extensive stream channel modification activities permitted under sections 401 and 404 of the act or Chapter 6131. of the Revised Code, extensive sedimentation resulting from abandoned mine land runoff, and extensive permanent impoundment of free-flowing water bodies. The attributes of species composition, diversity and functional organization will be measured using the index of biotic integrity, the modified index of well-being and the invertebrate community index as defined in "Biological Criteria for the Protection of Aquatic Life: Volume II, Users Manual for Biological Field Assessment of Ohio Surface Waters," as cited in paragraph (B) of rule 3745-1-03 of the Administrative Code. Attainment of this use designation is based on the criteria in table 7-14 of this rule. Each water body designated modified warmwater habitat will be listed in the appropriate use designation rule (rules 3745-1-08 to 3745-1-32 of the Administrative Code) and will be identified by ecoregion and type of physical habitat modification as listed in table 7-14 of this rule. The modified warmwater habitat designation can be applied only to those waters that do not attain the warmwater habitat biological criteria in table 7-14 of this rule because of irretrievable modifications of the physical habitat. All water body segments designated modified warmwater habitat will be reviewed on a triennial basis (or sooner) to determine whether the use designation should be changed. A temporary variance to the criteria associated with this use designation may be granted as described in paragraph (F) of rule 3745-1-01 of the Administrative Code.

(e) "Seasonal salmonid" - these are rivers, streams and embayments capable of supporting the passage of salmonids from October to May and are water bodies large enough to support recreational fishing. This use will be in effect the months of October to May. Another aquatic life habitat use designation will be enforced the remainder of the year (June to September). A temporary variance to the criteria associated with this use designation may be granted as described in paragraph (F) of rule 3745-1-01 of the Administrative Code.

(f) "Coldwater" - these are waters that meet one or both of the characteristics described in paragraphs (B)(1)(f)(i) and (B)(1)(f)(ii) of this rule. A temporary variance to the criteria associated with this use designation may be granted as described in paragraph (F) of rule 3745-1-01 of the Administrative Code.

(i) "Coldwater habitat, inland trout streams" -these are waters which support trout stocking and management under the auspices of the Ohio department of natural resources, division of wildlife, excluding waters in lake run stocking programs, lake or reservoir stocking programs, experimental or trial stocking programs, and put and take programs on waters without, or without the potential restoration of, natural coldwater attributes of temperature and flow. The director shall designate these waters in consultation with the director of the Ohio department of natural resources.

(ii) "Coldwater habitat, native fauna" - these are waters capable of supporting populations of native coldwater fish and associated vertebrate and invertebrate organisms and plants on an annual basis. The director shall designate these waters based upon results of use attainability analyses.

(g) "Limited resource water" - these are waters that have been the subject of a use attainability analysis and have been found to lack the potential for any resemblance of any other aquatic life habitat as determined by the biological criteria in table 7-14 of this rule. The use attainability analysis must demonstrate that the extant fauna is substantially degraded and that the potential for recovery of the fauna to the level characteristic of any other aquatic life habitat is realistically precluded due to natural background conditions or irretrievable human-induced conditions. All water body segments designated limited resource water will be reviewed on a triennial basis (or sooner) to determine whether the use designation should be changed. Limited resource waters are also termed nuisance prevention for some water bodies designated in rules 3745-1-08 to 3745-1-30 of the Administrative Code. A temporary variance to the criteria associated with this use designation may be granted as described in paragraph (F) of rule 3745-1-01 of the Administrative Code. Waters designated limited resource water will be assigned one or more of the following causative factors. These causative factors will be listed as comments in rules 3745-1-08 to 3745-1-30 of the Administrative Code.

(i) "Acid mine drainage" - these are surface waters with sustained pH values below 4.1 s.u. or with intermittently acidic conditions combined with severe streambed siltation, and have a demonstrated biological performance below that of the modified warmwater habitat biological criteria.

(ii) "Small drainageway maintenance" - these are highly modified surface water drainageways (usually less than three square miles in drainage area) that do not possess the stream morphology and habitat characteristics necessary to support any other aquatic life habitat use. The potential for habitat improvements must be precluded due to regular stream channel maintenance required for drainage purposes.

(iii) Other specified conditions.

(2) Nuisance prevention This use designation is being replaced by the limited resource water use designation described in paragraph (A)(1)(g) of this rule. All water body segments currently designated nuisance prevention in rules 3745-1-08 to 3745-1-30 of the Administrative Code must meet the limited resource water criteria in this rule. All references to the nuisance prevention use designation in rules 3745-1-08 to 3745-1-30 of the Administrative Code will be phased out over time and replaced with limited resource water.

(3) Water supply

(a) "Public" - these are waters that, with conventional treatment, will be suitable for human intake and meet federal regulations for drinking water. Criteria associated with this use designation apply within five hundred yards of surface water intakes. Although not necessarily included in rules 3745-1-08 to 3745-1-30 of the Administrative Code, the bodies of water with one or more of the following characteristics are designated public water supply: (i) All publicly owned lakes and reservoirs, with the exception of Piedmont reservoir;
(ii) All privately owned lakes and reservoirs used as a source of public drinking water; (iii) All surface waters within five hundred yards of an existing public water supply surface water intake; (iv) All surface waters used as emergency water supplies.

(b) "Agricultural" - these are waters suitable for irrigation and livestock watering without treatment.

(c) "Industrial" - these are waters suitable for commercial and industrial uses, with or without treatment. Criteria for the support of the industrial water supply use designation will vary with the type of industry involved.

(4) Recreation. These use designations are in effect only during the recreation season, which is the period from May first to October fifteenth, for all water bodies except those designated seasonal salmonid habitat. The recreation season for streams designated seasonal salmonid habitat is June first to September thirtieth.

(a) "Bathing waters" - these are waters that, during the recreation season are suitable for swimming where a lifeguard and/or bathhouse facilities are present, and include any additional such areas where the water quality is approved by the director. Water bodies assigned the bathing waters use designation are not necessarily indicated in rules 3745-1-08 to 3745-1-30 of the Administrative Code but include local areas of those water bodies meeting this definition.

(b) "Primary contact" - these are waters that, during the recreation season, are suitable for full-body contact recreation such as, but not limited to, swimming, canoeing, and scuba diving with minimal threat to public health as a result of water quality. In addition to those water body segments designated in rules 3745-1-08 to 3745-1-32 of the Administrative Code, all lakes and reservoirs, except upground storage reservoirs and those lakes and reservoirs meeting the definition of bathing waters, are designated primary contact recreation.

(c) "Secondary contact" - these are waters that, during the recreation season, are suitable for partial body contact recreation such as, but not limited to, wading with minimal threat to public health as a result of water quality.

(C) Protection of aquatic life - whole-effluent approach. Whole-effluent toxicity levels shall be applied in accordance with rules 3745-2-09 and 3745-33-07 of the Administrative Code.

Table 7-14
Biological criteria for warmwater, exceptional warmwater and modified warmwater habitats. Description and derivation of indices and ecoregions are contained in "Biological Criteria for the Protection of Aquatic Life: Volume II, Users Manual for Biological Field Assessment of Ohio Surface Waters" cited in paragraph (B) of rule 3745-1-03 of the Administrative Code. These criteria do not apply to the Ohio river, lakes or Lake Erie river mouths

Index	Modified Warmwater Habitat				
Sampling Site Ecoregion[1]	Channel Modif.	Mine Affected	Impounded	Warmwater Habitat	Exceptional Warmwater Habitat
(A) Index of biotic integrity (fish)					
(1) Wading sites[*]					
HELP	22	–	–	32	50
IP	24	–	–	40	50
EOLP	24	–	–	38	50
WAP	24	24	–	44	50
ECBP	24	–	–	40	50
(2) Boat sites[2]					
HELP	20	–	22	34	48
IP	24	–	30	38	48
EOLP	24	–	30	40	48
WAP	24	24	30	40	48
ECBP	24	–	30	42	48
(3) Headwater sites[**]					
HELP	20	–	–	28	50
IP	24	–	–	40	50
EOLP	24	–	–	40	50
WAP	24	24	–	44	50
ECBP	24	–	–	40	50

[*] Sampling methods descriptions are found in the "Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices," cited in paragraph (B) of rule 3745-1-03 of the Administrative Code.

[**] Modification of the IBI that applies to sites with drainage areas less than twenty square miles.

Index	Modified Warmwater Habitat				
Sampling Site Ecoregion[1]	Channel Modif.	Mine Affected	Impounded	Warmwater Habitat	Exceptional Warmwater Habitat
(B) Modified index of well-being (fish)***					
(1) Wading sites[2]					
HELP	5.6	—	—	7.3	9.4
IP	6.2	—	—	8.1	9.4
EOLP	6.2	—	—	7.9	9.4
WAP	6.2	5.5	—	8.4	9.4
ECBP	6.2	—	—	8.3	9.4
(2) Boat sites[2]					
HELP	5.7	—	5.7	8.6	9.6
IP	5.8	—	6.6	8.7	9.6
EOLP	5.8	—	6.6	8.7	9.6
WAP	5.8	5.4	6.6	8.6	9.6
ECBP	5.8	—	6.6	8.5	9.6
(C) Invertebrate community index (macroinvertebrates)					
(1) Artificial substrate samplers[2]					
HELP	22	–	–	34	46
IP	22	–	–	30	46
EOLP	22	–	–	34	46
WAP	22	30	–	36	46
ECBP	22	–	–	36	46

Oklahoma

SOURCE: Oklahoma Administrative Code, Title 785, Oklahoma Water Resources Board Rules, Chapter 45 Oklahoma Water Quality Standards, August 13, 2001:
http://www.oklaosf.state.ok.us/~owrb/rules/Chap45.pdf,
http://www.oklaosf.state.ok.us/~owrb/rules/Chap46.pdf and www.state.ok.us/~owrb

785:45-1-2. Definitions

"Benthic macroinvertebrates" means invertebrate animals that are large enough to be seen by the unaided eye, can be retained by a U. S. Standard No. 30 sieve, and live at least part of their life cycles within or upon available substrate in a body of water or water transport system.

*** Does not apply to sites with drainage areas less than twenty square miles.

"Intolerant climax fish community" means habitat and water quality adequate to support game fishes or other sensitive species introduced or native to the biotic province or ecological region, which require specific or narrow ranges of high quality environmental conditions.

"Sensitive representative species" means Ceriodaphnia dubia, Daphnia magna, Daphnia pulex, Pimphales promelas (Fathead minnow), Lepomis macrochirus (Bluegill sunfish), or other sensitive organisms indigenous to a particular waterbody.

"Warm Water Aquatic Community" means a subcategory of the beneficial use category "Fish and Wildlife Propagation" where the water quality and habitat are adequate to support intolerant climax fish communities and includes an environment suitable for the full range of warm water benthos.

"Water quality" means physical, chemical, and biological characteristics of water which determine diversity, stability, and productivity of the climax biotic community or affect human health.

785:45-5-12. Fish and wildlife propagation

(b) Habitat Limited Aquatic Community subcategory.

(1) Habitat limited aquatic community means a subcategory of the beneficial use "Fish and Wildlife Propagation" where the water chemistry and habitat are not adequate to support a "Warm Water Aquatic Community" because:

(A) Naturally occurring water chemistry prevents the attainment of the use; or

(B) Naturally occurring ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of a sufficient volume of effluent to enable uses to be met; or

(C) Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or

(D) Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the waterbody to its original condition or to operate such modification in a way that would result in the attainment of the use; or

(E) Physical conditions related to the natural features of the waterbody, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of the "Warm Water Aquatic Community" beneficial use.

(2) Habitat Limited Aquatic Community may also be designated where controls more stringent than those required by sections 301(b) and 306 of the federal Clean Water Act as amended, which would be necessary to meet standards or criteria associated with the beneficial use subcategories of Cool Water Aquatic Community or Warm Water Aquatic Community, would result in substantial and widespread economic and social impact.

(c) Warm Water Aquatic Community subcategory. Warm Water Aquatic Community means a subcategory of the beneficial use category "Fish and Wildlife Propagation" where the water quality and habitat are adequate to support climax fish communities.

(d) Cool Water Aquatic Community subcategory. Cool Water Aquatic Community means a subcategory of the beneficial use category "Fish and Wildlife Propagation" where the water quality, water temperature and habitat are adequate to support cool water climax fish communities and includes an environment suitable for the full range of cool water benthos. Typical species may include smallmouth bass, certain darters and stoneflies.

(e) Trout Fishery subcategory. Trout Fishery (Put and Take) means a subcategory of the beneficial use category "Fish and Wildlife Propagation" where the water quality, water temperature and habitat are adequate to support a seasonal put and take trout fishery. Typical species may include trout.

(f) Criteria used in protection of fish and wildlife propagation. The narrative and numerical criteria to maintain and protect the use of "Fish and Wildlife Propagation" and its subcategories shall include...

(5) Biological Criteria.

(A) Aquatic life in all waterbodies designated Fish and Wildlife Propagation (excluding waters designated "Trout, put-and-take") shall not exhibit degraded conditions as indicated by one or both of the following:

(i) comparative regional reference data from a station of reasonably similar watershed size or flow, habitat type and Fish and Wildlife beneficial use subcategory designation or

(ii) by comparison with historical data from the waterbody being evaluated.

(B) Compliance with the requirements of 785:45-5-12(f)(5) shall be based upon measures including, but not limited to, diversity, similarity, community structure, species tolerance, trophic structure, dominant species, indices of biotic integrity (IBI's), indices of well being (IWB's), or other measures.

785:46-15-5. Assessment of Fish and Wildlife Propagation support

(e) **Biological criteria.**

(1) If data demonstrate that an assemblage of fish or macro invertebrates from a waterbody is significantly degraded, according to 785:45-5-12(f)(5), from that expected for thesubcategory of Fish and Wildlife Propagation designated in OAC 785:45 for that waterbody, then that subcategory may be deemed by the appropriate state environmental agency to be not supported.

(2) All physical assessments and biological collections shall be performed in accordance with the requirements set forth in OWRB Technical Report No. 99-3 entitled "Standard Operating Procedures for Stream Assessments and Biological Collections Related to Biological Criteria in Oklahoma".

(3) Evaluation of the biological collections shall include identification of fish samples to species level.

(4) The determination of whether the use of Fish and Wildlife Propagation is supported in wadeable streams in Oklahoma ecoregions shall be made according to all of the requirements of this subsection (e), the application of Appendix C of this Chapter, and the special provisions in subsections (g) through (i), where applicable, of this Section. Streams with undetermined use support status shall be subject to additional investigation that considers stream order, habitat factors and local reference streams before the use support determination is made.

(f) **Turbidity.** The criteria for turbidity stated in 785:45-5-12(f)(7) shall constitute the screening levels for turbidity. The tests for use support shall follow the default protocol in 785:46-15-4(b).

(g) **Special provisions for Ouachita Mountains wadeable streams**. The determination of whether the use of Fish and Wildlife Propagation is supported for wadeable streams located in the Ouachita Mountains ecoregion shall be made according to the application of Appendix C of this Chapter, together with this subsection, as follows:

(1) Where designated, the subcategory of Warm Water Aquatic Community shall be deemed fully supported if the application of Appendix C produces a score of 35 or more. Such subcategory shall be deemed not supported if the application of Appendix C produces a score of 24 or less. If a score is 25 to 34 inclusive, the issue of whether this subcategory is supported shall be deemed undetermined.

(2)Where designated, the subcategory of Habitat Limited Aquatic Community shall be deemed fully supported if the application of Appendix C produces a score of 27 or more. Such subcategory shall be deemed not supported if the application of Appendix C produces a score of 18 or less. If a score is 19 to 26 inclusive, the issue of whether this subcategory is supported shall be deemed undetermined.

(h) **Special provisions for Arkansas Valley wadeable streams.** The determination of whether the use of Fish and Wildlife Propagation is supported for wadeable streams located in the Arkansas Valley ecoregion shall be made according to the application of Appendix C of this Chapter, together with this subsection, as follows:

(1) Where designated, the subcategory of Warm Water Aquatic Community shall be deemed fully supported if the application of Appendix C produces a score of 35 or more. Such subcategory shall be deemed not supported if the application of Appendix C produces a score of 24 or less. If a score is 25 to 34 inclusive, the issue of whether this subcategory is supported shall be deemed undetermined.

(2) Where designated, the subcategory of Habitat Limited Aquatic Community shall be deemed fully supported if the application of Appendix C produces a score of 27 or more. Such subcategory shall be deemed not supported if the application of Appendix C produces a score of 18 or less. If a score is 19 to 26 inclusive, the issue of whether this subcategory is supported shall be deemed undetermined.

(i) **Special provisions for Boston Mountains and Ozark Highlands wadeable streams.** The determination of whether the use of Fish and Wildlife Propagation is supported for wadeable streams located in the Boston Mountains and Ozark Highlands ecoregions shall be made according to the

application of Appendix C of this Chapter, together with this subsection, as follows:
(1) Where designated, the subcategory of Cool Water Aquatic Community shall be deemed fully supported if the application of Appendix C produces a score of 37 or more. Such subcategory shall be deemed not supported if the application of Appendix C produces a score of 29 or less. If a score is 30 to 36 inclusive, the issue of whether this subcategory is supported shall be deemed undetermined.
(2) Where designated, the subcategory of Warm Water Aquatic Community shall be deemed fully supported if the application of Appendix C produces a score of 31 or more. Such subcategory shall be deemed not supported if the application of Appendix C produces a score of 22 or less. If a score is 23 to 30 inclusive, the issue of whether this subcategory is supported shall be deemed undetermined.

(j) **Special provisions for Central Irregular Plains wadeable streams.** The determination of whether the use of Fish and Wildlife Propagation is supported for wadeable streams located in the Central Irregular Plains ecoregion shall be made according to the application of Appendix C of this Chapter, together with this subsection, as follows:
(1) Where designated, the subcategory of Cool Water Aquatic Community shall be deemed fully supported if the application of Appendix C produces a score of 35 or more. Such subcategory shall be deemed not supported if the application of Appendix C produces a score of 28 or less. If a score is 29 to 34 inclusive, the issue of whether this subcategory is supported shall be deemed undetermined.
(2) Where designated, the subcategory of Warm Water Aquatic Community shall be deemed fully supported if the application of Appendix C produces a score of 30 or more. Such subcategory shall be deemed not supported if the application of Appendix C produces a score of 22 or less. If a score is 23 to 29 inclusive, the issue of whether this subcategory is supported shall be deemed undetermined.
3) Where designated, the subcategory of Habitat Limited Aquatic Community shall be deemed fully supported if the application of Appendix C produces a score of 25 or more. Such subcategory shall be deemed not supported if the application of Appendix C produces a score of 16 or less. If a score is 17 to 24 inclusive, the issue of whether this subcategory is supported shall be deemed undetermined.

SOURCE: Added at 17 Ok Reg 1775, effective 7/1/2000; Amended at 18 Ok Reg 3379, effective 8/13/2001; Amended at 19 Ok Reg 2524-2526, eff 7/1/2002

APPENDIX C. INDEX OF BIOLOGICAL INTEGRITY

		5	3	1	SCORE
Sample Composition	Total no. of species	See figure 1*	2.49 -1.50	<1.50	
	Shannon diversity** based upon numbers	>2.50	2 - 3	<2	
	No. of sunfish species	>3	4 - 3	<3	
	No. of species comprising 75% of sample	>5	3 - 5	<3	
	No. of intolerant species <100mi2 area >100mi2 area	>5			
	Percentage of tolerant species	See figure 3*			
Fish Condition	Percentage of lithophils	>36	18 - 36	<18	
	Percentage of DELT anomalies***	<0.1	0.1 -1.3	>1.3	
	Fish numbers (total individuals)	>200	200 - 75	<75	

**Figure 2. Number of Intolerant Species* and *Figure 3. Percent Tolerant Species*, (Unofficial) Oklahoma

Administrative Code, Title 785, Oklahoma Water Resources Board Rules, Chapter 46. Implementation of Oklahoma Water Quality Standards, p. 47, 48.

**$d = - \sum \frac{n_i}{N} In \frac{n_i}{N}$

***DELT = deformities, eroded fins, lesions, tumors

Oregon

SOURCE: Oregon Administrative Rules: Chapter 340 Department of Environmental Quality, Water Pollution, Division 41 State-Wide Water Quality Management Plan; Beneficial Uses, Policies, Standards, and Treatment Criteria for Oregon, amended February 15, 2001:
http://arcweb.sos.state.or.us/rules/OARS_300/OAR_340/340_041.html and
http://www.deq.state.or.us/lab/biomon/bio-rpt.htm

340-04l-0006 Definitions

(32) "Aquatic Species" means any plants or animals which live at least part of their life cycle in waters of the State.

(33) "Biological Criteria" means numerical values or narrative expressions that describe the biological integrity of aquatic communities inhabiting waters of a given designated aquatic life use.

(35) "Indigenous" means supported in a reach of water or known to have been supported according to historical records compiled by State and Federal agencies or published scientific literature.

(36) "Resident Biological Community" means aquatic life expected to exist in a particular habitat when water quality standards for a specific ecoregion, basin, or water body are met. This shall be established by accepted biomonitoring techniques.

(37) "Without Detrimental Changes in the Resident Biological Community" means no loss of ecological integrity when compared to natural conditions at an appropriate reference site or region.

(38) "Ecological Integrity" means the summation of chemical, physical and biological integrity capable of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region.

(39) "Appropriate Reference Site or Region" means a site on the same water body, or within the same basin or ecoregion that has similar habitat conditions, and represents the water quality and biological community attainable within the areas of concern.

(40) "Critical Habitat" means those areas which support rare, threatened or endangered species, or serve as sensitive spawning and rearing areas for aquatic life.

(41) "High Quality Waters" means those waters which meet or exceed those levels that are necessary to support the propagation of fish, shellfish, and wildlife and recreation in and on the water, and other designated beneficial uses.

(42) "Outstanding Resource Waters" means those waters designated by the Environmental Quality Commission where existing high quality waters constitute an outstanding state or national resource based on their extraordinary water quality or ecological values, or where special water quality protection is needed to maintain critical habitat areas.

(51) "Cold-Water Aquatic Life" -- The aquatic communities that are physiologically restricted to cold water,

composed of one or more species sensitive to reduced oxygen levels. Including but not limited to Salmonidae and cold-water invertebrates.

(52) "Cool-Water Aquatic Life" -- The aquatic communities that are physiologically restricted to cool waters, composed of one or more species having dissolved oxygen requirements believed similar to the cold-water communities. Including but not limited to Cottidae, Osmeridae, Acipenseridae, and sensitive Centrarchidae such as the small-mouth bass.

(53) "Warm-Water Aquatic Life" -- The aquatic communities that are adapted to warm-water conditions and do not contain either cold- or cool-water species.

(57) "Ecologically Significant Cold-Water Refuge" exists when all or a portion of a waterbody supports stenotypic cold-water species (flora or fauna) not otherwise widely supported within the subbasin, and either:
(a) Maintains cold-water temperatures throughout the year relative to other segments in the subbasin, providing summertime cold-water holding or rearing habitat that is limited in supply, or;
(b) Supplies cold water to a receiving stream or downstream reach that supports cold-water biota.

340-041-0027 Biological Criteria
Waters of the state shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.

Pennsylvania

SOURCE: Pennsylvania Code Chapter 93, Title 25, § 93.3, 93.4, 93.6. General water quality criteria, amended November 17, 2000: http://www.pacode.com/secure/data/025/chapter93/s93.3.html, http://www.pacode.com/secure/data/025/chapter93/s93.4.html http://www.pacode.com/secure/data/025/chapter93/s93.6.html www.dep.state.pa.us

§ 93.3. Protected water uses.
Water uses which shall be protected, and upon which the development of water quality criteria shall be based, are set forth, accompanied by their identifying symbols, in Table 1:

Table 1

Symbol	Protected Use
Aquatic Life	
CWF	Cold Water Fishes—Maintenance or propagation, or both, of fish species including the family Salmonidae and additional flora and fauna which are indigenous to a cold water habitat.
WWF	Warm Water Fishes—Maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat.
MF	Migratory Fishes—Passage, maintenance and propagation of anadromous and catadromous fishes and other fishes which ascend to flowing waters to complete their life cycle.

Symbol	Protected Use
TSF	Trout Stocking—Maintenance of stocked trout from February 15 to July 31 and maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat.
Water Supply	
AWS	Wildlife Water Supply—Use for waterfowl habitat and for drinking and cleansing by wildlife.
Special Protection	
HQ	High Quality Waters
EV	Exceptional Value Waters

§ 93.4. Statewide water uses.

(a) Statewide water uses. Except when otherwise specified in law or regulation, the uses set forth in Table 2 apply to all surface waters. These uses shall be protected in accordance with this chapter, Chapter 96 (relating to water quality standards implementation) and other applicable State and Federal laws and regulations.

Table 2

Symbol	Protected Use
Aquatic Life	
WWF	Warm Water Fishes
AWS	Wildlife Water Supply

§ 93.6. General water quality criteria.

(a) Water may not contain substances attributable to point or nonpoint source discharges in concentration or amounts sufficient to be inimical or harmful to the water uses to be protected or to human, animal, plant or aquatic life.

Rhode Island

SOURCE: State of Rhode Island And Providence Plantations Department of Environmental Management Water Resources, Water Quality Regulations, Regulation EVM 112-88.97-1, amended June 23, 2000: http://www.epa.gov/waterscience/standards/wqslibrary/ri/ri_1_wqr.pdf, and http://www.state.ri.us/dem/pubs/regs/REGS/WATER/QUALREGS.PDF

Rule 7. - DEFINITIONS

"Outstanding National Resource Waters (ONRW)" means waters of National and State Parks, Wildlife Refuges, and other such waters designated as having special recreational or ecological value.

"Special Resource Protection Waters (SRPW)" means surface waters identified by the Director as having significant recreational or ecological uses, and may include but are not limited to: wildlife refuge or management areas; public drinking water supplies; State and Federal parks; State and Federal designated Estuarine Sanctuary Areas; waterbodies containing critical habitats, including but not limited to waterbodies identified by the RIDEM Natural Heritage Program as critical habitat for rare or endangered species; wetland types or specific wetlands listed as rare, threatened, endangered, of special interest or of special concern by the Rhode Island Natural Heritage Program; waterbodies identified by the U. S. Department of the Interior on the Final List of Rivers for potential inclusion in the National Wild and Scenic Rivers System.

"Undesirable or Nuisance Species" means any plant or animal aquatic species which becomes so numerous due to pollutants or physical or hydrological modifications that it interferes with, or indicates an impairment of, the designated use(s) of a waterbody.

"Use Attainability Analyses" means a structured scientific assessment of the factors affecting the attainment of a use which may include physical, chemical, biological, and economic factors. The physical, chemical and biological factors affecting the attainment of a use shall be evaluated through a waterbody survey and assessment. Waterbody surveys and assessments shall be sufficiently detailed to evaluate at a minimum:

a. current aquatic uses achieved in the waterbody;
b. causes of any impairment of the aquatic uses and why the impairment cannot be rectified; and
c. aquatic uses(s) that can be attained based on the physical, chemical, and biological characteristics of the water body.

Rule 8. - SURFACE WATER QUALITY STANDARDS

B. Water Use Classification
   (1) Freshwater: Class A, Class B, Class B1, and Class C waters are designated... for fish and wildlife habitat...
   (2) Seawater: Class SA, Class SB, Class SB1, and Class SC waters are designated for ... fish and wildlife habitat...

D. Water Quality Criteria - The following physical, chemical and biological criteria are parameters of minimum water quality necessary to support the surface water use classifications of rule 8.B. and shall be applicable to all waters of the State.
   (1) General Criteria - The following minimum criteria are applicable to all waters of the State, unless criteria specified for individual classes are more stringent:
      (a) At a minimum, all waters shall be free of pollutants in concentrations or combinations or from anthropogenic activities subject to these regulations that:
         i. Adversely affect the composition of fish and wildlife;
         ii. Adversely affect the physical, chemical, or biological integrity of the habitat;
         iii. Interfere with the propagation of fish and wildlife;
         iv. Adversely alter the life cycle functions, uses, processes and activities of fish and wildlife;...
      (b) Aesthetics - all waters shall be free from pollutants in concentrations or combinations that:
         iv. Result in the dominance of species of fish and wildlife to such a degree as to create a nuisance or interfere with the existing or designated uses.

South Carolina

SOURCE: South Carolina Regulation 61-68, Water Classification and Standards, September 28, 2001: http://www.lpitr.state.sc.us/coderegs/chap61/61-69.htm, and
http://www.scstatehouse.net/coderegs/c061c.htm#61-68

61-68. Water Classifications and Standards

B. DEFINITIONS.
   1. Biological assessment means an evaluation of the biological condition of a waterbody using biological surveys and other direct measurements of resident biota in surface waters and sediments.

   18. Biological criteria, also known as biocriteria, mean narrative expressions or numeric values of the biological characteristics of aquatic communities based on appropriate reference conditions. Biological criteria serve as an index of aquatic community health.

F. NARRATIVE BIOLOGICAL CRITERIA.
   1. Narrative biological criteria are contained in this regulation and are described throughout the sections where applicable. The following are general statements regarding these narrative biological criteria.
      a. Narrative biological criteria in Section A.4. describe the goals of the Department to maintain and improve all surface waters to a level that provides for the survival and propagation of a balanced indigenous aquatic community of fauna and flora. These narrative criteria are determined by the

Department based on the condition of the waters of the State by measurements of physical, chemical, and biological characteristics of the waters according to their classified uses.

b. Section C.10. describes narrative biological criteria relative to surface water mixing zones and specifies requirements necessary for the protection and propagation of a balanced indigenous aquatic community.

c. Narrative biological criteria shall be consistent with the objective of maintaining and improving all surface waters to a level that provides for the survival and propagation of a balanced indigenous aquatic community of fauna and flora attainable in waters of the State; and in all cases shall protect against degradation of the highest existing or classified uses or biological conditions in compliance with the Antidegradation Rules contained in this regulation. Section D.1.a describes narrative biological criteria relative to activities in Outstanding National Resource Waters, Outstanding Resource Waters and Shellfish Harvesting Waters.

d. In order to determine the biological quality of the waters of the State, it is necessary that the biological component be assessed by comparison to a reference condition(s) based upon similar hydrologic and watershed characteristics that represent the optimum natural condition for that system. Such reference condition(s) or reaches of waterbodies shall be those observed to support the greatest variety and abundance of aquatic life in the region as is expected to be or would be with a minimal amount of disturbance from anthropogenic sources. Impacts from urbanization and agriculture should be minimal and natural vegetation should dominate the land cover. There should also be an appropriate diversity of substrate. Reference condition(s) shall be determined by consistent sampling and reliable measures of selected indicative communities of flora and fauna as established by the Department and may be used in conjunction with acceptable physical, chemical, and microbial water quality measurements and records judged to be appropriate for this purpose. Narrative biological criteria relative to activities in all waters are described in Section E.

e. In the Class Descriptions, Designations, and Specific Standards for Surface Waters Section, all water use classifications protect for a balanced indigenous aquatic community of fauna and flora. In addition, Trout Natural and Trout Put, Grow, and Take classifications protect for reproducing trout populations and stocked trout populations, respectively.

Antidegradation Rules.

8. Trout Waters. The State recognizes three types of trout waters: Natural; Put, Grow, and Take; and Put and Take.
   a. Natural (TN) are freshwaters suitable for supporting reproducing trout populations and a cold water balanced indigenous aquatic community of fauna and flora. Also suitable for primary and secondary contact recreation and as a source for drinking water supply after conventional treatment in accordance with the requirements of the Department. Suitable for fishing and the survival and propagation of a balanced indigenous aquatic community of fauna and flora. Suitable also for industrial and agricultural uses.
   b. Put, Grow, and Take (TPGT) are freshwaters suitable for supporting growth of stocked trout populations and a balanced indigenous aquatic community of fauna and flora. Also suitable for primary and secondary contact recreation and as a source for drinking water supply after conventional treatment in accordance with the requirements of the Department. Suitable for fishing and the survival and propagation of a balanced indigenous aquatic community of fauna and flora. Suitable also for industrial and agricultural uses.
   c. Put and Take (TPT) are freshwaters suitable for primary and secondary contact recreation and as a source for drinking water supply after conventional treatment in accordance with the requirements of the Department. Suitable for fishing and the survival and propagation of a balanced indigenous aquatic community of fauna and flora. Suitable also for industrial and agricultural uses. The standards of Freshwaters classification protect these uses.

South Dakota

SOURCE: Administrative Rules of South Dakota, Article 74:51, Surface Water Quality Standards, effective January 27, 1999: http://legis.state.sd.us/rules/rules/7451.htm#74:51:01 and http://www.state.sd.us/denr/denr.html

74:51:01:01. Definitions.

(4) "Aquatic life," an organism dependent on the water environment to either propagate or survive, or both;

(5) "Aquatic community," an association of interacting populations and stages of aquatic life in a given water body or habitat;

(10) "Biological integrity," the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region;

(13) "Coldwater aquatic life," aquatic life including fish of the family Salmonidae, for example, trout and salmon;

(14) "Coldwater marginal fish life propagation," a beneficial use assigned to surface waters of the state which support aquatic life and are suitable for stocked catchable-size coldwater fish during portions of the year, but which, because of critical natural conditions including low flows, siltation, or warm temperatures, are not suitable for a permanent coldwater fish population. Warmwater fish may also be present;

(15) "Coldwater permanent fish life propagation," a beneficial use assigned to surface waters of the state which are capable of supporting aquatic life and are suitable for supporting a permanent population of coldwater fish from natural reproduction or fingerling stocking. Warmwater fish may also be present;

(27) "High-quality fishery waters," surface waters of the state designated for the beneficial use of coldwater permanent fish life propagation, coldwater marginal fish life propagation, or warmwater permanent fish life propagation;

(30) "Impairment," a detrimental effect on the aquatic community caused by an impact that prevents attainment of the designated use;

(57) "Warmwater aquatic life," aquatic life including the Ictaluridae, Centrarchidae, and Cyprinidae families of fish, for example, catfish, sunfish, and minnows, respectively;

(58) "Warmwater marginal fish life propagation," a beneficial use assigned to surface waters of the state which will support aquatic life and more tolerant species of warmwater fish naturally or by frequent stocking and intensive management but which suffer frequent fish kills because of critical natural conditions;

(59) "Warmwater permanent fish life propagation," a beneficial use assigned to surface waters of the state which support aquatic life and are suitable for the permanent propagation or maintenance, or both, of warmwater fish;

(60) "Warmwater semipermanent fish life propagation waters," a beneficial use assigned to surface waters of the state which support aquatic life and are suitable for the propagation or maintenance, or both, of warmwater fish but which may suffer occasional fish kills because of critical natural conditions;

62) "Wetlands," those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions including swamps, marshes, bogs, and similar areas;

(63) "Fish and wildlife propagation, recreation, and stock watering," a beneficial use classification assigned to all surface waters of the state which may support recreation in and on the water and fish and aquatic life, when sufficient quantities of water are present for sufficient duration to support those uses; provide habitat for aquatic and semi-aquatic wild animals and fowl; provide natural food chain maintenance; and are of suitable quality for watering domestic and wild animals;

74:51:01:12. Biological integrity of waters.
All waters of the state must be free from substances, whether attributable to human-induced point source discharges or nonpoint source activities, in concentrations or combinations which will adversely impact the structure and function of indigenous or intentionally introduced aquatic communities.

Tennessee

SOURCE: Rules of the Tennessee Department of Health and Tennessee Department of Environment and Conservation, Chapter 1200-4-3 General Water Quality Criteria, revised October 1999: http://www.state.tn.us/sos/rules/1200/1200-04/1200-04-03.pdf and www.state.tn.us/environment

1200-4-3-.03 Criteria for Water Uses:
(3) Fish and Aquatic Life.
(j) Biological Integrity - The waters shall not be modified through the addition of pollutants or through physical alteration to the extent that the diversity and/or productivity of aquatic biota within the receiving waters are substantially decreased or adversely affected, except as allowed under 1200-4-3-.06. The condition of biological communities will be measured by use of metrices suggested in guidance such as Rapid Bioassessment Protocols for Use in Streams and Rivers (EPA/444/4-89-001) or other scientifically defensible methods. Effects to biological populations will be measured by comparisons to upstream conditions or to appropriately selected reference sites in the same ecoregion.

Texas

SOURCE: Texas Administrative Code, Title 30 Environmental Quality, Part 1, Texas Natural Resource Conservation Commission, Chapter 307, Texas Surface Water Quality Standards, amended effective August 17, 2000: http://info.sos.state.tx.us:80/pub/plsql/readtac$ext.ViewTAC?tac_view=4&ti=30&pt=1&ch=307&rl=Y

Rule 307.3 Definitions and Abbreviations
(a) Definitions
(9) Biological integrity--The species composition, diversity, and functional organization of a community of organisms in an environment relatively unaffected by pollution.

(27) Incidental fishery--A level of fishery which applies to water bodies that are not considered to have a sustainable fishery but which have an aquatic life use of limited, intermediate, high, or exceptional.

(45) Seagrass propagation--A water-quality-related existing use which applies to saltwater with significant stands of submerged seagrass.

(50) Significant aquatic life use--A broad characterization of aquatic life which indicates that a subcategory of aquatic life use (limited, intermediate, high, or exceptional) is applicable. Some aquatic life is expected to be present even in water bodies which are not designated for specific categories of aquatic life use. Some provisions to protect aquatic life applies to any water body in the state whether an aquatic life use is assigned or not.

Rule 307.7 Site-specific Uses and Criteria
(a) Aquatic life. The establishment of numerical criteria for aquatic life is highly dependent on desired use, sensitivities of usual aquatic communities, and local physical and chemical characteristics. Five subcategories of aquatic life use are established. They include limited, intermediate, high, and exceptional aquatic life and oyster waters. Aquatic life use subcategories designated for segments listed in Appendix A of §307.10 of this title recognize the natural variability of aquatic community requirements and local environmental conditions.

(b) Appropriate uses and criteria for site-specific standards are defined as follows.

(3) Aquatic life. The establishment of numerical criteria for aquatic life is highly dependent on desired use, sensitivities of usual aquatic communities, and local physical and chemical characteristics. Five subcategories of aquatic life use are established. They include limited, intermediate, high, and exceptional aquatic life and oyster waters. Aquatic life use subcategories designated for segments listed in Appendix A of §307.10 of this title recognize the natural variability of aquatic community requirements and local environmental conditions.

(5) Additional uses. Other basic uses, such as navigation, agricultural water supply, industrial water supply, seagrass propagation, and wetland water quality functions will be maintained and protected for all water in the state in which these uses can be achieved

Table 4: Aquatic Life Subcategories (Figure: 30 TAC §307.7(b)(3)(A)(i))

Aquatic Life Use Subcategory	Dissolved Oxygen, mg/L			Aquatic Life Attributes					
	Freshwater mean/ minimum	Freshwater in Spring mean/ minimum	Saltwater mean/ minimum	Habitat Characteristics	Species Assemblage	Sensitive Species	Diversity	Species Richness	Trophic Structure
Exceptional	6.0/4.0	6.0/5.0	5.0/4.0	Outstanding natural variability	Exceptional or unusual	Abundant	Exceptionally high	Exceptionally high	Balanced
High	5.30/3.0	5.5/4.5	4.0/3.0	Highly diverse	Usual association of regionally expected species	Present	High	High	Balanced to slightly imbalanced
Intermediate	4.0/3.0	5.0/4.0	3.0/2.0	Moderately diverse	Some expected species	Very low in abundance	Moderate	Moderate	Moderately imbalanced
Limited	3.0/2.0	4.0/3.0		Uniform	Most regionally expected species absent	Absent	Low	Low	Severely imbalanced

Utah

SOURCE: Title R317. Environmental Quality, Water Quality, R317-1. Definitions and General Requirements and Rule R317.2 Standards of Quality for Waters of the State, as in effect January 1, 2002: http://www.rules.state.ut.us/publicat/code/r317/r317-001.htm#T1 , and http://www.rules.state.ut.us/publicat/code/r317/r317-002.htm#T7

R317-1-1. Definitions

1.20 "Pollution" means such contamination, or other alteration of the physical, chemical, or biological properties of any waters of the state, or such discharge of any liquid, gaseous or solid substance into any waters of the state as will create a nuisance or render such waters harmful or detrimental or injurious to public health, safety or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or to livestock, wild animals, birds, fish or other aquatic life.

317-2-6. Use Designations

6.3 Class 3 -- Protected for use by aquatic wildlife.

(a) Class 3A -- Protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.

(b) Class 3B -- Protected for warm water species of game fish and other warm water aquatic life, including the necessary aquatic organisms in their food chain.

(c) Class 3C -- Protected for nongame fish and other aquatic life, including the necessary aquatic organisms in their food chain.

(d) Class 3D -- Protected for waterfowl, shore birds and other water-oriented wildlife not included in Classes 3A, 3B, or 3C, including the necessary aquatic organisms in their food chain.

(e) Class 3E -- Severely habitat-limited waters. Narrative standards will be applied to protect these waters for aquatic wildlife.

6.5 Class 5 -- The Great Salt Lake. Protected for primary and secondary contact recreation, aquatic wildlife, and mineral extraction.

Vermont

SOURCE: Vermont Water Quality Standards, effective July 2, 2000:
http://www.state.vt.us/wtrboard/docs/adoptedwqs.pdf

Section 1-01B. Applicability and Definitions

5. **Aquatic biota** means all organisms that, as part of their natural life cycle, live in or on waters.

6. **Aquatic habitat** means the physical, chemical, and biological components of the water environment.

10. **Biological integrity** means the ability of an aquatic ecosystem to support and maintain, when consistent with reference conditions, a community of organisms that is not dominated by any particular species or functions (balanced), is fully functional (integrated), and is resilient to change or impact (adaptive), and which has the expected species composition, diversity, and functional organization.

20. **Functional component** of the aquatic ecosystem means a portion of the aquatic biological community identified by its role in the processing of energy within the aquatic ecosystem (e.g., primary producers, predators, detritivores, etc.).

23. **Intolerant aquatic organisms** means those organisms which are particularly sensitive to, and likely to be adversely affected by, the stress of pollution, flow modification or habitat alteration (e.g., mayflies and stoneflies).

29. **Natural condition** means the condition representing chemical, physical, and biological characteristics that occur naturally with only minimal effects from human influences.

39. **Reference condition** means the range of chemical, physical, and biological characteristics of waters minimally affected by human influences. In the context of an evaluation of biological indices, or where necessary to perform other evaluations of water quality, the reference condition establishes attainable chemical, physical, and biological conditions for specific water body types against which the condition of waters of similar water body type is evaluated.

44. **Taxonomic component of the aquatic ecosystem** means a portion of the biological community identified by a hierarchical classification system for identifying biological organisms that uses physical and biological characteristics (e.g., Insecta: Plecoptera: Perlidae: Agnetina capitata).

45. **Tolerant aquatic organisms** means organisms (e.g., midges and annelids) that, although they may be affected by the stress of pollution, flow modification or habitat alteration, are less sensitive and less likely to be adversely affected than are intolerant aquatic organisms.

Section 3-01C. Numeric Biological Criteria

C. Numeric Biological Indices
   1. In addition to other applicable provisions of these rules and other appropriate methods of evaluation, the Secretary may establish and apply numeric biological indices to determine whether there is full support of aquatic biota and aquatic habitat uses. These numeric biological indices shall be derived from measures of the biological integrity of the reference condition for different water body types. In establishing numeric biological indices, the Secretary shall establish procedures that employ standard sampling and analytical methods to characterize the biological integrity of the appropriate reference condition. Characteristic measures of biological integrity include but are not limited to community level measurement such as: species richness, diversity, relative abundance of tolerant and intolerant species, density, and functional composition.
   2. In addition, the Secretary may determine whether there is full support of aquatic biota and aquatic

habitat uses through other appropriate methods of evaluation, including habitat assessments.

Section 3-02 Class A(1) Ecological Waters

B. Water Quality Criteria for Class A(1) Ecological Waters
   3. Aquatic Biota, Wildlife, and Aquatic Habitat - Change from the natural condition limited to minimal impacts from human activity. Measures of biological integrity for aquatic macroinvertebrates and fish assemblages are within the range of the natural condition. Uses related to either the physical, chemical, or biological integrity of the aquatic habitat or the composition or life cycle functions of aquatic biota or wildlife are fully supported. All life cycle functions, including overwintering and reproductive requirements are maintained and protected.

Section 3-03. Class A(2) Public Water Supplies

A. Management Objectives. Waters managed for public water supply purposes to achieve and maintain waters with a uniformly excellent character and a level of water quality that is compatible with the following designated uses:
   1. Aquatic Biota, Wildlife, and Aquatic Habitat - high quality aquatic biota and wildlife sustained by high quality aquatic habitat necessary to support their life-cycle and reproductive requirements.

B. Water Quality Criteria for Class A(2) Public Water Supplies. The following water quality criteria shall be achieved in all Class A(2) public water supplies.
   3. Aquatic Biota, Wildlife and Aquatic Habitat - Biological integrity is maintained, no change from the reference condition that would prevent the full support of aquatic biota, wildlife or aquatic habitat uses. Change from the reference condition for aquatic macroinvertebrates and fish assemblages shall not exceed moderate changes in the relative proportions of taxonomic, functional, tolerant and intolerant components. All expected functional groups are present in a high quality habitat and none shall be eliminated. All life cycle functions, including overwintering and reproductive requirements are maintained and protected. Changes in the aquatic habitat shall not exceed moderate differences from the reference condition consistent with the full support of all aquatic biota and wildlife uses.

Section 3-04. Class B Waters

A. Management Objectives. Class B waters shall be managed to achieve and maintain a level of quality that fully supports the following designated uses:
   1. Aquatic Biota, Wildlife, and Aquatic Habitat - aquatic biota and wildlife sustained by high quality aquatic habitat with additional protection in those waters where these uses are sustainable at a higher level based on Water Management Type designation.

B. Water Quality Criteria for Class B waters. In addition to the criteria specified in §3-01 of these rules, the following criteria shall be met in all Class B waters:
   4. Aquatic Biota, Wildlife and Aquatic Habitat - No change from the reference condition that would prevent the full support of aquatic biota, wildlife, or aquatic habitat uses. Biological integrity is maintained and all expected functional groups are present in a high quality habitat. All life-cycle functions, including overwintering and reproductive requirements are maintained and protected. In addition, the following criteria shall be achieved:
      a. In Water Management Type One waters - change from the reference condition for aquatic macroinvertebrate and fish assemblages shall be limited to minor changes in the relative proportions of taxonomic and functional components; relative proportions of tolerant and intolerant components are within the range of the reference condition. Changes in the aquatic habitat shall be limited to minimal differences from the reference condition consistent with the full support of all aquatic biota and wildlife uses.
      b. In Water Management Type Two waters - change from the reference condition for aquatic macroinvertebrate and fish assemblages shall be limited to moderate changes in the relative proportions of tolerant, intolerant, taxonomic, and functional components. Changes in the aquatic habitat shall be limited to minor differences from the reference condition consistent with the full support of all aquatic biota and wildlife uses.
      c. In Water Management Type Three waters - change from the reference condition for aquatic macroinvertebrate and fish assemblages shall be limited to moderate changes in the relative proportions of tolerant, intolerant, taxonomic, and functional components. Changes in the aquatic habitat shall be limited to moderate differences from the reference condition consistent with the full support of all aquatic biota and wildlife uses. When such habitat changes are a result of hydrological modification or water level fluctuation, compliance may be determined on the basis

of aquatic habitat studies.

d. In all other Class B waters - no change from reference conditions that would have an undue adverse effect on the composition of the aquatic biota, the physical or chemical nature of the substrate or the species composition or propagation of fishes.

Section 3-05 Fish Habitat Designation

To provide for the protection and management of fisheries, the waters of the State are designated in Appendix A as being either a cold or a warm water fish habitat. Where appropriate, such designations may be seasonal.

Virginia

SOURCE: State Water Control Board, Virginia Administrative Code (9 VAC 25-260-5 et seq. Water Quality Standards). Statutory Authority: § 62.1-44.15(3a) of the Code of Virginia. Effective Date: December 10, 1997: http://www.deq.state.va.us/wqs/

PART I
SURFACE WATER STANDARDS WITH GENERAL, STATEWIDE APPLICATION

9 VAC 25-260-10. Designation of uses.

A. All state waters, including wetlands, are designated for the following uses: recreational uses, e.g., swimming and boating; the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish.

9 VAC 25-260-20. General standard.

A. All state waters, including wetlands, shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or interfere directly or indirectly with designated uses of such water or which are inimical or harmful to human, animal, plant, or aquatic life.

9 VAC 25-260-370. Classification column.

B. DGIF trout waters. The Department of Game and Inland Fisheries (DGIF) has established a classification system for trout waters based on aesthetics, productivity, resident fish population and stream structure. Classes i through iv rate wild trout habitat; Classes v through vii rate cold water habitat not suitable for wild trout but adequate for year-round hold-over of stocked trout. The DGIF classification system is included in this publication with the board's trout water classes (Class V - Stockable trout waters and Class VI - Natural trout waters) in the class column of the River Basin Section Tables 9 VAC 25-260-390 et seq.

DGIF trout water classifications which are not consistent with board classifications for stockable trout waters or natural trout waters are shown with a double asterisk (**) in the class column of the River Basin Section Tables 9 VAC 25-260-390 et seq. These trout waters have been identified for reevaluation by the DGIF. Those trout waters which have no DGIF classification are shown with a triple asterisk (***). The DGIF classes are described below. Inclusion of these DGIF classes provides additional information about specific streams for permit writers and other interested persons. Trout waters classified as classes i or ii by the DGIF are also recognized in 9 VAC 25-260-110.

DGIF STREAM CLASS DESCRIPTIONS.

Wild natural trout streams.

Class i. Stream of outstanding natural beauty possessing wilderness or at least remote characteristics, an abundance of large deep pools, and excellent fish cover. Substrate is variable with an abundance of coarse gravel and rubble. Stream contains a good population of wild trout or has the potential for such. Would be considered an exceptional wild trout stream.

Class ii. Stream contains a good wild trout population or the potential for one but is lacking in aesthetic quality, productivity, and/or in some structural characteristic. Stream maintains good water quality and temperature, maintains at least a fair summer flow, and adjacent land is not extensively developed. Stream would be considered a good wild trout stream and would represent a major portion of Virginia's wild trout waters.

Class iii. Stream which contains a fair population of wild trout with carrying capacity depressed by natural factors or more commonly man-related land use practices. Land use activities may result in heavy siltation of the stream, destruction of banks and fish cover, water quality degradation, increased water temperature, etc. Most streams would be considered to be in the active state of degradation or recovery from degradation. Alteration in land use practices would generally improve carrying capacity of the stream.

Class iv. Stream which contains an adequately reproducing wild trout population but has severely reduced summer flow characteristics. Fish are trapped in isolated pools where they are highly susceptible to predators and fishermen. Such streams could quickly be over-exploited and, therefore, provide difficult management problems.

Stockable trout streams.

Class v. Stream does not contain an adequately reproducing wild trout population nor does it have the potential for such. However, water quality is adequate, water temperature is good, and invertebrate productivity is exceptional. Pools are abundant with good size and depth and fish cover is excellent. Stream would be good for stocked trout but may offer more potential for a fingerling stocking program.

Class vi. Stream does not contain a significant number of trout nor a significant population of warmwater gamefish. Water quality is adequate and water temperature good for summer carryover of stocked trout. Summer flow remains fair and adjacent land is not extensively developed. All streams in this class would be considered good trout stocking water.

Class vii. Stream does not contain a significant number of trout nor a significant population of warmwater gamefish. Water quality and temperature are adequate for trout survival but productivity is marginal as are structural characteristics. Streams in this class could be included in a stocking program but they would be considered marginal and generally would not be recommended for stocking.

Class viii. Stream does not contain a significant number of trout nor a significant population of warmwater gamefish. Water quality and temperature are adequate for trout but summer flows are very poor (less than 30% of channel). Streams in this class can provide good trout fishing during spring and early summer but would not be recommended for summer or fall stocking.

Other. Remaining streams would be considered unsuitable for any type of trout fishery. Streams would be considered unsuitable under any of the following conditions:
(a) summer temperatures unsuitable for trout survival;
(b) stream contains a significant population of warmwater gamefish;
(c) insufficient flow; or
(d) intolerable water quality.

Washington

SOURCE: Chapter 173-201A Washington Administrative Code. Water Quality Standards for Surface Waters of the State of Washington, November 18, 1997: http://www.ecy.wa.gov/pubs/wac173201a.pdf

WAC 173-201A-010 Introduction.

(1) The purpose of this chapter is to establish water quality standards for surface waters of the state of Washington consistent with public health and public enjoyment thereof, and the propagation and protection of fish, shellfish, and wildlife, pursuant to the provisions of chapter 90.48 RCW [Revised Code of Washington] and the policies and purposes thereof.

WAC 173-201A-020 Definitions.

"Biological assessment" is an evaluation of the biological condition of a water body using surveys of aquatic community structure and function and other direct measurements of resident biota in surface waters.

"Damage to the ecosystem" means any demonstrated or predicted stress to aquatic or terrestrial organisms or communities of organisms which the department reasonably concludes may interfere in the health or survival success or natural structure of such populations. This stress may be due to, but is not limited to, alteration in habitat or changes in water temperature, chemistry, or turbidity, and shall consider the potential build up of discharge constituents or temporal increases in habitat alteration which may create such stress in the long term.

"Ecoregions" are defined using EPA's *Ecoregions of the Pacific Northwest* Document No. 600/3-86/033 July 1986 by Omernik and Gallant.

"Wildlife habitat" means waters of the state used by, or that directly or indirectly provide food support to, fish, other aquatic life, and wildlife for any life history stage or activity.

WAC 173-201A-030 General water use and criteria classes.
The following criteria shall apply to the various classes of surface waters in the state of Washington:

Class AA (extraordinary), Class A (excellent), and Class B (good). Characteristic uses shall include, but not be limited to, the following:

- (iii) Fish and shellfish: Salmonid migration, rearing, spawning, and harvesting. Other fish migration, rearing, spawning, and harvesting. Clam, oyster, and mussel rearing, spawning, and harvesting. Crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, etc.) rearing, spawning, and harvesting.
- (iv) Wildlife habitat.

Class C (fair). Characteristic uses shall include, but not be limited to, the following:

- (ii) Fish (salmonid and other fish migration).

Lake class. Characteristic uses shall include, but not be limited to, the following:

- (iii) Fish and shellfish: Salmonid migration, rearing, spawning, and harvesting. Other fish migration, rearing, spawning, and harvesting. Clam and mussel rearing, spawning, and harvesting. Crayfish rearing, spawning, and harvesting.
- (iv) Wildlife habitat.

West Virginia

SOURCE: Title 46, West Virginia Secretary of State, Code of State Rules (CSR), Legislative Rule, Environmental Quality Board, Series 1, Requirements Governing Water Quality Standards, effective May 17, 2001: http://www.state.wv.us/csr/verify.asp?TitleSeries=46-01

§46-1-3. Conditions Not Allowable In State Waters.

3.2.i. Any other condition, including radiological exposure, which adversely alters the integrity of the waters of the State including wetlands; no significant adverse impact to the chemical, physical, hydrologic, or biological components of aquatic ecosystems shall be allowed.

§46-1-6. Water Use Categories.

6.3. Category B – Propagation and maintenance of fish and other aquatic life. -- This category includes:

- 6.3.a. Category B1 -- Warm water fishery streams. -- Streams or stream segments which contain populations composed of all warm water aquatic life.
- 6.3.b. Category B2 -- Trout Waters. -- As defined in Section 2.19 (See Appendix A for a representative list.)
- 6.3.c. Category B4 -- Wetlands. -- As defined in section 2.22; certain numeric stream criteria may not be appropriate for application to wetlands (see Appendix E).

6.5. Category D. -- Agriculture and wildlife uses.

- 6.5.c. Category D3 -- Wildlife. -- This category includes all stream segments and wetlands used by wildlife.

Wisconsin

Source: Wisconsin Administrative Code, Department of Natural Resources, Chapter NR 102, Water Quality Standards for Wisconsin Surface Waters, February 1998: http://www.legis.state.wi.us/rsb/code/nr/nr102.pdf

NR 102.04 Categories of standards.

(3) FISH AND OTHER AQUATIC LIFE USES. The department shall classify all surface waters into one of the fish and other aquatic life subcategories described in this subsection. Only those use subcategories identified in pars. (a) to (c) shall be considered suitable for the protection and propagation of a balanced fish and other aquatic life community as provided in the federal water pollution control act amendments of 1972, P.L. 92–500; 33 USC 1251 et seq.

- (a) *Cold water communities*. This subcategory includes surface waters capable of supporting a community of cold water fish and other aquatic life, or serving as a spawning area for cold water fish species. This subcategory includes, but is not restricted to, surface waters identified as trout water by the department of natural resources (Wisconsin Trout Streams, publication 6–3600 (80)).
- (b) *Warm water sport fish communities*. This subcategory includes surface waters capable of supporting a community of warm water sport fish or serving as a spawning area for warm water sport fish.
- (c) *Warm water forage fish communities.* This subcategory includes surface waters capable of supporting an abundant diverse community of forage fish and other aquatic life.
- (d) *Limited forage fish communities*. (Intermediate surface waters). This subcategory includes surface waters of limited capacity and naturally poor water quality or habitat. These surface waters are capable of supporting only a limited community of forage fish and other aquatic life.
- (e) *Limited aquatic life*. (Marginal surface waters). This sub-category includes surface waters of severely limited capacity and naturally poor water quality or habitat. These surface waters are capable of supporting only a limited community of aquatic life.

(7) STANDARDS FOR WILDLIFE. All surface waters shall be classified for wildlife uses and meet the wildlife criteria specified in or developed pursuant to NR 105.07.

Wyoming

SOURCE: Wyoming Rules and Regulations, Water Quality Rules and Regulations: Chapter 1, Quality Standards for Wyoming Surface Waters Sections 2, 3, and 4, March 7, 2000: http://soswy.state.wy.us/RULES/3925.pdf

Section 2. Definitions. The following definitions supplement those definitions contained in section 35-11-103 of the Wyoming Environmental Quality Act.

(e) "Cold Water Game Fish " means Grayling (Thymallus arcticus), Northern Pike (Esox lucius), Salmon (Oncorhynchus spp.), Sauger (Stizostedion canadense), Tiger muskie (Esox Masquinongy), Trout (Salmo, Oncorhynchus, and Salvelinus spp.), Walleye (Stizostedion vitreum), and Whitefish (Prospium williamsoni).

(p) "Game fish" means Bass (Micropterus spp.), Catfish (Ictalurus punctatus), Crappie (Pomoxis spp.), Grayling (Thymallus arcticus), Ling (Lota lota), Northern Pike (Esox lucius), Perch (Perca flavescens), Salmon (Oncorhynchus spp.), Sauger (Stizostedion canadense), Sunfish (Lepomis spp.), Tiger Muskie (Esox Masquinongy), Trout (Salmo, Oncorhynchus, and Salvelinus spp.), Walleye (Stizostedion vitreum), White Bass (Morone chrysops), and Whitefish (Prospium williamsoni).

(w) "Natural" means that condition which would exist without the measurable effects or measurable influence of man's activities.

(x) "Natural biotic community" means the population structures which were historically or normally present under a given set of chemical and physical conditions or which would potentially exist had not the habitat been degraded.

(y) "Natural water quality" means that quality of water which would exist without the measurable effects or measurable influence of man's activities.

(ll) "Undesirable aquatic life" means organisms generally associated with degraded or eutrophic conditions. These may include the following organisms where they have replaced members of the natural biotic community: nongame fish, bluegreen algae, certain diatoms, fungi, tubificid worms, and certain syrphid flies.

(mm) "Warm water game fish" means Bass (Micropterus spp.), Catfish (Ictalurus punctatus), Crappie (Pomoxis spp.), Ling (Lota lota), Perch (Perca flavescens), Sunfish (Lepomis spp.), and White Bass (Morone Chrysops).

<u>Section 3. Water Uses</u>.
(b) Protection and propagation of fish and wildlife;...and to achieve the goal of the federal act, which is to achieve, wherever attainable, surface water quality which provides for the protection and propagation of fish, shellfish, wildlife, and recreation in and on the water.

<u>Section 4. Surface Water Classes and Uses</u>. There are four classes of surface water in Wyoming:
(a) Class 1 - Those surface waters in which no further water quality degradation by point source discharges other than from dams will be allowed. Nonpoint sources of pollution shall be controlled through implementation of appropriate best management practices. In designating Class 1 waters, the Environmental Quality Council shall consider water quality, aesthetic, scenic, recreational, ecological, agricultural, botanical, zoological, municipal, industrial, historical, geological, cultural, archaeological, fish and wildlife, the presence of significant quantities of developable water and other values of present and future benefit to the people.
(b) Class 2 - Those surface waters, other than those classified as Class 1, which are determined to:
  (i) Be presently supporting game fish; or
  (ii) Have the hydrologic and natural water quality potential to support game fish; or
  (iii) Include nursery areas or food sources for game fish.
(c) Class 3 - Those surface waters, other than those classified as Class 1, which are determined to:
  (i) Be presently supporting nongame fish only; or
  (ii) Have the hydrologic and natural water quality potential to support nongame fish only; or
  (iii) Include nursery areas or food sources for nongame fish only.
(d) Class 4 - Those surface waters, other than those classified as Class 1, which are determined to not have the hydrologic or natural water quality potential to support fish and include all intermittent and ephemeral streams. Class 4 waters shall receive protection for agriculture uses and wildlife watering.

<u>TERRITORIES</u>

American Samoa

SOURCE: American Samoa Water Quality Standards (1999 Revision provided by ASEPA), Sections 24.0205 and 24.0206:

<u>§24.0205 Water Classifications-Protected and Prohibited Uses</u>
(1) Class 1 Fresh Surface Waters
  (A) Class 1 waters are to remain in as near their natural state as possible with a minimum of pollution from any human activity. Protected uses of these waters are: potable water supplies, support and propagation indigenous aquatic and terrestrial life and compatible recreation and aesthetic enjoyment.
  (B) Prohibited uses and activities include, but are not limited to:
    (i) Point source discharges of pollutants
    (ii) Dredging and filling activities
    (iii) Bathing, including washing clothes and dishes
    (iv) Animal pens over or within 100 feet of the water body
    (v) Siting of septic tanks or cesspools within 200 feet of the water body

(vi) Land disturbing (e.g., grading, tillage) activities within 100 feet of the water body
(vii) Wood cutting or clearing within 100 feet of the water body

(2) Class 2 Fresh Surface Waters
   (A) Class 2 waters shall be protected for the support and propagation of indigenous aquatic life, recreation in and on the water, and aesthetic enjoyment.
   (B) Prohibited uses and activities include, but are not limited to:
      (i) No zones of mixing will be granted
      (ii) Dredging or filling activities, except as approved by EQC
      (iii) Animal pens over or immediately adjacent to the water body

§24.0206 Standards of Water Quality

(i) There shall be no changes in basin geometry or freshwater inflow that will alter current patterns in such a way as to adversely affect existing biological populations or sediment distribution. To protect estuarine organisms, no change in channels, basin geometry, or freshwater influx shall be made which would cause permanent changes in existing isohaline patterns of more than 10 percent.

Commonwealth of Northern Mariana Islands

Source: http://www.epa.gov/ost/standards/wqslibrary/ and http://www.deq.gov.mp/

PART 5 CLASSIFICATION OF WATER USES

5.1 Marine Waters

(a) CLASS AA - It is the objective of this class that these waters remain in their natural pristine state as nearly as possible with an absolute minimum of pollution or alteration of water quality from any human-related source or actions. To the extent practicable, the wilderness character of such areas shall be protected. No zones of mixing shall be permitted. The uses to be protected in this class of waters are the support and propagation of shellfish and other marine life, conservation of coral reefs and wilderness areas, oceanographic research, and aesthetic enjoyment and compatible recreation inclusive of whole body contact and related activities. / The classification of any water area as Class AA shall not preclude other uses of such waters compatible with these objectives and in conformance with the criteria applicable to them.

(b) CLASS A - It is the objective of this class of waters that their use for recreational purposes and aesthetic enjoyment be protected. Any other use shall be allowed as long as it is compatible with the protection and propagation of fish, shellfish, and wildlife, and with recreation in and on these waters of a limited body contact nature. Such waters shall be kept clean of solid waste, oil and grease, and shall not act as receiving waters for any effluent which has not received the best degree of treatment of control practicable under existing technology and economic conditions and compatible with standards established for this class. A zone of mixing is [approvable] in such waters.

5.2 Fresh Surface Waters

(a) Class 1 - It is the objective of this class that these waters remain in their natural state as nearly as possible with an absolute minimum Of pollution from any human-caused source. To the extent possible, the wilderness character of such areas shall be protected. Wastewater discharges and zone of mixing into these waters are prohibited. The uses to be protected in this class of water are for domestic water supplies, food processing, the support and propagation of aquatic life, compatible recreation and aesthetic enjoyment including water contact recreation.

(b) Class 2 - It is the objective of this class of waters that their use for recreational purposes, propagation of fish and other aquatic life, and agricultural and industrial water supply not be limited in any way. The uses to be protected in this class of waters are all uses compatible with the protection and propagation of fish and other aquatic life, and with recreation in and on these waters. Compatible recreation may include limited body contact activities. Such waters shall not act as receiving waters for any discharge which has not received the best degree of treatment or control practical under technological and economic conditions and compatible with the standards established for this class. A zone of mixing is permissible in these waters.

5.3 Protection of wetlands
Wetlands are waters of the State and are subject to the provisions of this rule. Point or nonpoint sources of pollution shall not cause destruction or impairment of wetlands. The general application of the Water Quality Standards shall apply to all wetlands unless replaced by site specific standards for wetlands based on their function are adopted by the Commonwealth and approved by EPA.

7.6 Salinity
Marine Waters (applicable to Class A, Class AA): No alterations of the marine environment shall occur that would: (1) alter the salinity of marine or estuarine waters more than 10% of the ambient conditions, or (2) which would otherwise adversely affect the sedimentary patterns and indigenous biota, except when due to natural causes.

7.10 Oil and Petroleum Products
The concentration of oil or petroleum products shall not:
(b) Cause tainting of fish or other aquatic life, be injurious to the indigenous biota or cause objectionable taste in drinking water.

7.12 General Considerations
(d) The health and life history characteristics of aquatic organisms in waters affected by controllable water quality factors shall not differ substantially from those for the same waters in areas unaffected by controllable water quality factors. Also, controllable water quality factors shall not cause a detrimental increase in concentrations of toxic substances found in bottom sediments or aquatic life.

Guam*

*This language has not been reviewed for accuracy by state/tribal agency.

SOURCE: Section II, Guam STATEMENT OF POLICY, amended 1986:
http://www.epa.gov/ost/standards/wqslibrary/

It shall be the public policy of the Territory of Guam to:
1. conserve, protect, maintain, and improve the quality of the Guam's waters for (drinking and food processing) human consumption, for the growth and propagation of aquatic life, for marine research and for the preservation of coral reefs and wilderness areas, and for domestic, agricultural, commercial, industrial, recreational and other legitimate uses;
4. maintain and improve the chemical, physical, and biological integrity of wetlands water quality as necessary to meet the Clean Water Act Section 101(a), and to protect wetlands...

SECTION I: CATEGORIES OF WATERS
A. **MARINE WATERS.** This category includes all coastal waters off-shore from the mean high water mark, including estuarine waters, lagoons and bays, brackish areas, wetlands and other special aquatic sites, and other inland Waters that are subject to ebb and flow of the tides. Refer to Water Classification Map.

CATEGORY M-1 EXCELLENT: Waters in this category must be of high enough quality to ensure preservation and protection of marine life, including corals and reef dwelling organisms, fish and related fisheries resources, and enable the pursuit of marine scientific research as well as aesthetic enjoyment. This category of water shall remain substantially free from pollution attributed to domestic, commercial and industrial discharges, shipping and boating, or agriculture, construction and other activities which can reduce the waters' quality. Furthermore, there shall be no zones of mixing within this category water.

CATEGORY M-2 GOOD: Water in this category must be of sufficient quality to allow for the propagation and survival of marine organisms, particularly shellfish, corals and other reef related resources. Other important and intended uses include mariculture activities, aesthetic enjoyment and compatible recreation inclusive of whole body contact and related activities.

CATEGORY M-3 FAIR: Water in this category is intended for general, commercial and industrial use. Specific intended uses include the following: shipping, boating and berthing, industrial cooling water, marinas, while allowing for protection of aquatic life, aesthetic enjoyment and compatible recreation with limited body contact.

B. **MIXING ZONES IN RECEIVING WATERS**. ...The following criteria apply to all mixing zones:

3. Biologically important areas, including spawning and nursery areas, shall be protected.

CHAPTER IV DEFINITIONS

BIOTA: The animal, plant and microbial life of a region.

COMMUNITY: An association of living organisms in a given area or region in which the various species are more or less interdependent upon each other.

HABITAT: The environment occupied by individuals of a particular species, population or community.

SPECIAL AQUATIC SITES: Sites possessing special ecological characteristics and values including wetlands, wildlife sanctuaries and refuges, mud flats, vegetated shallows, coral reefs, riffle and pool complexes.

WETLANDS: Means areas of land where the water table is at, near or above the land surface long enough each year to result in the formation of characteristically wet (hydric) soil types, and support the growth of water dependent (hydrophytic) vegetation. Wetlands include, but are not limited to, marshes, swamps, mangroves, natural ponds, surface springs, estuaries, bogs, and other such low-lying or similar areas. Inland wetlands will include all wetlands meeting the following conditions.

1) Wetlands greater than one hectare in size with less than 0.5% (ocean derived) salinity; and
2) Palustrine, Riverine and Lacustrine wetlands with greater than 30% wetland vegetation cover.

WETLAND FUNCTIONS: The beneficial uses of wetlands which are protected by these Water Quality Standards including but not limited to groundwater recharge/discharge, flood water retention, sediment stabilization, nutrient removal/transformation, wildlife diversity/ abundance, aquatic diversity/abundance, and recreation.

Puerto Rico

SOURCE: Commonwealth of Puerto Rico, Office of the Governor, Environmental Quality Board, Puerto Rico Water Quality Standards, amended November 1987: http://www.epa.gov/ost/standards/wqslibrary/

Article I. Definitions

Benthic Species. Organisms that inhabit on, over, or in the bottom of the water body.;live adhered to the bottom or crawl over the bottom.

Biota. All living organisms.

Desirable Species. Species indigenous to the area or introduced to the area because of ecological or commercial value.

Ecological Community. Group of organisms dominated by one species or a specific group of species. The ecological community derives its name from that of the dominant species, such as coral reefs and mangroves.

Ecological Value. Refers to the existing interrelations between water body, fauna and flora that result in the continuity, stability and permanence of the ecological community.

Pelagic Species. Organisms that have the ability of self locomotion and can overcome the currents. These organisms can be found anywhere in the water column, near the surface, the bottom or at any point between the surface and the bottom.

Planktonic Species. Marine organisms that mainly inhabit the surface of the receiving body of water. Their main characteristic is that they cannot overcome the currents even if they have self locomotion.

Propagation and Preservation of Desirable Species. This refers to the reproduction and continuance of flora and fauna associated with water bodies and which have ecologic importance and/or commercial value, whether individually or as part of an ecological community.

Wetlands. Areas inundated or saturated by coastal, surface cr ground water at a frequency and duration sufficient to support, and under normal circumstances do support a prevalence of vegetation typically adapted for life in saturated soil conditions.

ARTICLE 2. CLASSIFICATION OF THE WATERS OF PUERTO RICO ACCORDING TO THE DESIGNATED USES TO BE PROTECTED

3.2 Use Classifications and Water Quality Standards for Specific Classifications:

- 3.2.1 Class SA:
  - (A) Usages and Description: Coastal waters and estuarine waters of high quality and/or exceptional ecological or recreational value whose existing characteristics shall not be altered, except by natural causes, in order to preserve the existing natural phenomena.
- 3.2.2 Class SB:
  - (A) Usages and Description. Coastal waters and estuarine waters for use in primary and secondary contact recreation, and for propagation and preservation of desirable species.
- 3.2.3 Class SC:
  - (A) Usages and Description: Coastal waters intended ...for use in propagation and preservation of desirable species.
- 3.2.4 Class SD:
  - (A) Usages and Description: Surface waters intended for ... propagation and preservation of desirable species as well as primary and secondary contact recreation...
- 3.2.5 Class SE:
  - (A) Usages and Description: Surface waters and wetlands of exceptional ecological value, whose existing characteristics should not be altered in order to preserve the existing natural phenomena.

U.S. Virgin Islands

SOURCE: T.12 Subchapter 186. Water Quality Standards for Coastal Waters of the Virgin Islands Ch. 7 WATER POLLUTION CONTROL §186-2 - 186.4: http://www.epa.gov/ost/standards/wqslibrary

§ 186-2. Class A

(a) Best usage of waters: Preservation of natural phenomena requiring special conditions, such as the Natural Barrier Reef at Buck Island, St. Croix and the Under Water Trail at Trunk Bay, St. John.

(b) Quality criteria: Existing natural conditions shall not be changed.

§ 186-3. Class B

(a) Best usage of waters: For propagation of desirable species of marine life...

§ 186-4. Class C

(a) Best usage of waters: For the propagation of desirable species of marine life...

TRIBES

Confederated Tribes of the Colville Reservation

SOURCE: Source: 40 CFR 131.35, July 1, 2000 edition:
http://www.epa.gov/ost/standards/wqslibrary/tribes/131.35.pdf

§ 131.35

(f) General water use and criteria classes. The following criteria shall apply to the various classes of surface waters on the Colville Indian Reservation:

(1) *Class I (Extraordinary)—(i) Designated uses.* The designated uses include, but are not limited to, the following:

(C) Fish and shellfish: Salmonid migration, rearing, spawning, and harvesting; other fish migration, rearing, spawning, and harvesting.

(D) Wildlife habitat.

(2) *Class II (Excellent)*—(i) *Designated uses.* The designated uses include but are not limited to, the following:

(C) Fish and shellfish: Salmonid migration, rearing, spawning, and harvesting; other fish migration, rearing, spawning, and harvesting; crayfish rearing, spawning, and harvesting.

(D) Wildlife habitat.

(3) *Class III (Good)*—(i) *Designated uses.* The designated uses include but are not limited to, the following:

(C) Fish and shellfish: Salmonid migration, rearing, spawning, and harvesting; other fish migration, rearing, spawning, and harvesting; crayfish rearing, spawning, and harvesting.

(D) Wildlife habitat.

(4) *Class IV (Fair)*—(i) *Designated uses.* The designated uses include but are not limited to, the following:

(C) Fish (salmonid and other fish migration).

Nez Perce Tribe

WQS under development. Currently collecting chemical and physical habitat data to eventually establish WQS for the reservation area. No website available.

Oneida Nation of Wisconsin

(WQS were federally approved in 1996 and then rescinded after a lawsuit.)
SOURCE: Oneida Nation Water Quality Standards, hard copy provided by contact

Article VII. Narrative Criteria

7-1. Narrative criteria shall be used to guide water management decisions and activities that affect the Waters of the Reservation, and to protect and enhance water quality. The following narrative criteria shall apply to all Waters of the Reservations provided, however, where more stringent criteria exist, the stricter standards shall supersede.

7-2. All Waters of the Reservation shall be free from:

a. pollutants in quantities that, either alone or as a result of interaction with other pollutants, cause any designated use to become impaired.

b. pollutants in quantities that produce or contribute to the production of nuisance aquatic life.

c. pollutants in quantities that produce objectionable color, odor, taste or turbidity.

d. hazardous substances, toxic corrosive, nonconventional materials concentrations, or other deleterious substances, chemicals, and materials, which alone or in combination with other substances or in combination with other components of discharges, or their breakdown products, are acutely or chronically toxic, carcinogenic, teratogenic, and injure, or bioaccumulate, biomagnify, bioconcentrate, or produce adverse physiological responses in human beings and/or fish and aquatic life, or which interfere directly or indirectly with designated, existing, or other uses.

e. exotic nuisance species, e.g. purple loosestrife, zebra mussels, etc.

f. toxic pollutants in quantities that result bioaccumulation in aquatic organisms leading to toxicity to consumers of the aquatic organisms.

g. excess nutrients that may cause a condition harmful to human health, decrease fish habitat, cause nuisance aquatic growths, or that in any way impair designated uses. Nitrogen and phosphorous concentrations shall not exceed the levels stated in Article XIII of this document.

h. microorganisms at levels that make recreation in and on Reservation waters unsafe.

i. floating debris, oil, scum and other floating materials as a result of human activity in amounts sufficient to be unsightly, cause degradation or impair designated uses.

j. materials entering the waters as a result of human activity producing color, odor, taste or other conditions in amounts sufficient to be unsightly, cause degradation or in any way impair designated uses.

k. substances other than from natural causes that may settle to form objectionable deposits or adversely impact designated uses.

l. contaminants, from other than natural causes, that may settle or remain suspended that have a deleterious effect on the aquatic life or that will significantly alter the physical or chemical properties of the water body or that in any way impairs designated uses.

7-3. All wetlands shall be protected to maintain and restore their natural physical, biological, and chemical characteristics, including substrate, vegetative and hydrological conditions necessary to support natural amounts of native vegetation, maintain natural hydrodynamics and maintain natural water temperature variations that are necessary to protect and support all existing and designated uses.

7-4. All naturally occuring biological communities and the habitat needed to support them shall be maintained and protected in all waters and wetlands of the Reservation at all times.

7-5. Concentrations of radioactive materials shall not exceed concentrations caused by local naturally occuring materials.

7-6. All Waters of the Reservation shall be free from unauthorized discharges at all places at all times.

7-7. Any activity that allows storm discharges or base flow conditions to significantly degrade stream morphology or result in a waterway's inability to maintain existing aquatic life shall be prohibited. Cumulative impacts of any such activity shall be considered.

7-8. Waters contained in intermittent and ephemeral streams shall meet all water quality criteria applicable to any perennial streams to which they are tributaries.

7-9. All criteria should be met at all times and all locations, including low flow rates. However, allowance may be made for mixing, on a case by case basis, where compliance with the chronic criteria is not technically feasible. In such cases mixing zones shall be established consistent with 40 C. F. R. Pt. 132, Appendix F, Procedure 3. In no case will mixing be permitted in biologically or recreationally sensitive areas. In no case may the acute criteria be exceeded.

7-10. Natural native biological/ecological communities associated with Waters of the Reservation and their biotic and abiotic components and relationships shall be protected.

7-11. Waters of the Reservation shall not be degraded below their present water quality nor shall new or increased discharges be permitted unless it is determined by the Environmental Department that the accompanying water quality degradation from such discharges will provide unique benefits in accordance with Section 6-7 and Section 6-8. All existing and designated uses shall be protected at all times.

7-12. Any activities that degrade the aesthetic quality, stability and/or ecological integrity of the Waters of the Reservation shall be prohibited unless authorized in a manner consistent with the water quality standards contained herein.

7-13. The discharge of toxicants into the Waters of Reservations that are known or found to be synergistic with other pollutants shall be addresses on a case by case basis.

7-14. For substances where numeric criteria have not yet been adopted by the Oneida Nation, the numeric criteria and methodologies in 40 C. F. R. Pt. 132, Appendices A-D shall be used and are incorporated into these standards by reference.

Article IX. Designated Uses

9-1. All of the following categories of designated uses shall apply to all Waters of the reservation except where noted.

9-2. *Public Water Supply*. Waters specifically designated as suitable or intended to become suitable for providing an adequate supply of drinking water for the continuation of the health, safety and welfare of the Nation's members and residents of the Oneida Reservation.

9-3. *Wildlife.* All surface waters capable of providing a water supply and vegetative habitat for the support and propagation of all wildlife located within the exterior boundaries of the Oneida Nation Reservation.

9-4. *Aquatic Life.* Waters of the Reservation shall be categorized as one the following:

1. *Cold Water Ecosystems*: Waters of the Reservation where water temperature, habitat and other characteristics are suitable or intended to be suitable for the support and propagation of cold water fish and other aquatic life, or serving as a spawning or nursery area for cold water fish species. Examples of cold water fish include brook trout and rainbow trout. Trout Creek, Lancaster Brook and associated tributaries are hereby designated as cold water ecosystems.
2. *Warm Water Ecosystems:* Waters of the Reservation where water temperature, habitat and other characteristics are suitable or intended to be suitable for support and propagation of warm water fish and other aquatic life, or serving as a spawning or nursery area for warm water fish species. Examples of warm water fish species include large mouth bass and bluegills. All Waters of the Reservation are hereby designated as warm water ecosystems except those mentioned in Section 9-4(a).

9-5. *Subsistence Fishing.* Water of the Reservation where spearing, netting or bow fishing is allowed as stated in the Oneida Conservation Hunting and Fishing Law.

9-6. *Cultural.* Waters that are suitable or intended to be suitable for traditional, cultural, historic and modern ceremonial uses which uses which may include, but are not limited to the harvest and use of medical plants and wildlife associated with aquatic, wetland and riparian habitats; cultural educational uses including but not limited to ethnohydrological learning experiences that are passed from one generation to the next regarding the harvest of plants, fish, and animals; subsistence fishing; and activities that may require the protection of sensitive and valuable aquatic plant and wildlife, and aquatic, wetland and riparian habitat.

9-7. Recreation.

1. *Primary Contact Recreational:* Waters that are suitable for activities involving prolonged human contact where the risk of ingesting small quantities of water is likely; examples of this type of activity include, but are not limited to, swimming, tubing, rafting, skin diving, etc. The Norbert Hill Pond is hereby designated as a primary contact recreational area.
2. *Secondary Contact Recreational:* Waters that are suitable for activities in which human contact with the water may, but need not occur and in which the probability of ingesting raw water is unlikely. Examples of this type of activity include, but are not limited to, fishing, wading, boating, etc. All Waters of the Reservation are hereby designated as secondary contact recreational

areas except for those mentioned in Section 9-5(a).

9-8. *Agricultural.* Waters that are suitable for crop irrigation and livestock ingestion.

9-9. *Navigational.* Waters that are suitable for navigation in and on the water.

9-10. *Industrial.* Waters that are suitable for manufacturing and/or production enterprises.

Passamaquoddy Tribe, Pleasant Point Reservation

[WQS currently awaiting approval by EPA Region 9]

Pyramid Lake Paiute Tribe

[WQS currently awaiting approval by EPA Region 9]

INTERSTATE COMMISSIONS

Delaware River Basin Commission

SOURCE: Delaware River Basin Commission West Trenton, New Jersey. Administrative Manual — Part III, Water Quality Regulations, Revised to Include Amendments Through October 23, 1996, Article 3 Water Quality Standards for the Delaware River Basin [Comprehensive Plan, Section X]: http://www.state.nj.us/drbc/regs/wq-regs.pdf

3.10 BASINWIDE SURFACE WATER QUALITY STANDARDS

3.10.2 Water Uses

B. Uses to be Protected. The quality of Basin waters, except intermittent streams, shall be maintained in a safe and satisfactory condition of the following uses:

2. wildlife, fish and other aquatic life;

3.10.3 Stream Quality Objectives

A. Antidegradation of Waters

2. Special Protection Waters. It is the policy of the Commission that there be no measurable change in existing water quality except towards natural conditions in waters considered by the Commission to have exceptionally high scenic, recreational, ecological, and/or water supply values. Waters with exceptional values could be classified by the Commission as Outstanding Basin Waters or Significant Resource Waters.

In determining waters suitable for classification as Special Protection Waters, the Commission will consider nomination petitions from local, state and federal agencies and governing bodies, and the public for waters potentially meeting the definition of Outstanding Basin Waters and Significant Resource Waters as described in 3.10.3A.2.a.

The following policies shall apply to waters classified by the Commission as Outstanding Basin Waters or Significant Resource Waters and their drainage areas:

a. Definitions

1) "Outstanding Basin Waters" are interstate and contiguous intrastate waters that are contained within the established boundaries of national parks; national wild, scenic and recreational rivers systems; and/or national wildlife refuges that are classified by the Commission under Subsection 2.g.1). hereof as having exceptionally high scenic,

recreational, and ecological values that require special protection.

2) "Significant Resource Waters" are interstate waters classified by the Commission under Subsection 2.g.2). hereof as having exceptionally high scenic, recreational, ecological, and/or water supply uses that require special protection.

3) "Existing Water Quality" is defined as the actual concentration of a water constituent at an in-stream site or sites, as determined through field measurements and laboratory analysis of data collected over a time period determined by the Commission to adequately reflect the natural range of the hydraulic and climatologic factors which affect water quality. Existing water quality shall be described in terms of (a) an annual or seasonal mean of the available water quality data, (b) two-tailed upper and lower 95 percent confidence limits around the mean, and (c) the 10th and 90th percentiles of the data set from which the mean was calculated. Where available data are insufficient to determine existing water quality, existing water quality may be estimated from data obtained from sites within the same ecoregion or from best scientific judgment.

4) "Measurable Change" is defined as an actual or estimated change in a mean (annual or seasonal) in-stream pollutant concentration that is outside the range of the two-tailed upper and lower 95 percent confidence limits that define existing water quality. In the absence of adequate available data, background concentrations will be assumed to be zero and "measurable change" will be based on in-stream concentrations greater than the detection limit for each parameter, based on the lowest limit of the most sensitive technique specified in 40 CFR Part 136.

Excerpted from Table 1: Definition of Existing Water Quality in the Delaware River Between Hancock, NY and the Delaware Water Gap:

Part A: Upper Delaware Scenic & Recreational River

Parameter	Mean	95 Percent Confidence Limits of Mean	10^{th} and 90^{th} Percentiles	Additional
....	....	....	...	....
Biocriteria: Shannon-Weiner	3.6	3.4 to 3.8	2.7 and 4.3	May - Sept; reachwide
Biocriteria: Equitability	0.8	0.7 to 0.9	0.5 and 1.1	May - Sept; reachwide
Biocriteria:: EPT	15.5	13.8 to 17.2	8.0 and 24.0	May - Sept; reachwide

Part B: Delaware River from Millrift through the Delaware Water Gap Including the Middle Delaware Scenic and Recreational River

Parameter	Mean	95 Percent Confidence Limits of Mean	10^{th} and 90^{th} Percentiles	Additional
....	....	....	...	....
Biocriteria: Shannon-Weiner	3.6	3.4 to 3.7	3.2 and4.1	May - Sept; reachwide
Biocriteria: Equitability	0.8	0.7 to 0.9	0.5 and 1.1	May - Sept; reachwide

Biocriteria: EPT	13.9	12.8 to 15.1	8.0 and 20.0	May - Sept; reachwide

Ohio River Valley Water Sanitation Commission

SOURCE: Ohio River Valley Water Sanitation Commission Pollution Control Standards for discharges to the Ohio River, 2000 Revision: http://www.orsanco.org/watqual/standards/PollutionControl.pdf and http://www.orsanco.org/

II. Definitions

B. "Biological integrity" means the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to those best attainable given ecoregional attributes and the modified habitat types of the river.

H. "Early Life Stages" of fish means the pre-hatch embryonic period, the post-hatch free embryo or yolk-sac fry, and the larval period, during which the organism feeds. Juvenile fish, which are anatomically rather similar to adults, are not considered an early life stage.

R. "Representative Aquatic Species" means those species of aquatic life whose protection and propagation will assure the sustained presence of a balanced indigenous community. Such species are representative in the sense that maintenance of suitable water quality conditions will assure the overall protection and sustain propagation of the balanced, indigenous community.

IV. Water Quality Criteria

B. Aquatic Life Protection. To provide protection of warm water aquatic life habitats, the following criteria shall be met outside the mixing zone:
   1. BIOLOGICAL: The biological integrity of the Ohio River shall be protected and preserved.

5. LIST OF ACRONYMS AND DEFINITION OF TERMS

5.1 Acronyms

AL	Aquatic Life
ALU	Aquatic Life Use
ALUS	Aquatic Life Use Support
ANOVA	Analysis of Variance
BMP	Best Management Practice
CALM	Consolidated Assessment Listing Methodology
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CWA	Clean Water Act
DO	Dissolved Oxygen
DQO	Data Quality Objectives
EDAS	Ecological Data Application System
EMAP	Environmental Monitoring and Assessment Program
EPT	Ephemeroptera, Plecoptera, Trichoptera
FTE	Full Time Employees
GIS	Geographic Information System
GPS	Global Positioning System
HBI	Hilsenhoff Biotic Index
IBI	Index of Biological/Biotic Integrity
MACS	Mid-Atlantic Coastal Streams
NAWQA	National Water Quality Assessment Program
NCBI	North Carolina Biotic Index
NHD	National Hydrography Database
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
POTW	Publicly Owned Treatment Works
QA	Quality Assurance

QAPP	Quality Assurance Project Plan
QC	Quality Control
QHEI	Qualitative Habitat Evaluation Index
QMP	Quality Management Plan
RBP	Rapid Bioassessment Protocols
RCRA	Resource Conservation and Recovery Act
REMAP	Regional Environmental Monitoring and Assessment Program
RIVPACS	River Invertebrate Prediction and Classification System
RF3	River Reach File 3
SOP	Standard Operating Procedures
STORET	Data Storage and Retrieval System
TMDL	Total Maximum Daily Load
UAA	Use Attainability Analyses
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WQ	Water Quality
WQS	Water Quality Standards
WWTP	Waste Water Treatment Plant

5.2 Definition of Terms

Accuracy	the degree of agreement between an observed value and an accepted reference value.
Ambient Monitoring	sampling and evaluation of receiving waters not necessarily associated with episodic perturbations.
Analysis of Variance	a general statistical method for comparing the mean response to different treatments using the ratio of among-group to between-group variance. The method has also been applied to estimating precision and quantifying sources of variance.
Antidegradation Statement	statement that protects existing designated uses and prevents high-quality waterbodies from deteriorating below the water quality necessary to maintain existing or anticipated designated beneficial uses.

Aquatic Assemblage	an association of interacting populations of organisms in a given waterbody, for example, fish assemblage or a benthic macroinvertebrate assemblage.
Aquatic Community	an association of interacting assemblages in a given waterbody, the biotic component of an ecosystem.
Aquatic Life Use	a beneficial use designation in which the waterbody provides suitable habitat for survival and reproduction of desirable fish, shellfish, and other aquatic organisms; classifications specified in state water quality standards relating to the level of protection afforded to the resident biological community by the state agency.
Beneficial Uses	desirable uses that water quality should support. Examples are drinking water supply, primary contact recreation (such as swimming), and aquatic life support.
Benthic Macroinvertebrates	animals without backbones, living in or on the sediments, of a size large enough to be seen by the unaided eye and which can be retained by a U.S. Standard No. 30 sieve (28 meshes per inch, 0.595 mm openings). Also referred to as benthos, infauna, or macrobenthos.
Benthos	see Benthic Macroinvertebrates.
Best Management Practice	an engineered structure or management activity, or combination of these, that eliminates or reduces an adverse environmental effect of a pollutant.
Bias	the systematic or persistent distortion of a measurement process which deprives the result of representativeness (i.e., the expected sample measurement is different than the sample's true value).
Biological Assessment or Bioassessment	an evaluation of the biological condition of a waterbody using surveys of the structure and function of the community of resident biota.
Biological Criteria or Biocriteria	narrative expressions or numerical values that describe the reference biological condition (structure and function) of aquatic communities inhabiting waters of a given designated aquatic life use. Biocriteria are based on the numbers and kinds of organisms present and are regulatory-based biological measurements.
Biological Diversity or Biodiversity	refers to the variety and variability among living organisms and the ecological complexes in which they occur. Diversity can be defined as the number of different items and their relative frequencies. For biological diversity, these items are organized at many levels, ranging from complete ecosystems to the biochemical structures that are the molecular basis of heredity. Thus, the term encompasses different ecosystems, species, and genes.
Biological Indicator or Bioindicator	an organism, species, assemblage, or community characteristic of a particular habitat, or indicative of a particular set of environmental conditions.

Biological Integrity	the ability of an aquatic ecosystem to support and maintain a balanced, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats within a region.
Biological Monitoring or Biomonitoring	use of a biological entity as a detector and its response as a measure to determine environmental conditions. Ambient biological surveys and toxicity tests are common biological monitoring methods.
Biological Survey or Biosurvey	collecting, processing, and analyzing a representative portion of the resident aquatic community to determine its structural and/or functional characteristics.
Bioregion	any geographical region characterized by a distinctive flora and/or fauna.
Clean Water Act	an act passed by the U.S. Congress to control water pollution (formerly referred to as the Federal Water Pollution Control Act of 1972). Public Law 92-500, as amended. 33 U.S.C. 1251 et seq.
Clean Water Act 303(d)	This section of the Act requires States, territories, and authorized tribes to develop lists of impaired waters for which water quality standards are not being met, even after point sources of pollution have installed the minimum required levels of pollution control technology. The law requires that these jurisdictions establish priority rankings for waters on the lists and develop TMDLs for these waters. States, territories, and authorized tribes are to submit their list of waters on April 1 in every even-numbered year.
Clean Water Act 305(b)	biennial reporting requires description of the quality of the Nation's surface waters, evaluation of progress made in maintaining and restoring water quality, and description of the extent of remaining problems.
Criteria	limits on a particular pollutant or condition of a waterbody presumed to support or protect the designated use or uses of a waterbody. Criteria may be narrative or numeric.
Data Quality Objectives	qualitative and quantitative statements developed by data users to specify the quality of data needed to support specific decisions; statements about the level of uncertainty that a decision maker is willing to accept in data used to support a particular decision.
Data Storage and Retrieval System (STORET)	EPA's largest computerized environmental data system; repository for biological, chemical, and physical data used by state environmental agencies, EPA and other federal agencies, universities, private citizens, and many others.
Designated Use	classification specified in water quality standards for each waterbody or segment describing the level of protection from perturbation afforded by the regulatory programs. The designated aquatic life uses established by the state or authorized tribes set forth the goals for the restoration and/or baseline conditions for maintenance and prevention from further degradation of the aquatic life in specific waterbodies.

Ecological Data Application System (EDAS)	relational database system that allows the user to input, compile, and analyze complex ecological data to make assessments of ecosystem condition.
Ecological Integrity	the condition of an unimpaired ecosystem as measured by combined chemical, physical (including habitat), and biological attributes.
Ecoregion	a relatively homogeneous ecological area defined by similarity of climate, landform, soil, potential natural vegetation, hydrology, or other ecologically relevant variables.
Environmental Monitoring and Assessment Program	a US EPA research program to develop the tools necessary to monitor and assess the status and trends of national ecological resources. EMAP's goal is to develop the scientific understanding for translating environmental monitoring data from multiple spatial and temporal scales into assessments of ecological condition and forecasts of the future risks to the sustainability of our natural resources.
Eutrophication	enrichment of a waterbody with nutrients, resulting in high levels of primary production, often leading to depletion of dissolved oxygen.
Habitat	a place where the physical and biological elements of ecosystems provide a suitable environment including the food, cover, and space resources needed for plant and animal livelihood.
Historical Data	data sets from previous studies, which can range from handwritten field notes to published journal articles.
Index of Biological/Biotic Integrity	an integrative expression of site condition across multiple metrics. An index of biological integrity is often composed of at least seven metrics.
Least Disturbed/Impaired	the physical, chemical and biological conditions of a site, reach, segment, or water body that has the least amount of human disturbance in comparison to others within the water body, class, region, or basin. Least disturbed conditions change over time as land use and management practices change and, therefore, are not a "target" or upper bound of water quality potential (Best available current condition).
Macroinvertebrates	see Benthic Macroinvertebrates.
Macrophytes	large aquatic plants that may be rooted, unrooted, vascular, or algiform (such as kelp); includes submerged aquatic vegetation, emergent aquatic vegetation, and floating aquatic vegetation.
Metric	a calculated term or enumeration representing some aspect of biological assemblage, function, or other measurable aspect and is a characteristic of the biota that changes in some predictable way with increased human influence.

Minimally Disturbed/Impaired	the physical, chemical and biological conditions of a site, reach, segment, or water body in the absence of significant, or with minimal, human disturbance. Historical information or models may be used to help describe the minimally disturbed condition. Minimally disturbed conditions change little over time mostly due to natural processes and, therefore, provide a "target" or upper bound of water quality potential (Best potential condition).
Multimetric Index	an index that combines indicators, or metrics, into a single index value. Each metric is tested and calibrated to a scale and transformed into a unitless score prior to being aggregated into a multimetric index. Both the index, and metrics, are useful in assessing and diagnosing ecological condition. See Index of Biotic Integrity.
Multivariate Analysis	statistical methods (e.g. ordination or discriminant analysis) for analyzing physical and biological community data using multiple variables.
Narrative Biocriteria	general statements of attainable or attained conditions of biological integrity and water quality for a given designated aquatic life use.
Nonpoint Source Pollution	pollution that occurs when rainfall, snowmelt, or irrigation water runs over land or through the ground, picks up pollutants, and deposits them into rivers, lakes, and coastal waters or introduces them into ground water.
Numeric Biocriteria	specific quantitative measures (metrics) of desired level of biological condition.
Perennial Streams	permanently inundated surface stream courses. Surface water flows throughout the year except in years of drought.
Periphyton	a broad organismal assemblage composed of attached algae, bacteria, their secretions, associated detritus, and various species of microinvertebrates.
Point Source	an origin of pollutant discharge that is known and specific, usually thought of as effluent from the end of a pipe.
Precision	the degree of variation among individual measurements of the same property, usually obtained under similar conditions.
Quality Assurance	includes quality control functions and involves a totally integrated program for ensuring the reliability of monitoring and measurement data; the process of management review and oversight at the planning, implementation, and completion stages of environmental data collection activities. Its goal is to assure that the data provided are of the quality needed and claimed.

Quality Assurance Plan	a written document that describes the quality assurance procedures, quality control requirements, and other technical activities that must be implemented to ensure that the results of the project or task to be performed will meet project requirements; contains several important guidelines for a program to follow such as objectives and milestones for achieving those objectives, lines of responsibility, accountability of staff for meeting data quality objectives, and accountability for ensuring precision, accuracy, completeness of the data collection activities, and documentation of the sample custody process.
Quality Control	refers to the routine application of procedures for obtaining prescribed standards of performance in the monitoring and measurements process; focuses on the detailed technical activities needed to achieve data of the quality specified by data quality objectives. Quality control is implemented at the bench or field level.
Quality Management Plan	a document that describes an organization's quality system. It identifies the organizational structure, policy and procedures, functional responsibilities of management and staff, lines of authority, and its processes for planning, implementing, documenting, and assessing all activities conducted under the organization's quality system.
Rapid Bioassessment Protocols	cost-effective techniques used to survey and evaluate the aquatic community to detect aquatic life impairments and their relative severity.
Reference Condition	the set of selected measurements or conditions of unimpaired or minimally impaired waterbodies characteristic of a waterbody type in a region.
Reference Site	a specific locality on a waterbody which is unimpaired or minimally impaired and is representative of the expected ecological integrity of other localities on the same waterbody or nearby waterbodies.
Regional Environmental Monitoring and Assessment Program	a US EPA program initiated to assess the applicability of the EMAP approach to answer questions about ecological conditions at regional and local scales. REMAP conducts projects at smaller geographic scales and in shorter time frames than the national EMAP program.
Regional Reference Condition	a description of the chemical, physical, or biological condition based on an aggregation of data from minimally impaired sites that are representative of a waterbody type in an ecoregion, subecoregion, watershed, or political unit.
River Invertebrate Prediction and Classification System	a predictive method developed for use in the United Kingdom to assess water quality using a comparison of observed biological species distributions to those expected to occur based on a model derived from reference data.

River Reach File 3	a national database of 1:100,000 scale Digital Line Graph (DLG) hydrography data in a processed, edgematched, hydrologically networked format. RF3 data are a "directed network" dataset meaning that all stream segments, or reaches, are ordered in a uniform direction.
Sensitivity	capability of a method or instrument to discriminate between measurement responses of a variable of interest.
Standard Operating Procedures	a set of written instructions that document a routine or repetitive activity. SOPs describe both technical and administrative operational elements of an organization that would be managed under a Quality Assurance Project Plan and under an organization's Quality Management Plan.
Stressors	physical, chemical, and biological factors that adversely affect aquatic organisms.
Taxa	a grouping of organisms given a formal taxonomic name such as species, genus, family, etc.
Total Maximum Daily Load	calculation of the maximum amount of a pollutant a waterbody can receive and still meet water quality standards and an allocation of that amount to the pollutant's source.
Use Attainability Analysis	structured scientific assessment of the physical, chemical, biological and economic factors affecting attainment of the uses of waterbodies.
Water Quality Standards	a law or regulation that consists of the beneficial designated use or uses of a waterbody, the narrative or numerical water quality criteria (including biocriteria) that are necessary to protect the use or uses of that particular waterbody, and an antidegradation statement.
Water Resource Management (Non-Regulatory)	decisions on management activities relevant to a water resource such as problem identification, need for and placement of best management practices, pollution abatement actions, and effectiveness of program activity.
Zooplankton	refers to animals which are unable to maintain their position or distribution independent of the movement of water or air.

6. LITERATURE CITED AND ADDITIONAL RESOURCES

6.1 Literature Cited

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6.2 Additional Resources

More information and guidance on biological assessments and criteria can be found in the documents and websites listed below.

Federal Water Pollution Control Act, as amended by the Clean Water Act of 1977: [Commonly Referred to as Clean Water Act] [Enacted by Public Law 92-500, October 18, 1972, 86 Stat. 816; 33 U.S.C. 1251 et seq.; Amended by PL 93-207, December 28, 1973, and PL 93-243, January 2, 1974; PL 93-592, January 2, 1975; PL 94-238, March 23, 1976; PL 94-273, April 21, 1976; PL 94-558, October 19, 1976; PL 95-217, December 28, 1977; PL 95-576, November 2, 1978; PL 96-148, December 16, 1979; PL 96-478, PL 96-483, October 21, 1980; PL 96-510, December 11, 1980; PL 96-561, December 22, 1980; PL 97-35, August 13, 1981; PL 97-117, December 29, 1981; PL 97-164, April 2, 1982; PL 97-440, January 8, 1983; Amended by PL 100-4, February 4, 1987]

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USEPA. 1997. *Volunteer stream monitoring: A methods manual*. EPA 841-B-97-003. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 1998. *Development of biological criteria for coral reef ecosystem assessment*. U.S. Environmental Protection Agency, Office of Science and Technology, Health and Ecological Criteria Division, Washington, DC.

USEPA. 1998. *Wetland bioassessment fact sheets*. EPA 843-F-98-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 2000. *Stressor identification guidance document*. EPA 822-B-00-025. U.S. Environmental Protection Agency, Offices of Water and Research and Development, Washington, DC.

USEPA. 2002. *Biological assessment and criteria: Crucial components of water quality programs*. EPA 822-F-02-006. U.S. Environmental Agency, Office of Water, Washington, DC.

USEPA Office of Environmental Information, Biological Indicators of Watershed Health website: http://www.epa.gov/bioindicators/index.html

USEPA Office of Science and Technology, Bioassessment and Biocriteria website: http://www.epa.gov/ost/biocriteria/index.html

USEPA Office of Water, Monitoring and Assessing Water Quality, Biological Assessment website: http://www.epa.gov/owow/monitoring/bioassess.html

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APPENDIX A.

BIOASSESSMENT PROGRAMS FOR STREAMS AND WADEABLE RIVERS (2001)

Appendix A. Bioassessment programs for streams and wadeable rivers (2001)

Entity	Stream/river miles		Number of miles assessed using biology				Assemblages assessed				Habitat assessment	Reference site determination	Characterization of regional reference sites	Data analysis tools & methods	Impairment thresholds	Bioassessment uses				Other waterbody types with biological programs
Name	Total miles	Perennial miles	Total miles assessed	fully supporting for 305(b)	partially/non-supporting for 305(b)	listed for 303(d)	Benthos	Fish	Periphyton	Other	VB = visual based; QM = quantitative measurements; HY = hydrogeomorphology; O = other	SS = site specific; PW = paired watersheds; R =regional; PJ = professional judgment; O = other	HC = historical conditions; LD = least disturbed sites; GR = gradient response; PJ = professional judgment; MD = minimally disturbed; O = other	TG = tables & graphs; PA = parametric ANOVAs; MV = multivariate; BM = biological metrics; DG = disturbance gradients; O = other	MM = multimetric; MV = multivariate; CDF = cumulative distribution function; O = other	Water resource management	Aquatic Life Use Support (ALUS) in 305(b) reporting	Biocriteria in WQS: Narrative	Biocriteria in WQS: Numeric	LR = large rivers; LK = lakes; RES = reservoirs; ENC = estuaries/ near coastal marine; WL = wetlands
STATES																				
Alabama	77,274	47,077	7,103.5	5,124.4	1,979.1	1,979.1	Y	Y	N	Y	VB	R	LD	TG, BM	MM - O	Y	Y	N	N	LR, WL
Alaska	>3 million	unknown	150 watersheds	140 watersheds	10 watersheds	10 watersheds	Y	N	UD	N	VB, HY	SS, PJ	MD	TG, BM	MM - 1st quartile from the 95th %tile	Y	UD	N	N	LR, LK, ENC, WL
Arizona	127,505	4,980	0	n/a	n/a	n/a	Y	N	Y	N	VB, QM, HY	R	LD, PJ, MD	BM	MM - 25th %tile of ref. pop.	Y	N	UD	N	RES (UD)
Arkansas	87,617	28,408	245 stream segments	n/a	n/a	n/a	Y	Y	N	N	VB, QM, HY, O	SS, PW, R, PJ, O	HC, LD, PJ	TG, MV, BM, DG	MM - O	Y	N	Y	N	LR, LK, RES, WL
California	211,513	64,438	unknown	unknown	unknown	unknown	Y	N	N	N	VB	PJ, O	LD	PA, MV, BM	MV - UD	Y	UD	Y	N	LR, LK, ENC (limited)
Colorado	107,403	31,415	n/a	n/a	n/a	85.1	Y	Y	**UD**	N	VB, HY, O	SS, PJ	HC, LD, PJ, O	TG, BM	MM - UD	Y	N	UD	N	LR, LK, RES

n/a = not applicable; pop. = population; ref. = reference; UD = under development; WQS = water quality standards; – = none or information not reported

Entity	Stream/river miles		Number of miles assessed using biology				Assemblages assessed				Habitat assessment	Reference site determina-tion	Characteri-zation of regional reference sites	Data analysis tools & methods	Impairment thresholds	Bioassessment uses				Other waterbody types with biological programs
																		Biocriteria in WQS		
Name	Total miles	Perennial miles	Total miles assessed	fully supporting for 305(b)	partially/non-supporting for 305(b)	listed for 303(d)	Benthos	Fish	Periphyton	Other	VB = visual based; QM = quantitative measurements; HY = hydrogeomorphology; O = other	SS = site specific; PW = paired watersheds; R =regional; PJ = professional judgment; O = other	HC = historical conditions; LD = least disturbed sites; GR = gradient response; PJ = professional judgment; MD = minimally disturbed; O = other	TG = tables & graphs; PA = parametric ANOVAs; MV = multivariate; BM = biological metrics; DG = disturbance gradients; O = other	MM = multimetric; MV = multivariate; CDF = cumulative distribution function; O = other	Water resource management	Aquatic Life Use Support (ALUS) in 305(b) reporting	Narrative	Numeric	LR = large rivers; LK = lakes; RES = reservoirs; ENC = estuaries/ near coastal marine; WL = wetlands
Connecticut	5,830	5,484	961	764	195	n/a	Y	Y	Y	Y	VB	SS, O	LD	TG, BM	MM - O	Y	Y	Y	N	ENC
Delaware	2,506	1,778	2,506	741	1,765	1,173	Y	N	N	N	VB	R, PJ	LD	BM	MM - 67th %tile of ref. pop.	Y	N	N	UD	WL
District of Columbia	39	–	39	0	39	unknown	Y	Y	N	Y	HY	PJ	–	BM	–	Y	Y	Y	N	LR, WL
Florida	51,858	22,993	4,795	4,365	430	430	Y	N	Y	Y	VB	R, PJ	LD, GR	TG, BM, DG	MM - quadra-section of best score	Y	Y	Y	Y	LR, LK, RES, ENC, WL
Georgia	70,150	44,056	1,416	477	939	–	Y	Y	N	N	VB, O	R	LD	TG, BM	MM - UD, MV - UD	Y	Y	Y	N	LR
Hawai`i	249	249	15	5	10	10	UD	Y	N	N	VB, O	R	LD	TG, BM	MM - UD	Y	UD	UD	UD	–
Idaho	96,200	49,500	16,742	8,434	8,312	8,312	Y	Y	Y	N	VB, O	R, PJ	LD, PJ, MD	TG, PA, MV, BM, DG	MM - 25th %tile of ref. pop.	Y	Y	Y	N	LK, RES
Illinois	86,021	30,246	15,304	9,498	5,806	unknown	Y	Y	N	N	VB, QM	SS, O	HC, LD, PJ	TG, PA, MV, BM, DG, O	MM - O	Y	Y	UD	N	LR
Indiana	35,673	21,094	35,430	23,000	12,430	unknown	Y	Y	Y	Y	VB	R, PJ	HC, LD, GR, O	TG, PA, MV, BM, DG	MM - CDF, O, MV - O	Y	Y	UD	N	LR, LK, RES, WL

n/a = not applicable; pop. = population; ref. = reference; UD = under development; WQS = water quality standards; – = none or information not reported

Entity	Stream/river miles		Number of miles assessed using biology				Assemblages assessed				Habitat assessment	Reference site determination	Characterization of regional reference sites	Data analysis tools & methods	Impairment thresholds	Bioassessment uses				Other waterbody types with biological programs
																		Biocriteria in WQS		
Name	Total miles	Perennial miles	Total miles assessed	fully supporting for 305(b)	partially/non-supporting for 305(b)	listed for 303(d)	Benthos	Fish	Periphyton	Other	VB = visual based; QM = quantitative measurements; HY = hydrogeomorphology; O = other	SS = site specific; PW = paired watersheds; R =regional; PJ = professional judgment; O = other	HC = historical conditions; LD = least disturbed sites; GR = gradient response; PJ = professional judgment; MD = minimally disturbed; O = other	TG = tables & graphs; PA = parametric ANOVAs; MV = multivariate; BM = biological metrics; DG = disturbance gradients; O = other	MM = multimetric; MV = multivariate; CDF = cumulative distribution function; O = other	Water resource management	Aquatic Life Use Support (ALUS) in 305(b) reporting	Narrative	Numeric	LR = large rivers; LK = lakes; RES = reservoirs; ENC = estuaries/ near coastal marine; WL = wetlands
Iowa	71,665	26,630	2,018	1,418	600	n/a	Y	Y	N	N	VB, QM	R, PJ	LD	TG, PA, MV, BM, DG	MM - 25th %tile of ref. pop.	Y	Y	UD	N	LR
Kansas	134,338	23,731	23,731	n/a	n/a	n/a	Y	Y	Y	Y	VB, QM	PJ	HC, LD	TG, BM, O	MM - UD	Y	Y	Y	N	LK, RES, WL
Kentucky	89,431	34,334	~30,000	~20,000	~10,000	7,500	Y	Y	Y	N	VB	R	LD, MD	MV, BM	MM - 25th %tile of ref. pop.	Y	Y	Y	N	LR
Louisiana	66,294	–	–	n/a	n/a	n/a	Y	Y	N	N	VB	SS, PJ	HC, LD, O	TG, MV, BM, O	MM - CDF, O	Y	N	Y	N	–
Maine	31,672	23,879	1,000	858.5	141.5	141.5	Y	N	Y	N	VB	R, PJ	LD, GR, PJ, MD	TG, MV, BM, DG	MV	Y	Y	Y	UD	LR, LK (UD), RES, ENC
Maryland	17,000	12,343	6,142	3,429	2,713.4	178 actual listings	Y	Y	N	Y	VB, QM, O	O	LD	TG, PA, MV, BM, DG, O	MM - 10th %tile	Y	Y	UD	N	ENC
Massachusetts	8,229	7,133	1,344	649	695	695	Y	Y	Y	Y	VB	SS, PW, R, PJ	LD	TG, BM	MM - 83rd %tile of ref. pop.	Y	Y	N	N	LK, RES
Michigan	49,141	27,873	21,469	15,469	6,000	2,600	Y	Y	N	N	VB	SS	n/a	TG, BM	MM - O	Y	Y	N	N	LR
Minnesota	91,944	32,985	2,047	1,575	472	785	Y	Y	N	Y	QM	R, PJ	LD, O	TG, BM, DG	MM - O	Y	Y	Y	N	LR, LK, RES, WL

n/a = not applicable; pop. = population; ref. = reference; UD = under development; WQS = water quality standards; – = none or information not reported

Entity	Stream/river miles		Number of miles assessed using biology				Assemblages assessed				Habitat assessment	Reference site determina-tion	Characteri-zation of regional reference sites	Data analysis tools & methods	Impairment thresholds	Bioassessment uses				Other waterbody types with biological programs
Name	Total miles	Perennial miles	Total miles assessed	fully supporting for 305(b)	partially/non-supporting for 305(b)	listed for 303(d)	Benthos	Fish	Periphyton	Other	VB = visual based; QM = quantitative measurements; HY = hydrogeomorphology; O = other	SS = site specific; PW = paired watersheds; R =regional; PJ = professional judgment; O = other	HC = historical conditions; LD = least disturbed sites; GR = gradient response; PJ = professional judgment; MD = minimally disturbed; O = other	TG = tables & graphs; PA = parametric ANOVAs; MV = multivariate; BM = biological metrics; DG = disturbance gradients; O = other	MM = multimetric; MV = multivariate; CDF = cumulative distribution function; O = other	Water resource management	Aquatic Life Use Support (ALUS) in 305(b) reporting	Biocriteria in WQS: Narrative	Biocriteria in WQS: Numeric	LR = large rivers; LK = lakes; RES = reservoirs; ENC = estuaries/ near coastal marine; WL = wetlands
Mississippi	84,003	26,454	1,365	505	860	860	Y	N	N	N	VB, O	R	LD	TG, MV, BM, DG	MM - UD	Y	Y	N	N	LR, LK, ENC
Missouri	52,194	22,194	21,996	11,519	10,477	n/a	Y	Y	N	N	VB, QM, O	SS, R, PJ, O	LD, MD	TG, PA, MV, BM	MM - cumulative score = 81% of ref. condition	Y	Y	Y	UD	LR
Montana	176,750	53,221	9,076	1,340	7,736	7,736	Y	Y	Y	Y	VB, QM, HY, O	SS, R, PJ	HC, LD, PJ, MD	TG, PA, MV, BM, DG	MM - 75% of ref. condition	Y	UD	UD	N	LR, LK, RES
Nebraska	81,573	16,090	16,314	13,867	2,447	0	Y	Y	N	N	VB, QM	SS, R, PJ	LD, O	TG, PA, BM	MM - 25th %tile of ref. pop.	Y	Y	Y	N	LK, RES , WL
Nevada	143,578	14,988	602	0	0	0	Y	N	UD	N	VB, QM, O	SS, PW, R, PJ (all UD)	HC, LD, PJ (all UD)	TG, MV, BM (UD), DG	–	Y	UD	UD	N	RES
New Hampshire	10,881	8,636	400	389	11	0	Y	Y	N	Y	VB	SS, PJ	n/a	TG, BM	–	Y	Y	Y	UD	LK, WL
New Jersey	6,500	–	330	121	209	–	Y	Y	N	N	VB	R, PJ	LD	BM	MM - USEPA RBPs	Y	Y	N	N	LK, ENC (all UD)
New Mexico	110,741	8,682	~5,875	~3,200	~2,675	UD	Y	Y	Y	Y	VB, HY, O	PJ	n/a	TG, BM	MM - 95th %tile of ref. pop.	Y	Y	**N**	N	LR, LK

n/a = not applicable; pop. = population; ref. = reference; UD = under development; WQS = water quality standards; – = none or information not reported

Entity	Stream/river miles		Number of miles assessed using biology				Assemblages assessed				Habitat assessment	Reference site determination	Characterization of regional reference sites	Data analysis tools & methods	Impairment thresholds	Bioassessment uses				Other waterbody types with biological programs
Name	Total miles	Perennial miles	Total miles assessed	fully supporting for 305(b)	partially/non-supporting for 305(b)	listed for 303(d)	Benthos	Fish	Periphyton	Other	VB = visual based; QM = quantitative measurements; HY = hydrogeomorphology; O = other	SS = site specific; PW = paired watersheds; R =regional; PJ = professional judgment; O = other	HC = historical conditions; LD = least disturbed sites; GR = gradient response; PJ = professional judgment; MD = minimally disturbed; O = other	TG = tables & graphs; PA = parametric ANOVAs; MV = multivariate; BM = biological metrics; DG = disturbance gradients; O = other	MM = multimetric; MV = multivariate; CDF = cumulative distribution function; O = other	Water resource management	Aquatic Life Use Support (ALUS) in 305(b) reporting	Biocriteria in WQS: Narrative	Biocriteria in WQS: Numeric	LR = large rivers; LK = lakes; RES = reservoirs; ENC = estuaries/ near coastal marine; WL = wetlands
New York	52,337	46,266	16,000	15,430	570	484	Y	Y	Y	N	QM	SS	n/a	TG, BM, O	MM - 75th %tile of all sites	Y	Y	N	N	–
North Carolina	37,662	–	32,072	29,929	2,143	2,143	Y	Y	Y	Y	VB	R	LD	TG, PA, BM, DG	MM - O	Y	Y	Y	N	WL, RES
North Dakota	54,427	unknown	14,426	9,923	4,503	–	Y	Y	Y	N	VB, HY	R	LD	TG, BM, DG	MM - O	Y	Y	Y	N	–
Ohio	29,113	29,113	9,535	5,204	4,331	2,052	Y	Y	N	N	VB	R	LD	TG, BM	MM - 25th & 75th %tile of ref. pop.	Y	Y	Y	Y	LR, LK, RES, WL
Oklahoma	78, 778	22,386	13,313	UD	UD	UD	Y	Y	N	N	QM	R, O	LD	TG, BM	MM - CDF	Y	UD	Y	Y	UD
Oregon	114,823	51,695	40,188	12,056	28,132	unknown	Y	Y	Y	Y	QM	R, PJ, O	LD, MD	TG, PA, MV, BM, DG	MM - CDF, MV	Y	Y	Y	UD	LR, ENC
Pennsylvania	83,000	–	45,000	36,900	8,100	8,100	Y	Y	N	Y	VB	PW, R	MD	TG, PA, MV, BM, DG	MM - UD	Y	Y	N	N	LR, LK, ENC, WL
Rhode Island	1,498	979	272.8	188.1	84.7	78.5	Y	N	N	Y	VB	SS, PJ	HC, MD	TG, BM	MM - 75th %tile of ref. pop.	Y	Y	Y	N	–
South Carolina	35,461	25,729	**678.6**	**563.98**	**114.6**	**114.6**	Y	N	N	N	VB	R	LD	TG, BM	MM - CDF	Y	Y	Y	N	LR
South Dakota	9,937	1,932	3.73	n/a	n/a	n/a	Y	N	Y	N	VB, QM, HY	PJ (UD)	LD (UD)	TG, BM	MM - 25th %tile of ref. pop.	Y	N	Y	N	LR, LK, RES

n/a = not applicable; pop. = population; ref. = reference; UD = under development; WQS = water quality standards; – = none or information not reported

Entity	Stream/river miles		Number of miles assessed using biology				Assemblages assessed				Habitat assessment	Reference site determination	Characterization of regional reference sites	Data analysis tools & methods	Impairment thresholds	Bioassessment uses				Other waterbody types with biological programs
																		Biocriteria in WQS		
Name	Total miles	Perennial miles	Total miles assessed	fully supporting for 305(b)	partially/non-supporting for 305(b)	listed for 303(d)	Benthos	Fish	Periphyton	Other	VB = visual based; QM = quantitative measurements; HY = hydrogeomorphology; O = other	SS = site specific; PW = paired watersheds; R =regional; PJ = professional judgment; O = other	HC = historical conditions; LD = least disturbed sites; GR = gradient response; PJ = professional judgment; MD = minimally disturbed; O = other	TG = tables & graphs; PA = parametric ANOVAs; MV = multivariate; BM = biological metrics; DG = disturbance gradients; O = other	MM = multimetric; MV = multivariate; CDF = cumulative distribution function; O = other	Water resource management	Aquatic Life Use Support (ALUS) in 305(b) reporting	Narrative	Numeric	LR = large rivers; LK = lakes; RES = reservoirs; ENC = estuaries/ near coastal marine; WL = wetlands
Tennessee	60,187	–	24,233	16,693	7,540	14,333	Y	N	N	N	VB	R	LD	TG,PA, MV, BM	MM - 25% of 90th %tile of ref. pop.	Y	Y	Y	UD	–
Texas	191,228	40,194	266.9	196.1	70.8	–	Y	Y	N	N	QM	SS, PW, R, PJ	LD	TG, PA, BM	MM - 50th %tile of ref. pop.	Y	Y	Y	N	LR, ENC, WL
Utah	85,916	14,000+	705	75	630	300	Y	N	UD	N	QM, O	n/a	n/a	TG, BM, O	–	Y	N	N	N	LK, RES
Vermont	7,099	7,099	~800	~650	~150	~150	Y	Y	Y	N	VB, HY, O	SS, R, PJ	HC, PJ, MD	TG, PA, MV, BM	MM - CDF	Y	Y	Y	N	–
Virginia	50,329	50,329	15,540.4	13,321.9	2,218.5	2,218.5	Y	N	N	N	VB	SS, PW, PJ	–	TG	–	Y	Y	N	N	LK
Washington	73,886	39,483	3,275	982.5	2,292.5	0	Y	Y	Y	Y	VB, QM, HY	R, PJ	HC, LD, MD	TG, MV, BM	MM - 25th %tile of ref. pop.	Y	Y	UD	N	–
West Virginia	32,278	21,114	5,745	3,706	2,039	1,315	Y	Y	N	N	VB, QM, O	R, PJ	MD	TG, BM	MM - 5th %tile of ref. pop.	Y	Y	N	N	–
Wisconsin	55,000	32,000	24,422	7,989	12,028	–	Y	Y	Y	N	QM	SS, R	LD, PJ, O	TG, PA, MV, BM, DG	MM - 25th %tile of ref. pop.	Y	Y	N	N	LR, LK, RES, WL
Wyoming	113,422	32,520	2,639	2,124	177	177	Y	N	UD	N	VB, QM, HY,	R, PJ	LD, PJ	MV (UD), TG,	MM - 25th %tile	Y	Y	**Y**	UD	LR, LK,

n/a = not applicable; pop. = population; ref. = reference; UD = under development; WQS = water quality standards; – = none or information not reported

Entity	Stream/river miles		Number of miles assessed using biology				Assemblages assessed				Habitat assessment	Reference site determina-tion	Characteri-zation of regional reference sites	Data analysis tools & methods	Impairment thresholds	Bioassessment uses				Other waterbody types with biological programs
Name	Total miles	Perennial miles	Total miles assessed	fully supporting for 305(b)	partially/non-supporting for 305(b)	listed for 303(d)	Benthos	Fish	Periphyton	Other	VB = visual based; QM = quantitative measurements; HY = hydrogeomorphology; O = other	SS = site specific; PW = paired watersheds; R =regional; PJ = professional judgment; O = other	HC = historical conditions; LD = least disturbed sites; GR = gradient response; PJ = professional judgment; MD = minimally disturbed; O = other	TG = tables & graphs; PA = parametric ANOVAs; MV = multivariate; BM = biological metrics; DG = disturbance gradients; O = other	MM = multimetric; MV = multivariate; CDF = cumulative distribution function; O = other	Water resource management	Aquatic Life Use Support (ALUS) in 305(b) reporting	Biocriteria in WQS: Narrative	Biocriteria in WQS: Numeric	LR = large rivers; LK = lakes; RES = reservoirs; ENC = estuaries/ near coastal marine; WL = wetlands
TERRITORIES																				
American Samoa	–	–	–	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	N	N	N	N	–
Commonwealth of Northern Mariana Islands (CNMI)	–	–	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	N	N	**N**	N	ENC
Puerto Rico	5,394.2	–	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	UD	N	N	N	–
U.S. Virgin Islands	–	–	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	N	N	N	N	–
TRIBES																				
Confederated Tribes of the Colville Res.	–	–	–	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	N	N	N	N	–
Nez Perce Tribe	–	–	–	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	UD	n/a	n/a	n/a	–
Oneida Nation of Wisconsin	233	–	–	n/a	n/a	n/a	Y	Y	N	N	VB, QM	PJ	LD	TG, PA, BM	MM	Y	n/a	n/a	n/a	LR, LK, WL

n/a = not applicable; pop. = population; ref. = reference; UD = under development; WQS = water quality standards; – = none or information not reported

Entity	Stream/river miles		Number of miles assessed using biology				Assemblages assessed				Habitat assessment	Reference site determination	Characterization of regional reference sites	Data analysis tools & methods	Impairment thresholds	Bioassessment uses				Other waterbody types with biological programs
																		Biocriteria in WQS		
Name	Total miles	Perennial miles	Total miles assessed	fully supporting for 305(b)	partially/non-supporting for 305(b)	listed for 303(d)	Benthos	Fish	Periphyton	Other	VB = visual based; QM = quantitative measurements; HY = hydrogeomorphology; O = other	SS = site specific; PW = paired watersheds; R =regional; PJ = professional judgment; O = other	HC = historical conditions; LD = least disturbed sites; GR = gradient response; PJ = professional judgment; MD = minimally disturbed; O = other	TG = tables & graphs; PA = parametric ANOVAs; MV = multivariate; BM = biological metrics; DG = disturbance gradients; O = other	MM = multimetric; MV = multivariate; CDF = cumulative distribution function; O = other	Water resource management	Aquatic Life Use Support (ALUS) in 305(b) reporting	Narrative	Numeric	LR = large rivers; LK = lakes; RES = reservoirs; ENC = estuaries/ near coastal marine; WL = wetlands
Passamaquoddy Tribe, Pleasant Point Res.	–	–	–	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	N	n/a	n/a	n/a	ENC
Pyramid Lake Paiute Tribe	–	–	31+	–	–	–	Y	Y	Y	N	VB, QM	PJ	HC, PJ	UD	UD	Y	n/a	UD	UD	LK
Seminole Tribe of Florida	–	–	–	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	N	N	N	N	–
INTERSTATE COMMISSIONS																				
DRBC	200	–	200	n/a	n/a	n/a	Y	Y	N	Y	VB, HY, O	R, O	HC, LD	TG, BM	–	Y	n/a	Y	Y	LR
ICPRB	383	–	n/a	n/a	n/a	n/a	Y	Y	N	Y	VB	R	LD, GR	TG, PA, MV, BM	MM - UD	Y	n/a	n/a	n/a	–
ORSANCO	981	–	981	974	7	55	Y	Y	N	N	O	SS, R, PJ	LD	TG, PA, MV, BM, DG	MM - 25th %tile of ref. pop.	Y	Y	Y	UD	LR
SRBC	31,193	–	3,520	2,525	995	n/a	Y	N	N	N	VB	R, PJ	LD	TG, BM	MM - O	Y	Y	n/a	n/a	LR

n/a = not applicable; pop. = population; ref. = reference; UD = under development; WQS = water quality standards; – = none or information not reported

APPENDIX B.

EPA CONTACTS

Appendix B. EPA CONTACTS

Regional Biocriteria Coordinators

REGION 1
(CT, ME, MA, NH, Passamaquoddy Tribe - Pleasant Point Reservation, RI, VT)

Peter Nolan, *Regional Biocriteria Coordinator*
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(DRBC, NJ, NY, Puerto Rico and the US Virgin Islands)

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Edison, NJ 08837-3679
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REGION 3
(DE, DC, ICPRB, MD, PA, SRBC, VA, WV)

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REGION 4
(AL, FL, GA, KY, MS, NC, Seminole Tribe, SC, TN)

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REGION 5
(IL, IN, MI, MN, OH, ORSANCO, Oneida Nation of Wisconsin, WI)

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REGION 6
(AR, LA, NM, OK, TX)

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REGION 7
(IA, KS, MO, NE)

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REGION 8
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Jill Minter, *Regional Biocriteria Coordinator*
USEPA - Region 8
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REGION 9
(American Samoa, AZ, CA, CNMI, HI, NV, Pyramid Lake Paiute Tribe)

Gary Wolinsky, *Regional Biocriteria Coordinator*
USEPA - Region 9
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75 Hawthorne Street
San Francisco, CA 94105
Phone 415/972-3498, Fax 415/947-3545
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REGION 10
(AK, Confederated Tribes of the Colville Reservation,
ID, Nez Perce Tribe, OR, WA)

Gretchen Hayslip, *Regional Biocriteria Coordinator*
USEPA - Region 10
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Phone 206/553-1685
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EPA Headquarters

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Washington, D.C. 20460
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email: swietlik.william@epa.gov

Questions regarding a specific entity's program should be directed to the contact(s) listed at the top of each entity's program summary in Chapter 3. Questions regarding other sections of this document may be directed to any of the following USEPA Headquarters contacts:

Wayne Davis
USEPA Office of Environmental Information
Environmental Science Center
701 Mapes Road
Ft. Meade, Maryland 20755-5350
410-305-3030 410-305-3096 (fax)
email: davis.wayne@epa.gov

Beth Jackson
USEPA Office of Environmental Information
Environmental Analysis Division
1200 Pennsylvania Avenue (2842T)
Washington, D.C. 20460
Phone 202/566-0626, Fax 202/566-0706
email: jackson.elizabeth@epa.gov

Treda Smith
USEPA Office of Water
Office of Science and Technology
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email: smith.treda@epa.gov

APPENDIX C.

ORIGINAL CHECKLIST TEMPLATE

Appendix C. ORIGINAL CHECKLIST TEMPLATE

Form Approved
OMB Control No. 2040-0049
Approval Expiration: 7/31/02

Survey of State/Tribal Water Quality Programs for Protecting Aquatic Life Through the Use of Bioassessments and Biocriteria

Contact Information:

state	
name	
position	
agency/organization	
mailing address	
phone	
fax	
email	
website	

Briefly describe your professional responsibilities as they relate to water quality standards, conducting bioassessments, and establishing biocriteria.

For each waterbody type below with biological programs, please provide a contact (if different than yourself)

	name	phone	email
non-wadeable rivers			
lakes			
reservoirs			
estuaries/near-coastal marine			
wetlands			

Please attach any ancillary materials that will provide further in insight or background about your program and/or agency. Examples might include an organizational chart, promotional materials, etc. THANK YOU!

State/Tribal WaterQuality Supporting Aquatic Life Use Designations and Biocriteria Development

1 With respect to your program, which waterbody type categories apply ("X"), and which is being described using this checklist ("XX)"?

	wadeable streams, creeks, rivers
	non-wadeable rivers
	lakes
	reservoirs
	estuaries and near-coastal marine
	wetlands

2 For lotic systems, how are they defined?

	stream order
	drainage area
	other (please describe)

3 With respect to the resource type for this checklist, what is the percentage of information in your state, tribal land, or basin, coming from the following entities?

	state/tribal water quality agency
	state fish & game agency
	USEPA
	other federal agency
	consultants
	volunteer monitoring programs
	local college or university
	regulated entities
	other (please describe)

4 Do you contract out any or all or your bioassessment work?

	Yes
	No

4a If you answered yes to #4, please specify the percentage contracted out to each type of entity for field and lab work.

field	lab	
		consultants
		other state agency
		volunteer monitoring groups
		federal agency
		college or university
		other (please describe)

5 What is the lead agency USING the bioassessment information?

6 In which ways are bioassessments used within the water quality program in your state, tribe, or basin? Please check Yes (Y), No (N), or Unsure (?) for all that apply.

Y	N	?	
			problem identification (screening)
			nonpoint source assessments
			monitoring the effectiveness of BMPs
			aquatic life use determinations/ambient monitoring
			promulgated into state WQ standards as biocriteria
			support of antidegradation
			evaluation of discharge permit conditions
			TMDL assessment & monitoring
			other (please describe)

7 Which of the following monitoring designs are used (please check all that apply)?

	targeted (i.e., sites selected for a specific purpose)
	fixed station (i.e., WQ monitoring stations)
	probabalistic by stream order/catchment area
	probalistic by ecoregion, or statewide
	rotating basin
	other (please describe)

7a For each monitoring design checked in #7, please indicate how it is implemented (check all that apply for each design).

special projects only	specific river basins or watersheds	comprehensive use throughout jurisdiction

8 Indicate the extent of resources assessed using biology (e.g., miles, acres, etc.)

- [ ] extent of resource assessed for biology (total)
- [ ] extent of resource fully supporting for 305b
- [ ] extent of resource partially supporting/non supporting for 305b
- [ ] extent of resource listed for 303d
- [ ] number of sites sampled
- [ ] extent of resource per site (if predetermined)

8a Please indicate which of the following units of measure you used to answer #8

- [ ] watersheds
- [ ] acreage
- [ ] miles
- [ ] other (please describe)

9 What is the basis for determining the extent of the resource?

- [ ] RF3
- [ ] National Hydrography Database
- [ ] state based
- [ ] other (please describe)

10 Please use this space to add any additional information you'd like about programmatic elements.

11 What are your Aquatic Life Use Support (ALUS) designations based on?

☐	Single Aquatic Life Use
☐	Class System (A,B,C)
☐	Fishery Based Uses
☐	Warm Water vs. Cold Water

11a How many different aquatic life use designations are contained in your water quality standards (WQS)? Please describe.

11b Does your state plan to further refine its AL designated uses in the next triennial WQS review?

☐ Yes
☐ No

12 If you have narrative biocriteria in your WQS. Is the attached description accurate?

☐ Yes
☐ No

12a If you answered no to #12, please correct below

13 For your narrative biocriteria, do you have formal/informal numeric procedures to support your decisions?

☐ Yes
☐ No

*If you answered yes to #13, where are these procedures located (e.g., in the WQS)?

13a If you answered no to #13, do you use a qualitative and/or narrative scale of condition?

☐ Yes
☐ No

*Where are the scale(s) located?

14 Do you have numeric biocriteria?

☐ Yes
☐ No

*If you answered yes to #14, where are they located?

14a If you have numeric biocriteria, please describe or attach separate description.

15 Are bioassessment data used in an integrated assessment with other environmental data (e.g., toxicity testing and chemical specific criteria)? Please check Yes (Y), No (N), or Unsure (?) for all that apply.

Y	N	?	
			for assessment of aquatic resources
			for cause and effect determinations
			for permitted discharges
			for monitoring (e.g., improvements after mitigation)
			for watershed based management

15a For each box you answered yes to in #15, do you use

☐ independent application (IA)
☐ weight-of-evidence
☐ combination
☐ other (explain)

16 Do you know where bioassessments/biocriteria have been used in making management decisions regarding restoration of the aquatic resources to its designated ALUS?

[ ]	Yes
[ ]	No

16a If you answered yes to #16, please elaborate.

17 How many full time employees were devoted to

[ ]	developing the bioassessment/biocriteria program
[ ]	maintaining the bioassessment/biocriteria program

18 Please use this space to add any additional information you'd like about your ALUS descision making process

Field & Lab Methods for Determining Existing Uses, Designated Uses & Collecting Data for Biocriteria Development

19 How are your reference sites determined?

- [ ] site-specific
- [ ] paired watersheds
- [ ] regional (aggregate of sites)
- [ ] professional judgement
- [ ] other (please describe)

19a How do you define a reference site?

19b Do you have reference site criteria?

- [ ] No
- [ ] Yes (If so, please describe in space below.)

20 If you use regional reference conditions, how do you characterize those sites?

- [ ] historical conditions
- [ ] least-disturbed sites
- [ ] gradient response
- [ ] judgement prescription
- [ ] other (please describe)

21 If you use regional reference sites, how do you characterize (stratify) your streams?

- [ ] ecoregions (or some aggregate)
- [ ] elevation
- [ ] stream type
- [ ] multivariate grouping
- [ ] jurisdictional (i.e., statewide)
- [ ] other (please describe)

22 Please indicate how many reference sites you have

- [ ] by strata
- [ ] total

23 What are your criteria for defining reference sites and, if applicable, disturbed sites (e.g., D.O., sulfates, habitat)?

23a Are your reference sites linked to your aquatic life designated uses?

- [ ] Yes
- [ ] No

23b Are your reference sites/conditions identified or referenced in your WQS?

- [ ] Yes (provide citation_______________________)
- [ ] No

23c Do any of your reference sites represent acceptable man-induced conditions?

- [ ] Yes
- [ ] No

24 Which of the following assemblages are assessed by your program? Please check Yes (Y), No (N), or Unsure (?) for all that apply.

Y	N	?	
			phytoplankton
			periphyton
			macrophytes
			zooplankton
			benthos
			fish
			amphibians/reptiles
			waterfowl

24a For each assemblaged assessed in #24, please indicate the range of samples processed per year

< 100	100-500	> 500

24b For each assemblaged assessed in #24, please indicate the level of rigor by choosing A, B, C, D, or E

☐ phytoplankton
☐ periphyton
☐ macrophytes
☐ zooplankton
☐ benthos
☐ fish
☐ amphibians/reptiles
☐ waterfowl

A single observation (no discrete season), limited sampling (e.g., 1-2 sites)
B single season, multiple sites (not at watershed level)
C single season, multiple sites (watershed level)
D single season, multiple sites (broad coverage)
E multiple seasons, multiple sites (broad coverage for watershed level)

25 Do you perform habitat assessments at your sites?
☐ Yes
☐ No

25a If you answered yes to #25, how are they conducted?
☐ with bioassessments
☐ independent of bioassessments

25b If you answered yes to #25, what type of habitat assessment is used?

☐ visual based (e.g., QHEI, RBP, etc.)
☐ quantitative measurements (e.g., EMAP)
☐ hydrogeomorphology (e.g., Rosgen)
☐ other quantitative parameters (e.g., pebble counts, sediment index, etc.) (please describe)

25c Are these habitat reference conditions cited or mentioned in your WQS?
☐ Yes (provide citation________________________)
☐ No

26 Do you use biological information to facilitate public participation in setting WQS?
☐ Yes (please describe in space below)
☐ No

27 Which of the following are part of your quality assurance (QA) program? Please check Yes (Y), No (N), or Unsure (?) for all that apply.

Y	N	?	
			standard operating procedures (SOPs)
			quality assurance plan (QAP)
			periodic meetings, training for biologists
			sorting proficiency checks
			taxonomic proficiency checks
			specimen archival
			other (please describe)

28 Do you have a certification program for bioassessment?

- [ ] Yes
- [ ] No

If yes, briefly describe:

Questions 29 -33 deal with field issues specific to BENTHOS. Please describe your program by checking all that apply. If your program does not assess this assemblage, please skip these questions.

29 Sampling gear-- please check all that apply to your program

- [ ] Surber
- [ ] Hess
- [ ] Slack (0.5 m)
- [ ] D-frame
- [ ] dipnet
- [ ] kick net (1 m)
- [ ] multiplate
- [ ] rock baskets
- [ ] collect by hand
- [ ] other (please describe)

29a Indicate the mesh size used by your program (in microns)

- [ ] 200 - 400
- [ ] 500 - 600
- [ ] > 800
- [ ] other (please describe)

29b Indicate the area sampled

- [ ] < 1 m^2
- [ ] 1 - 3 m2
- [ ] 3 - 6 m
- [ ] other (please describe)

30 Reach length

- [ ] selected habitat
- [ ] habitat sequences or cycles
- [ ] fixed distance
- [ ] stream width formula
- [ ] time
- [ ] other (please describe)

31 Habitat selection

- [ ] richest habitat
- [ ] riffle/run (cobble)
- [ ] multihabitat
- [ ] artificial substrate
- [ ] woody debris
- [ ] other (please describe)

32 Where are samples processed?

- [ ] field
- [ ] lab

32a What is the target subsample size?

- [ ] 100 count
- [ ] 200 count
- [ ] 300 count
- [ ] 500 count
- [ ] proportional/volume
- [ ] entire sample
- [ ] other (please describe)

33 What level of taxonomy do you use?

- [ ] order
- [ ] family
- [ ] genus
- [ ] species
- [ ] combination
- [ ] other (please describe)

Questions 34 - 38 deal with field issues specific to FISH/AMPHIBIANS. Please describe your program by checking all that apply. If your program does not assess these assemblages, please skip these questions.

34 Sampling gear-- please check all that apply to your program

- [ ] seine
- [ ] backpack electrofisher
- [ ] boat electrofisher
- [ ] pram unit (tote barge)
- [ ] other (please describe)

34a Seine and/or dipnet mesh size (in inches)

- [ ] 1/8"
- [ ] 3/16"
- [ ] 1/4"
- [ ] 3/8"
- [ ] 1/2"

35 Reach length

- [ ] selected habitat
- [ ] habitat sequences or cycles
- [ ] fixed distance
- [ ] stream width formula
- [ ] time
- [ ] other (please describe)

36 Habitat selection

- [ ] pool/glide
- [ ] riffle/run (cobble)
- [ ] multihabitat
- [ ] other (please describe)

37 Where are the samples processed?

- [ ] field
- [ ] lab

37a How are the samples processed?

- [ ] length measurement
- [ ] biomass--individual
- [ ] biomass--batch
- [ ] anomalies

37b How are samples subsampled?

- [ ] selected species
- [ ] batch
- [ ] selected size
- [ ] none
- [ ] other (please describe)

38 What level of taxonomy do you use

- [ ] species
- [ ] subspecies
- [ ] life stage
- [ ] other (please describe)

Questions 39 -43 deal with field issues specific to PERIPHYTON. Please describe your program by checking all that apply. If your program does not assess this assemblage, please skip these questions.

39 Sampling gear-- natural substrate

- [ ] suction device
- [ ] bar clamp sample
- [ ] brushing/scraping device (razor, toothbrush, etc.)
- [ ] collect by hand
- [ ] other (please describe)

39a Sampling gear-- artificial substrate

- [ ] periphytometer
- [ ] microslides or other suitable substratum
- [ ] collect by hand
- [ ] other (please describe)

40 Reach length

- [ ] selected habitat
- [ ] habitat sequences or cycles
- [ ] fixed distance
- [ ] stream width formula
- [ ] time
- [ ] other (please describe)

41 Habitat selection

- [ ] richest habitat
- [ ] riffle/run (cobble)
- [ ] multihabitat
- [ ] artificial substrate
- [ ] other (please describe)

42 How are samples processed?

- [ ] chlorophyll *a*/ phaeophytin
- [ ] biomass
- [ ] taxonomic identification
- [ ] other (please describe)

43 What level of taxonomy do you use?

- [ ] diatoms only
- [ ] all algae
- [ ] division level
- [ ] genus level
- [ ] species level
- [ ] other (please describe)

44 Please use this space to add any additional information you'd like about your field and lab methods.

Data Analysis and Interpretation for Determining Biological Condition of Aquatic Life Uses and Deriving Biocriteria

45 Which data analysis tools and methods do you use (check all that apply)?

- [ ] summary tables, illustrative graphs
- [ ] parametric ANOVAs
- [ ] multivariate analysis
- [ ] biological metrics
- [ ] disturbance gradients
- [ ] other (please describe)

46 If you use biological gradients, how are the metrics selected and tested?

- [ ] selected by consensus
- [ ] tested for sensitivity, ecological value
- [ ] calibrated for natural gradients (and covariates)

46a Please describe your response to #46

47 If you use biological metrics, how is the threshold determined for transforming metrics into unitless scores?

- [ ] 25th %tile of reference population
- [ ] 50th %tile of reference population
- [ ] 75th %tile of reference population
- [ ] 95th %tile of reference population
- [ ] 95th %tile of all sites
- [ ] cumulative distribution function
- [ ] other (please describe)

48 If you use biological metrics do you

- [ ] aggregate metrics into an index
- [ ] return single metrics (use endpoint for each single metric)

49 If you use a multimetric index, how do you define the impairment threshold?

- [ ] 25th %tile of reference population
- [ ] 50th %tile of reference population
- [ ] 75th %tile of reference population
- [ ] 95th %tile of reference population
- [ ] 95th %tile of all sites
- [ ] cumulative distribution function
- [ ] other (please describe)

50 If you use a multivariate technique, how do you define the impairment threshold?

- [ ] 5th %tile of reference population
- [ ] 10th %tile of reference population
- [ ] Significant departure from mean of reference population
- [ ] other (please describe)

51 Have you evaluated the performance characteristics of your bioassessment results?

- [ ] Yes
- [ ] No

51a If you answered yes to #51, please describe. Please check Yes (Y), No (N), or Unsure (?) for all that apply.

Y	N	?		
			repeat sampling (please describe)	
			precision (please describe)	
			sensitivity (please describe)	
			bias (please describe)	
			accuracy (please describe)	

52 Please use this space to add any additional information you'd like about your data analysis and interpretation methods.

53 Identify where your biological data are stored. Please check Yes (Y), No (N), or Unsure (?) for all that apply.

Y	N	?	
			STORET
			other database (what program/application)
			spreadsheets (what program/application)
			paper files only
			other (please describe)

54 Please describe how data are retrieved and analyzed. Please check Yes (Y), No (N), or Unsure (?) for all that apply.

Y	N	?	
			SAS
			Systat
			Statistica
			EDAS
			other (please describe)

55 Please list any website URLs for all relevant data.

56 Please list all documents and references used to provide this information (e.g., SOPs, 305(b) reports, etc.)any website URLs for all relevant data.

57 Please use this space to add any additional information you'd like about your information management.

APPENDIX D.

PROGRAM SUMMARY TEMPLATE

Appendix D. PROGRAM SUMMARY TEMPLATE

The numbers of relevant checklist questions (see Appendix C) are colored black and found within each corresponding program summary section.

ENTITY NAME

Contact Information

Contact name, title
Agency
Street ■ city/state/zip
Phone ■ Fax
email:

Program Description

Documentation and Further Information

#55, 56

ENTITY NAME

Contact Information

Contact name, title
Agency
Street ■ city/state/zip
Phone ■ Fax
email:

Programmatic Elements

Uses of bioassessment within overall water quality program **#6**	☐	problem identification (screening)
	☐	nonpoint source assessments
	☐	monitoring the effectiveness of BMPs
	☐	ALU determinations/ambient monitoring
	☐	promulgated into state water quality standards as biocriteria
	☐	support of antidegradation
	☐	evaluation of discharge permit conditions
	☐	TMDL assessment and monitoring
	☐	other:
Applicable monitoring designs **#7, (7a)**	☐	targeted (i.e., sites selected for specific purpose)
	☐	fixed station (i.e., water quality monitoring stations)
	☐	probabilistic by stream order/catchment area
	☐	probabilistic by ecoregion, or statewide
	☐	rotating basin
	☐	other:

Stream Miles

Total miles

(determined using... **#8b**)

Total perennial miles

Total miles assessed for biology **#8**

fully supporting for 305(b)

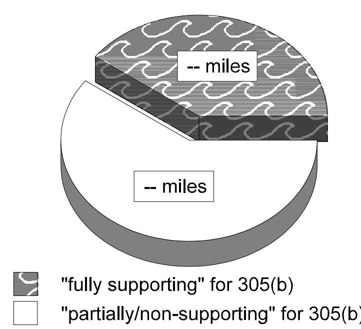
partially/non-supporting for 305(b)

listed for 303(d)

number of sites sampled

number of miles assessed per site

Miles Assessed for Biology



Aquatic Life Use (ALU) Designations and Decision-Making

ALU designation basis	#11	
ALU designations in state water quality standards	#11a	
Narrative Biocriteria in WQS	#12 to 13a	
Numeric Biocriteria in WQS	#14, 14a	
Uses of bioassessment data in integrated assessments with other environmental data (e.g., toxicity testing and chemical specific criteria) #15	☐	assessment of aquatic resources
	☐	cause and effect determinations
	☐	permitted discharges
	☐	monitoring (e.g., improvements after mitigation)
	☐	watershed based management
Uses of bioassessment/ biocriteria in making management decisions regarding restoration of aquatic resources to a designated ALU	#16, 16a	

Reference Site/Condition Development

Number of reference sites	#22		
Reference site determinations #19	☐	site-specific	
	☐	paired watershed	
	☐	regional (aggregate of sites)	
	☐	professional judgment	
	☐	other:	
Reference site criteria	#19b, 23		
Characterization of reference sites within a regional context #20	☐	historical conditions	
	☐	least disturbed sites	
	☐	gradient response	
	☐	professional judgment	
	☐	other:	
Stream stratification within regional reference conditions #21	☐	ecoregions (or some aggregate)	
	☐	elevation	
	☐	stream type	
	☐	multivariate grouping	
	☐	jurisdictional (i.e., statewide)	
	☐	other:	
Additional information	☐	reference sites linked to ALU	#23a
	☐	reference sites/condition referenced in water quality standards	#23b
	☐	some reference sites represent acceptable human-induced conditions	#23c

Field and Lab Methods

Assemblages assessed #24, (24a, 24b)	☐	benthos *(# samples/year; level of rigor)*
	☐	fish
	☐	periphyton
	☐	other:
Benthos		
sampling gear		#29, 29a
habitat selection		#31
subsample size		#32a
taxonomy		#33
Fish		
sampling gear		#34, 34a
habitat selection		#36
sample processing		#37a
subsample		#37b
taxonomy		#38
Periphyton		
sampling gear		natural substrate #39; artificial substrate #39a
habitat selection		#41
sample processing		#42
taxonomy		#43
Habitat assessments		#25 to 25c
Quality assurance program elements		#27, 28

Data Analysis and Interpretation

Data analysis tools and methods #45	☐	summary tables, illustrative graphs
	☐	parametric ANOVAs
	☐	multivariate analysis
	☐	biological metrics (#48)
	☐	disturbance gradients
	☐	other:
Multimetric thresholds		
transforming metrics into unitless scores		#47
defining impairment in a multimetric index		#49
Multivariate thresholds		
defining impairment in a multivariate index		#50
Evaluation of performance characteristics #51, 51a	☐	repeat sampling
	☐	precision
	☐	sensitivity
	☐	bias
	☐	accuracy
Biological data		
Storage		#53
Retrieval and analysis		#54

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Environmental Protection
Agency

Office of Environmental Information
and Office of Water
Washington, DC 20460

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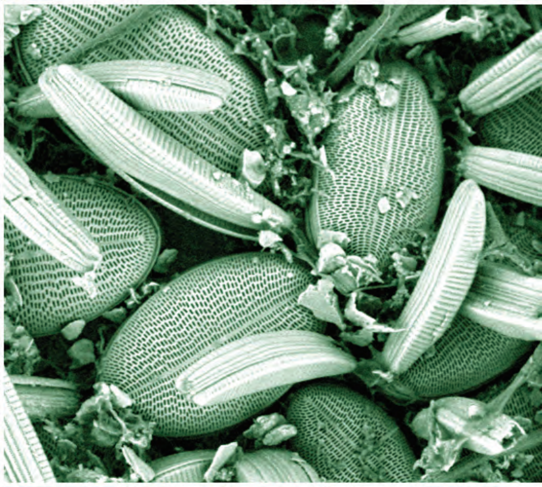
A Primer on Using Biological Assessments to Support Water Quality Management

October 2011






Ken Norton, Hoopa Valley Tribe

The Hoopa Valley Tribe and neighboring tribes use traditional redwood canoes for subsistence fishing and ceremonial purposes.

U.S. Environmental Protection Agency
Office of Science and Technology
Office of Water, Washington, DC
EPA 810-R-11-01

A Primer on Using Biological Assessments to Support Water Quality Management

Contact Information

For more information, questions, or comments about this document, please contact Susan Jackson, U.S. Environmental Protection Agency, at Office of Science and Technology, Office of Water, U.S. Environmental Protection Agency, 1200 Pennsylvania Avenue, Mail Code 4304T, Washington, DC 20460 or by email at jackson.susank@epa.gov.

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Maine Department of Environmental Protection
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Michigan Department of Environmental Quality
Minnesota Pollution Control Agency
Narragansett Bay Estuary Program
New Jersey Department of Environmental Protection
Ohio Environmental Protection Agency
Oregon Department of Environmental Quality
Pennsylvania Department of Environmental Protection
Tampa Bay Estuary Program
Utah Department of Environmental Quality
Vermont Department of Environmental Conservation
Virginia Department of Conservation and Recreation

Acknowledgements (continued)

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Tool #1: Biological Assessment Program Evaluation (2001 – 2009)

Alabama, Arizona,
California, Connecticut, Colorado, Florida, Illinois, Indiana, Iowa, Maine, Massachusetts, Michigan, Minnesota, Missouri, Montana, Fort Peck Tribes (Assiniboine and Sioux), New Hampshire, New Mexico, Ohio, Rhode Island, Texas, Vermont, Wisconsin

Tool #2: The Biological Condition Gradient (2000–2005)

State and Tribal Workgroup Members
Arizona Department of Environmental Quality – Patti Spindler
California Department of Fish and Game – Jim Harrington
Colorado Department of Public Health and Environment – Robert McConnell, Paul Welsh
Florida Department of Environmental Protection – Russ Frydenborg, Ellen McCarron, Nancy Ross
Idaho Department of Environmental Quality – Mike Edmondson
Kansas Department of Health and Environment – Bob Angelo, Steve Haslouer, Brett Holman
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Maine Department of Environmental Protection – David Courtemanch, Susan Davies
Maryland Department of the Environment – Joseph Beaman, Richard Eskin, George Harmon
Minnesota Pollution Control Agency – Greg Gross
Mississippi Department of Environmental Quality – Leslie Barkley, Natalie Guedon
Montana Department of Environmental Quality – Randy Apfelbeck, Rosie Sada
Nevada Division of Environmental Protection – Karen Vargas
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Ohio Environmental Protection Agency – Jeff DeShon, Dan Dudley
Ohio River Valley Water Sanitation Commission – Erich Emery
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Pyramid Lake Paiute Tribe – Dan Mosley
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Vermont Department of Environmental Conservation – Doug Burnham, Steve Fisk
Virginia Department of Environmental Quality – Alexander Barron, Larry Willis
Washington State Department of Ecology – Robert Plotnikoff
Wisconsin Department of Natural Resources – Joe Ball, Ed Emmons, Robert Masnado, Greg Searle, Michael Talbot, Lizhu Wang

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Regional (R) Offices: Peter Nolan (R1), Jim Kurtenbach (R2), Maggie Passmore (R3), Ed Decker, Jim Harrison, Eve Zimmerman (R4), Ed Hammer, David Pfeifer (R5), Philip Crocker, Charlie Howell (R6), Gary Welker (R7), Tina Laidlaw, Jill Minter (R8), Gary Wolinsky (R9), Gretchen Hayslip (R10)

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Bob Hughes, Oregon State University
Lucinda Johnson, University of Minnesota
James Karr, University of Washington
Dennis McIntyre, Great Lakes Environmental Center
Gerald Niemi, University of Minnesota
Ed Rankin, Center for Applied Bioassessment and Biocriteria
Jan Stevenson, Michigan State University
Denice Wardrop, Pennsylvania State University
Chris Yoder, Midwest Biodiversity Institute

Tool #3: The Stressor Identification and Causal Analysis/Diagnosis Decision Information System (2000 – 2010)

States
Connecticut, Iowa, Maine, Minnesota, Mississippi, Ohio, Washington, West Virginia

Office of Research and Development: Core Technical Development Team
Laurie Alexander, Susan Cormier, David Farrar, Michael Griffith, Maureen Johnson, Michael McManus, Susan Norton, John Paul, Amina Pollard, Kate Schofield, Patricia Shaw-Allen, Glenn Suter, Lester Yuan, C. Richard Ziegler

For a full list of authors and contributors for this tool, please go to:
http://www.epa.gov/caddis/caddis_authors.html

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The reference section and Appendix A of this document were updated February 2012 to include publication dates for USEPA technical documents and website that were originally cited as draft.

Contents

Figures

Tables

Foreword

This guide serves as a primer on the role of biological assessments in a variety of water quality management program applications, including reporting on the condition of the aquatic biota, establishing biological criteria, and assessing the effectiveness of Total Maximum Daily Load determinations and pollutant source controls. This guide provides a brief discussion of technical tools and approaches for developing strong biological assessment programs and presents examples of successful application of those tools.

The objective of the Clean Water Act (CWA), and water quality management programs generally, is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." Although we have achieved major water quality improvements over the past four decades and have reduced the discharge of many toxic chemicals into our nation's waters, many environmental challenges remain, such as loss and fragmentation of habitat, altered hydrology, invasive species, climate change, discharge of new chemicals, stormwater, and nitrogen or phosphorus (nutrient) pollution. In the face of such challenges, how can we best deploy our water quality programs to meet the vision of the CWA for protection of aquatic life?

Biological integrity has been defined to mean the capability of supporting and maintaining a balanced, integrated, and adaptive community of organisms having a composition and diversity comparable to that of natural habitats of the region (Frey 1975; modified by Karr and Dudley 1981). **Biological assessments** can be used to directly measure the condition of the biota residing in a waterbody and provide information on biological integrity. Resident biota include species that spend all or a part of their life cycle in the aquatic environment.

Measuring the condition of the resident biota in surface waters using biological assessments and incorporating that information into management decisions can be an important tool to help federal, state, and tribal water quality management programs meet many of the challenges. Biological assessments are an evaluation of the condition of a waterbody using surveys of the structure and function of a community of resident biota (e.g., fish, benthic macroinvertebrates, periphyton, amphibians) (for more information, see *Biological Assessment Key Concepts and Terms*)[1]. Assessments of habitat condition, both instream and riparian, are typically conducted simultaneously. Such information can reflect the overall ecological integrity of a waterbody and provides a direct measure of both present and past effects of stressors on the biological integrity of an aquatic ecosystem. The benefit of a biological assessment program is based in its capability to:

- Characterize the biological condition of a waterbody relative to water quality standards (WQS).
- Integrate the cumulative effects of different stressors from multiple sources, thus providing a holistic measure of their aggregate effect.
- Detect aquatic life impairment from unmeasured stressors and unknown sources of impairment.
- Provide field data on biotic response variables to support development of empirical stressor response models.
- Inform water quality and natural resource managers, stakeholders, and the public on the environmental outcomes of actions taken.

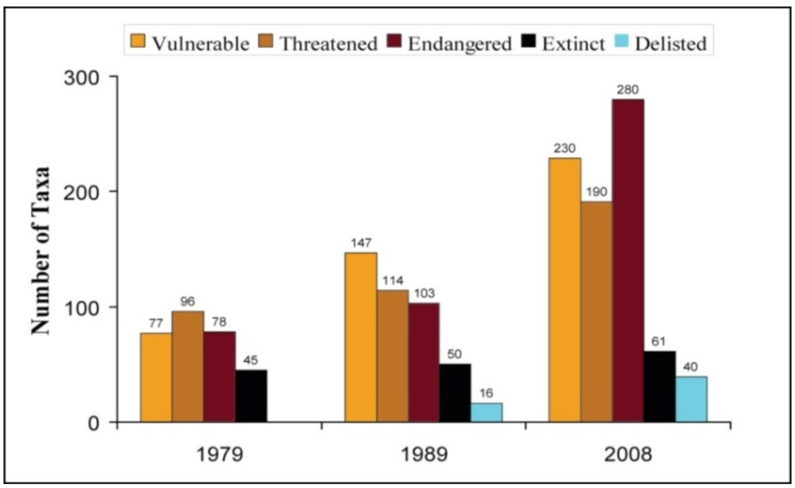
[1] http://water.epa.gov/scitech/swguidance/standards/criteria/aqlife/biocriteria/upload/primer_factsheet.pdf

It is EPA's long-standing policy that biological assessments should be fully integrated in state and tribal water quality programs and used together with whole effluent and ambient toxicity testing, and with chemical-specific analyses, to assess attainment of designated aquatic life uses in WQS (USEPA 1991b). Each of these methods can be used to provide a valid assessment of aquatic life use impairment. Biological assessments complement chemical-specific, physical, and whole effluent toxicity measures of stress and exposure by directly assessing the response of the community in the field (USEPA 1991a). Measurable changes in the biotic community—for example, the return of native species, decrease in anomalies and lesions in fish and amphibians, and decrease in pollution-tolerant species paired with an increase in pollution-sensitive species—can be readily communicated to the public and the regulated community. This can result in greater stakeholder understanding of effects from stressors and support for management actions. Additionally, as response-stressor relationships are documented, biological assessments in concert with stressor data can be used to help predict and track environmental outcomes of management actions.

Chapter 1. Incorporating Biological Assessments into Water Quality Management

1.1 Why Is Measuring Biological Condition Important?

With the passage of the Clean Water Act (CWA) in 1972 and subsequent national investment in water infrastructure and regulation, much work has been done to restore rivers, lakes, streams, wetlands, and estuaries. However, despite our best efforts and many documented successes, we continue to lose aquatic resources (Figure 1-1) (H. John Heinz III Center for Science, Economics, and the Environment 2008; Jelks et al. 2008; USEPA 2006). Pollutants (e.g., pathogens, metals, nitrogen, phosphorus pollution) continue to be major causes of water quality degradation. Additionally, the impact of other significant stressors, including habitat loss and fragmentation, hydrologic alteration, invasive species, and climate change, can be better understood using analytical tools and information that can operate at the ecosystem scale, such as biological assessments.



Source: Jelks et al. 2008

Figure 1-1. Numbers of imperiled North American freshwater and diadromous fish taxa.

Note: The increase in total number of taxa identified as vulnerable, threatened, or endangered might be due in part to improvements in our understanding, naming, and assessing aquatic resources, resulting in more complete and accurate assessments.

Biological assessments can be used to directly measure the overall biological integrity of an aquatic community and the synergistic effects of stressors on the aquatic biota residing in a waterbody where there are well-developed biological assessment programs (Figure 1-2) (USEPA 2003). Resident biota function as continual monitors of environmental quality, increasing the sensitivity of our assessments by providing a continuous measure of exposure to stressors and access to responses from species that cannot be reared in the laboratory. This increases the likelihood of detecting the effects of episodic events (e.g., spills, dumping, treatment plant malfunctions), toxic nonpoint source (NPS) pollution (e.g., agricultural pesticides), cumulative pollution (i.e., multiple impacts over time or continuous low-level stress), nontoxic mechanisms of impact (e.g., trophic structure changes due to nutrient enrichment), or other impacts that periodic chemical sampling might not detect. Biotic response to impacts on the physical habitat such as sedimentation from stormwater runoff and physical habitat alterations from dredging, filling, and channelization can also be detected using biological assessments.

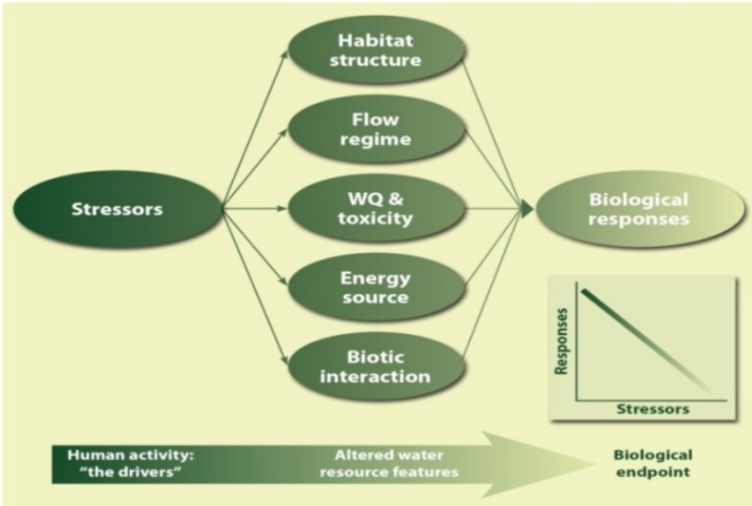
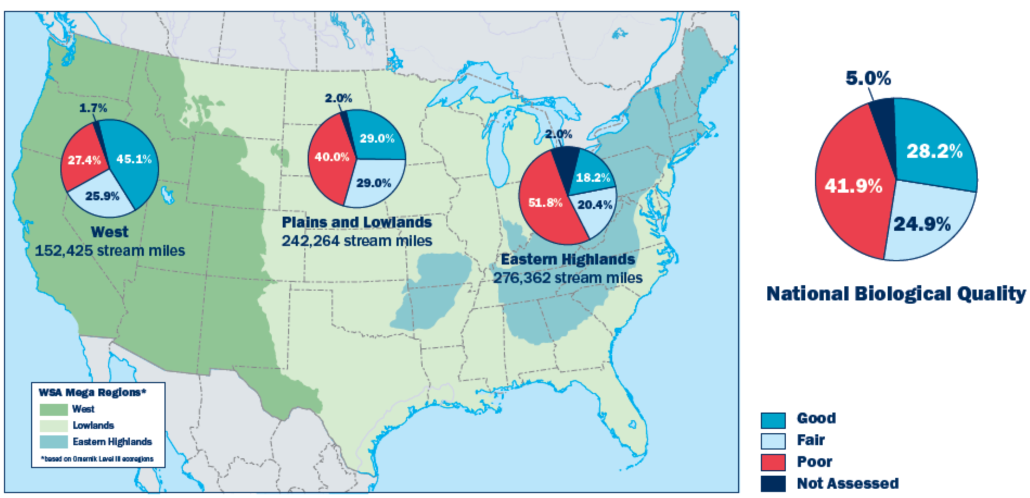


Figure 1-2. Biological assessments provide information on the cumulative effects on aquatic communities from multiple stressors. Figure courtesy of David Allen, University of Michigan.

States and tribes have used biological assessments to set environmental goals, detect degradation, prioritize management actions, and track improvements (USEPA 2002). Multiple examples of applications are presented in Chapter 3. Additionally, the U.S. Environmental Protection Agency (EPA) [2] and U.S. Geological Survey (USGS) [3] are conducting national and regional assessments of the condition of aquatic communities and the presence and distribution of stressors that affect the aquatic biota. The EPA National Aquatic Resource Surveys (NARS) program employs a probability-based sampling design while the USGS National Water-Quality Assessment (NAWQA) Program utilizes a targeted design. The data provide a baseline for assessing biological conditions and key stressors over time and tracking environmental improvements at the national or regional level (Figure 1-3).



Source: USEPA 2006.

Figure 1-3. Biological condition of our nation's streams. In its first survey of stream condition, EPA found that 28 percent of the nation's stream miles are in good condition compared to the best existing reference sites in their regions, 25 percent are in fair condition, and 42 percent are in poor condition.

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[2] http://water.epa.gov/type/watersheds/monitoring/nationalsurveys.cfm.

[3] http://water.usgs.gov/nawqa.

1.2 Using Biological Assessment Information in State and Tribal Water Quality Management Programs

Biological assessment information has been used by states and tribes to:

- ***Define goals for a waterbody***—Information on the composition of a naturally occurring aquatic community can provide a description of the expected biological condition for other similar waterbodies and a benchmark against which to measure the biological integrity of surface waters. Many states and tribes have used such information to more precisely define their designated aquatic life uses, develop *biological criteria*, and measure the effectiveness of controls and management actions to achieve those uses.
- ***Report status and trends***—Depending on level of effort and detail, biological assessments can provide information on the status of the condition of the expected aquatic biota in a waterbody and, over time with continued monitoring, provide information on long-term trends.
- ***Identify high-quality waters and watersheds***—Biological assessments can be used to identify high-quality waters and watersheds and support implementation of state and tribal antidegradation policies.
- ***Document biological response to stressors***—Biological assessments can provide information to help develop biological response signatures (e.g., a measurable, repeatable response of specific species to a stressor or category of stressors). Examples include sensitivity of mayfly species (pollution-sensitive aquatic insects) to metal toxicity or temperature-specific preferences of fish species. Such information can provide an additional line of evidence to support stressor identification and causal analysis (USEPA 2000a), as well as to inform numeric criteria development (USEPA 2010a).
- ***Complement pollutant-specific ambient water quality criteria***—Biological assessment information can complement water quality standards (WQS) by providing field information on the cumulative effects on aquatic life from multiple pollutants, as well as detecting impacts from pollutants that do not have EPA recommended numeric criteria.
- ***Complement direct measures of whole effluent toxicity (WET) tests***—Biological assessments can provide information to help document improvements in aquatic life following actions taken to address the aggregate toxic effects of wastewater discharge effluents detected through laboratory WET tests. Additionally, biological assessments complement WET tests by directly measuring the cumulative or post-impact effects that both point source and NPS contaminants have on aquatic biota in the field.
- ***Address water quality impacts of climate change***—EPA, states, and tribes are exploring how biological assessments can be used in concert with physical, chemical, and land use data to help identify baseline biological conditions against which the effects of global climate change on aquatic life can be studied and compared. Such information could enable a water quality management program to calibrate biological assessment endpoints and criteria to adjust for long-term climate change conditions. Additionally, long-term data sets will enable trends analysis and support predictive modeling and forecast analysis.

1.3 Water Quality Program Applications and Case Studies

The CWA employs a variety of regulatory and nonregulatory approaches to reduce direct pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff. Those approaches are employed to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters. The role of biological assessment information to support such approaches is described below, and case studies of successful implementation are provided in Chapter 3.

Water Quality Standards

State and tribal WQS programs can use biological assessment information in developing descriptions of CWA-designated aquatic life uses in terms of the expected biological community. For example, in states and tribes that identify high-quality waters for antidegradation purposes on a waterbody-by-waterbody basis, biological assessments can provide information to help define and protect existing aquatic life uses and identify Tier 2 waters (e.g., where the quality of the waters exceed levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water) and Outstanding National Resource Waters (ONRWs). Maryland is using biological assessments to help identify high-quality streams for antidegradation purposes on a waterbody-by-waterbody basis (case study 3.3). Pennsylvania is exploring the use of biological assessment information to help assess attainment of aquatic life uses and to describe biological characteristics of waters along a gradient of condition (case study 3.4). This information may potentially be used to support protection of waters of the highest quality that require special protection. Arizona used biological assessments to develop numeric biological criteria using the reference condition approach (Stoddard et al. 2006) that takes into account the quality of the reference sites (case example 3.2).

Some states have calibrated biological response to gradients of anthropogenic stress impacting surface waters (see Chapter 2, Tool #2, *The Biological Condition Gradient*). This approach, when applied to WQS by defining the designated aquatic life uses along a gradient of condition, has provided these states with the capability to improve waters incrementally, protect high-quality waters, and help identify factors that affect attainability. For example, Maine assigns a waterbody to a specific condition class on the basis of its current condition and potential for improvement. Numeric biological criteria have been developed for each class and adopted into their WQS (case study 3.1). Over the past 30 years, the use designations for many streams and rivers in Maine have been upgraded according to documented biological improvements and attainment of the biological criteria that define higher quality use classes. This approach is sometimes referred to as tiered aquatic life uses and has also been implemented by the State of Ohio (case study 3.5).

Additionally, biological assessments can provide information on the species composition at a site under consideration for site-specific criteria. Using the species recalculation procedure, a state or tribe can adjust chemical water quality to reflect the chemical sensitivity of species that occur at a site (USEPA 1994). Biological assessment information may support modification of the default species sensitivity distribution to better reflect the expected community composition at the site. For example, if the site is a naturally occurring warm body of water, coldwater fish species could be replaced by resident warmwater fish species in the species sensitivity distribution from which a site-specific criterion is calculated.

Monitoring and Assessment

Biological monitoring and assessments provide data to aquatic resources managers at the local, state, tribal, regional, and national levels to help assess status and trends of aquatic resources as well as to measure the effectiveness of management actions to protect or restore waters. For example, the biological monitoring program in Montgomery County, Maryland, produces biological assessment information on the condition of the County's streams and the effectiveness of innovative best management practices (BMPs) for stormwater control.[4] At the state level, the Maryland Department of the Environment (MDE) conducts biological monitoring to evaluate permit effectiveness, conduct impact assessments, and identify high-quality waters (case studies 3.3 and 3.12). Also, Maryland Department of Natural Resources (MDNR)[5] provides MDE and the public with a statewide biological assessment of status and trends for streams and rivers that may serve as a yardstick for measuring the overall effectiveness of local and state management actions.

Biological assessment information has been used by counties and state/tribal agencies to facilitate collaboration and effective use of limited resources. For example, two state agencies in Oregon jointly conducted biological assessments to address their information needs (case study 3.17). For the Oregon Department of Fish and Wildlife (ODFW), monitoring of aquatic benthic macroinvertebrate communities in streams and rivers, in conjunction with chemical and physical monitoring, provided important information on water quality and habitat conditions identified as critical to coho salmon viability. Oregon's Department of Environmental Quality (ODEQ) used the same biological assessment information to assess attainment of the designated uses to protect and maintain salmonid populations.

At the national level, biological data from the *National Aquatic Resource Surveys*[6] are being used in EPA's strategic plan to track improvements in water quality for streams, rivers, wetlands, and coastal waters. The results of the first national surveys for streams and coastal waters are included in EPA's *Report on the Environment.*[7] These surveys, which incorporate a statistical probabilistic design, are key tools for communicating to the public what the Agency knows about the condition of the nation's waters at national and regional scales. The biological components of the national surveys will continue to provide nationally consistent indicators of water quality that can be used to gauge the overall effect of the national investment in protecting and restoring the nation's watersheds.

EPA also uses biological assessments to assess status and trends at a regional or large ecosystem scale (e.g., in the Upper Mississippi River Basin or the Great Lakes) and measure biological response to restoration efforts related to disasters (e.g., Hurricane Katrina and the Gulf of Mexico oil spill). National and regional biological assessments provide information that helps facilitate interagency collaboration for large-scale restoration and protection efforts. For example, a recent USGS multiregional assessment found that alteration of streamflow is a major predictor of biological integrity of both fish and macroinvertebrate communities (Carlisle et al. 2010). Alterations in stream flow are associated with riparian disturbance and can influence the release of nitrogen, phosphorus, and sediments into streams (Poff and Zimmerman 2010). The combined results of national, regional, and state/tribal ecological assessments will provide the data needed to predict and better manage future impacts of stressors from

[4] For an additional example, see http://water.epa.gov/scitech/swguidance/waterquality/standards/criteria/aqlife/biocriteria/npdesmaryland.cfm.

[5] http://www.dnr.state.md.us.

[6] http://water.epa.gov/type/watersheds/monitoring/nationalsurveys.cfm.

[7] http://www.epa.gov/roe.

human activities such as urban development, water allocation, and agriculture. The results of different program actions to address different stressors and their sources can be related to a common measure of environmental improvement—the condition of the aquatic biota.

Identification of Impaired and Threatened Waters in States' Integrated Water Quality Reports

Under section 303(d) of the CWA and supporting regulations (40 CFR 130.7), states, territories, and authorized tribes (hereafter referred to as states) are required to develop lists of impaired and threatened waters that require Total Maximum Daily Loads (TMDLs). Impaired waters are those that do not meet any applicable WQS, including designated uses, narrative criteria and numeric criteria such as biological criteria adopted as a standard. EPA recommends that states consider as threatened those waters that are currently attaining WQS, but which are expected to not meet WQS by the next listing cycle (every 2 years). Consistent with EPA recommendation, many states consolidate their section 303(d) and section 305(b) reporting requirement into one "integrated" report.

If biological assessments indicate that a waterbody is impaired or threatened, the waterbody is included on the state's section 303(d) list and scheduled for TMDL development. Some 30 states have used biological assessment information as the basis for concluding that designated aquatic life use(s) were not supported and included these waters on their section 303(d) lists. In some cases, these listings were based on comparison of the biological assessments to state-adopted numeric biological water quality criteria. However, in most cases, biological assessments were treated as translations of one or more of a state's narrative water quality criteria or as direct evidence that designated aquatic life uses were not supported.

How to reconcile conflicting results among different datasets (e.g., chemical, physical, biological) is discussed in EPA's Integrated Reporting Guidance (IRG) for the 2006 sections 303(d) and 305(b) reporting cycle. Also discussed in the IRG, if a designated use, such as aquatic life, is not supported and the water is impaired or threatened, the fact that the specific pollutant may not be known does not provide a basis for excluding the water from the section 303(d) list.[8] These waters are often identified on a state's list as cause or pollutant unknown. These waters must be included on the list until the pollutant is identified and a TMDL completed or the state can demonstrate that no pollutant(s) cause or contribute to the impairment. For example, in 1998, Iowa listed a 20-mile segment of the North Fork Maquoketa River as aquatic life use impaired—cause unknown, based on biological assessments. Using EPA's CADDIS stressor identification (SI) methodology, Iowa determined that the aquatic life use was impaired due to sediments, nutrients, and ammonia (see Tool #3, Stressor Identification and Causal Analysis/Diagnosis Decision Information System). A TMDL was developed for each of these pollutants and these were approved by EPA in 2007 (case study 3.7).

Development of Total Maximum Daily Loads

Under the CWA, states are required to develop TMDLs for impaired and threatened waters on their 303(d) lists. States and tribes may use biological assessments to support developing one or more water quality targets for the pollutant of concern on the basis of well-documented stressor-response relationships, from reference conditions or through use of mechanistic modeling. This is done in conjunction with other water quality monitoring data, such as data on concentrations of specific

[8] EPA Integrated Reporting Guidance for the 2006 Section 303(d) and 305(b) Reporting Cycle website: http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/2006IRG_index.cfm

stressors and toxicity effects. For example, Connecticut has developed a relationship between pollutant loads, stormwater flows, and impervious land cover (IC) for streams in small watersheds with no other known point source discharge (case study 3.8). Connecticut used these relationships to develop a TMDL for a small stream identified as impaired based on biological assessments. Because the cause of impairment was unknown, an SI was completed. The SI determined that the most probable cause of impairment was the complex array of pollutants transported by stormwater into the stream. The TMDL is expressed as a reduction target for specific segments of the stream and is to be implemented through reduction of IC where practical and improved stormwater management throughout the watershed. Connecticut will evaluate progress toward the TMDL's implementation using biological assessments in conjunction with surface water chemistry assessments.

Additionally, EPA is encouraging states and tribes to develop TMDLs on a watershed basis (e.g., to bundle TMDLs together) to enhance program efficiencies and foster more holistic analysis. Ideally, TMDLs would be incorporated into comprehensive watershed strategies, while biological assessments would provide information on how the aquatic community responds to the full array of restoration activities. EPA is launching the Recovery Potential Screening Tools and Resources website (USEPA 2012),[9] designed to help state, tribal, and other restoration programs evaluate the relative restorability of impaired waters and help prioritize TMDL development. The website provides an approach to identify the use impaired waters and watersheds most likely to respond well to restoration, as well as information on methods, tools, technical information, and instructional examples that managers can customize for restoration programs in any geographic locality. Application of a gradient of biological response to levels of stress, like the Biological Condition Gradient (BCG) (see Chapter 2, Tool # 2, *The Biological Condition Gradient*), can provide a framework to help assess incremental progress in restoring a waterbody's aquatic life use and report environmental outcomes.

National Pollutant Discharge Elimination System Permits

Under section 402 of the CWA, point source discharges of pollutants to waters of the United States are covered by National Pollutant Discharge Elimination System (NPDES) permits. Under EPA regulations at 40 CFR 122.44(d), an NPDES permit must contain water quality-based effluents if it is found that a discharge will cause, have the reasonable potential to cause, or contribute to an excursion above a WQS. States must assess permitted effluent discharges in a manner that is consistent with EPA NPDES regulations (40 CFR 122.44).[10] States and tribes can use biological assessment information in addition to chemical-specific and WET data to support development of permit conditions that will protect water quality, including attainment of state WQS. Data from biological assessments can be used independently from, or in combination with, WET or chemical data to assess WQS attainment (USEPA 1991b). If any one or a combination of these three assessment methods demonstrates that the applicable WQS are not attained, appropriate and corrective action would be taken to address the findings as necessary, including compliance with applicable NPDES permit development provisions at 40 CFR PART 122.44(d)(1).

While narrative biological criteria might exist for many states and some authorized tribes in their WQS, in order for biological assessment information to effectively support the NPDES permit process there should be an EPA-approved numeric interpretation of the narrative biological criteria. States and tribes that have adopted biological criteria in their WQS may benefit from the use of biological assessment

[9] EPA Recovery Potential Screening website: http://www.epa.gov/recoverypotential.

[10] For more information on NDPES regulations, go to http://cfpub.epa.gov/npdes/regs.cfm?program_id=45.

data as an additional biological check of permit controls, including limits, to see if they result in abating pollutant impacts, restoring water quality, or preventing further degradation. In addition, biological assessments as a "special studies/additional monitoring" permit condition can be used to assess overall permit effectiveness to control source pollutant(s) and used as an NPDES permit trigger to reopen and potentially modify the permit[11] if the biological assessment studies indicate that the permitted discharge continues to impact the receiving waterbody.

Also, while biological assessments can establish that aquatic life use impairment exists in the area of the discharge, the cause of the impairment might be wholly or partially due to point sources or NPS pollution. In such cases, an NPDES permit could establish controls based on the portion of impairment that is related to the effluent. Thus, additional chemical analysis and WET tests and/or source identification are typically conducted. For example, Vermont has used biological assessment information to support changes to effluent limits for metals on the basis of impact analysis, WET tests, and documented stressor-response relationships between metals and the aquatic biota (case study 3.9). That information helped support requiring additional treatment technologies that resulted in improved water quality. Upstream and downstream biological assessments were part of the follow-up monitoring plan and, with chemical and WET data, documented the resulting improvements in ambient biological and chemical conditions. Thus, in conjunction with required NPDES effluent monitoring such as WET and chemical-specific information, Vermont used biological assessments and its EPA-approved biological criteria to support narrative NPDES permit requirements to protect aquatic life. Currently Vermont has refined aquatic life uses (e.g., tiered aquatic life uses) and narrative biological criteria in its WQS supported by published peer-reviewed technical procedures for translating the narrative biological criteria into a numeric threshold.

NPS Pollution

Biological assessments can be a sensitive indicator of cumulative effects from multiple and unpredictable stressors from NPS pollution. Tracking water quality conditions using biological assessments is one way to assess whether the biological community is affected by NPS pollution and that efforts to improve degraded waters using voluntary BMPs are effective. In managing NPS pollution, a natural resource agency could initiate cooperative land use programs in an area or install BMPs to improve the water resource and establish biological goals as a benchmark for restoration. Before-and-after biological assessments compared to the biological benchmark make it possible to evaluate the success of management actions. For example, Michigan has used biological assessments to help determine biological impairments, target restoration efforts, and monitor results in Carrier Creek (case study 3.11).

Compliance Evaluation and Enforcement Support

Regulatory authorities can use biological assessment information to support enforcement actions by helping to document biological impacts and measure recovery of the aquatic community due to mitigation and cleanup actions. For example, a fish kill in a tributary to the Potomac River in Maryland and the District of Columbia was caused by illegal dumping of pesticide wastes in Maryland. Biological and chemical sampling data were used to locate the source of the pesticide wastes, identify the responsible party, and show subsequent improvements in water quality as a result of enforcement activities (case study 3.12). Biological assessment information, in conjunction with biological assays and chemical and physical assessments, can assist enforcement agencies in assessing damage and levying

[11] As prescribed under NPDES regulatory requirements for permit reopeners/modifications (CFR 122.44). For more information on NDPES regulations, go to http://cfpub.epa.gov/npdes/regs.cfm?program_id=45.

fair and reasonable damage assessments on those proven responsible for toxic spills, and determining the rate and level of stream recovery.

Watershed Protection

Increasingly, EPA, states, territories, and tribes are implementing CWA programs on an integrated watershed basis—including air, land, and ecosystem relationships and related regulatory tools such as those used in the Chesapeake Bay[12] and the National Estuary programs (NEPs)[13] (USEPA 2007). Biological assessments are used in watershed-level programs to help define ecological goals and assess progress in achieving those goals. Recently, EPA has embarked on the Healthy Watershed Initiative, which focuses on protecting high-quality waters and watersheds (USEPA In draft). It is a strategic approach that identifies healthy waters and watersheds at the state level and then targets resources at both the state and local levels for their protection. Biological assessments provide critical information and measurable benchmarks to identify high-quality waters in healthy watersheds and then, over time, evaluate how effectively such systems are being protected. The State of Virginia is using biological assessments in its own Healthy Watersheds initiative to define protection and restoration goals that resonate with the public (case study 3.14). EPA's Office of Research and Development (ORD) is working with several states, territories, and NEPs to develop biological assessment tools and approaches that can be applied at multiple scales to protect estuarine and coastal ecosystems and their watersheds (case study 3.16). Additionally, the BCG (see Chapter 2, Tool # 2) can be applied as a field-based assessment framework to describe the health of waterbodies and their watersheds and communicate the biological condition to the public (USEPA In draft). And, in conjunction with refined aquatic life uses and biological criteria adopted into WQS, a BCG-like framework can be used to support management actions to protect existing high-quality waters in a healthy watershed, as demonstrated by the State of Maine (case study 3.1).

[12] Chesapeake Bay Program website: http://www.chesapeakebay.net.

[13] National Estuary Program website: http://water.epa.gov/type/oceb/nep/estuaries_index.cfm.

Chapter 2. Tools for Improving the Use of Biological Assessments in Water Quality Management

EPA has published several documents that provide guidance on incorporating biological assessment information into water quality programs, many of which have been in use for several years. They include technical guidance on developing biological criteria and general program guidance on application of biological assessment information in different water quality programs. A summary of these documents is provided in Appendix A. Additionally, other technical support documents, or technical tools, have been recently developed to further assist states and tribes in developing robust biological assessment programs and applying biological assessment information. Three of these recent tools are listed below and briefly summarized in the following pages.

- ***Tool #1: The Biological Assessment Program Review.*** The level of program rigor determines how well the monitoring and assessment program produces the information needed to support management decision making. A review process and checklist have been developed and piloted by regions, states, and tribes to help assess the technical capability of a state or tribal biological assessment program and strategically determine where to invest resources to develop a technically robust biological assessment program.
- ***Tool #2: The Biological Condition Gradient (BCG).*** The BCG is a conceptual model that describes how biological attributes of aquatic ecosystems might change along a gradient of increasing anthropogenic stress. The model can serve as a template for organizing field data (biological, chemical, physical, landscape) at an ecoregional, basin, watershed, or stream segment level. A BCG calibrated with field data can help states and tribes more precisely define biological expectations for their designated aquatic life uses, interpret current condition relative to CWA objective and goals, track biological community response to management actions, and communicate environmental outcomes to the public. The BCG was designed to help map different biological indicators on a common scale of biological condition to facilitate communication among programs and across jurisdictional boundaries. The BCG is currently being field tested in several regions and states.
- ***Tool #3: Stressor Identification (SI) and Causal Analysis/Diagnosis Decision Information System (CADDIS).*** In 2010 EPA updated its technical support document on causal analysis and literature database to help states and tribes identify the most probable cause of impairment to a waterbody. Specific databases on biological response to stress have been compiled and will undergo continuous updating so that the best available and peer-reviewed literature will be accessible as part of CADDIS. This document and database will assist states that have listed waters as impaired on the basis of biological assessments when the cause of impairment is not known.

2.1 Tool #1: Biological Assessment Program Review

Purpose: To provide a stepwise process to assist states in evaluating the technical capability of their biological assessment programs and to strategically determine where to invest resources to enhance the technical capability of their programs.

This tool can be used to answer questions, including the following:

- Does the quality of data being generated support the management decisions I need to make?
- What are the strengths and needs of my existing program?
- How do I build on my current program and further strengthen it?

Source: EPA's website on key concepts for using biological indicators: http://www.epa.gov/bioiweb1/html/keyconcepts.html

The information provided below describes technical elements of a biological assessment program, summarizes the process and benefits of conducting a program review, and discusses regional/state pilot programs.

The Program Review Process

The critical technical elements review is a systematic ***process*** to evaluate biological assessment program rigor and to identify logical next steps for overall program improvement. The document provides a ***template*** for evaluating critical technical components of a biological assessment program that are scored to arrive at a level of program rigor, from level 1 (the least rigorous) to level 4 (the most rigorous) (Table 2-1). The review provides a framework for identifying programmatic strengths and weaknesses and helps program managers and technical staff members determine key tasks to upgrade the technical abilities of their program (Figure 2-1). The evaluation process also identifies opportunities to improve integration of WQS and monitoring and assessment programs. This review process was initially piloted in EPA Region 5 and more recently applied and further refined in Region 1. Initial programs reviews have focused on biological assessments of streams and rivers, but with some refinements in methodology this evaluation process can be applied to other types of waterbodies. The states have used the results of the review to target resources and prioritize actions to strengthen the technical basis of their biological assessment programs.

The first part of the review involves discussion on the design of the existing monitoring and assessment program, the degree to which there is systematic collection of data from the environment, and how well the data analysis produces information suitable for making the various decisions asked of it—such as determining attainment of aquatic life uses, identifying high-quality waters for antidegradation purposes on a waterbody-by-waterbody basis, evaluating the severity and extent of impairments, and supporting causal analysis and pollutant source identification (i.e., toxicity identification evaluation [TIE] and toxicity reduction evaluation [TRE]). It is essential that experts in the different program areas be engaged in the discussions to help ensure that data quality and information requirements are accurately represented and properly implemented, especially with regard to EPA-published methodologies. The information helps document how monitoring and assessment information is used to support the reporting requirements mandated by the CWA and other state or tribal efforts to characterize the status of waterbodies and plan for implementing restoration efforts. This part of the program review might also examine how the state or tribe uses biological assessment information to more precisely define aquatic life uses and develop biological criteria.

Table 2-1. Key features of the technical attributes for levels of rigor in state/tribal biological assessment programs (streams and rivers).
(Terms in the table are included in the glossary, this template can be modified and applied to other waterbody types.)

	Attributes of levels of biological assessment program rigor			
Key features	**Level 1**	**Level 2**	**Level 3**	**Level 4**
Temporal and spatial coverage	Variable data collection times; upstream/downstream and fixed stations	Index period for convenience; non-random design at a coarse scale (e.g., 4- to 8-digit hydrologic unit code [HUC])	Calibrated seasonal index periods; statewide spatial design using rotating basins at a coarse scale (e.g., 4- to 8-digit HUC)	Scientifically-derived temporal sampling for management decisions; multiple spatial designs for multiple issues; 11- to 14-digit HUC
Natural classification of aquatic ecosystems	No partitioning of natural variability; no incorporation of differences in stream characteristics such as size, gradient	Classification usually a geo-graphical or other similar organization (e.g., fishery-based cold or warmwater; lacks intra-regional strata [size, gradient])	Classification based on a combination of landscape features and physical habitat structure; considers all intra-regional strata and specific ecosystems	Fully partitioned and stratified classification scheme that transcends jurisdictions and recognizes zoogeographical aspects of assemblages
Reference conditions	No reference conditions; presence and absence of key taxa are based on best professional judgment	A site-specific control or paired watershed approach can be used for assessment; regional reference sites are lacking	Reference conditions used in watershed assessments; regional reference sites are too few in number or spatial density	Regional reference conditions are established in the applicable waterbody ecotypes and aquatic resource classes
Sampling and sample processing	Approach is cursory and relies on operator skill and best professional judgment, producing highly variable and less comparable results	Textbook methods are used rather than in-house development of standard operating procedures to specify methods	Methods are calibrated for state purposes and are detailed and well documented; supported by in-house testing and development	Same as Level 3, but methods cover multiple assemblages; high taxonomic resolution
Data management	Sampling event data are organized in a series of spreadsheets	Separate databases are used for physical, chemical, and biological data with separate GIS shapefiles of sites	A true relational database is specifically designed to include data validation checks (e.g., Oracle, SQL Server, Access)	Relational database of biological assessment data with automated data review validation tools and geospatial analysis
Biological endpoints and thresholds	Assessment based on presence or absence of targeted or key species; attainment thresholds are not specified and no BCG	A biological index or endpoint is by specific waterbodies; single dimension measures used	A biological index, or model, developed and calibrated for use throughout the state for the various waterbody types	Biological indexes, or models, for multiple assemblages are developed and calibrated for a state and uses the BCG
Causal analysis	Support for causal analysis is lacking	Coarse indications of response via assemblage attributes at gross level (i.e., general indicator groups)	Developed indicator guilds and other aggregations to support causal associations; diagnostic capability is supported by studies	Response patterns are most fully developed and supported by extensive research and case studies across spatial and temporal scales

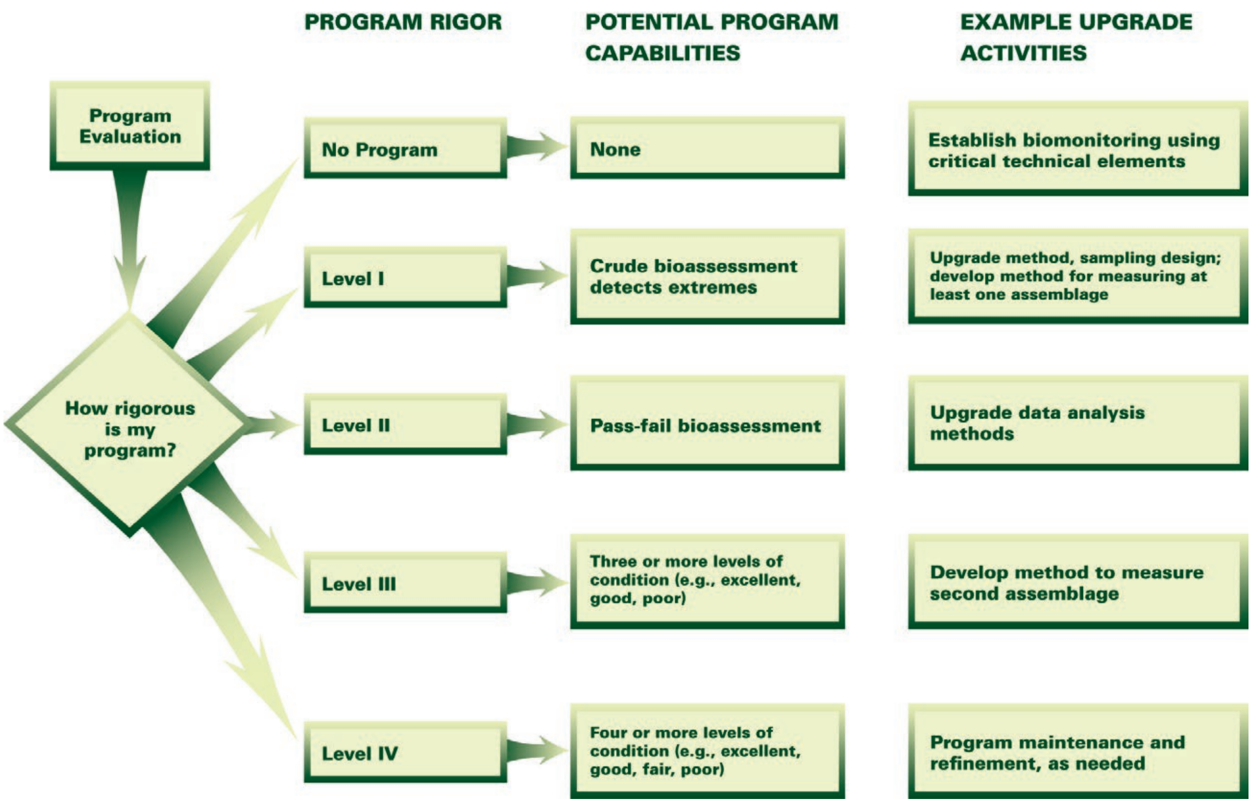


Figure 2-1. Key features of the program review process and examples of commensurate upgrades.

Evaluation of Critical Technical Elements of a State's or Tribe's Biological Assessment Program

The program review evaluates 13 critical technical elements of a biological assessment program associated with design, methods, and data interpretation (e.g., survey design, method of classification, procedures to establish reference conditions, protocols for sampling collection and processing, data management and analysis, formal peer review). On the basis of the discussions in the first phase of the review, where program information needs are identified, a list of recommendations is developed according to the strengths and gaps identified in the technical program evaluation. The recommendations are presented in a logical, stepwise progression so that a state or tribe can build on its technical program strengths and target resources effectively to address the program gaps. Participation of program managers and technical staff representing different water quality programs is important in the review to build a shared understanding and broad perspective on existing use of biological assessment information and begin to identify the technical program gaps and areas for improved use.

Case Example: Technical Evaluations in Minnesota and Connecticut

The Minnesota Pollution Control Agency (MPCA) decided in 2005 to use biological assessment information to develop refined aquatic life uses and numeric biological criteria in its WQS to meet its objectives of setting management goals for waterbodies on the basis of their best potential condition. MPCA also found biological assessment information as useful to educate and engage stakeholders and the public. MPCA used the Critical Technical Elements Program Evaluation process to determine *where* its program was in 2005 and what tasks were yet to be accomplished to reach its stated goals. Using the findings, MPCA developed a detailed plan for developing a technical program sufficiently rigorous to support adoption in the state's WQS in 2011–2014 of the most appropriate aquatic life uses and numeric biological criteria. MPCA continues to follow the plan, addressing the priority recommendations identified in the program evaluation, and is proceeding with biological criteria development. As part of this effort, MPCA is exploring application of the BCG, the second tool discussed in this document, to develop biological goals for their waters that are tailored to specific waterbody types and uses.

The Connecticut Department of Environmental Protection (CT DEP) has been monitoring aquatic biological conditions using benthic macroinvertebrates since the late 1980s and has steadily upgraded its technical program over the years. The state operates a statewide monitoring and assessment program that includes multiple spatial designs to produce both statewide assessments using probabilistic design and listings of impaired waters using targeted sampling design. CT DEP underwent a Critical Elements Program Evaluation in 2006 to help identify and prioritize additional technical program improvements needed to develop numeric biological criteria for different levels of quality along a gradient of condition (e.g., excellent and good quality waters). The program was evaluated at a level 2 with specific tasks identified to build its technical capability (e.g., improved spatial resolution in watershed assessment design from 8-digit HUC to 10- to 12-digit HUC; a regionally-calibrated multimetric index for benthic macroinvertebrates and one for fish that distinguishes between coldwater and warmwater assemblages; instituting an independent peer review process). Since the review, CT DEP has improved the technical capability of the biological assessment program to a level 3 and now has two numeric indices and enhanced spatial monitoring design.

These examples show how states and tribes can use the results of the Critical Elements Program Evaluation to develop a *blueprint* for making orderly improvements and attaining the technical proficiency to respond to management questions and improve decision making—including support for condition assessments, attainment of WQS, diagnosis of biological impairment, and effectiveness monitoring. The program review process identifies specific and successive improvements that are needed to improve the rigor of the biological assessment program and a checklist so that progress can be identified and tracked.

2.2 Tool #2: The Biological Condition Gradient

Purpose: To provide a common scale of biological condition to support comparisons between programs and across jurisdictional boundaries.

This tool can be used to help answer questions, including the following:

- What biological community should be at a site, e.g., natural conditions?
- Are we protecting our high-quality waters?
- Are we making progress to restore our degraded systems?
- Are our actions making real and lasting environmental improvements?

Source: *The biological condition gradient: A descriptive model for interpreting change in aquatic ecosystems* (Davies and Jackson 2006)

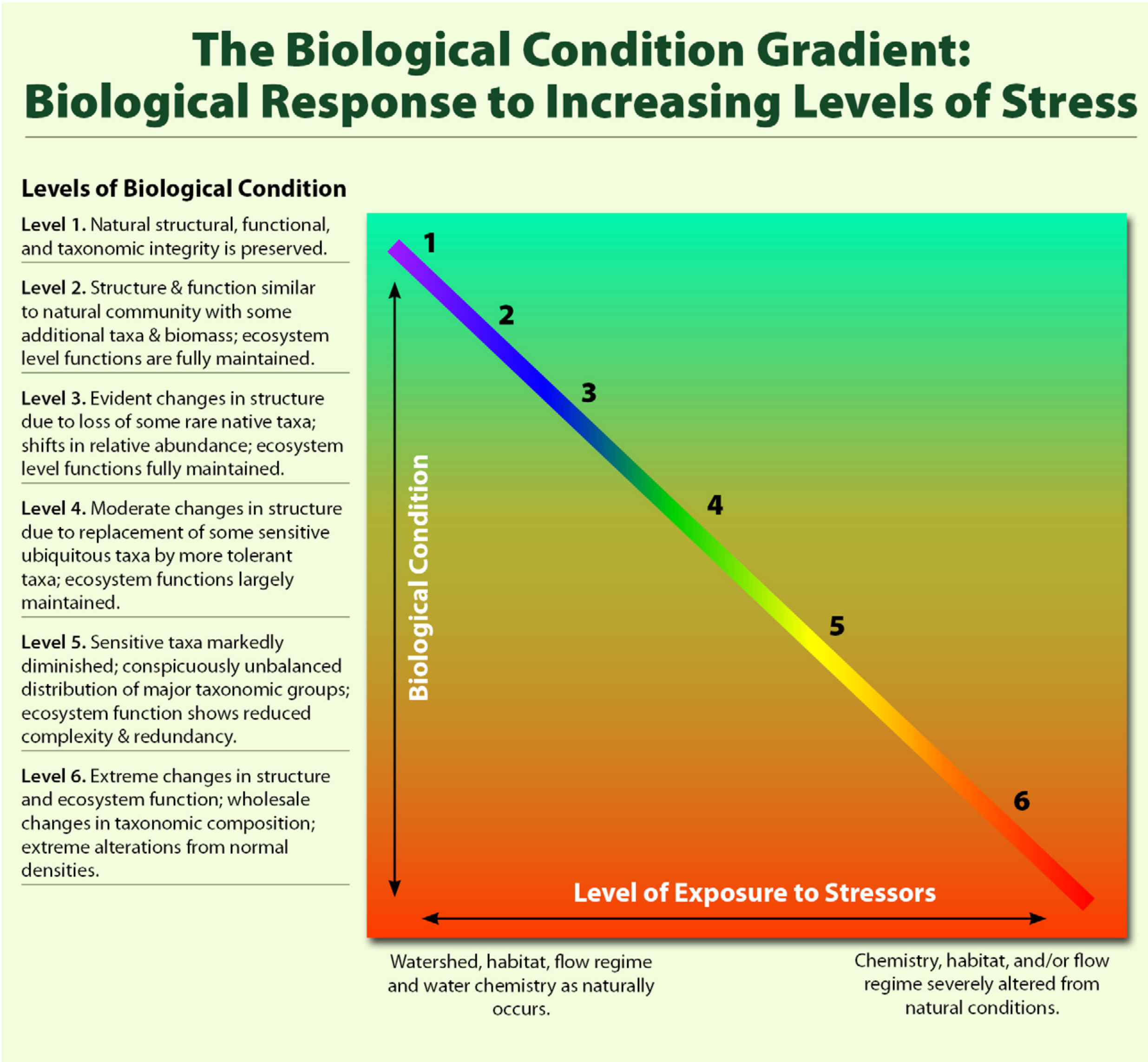
This section provides an overview of the BCG and how it can be calibrated for specific use by a state or tribe. The BCG is being applied and tested in several regions and states.

What Is the BCG?

Over the past 40 years, states have independently developed technical approaches to assess biological condition and set designated aquatic life uses for their waters. The BCG was designed to provide a means to map different indicators on a common scale of biological condition to facilitate comparisons between programs and across jurisdictional boundaries in context of the CWA. The BCG is a conceptual, narrative model that describes how biological attributes of aquatic ecosystems change along a gradient of increasing anthropogenic stress. It provides a framework for understanding current conditions relative to natural, undisturbed conditions (Figure 2-2). Some states, such as Maine and Ohio, have used a framework similar to the BCG to more precisely define their designated aquatic life uses (case studies 3.1 and 3.5).

Agreeing that, even in different geographic and climatological areas, a similar sequence of biological alterations occurs in streams and rivers in response to increasing stress, biologists from across the United States developed the model (Davies and Jackson 2006). The model shows an ecologically based relationship between the stressors affecting a waterbody (e.g., physical, chemical, biological impacts) and the response of the aquatic community (i.e., biological condition). The model is consistent with ecological theory and can be adapted or calibrated to reflect specific geographic regions and waterbody type (e.g., streams, rivers, wetlands, estuaries, lakes). Approaches to calibrate the BCG to region-, state-, or tribe-specific conditions are being piloted in several ecological regions by multiple states and tribes.

In practice, the BCG is used to first identify the critical attributes of an aquatic community (see Table 2-2) and then describe how each attribute changes in response to stress. Practitioners can use the BCG to interpret biological condition along a standardized gradient, regardless of assessment method, and apply that information to different state or tribal programs. For example, Pennsylvania is exploring the use of a BCG calibrated to its streams to complement its existing biological indices for macroinvertebrates and to describe the biological characteristics of waters along a gradient of condition. The state is evaluating using this information to help assess aquatic life use impairments and to describe waters of the highest quality (case study 3.4).



Source: Modified from Davies and Jackson 2006.

Figure 2-2. The BCG.

Note: The BCG was developed to serve as a scientific framework to synthesize expert knowledge with empirical observations and develop testable hypotheses on the response of aquatic biota to increasing levels of stress. It is intended to help support more consistent interpretations of the response of aquatic biota to stressors and to clearly communicate this information to the public, and it is being evaluated and piloted in several regions and states.

The BCG model provides a framework to help water quality managers do the following:

- Decide what environmental conditions are desired (goal-setting)—The BCG can provide a framework for organizing data and information and for setting achievable goals for waterbodies relative to “natural” conditions (e.g., condition comparable or close to undisturbed or minimally disturbed condition).
- Interpret the environmental conditions that exist (monitoring and assessment)—Practitioners can get a more accurate picture of current waterbody conditions.

- Plan for how to achieve the desired conditions and measure effectiveness of restoration—The BCG framework offers water program managers a way to help evaluate the effects of stressors on a waterbody, select management measures by which to alleviate those stresses, and measure the effectiveness of management actions.
- Communicate with stakeholders—When biological and stress information is presented in this framework, it is easier for the public to understand the status of the aquatic resources relative to what high-quality places exist and what might have been lost.

How Is the BCG Constructed?

The BCG is divided into six levels of biological conditions along the stressor-response curve, ranging from observable biological conditions found at no or low levels of stress (level 1) to those found at high levels of stress (level 6) (Figure 2-2). The technical document provides a detailed description of how 10 attributes of aquatic ecosystems change in response to increasing levels of stressors along the gradient, from level 1 to 6 (see Table 2-2). The attributes include several aspects of community structure, organism condition, ecosystem function, spatial and temporal attributes of stream size, and connectivity.

Each attribute provides some information about the biological condition of a waterbody. Combined into a model like the BCG, the attributes can offer a more complete picture about current waterbody conditions and also provide a basis for comparison with naturally expected waterbody conditions. All states and tribes that have applied a BCG used the first seven attributes that describe the composition and structure of biotic community on the basis of the tolerance of species to stressors and, where available, included information on the presence or absence of native and nonnative species and, for fish and amphibians, observations on overall condition (e.g., size, weight, abnormalities, tumors).

The last three BCG attributes of ecosystem function and connectance and spatial and temporal extent of detrimental effects can provide valuable information when evaluating the potential for a waterbody to be protected or restored. For example, a manager can choose to target resources and restoration activities to a stream where there is limited spatial extent of stressors or there are adjacent intact wetlands and stream buffers or intact hydrology versus a stream with comparable biological condition but where adjacent wetlands have been recently eliminated, hydrology is being altered, and stressor input is predicted to increase. Pennsylvania is evaluating indicators comparable to the BCG spatial and connectance attributes IX and X to characterize the biological conditions of streams in healthy watersheds where resources may be well spent to successfully protect such waters (see case study 3.4). Additionally, several of EPA's NEPs, in conjunction with EPA ORD, are exploring application of those attributes at a whole-estuary scale (e.g., distribution and connectance of critical aquatic habitats and associated biota) (see case study 3.16).

Additionally, individual attributes might uniquely respond to a specific stressor or group of associated stressors (biological response signatures) (Yoder and Rankin 1995; Yoder and Deshon 2003). That information could contribute to the causal analysis of biological impairment discussed in Tool #3*, Stressor Identification (SI) and Causal Analysis/Diagnosis Decision Information System (CADDIS)*.

Table 2-2. Biological and other ecological attributes used to characterize the BCG.

Attribute	Description
I. Historically documented, sensitive, long-lived, or regionally endemic taxa	Taxa known to have been supported according to historical, museum, or archeological records, or taxa with restricted distribution (occurring only in a locale as opposed to a region), often due to unique life history requirements (e.g., sturgeon, American eel, pupfish, unionid mussel species).
II. Highly sensitive (typically uncommon) taxa	Taxa that are highly sensitive to pollution or anthropogenic disturbance. Tend to occur in low numbers, and many taxa are specialists for habitats and food type. These are the first to disappear with disturbance or pollution (e.g., most stoneflies, brook trout [in the east], brook lamprey).
III. Intermediate sensitive and common taxa	Common taxa that are ubiquitous and abundant in relatively undisturbed conditions but are sensitive to anthropogenic disturbance/pollution. They have a broader range of tolerance than attribute II taxa and can be found at reduced density and richness in moderately disturbed sites (e.g., many mayflies, many darter fish species).
IV. Taxa of intermediate tolerance	Ubiquitous and common taxa that can be found under almost any conditions, from undisturbed to highly stressed sites. They are broadly tolerant but often decline under extreme conditions (e.g., filter-feeding caddisflies, many midges, many minnow species).
V. Highly tolerant taxa	Taxa that typically are uncommon and of low abundance in undisturbed conditions but that increase in abundance in disturbed sites. Opportunistic species able to exploit resources in disturbed sites. These are the last survivors (e.g., tubificid worms, black bullhead).
VI. Nonnative or intentionally introduced species	Any species not native to the ecosystem (e.g., Asiatic clam, zebra mussel, carp, European brown trout). Additionally, there are many fish native to one part of North America that have been introduced elsewhere.
VII. Organism condition	Anomalies of the organisms; indicators of individual health (e.g., deformities, lesions, tumors).
VIII. Ecosystem function	Processes performed by ecosystems, including primary and secondary production; respiration; nutrient cycling; decomposition; their proportion/dominance; and what components of the system carry the dominant functions. For example, shift of lakes and estuaries to phytoplankton production and microbial decomposition under disturbance and eutrophication.
IX. Spatial and temporal extent of detrimental effects	The spatial and temporal extent of cumulative adverse effects of stressors; for example, groundwater pumping in Kansas resulting in change in fish composition from fluvial dependent to sunfish.
X. Ecosystem connectance	Access or linkage (in space/time) to materials, locations, and conditions required for maintenance of interacting populations of aquatic life; the opposite of fragmentation. For example, levees restrict connections between flowing water and floodplain nutrient sinks (disrupt function); dams impede fish migration, spawning.

Source: Modified from Davies and Jackson 2006.

Calibrating the Conceptual Model to Local Conditions

The BCG can serve as a starting point for defining the response of aquatic biota to increasing levels of stress in a specific region. Although the BCG was developed primarily using forested stream ecosystems, the model can be applied to any region or waterbody by calibrating it to local conditions using specific expertise and local data. To date, most states and tribes are calibrating the BCG using the first seven attributes that characterize the biotic community primarily on the basis of tolerance to stressors, presence/absence of native and nonnative species, and organism condition. Although the model has been developed for six levels of condition, six levels might not be necessary or feasible depending on limitations in data or level of technical rigor (see Chapter 2, Tool #1, *Biological Assessment Program Evaluation*) or naturally occurring conditions. For example, ephemeral streams in the arid Southwest naturally support a community of aquatic organisms that tolerate extreme conditions that range from intense, monsoon-like precipitation to extensive periods of drought. Those organisms might also be able to tolerate the presence of stressors. Thus, the range of response to anthropogenic stress in such streams (e.g., moderately tolerant to very tolerant species) might be abbreviated compared to that of a forested stream community in a temperate climate (e.g., very sensitive to very tolerant species). Three or four tiers might be suitable for those waters.

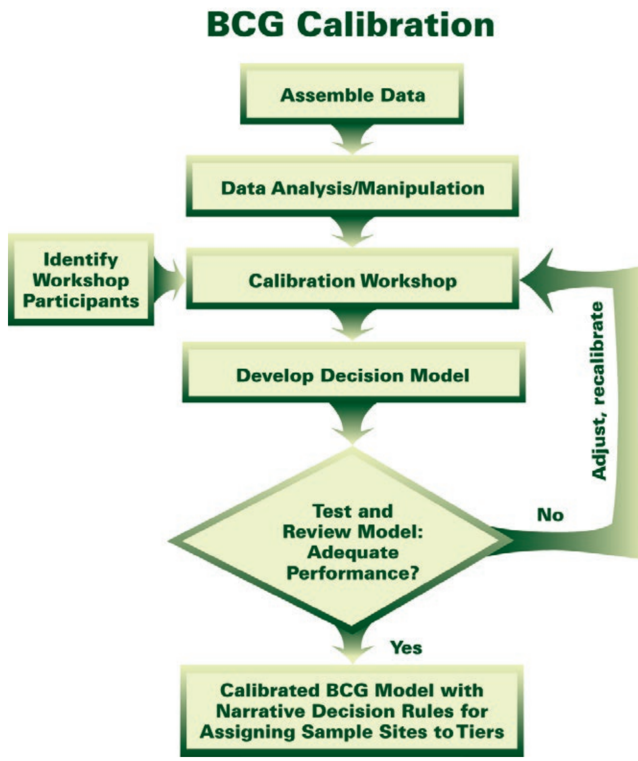


Figure 2-3. Steps in a BCG calibration.

It is a multistep process to calibrate a BCG to local conditions (Figure 2-3). That process is followed to describe the native aquatic assemblages under natural conditions; identify the predominant regional stressors; and describe the BCG, including the theoretical foundation and observed assemblage response to stressors. Calibration begins with the assembly and analysis of biological monitoring data. Next, a calibration workshop is held in which experts familiar with local conditions use the data to define the ecological attributes and set narrative statements. For example, narrative decision rules for assigning sites to a BCG level on the basis of the biological information collected at sites. New Jersey is one of several states that are field testing this approach. Documentation of expert opinion in assigning sites to tiers is a critical part of the process. A decision model can then be developed that encompasses those rules and is tested with independent data sets. A decision model based on the tested decision rules is a transparent, formal, and testable method for documenting and validating expert knowledge (see Table 2-3 for examples). A quantitative data analysis program can then be developed using those rules. EPA recommends peer review of model.

Table 2-3. Example of narrative decision rules for distinguishing BCG Level 2 from Level 3 for streams, modified from New Jersey BCG expert workshop

Attributes	**Rules for BCG Level 2** Structure and function of community similar to natural community with some additional taxa and biomass	**Rules for BCG Level 3** Evident changes in structure due to loss of some rare native taxa; shifts in relative abundance
Total taxa	More than 12 taxa	More than 12 taxa
Highly Sensitive Taxa (Attribute II only)	More than two taxa	May be absent
Richness of Sensitive Taxa (combination of Attributes II and III,see table 2-2)	Attribute II + Attribute III are more than 50% of total taxa richness	Attribute II + Attribute III are more than 35% of total taxa richness
Abundance of Tolerant Taxa (Attribute V)	Abundance of Attribute V is less than 20% of community	Abundance of Attribute V is less than 50% of community

In the example above, both BCG levels 2 and 3 support comparable levels of overall taxa (e.g., total taxa). However, there is a shift from BCG level 2 to BCG level 3 in proportion and abundance of sensitive and tolerant taxa (e.g., a decrease in proportion of sensitive taxa and an increase in abundance of pollution-tolerant taxa). The BCG describes incremental shifts in community composition and other biological parameters along a gradient of increasing anthropogenic stress. The BCG can be used to detect measurable changes in the aquatic biota before there is a complete loss of a certain type or category of taxa such as loss of pollution sensitive or native species. This tool will enable earlier detection and support action to prevent loss of species or other biological changes. This tool can be used to raise the discriminatory power of biological assessment programs in a nationally consistent, transparent manner. Narrative decision rules are the first step in formalizing expert opinion and expressing empirical findings that can then be tested and validated.

Case Example: New Jersey BCG Calibration

New Jersey developed and calibrated a BCG for its upland streams. The New Jersey Department of Environmental Protection (NJ DEP) convened an expert panel workshop that included aquatic biologists and water quality experts familiar with the aquatic fauna that inhabit these streams. The panel developed descriptions of the ecological attributes for these streams in New Jersey and created the narrative rules for assigning sites to levels along the stressor gradient.

The expert panel reviewed the list of taxa from the New Jersey Ambient Biological Monitoring Network to assign taxa to attributes I–VI. Next, the panel examined macroinvertebrate data from 58 upland stream sites and reached consensus on the level assignments for all sites reviewed. The panel was able to distinguish five separate levels (levels 2–6, see below) for New Jersey upland streams. The first level described in Davies and Jackson (2006) consists of entirely pristine sites and was not included because the panel could not identify any level 1 (pristine) sites in New Jersey.

On the basis of the characterization of sites identified as belonging to different BCG levels, the panel developed a set of narrative decision rules and descriptions for distinguishing among the levels.

BCG level 2 (Minimal changes in structure and function)—Because of extensive historical land clearing, cultivation, and early industrial use followed by abandonment and reforestation from the early 20th century, the least stressed watersheds are thought to reflect at best BCG level 2. Most of the 19th century legacy is in changed stream morphology and hydrology that persist in valley bottoms (Walter and Merritts 2008). Watersheds are predominantly forested, with recreational use but little residential or agricultural use. The group consensus was that several richness criteria (i.e., total taxa, highly sensitive taxa, and all sensitive taxa) must all be met for a site to be considered to be in level 2.

BCG level 3 (Evident changes in structure and function)—A typical level 3 stream has a largely forested watershed but some areas of suburban development or limited agriculture. Criteria for level 3 are similar to those for level 2, but richness of the sensitive organisms is somewhat reduced and sensitive organisms do not numerically dominate the assemblage. All the criteria for level 3 were considered critical.

BCG level 4 (Moderate changes in structure and function)—Typical level 4 streams in New Jersey often have relatively extensive suburban and commercial development, some agricultural land use, but substantial areas of natural land cover, often mixed with residential areas. In BCG level 4, the sensitive taxa are present and still constitute a significant fraction of the community, but they are far reduced below their dominance in level 2 and their subdominance in level 3. The assemblage has degraded but maintains ecosystem functions as represented by the sensitive taxa.

BCG level 5 (Major changes in structure and function)—BCG level 5 is discriminated from level 4 by a significant reduction of sensitive taxa (attributes II and III) to the point where they are merely incidental if present and are not a functional part of the community. Although BCG level 5 can have high abundance and high taxa richness, the assemblage is dominated by intermediate and tolerant taxa, and sensitive taxa have all but disappeared.

BCG level 6 (Severe changes in structure and function)—BCG level 6 reflects nearly complete disruption and degradation of the biological community to either very low abundance (less than 50 organisms in New Jersey's standard sampling procedure) or very low taxon richness. While extremely low abundance often indicates toxic conditions, extremely low richness coupled with high abundance often indicates organic enrichment and high-density urban runoff.

New Jersey is considering using the calibrated BCG and the narrative decision rules to help identify high-quality waters on a waterbody-by-waterbody basis for antidegradation purposes.

2.3 Tool #3: Stressor Identification (SI) and Causal Analysis/Diagnosis Decision Information System (CADDIS)

Purpose: To identify the cause of aquatic life impairment when a waterbody is listed because of biological impairment and the cause is unknown.

This tool can be used to answer questions such as the following:

- How can I use biological and stressor information to identify cause of biological impairment?

Sources: *Stressor Identification Guidance Document* (USEPA 2000a); EPA's CADDIS website: http://www.epa.gov/caddis

This section describes how biological assessment information can be used to help identify stressors for impaired waters where cause of impairment is unknown.

How Can Biological Information Be Used for Stressor Identification?

Once a biological impairment has been determined, water quality managers examine existing water quality and landscape data and information to determine the cause and source of impairment, also known as stressor identification (SI). Typically, states and tribes identify the probable causes of the impairment and then, step-by-step, implement additional controls or management practices (or both) to fix the problem. Monitoring the response of the biota to management actions then helps to provide the necessary information on whether the primary stressors were correctly identified and the management actions effective. The biological response information provided in the initial assessment often includes useful information for identifying stressors; for example, the relationship between biological indicators and stressors such as the disappearance of certain benthic species sensitive to a specific toxin (e.g., sensitivity of aquatic life stage of mayflies to metal toxicity) or a shift in dominate community traits related to the increase of a stressor (e.g., a change in primary producer base because of zebra mussel invasion). Additionally, states and tribes have successfully implemented management actions that address co-occurring stressors supported by documented improvements in water quality. Maryland and the District of Columbia were able to use biological assessment data to document the biological effects of a pesticide spill that resulted in a fish kill in Rock Creek, a tributary to the Potomac River. The information was used as the basis for enforcement actions, and subsequent data were able to support a quantitative assessment of the biological impact and evidence of stream recovery (case study 3.12).

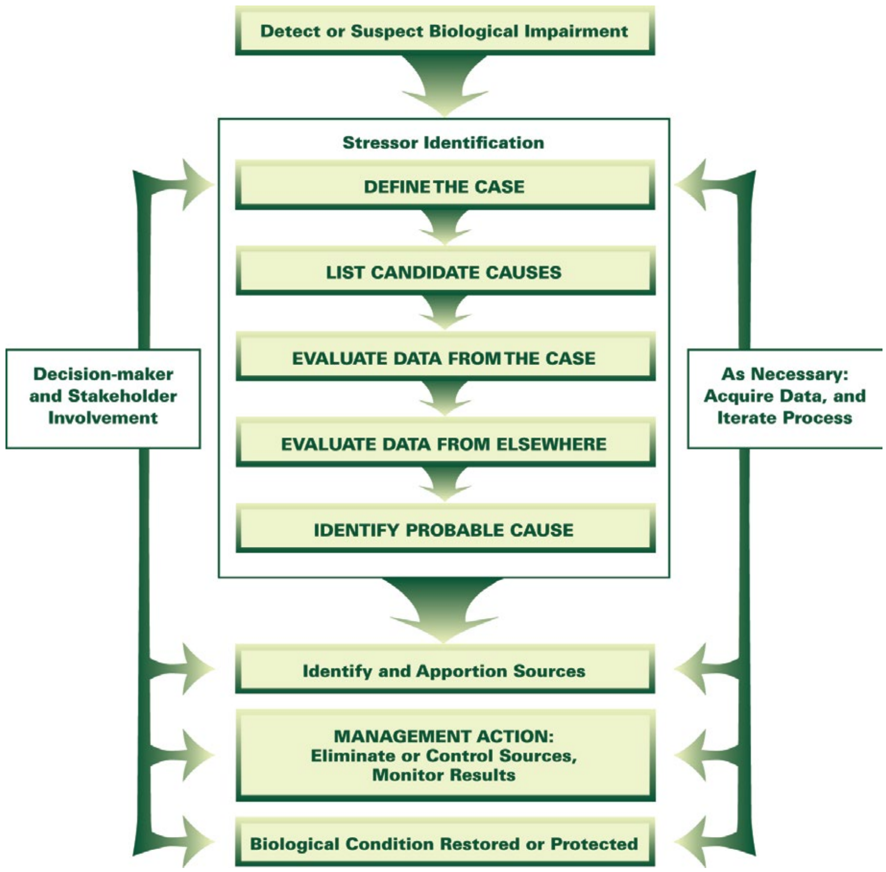
Stressor ID/CADDIS

In 2000 EPA's Office of Water and ORD developed a process for identifying any type of stressor or combination of stressors that causes biological impairment. The *Stressor Identification Guidance Document* (USEPA 2000a) is intended to lead water resource managers through a formal and rigorous process that identifies stressors causing biological impairment in aquatic ecosystems and provides a structure for organizing the scientific evidence supporting the conclusions.

The SI process is prompted by biological assessment data indicating that a biological impairment has occurred. The general SI process entails critically reviewing available information, forming possible stressor scenarios that might explain the impairment, analyzing those scenarios, and providing conclusions about which stressor(s) are causing the impairment. The SI process is iterative, usually beginning with a retrospective analysis of available data. The accuracy of the identification depends on the quality of data and other information used in the SI process. In some cases, additional data collection might be necessary to accurately identify the stressor(s). The conclusions can be translated into management actions, and the effectiveness of those management actions can be monitored (Figure 2-4).

The core of the SI process consists of the following three main steps:

- Listing candidate causes of impairment.
- Analyzing new and previously existing data to generate evidence for each candidate cause.
- Producing a causal characterization using the evidence generated to draw conclusions about the stressors that are most likely to have caused the impairment.



Source: USEPA 2010b

Figure 2-4. Stressor identification process.

Again, the SI process is iterative. Practitioners will begin by analyzing available data to see if sufficient information is already available. The kinds of information needed include information on the type of impairment, the extent of the impairment, any evidence of the usual causes of impairment (e.g., hydrologic alteration, invasive species, habitat loss, toxicants, total nitrogen and phosphorus), and other information from the site. The evidence is considered first and then other, less direct kinds of evidence are gathered and evaluated, if needed. For example, one might consider other situations that are similar and can provide useful insights.

CADDIS is an online application of the SI process that uses a step-by-step guide, worksheets, technical information, and examples to help scientists and engineers find, access, organize, share, and use environmental information to evaluate causes of biological effects observed in aquatic systems such as streams, lakes, and estuaries.[14] CADDIS also contains updates, clarifications, and additional material developed since the SI guidance document was published in 2000.

[14] http://cfpub.epa.gov/caddis/index.cfm.

Case Example: Nutrient Management in the Little Miami River, Ohio

In the early 1980s, Ohio EPA designated the Little Miami River as an Exceptional Warmwater Habitat (EWH) following the first complete biological survey of the mainstem and key tributaries in the Ohio WQS under the new system of tiered aquatic life uses adopted in 1978. While not all sites sampled in 1983 attained the EWH biological criteria for both the fish and macroinvertebrate assemblages, sufficient sites did attain the EWH use, thus demonstrating the potential for attainment of that use as long as critical habitat were present.

In 1988, more stringent effluent limits for typical wastewater treatment plant (WWTP) parameters (e.g., biochemical oxygen demand [BOD], ammonia-N, common heavy metals) were established for municipal WWTPs. In 1993, as part of the Ohio EPA rotating basin approach, both water quality and biological improvements were observed, accompanied by increase in waters achieving the EWH use. These improvements resulted from water quality-based permitting at municipal WWTPs and compliance with more stringent effluent limits. However, suburban development in the surrounding communities resulted in increased WWTP flows and loads through the 1990s and the level of stress on aquatic systems increased. In 1998 biological assessment results again documented a decline in EWH attainment. The decline was associated with increased phosphorus loadings, which had not been targeted as part of the earlier water quality-based permitting. Additionally, increased diel dissolved oxygen variations and elevated phosphorus concentrations were observed. Following a determination that the observed degradation was related to loadings discharged primarily during summer low flows (i.e., from municipal WWTPs), the largest WWTPs implemented a phased reduction of phosphorus loadings through NPDES permits.

A follow-up biological assessment in 2007 documented attainment of the EWH biological criteria along most of the mainstem of the Little Miami River after point source phosphorus controls were implemented. The findings documented the effectiveness of the nutrient removal provided by the WWTPs and confirmed the original hypothesis that the biological impairments were indeed linked to phosphorus loadings discharged by the point sources. This example highlights the value of conducting before-and-after biological assessments to support NPDES permitting.

Source: Ohio EPA (Environmental Protection Agency). 2009. *Biological and Water Quality Study of the Lower Little Miami River and Selected Tributaries 2007 Including the Todd Fork Watershed*. Watershed assessment units 05090202 06, 07, 08, 09 and 14. Clermont, Clinton, Hamilton, and Warren counties. Ohio EPA technical report EAS/2009-10-06. 201 pp.

Case Example: Causal Assessments of Impairment in Iowa

The Iowa Department of Natural Resources (IDNR) identified causes of biological impairment of the Little Floyd River using EPA's SI methodology (Haake et al. 2010). Through its biological monitoring program and using Iowa's benthic macroinvertebrate index, IDNR identified the Little Floyd River as impaired, with biotic index scores well below the reference population for the area. IDNR applied the SI process to biological, chemical, and physical data collected from the river.

Candidate causes for the biological impairment were flow alteration, substrate alteration, turbidity, altered basal food source, low dissolved oxygen concentrations, high temperature, and high ammonia concentrations. Biological metrics specific to the impairment were used to identify a less impaired location in the stream to help discover the cause of more severe effects in other parts of the stream. These paired biological, physical, and chemical data from the stream were used to develop evidence of co-occurrence of exposure and effects and evidence of preceding causation; that is, the presence of sources and mechanistic pathways leading to conditions where exposure could occur. Evidence that the exposure level was sufficient to cause either the fish or the invertebrate effects was developed from two Iowa data sets with paired biological, physical, and chemical data. The interquartile range of values for the various stressors from ecoregion reference sites were compared to the values observed for the Little Floyd River. Also, the mean value at statewide random sites was compared to the values in the Little Floyd River. All the supporting or discounting evidence was weighted, and the body of evidence for each candidate cause was weighed.

The formal process revealed that sediment deposition, hypoxia, heat stress, and ammonia toxicity were probable causes of impaired biological condition in the Little Floyd River. Other causes were discounted if they were unlikely or deferred if the data were insufficient to make a determination. The assessment was used to develop a recovery plan for the stream and was a contributing impetus for developing temperature criteria as part of IDNR's WQS. Without Iowa's basic commitment to integrated monitoring and use of biological, physical, and chemical data, the analysis and the SI would not have been possible.

Source: Haake, D.M., T. Wilton, K. Krier, A.J. Stewart., and S.M. Cormier. 2010. Causal assessment of biological impairment in the Little Floyd River, Iowa, USA. *Human Ecological Risk Assessment* 16(1):116–148.

Chapter 3. Case Studies

Biological assessments, in conjunction with other data (chemical, toxicity, physical, landscape), provide water quality management programs the data and information necessary to document the effectiveness of management actions to protect and restore water quality and to clearly communicate that information to the public. Biological assessment data, WET test results, and physical and chemical monitoring are used to build the relationship between the stressors being managed and the biological impact of the stressors. By relating biological condition to the level and type of stress, results of individual program actions can be related to a common measure of actual environmental improvements—the condition of the aquatic biota (Figure 3-1). The ultimate goal is a water quality management program that integrates biological, physical, and chemical data to create a more complete picture of resource conditions that supports effective implementation of the NPDES and TMDL programs.

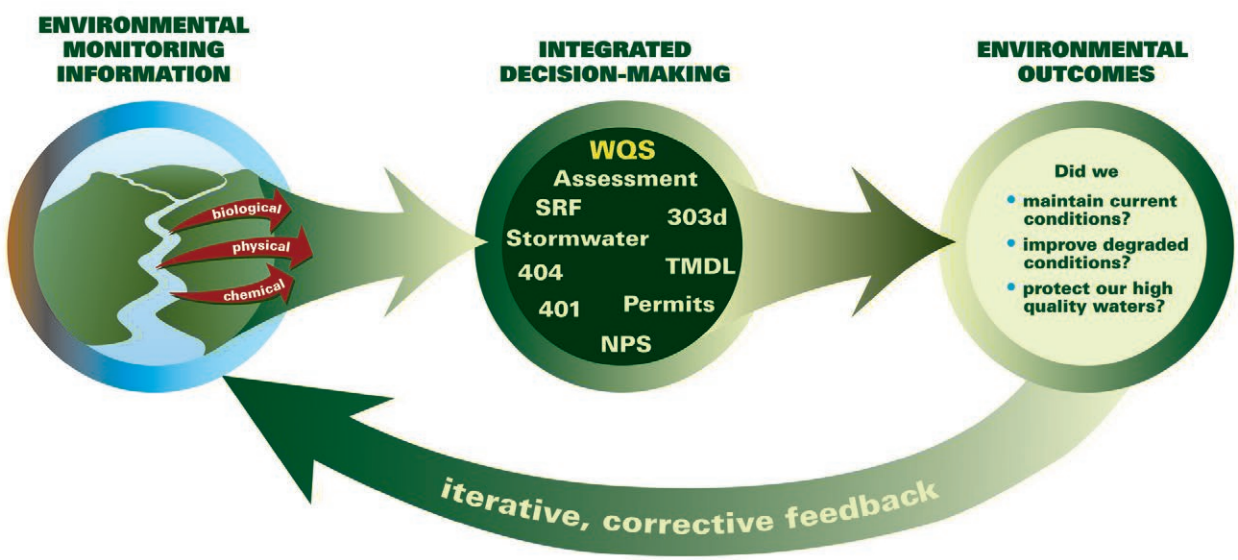


Figure 3-1. Biological data and assessments support integrated decision making.

By quantifying the stressor-response relationships, it is possible to explain to stakeholders the effects on aquatic life. For example, biological assessment data can be used to document the effects on aquatic life from an undetected toxic effluent from a point source, increasing impervious surfaces in a watershed, the loss of wetlands, or the effects of channelization. Once management actions are implemented, biological assessment data can measure the biological benefits of addressing those effects. That information helps the public understand what is being protected or what could be restored and whether state or tribal water quality standards (WQS) (i.e., aquatic life protection) are being met. Typically, with improved understanding of what is at stake, the public is more informed, motivated, and engaged in working with the state/tribal or local agencies in setting goals for protection or restoration and designing solutions that work.

Over the past four decades, state and tribal water quality programs have used technical tools and information on biological condition to support management decisions. Development of practical methods and technical approaches for biological assessment programs includes field testing by state and tribal programs. These technical advancements build upon existing approaches and can be used by states and tribes to strengthen their biological assessment and biological criteria programs. This chapter presents 17 examples of how states and tribes have incorporated such information and tools into their programs or are exploring additional biological condition applications.

The case studies are listed below.

Case Studies

3.1 Protecting Water Quality Improvements and High Quality Conditions in Maine

3.2 Arizona's Development of Biological Criteria

3.3 Protection of Antidegradation Tier II Waters in Maryland

3.4 Using Complementary Methods to Describe and Assess Biological Condition of Streams in Pennsylvania

3.5 Use of Biological Assessments to Support Use Attainability Analysis in Ohio

3.6 Screening Tool to Assess Both the Health of Oregon Streams and Stressor Impacts

3.7 North Fork Maquoketa River TMDL in Iowa

3.8 Addressing Stormwater Flow in Connecticut's Eagleville Brook TMDL for Biological Impairment

3.9 Vermont's Use of Biological Assessments to List Impaired Waters and to Support NPDES Permit Modification and Wastewater Treatment Facility Upgrades

3.10 Restoration of Red Rock Creek by the Grand Portage Band of Lake Superior Chippewa

3.11 Using Biological Assessment Data to Show Impact of NPS Controls in Michigan

3.12 Using Biological Assessment as Evidence of Damage and Recovery Following a Pesticide Spill in Maryland and the District of Columbia

3.13 Support for Dredge and Fill Permitting in Ohio

3.14 Virginia INSTAR Model for Watershed Protection

3.15 Examination of Climate Change Trends in Utah

3.16 Applications of Biological Assessment at Multiple Scales in Coral Reef, Estuarine, and Coastal Programs

3.17 Partnerships in the Protection of Oregon's Coho Salmon

3.1 Protecting Water Quality Improvements and High Quality Conditions in Maine

Abstract

Maine has used biological, habitat, and other ecological information to designate aquatic life uses that reflect the highest achievable conditions of its waterbodies and has used antidegradation policy to maintain and protect high existing conditions. Maine uses a Biological Condition Gradient to designate levels of protection for its waterbodies (e.g., designated aquatic life uses) and to assign numeric biological criteria to protect those uses. Maine describes the system as a tiered use classification. For Maine, tiered aquatic life uses highlight the relationship between biology, water quality, and watershed condition in determining the need for waterbody protection to maintain existing high quality conditions or the potential for water quality improvement to attain water quality standards. Maine's integrated, data-driven approach has resulted in documented improvement in water quality throughout the state, including upgrades of designated uses of more than 1,300 stream miles, from Class C to Class B, and from Class B to Class A or AA waters (Outstanding National Resource Waters).

In 1983 the Maine Department of Environmental Protection (ME DEP) initiated a statewide biological monitoring and assessment program and revised water quality standards (WQS) by 1986 to recognize high levels of water quality condition. Maine established four classes for freshwater rivers and streams (see Table 3-1). All four classes meet or exceed the Clean Water Act (CWA) section 101(a)(2) goal for aquatic life protection. Every waterbody is assigned to one of four tiers by considering its existing biological condition, its highest achievable condition on the basis of biological potential, aquatic habitat, watershed condition, levels of dissolved oxygen, and numbers of bacteria (Table 3-1). Agency biologists developed a linear discriminant model to measure the biological attainment of each class, establish numeric biological criteria, and assign corresponding antidegradation tiers for purposes of statewide planning (see Table 3-1, column 6). Part of Maine's antidegradation policy requires that where any actual measured water quality criterion exceeds that of a higher class, that quality must be maintained and protected [Maine Revised Statutes Title 38, §464.4(F)]. In effect, by having multiple levels of aquatic life use standards in law, Maine has established a means of improving water quality in incremental steps, and of using antidegradation reviews and reclassification upgrades to maintain and protect water quality and aquatic life conditions that exceed existing or designated aquatic life uses.

The following case study offers an example of how Maine has used tiered use classifications and antidegradation policy cooperatively in its water quality management program. In conjunction with habitat and other chemical and physical parameters, Maine assigns waters to designated use classes (AA, A, B, or C; Table 3-1) on the basis of the *potential* for water quality improvement. In the 1980s, monitoring on the Piscataquis River near the towns of Guilford and Sangerville found aquatic life conditions insufficient to meet even the minimum Class C conditions at which the river was classified. The segment of the river in the Guilford-Sangerville area had a history of poor water quality, including recurrent fish kills from poorly treated industrial and municipal wastes. However, the state determined that this segment of the river could attain at least Class C. The state determined that sewage treatment plant and industrial discharges were the only significant source of stressors to the river, with very good quality upstream conditions and good salmonid production elsewhere. Additionally, the river's habitat structure and hydrologic regime were very good.

Table 3-1. Criteria for Maine river and stream classifications and relationship to antidegradation policy.

Class	Dissolved oxygen criteria	Bacteria criteria	Habitat narrative criteria	Aquatic life narrative criteria*** and management limitations/restrictions	Corresponding federal antidegradation policy tiers
AA	As naturally occurs	As naturally occurs	Free-flowing and natural	As naturally occurs**; no direct discharge of pollutants; no dams or other flow obstructions.	3 (Outstanding National Resource Water [ONRW])
A	7 ppm; 75% saturation	As naturally occurs	Natural**	Discharges permitted only if the discharged effluent is of equal to or better quality than the existing quality of the receiving water; before issuing a discharge permit the Department shall require the applicant to objectively demonstrate to the department's satisfaction that the discharge is necessary and that there are no reasonable alternatives available. Discharges into waters of this class licensed before 1/1/1986 are allowed to continue only until practical alternatives exist.	2 1/2
B	7 ppm; 75% saturation	64/100 mg (g.m.) or 236/100 ml (inst.)*	Unimpaired**	Discharges shall not cause adverse impact to aquatic life** in that the receiving waters shall be of sufficient quality to support all aquatic species indigenous** to the receiving water without detrimental changes to the resident biological community.**	2 to 2 1/2
C	5 ppm; 60% saturation; and 6.5 ppm (monthly avg.) when temperature is </= 24 °C	125/100 mg (g.m.) or 236/100 (inst.)*	Habitat for fish and other aquatic life	Discharges may cause some changes to aquatic life**, provided that the receiving waters shall be of sufficient quality to support all species of fish indigenous** to the receiving waters and maintain the structure** and function** of the resident biological community. **	1 to 2

Source: Maine DEP (modified). http://www.maine.gov/dep/blwq/docmonitoring/classification/reclass/appa.htm.
Notes:
* g.m. = geometric mean; inst. = instantaneous level.
** Terms are defined by statute (Maine Revised Statutes Title 38, §466).
*** Numeric biological criteria in Maine regulation Chapter 579, Classification Attainment Evaluation Using Biological Criteria for Rivers and Streams.

Four years after issuance of new National Pollutant Discharge Elimination System (NPDES) permits requiring better industrial pretreatment and improved wastewater treatment at the Guilford-Sangerville treatment facility, follow-up monitoring found water quality improvements that exceeded Class C and attained Class B aquatic life conditions. The achievement of higher water quality conditions was preserved through a classification upgrade process (supported by the industry and the two towns). The river was upgraded to Class B and now attains those higher aquatic life use goals. The redesignation process requires the state legislature to enact a statutory change of a waterbody's classification and can take considerable time to complete. However, during the reclassification process the improved water quality conditions existing in the Piscataquis River were protected through implementation of the state's Tier II antidegradation policy. The value secured by maintaining the higher quality condition was demonstrated in 2009 when the Piscataquis River was designated as critical habitat for the restoration of the endangered Atlantic salmon.

The management actions based on documented improvements in the biological condition in this example demonstrate the complementary application of the state's tiered aquatic life use classification and the Tier 2 and 2½ antidegradation policy. Using that approach, water quality upgrades from Class C to B and from B to A or AA have been repeated in many parts of the state, and subsequently maintained and protected. Overall, Maine has redesignated more than 1,300 miles of streams to a higher class on the basis of biological information (e.g., biological improvements due to point source controls, nonpoint source practices, dam operational modifications or removal) and societal values (e.g., water quality and habitat protection for wild trout populations; critical species protection, especially Atlantic salmon habitat and tribal petitions).

3.2 Arizona's Development of Biological Criteria

Abstract

Arizona has adopted in its water quality standards both narrative and numeric biological criteria to help protect aquatic life uses in wadeable, perennial streams designated for either coldwater aquatic and wildlife or warmwater aquatic and wildlife. The biological criteria allow the state to define expected conditions relative to reference streams. The state implements a two-step verification process to confirm attainment of the biological criteria for waters that score just below the attainment threshold. Arizona Department of Environmental Quality uses the biological assessment results in its 305(b) reports on the condition of its aquatic resources.

Development of Numeric Biological Criteria

Arizona began a biological assessment program in 1992, following EPA's Rapid Biological Assessment Protocols for wadeable streams and rivers (Plafkin et al. 1989). Standard operating procedures for macroinvertebrate monitoring in perennial, wadeable streams and for laboratory processing and taxonomic identification were established and have been periodically reviewed and updated (ADEQ 2010). A statewide reference monitoring network was established to develop an index of biological integrity (IBI) as the macroinvertebrate assessment method.

A classification analysis was first performed on the statewide macroinvertebrate data set to identify regions of statistically different macroinvertebrate communities across the state (Spindler 2001). Elevation-based regions were the result of the classification analysis, consisting of two broad macroinvertebrate regions and community types:

- A warmwater community below 5,000 feet elevation
- A coldwater community above 5,000 feet elevation

All wadeable, non-effluent-dependent perennial streams in the regions, with some documented exceptions, are predicted to have the same general macroinvertebrate community type. IBIs were then developed for both a warmwater and coldwater community using the statewide reference site data (ADEQ 2007).

In the initial stages of development, Arizona's numeric biological criteria were based on the idea that the structure and function of aquatic benthic macroinvertebrate communities provide information on the overall quality of their surface waters and on attainment of the state's designated aquatic life uses. Measuring the composition and structure of the biological communities in minimally disturbed surface waters provides reasonable approximation of biological integrity and, thus, the basis for establishing the reference condition (Stoddard et al. 2006). The reference condition provides the benchmark for evaluating the biological condition of surface waters that could have been subjected to relatively greater amounts of disturbance.

However, on the basis of the state's scrutiny of the reference site database and further investigation of surrounding land use, the state concluded that its reference sites represent *best available*, or *least disturbed*, conditions for each watershed. There was uncertainty as to whether some of the reference sites at the lower range of the reference distribution were truly minimally disturbed conditions. For example, while reference sites were in a wilderness area for streams considered to be in pristine condition, much of the watershed upstream was extensively grazed, and the index scores for the reference sites were lower than the mean. In addition, there was variability because of sites later found to be intermittent in flow, and samples were affected by extreme flooding in the reference data set. Because of that uncertainty in reference quality in the low end of the reference database, Arizona selected the 25th percentile of the reference site distribution to be protective of the aquatic life use.

Minimally Disturbed Condition: The physical, chemical, and biological conditions of a waterbody with very limited human disturbance compared with natural, undisturbed conditions. There might be some changes to the composition of the resident aquatic biota, but native species are present.

Least Disturbed Condition: The best existing physical, chemical, and biological condition of a waterbody affected by human disturbance. These waters have the least amount of human disturbance in comparison to others within the waterbody class, region, or basin. Least disturbed condition is a relative term, and the actual condition may depart significantly from natural, undisturbed conditions or minimally disturbed conditions. Least disturbed condition might change significantly over time as human disturbances change.

Arizona established a two-stage process for determining nonattainment of the numeric biological criteria. On the basis of statistical analysis of reference, stressed, and test data sets, an attainment threshold of 25 percent was selected. The nonattainment biological criteria threshold was set at the 10th percentile of reference, the level at which a majority of stressed samples occurs in the Arizona Department of Environmental Quality (ADEQ) database. An inconclusive zone falls between the 10th and 25th percentiles of reference. The zone of uncertainty encompasses variability in IBI scores near the 25th percentile. To verify the biological integrity of the *inconclusive* samples, verification sampling is required before making an attainment decision. Verification monitoring must be conducted during the next immediate spring or fall index period. (A fall-based IBI scoring system is being developed.) If the waterbody in question scores at or less than the 25th percentile of reference, it will then be judged as not attaining. Such a verification approach provides an opportunity to confirm the status of waters that score just below the attainment threshold of the biological criteria.

Adoption of Numeric Biological Criteria

On January 31, 2009, Arizona adopted biological criteria, as part of the revised Arizona surface water quality standards (WQS), applicable to wadeable, perennial streams with either a coldwater or warmwater designated aquatic life use. The biological criteria consist of two parts: a narrative statement (Arizona R18-11-108) and numeric criteria (ARS R18-11-108.01). The narrative is presented as follows:

> A wadeable, perennial stream shall support and maintain a community of organisms having a taxa richness, species composition, tolerance, and functional organization comparable to that of a stream with reference conditions in Arizona.

The numeric criteria are laid out in text and numeric form (Table 3-2) in the state's biological criteria rule in the WQS as follows:

> The biological standard in R18-11-108(E) is met when a biological assessment result, as measured by the Arizona IBI [index of biological integrity], for cold or warm water is: 1) Greater than or equal to the 25th percentile of reference condition, or 2) Greater than the 10th percentile of reference

condition and less than the 25th percentile of reference condition and a verification biological assessment result is greater than or equal to the 25th percentile of reference condition.

Table 3-2. Arizona numeric biological criteria IBI scores

Biological assessment result	IBI scores	
	coldwater	**warmwater**
Greater than or equal to the 25th percentile of reference condition	$\geq$ 52	$\geq$ 50
Greater than the 10th and less than the 25th percentile of reference condition	46–51	40–49

Source: Arizona R18-11-108.01

ADEQ uses the biological assessment results in its 305(b) reports on the condition of its aquatic resources. More information about the biological criteria, sampling methods, establishing reference condition, and the method for determining nonattainment of the biological criteria is provided in *Biocriteria Implementation Procedures* (ADEQ 2008) and in *Technical Support Documentation for the Narrative Biocriteria Standard* (ADEQ 2007).

3.3 Protection of Antidegradation Tier II Waters in Maryland

Abstract

Maryland is identifying high-quality waters for antidegradation purposes on a waterbody-by-waterbody basis. Maryland has designated Tier II waters on the basis of two indices of biotic integrity—fish and benthic invertebrates—and provides additional protection so that those waters are not degraded. New or increased point source dischargers and local sewer planning activities that have the potential to affect Tier II waters are required to examine alternatives to eliminate or reduce discharges or impacts. The state has developed requirements that must be met for projects that do not implement a no-discharge alternative. To help local planners to determine whether a planned activity has the potential to affect a Tier II water, the state has developed geographic information system shapefiles that identify such waters. Those files are provided to local jurisdictions to improve their knowledge of where Tier II waters occur. Biological assessments, in conjunction with chemical and physical assessments, are then conducted to determine the status of those waters and detect trends in condition.

In its state water quality standards (WQS), Maryland adopted an antidegradation policy for protecting all waters for existing and designated uses. High-quality (Tier II) waters receive additional attention and regulatory protections. Identification of Tier II waters, in this case streams, is based on a waterbody-by-waterbody approach using biological survey data, from which two indices of biotic integrity (IBIs) are developed—one for benthic invertebrates and one for fish. Those with both scores above 4 are designated Tier II waters. The state has identified more than 230 high-quality water segments. To protect downstream high-quality waters, a watershed approach to protection is applied. Tier II waters must be protected so that water quality does not degrade to minimum standards, and that requirement has implications for potential discharges and local planning activities.

Application of Tier II Protection

The Maryland Department of the Environment (MDE) requires that applicants for amendments to county plans (i.e., water and sewer plans) or permits for new or expanding point source discharges evaluate alternatives to eliminate or reduce discharges or impacts [COMAR 26.08.02.04-1(B)]. Applicants for permits must consider whether the receiving waterbody is Tier II (or whether a Tier II determination is pending); MDE reviews proposed amendments to county plans discharging to Tier II waters. In both cases, discharges to Tier II waters require a Tier II review [2.26.08.02.04-1(F)].

MDE has developed a cooperative approach to protecting Tier II waters. Monitoring and WQS programs work with the National Pollutant Discharge Elimination System (NPDES) permitting program to help screen for potential effects from new or expanded discharges and to develop permit conditions to minimize those effects and maintain existing high-quality waters. Outreach materials are available to educate county planners about Tier II waters, and geographic information system (GIS) shapefiles that planners can use to help locate Tier II waters within their jurisdictions have been developed.[15] That information provides Maryland county planners a way to determine early on whether their projects could affect Tier II waters.

[15] More information about GIS is at http://www.gis.com/content/what-gis.

A list of recommendations for land-disturbing projects that are not able to implement a no-discharge alternative provides the following initial guidance:

1. Implementation of environmental site design (also known as low-impact development)—Design elements and practices must be approved for Tier II waters with opportunity provided for exploration of appropriate alternatives and justification for structural elements in the proposed designs.
2. Expanded riparian buffers—Buffers must be at a minimum of 100 feet; wider buffers may be required depending on slope and soil type.
3. Biological, chemical, and flow monitoring in the Tier II watershed—Applicants may be required to conduct biological assessments in conjunction with chemical, physical, and flow assessments to help determine the remaining assimilative capacity and cumulative impacts of current and future development. Depending on project specifics, additional monitoring may be required, such as the completion of a hydrogeologic study for a major mining project or additional pH monitoring because of impacts associated with instream grout applications seen in many common transportation projects.
4. Additional practices—Depending on the potential for project-specific effects on water quality, applicants may be required to implement other practices, such as enhanced sediment and erosion control practices or implementation of more environmentally protective alternatives.

If those general requirements cannot be implemented, applicants must submit a detailed hydrologic study and alternatives analysis to demonstrate that the assimilative capacity of a waterbody will be maintained. The assimilative capacity of a waterbody is typically site-specific and determined through studies of the waterbody. In terms of WQS, assimilative capacity is a measure of the capacity of a receiving water to assimilate additional pollutant(s) but still meet the applicable water quality criteria and designated uses.

3.4 Using Complementary Methods to Describe and Assess Biological Condition of Streams in Pennsylvania

Abstract

The Pennsylvania Department of Environmental Protection (PA DEP) has developed a new benthic macroinvertebrate index of biotic integrity (IBI) to assess the health of wadeable, freestone (e.g., high gradient, soft water) streams. Additionally, PA DEP calibrated a benthic macroinvertebrate Biological Condition Gradient (BCG) and is exploring using the BCG to more precisely describe biological characteristics in Pennsylvania streams. Potentially, the BCG can be used in conjunction with the IBI to identify aquatic life impairments and to describe the biological characteristics of waters assigned special protection. PA DEP is also exploring using a discriminant analysis model with additional taxonomic, habitat, and landscape parameters to describe exceptional value waters.

Describing Waters along a Gradient of Condition

Pennsylvania Department of Environmental Protection (PA DEP) has developed a new benthic macroinvertebrate index of biotic integrity (IBI) for the wadeable, freestone (high-gradient, soft-water) streams in Pennsylvania using the reference condition approach (PA DEP 2009). PA DEP has alternative assessment methods in place for other stream types (i.e., low-gradient pool-gliders, karst [limestone]-dominated). The IBI provides an integrated measure of the overall condition of a benthic macroinvertebrate community by combining multiple metrics into a single index value. PA DEP uses the IBI to assess attainment of aquatic life uses.

A **metric** is a measurable aspect of a biological community that responds in a consistent, predictable manner to increasing anthropogenic stress. Examples of metrics include **taxa richness**, which is a measure of the number of different kinds of organisms (taxa) in a sample collection, and **% dominance**, which is a measure of which species compose the majority of organisms present in a sample collection.

To gain a more comprehensive view of an aquatic community, multiple types of metrics are combined into a **biological, or biotic, index**. The typical biological index may include information from 7 to 12 different metrics. The metric values are typically scored on a unitless scale of 0 to 100 and averaged to obtain a single value.

Additionally, PA DEP is exploring use of a Biological Condition Gradient (BCG) to describe the biological characteristics of freestone streams along a gradient of condition. PA DEP conducted a series of three expert workshops in 2006, 2007, and 2008 to calibrate a BCG along a gradient from minimally to heavily stressed conditions (PA DEP 2009). The BCG is a narrative model based on measurable attributes, or characteristics, of aquatic biological communities expected in natural conditions (e.g., presence of native taxa, some pollution tolerant taxa present but typically not dominant, absence of invasive species). Additionally, the BCG model includes attributes that describe interactions among biotic communities (e.g., food web dynamics), the spatial and temporal extent of stress, and the presence of naturally occurring habitats and landscape condition (for more information, see Tool # 2, *The Biological Condition Gradient*). To date, states and tribes that have applied the BCG have used the BCG attributes that describe the taxonomic composition of the resident aquatic biota and, where available, information on fish condition, for example lesions and abnormalities (BCG attributes I–VII) (see Table 2-2). Some states are exploring the application of additional attributes on food web dynamics, extent of stress, and landscape condition (BCG attributes VIII–X). These efforts are providing valuable information that will aid the U.S. Environmental Protection Agency (EPA) in further refining the BCG.

To develop the BCG for its streams, biologists from PA DEP, in conjunction with external taxonomic experts and scientists, e.g., the Delaware River Basin Commission, Western Pennsylvania Conservancy, and EPA, used the BCG attributes that characterize specific changes in community taxonomic composition (PA DEP 2009). For example, in the highest tiers of the BCG, locally endemic, native, and sensitive taxa are well represented (attributes I and II) and the relative abundances of pollution-tolerant organisms (attribute V) are typically lower. With increasing stress, more pollution-tolerant species may be found with concurrent loss of pollution-sensitive species (attribute VI). At the beginning of the expert workshops, the biologists first assigned or adjusted BCG attributes to each macroinvertebrate taxon (e.g., pollutant-sensitive or tolerant) and then reviewed taxa lists from samples representing minimally disturbed to severely disturbed site conditions (Figure 3-2). The evaluated samples included sites judged as either reference quality (e.g., at or close to minimally disturbed conditions) or heavily stressed based on specific selection criteria (PA DEP 2009). To further test the robustness of the BCG process, additional sites that were not part of the reference or heavily stressed sample groups were evaluated. Those sites represented a range of site conditions, including moderately to heavily stressed site conditions (non-reference and moderately stressed; see Figure 3-2). Using the BCG tier descriptions of predicted changes in the attributes as a guide, they assigned each site to one of the six BCG tiers.

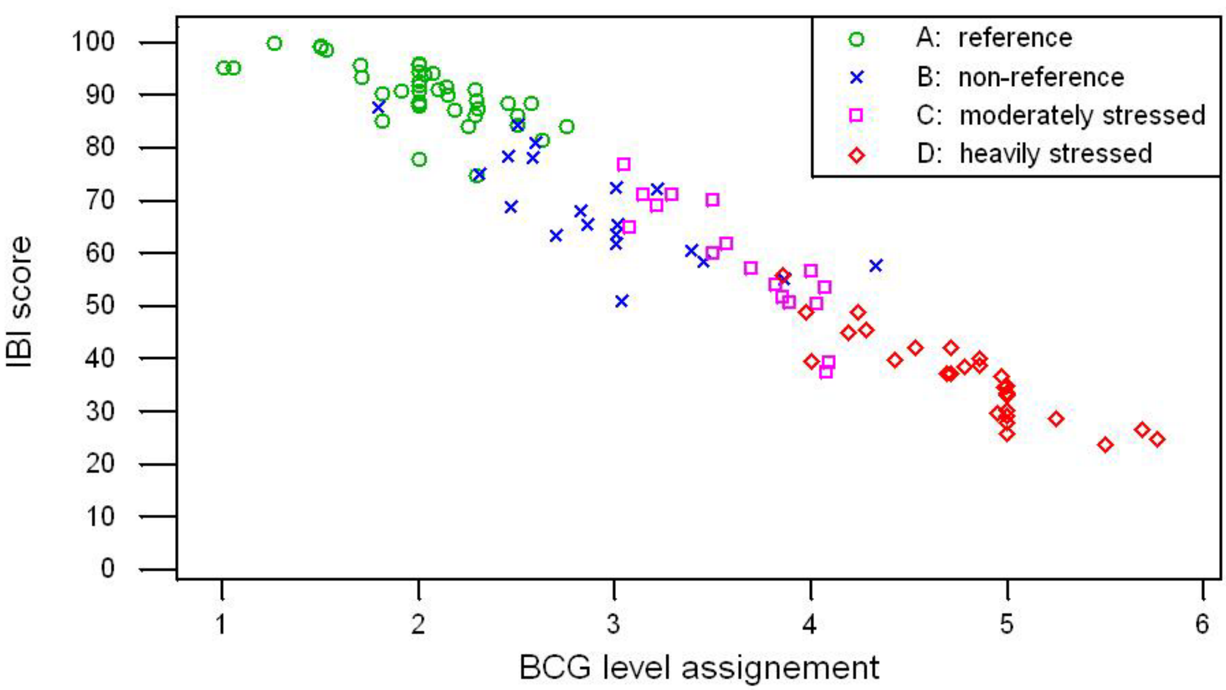


Figure 3-2. Comparison of calibrated BCG tier assignments (mean value) and IBI scores for freestone streams representing range of conditions from minimal to severely stressed.

For all the evaluated samples, PA DEP biologists analyzed the relationship between a sample's BCG tier assignment with its corresponding IBI score (PA DEP 2009). A strong correlation existed between the calibrated BCG tier assignments and the IBI scores (Figure 3-2). Based on these results, PA DEP is evaluating using the BCG to describe the biological characteristics of streams along a gradient of condition; for example, the reference sites clustered at IBI scores near 80 and above. Based on taxonomic information and without knowledge of the IBI scores, the experts assigned these sites to BCG tiers 1.5 to 2.5. BCG tier 2 represents close to natural conditions (e.g., minimal changes in structure and function relative to natural, or pristine, conditions; supports reproducing populations of native species of fish and benthic macroinvertebrates). This information can meaningfully convey to the public the biological characteristics of waters in the context of the Clean Water Act and the goal to protect aquatic life. Using both the IBI and BCG, PA DEP might be able to develop a cost-effective, publicly transparent approach to routinely monitor and assess the condition of its freestone streams and to help identify potential high-quality (HQ) or exceptional value (EV) streams.

Describing Exceptional Value Waters

Pennsylvania's regulations define waters of EV that are of unique ecological or geological significance. EV streams are given the highest level of protection and constitute a valuable subset of Pennsylvania's aquatic resources. To support protection of these waters, PA DEP is considering the use of a discriminant analysis model to evaluate the relationship between condition of the watershed, a stream, and its aquatic biota (e.g., the connection of riparian areas with a stream and the floodplain or the spatial extent of stressors and their sources in the watershed). PA DEP is evaluating the use of a discriminant model that incorporates measures of land use and physical habitat along with IBI scores and indicator taxa richness to make distinctions between EV and HQ waters. The abiotic measures PA DEP is using address habitat fragmentation and spatial and temporal extent of stress and are comparable to the national BCG model attributes IX (extent of stress) and X (ecosystem connectance). The results of this effort could potentially support decisions on where to target resources for sustainable, cost-effective protection of EV waters and healthy watersheds. Through this work, PA DEP is providing EPA valuable feedback on the technical development and potential program application for BCG attributes IX and X.

Potential Application to Support Protection of Waters of Highest Quality

PA DEP is exploring new approaches to help identify streams that are of the highest quality and might require special protection. For example, a stream might be found to meet the expected biological condition of an HQ or EV water based on its IBI score and BCG tier assignment. This information could be used to support further study to determine whether its designation should be as an HQ water or if it meets the additional criteria for designation as an EV water. When biological information is presented in context of a BCG framework, it is easier for the public to understand the status of the aquatic resources, including waters that are in excellent condition and require additional protection.

3.5 Use of Biological Assessments to Support Use Attainability Analysis in Ohio

Abstract

Ohio uses biological assessment information in conjunction with physical habitat assessments to strengthen use attainability analyses (UAAs) in the state. The technical and programmatic underpinnings for Ohio's use attainability determinations is the state's aquatic life use classification approach, which is based on the relationship between biology, habitat, and the potential for water quality improvement. Ohio's biological monitoring and assessment program provides timely, statewide information on the status of waterbodies and the data to support a UAA if needed, including when biological conditions improve and an upgrade of a designated use is warranted. Typically, in situations where the habitat needed to meet aquatic life uses is present, Ohio has taken management actions to address water quality issues and restore impairments.

In 1990 Ohio used biological assessment information to specify levels of biological condition for specific streams and rivers based on ecoregional reference sites. As a result, the state refined definitions of some aquatic life uses, adopted new ones, and assigned biological criteria to key uses to support a tiered approach to water quality management within the Ohio water quality standards (Table 3-3).

Table 3-3. Summary of Ohio's beneficial use designations for the protection of aquatic life in streams.

Beneficial use designation	Key attributes
Coldwater habitat (CWH)	Native cold water or cool water species; put and take trout stocking.
Exceptional warmwater habitat (EWH)	Unique, unusual, and highly diverse assemblage of fish and invertebrates.
Seasonal salmonid habitat (SSH)	Supports lake run steelhead trout fisheries.
Warmwater habitat (WWH)	Typical assemblages of fish and invertebrates, similar to least impacted reference conditions.
Limited warmwater habitat (LWH)	Temporary designations based on 1978 WQS. Predate Ohio tiered aquatic life use classification and were not subjected to UAA; being phased out as UAA are conducted for each LWH waterbody or segment. Most of the LWH waterbodies or segments have been redesignated as WWH or higher with the exception of some mine-drainage-affected segments that were designated LRW.
Modified warmwater habitat (MWH)	More tolerant assemblages of fish and macroinvertebrates are present relative to a WWH assemblage, but otherwise generally similar species to WWH present; irretrievable modifications of habitat preclude complete recovery to least impacted reference condition.
Limited resource water (LRW)	Fish and macroinvertebrates severely limited by physical habitat or other irretrievable condition; minimum protection afforded by the CWA.

Source: Ohio EPA, April 2004. http://www.epa.ohio.gov/portals/35/wqs/designation_summary.pdf.

When designating aquatic life uses, the quality of habitat is a major factor in a use attainability analysis (UAA) process to determine the potential for restoration and expected biological condition for streams and rivers in Ohio. If sufficient good habitat attributes are not present, such as higher quality substrates and sufficient instream cover, a determination about restorability is made. If habitat is sufficient or could be restored, it is assumed that any observed biological impairments are due to the effects of other stressors (e.g., metals, nutrients) that could be remediated through readily available water quality management options (e.g., permit conditions and/or best management practices [BMPs]) and the biological assemblage restored. The aquatic life use classifications are based on ecological conditions, and in 1990 biological criteria were developed to protect each use. Ohio's biological criteria include two indices based on stream fish assemblages (Index of Biological Integrity [IBI] and Modified Index of Well-Being [MIwb]) and one index based on stream macroinvertebrate assemblages (Invertebrate Community Index [ICI]). The biological criteria were developed based on regional reference conditions and are stratified by each of the state's five level 3 ecoregions and three site types (headwater, wadeable, and boatable sites).

Using these aquatic life use classifications, Ohio has been able to determine attainable levels of condition for streams and rivers. For example, in the mid-1980s biological surveys of Hurford Run, a small stream located in an urban/industrial area of Canton, Ohio, showed that the stream was severely impaired by toxic chemical pollutants and that some sites had no fish at all. Hurford Run is channelized for nearly its entire length. Because of the severity of the biological impairment, a UAA was conducted to determine if the warmwater habitat (WWH) aquatic life use was attainable and, if not, to determine the most appropriate designated use for the stream. Based on biological and habitat assessments, the most appropriate aquatic life uses for the different segments of Hurford Run could be determined. For example, very poor habitat quality from historical channelization in the *upper reach of Hurford Run* and the associated hydrological modifications (e.g., ephemeral flows) resulted in a limited warmwater habitat (LWH) designation for this upper reach.

The *middle reach of Hurford Run* has been subject to extensive, maintained channel modifications that also resulted in degraded habitat features, though water is always present. Channel maintenance practices resulting in poor-quality substrates, poorly developed pools and riffles, and a lack of instream cover preclude biological recovery to assemblages consistent with the WWH use, which indicated that the middle reach should be designated a modified warmwater habitat (MWH), reflecting the attainable biological potential for a channel-modified stream determined by scientific studies. The *lower reach of Hurford Run* was previously relocated and channelized, but over time the reach has naturally recovered sufficient good-quality habitat attributes, such as coarse substrates and better developed riffle and pool features associated with the WWH use for this ecoregion. Biological assessments confirmed the presence of aquatic assemblages typical of WWH. Based on this information, this segment was designated as WWH. The designated aquatic life uses reflect the current best possible condition in each segment of Hurford Run and provide a basis for management actions to ensure that the associated criteria are met and the use is protected. Numeric biological criteria have been established for key designated aquatic life uses, and a segment is listed on the 303(d) list if it is in nonattainment of the biological criteria. Additionally, the different segments are routinely monitored by the state and the condition reevaluated on a regular basis. If there is any information indicating that a higher use is being attained or could be attained, that water is considered for redesignation to the higher use.

Ohio has also used biological assessment data to refine its water quality criteria in some cases. For instance, when Ohio's aquatic life use classifications were established in 1978, Ohio established dissolved oxygen criteria to protect each designated use. Initially, a dissolved oxygen criterion of 6 mg/L as a minimum was established for exceptional warmwater habitat (EWH) waters to protect highly sensitive species supported by this use. However, analyses of ambient biological and chemical data suggested that the 6 mg/L minimum criterion was over-protective for EWH waters. Data showed a relationship between stressors and biological measures, with dissolved oxygen concentrations less than 5.0 mg/L being associated with IBI scores not in attainment of EWH biological criteria. And, in general, data showed that with dissolved oxygen greater than 5.0 mg/L, IBI scores are much more likely to attain EWH. These results were used to justify refining the EWH criteria to the current 6 mg/L average, 5 mg/L minimum (Ohio EPA 1996). The criterion revision also supported the redesignation of some rivers and streams from WWH to EWH.

3.6 Screening Tool to Assess Both the Health of Oregon Streams and Stressor Impacts

Abstract

The Oregon Department of Environmental Quality conducted a study in the John Day River Basin to both evaluate the biological health of streams using biological sampling for macroinvertebrates and to identify the causes of stream impairment using biological monitoring information. The state used the PREDATOR model to evaluate waterbody conditions in perennial streams. Stressor identification models were used to measure the effects of stress from two sources of nonpoint source pollution (excessive temperature and fine sediment). A comparison of modeling results to sampling data showed that both modeling and direct measurements are useful in identifying streams not meeting benchmarks and identifying cause of impairment. Oregon will continue to use the model results to evaluate the ability to identify causes of biological impairment on the basis of macroinvertebrate data and will use that information to improve water quality.

The John Day River Basin in northeastern Oregon is one of the state's most important scenic waterways. It drains nearly 8,100 square miles of land and is one of the nation's longest free-flowing river systems (BLM 2010). Oregon Department of Environmental Quality (ODEQ) evaluated the biological health of streams in the John Day River Basin using biological sampling for macroinvertebrates. The study also identified the causes of stream impairment with the aid of biological monitoring information. The focus of the studies conducted by ODEQ was to model the biological condition and explore the relative importance of the two most common nonpoint source (NPS) stressors—elevated temperature and excess fine sediments—using macroinvertebrate data.

Biological Condition Model (PREDATOR)

ODEQ sampled benthic macroinvertebrates in 76 perennial, wadeable streams in the John Day River Basin. The biological condition of the streams was modeled using ODEQ's PREDictive Assessment Tool for ORegon (PREDATOR) (Hubler 2008). The model predicts the kinds of macroinvertebrates expected to occur at reference sites with similar environmental conditions (precipitation, air temperature, elevation, and ecoregion). For example, high-elevation sites that experience higher precipitation levels and cooler air temperatures in eastern Oregon would be expected to support macroinvertebrates similar to those found at reference sites that are both geographically and environmentally similar.

The PREDATOR model uses 176 reference sites across five Level III ecoregions in Oregon (Omernik 1987). The model output is the ratio of the macroinvertebrates observed at a test site (O) to the expected macroinvertebrates (E), or O/E. Values less than 1.0 represent a loss of reference macroinvertebrates at the test site relative to natural conditions. ODEQ classifies sites into one of three biological condition classes: *least disturbed*, *moderately disturbed*, and *most disturbed*. Oregon's least disturbed class supports native populations of aquatic macroinvertebrates and natural habitat.

The results of the study indicated that almost half of the sites were in least disturbed conditions, or equivalent to reference (O/E values close to 1.0). Just over one-quarter (28 percent) were in most disturbed conditions with O/E values down to 0.47, indicating loss of over half of the expected, or native, species.

NPS Pollutant Stressor Models

To use macroinvertebrates to measure the effects of stress from NPS pollution (temperature and fine sediments), ODEQ used two *stressor identification (*SI) models (Huff et al. 2006). Temperature stress (TS) and fine sediment stress (FSS) are two new biological indices used to infer seasonal maximum temperature and percent fine sediments based entirely on the macroinvertebrates collected at a site.

Those indices consistently and predictively respond to increased levels of temperature or fine sediments and are used to model macroinvertebrate-specific changes to the stressors (e.g., stressor-response signatures).

Comparisons of Stressor Model Output to Field Measurements

Water quality and physical habitat information was also collected as part of the John Day River Basin study. Direct comparisons of the SI models (assemblage response signatures) to their equivalent physical measurements (water column temperature and fine sediment load) show similar abilities in determining the extent of streams failing to meet benchmarks. However, the SI models showed a stronger relationship to biological condition than did the physical measurements of temperature and fine sediments. Most of the test sites in good condition according to the PREDATOR model coincided with the SI model outcomes also in good condition. The test sites in good biological condition supported specific macroinvertebrates with temperature and fine sediment preferences similar to reference assemblages. Conversely, the majority of sites in poor biological condition (most disturbed) had TS and FSS values above the reference benchmark for the SI model. To further identify the relative importance of temperature and fine sediments to biological condition, ODEQ routinely performs more quantitative analyses. Regression models of the relationship between PREDATOR and SI models can be used to identify the strength and significance of relationships. Additionally, relative risk analysis is used to quantitatively rank the importance of stressors to biological condition.

Conclusions

ODEQ developed two SI models that can be used to identify the relative importance of two common NPS stressors— elevated temperatures and fine sediments—to biological condition. ODEQ’s primary objective with the analysis was to explore the ability of macroinvertebrate data to identify causes of biological impairment.

The results from the study show that about one-half of the perennial, wadeable streams in the John Day River Basin are in good condition, one-quarter are in fair condition, and one-quarter are in poor condition. SI models were used to identify primary causes of biological impairment from NPS pollution. Although biological measures and physical measures were comparable in their ability to detect the extent of sites with NPS stressors above levels typically observed at reference sites, the biological measures showed a stronger relationship to biological condition.

The models for biological condition and SI show promise as sensitive and cost-effective screening tools for detecting NPS impairment to streams and targeting best management practices (BMPs) to address the primary stressors, elevated temperature and excessive fine sediment loads. The SI models also provide benchmarks to measure the response of the biological community to BMP implementation. Combining the information from the models can help scientists better understand the risks associated with NPS pollution in Oregon streams and more efficiently target resources to improve water quality.

Complementary Application of Biological Condition and Stressor Identification Models: An Example

Biological Condition: North Fork Deer Creek had a list of 14 expected macroinvertebrate taxa that were frequently observed at reference sites with similar geographical and environmental characteristics. However, only nine of the expected taxa were observed at the sampling site, resulting in a rating of most disturbed condition (O/E = 9/14 = 0.64).

Stressor Identification: The SI models were used to infer temperature and fine sediment conditions using the tolerances and abundances of all macroinvertebrates collected at North Fork Deer Creek. The dominant macroinvertebrates in the creek showed high tolerances to fine sediments, while the same taxa showed preferences for cooler water over warmer water. For example, five taxa were indicators (taxa that exhibit strong preferences) of higher fines at a site, compared to one indicator taxa for low fines. Additionally, five taxa were indicators of cool water conditions in North Fork Deer Creek, compared to one indicator taxa of warmwater conditions.

The tolerances of the most abundant macroinvertebrates observed in North Fork Deer Creek indicate that excess fine sediments are the most likely cause of the poor (most disturbed) biological condition.

3.7 North Fork Maquoketa River TMDL in Iowa

Abstract

In 1998 the Iowa Department of Natural Resources (IDNR) determined that a 19.5-mile segment of the North Fork Maquoketa River (NFMR) was not meeting its aquatic life use due to a biological impairment of "unknown cause." This determination was based on biological assessments of benthic macroinvertebrate and fish populations. All collected data were used by IDNR in the development of a stressor identification (SI) process that showed that the primary pollutants in the NFMR were sediment, nutrients (specifically phosphorus), and ammonia. In 2007 IDNR completed a Total Maximum Daily Load report for the NMFR that used results of the SI process and calls for steep reductions in sediment reaching the river and in nutrients and agricultural manure releases. IDNR also identified a variety of best management practices to improve water quality and is encouraging local residents and businesses to take action to restore their watershed.

Water Quality Impairment of the North Fork Maquoketa River

The North Fork Maquoketa River (NFMR) is designated by Iowa for aquatic life protection as a class B (WW-2)[16] water. In 1998 the NFMR was determined not to be meeting its aquatic life uses based on biological assessments of the benthic macroinvertebrate population that showed low total abundance and species diversity and several reported fish kill events of unknown source. Iowa subsequently placed the 19.5-mile segment that extends from the headwaters near Luxemburg to Dyersville on its 1998 Clean Water Act (CWA) section 303(d) list of impaired waters. The segment was listed for a biological impairment of "unknown causes" (IDNR no date).

Monitoring and Stressor Identification

Iowa Department of Natural Resources (IDNR) conducted additional biological monitoring of the NFMR between 1999 and 2005. Data collection included the number of benthic macroinvertebrates (by lowest practical taxon), number of fish (by species), and instream and riparian habitat assessments. IDNR used these data to calculate a Benthic Macroinvertebrate Index of Biotic Integrity (BMIBI) and a Fish Index of Biotic Integrity (FIBI) that quantify several aquatic community characteristics such as relative abundance of sensitive and tolerant species, and the proportion of organisms belonging to various feeding, spawning, or habitat classifications. BMIBI and FIBI scores for the NFMR watershed are provided in Table 3-6. For the sites sampled, the BMIBI and FIBI ranged from poor to fair (Table 3-4). None of the BMIBI or FIBI scores attained the reference biological criteria (Table 3-5). Qualitative scoring guidelines for the BMIBI and FIBI are summarized in Table 3-4, while reference values are included in Table 3-5.

[16] Under the CWA, class B waters are designated for the protection of aquatic life uses. The WW-2 classification is for small streams.

Table 3-4. Qualitative scoring guidelines for the BMIBI and FIBI.

Biological Condition Rating (BCR)	BMIBI	FIBI
Poor	0–30	0–25
Fair	31–55	26–50
Good	56–75	51–70
Excellent	76–100	71–100

Source: http://www.iowadnr.gov/Environment/WaterQuality/WatershedImprovement/WatershedResearchData/WaterImprovementPlans/PublicMeetingsPlans.aspx. (Note that the NFMR TMDL .pdf document is available under the heading "Final Water Quality Improvement Plans.")

Table 3-5. Reference criteria for assessing biological integrity.

Ecoregion[a]	BMIBI	FIBI
52B Ref. (Paleozoic Plateau)	61	59
47C Ref. (Iowan Surface)	59	71 (riffle), 43 (non-riffle)

Source: http://www.iowadnr.gov/Environment/WaterQuality/WatershedImprovement/WatershedResearchData/WaterImprovementPlans/PublicMeetingsPlans.aspx. (Note that the NFMR TMDL .pdf document is available under the heading "Final Water Quality Improvement Plans.")

[a] The watershed contributing to flow in the NFMR upstream from Dyersville, Iowa, is a transitional area that is divided between two ecological regions of Iowa. Roughly two-thirds of the lower portion of the watershed is located in the Iowan Surface of the Western Corn Belt Plains, while the upper third is located in the Paleozoic Plateau (Driftless Area) ecoregion.

Table 3-6. BMIBI and FIBI results for the NMFR Watershed.

(BCR rating in parenthesis)

Site	Year	BMIBI	FIBI
REMAP 147	2005	42 (Fair)	34(Fair)
TMDL 28	2001	47 (Fair)	29 (Fair)
TMDL 28	2005	26 (Poor)	37 (Fair)
New Wine Park	1999	N/A[a]	32
TMDL 29	2001	47 (Fair)	26 (Fair)
TMDL 30	2001	51 (Fair)	33 (Fair)
TMDL 30	2005	48 (Fair)	7 (Poor)
H2	1999	53 (Fair)	37 (Fair)

Modified from http://www.iowadnr.gov/Environment/WaterQuality/WatershedImprovement/WatershedResearchData/WaterImprovementPlans/PublicMeetingsPlans.aspx. [Note that a new link to the Web page where the NFMR TMDL .pdf document is available under heading "Final Water Quality Improvement Plans."]

[a] Insufficient numbers of organisms for BMIBI calculation. To calculate the BMIBI, at least 1 of 3 quantitative benthic macroinvertebrate sample replicates must contain 85 or more individual specimens. The three replicates had 70, 25, and 54 specimens, respectively.

In addition to biological monitoring, IDNR also collected monthly water quality samples in 2001 and 2005 (March through November) for several chemical and physical parameters, such as flow, dissolved oxygen, temperature, pH, nitrate + nitrite, and total phosphorus. The data showed water quality impacts relative to levels measured at least disturbed ecoregion reference stream sites—especially elevated concentrations of ammonia, nitrate-nitrogen, total phosphorus, and total suspended solids. Occasional violations of dissolved oxygen criteria were found, and large diurnal fluctuations in dissolved oxygen concentrations in the stream were indicative of elevated primary production levels. All collected biological, chemical, and physical data were used in the stressor identification (SI) process (IDNR 2006).

IDNR staff followed the Protocol for SI to determine the cause of the biological impairment in NFMR (see Tool # 3, *Stressor Identification (SI) and Causal Analysis/Diagnosis Decision Information System (CADDIS)*). The SI procedure relates impairments described by biological assessments to one or more specific causal agents (pollutants). It also separates water quality (pollutant) impacts from habitat alteration impacts. Although the SI did not reveal any single stressor that is clearly the dominant cause of biological impairment, IDNR determined that the primary pollutant-related causal factors in the NFMR were sediment, nutrients (specifically phosphorus), and ammonia.

Total Maximum Daily Load Development

In 2007, IDNR completed *Total Maximum Daily Loads for Sediment, Nutrients, and Ammonia: North Fork Maquoketa River, Dubuque County, Iowa*. Results of the SI process were used, and IDNR considered impacts from the point and nonpoint sources of pollution in development of the Total Maximum Daily Load (TMDL). Although IDNR concluded that one wastewater treatment plant in the NFMR watershed should be included in the TMDL and in developing a wasteload allocation for the existing phosphorus load, that facility did not contribute significantly to the overall sediment load. IDNR also identified several potential nonpoint sources for nutrients, sediment, and ammonia—failed on-site septic tank treatment systems, agricultural activities (e.g., cattle in streams, fertilizer use, soil erosion, land-applied manure), wildlife, and runoff from developed areas (IDNR 2007).

To meet water quality improvement goals for the NFMR, the TMDL includes a 77 percent reduction in sediment reaching the river (20,200 pounds of sediment per year) and a 73 percent reduction in nutrients and manure releases. The TMDL has two parts. The first includes setting specific and quantifiable targets for sediment, oxygen demand, total phosphorus, and ammonia loads to the stream. Additional biological and water quality monitoring will determine whether the prescribed load reductions result in attainment of water quality standards. These monitoring data will also be used to determine whether the implemented TMDL and watershed management plans have been effective in addressing water quality impairments in the NFMR. EPA approved the IDNR TMDL in 2008.

IDNR has identified a variety of BMPs to improve water quality, as well as to encourage residents and businesses in the watershed to take action. IDNR has also identified possible practices to reduce sediment and nutrients reaching the NFMR, such as installing structures to reduce both agricultural and urban runoff; limiting cattle access to streams and installing alternative water sources for cattle; and using agricultural management practices that increase crop residue, such as no-till. IDNR also suggested that proper control of open agricultural animal feedlots will help prevent contaminated runoff from reaching streams, which in turn will reduce ammonia loading. Ongoing monitoring of this impaired stream segment will be used to periodically assess progress made toward attainment of the NFMR designated aquatic life uses.

3.8 Addressing Stormwater Flow in Connecticut's Eagleville Brook TMDL for Biological Impairment

Abstract

In 2004 Connecticut used biological assessment information to place Eagleville Brook on its 303(d) list of water quality limited (WQL) waters for failure to meet the brook's aquatic life uses. Before Total Maximum Daily Load (TMDL) development, the state conducted a stressor identification analysis that pointed to the complex array of pollutants transported by stormwater as the most likely cause of impairment. A statewide study that correlated impervious cover (IC) with benthic macroinvertebrate data collected from wadeable streams was conducted, and results showed that the designated aquatic life use was not supported when IC was more than 12 percent of the watershed area. A TMDL was developed in 2007 using a target of 12 percent IC—the first in the nation to use IC as a surrogate for stormwater. Objectives to reduce IC were established for each waterbody segment, and progress toward attainment of the designated aquatic life use will be evaluated by monitoring the condition of the benthic macroinvertebrate community in conjunction with ongoing chemical assessments.

Eagleville Brook has a 2.4-square-mile drainage area, and the watershed drains a portion of the University of Connecticut (UCONN) campus and the town of Mansfield. The brook is designated as a Class A waterbody, but fisheries sampling in 2002 showed that the waterbody was not meeting its aquatic life uses, with low fish density and large areas with no fish. Additionally, benthic macroinvertebrate sampling in 2003 showed low total abundance and species diversity, documenting that the waterbody was in nonattainment of the state's narrative biological criteria for Class A waters. In 2004 Connecticut added Eagleville Brook to its list of impaired waters for cause unknown on the basis of the biological assessment results.

Stressor Identification and Total Maximum Daily Load Development

Before Total Maximum Daily Load (TMDL) development, Connecticut conducted a stressor identification (SI) analysis to evaluate the potential stressors and determine the most likely causes of impairment. The SI study concluded that biological impairments were most likely from a combination of pollutants related to stormwater runoff from developed areas and other related stressors (such as the physical impacts of stormwater flows). There are no other known point source discharges in this small watershed. The major source of stormwater is runoff from the impervious surfaces in the watershed (e.g., roads in Mansfield and UCONN campus). A statewide study of the impact of impervious cover (IC) on aquatic habitats was also conducted; Connecticut's Rapid Biological Assessment Protocol III data from 125 small (< 50 square miles) watersheds showed that no stream monitoring location with more than 12 percent IC in the upstream watershed meets Connecticut's biological criteria for full support of aquatic life use.

In 2007 Connecticut developed the TMDL with a loading capacity (TMDL target) of 12 percent IC. The 12 percent TMDL target was chosen on the basis of the threshold observed for applicable Connecticut streams in the statewide study. In the TMDL, Eagleville Brook was partitioned into three segments, and the IC was calculated for each. For each segment, a TMDL implementation objective was also developed (Table 3-7).

Table 3-7. Summary of TMDL analysis for Eagleville Brook.

Waterbody segment	TMDL target	IC	Implementation objective
From the mouth at Eagleville Pond upstream to the confluence with Kings Brook, Mansfield	12%	5%	Antidegradation
The confluence with Kings Brook to headwaters near UCONN campus	12%	14%	21% reduction in the percent IC
Unnamed pond on UCONN campus	12%	27%	59% reduction in the percent IC

The targets apply at all times (instantaneously, daily, monthly, seasonally, and annually) and will achieve reductions in stormwater runoff volume in all storm events whenever they occur (e.g., on any day) throughout the year. The reductions associated with the implementation objectives were to be accomplished by improved stormwater management. The Connecticut Department of Environmental Protection (CT DEP) provided general and specific implementation recommendations in the TMDL and recommended using an adaptive management approach toward reducing stormwater impacts and improving water quality.

TMDL Implementation

Progress toward attainment of the aquatic life use will be evaluated by CT DEP's monitoring the macroinvertebrate and fish communities and assessing surface water chemistry according to an existing rotating basin sampling schedule. UCONN, the Town of Mansfield, and the Willimantic River Alliance have pledged support for TMDL implementation. EPA and CT DEP have funded a project using section 319 NPS funds to map locations and identify ways to reduce the effect of IC as required by the TMDL. The project also examined the estimated costs of such actions and developed initial engineering sketches for a *top ten* list for recommended retrofit management actions that are most cost-effective, primarily in the upper watershed. In addition, other projects have been completed on the UCONN campus to reduce IC, including installation of two green roofs and parking lots with pervious asphalt and concrete. The Town of Mansfield has received technical guidance on local land use regulations and practices, primarily in the lower watershed. Low-impact development concepts are expected to be incorporated into future development. An overall watershed management plan that supports a framework to pursue high-priority projects to reduce the effect of IC has been developed. Considerable stakeholder input has crafted a consensus approach to seize opportunities to reduce the effect of IC as situations arise during normal maintenance operations at UCONN and Mansfield. A tiered system to track progress will focus in the short term on close tracking of the area of new and disconnected IC, as well as flow monitoring to determine whether changes in IC will improve the hydrologic regime of Eagleville Brook. The TMDL has led to an increase in dialog among stakeholders and has led to changes in how people think about managing IC in the Eagleville Brook watershed. Additional information on the implementation of the Eagleville Brook TMDL can be found at http://clear.uconn.edu/projects/tmdl/index.htm.This site, hosted by UCONN, provides additional information and will be used to track the progress of TMDL implementation over time.

3.9 Vermont's Use of Biological Assessments to List Impaired Waters and to Support NPDES Permit Modification and Wastewater Treatment Facility Upgrades

Abstract

In the 1990s, the Vermont Department of Environmental Conservation's biological assessment of the Dog River showed aquatic life use impairments downstream of a wastewater treatment facility. Whole effluent toxicity and biological assessment data were used to support revisions to National Pollutant Discharge Elimination System permits for dischargers, and subsequent management actions at the facilities resulted in the segment's meeting its designated aquatic life use and its removal from the 303(d) listing for water impairment.

Biological Assessments Detect Impairment and Support Permit Modifications

Between 1993 and 1995, biological assessments of Vermont's Dog River showed that the river was not meeting its aquatic life use according to changes in the aquatic community typically associated with toxicity stress and moderate phosphorus pollution. In 1996, Vermont Department of Environmental Conservation (VT DEC) listed the Dog River on the state's 303(d) list of impaired waters, based on the biological assessment information, for cause unknown. Further investigation indicated two factors contributing to the degraded instream water quality. First, the Northfield Wastewater Treatment Facility (WWTF) had reached its design life and was no longer able to function properly and reliably meet National Pollutant Discharge Elimination System (NPDES) permit limits. Second, wastewater influent to the facility from two industrial textile facilities had high concentrations of metals and possibly surfactants. In WWTF effluent samples, metal concentrations were high and predicted to exceed water quality criteria at permitted flows. Whole effluent toxicity (WET) testing confirmed significant toxic effects at effluent concentrations greater than 12 percent. Through a toxicity identification evaluation (TIE) study, copper was identified as the most significant metal of concern in the WWTF effluent, with a maximum copper concentration of 184 micrograms per liter (µg/L). This level would have resulted in an instream concentration of 36 µg/L copper at 7Q10 (i.e., the lowest 7-day, consecutive low flow period occurring over the preceding 10-year period) permitted flows. Copper levels correlated with the level of toxicity found in the WET testing.

In 1999 pretreatment discharge permits with compliance schedules were issued to the textile facilities. The pretreatment permits established copper limitations for those influent waste streams that required the installation of pretreatment systems for the removal of copper (see Table 3-8). Although the systems were operational in 2000, biological assessments conducted between 2000 and 2003 showed continued aquatic life use impairment in the river. That monitoring showed a shift in the benthic macroinvertebrate community that, in addition to chemical data, indicated that phosphorus pollution had become the most likely cause of the aquatic life impairment. Specifically, the macroinvertebrate community was significantly higher in density and dominated by nutrient-tolerant taxa relative to previous sampling results. To measure this increase in nutrient-tolerant taxa, VT DEC used a ratio that compares the proportion of pollution- sensitive benthic macroinvertebrate species to more pollutant-tolerant species, the EPT/EPTc ratio. This reflects the ratio of generally pollution-sensitive species (e.g., **E**phemeroptera [mayflies], **P**lecoptera [stone flies] and **T**richoptera [caddisflies]) compared to the more pollutant-tolerant species (Chironomids [midges/flies]). A low threshold indicates dominance of midges

(EPTc) that have been observed in streams with significant levels of nitrogen, phosphorus, or other pollutants. Additionally, the higher biological index value reflected the increase in the midges and provides complementary information.

Table 3-8. Permit limitations for two textile facilities.

Facility	Flow monthly average	Copper	
		Monthly average	Daily maximum
Facility A	150,000 gal/day	0.027 lb/day	0.038 lb/day
Facility B	35,000 gal/day	0.007 lb/day	0.0125 lb/day

In January 2003, VT DEC issued a compliance schedule to the Village of Northfield to upgrade its WWTF, and the upgraded facility became operational in November 2004. The upgraded WWTF process consists of upgraded headworks, two sequential batch reactors, a surge tank, and an upgraded chlorination and dechlorination system. Phosphorus removal was required to comply with the requirements of the Lake Champlain TMDL and Vermont regulations (10 VSA 1266a). To achieve that, permit limits for a 1.0-mg/day discharge of phosphorus were set at 6.78 lb/day, at concentration of 0.8 mg/L monthly average. Northfield treatment plant copper effluent limitations were also established at 0.26 lb/day monthly average and 0.36 lb/max daily at a pH of between 6.5 and 8.5. Improved sludge management was also incorporated into the upgraded WWTF, including refurbishing the existing digester, adding a new digester, and adding a centrifuge for dewatering. Water quality and habitat improvements were observed, but the aquatic system's recovery was further complicated by a chlorine spill from the WWTF's temporary disinfection system during the upgrade in July 2004, leading to a further short-term decline in EPT.

Conclusion

Despite the short-term adverse effects from the 2004 chlorine spill, the compliance schedules and changes to both predischarge and the WWTF permits have resulted in changes in facility operations that, in turn, have resulted in improvements in water quality. Biological assessments showed improvement only after copper was reduced and wastewater treatment of phosphorus was improved. These combined efforts enabled a site that was classified as fair-poor to recover to excellent condition. Biological assessments in 2005 and 2006 showed that the Dog River was meeting its aquatic life uses, with specific measures, or metrics, showing density to be moderate; richness, EPT, and EPT/EPTc ratio to be high; and biological index (BI) to be lower relative to previous sampling. Chemical monitoring has documented that the applicable chemical water quality criteria were being met, and WET test results have shown that the effluent is nontoxic (i.e., no significant toxicity to test organisms using 100 percent effluent). The biological assessment information documents that the stream macroinvertebrate community is now dominated by water-quality-sensitive taxa more typical of its *natural* expectation—with recovery of sensitive species and a more balanced community. (Data from sampling between 1993 and 2006 are shown in Table 3-9.) As a result, in 2006 Vermont removed Dog River from its impaired waters list.

Table 3-9. Macroinvertebrate assessments for Dog River—Northfield WWTF.

Date	1993	1994	1995	2000	2001	2003	2004	2005	2006
Assess (criteria)	Fair	Fair	Fair	Fair-Poor	Poor	Poor	Poor	Very Good	Excellent
Density (> 300)	1,862	3,282	1,037	4,556	5,640	4,264	668	2,160	5,870
Richness (> 30)	39	43	41	50	50	62	34	51	62
EPT (> 18)	12	16	16	14	11	22	12	28	33
BI (< 5.00)	4.73	4.74	4.61	5.51	6.00	5.26	5.12	4.38	3.48
Ept/EptC (> 0.45)	0.029	0.50	0.52	0.29	0.07	0.22	0.14	0.89	0.89

Milestones:
2000 – Metals removed.
2004 – Chlorine spill late summer; WWTF upgrade with phosphorus removal completed in November.
2005 – First year of river meeting designated aquatic life use.
2006 – Second year of river meeting aquatic life use; stream removed from impaired waters listing.

3.10 Restoration of Red Rock Creek by the Grand Portage Band of Lake Superior Chippewa

Abstract

For the past 15 years, the Grand Portage Band of Lake Superior Chippewa (tribe) has led efforts to restore one of the Band's most impaired waters—Red Rock Creek. Biological assessment information has played a central role in establishing and assessing whether biological, chemical, and physical targets for restoration are being met. To date, the tribe has implemented multiple and interrelated restoration activities that have resulted in significant water quality improvements, as demonstrated by periodic sampling of the creek's benthic macroinvertebrate and plant communities.

Background

Over the past decade, the Grand Portage Band of Lake Superior Chippewa (tribe) has been leading restoration efforts to improve the physical, chemical, and biological integrity of one of the Band's impaired waters—Red Rock Creek. To date, biological assessment information has played a central role in defining biological goals for restoration in concert with chemical and physical targets that have also been established. The tribe has implemented restoration activities that have resulted in water quality improvements, as shown in sampling of both the benthic macroinvertebrate and plant communities.

Red Rock Creek Impairment

The Red Rock Creek watershed encompasses approximately 1,200 acres in Minnesota north of Lake Superior. While the upper reaches of the watershed are in relatively pristine condition, the creek flows through an abandoned gravel pit located approximately one-half mile from Lake Superior. Past gravel mining activities—most notably the removal of riparian (streamside) vegetation and cutting of a portion of the stream bank—have adversely affected the stream, resulting in severe sedimentation. This has resulted in a net loss of fish species and benthic macroinvertebrate communities. For instance, by 2006, steelhead trout, chinook salmon, coho salmon, and coaster brook trout were found only near the mouth of the stream, rather than their previous habitation along several miles of the stream. Gravel extraction has also caused the stream to leave its former channel and to spread into the gravel pit area. Notably, beaver damming has exacerbated problems associated with braiding and flow and has led to clogging of Red Rock Creek.

Monthly sampling of Red Rock Creek began in 1997. Turbidity measurements were high, with a mean concentration of 12.3 nephelometric turbidity units (NTUs). Gravel mining activities ceased in 1998, and in 2000 the Tribe reported that water quality was impaired based on biological and chemical assessments. Specifically, monitoring showed low dissolved oxygen concentrations, high turbidity, and low benthic macroinvertebrate densities and species abundance. In the impacted portion of the creek, mean dissolved oxygen concentrations were 6.3 mg/L—more than 2 mg/L lower than the concentrations measured in unimpacted upstream reaches. A total of27 macroinvertebrates were collected in the impacted stream reach, with a large proportion of pollution/sediment-tolerant diptera (e.g., Chironomides [midges]) present but no pollution-sensitive EPT taxa (e.g., **E**phemeroptera [mayflies], **P**lecoptera [stone flies] and **T**richoptera [caddisflies])). However, in 2004, 6 years after the cessation of gravel mining operations, over 100 macroinvertebrates were collected. Possible explanations for this improvement in macroinvertebrate density might be the subsequent regrowth of some of the stream's riparian buffer and instream habitat (Table 3-10). However, only 27 percent of the total taxa were EPT taxa, which is much lower than the 60–75 percent proportion of EPT taxa expected in unimpacted or minimally impacted streams in this area. Increases in EPT taxa are expected with continued restoration and allowing time for the aquatic system to recover natural flow and habitat conditions.

In addition to benthic macroinvertebrates, the tribe also assesses plant communities to evaluate the biological health of its waterways. To measure the natural quality of the area, the tribe uses a Floristic Quality Index (FQI),[17] a weighted species richness index that can be calculated by identifying all plant species in a given plot or transect. To evaluate streams, the Grand Portage Tribe uses an FQI score ≥ 20, the presence of at least 20 plant taxa, no exotic invasive plant species, and at least 5 sensitive or rare plant taxa. In 2004, Red Rock Creek had a total of 13 plant taxa, an FQI score of 14, 3 invasive exotic plant species, and no sensitive or rare plant taxa (Table 3-11).

Restoration Efforts

The tribe set biological, chemical, and physical goals for improving overall water quality in Red Rock Creek (Table 3-10). Restoration goals were established for increased dissolved oxygen concentrations, reduced turbidity, reduced diptera taxa to less than 5 percent of macroinvertebrates collected, and increased proportion of pollution-sensitive macroinvertebrate taxa. Restoration efforts began in 2006 with the removal of the beaver dam and installation of sediment traps. Monitoring results conducted immediately following restoration showed a mean turbidity concentration of 10.3 NTUs, dissolved oxygen concentrations that continued to be approximately 2 mg/L less than those in undisturbed reaches of the stream, and changes in the benthic macroinvertebrate community. Although sampling of the macroinvertebrate community showed a dramatic increase in the number of organisms collected (350), only 9.8 percent of the total insects collected were EPT taxa and 22 percent were diptera—similar to pre-restoration sampling results. In 2008 additional restoration measures were completed, including reinforcement of banks upstream of the sediment basin using live fascines and stakes, physical removal of excess sediment from the basin, and seeding and tree planting to further stabilize the banks and restore riparian vegetation.

Results

Monitoring results from 2008 and 2009 show that the restoration goals for Red Rock Creek have been exceeded for most biological, chemical, and physical measures of water quality (Tables 3-10 and 3-11). Dissolved oxygen concentrations and turbidity levels are comparable to those expected in unimpacted conditions with improvements in both benthic and floristic assessments of biological condition, though the continued presence of invasive plant species remains a challenge. The tribe will continue to maintain the sediment ponds and bank stabilization projects in order to achieve the restoration goal for percent EPT taxa. Regular removal of excess sediment from the basin, efforts to reestablish native vegetation in the riparian zone, and potential removal of invasive species from the basin will be considered in an adaptive management approach to fully achieve biological restoration goals.

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[17] Anthropogenic stressors can be manifest changes in plant communities through displacement and competition from exotic invasive species. The FQI is the calculation of the plant communities' mean coefficient of conservatism multiplied by the square root of the number of species. The coefficient of conservatism is a measure of an individual species' fidelity to natural habitats and communities.

Table 3-10. Sampling to assess progress toward restoration goals.

Parameter	Pre-restoration sampling results (year)	Restoration goal	Post-restoration sampling results (year)
Turbidity	12.3 NTU (1997)	50% reduction	2.4 NTU (2009)
Dissolved oxygen	6.3 mg/L (2000)	2 mg/L increase	9.6 mg/L (2009)
Number of macroinvertebrates	27 (2000) 10 (2004)	200	350 (2008)
% diptera	29.6% (2004)	Reduction to 5% of total	1.3% (2008)
% EPT species	27% (2004)	Increase to 60% of total	30% (2009)

Table 3-11. Plant sampling results.

Parameter	2004	2008
Number of plant taxa	13	21
FQI score	14	19
Number of invasive plant species	3	3
Number of sensitive or rare taxa	0	3

3.11 Using Biological Assessment Data to Show Impact of NPS Controls in Michigan

Abstract

In the 1990s biological assessments of Carrier Creek in Eaton County, Michigan, showed that the waterbody was not attaining its designated aquatic life uses, resulting in its inclusion on the state's 303(d) list in 1996 for cause unknown. Subsequent surveys indicated that stream biota was affected by urban runoff, poor instream habitat, and sediment deposition. In 2002 a Total Maximum Daily Load for biota was completed. Watershed partners are conducting several stream restoration projects to improve aquatic life use attainment. The restoration activities stabilized the stream channel and its hydrology, reduced stream bank erosion, and improved aquatic habitat. Improvements in fish and macroinvertebrate communities have been documented.

Background

Carrier Creek, a tributary to the Grand River, flows through a rapidly developing area in Eaton County near Lansing, Michigan. Historical channelization and more recent urban runoff resulted in eroding stream banks, high sedimentation rates, and degraded aquatic habitat for fish and macroinvertebrate communities. In 1996 Michigan included a 4-mile segment of the creek—from its confluence with the Grand River upstream to where it flows under Interstate 496—on its 303(d) list of impaired waters based on biological assessment information used to interpret its narrative standard that all surface waters of the state are "designated for and shall be protected for … aquatic life and wildlife." The Michigan Department of Environmental Quality (MDEQ) determined that the quality of the aquatic biota in that segment of the creek was reduced by urban runoff, poor instream habitat, and excessive sediment deposition. MDEQ completed a Total Maximum Daily Load (TMDL) for Carrier Creek biota in 2002. As noted in the TMDL, achievement of the water quality standards (WQS) for designated uses for Carrier Creek will be demonstrated by assessing the macroinvertebrate community and the instream habitat as it relates to sediment.

Stream Restoration

Between 2000 and 2006, state and local agencies and volunteer groups partnered in various stream restoration projects designed to achieve the TMDL goals. For example, in 2000 local agencies and volunteers stabilized and restored 5 miles of channel. The projects increased channel stability, improved instream habitat, and reconnected the channel to its floodplain. The upstream end of the channel was narrowed, and the stream pattern was reestablished to promote meandering. In some locations, the project team removed dredge spoils that were separating the stream from its natural floodplain.

In 2002 project partners created a 32-acre wetland in the headwaters of the watershed to intercept stormwater runoff and decrease stream flashiness. In 2004 the Perrin Chapter of Trout Unlimited installed structures along the creek to provide shelter and resting points for fish. In addition, the Eaton County Drain Commissioner is enhancing stormwater detention and flow control throughout the upper portion of the watershed to stabilize the channel, reduce the velocity of the flow, reduce erosion downstream, and reduce the amount of flooding. That work is ongoing.

Results

Biological assessment data have been used to assess the project's progress. The State of Michigan and the Eaton County Drain Commission collected data on fish, macroinvertebrates, and aquatic habitat quality at two locations in the project area, both before (2000) and after (2006) the restoration activities occurred. A consultant for the Eaton County Drain Commission collected additional fish data in 2007.

As of 2006, aquatic habitat was unchanged at one site and had improved at the other, but macroinvertebrate populations had not responded. However, by 2009, both macroinvertebrate and habitat quality scores had improved at all sites. The improvement in habitat scores was due to continued stream restoration activities that provided meandering channels and suitable instream habitat for the aquatic biota, such as fish and benthic macroinvertebrates. In fact, the 2007 fish data show that the number of fish taxa increased at both locations following restoration activities, more than doubling at one site and quadrupling at the other. There is another encouraging signal of improvement to date: a single slippershell mussel (*Alasmidonta viridis*) was found during an informal inspection of the restored reach in 2007. The slippershell is listed on the state's threatened list by the Michigan Natural Features Inventory and had not been observed in the stream before restoration. MDEQ will conduct further monitoring in the fall of 2011.

The restoration activities conducted to date have stabilized the stream channel and its hydrology, reduced stream bank erosion, and improved aquatic habitat. Fish communities are recovering, and future monitoring should show further improvements in the biota and eventually result in removing Carrier Creek from the list of impaired waters based on assessing the macroinvertebrate community and the instream habitat as it relates to sediment.

3.12 Using Biological Assessment as Evidence of Damage and Recovery Following a Pesticide Spill in Maryland and the District of Columbia

Abstract

In response to a fish kill in a tributary of the Potomac River in 2000, biological assessment data were used to show the impact of a pesticide spill and to document the waterbody's recovery. Sampling data collected before the spill provided a baseline of the expected aquatic community in the waterbody. Data from biological assessments before the spill were compared with sampling data collected immediately after the fish kill and several months later. The data were used to support enforcement actions and to support criminal charges against the polluter.

Problem Overview

In the spring of 2000 a fish kill (estimated to be 150,000 fish) was observed along an 8-mile stretch of Rock Creek, a major tributary of the Potomac River in Maryland and the District of Columbia. Responding to the kill, the Maryland Department of the Environment (MDE) sampled the water column and sediments and found high concentrations of the insecticides cypermethrin and bifenthrin, both of which are highly toxic to fish. Concentrations were especially high in a storm drain entering the stream from the parking lot of a pest control company, suggesting that a pesticide spill had occurred.

The case was investigated by EPA's Criminal Investigation Division with assistance from the State of Maryland, Montgomery County, the National Park Service, and the District of Columbia. Within 2 weeks, a coordinated, multiagency effort sampled sediments, fish, and benthic macroinvertebrates upstream and downstream of the outfall. Fish sampling was repeated after 5 months, and sediments were retested 9 months after the spill.

Data Collection and Analysis

Samples were analyzed in three time frames—before the spill occurred, just after the fish kill was observed, and some months afterward. Samples were also categorized by location; before and upstream samples served as controls for the suspected effects of the spill. Several hours after the fish kill was first observed, cypermethrin and bifenthrin concentrations in downstream waters were near the acute toxicity thresholds for fish and invertebrates. Pesticide concentrations in the storm drain were many times greater than the acute toxicity levels. Sediments tested 2 weeks after the fish kill showed elevated levels of cypermethrin and bifenthrin below the storm drain when compared to levels above the storm drain. When retested 9 months later, cypermethrin and bifenthrin concentrations in all sediment samples were below detection limits.

Fish and benthic macroinvertebrates were collected from 11 stations, including 4 above and 7 below the storm drain. Several sites had been sampled before the spill in routine monitoring programs by the District of Columbia and Montgomery County. Historical data from 1996–1998 were available for three stations below the outfall, and one site well below the spill had been sampled several times weeks before the spill. Just after the spill, both fish and macroinvertebrate communities showed severe degradation when compared to upstream controls and, for fish only, when compared to downstream samples taken before the kill event.

Decreases in numbers of fish and the number of fish species were observed, with a reduction in the fish index of biotic integrity at all sites below the spill. On average, 20 macroinvertebrate taxa, of 46 taxa found upstream, were absent from downstream sites. After 5 months, most minnow species had returned to the affected sites. Overall, the fish community had recovered to approximately 75 percent of upstream species composition.

Conclusion

Biological assessment provided a powerful tool for documenting stream degradation and stream recovery following the toxic spill. Evidence was further strengthened by baseline data collected in routine monitoring programs. Comparison of the post-spill samples to samples taken before the spill provided a quantitative assessment of the biological impact and evidence of stream recovery. In November 2001, the owner and an employee of the pest control firm were charged with violations of the Clean Water Act and the Federal Insecticide, Fungicide, and Rodenticide Act. Ongoing biological assessments, in conjunction with bioassays and chemical and physical assessments, can assist enforcement agencies in assessing damage, levying fair and reasonable damage assessments on those proven responsible for toxic spills, and determining the rate and level of stream recovery.

3.13 Support for Dredge and Fill Permitting in Ohio

Abstract

Ohio uses biological assessments to help inform its decisions about certifying permits for dredge and fill activities and to ensure that the impacts of those activities on aquatic habitats do not violate Ohio water quality standards (WQS). Ohio's tiered aquatic life uses, in conjunction with antidegradation policies and numeric biological criteria adopted into the state's WQS, enable Ohio to better assess the potential impact of dredge and fill activities and to make management decisions on the basis of its designated aquatic life uses. Ohio's designated aquatic life uses are based on the relationship of habitat and the resident biota. It is presumed that if critical aquatic habitat is present or can be restored, the aquatic life associated with the habitat can be supported. Additionally, when implementing nationwide permits, Ohio has been able to include additional conditions to protect high-quality waters as revealed by biological assessments.

Dredge and Fill Permitting

States use Clean Water Act (CWA) section 401 to regulate activities that might impact aquatic habitats. Those wanting to modify a stream in a way that will result in the discharge of dredge or fill material into waters of the United States must obtain a section 404 permit from the U.S. Army Corps of Engineers and a section 401 water quality certification from the state. The state must certify that the proposed activities will comply with and not violate water quality standards (WQS) or waive such certification. Ohio's designated aquatic life use classes, which are based on the relationship of habitat and the attendant numeric biological criteria adopted into the WQS, make that linkage a valid tool for evaluating the effects of habitat alterations that are covered under the CWA. In essence, the habitat tools employed are sufficiently predictive to serve the purpose of reviewing proposed stream habitat modification activities.

Ohio EPA used more than 20 years of data to develop habitat stressor gradients along several aspects of habitat quality at both the site and watershed scales, including overall habitat quality as measured by a habitat quality index, the Qualitative Habitat Evaluation Index (QHEI), and for specific attributes such as substrate and channel condition (Rankin 1989, 1995). This allows for sufficient predictive relationships such that this habitat tool can be used to help determine the attainability of the Ohio biological criteria.

Ohio's designated aquatic life uses for surface waters have enabled a range of management responses to dredge and fill projects related to the quality and sensitivity of the waterbody in the context of the CWA goal to protect aquatic life. Ohio's use classification system is tiered along a gradient of quality with the highest use class supporting pollution-sensitive, naturally occurring communities of benthic macroinvertebrates and fish (Exceptional Warmwater Habitat [EWH] Aquatic Life Use). A second class along the gradient (Warmwater Habitat [WWH]) also supports a community of pollution-sensitive, naturally occurring benthic macroinvertebrates and fish species that are consistent with least impacted reference conditions.

Nationwide permits are designed to minimize site-specific oversight where ecological risks are assumed to be low. Frequently, however, in reviewing the criteria where nationwide permits can apply, high-quality waters can be overlooked, leading to their unwarranted alteration and impairment. Small streams such as headwater streams are particularly vulnerable to not being properly assessed under nationwide permit conditions. The Ohio EWH use designation requires high-quality habitat and stable hydrological regimes (especially in headwater and wadeable streams). Because those essential attributes can be altered by direct modifications to the stream channel and other habitat features, Ohio requires individual reviews of projects that occur in such high-quality streams. Under a general use system, those sites would be lumped with all other streams under the nationwide permit system. In addition, antidegradation provisions for high-quality WWH and Coldwater Habitat (CWH) streams are also applied.

Mitigation Standards

The attention gained by biologically defined habitat impacts has prompted the development of mitigation standards, in conjunction with a process for rigorous validation, that will take Ohio's aquatic life uses into account and require enhancement or restoration wherever feasible. The stressor-response relationships that have been developed between biological assemblages and key habitat attributes have been applied to the 401 program in Ohio for more than 20 years. For nationwide permits, a series of general and specific exclusions and conditions that vary with the state's tiered uses have been derived (USACE 2002). They include a general exclusion (of nationwide permits) for streams that are EWH and for certain high-quality antidegradation tiers (State Resource Waters and Outstanding State Resource Waters, Superior High-Quality Waters), the delineation of which was based primarily on the same biological assemblage attributes on which the designated use classes are based.

Ohio's integrated approach for designating aquatic life uses, implementing antidegradation, and establishing biological criteria is based on relationships between the aquatic biota and critical aquatic habitat.

3.14 Virginia INSTAR Model for Watershed Protection

Abstract

The Virginia Department of Conservation and Recreation and Virginia Commonwealth University Center for Environmental Studies are collaborating in developing and implementing a statewide Healthy Waters program to identify and protect healthy streams. The Interactive Stream Assessment Resource (INSTAR) is an online, interactive database application that evaluates the ecological integrity of Virginia's streams using biological and habitat data. The Web-mapping application is available to the public as a free resource to help planners, advocacy groups, and individuals to support wise land use decision making.

In 2003 Virginia Commonwealth University's Center for Environmental Studies, Virginia Department of Conservation and Recreation (VA DCR), the Virginia Department of Environmental Quality, Virginia Coastal Zone Management Program, and other state agencies began collaboration on Interactive Stream Assessment Resource (INSTAR). INSTAR is an online, interactive database application that evaluates the ecological integrity of Virginia's streams using biological assessments and habitat data. INSTAR was developed as part of and to support Virginia's Healthy Waters Initiative. That initiative is an effort to raise awareness of the importance of stream ecological condition and how healthy it is and to make certain that conservation efforts are broad enough to include healthy streams and rivers, making them and restoration efforts a priority. The approach is complementary to water quality programs that focus on repairing degraded streams.

INSTAR is used to identify healthy streams using data that include information about fish and macroinvertebrates, instream habitat, and riparian borders. Users can access and manipulate the view of a comprehensive database representing more than 2,000 aquatic (stream and river) collections statewide. INSTAR was established to develop complementary, synoptic, and geospatial database for fish and macroinvertebrate community composition and abundance at stream locations throughout the state. INSTAR, and the extensive aquatic resources database on which it runs, supports a wide variety of stream assessment, management, and conservation activities aimed at restoring and protecting aquatic living resources throughout Virginia.

INSTAR was primarily designed as a tool that could be used for regional and local planning by providing support for making land use decisions and help in prioritizing stream protection and mitigation efforts. Advocacy groups and individuals might also want to use INSTAR to identify healthy streams in their communities and encourage their protection. INSTAR can support regional approaches to transportation, priority habitat corridor identification, greenways, zoning, and land conservation priorities. It can also be used to identify healthy streams vulnerable to development and those already protected. Locally, INSTAR can help raise awareness about the location of healthy waters and identify priority areas during comprehensive planning. Measures of the composition of the naturally expected benthic macroinvertebrate community provide a benchmark for determining a healthy stream.

INSTAR generates a Virtual Stream Assessment (VSA) score for each stream studied using data collected by biologists along a 150- to 500-meter length or reach of stream, depending on its width. Information collected includes the types and number of fish and aquatic macroinvertebrates, instream habitat (e.g., vegetation, rocks, fallen logs), and riparian vegetation. The information is compared statistically to a model reference stream that represents ideal conditions of biology and habitat for streams in that geographic region. How closely a stream compares to an appropriate model reference stream determines its VSA score and ranking. That information can help identify a range of condition, from streams that have exceptional health to streams that are good candidates for restoration. INSTAR also classifies Virginia's 1,275 small watersheds using a modified index of biological integrity (mIBI) that is based on occurrences of selected aquatic species found in each watershed.

With INSTAR, a user can generate stream data and mapping information at the local, regional, or statewide level. Searches can be done by locality, stream name, watershed, or drainage area, and specific locations can be pinpointed using global positioning system (GPS) coordinates or street addresses. Users can also access information about fish, macroinvertebrates, and habitat for a specific stream location and can turn on topographical views, road maps, wetland overlays, and aerial photos. Users can also measure, outline, and highlight areas; add and edit text; and generate customized maps and reports. INSTAR is available to the public through a free, user-friendly website: http://instar.vcu.edu.

Application of INSTAR in Richmond County

The Richmond County Local Tributary Strategy Pilot Project, funded through grants from the National Fish and Wildlife Foundation and VA DCR, focused on the capacity of stakeholders to develop and support a local program to implement statewide strategies to mitigate nutrient and sediment pollution delivered to local waters and the Chesapeake Bay. The project approach identified aspects of local/regional planning and implementation programs where consideration of strategies to meet regional water quality goals could lead to improved condition or improved protection of natural resources. The best outcome would be that implementation would affect local needs and the broader Chesapeake Bay goals. County-comprehensive planning and agricultural best management practice (BMP) implementation programs are examples of local programs that vary greatly in how they are managed and have regional impact. Central to success in the project was identifying a way to link such varied efforts so that their strategies might align with regional goals. The project worked to establish that link through a focus on linking land use to water quality or stream health. The link was defined by two data-collection efforts. A countywide INSTAR stream assessment was conducted, and a countywide chemical water assessment was conducted.

The stream health assessment became a central theme for the project as the data were reviewed under several different contexts.

1. The project participated in the county-comprehensive plan review and revision process as a partner in an extensive community engagement process. Work sessions were held to specifically discuss the link among land use, management and planning, stream health and natural resource conditions and trends, and a host of other social and economic sector interests. The stream health assessment was an important component of the natural resource workshop.
2. INSTAR-identified healthy stream sites were included as a component of secondary considerations in the local Soil and Water Conservation District Agricultural BMP Cost Share Program guidance.
3. The INSTAR stream assessment was used in combination with the chemical water quality and agricultural BMP implementation data to correlate stream health and the level of BMP implementation or the percentage of land treated in a site's drainage area. The map displays an enhanced view of INSTAR data that includes sites identified as Important Fisheries Resources

and their spatial distribution against the level of BMP implementation in corresponding watersheds.

4. The INSTAR stream assessment was used to review the health of streams that received drainage from the main urbanized area affecting the county's jurisdiction. The data allowed for prioritizing sites where improved stormwater management could affect local conditions and regional implementation goals.
5. The comprehensive nature of the stream assessment provides a baseline condition for the local effort to measure progress, impacts, identify threats, or conservation priorities.

The regional strategies developed under Virginia's initial Tributary Strategies and revisited in the development of the Chesapeake Bay Total Maximum Daily Load (TMDL) do not provide local data to assist with implementation planning. The INSTAR stream assessment is a way to fill that data gap.

3.15 Examination of Climate Change Trends in Utah

Abstract

U.S. Environmental Protection Agency and the Utah Department of Environmental Quality (UT DEQ) are partnering in analysis of long-term biological assessment data to evaluate the potential impact of global climatic trends on the aquatic biota in Utah's streams. UT DEQ's objective is to develop a defensible approach to account for systematic bias that these impacts might have on its biological assessment and biological criteria program. Reference condition (e.g., natural or near natural condition) provides a baseline for comparison between expected conditions and test sites so it is important for states to understand and, where possible, quantify the shifts in the *steady state* of local reference communities due to global climatic shifts, regardless of whether they are natural or human-induced. For example, test sites should not be expected to exhibit communities that no longer exist at reference sites. UT DEQ's objective is to quantify the proportion of variation attributed to temperature-driven effects.

U.S. Environmental Protection Agency (EPA) Office of Research and Development (2010c) analyzed biological assessment data from Utah to determine whether past climate trends could be detected and to characterize the vulnerabilities of the biological assessment program to future climate conditions. In particular, the Utah Department of Environmental Quality (UT DEQ) was concerned that systematic changes in the physical or biological characteristics of streams would bias biological assessment scores, leading to errors in its integrated report. The availability of long-term stream invertebrate data at four reference stations, in two ecoregions, formed the basis for the analyses.

Long-term declines in richness or abundance of cold-preference taxa was detectable (i.e., from statistically significant temporal trends) at the two longest-term (> 15 years) Utah reference stations—one in the Wasatch-Uinta ecoregion and the other in the Colorado Plateau. That response was supported by significant associations between declining richness or abundance of cold-preference taxa and increasing temperature. Fairly predictable losses in a metric considered sensitive to pollution and disturbance, EPT taxa richness, were observed with increasing temperatures at the locations, which represent both high- and low-elevation ecoregions. The EPT metric is a measure of the presence of generally pollution-sensitive species (e.g., **E**phemeroptera (mayflies), **P**lecoptera (stone flies) and **T**richoptera (caddisflies)) in a sample. The response of EPT taxa was largely driven by losses of coldwater-preference EPT taxa, but in some cases it was also influenced by gains in warm-preference EPT taxa.

From those results, it was estimated that a 25 - 40 percent loss of EPT taxa could occur with current scenarios of temperature increases by 2050 (USEPA 2010c). Should such substantial losses of EPT taxa due to climate change occur, it would confound measures of ecological condition and decisions regarding attainment of aquatic life uses in many state monitoring programs. The Utah results suggest that relative elevation is a contributing factor driving the temperature trait composition of regional benthic communities (USEPA 2010c), with a greater proportion of cold-preference taxa in the higher elevation ecoregions and a greater proportion of warm-preference taxa in low-elevation ecoregions. Higher elevation regions with a greater proportion of cold-preference taxa might have a greater vulnerability to temperature-driven effects on traditional, taxonomically based indicators of biological condition. However, with the results of these studies and others, temperature-modified metrics can be used to characterize the contribution of climate changes in temperature to the observed trends, which would minimize both false-positive and false-negative decisions about aquatic life use support.

UT DEQ uses a mathematical model, River Invertebrate Prediction and Classification System (RIVPACS), to predict the expected composition of benthic macroinvertebrate species inhabiting streams from observations made at numerous streams that are relatively unimpacted by anthropogenic stress. The expected composition provides the baseline against which a test stream is compared. The results of the study show that changes in climate-related parameters used as predictor variables in the model will potentially alter the model's precision. The model needs to be calibrated for the climate-sensitive parameters so that effects from global climate change (regardless of whether they are natural or enhanced by anthropogenic sources of carbon to the atmosphere) and effects from anthropogenic stress (e.g., toxic discharges, stormwater flows, nutrient enrichment) can be distinguished. UT DEQ recalibrates the model every 2 years for Integrated Report purposes. Recalibration includes new reference sites, updated data from existing reference sites, and new environmental predictor variables and data. Therefore, as part of its existing program, Utah is able to accommodate and adjust for changes to predictor variables due to climate change, provided that it is aware of the potential for systematic bias.

To continue support of the effort, UT DEQ intends to collect additional data at long-term reference sites. Using the initial 2006 RIVPACS model as baseline, which includes most historical data from reference sites, at least five sites from each of the eight biologically similar groups will be sampled. A site will be sampled when the basin rotation monitoring plan is implemented for that basin (six-basin rotation). The sites encompass various levels of elevation, watershed size, latitude, and such, which can provide clues where climate-change effects are most pronounced. The RIVPACS model will be recalibrated every 2 years including new reference sites and updated predictor variable data. These recalibrated models will then be applied to data collected from the revisited trend reference sites to quantify several measures of long-term biological changes, including observed/expected (O/E) trends sites, changes in biological group membership, and taxon-level changes within group membership, including patterns in trait-based community composition. Site-specific results from these recalibrated models will also be compared to historical results to evaluate the extent to which climate trends would have altered decisions regarding support or non-support of aquatic life uses if climate-related biases were not accounted for in the analyses.

3.16 Applications of Biological Assessment at Multiple Scales in Coral Reef, Estuarine, and Coastal Programs

Abstract

Biological assessments provide useful information on the cumulative impacts of multiple stressors on biological conditions. As integrators, biological assessments can also evaluate the effects of landscape and ecological processes on aquatic life. By applying biological assessments at multiple spatial scales and multiple levels of biological organization in large and spatially complex waterbodies such as estuaries, coral reefs, or large braided river networks, U.S. Environmental Protection Agency hopes to expand its ability to understand first the interactions of biological communities with the large-scale processes that define ecosystems and second the cumulative effects of multiple stressors over larger spatial scales and over decadal time periods. Approaches combining biological assessments at several scales and levels are being developed for estuaries in the National Estuary Program and for coral reefs.

Background

Biological assessments can be conducted at many spatial scales and at many levels of biological organization. *Spatial scale* refers to the area considered in a biological assessment and can range from a shoreline or stream reach to an entire waterbody, region, state, or nation. Level of biological organization makes note that biology self-organizes into levels of order or structure such as organism, population, community, biotope, bioregion, or biome. Each level is generally associated with a physical space, such as habitat, landscape, watershed, or region. For example, biological assessment is a valuable tool to examine a single stream reach by considering the biological community within a defined habitat or a consolidated group of habitats in the stream (USEPA 1990, 1999). Such habitat-specific community-level biological assessments can also be conducted at local, state, and national spatial scales. U.S. Environmental Protection Agency's (EPA's) National Coastal Assessments (2001–2006) and National Coastal Condition Assessment (2010)[18]—programs designed to assess the condition of the nation's estuaries and coastal waters—conduct habitat-specific community-level biological assessments (hereafter referred to as habitat-level assessments) at the national scale. Habitat-level assessments are consistent with the definition of biological integrity as the capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a composition and diversity comparable to those of natural habitats of the region (Frey 1975; modified by Karr and Dudley 1981).

At a different level of biological organization, several methods for biological assessment that are specific to the aquatic landscape or to landscape-level processes have been developed. These methods can be useful tools in spatially complex waterbodies that are defined by interconnections among biological communities and among many distinct environments or habitats. Landscape-level concepts can be applied to all waterbody types and provide particular insights for watershed management. They are potentially very helpful as evaluative tools in waterbodies that appear as intertwined, patchy (and often shifting) mosaics of environments that support different biota and respond differently to different stressors.

[18] For more information, see http://water.epa.gov/type/oceb/assessmonitor/nccr/index.cfm.

Coral Reef Biological Assessments

The concept of biological integrity at the landscape level has, for example, been identified as important in developing biological criteria for coral reefs. Coral reefs are spatially complex habitats that are inextricably intertwined with a larger set of adjacent habitats (e.g., mangroves and seagrasses). Coral reef biota have evolved life history strategies that rely on the availability of those adjacent habitats (Christensen et al. 2003; Mumby et al. 2004, 2008; Aguilar-Perera and Appeldoorn 2007; McField and Kramer 2007; Meynecke et al. 2008; Sale et al. 2008). EPA's Coral Reef Biological Criteria document (Bradley et al. 2010) points out that "[b]iological integrity also means that reef organisms...have a clean, healthy environment to support them, including habitats for propagation, nurseries, and refugia. In this context, a fully functioning coral reef ecosystem may include adjacent supporting ecosystems such as seagrasses and mangroves." That document also recommends area measures of coral reef extent (e.g., square meters) as a first-order method for biological assessment of coral reefs that is relevant to landscape-scale evaluations. While most monitoring programs portray coral quantity as two-dimensional (2-D) live coral cover, EPA has developed a rapid survey procedure for estimating three-dimensional (3-D) total coral cover, which more realistically characterizes coral structure available as community habitat (Fisher 2007; Fisher, Davis, et al. 2007; Fisher, Fore, et al. 2008).

In conjunction with National Oceanic and Atmospheric Administration (NOAA) and other partners, scientists from EPA's Atlantic and Gulf Ecology Divisions (Narragansett and Gulf Breeze) are exploring the use of biological assessments to describe the coral reef and fish community along a gradient of stress in Guánica Bay, Puerto Rico. This effort may expand to include other critical coastal habitats in the future, e.g., sea grass beds and mangrove forests. Scientists will examine the pollution sensitivity of different taxa, presence or absence of native species, and other ecological response variables and then map the changes in these variables along a gradient of increasing stress—a Biological Condition Gradient (BCG) (see Chapter 2, Tool #2). Additionally, if there is sufficient quality and quantity of field data available, the BCG can provide a framework for relating well documented numeric stressor-response relationships to biological condition and thereby more precisely define stressor concentrations that support a waterbody's designated aquatic life use. Establishing this relationship could involve two steps. One step is establishing a numeric biological threshold that corresponds to the desired level of biological condition. For example, State and Tribal programs often develop numeric biological thresholds based on reference site conditions using an index of biotic integrity (IBI) or modeling the ratio of observed to expected species (O/E). Quantifying the relationship between BCG tier assignments and IBI or O/E scores for sampling sites along a gradient of stress provides a mechanism to link the scores to different levels of biological condition. The other step is quantifying the relationship between the IBI or O/E values and the stressor/parameter of interest such as nitrogen or phosphorus. Once a significant relationship between the IBI or O/E values and the stressor is documented, numeric water quality criteria (NWQC) for nitrogen or phosphorous could potentially be derived by selecting the stressor value that corresponds to the selected biological threshold (USEPA 2010a). This process facilitates the development of NWQC for nitrogen or phosphorus that are explicitly associated with levels of biological condition supportive of designated aquatic life uses. Developing these relationships at multiple scales including landscape-scale biological assessments will facilitate linking state and tribal water quality standards with both watershed and national estuary programs (Cicchetti and Greening 2011, USEPA In draft).

Biological Assessment at Multiple Scales in Estuaries and Coastal Waters

A large body of estuarine work has been done in index development and in application of habitat-level biological assessments. For example, approaches have been developed for salt marshes, soft-bottom benthic invertebrate communities and seagrass beds (USEPA 2000b). As a supplement to these efforts, several environmental programs such as EPA's national estuary programs (NEPs) are working together with U.S. Environmental Protection Agency (EPA) Office of Research and Development to develop landscape-scale biological assessment tools to evaluate and understand large-scale changes that have occurred to multiple habitats over long time periods and to integrate them into management in conjunction with existing habitat-level biological assessment tools. Specifically, the Tampa Bay, Narragansett Bay, and Mobile Bay Estuary programs are evaluating complementary application of the BCG to estuaries at the individual habitat level of biological assessment and at the landscape level of biological assessment, for managing estuaries and watersheds at the spatial scale of the entire waterbody.

Definitions:

- Habitat-level biological assessments—Evaluations of biological condition that consider biological communities within a defined habitat or suite of habitats (see Frey 1975; Karr and Dudley 1981).
- Landscape-level biological assessments—Evaluations of biological condition that consider and attempt to integrate biological processes, multiple biological habitats, or multiple biological communities within a defined landscape, waterbody, watershed, or waterbody type. The extent or arrangement (or both) of multiple biological habitats in a defined waterbody type.
- ✓ Both of these types of assessments can apply at a wide range of spatial scales, from a single area or subembayment to a larger waterbody, state, region, or nation.

As an example of landscape level assessment, one method in development considers the habitat landscape or biotope mosaic. A *biotope* is an area that is relatively uniform in physical structure and is identified by a dominant biota (Madden et al. 2009; Davies et al. 2004). Biotopes in estuaries include seagrass beds, salt marshes, coral reefs, clam flats, and more. Biotopes are a foundation of many recent habitat classification schemes, including the Coastal and Marine Ecological Classification Standard, which has been sponsored by the Federal Geographic Data Committee, and the European Nature Information System (Davies et al. 2004). Arrangements of biotopes provide species with spawning grounds, nurseries, refuge, sustenance, and other vital needs; such arrangements are particularly critical for larger mobile species and for species that move among biotopes at different stages of their life. The areas and arrangements of biotopes in a waterbody are affected by the full range of anthropogenic stressors, including nitrogen and phosphorus pollution, toxics, shoreline development, and sediment loads. Because biotopes are inherently a biological component, NEPs are developing approaches for biological assessment that consider areas and distributions of biotopes and biotope landscapes at the whole-estuary scale, combining the landscape-level tools with more resolved habitat-level tools. Tampa Bay, Narragansett Bay, and other NEPs are working on these multi-level BCG approaches. Additionally, the Mobile Bay NEP is exploring how to incorporate the concept of ecosystem services in development of a Biological Condition Gradient for the estuary. Current efforts in Tampa Bay and Narragansett Bay are briefly discussed below.

Tampa Bay Estuary Program

The Tampa Bay Estuary Program (TBEP) initiated a system-wide management framework in the 1990s that developed estuarine habitat restoration and protection goals to support estuarine-dependent species and the habitat landscapes they require (e.g., the extent of seagrass beds, mangrove forests, *Spartina* marshes, *Salicornia* marshes, and low-salinity marshes). Although the term *biotope* was not used, the framework employed the basic concepts of biotope extent and distribution to evaluate condition of the waterbody, comparing current condition to a more naturally occurring condition that existed at a relatively undisturbed point in the past. This information supported the development of environmental protection and restoration goals for the waterbody and watershed that move the estuary closer to those more naturally occurring conditions. This approach was combined with habitat-level work, including water quality modeling to predict seagrass health, benthic macroinvertebrate surveys, and more. Tampa Bay has recovered many hundreds of acres of high-value biotopes (Cloern 2001; Duarte 2009). TBEP is now working with other NEPs to develop those approaches into transferable biological assessment tools using concepts from the BCG. The methods used by TBEP, together with their application to biological assessment at landscape scales, are discussed in Cicchetti and Greening (2011).

Narragansett Bay Estuary Program

The Narragansett Bay Estuary Program (NBEP) and partners, benefiting from the Tampa Bay experience, are developing a suite of biological assessment tools to apply on a range of biological levels and spatial scales. A pilot program in Greenwich Bay, a sub-estuary of Narragansett Bay, has examined macroinvertebrate communities and biotopes in the context of the BCG using historical documentation of early stressor levels and ecosystem conditions to recreate a biological baseline. The project is especially pertinent to highly altered systems where it is often impossible to find undisturbed or minimally disturbed conditions. To characterize the biological responses to increasing stress, the study identified current, recent and historical stressors to Greenwich Bay benthos, including water quality (e.g., hypoxia), sediment metals, nutrients (i.e., nitrogen-loading), and hydrodynamics (including dredging and shoreline modification), terrestrial runoff, storms, and temperature. Changes in these parameters through time were summarized. A critical but challenging aspect of the project was to establish a reference level, or minimally disturbed endpoint. Target reference levels derived from historical baselines can be problematic because (1) they are difficult to calibrate with current ecosystem status, (2) ecosystems were as dynamic in the past as they are today, and (3) climate change and the degree of anthropogenic influence can render these endpoints unattainable. However, Greenwich Bay is fortunate in having available a significant amount of cultural and scientific historical data; although much of the information is qualitative, even qualitative differences in the biological indicators can be useful for defining a minimally disturbed endpoint. Ecological timeline data were overlaid with a detailed cultural timeline in order to associate changes in biological indicators with changes in human activities. Records of significant storms and climate trends gave broader context to ecological observations. The combined cultural and ecological timeline suggest when thresholds in the biological indicators may have been exceeded.

Because nutrient pollution is a major stressor in Narragansett Bay, the tools consider habitats and landscapes that are sensitive to (and diagnostic of) nutrient stress. At the habitat scale, NBEP and EPA's Atlantic Ecology Division (Narragansett) are developing approaches for biological assessment of macroinvertebrates in deeper subtidal areas, camera-based approaches to examine biology in deeper subtidal areas, and approaches for evaluating seagrass and microalgae as tools to better manage nutrient inputs to the waterbody and watershed. The overall project goal is to develop an estuarine framework that can apply at multiple scales and levels using several methods of biological assessment, all brought together with the "common language" of the BCG.

Transferability to Freshwater Aquatic Ecosystems

By performing biological assessments and developing BCGs at multiple spatial scales and levels of biological organization in estuaries and coral reef ecosystems, EPA, NOAA, and their NEP partners will better understand the interactions among biological communities with system-level processes that define and regulate ecosystems, and will be able to assess the cumulative effects of multiple stressors over large spatial scales and over longer periods of time (e.g., decadal). The results of this work are expected to be adapted to large and complex freshwater systems, such as braided river networks, lakes, and large rivers and their attendant watersheds. In river systems, for example, EPA's Ecological Exposure Research Division (Cincinnati) is developing geographic information system- (GIS-) based tools to classify and characterize natural variability in watersheds and concurrently developing watershed-scale models integrating habitat and landscape biological assessments of classified river systems, incorporating main channel and lateral slackwaters (bays, side channels, and backwaters) with the floodscape (isolated oxbows, lakes, wetlands, and usually dry alluvial floodplains). A major component of this work focuses on defining critical ecological thresholds, or tipping points, of ecological condition and function in river systems in response to multiple stressors in watersheds at multiple spatial and temporal scales.

Tools such as these could support watershed and basin wide management and planning, enabling state, tribal and local resource managers to: 1) account for more of the natural variability within and across river systems, watershed and regions; 2) relate changes in stressors exposure to changes in biological (and functional) condition at both a watershed and system-wide level; and, 3) facilitate the extrapolation of findings from one system and/or watershed to other similarly located or functioning systems.

3.17 Partnerships in the Protection of Oregon's Coho Salmon

Abstract

Assessment of biological conditions in Oregon's Coast Coho Evolutionarily Significant Unit (ESU) has provided state agencies with valuable information that can be used to improve protection of coho salmon. Oregon Department of Environmental Quality and Oregon Department of Fish and Wildlife are using monitoring data to examine several indicators—temperature and fine sediments—that have been identified as potential causes of coho population decline in the state. Findings show that the two monitoring areas with the highest biological condition also showed the lowest evidence of stress from temperature and fine sediment. National Oceanic and Atmospheric Administration's Fisheries Division has also been able to use biological information to support a decision to list coho as *threatened* and to designate the Oregon Coast Coho ESU as a critical habitat.

Introduction

For more than a decade, state and federal agencies have been working to halt the decline of coho salmon in Oregon. In 1997 Oregon implemented the Oregon Plan for Salmon and Watersheds, a step toward reversing the decline of coho salmon in Oregon coastal streams. In response, Oregon Department of Environmental Quality (ODEQ) and Oregon Department of Fish and Wildlife (ODFW) began expanded monitoring in Oregon coastal streams to gather information on the status of water quality and watershed health indicators identified as potential causes for declining populations of Oregon coastal coho salmon (State of Oregon 1997).

In 2005 ODEQ and ODFW assessed the information collected on the factors for the decline of coho and evaluated the relative importance of each factor to the continued viability of Oregon's coastal coho runs into the future. Specifically, ODEQ and ODFW assessed data for the Oregon Coast Coho Evolutionarily Significant Unit (ESU). The Oregon Coast Coho ESU is in western Oregon, spanning approximately three-quarters of the coastline with the Pacific Ocean and contains more than 9,000 miles of rivers and streams. Most of the stream miles (more than 80 percent) are small, wadeable streams (1^{st} through 3^{rd} order). Two hundred and eighty-three randomly selected sites were characterized throughout the ESU, ranging from 61 to 86 sites per monitoring area. Specifically, data were analyzed for four monitoring areas nested within the ESU (North Coast, Mid-Coast, Mid-South Coast, and Umpqua).

In 2007 ODFW released the final draft of the *Oregon Coast Coho Conservation Plan* (State of Oregon 2007), which outlines Oregon's strategy to ensure the continued viability of threatened coastal coho salmon runs. Part of the plan identifies the need for higher-resolution monitoring of water quality and macroinvertebrates in the Oregon Coast Coho ESU (Lawson et al. 2007). Because of the ability of macroinvertebrates to integrate the effects of water quality and habitat stressors—and limited resources for comprehensive monitoring—ODEQ and ODFW agreed that macroinvertebrates would be used to relate water quality and overall watershed condition in the ESU. In 2008, National Oceanic and Atmospheric Administration (NOAA) Fisheries Division used the information in its final decision to re-list Oregon coastal coho as *threatened* under the Endangered Species Act.

Assessment of Biological Condition

In 2006–2007 ODEQ and ODFW jointly collected and analyzed macroinvertebrate data in the ESU. They evaluated biological condition for each of four monitoring areas in the ESU. Macroinvertebrates were also used as a screening tool to determine the relative contributions of temperature and fine sediment as stressors to biological condition.

A multivariate predictive model, PREDATOR, was used to assess the biological condition of wadeable streams throughout Oregon (Hubler 2008). The model compares observed taxa with expected taxa to generate an observed/expected (O/E) taxa ratio. Scores of less than 1.0 have fewer taxa at a site than were predicted by the model, representing a loss of native reference taxa richness. Benchmarks based on the distribution of O/E scores at reference sites were used to classify the samples into one of the three following biological condition classes: least disturbed, moderately disturbed, and most disturbed (Table 3-12).

Table 3-12. Biological benchmarks.

Biological condition class	O/E	Taxa loss
Least disturbed	> 0.91	8% or less
Moderately disturbed	0.86–0.91	9%–14%
Most disturbed	< 0.86	15% or more

Subsequent monitoring showed that approximately 50 percent of the streams could be classified as least disturbed (equivalent to reference), while almost 40 percent of streams in the ESU had macroinvertebrates in most disturbed conditions (missing a considerable amount of reference taxa). The four monitoring units showed different relative proportions of condition classes. The Mid-Coast monitoring area had the largest proportion of sites in highest biological condition with 69 percent of sites in least disturbed condition and 17 percent of sites in most disturbed condition. The Umpqua monitoring unit showed only about one-quarter of sites in least disturbed conditions and approximately two-thirds of sites in most disturbed conditions. That information, along with stressor information for each monitoring unit, became very important in developing the stressor-response model. The information was used to try to identify the relative importance of two key (NPS) stressors to macroinvertebrate conditions in the Oregon Coastal Coho ESU.

Stressor-Response Model

The relationships among macroinvertebrate abundances and environmental variables (seasonal maximum temperature and percent fines) were used to model the optimum conditions for each taxon. These optimal conditions were then used to infer the overall assemblage preference for temperature and fine sediments of any site using a macroinvertebrate sample alone (Huff et al. 2006). Benchmarks were established to identify sites where temperature or fine sediments or both can be at levels considered to be stressful to the macroinvertebrate assemblages. Temperature stress (TS) values above 18 °C were considered temperature stressed, as it relates directly to the WQS set to protect salmon and trout rearing and migration. Fine sediment stress (FSS) values above 10 percent were considered sediment stressed because that value has been shown to negatively affect macroinvertebrates in mountain streams (Bryce et al. 2010).

The North Coast monitoring area showed the lowest levels of TS (36 percent of sites) and FSS (22 percent). The Mid-Coast monitoring area showed approximately half of the sites as stressed for both temperature and fine sediment, despite showing the highest percentage of sites in least disturbed biological condition. Both the Mid-South and Umpqua monitoring areas showed two-thirds or more of the sites to be stressed for both temperature and fine sediment. Apart from the North Coast, stresses to the macroinvertebrate assemblages from temperature and fine sediments appear to be equivalent.

Conclusions

Biological data and stressor-response relationships were used as the basis for several findings. First, NOAA was able to make a decision to list coho as *threatened* and to designate the Oregon Coast ESU as a critical habitat. Second, several general trends were observed in the assessment of the macroinvertebrate data collected and assessed. The two monitoring areas with the highest biological condition (North Coast and Mid-Coast) showed the lowest evidence of stress from temperature and fine sediment. The Mid-South Coast and Umpqua monitoring areas showed higher levels of stress and lower biological condition (substantially so in the Umpqua). That information can be used in developing management plans for ESU monitoring areas or basins. Much emphasis has been placed on improving the temperature conditions in Oregon's streams and rivers, while less work has gone into developing sediment management plans. The data presented here suggest that excess fine sediments are affecting biological conditions in the ESU on a scale similar to that of temperature.

Finally, the monitoring project is an example of two state agencies working together to implement a monitoring program that is cost-effective by addressing both agencies' needs for information. For ODFW, the random macroinvertebrate, water quality, and habitat sampling protocol provides critical information on water quality and habitat conditions, which have been identified as limiting factors to coho salmon viability. For ODEQ, the macroinvertebrate sampling in conjunction with the water quality and habitat monitoring provides valuable information on attainment of the designated aquatic life uses for streams.

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Yoder, C.O., and E.T. Rankin. 1995. Biological Response Signatures and the Area of Degradation Value: New Tools for Interpreting Multimetric Data. In *Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making*, ed. W.S. Davis and P. Simon, pp. 263–286. Lewis Publishers, Boca Raton, FL.

Glossary

aquatic assemblage	An association of interacting populations of organisms in a given waterbody; for example, fish assemblage or a benthic macroinvertebrate assemblage.
aquatic community	An association of interacting assemblages in a waterbody, the biotic component of an ecosystem.
aquatic life use	A beneficial use designation in which the waterbody provides, for example, suitable habitat for survival and reproduction of desirable fish, shellfish, and other aquatic organisms.
attribute	The measurable part or process of a biological system.
benthic macroinvertebrates or benthos	Animals without backbones, living in or on the sediments, of a size large enough to be seen by the unaided eye and which can be retained by a U.S. Standard no. 30 sieve (28 meshes per inch, 0.595-mm openings); also referred to as benthos, infauna, or macrobenthos.
best management practice	An engineered structure or management activity, or combination of those, that eliminates or reduces an adverse environmental effect of a pollutant.
biological assessment or bioassessment	An evaluation of the biological condition of a waterbody using surveys of the structure and function of a community of resident biota.
biological criteria or biocriteria	Narrative expressions or numeric values of the biological characteristics of aquatic communities based on appropriate reference conditions; as such, biological criteria serve as an index of aquatic community health.
biological indicator or bioindicator	An organism, species, assemblage, or community characteristic of a particular habitat, or indicative of a particular set of environmental conditions.
biological integrity	The ability of an aquatic ecosystem to support and maintain a balanced, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats in a region.
biological monitoring or biomonitoring	Use of a biological entity as a detector and its response as a measure to determine environmental conditions; ambient biological surveys and toxicity tests are common biological monitoring methods.
biological survey or biosurvey	Collecting, processing, and analyzing a representative portion of the resident aquatic community to determine its structural and/or functional characteristics.

biotope	An area that is relatively uniform in physical structure and that is identified by a dominant biota.
Clean Water Act	The act passed by the U.S. Congress to control water pollution (formally referred to as the Federal Water Pollution Control Act of 1972). Public Law 92-500, as amended. 33 U.S.C. 1251 *et seq*.
Clean Water Act 303(d)	This section of the act requires states, territories, and authorized tribes to develop lists of impaired waters for which applicable WQS are not being met, even after point sources of pollution have installed the minimum required levels of pollution control technology. The law requires that the jurisdictions establish priority rankings for waters on the lists and develop TMDLs for the waters. States, territories, and authorized tribes are to submit their lists of waters on April 1 in every even-numbered year.
Clean Water Act 305(b)	Biennial reporting requires description of the quality of the nation's surface waters, evaluation of progress made in maintaining and restoring water quality, and description of the extent of remaining problems.
criteria	Elements of state water quality standards, expressed as constituent concentrations, levels, or narrative statements, representing a quality of water that supports a particular use. When criteria are met, water quality will generally protect the designated use.
designated uses	Those uses specified in WQS for each waterbody or segment whether or not they are being attained.
disturbance	Human activity that alters the natural state and can occur at or across many spatial and temporal scales.
ecological integrity	The condition of an unimpaired ecosystem as measured by combined chemical, physical (including physical habitat), and biological attributes. Ecosystems have integrity when they have their native components (plants, animals and other organisms) and processes (such as growth and reproduction) intact.
ecoregion	A relatively homogeneous ecological area defined by similarity of climate, landform, soil, potential natural vegetation, hydrology, or other ecologically relevant variables.
function	Processes required for normal performance of a biological system (may be applied to any level of biological organization).
guild	A group of organisms that exhibit similar habitat requirements and that respond in a similar way to changes in their environment.

historical data	Data sets from previous studies, which can range from handwritten field notes to published journal articles.
index of biological/biotic integrity	An integrative expression of site condition across multiple metrics; an IBI is often composed of at least seven metrics.
invasive species	A species whose presence in the environment causes economic or environmental harm or harm to human health. Native species or nonnative species can show invasive traits, although that is rare for native species and relatively common for nonnative species. (Note that this term is not included in the biological condition gradient [BCG].)
least disturbed condition	The best available existing conditions with regard to physical, chemical, and biological characteristics or attributes of a waterbody within a class or region. Such waters have the least amount of human disturbance in comparison to others in the waterbody class, region, or basin. Least disturbed conditions can be readily found but can depart significantly from natural, undisturbed conditions or minimally disturbed conditions. Least disturbed condition can change significantly over time as human disturbances change.
maintenance of populations	Sustained population persistence; associated with locally successful reproduction and growth.
metric	A calculated term or enumeration that represents some aspect of biological assemblage, function, or other measurable aspect and is a characteristic of the biota that changes in some predictable way with increased human influence.
minimally disturbed condition	The physical, chemical, and biological conditions of a waterbody with very limited, or minimal, human disturbance.
multimetric index	An index that combines indicators, or metrics, into a single index value. Each metric is tested and calibrated to a scale and transformed into a unitless score before being aggregated into a multimetric index. Both the index and metrics are useful in assessing and diagnosing ecological condition. See **index of biological/biotic integrity (IBI).**
narrative biological criteria	Written statements describing the structure and function of aquatic communities in a waterbody that support a designated aquatic life use.
native	An original or indigenous inhabitant of a region; naturally present.

nonnative or intentionally introduced species	With respect to an ecosystem, any species that is not found in that ecosystem; species introduced or spread from one region of the United States to another outside their normal range are nonnative or non-indigenous, as are species introduced from other continents.
numeric biological criteria	Specific quantitative measures of the structure and function of aquatic communities in a waterbody necessary to protect a designated aquatic life use.
periphyton	A broad organismal assemblage composed of attached algae, bacteria, their secretions, associated detritus, and various species of microinvertebrates.
rapid bioassessment protocols	Cost-effective techniques used to survey and evaluate the aquatic community to detect aquatic life impairments and their relative severity.
reference condition (biological integrity)	The condition that approximates natural, unaffected conditions (biological, chemical, physical, and such) for a waterbody. Reference condition (biological integrity) is best determined by collecting measurements at a number of sites in a similar waterbody class or region undisturbed by human activity, if they exist. Because undisturbed conditions can be difficult or impossible to find, minimally or least disturbed conditions, combined with historical information, models, or other methods can be used to approximate reference condition as long as the departure from natural or ideal is understood. Reference condition is used as a benchmark to determine how much other waterbodies depart from this condition because of human disturbance. See definitions for minimally and least disturbed condition
reference site	A site selected for comparison with sites being assessed. The type of site selected and the types of comparative measures used will vary with the purpose of the comparisons. For the purposes of assessing the ecological condition of sites, a reference site is a specific locality on a waterbody that is undisturbed or minimally disturbed and is representative of the expected ecological integrity of other localities on the same waterbody or nearby waterbodies.
refugia	Accessible microhabitats or regions in a stream reach or watershed where adequate conditions for organism survival are maintained during circumstances that threaten survival; for example, drought, flood, temperature extremes, increased chemical stressors, habitat disturbance.

sensitive taxa — Taxa intolerant to a given anthropogenic stress; first species affected by the specific stressor to which they are *sensitive* and the last to recover following restoration.

sensitive or regionally endemic taxa — Taxa with restricted, geographically isolated distribution patterns (occurring only in a locale as opposed to a region), often because of unique life history requirements. Can be long-lived, late-maturing, low-fecundity, limited-mobility, or require mutualist relation with other species. Can be among listed endangered/threatened or special concern species. Predictability of occurrence often low; therefore, requires documented observation. Recorded occurrence can be highly dependent on sample methods, site selection, and level of effort.

sensitive - rare taxa — Taxa that naturally occur in low numbers relative to total population density but can make up large relative proportion of richness. Can be ubiquitous in occurrence or can be restricted to certain micro-habitats, but because of low density, recorded occurrence is dependent on sample effort. Often stenothermic (having a narrow range of thermal tolerance) or coldwater obligates; commonly k-strategists (populations maintained at a fairly constant level; slower development; longer life span). Can have specialized food resource needs or feeding strategies. Generally intolerant to significant alteration of the physical or chemical environment; are often the first taxa observed to be lost from a community.

sensitive - ubiquitous taxa — Taxa ordinarily common and abundant in natural communities when conventional sample methods are used. Often having a broader range of thermal tolerance than sensitive or rare taxa. These are taxa that constitute a substantial portion of natural communities and that often exhibit negative response (loss of population, richness) at mild pollution loads or habitat alteration.

stressors — Physical, chemical, and biological factors that adversely affect aquatic organisms.

structure — Taxonomic and quantitative attributes of an assemblage or community, including species richness and relative abundance structurally and functionally redundant attributes of the system and characteristics, qualities, or processes that are represented or performed by more than one entity in a biological system.

taxa — A grouping of organisms given a formal taxonomic name such as species, genus, family, and the like.

taxa of intermediate tolerance	Taxa that compose a substantial portion of natural communities; can be r-strategists (early colonizers with rapid turnover times; boom/bust population characteristics). Can be eurythermal (having a broad thermal tolerance range). Can have generalist or facultative feeding strategies enabling utilization of relatively more diversified food types. Readily collected with conventional sample methods. Can increase in number in waters with moderately increased organic resources and reduced competition but are intolerant of excessive pollution loads or habitat alteration.
tolerant taxa	Taxa that compose a small proportion of natural communities. They are often tolerant of a broader range of environmental conditions and are thus resistant to a variety of pollution- or habitat-induced stresses. They can increase in number (sometimes greatly) in the absence of competition. Commonly r-strategists (early colonizers with rapid turnover times; boom/bust population characteristics), able to capitalize when stress conditions occur; last survivors.
total maximum daily load	The sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources; the calculated maximum amount of a pollutant a waterbody can receive and still meet WQS and an allocation of that amount to the pollutant's source.
toxicity identification evaluation	A set of procedures to identify the specific chemicals responsible for effluent toxicity.
toxicity reduction evaluation	A site-specific study conducted in a stepwise process designed to identify the causative agents of effluent toxicity, isolate the sources of toxicity, evaluate the effectiveness of toxicity control options, and then confirm the reduction in effluent toxicity.
water quality management (nonregulatory)	Decisions on management activities relevant to a water resource, such as problem identification, need for and placement of best management practices, pollution abatement actions, and effectiveness of program activity.
water quality standard	A law or regulation that consists of the designated use or uses of a waterbody, the narrative or numerical water quality criteria (including biological criteria) that are necessary to protect the use or uses of that waterbody, and an antidegradation policy.

whole effluent toxicity	The aggregate toxic effect of an aqueous sample (e.g., whole effluent wastewater discharge) as measured by an organism's response after exposure to the sample (e.g., lethality, impaired growth or reproduction); WET tests replicate the total effect and actual environmental exposure of aquatic life to toxic pollutants in an effluent without requiring the identification of the specific pollutants.

Abbreviations and Acronyms

ADEQ	Arizona Department of Environmental Quality
BCG	biological condition gradient
BMIBI	benthic macroinvertebrate index of biotic integrity
BMP	best management practice
CADDIS	Causal Analysis/Diagnosis Decision Information System
CT DEP	Connecticut Department of Environmental Protection
CWA	Clean Water Act
CWH	coldwater habitat
EPA	U.S. Environmental Protection Agency
EPT	ephemeroptera, plecoptera, trichoptera taxa
ESU	evolutionarily significant unit
EV	exceptional value (Pennsylvania)
EWH	exceptional warmwater habitat
FIBI	fish index of biotic integrity
FQI	Floristic Quality Index
FSS	fine sediment stress
GIS	geographic information system
GPS	global positioning system
HQ	high-quality (Pennsylvania)
HUC	hydrologic unit code
IBI	index of biological/biotic integrity
IC	impervious cover
ICI	invertebrate community index
IDNR	Iowa Department of Natural Resources
INSTAR	Interactive Stream Assessment Resource
IRG	Integrated Reporting Guidance
LRW	limited resource water
LWH	limited warmwater habitat
MDE	Maryland Department of the Environment
MDEQ	Michigan Department of Environmental Quality
MDNR	Maryland Department of Natural Resources
ME DEP	Maine Department of Environmental Protection
mIBI	modified index of biological integrity
MIwb	modified index of well-being
MPCA	Minnesota Pollution Control Agency
MWH	modified warmwater habitat
NARS	National Aquatic Resource Surveys
NAWQA	National Water-Quality Assessment
NBEP	Narragansett Bay Estuary Program

NEP	National Estuary Program
NFMR	North Fork Maquoketa River
NJ DEP	New Jersey Department of Environmental Protection
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	nonpoint source
NTU	nephelometric turbidity unit
NWQC	numeric water quality criteria
O/E	observed over expected
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
ONRW	Outstanding National Resource Water
ORD	Office of Research and Development (U.S. Environmental Protection Agency)
PA DEP	Pennsylvania Department of Environmental Protection
PREDATOR	PREDictive Assessment Tool for Oregon
QHEI	qualitative habitat evaluation index
RIVPACS	River Invertebrate Prediction and Classification System
SI	stressor identification
SSH	seasonal salmonid habitat
TBEP	Tampa Bay Estuary Program
TIE	toxicity identification evaluation
TMDL	Total Maximum Daily Load
TRE	toxicity reduction evaluation
TS	temperature stress
UAA	use attainability analysis
UCONN	University of Connecticut
USGS	U.S. Geological Survey
UT DEQ	Utah Department of Environmental Quality
VA DCR	Virginia Department of Conservation and Recreation
VSA	Virtual Stream Assessment
VT DEC	Vermont Department of Environmental Conservation
WET	whole effluent toxicity
WQL	water quality limited
WQS	water quality standards
WWH	warmwater habitat
WWTF	wastewater treatment facility
WWTP	wastewater treatment plant

Appendix A. Additional Resources

Biological Assessment and Biological Criteria: Technical Guidance

Biological assessment and biological criteria	**Description/summary**
Biological Criteria: National Program for Surface Waters (EPA 440-5-90-004) Source: U.S. Environmental Protection Agency Date of Publication: 1990	This document provides EPA regions, states and others with the conceptual framework and assistance necessary to develop and implement narrative and numeric biological criteria and to promote national consistency in application.
http://www.epa.gov/bioindicators/pdf/EPA-440-5-90-004Biologicalcriterianationalprogramguidanceforsurfacewaters.pdf	
Policy on the Use of Bioassessments and Criteria in the Water Quality Program Source: U.S. Environmental Protection Agency Date of Publication: 1991	This document provides policy guidance on integration of biological surveys, assessments, and criteria with chemical-specific analysis and whole effluent and ambient toxicity testing methods in the water quality program.
http://www.epa.gov/bioiweb1/pdf/PolicyonBiologicalAssessmentsandCriteria.pdf	
Coral reefs	**Description/summary**
Stony Coral Rapid Bioassessment Protocol (EPA 600-R-06-167) Source: U.S. Environmental Protection Agency Date of Publication: 2007	The principal purpose of the *Stony Coral Rapid Bioassessment Protocol* is to introduce a simple and rapid coral survey method that provides multiple biological indicators to characterize coral condition. The document offers insight on indicator relevance to ecosystem services (societal values), reef condition, and sustainability. It provides information regarding regulatory programs, and it presents a few examples describing how biological assessment indicators can be incorporated into a regulatory biological criteria program to conserve coral resources.
http://www.epa.gov/bioindicators/pdf/EPA-600-R-06-167StonyCoralRBP.pdf	
Coral Reef Biological Criteria: Using the Clean Water Act to Protect a National Treasure (EPA-600-R-10-054) Source: U.S. Environmental Protection Agency Date of Publication: 2010	Coral reef resource managers can use this document as a guide for developing and implementing biological criteria as part of water quality standards. Biological criteria are complementary to chemical and physical criteria and, once established, carry the same regulatory authority. The document introduces the role of biological criteria under the Clean Water Act and describes the process for identifying metrics, establishing reference values, designing a long-term monitoring program, and integrating biological criteria with existing management programs. It includes sections that link biological criteria to high-visibility issues such as ecosystem services, climate change, and ocean acidification.
http://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=223392	
Estuaries and coastal waters	**Description/summary**
Estuarine and Coastal Marine Waters: Bioassessment and Biocriteria Technical Guidance (EPA 822-B-00-024) Source: U.S. Environmental Protection Agency Date of Publication: 2000	This technical guidance provides an extensive collection of methods and protocols for conducting biological assessments in estuarine and coastal marine waters and the procedures for deriving biological criteria from the results. See also *National Coastal Condition Reports* (2001, 2004 and 2008) under *National Aquatic Resource Surveys* listed below.
http://www.epa.gov/waterscience/biocriteria/States/estuaries/estuaries.pdf	

Lakes and reservoirs	**Description/summary**
Lakes and Reservoir Bioassessment and Biocriteria Technical Guidance Document (EPA 841-B-98-007) Source: U.S. Environmental Protection Agency Date of Publication: 1998	This guidance is intended to provide managers and field biologists with functional methods and approaches that will facilitate the implementation of viable lake biological assessment and biological criteria programs that meet their needs and resources. Procedures for program design, reference condition determination, field biological surveys, biological criteria development, and data analysis are detailed. In addition, the document provides information on the application and effectiveness of lake biological assessment to existing EPA and state/tribal programs such as the Clean Lakes Program, 305(b) assessments, NPDES permitting, risk assessment, and watershed management. See also *National Lakes Assessment Report* (2010) under *National Aquatic Resource Surveys* listed below.
http://www.epa.gov/owow/monitoring/tech/lakes.html	
Non-wadeable streams and rivers	**Description/summary**
Concepts and Approaches for the Bioassessment of Non-wadeable Streams and Rivers (EPA 600-R-06-127) Source: U.S. Environmental Protection Agency Date of Publication: 2006	This document provides a framework for the development of biological assessment programs and biological criteria for large rivers. It helps states establish or refine their large river protocols for field sampling, laboratory sample processing, data management and analysis, and assessment and reporting.
http://www.epa.gov/eerd/rivers/non-wadeable_full_doc.pdf	
Streams and wadeable rivers	**Description/summary**
Biological Criteria: Technical Guidance for Streams and Small Rivers (EPA 822-B-96-001) Source: U.S. Environmental Protection Agency Date of Publication: 2001	The goal of this document is to help states develop and use biological criteria for streams and small rivers. It includes a general strategy for biological criteria development, identifies steps in the process, and provides technical guidance on how to complete each step, using the experience and knowledge of existing state, regional, and national surface water programs. See also *Wadeable Streams Assessment Report* (2006) under *National Aquatic Resource Surveys* listed below.
http://www.epa.gov/bioindicators/pdf/EPA-822-B-96-001BiologicalCriteria-TechnicalGuidanceforStreamsandSmallRivers-revisededition1996.pdf	
Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, 2nd ed. (EPA 841-B-99-002) Source: U.S. Environmental Protection Agency Date of Publication: 1999	This document is a practical technical reference for conducting cost-effective biological assessments of lotic systems. The Rapid Bioassessment Protocols (RBPs) are a blend of existing methods used by various states to sample biological assemblages and assess physical habitat.
http://www.epa.gov/owow/monitoring/rbp/download.html	

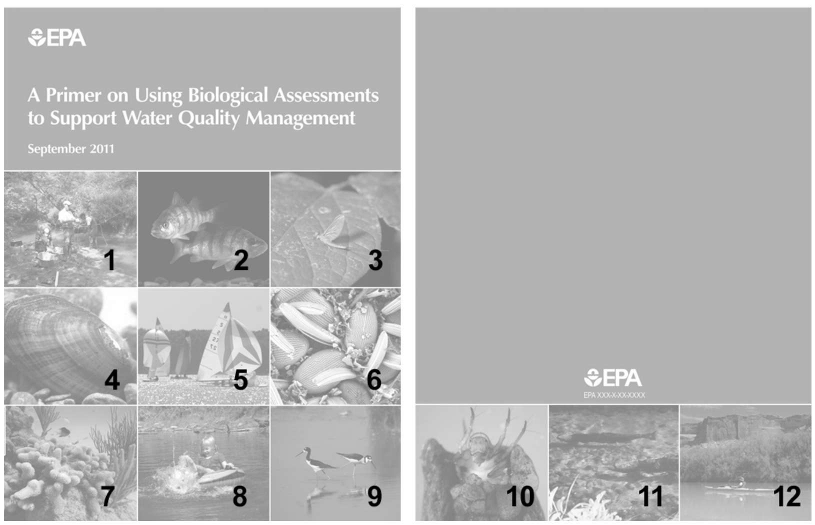
Other Relevant Water Program Guidance

Listing and TMDLs	Description/summary
Memorandum: Clarification of the Use of Biological Data and Information in the 2002 Integrated Water Quality Monitoring and Assessment Report Guidance Source: U.S. Environmental Protection Agency Date of Publication: 2002	This memorandum modified the 2002 *Integrated Water Quality Monitoring and Assessment Report Guidance* to provide clarity and promote consistency in the manner in which states use biological data and information in developing their submissions.
http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/biochange20302.cfm	
Guidance for 1994 Section 303(d) Lists Source: U.S. Environmental Protection Agency Date of Publication: 1994	This memorandum clarified how biological data can be used to support listing of a waterbody on the section 303(d) list.
http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/1994guid.cfm	
Recovery Potential Screening Source: U.S. Environmental Protection Agency Date of Publication: 2012	The Recovery Potential Screening website is a user-driven, flexible approach for comparing relative differences in restorability among impaired waters. The screening process uses ecological, stressor, and social indicators to evaluate and compare waters and reveal factors that may explain the relative restorability of waters. This technical method and website are intended to assist in complex planning and prioritizing decisions, provide a systematic and transparent comparison approach, reveal underlying environmental and social factors that affect restorability, and better inform restoration strategies to help achieve results. The website provides step-by-step directions in the screening process, downloadable tools for calculating indices and displaying results, summaries of indicators and their measurement from common data sources, a recovery literature database, and several case studies and related links.
http://www.epa.gov/recoverypotential/	

Monitoring and assessment	Description/summary
Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act Source: U.S. Environmental Protection Agency Date of Publication: 2005	This guidance is for states, territories, authorized tribes, and interstate commissions that help prepare and submit section 305(b) reports (referred to as *jurisdictions*). It outlines the development of biennial Integrated Reports, which that would support EPA's strategy for achieving a broad-scale, national inventory of water quality conditions. The objective of this guidance is to provide jurisdictions (1) a recommended reporting format and (2) suggested content to be used in developing a single document that integrates the reporting requirements of CWA sections 303(d), 305(b), and 314. (Pursuant to the CWA, jurisdictions report to EPA biannually on the condition of waters within their boundaries.)
http://www.epa.gov/owow/tmdl/2006IRG/report/2006irg-report.pdf	
Elements of a State Water Monitoring and Assessment Program (EPA 841-B-03-003) Source: U.S. Environmental Protection Agency Date of Publication: 2003	This document recommends 10 basic elements of a state water monitoring program and serves as a tool to help EPA and states determine whether a monitoring program meets the prerequisites of CWA section 106(e)(1).
http://www.epa.gov/owow/monitoring/elements/	
Consolidated Assessment and Listing Methodology (CALM): Toward a Compendium of Best Practices Source: U.S. Environmental Protection Agency Date of Publication: 2002	CALM provides a framework for states and other jurisdictions to document how they collect and use water quality data and information for environmental decision making. The primary purposes of the data analyses are to determine the extent to which all waters are attaining water quality standards, to identify waters that are impaired and need to be added to the 303(d) list, and to identify waters that can be removed from the list because they are attaining standards.
http://www.epa.gov/owow/monitoring/calm.html	
Biological Criteria: Technical Guidance for Survey Design and Statistical Evaluation of Biosurvey Data (EPA 822-B97-002) Source: U.S. Environmental Protection Agency Date of Publication: 1997	The emphasis of this guidance is on the practical application of basic statistical concepts to the development of biological criteria for surface water resource protection, restoration, and management.
http://www.epa.gov/bioindicators/pdf/EPA-822-B-97-002BiologicalCriteria-TechnicalGuidanceforSurveyDesignandStatisticalEvaluationofBiosurveyData.pdf	
Generic Quality Assurance Project Plan Guidance for Programs Using Community Level Biological Assessment in Wadeable Streams and Rivers (EPA 841-B-95-004) Source: U.S. Environmental Protection Agency Date of Publication: 1995	This document represents generic guidance for development of QAPPs for specific biological assessment projects or programs. It has been specifically designed for use by states using biological assessment protocols that focus on community-level responses as indicated by a multimetric approach and taxonomy to the genus/species level.
http://www.epa.gov/bioindicators/pdf/EPA-841-B-95-004GenericQualityAssuranceProjectPlanBioassessment.pdf	

National Aquatic Resource Surveys: *National Coastal Condition Report*. (2001) EPA-620/R-01/005 *National Coastal Condition Report II*. (2004) EPA-620/R-03/002 *Wadeable Streams Assessment.* (2006) EPA-841-B-06-002 *National Coastal Condition Report III*. (2008) EPA/842-R-08-002 *National Lakes Assessment*. (2010) EPA-841-R-09-001 Source: U.S. Environmental Protection Agency Dates of Publication: see above	The surveys are conducted using a statistical survey design to yield unbiased, statistically representative estimates of the biological condition of the whole water resource (e.g., wadeable streams, lakes, rivers). Data are collected, processed, and analyzed through EPA-state collaboration to assess and report on the condition of the nation's waters with documented confidence. Surveys collect a suite of indicators relating to the biological/physical habitat and water quality of the resource to assess the resource condition and determine the percentage meeting the goals of the CWA. Surveys collect information on biological and abiotic factors at 30–50 sites on an ecoregion level II scale for each resource.
http://www.epa.gov/owow/monitoring/nationalsurveys.html http://www.epa.gov/owow/oceans/nccr/ http://www.epa.gov/owow/streamsurvey/ http://www.epa.gov/owow/lakes/lakessurvey/	
Predictive Tools	**Description/summary**
Landscape and Predictive Tools: A Guide to Spatial Analysis for Environmental Assessment (draft) (EPA-100-R-11-002) Source: U.S. Environmental Protection Agency Date of Publication: In process of finalization. Release expected 2012.	This methods manual describes the purpose, rationale, and basic steps for using landscape and predictive tools for Clean Water Act monitoring, assessment, and management purposes such as filling monitoring gaps and prioritizing protection and rehabilitation actions. This guidance stresses simultaneous use of matched (or paired) landscape and in situ data for empirical modeling to enhance predictive capabilities and encourage science-based targeting and priority setting. Example and potential applications include criteria and standards development, problem identification and prevention, prioritization and targeting of rehabilitation, and advancing science, education, and society's ability to effectively manage aquatic and terrestrial resources. This methods guidance is organized into four sections: (I) Introduction to Landscape and Predictive Tools; (II) Geographic Frameworks, Spatial Data, and Analysis Tools; (III) Examples and Case Studies; and (IV) Gaps and Needs for Research and Applications; plus an extensive Toolbox providing links to and short descriptions of a wide range of easily accessed data sets and analytical tools. Wider application of these tools and approaches should yield better protection for high-quality waters and quicker, more cost-effective restoration of impaired waters.
http://www.epa.gov/raf/pubecological.htm	
Stressor Response	
Causal Analysis/Diagnosis Decision Information System (CADDIS) Source: U.S. Environmental Protection Agency Date: Last updated September 23, 2010	The Causal Analysis/Diagnosis Decision Information System, or CADDIS, is a website developed to help scientists and engineers in the Regions, States, and Tribes conduct causal assessments in aquatic systems. It is organized into five volumes: • Volume 1: Stressor Identification • Volume 2: Sources, Stressors & Responses • Volume 3: Examples & Applications • Volume 4: Data Analysis • Volume 5: Causal Databases
http://www.epa.gov/caddis	

Using Stressor-response Relationships to Derive Numeric Nutrient Criteria (EPA-820-2-10-001) Source: U.S. Environmental Protection Agency Date of Publication: 2010	This document provides guidance on statistical methods for estimating stressor-response relationships between changes in nutrient concentrations and changes in biological response variables. The document also provides guidance on methods for interpreting these relationships to derive numeric nutrient criteria. Other specific topics discussed include selecting appropriate covariates to improve the accuracy of estimated relationships, and methods for accounting for uncertainty in estimated relationships when deriving criteria.
http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/upload/finalstressor2010.pdf	
Water quality-based toxics control	**Description/summary**
Technical Support Document for Water Quality-based Toxics Control (EPA-5052-90-001) Source: U.S. Environmental Protection Agency Date of Publication: 1991	This document provides technical guidance for assessing and regulating discharge of toxic substances to waters of the United States. It was issued in support of EPA regulations and policy initiatives involving the application of biological assessment and chemical techniques to control toxic pollution to surface waters.
http://www.epa.gov/npdes/pubs/owm0264.pdf	
Watershed Protection	**Description/summary**
Identifying and Protecting Healthy Watersheds: A Technical Guide (draft) Source: U.S. Environmental Protection Agency Date of Publication: In process of finalization. Release expected 2012.	This draft technical document provides an overview of the key concepts behind an approach to identify and protect healthy watersheds, examples of assessments of healthy watershed components, an integrated assessment framework for identifying healthy watersheds, examples of management approaches, sources of national data, and key assessment tools. It contains numerous examples and case studies from across the country. The intended audience for this document is aquatic resource scientists and managers at the state, tribal, regional, and local levels; non-governmental organizations; and federal agencies. It will also benefit local government land use managers and planners as they develop protection priorities.
http://water.epa.gov/polwaste/nps/watershed/index.cfm	



Front cover:

1. Sampling in Rich Fork Creek, Davidson County, NC; Credit: Tetra Tech, Inc.
2. Yellow Perch, *P. flavescens*; Credit: U.S. Department of Agriculture
3. Adult Mayfly, Order: Ephemeroptera; Credit: Extension Entomology, Texas A&M University
4. Appalachian elktoe; Credit: Dick Biggins**,** U.S. Fish and Wildlife Service
5. Sailing in Carlyle Lake, IL; Credit: U.S. Army Corps of Engineers
6. Micrograph of freshwater diatoms; Credit: Algal Ecology Laboratory, Bowling Green State University
7. Coral Reef, St. Croix, USVI; Credit: Wayne Davis, U.S. Environmental Protection Agency
8. North River, Mount Crawford, VA; Credit: Tetra Tech, Inc.
9. Black-necked Stilt (*Himantopus mexicanus*), Maui, HI; Credit: John J. Mosesso, National Biological Information Infrastructure

Back cover:

10. Caddisfly; Credit: Rick Levey, Vermont Department of Environmental Conservation
11. California, salmon resting in a pool before resuming migration; Credit: U.S. Department of Agriculture, National Resources Conservation Service
12. Green River, UT; Credit: Scott T. Eblen, Medical University of South Carolina

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