BUREAU OF WATER QUALITY
PROGRAM GUIDANCE

Wisconsin 2014 Consolidated Assessment and Listing Methodology (WisCALM) for Clean Water Act Section 305(b), 314, and 303(d) Integrated Reporting

May 2013

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APPROVED:

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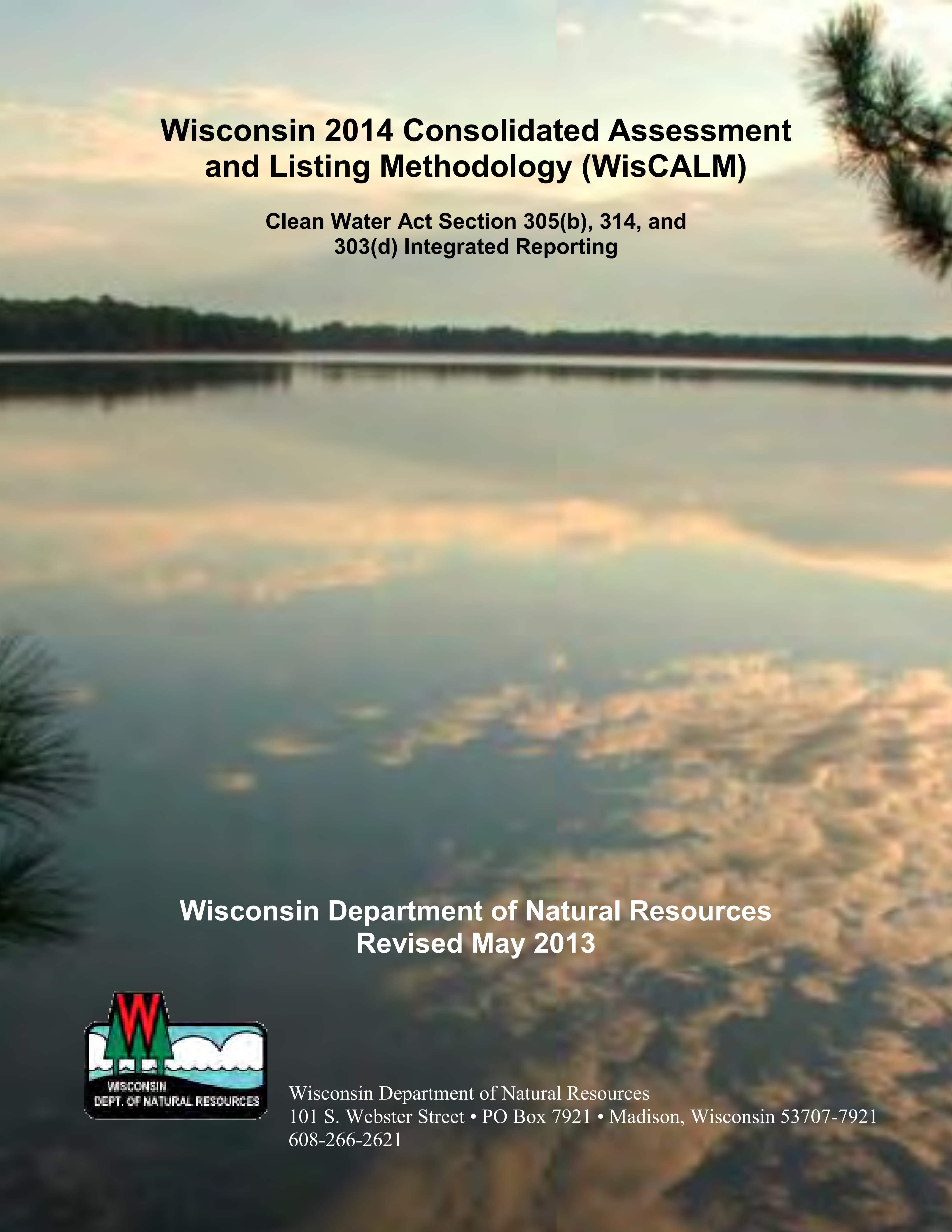
Susan Sylvester, Director Date
Bureau of Water Quality



Wisconsin 2014 Consolidated Assessment and Listing Methodology (WisCALM)

Clean Water Act Section 305(b), 314, and 303(d) Integrated Reporting

Wisconsin Department of Natural Resources
Revised May 2013

WISCONSIN
DEPT. OF NATURAL RESOURCES

Wisconsin Department of Natural Resources
101 S. Webster Street • PO Box 7921 • Madison, Wisconsin 53707-7921
608-266-2621

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- Susan Sylvester, Director, Water Quality Bureau

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Primary Authors/Editors

The 2014 Integrated Reporting Team:

Ashley Beranek, Mark Binder, Mark Hazuga, Lisa Helmuth, Jim Kreitlow, Aaron Larson, Robert Masnado, Molli MacDonald, Kristi Minahan, Ruth Person, Kurt Rasmussen, Alex Smith, Brian Weigel

Major Contributors

Nicki Clayton, Dan Helsel, John Lyons, Michael Miller, Tim Asplund, Mary Anne Lowndes

Additional Contributors

Jim Baumann, Jennifer Filbert, Toni Glymph, Mark Hazuga, Dave Heath, Russ Rasmussen, Candy Schrank, Ken Schreiber, Greg Searle, Tim Simonson, Mike Wenholz, Scott Van Egeren, Valerie Villeneuve

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Background

Over 15,000 lakes and 84,000 miles of streams and rivers in Wisconsin are managed to ensure that their water quality condition meets state and federal standards. Water quality standards (WQS) are the foundation of Wisconsin's water quality management program and serve to define goals for a waterbody by designating its uses, setting criteria to protect those uses, and establishing provisions to protect water quality from pollutants.

Waters are monitored to collect water quality data to determine, or *assess*, its current status or condition. Water quality monitoring results and assessment data are stored in state and federal databases and the majority of data are available online to agencies and the public. *General assessments* are known as "305(b) assessments" in the Federal Clean Water Act. Waters with available data are reviewed by Wisconsin Department of Natural Resources (WDNR) biologists and placed in one of four categories: excellent, good, fair and poor.

Specific assessments are conducted to determine if a waterbody is "impaired" or not meeting WQS. Waters that do not meet WQS are placed on Wisconsin's Impaired Waters List—also known as the 303(d) list—under Section 303(d) of the Clean Water Act. Wisconsin is required to submit list updates every 2 years to the United States Environmental Protection Agency (EPA) for approval. WDNR has submitted Impaired Waters Lists, as required[1], every other year since 1996.

Water quality assessments aid Department staff in determining management actions that are needed to meet WQS, including anti-degradation, or maintenance, of existing water quality condition, as well as restoration of impaired waters.

Each state must document the methodology used to assess waters, including how the state makes decisions to add or delete waters from the existing Impaired Waters List. Waters may be removed from the list (delisted) when water quality data identifies that the designated use has been restored (i.e., the water is meeting WQS). The methodology for conducting general and specific assessments is outlined, and updated for 2014, in this Wisconsin Consolidated Assessment and Listing Methodology (WisCALM) guidance document.

[1] EPA did not require and WDNR did not submit an Impaired Waters List in FFY 2000.

1.0 Water Quality Standards: Three Elements

Wisconsin's assessment process begins with water quality standards (WQS). WDNR is authorized to establish WQS that are consistent with the Federal Clean Water Act (Public Law 92-500) through Chapter 281 of the Wisconsin Statutes. These WQS are explained in detail in chs. NR 102, 103, 104, 105, and 207 of the Wisconsin Administrative Code (Wis. Adm. Code).

The WQS described in the Wis. Adm. Code rely on three elements to collectively meet the goal of protecting and enhancing the state's surface waters:

- *Use designations*, which define the goals for a waterbody by designating its uses,
- *Water quality criteria,* which are set to protect the water body's designated uses, and
- *Anti-degradation provisions* to protect water quality from declining.

Waters not meeting one or more of these water quality elements are to be included on the Impaired Waters List.

Designated Uses

Designated uses are goals or intended uses for surface waterbodies in Wisconsin which are classified into the categories of: Fish and Aquatic Life, Recreation, Public Health and Welfare, and Wildlife. The following designated uses are described in ch. NR 102, Wis. Adm. Code:

- *Fish and Aquatic Life:* All surface waters are considered appropriate for the protection of fish and other aquatic life. Surface waters vary naturally with respect to factors like temperature, flow, habitat, and water chemistry. This variation allows different types of fish and aquatic life communities to be supported. This category has subcategories as described below.
- *Recreational Use:* All surface waters are considered appropriate for recreational use unless a sanitary survey has been completed to show that humans are unlikely to participate in activities requiring full body immersion.
- *Public Health and Welfare:* All surface waters are considered appropriate to protect for incidental contact and ingestion by humans. All waters of the Great Lakes as well as a small number of inland water bodies are also identified as public water supplies and have associated water quality criteria to account for human consumption[2].
- *Wildlife:* All surface waters are considered appropriate for the protection of wildlife that relies directly on the water to exist or rely on it to provide food for existence.

Use Designations for Fish and Aquatic Life (FAL) are separated into the following sub-categories: Coldwater (Cold), Warmwater Sport Fish (WWSF), Warmwater Forage Fish (WWFF), Limited Forage Fish (LFF) and Limited Aquatic Life (LAL). More detail on these subcategories is located in the Streams and River Classification chapter of this report.

Water Quality Criteria – Numeric and Narrative

Each designated use has its own set of water quality criteria, either numeric or narrative requirements that must be met to protect the intended use. Some of these requirements relate to the amount of the physical (e.g., water temperature) or chemical (e.g., ammonia concentrations) conditions that must be met to avoid causing harm. Wisconsin's water quality criteria may be either numeric (quantitative) or narrative

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[2] Distinct water quality criteria are specified for public water supply and non-public water supply waters. Wisconsin does not currently have a formal "Drinking Water" use designation in its standards. Establishment of a "Drinking Water" use designation may be considered as part of a future standards change. If so, specific drinking water use assessment procedures will be included in future updates to the WisCALM document.

(qualitative) and are authorized by state statutes and enumerated in chs. NR 102, 104, and 105, Wis. Adm. Code.

Numeric criteria: Numeric criteria are quantitative and are expressed as a particular concentration of a substance or an acceptable range for a substance. For example, the pH value shall be from 6-9 standard units. Numeric surface water quality criteria have been established for conventional parameters (e.g., DO, pH, and temperature), toxics (e.g., metals, organics, and ammonia), and pathogens (e.g., *E. coli* and fecal coliform bacteria). These numeric criteria are established for each designated use.

Narrative criteria: All waterbodies must meet a set of narrative criteria which qualitatively describe the conditions that should be achieved. A narrative water quality criterion is a statement that prohibits unacceptable conditions in or upon the water, such as floating solids, scum, or nuisance algae blooms that interfere with public rights. These standards protect surface waters and aquatic biota from eutrophication, algae blooms, and turbidity, among other things. The association between a narrative criterion and a waterbody's designated use is less well defined than it is for numeric criteria; however, most narrative standards protect aesthetic or aquatic life designated uses. Wisconsin's narrative criteria are found in s. NR 102.04(1), Wis. Adm. Code.

Anti-degradation
Wisconsin's anti-degradation policy is intended to maintain and protect existing uses and high quality waters. This part of a waterbody quality standard is intended to prevent water quality from sliding backwards and becoming poorer without cause, especially when reasonable control measures are available. The anti-degradation policy in Wisconsin is stated in s. NR 102.05(1) of the Wis. Adm. Code:

> "No waters of the state shall be lowered in quality unless it has been affirmatively demonstrated to WDNR that such a change is justified as a result of necessary economic and social development, provided that no new or increased effluent interferes with or becomes injurious to any assigned uses made of or presently possible in such waters."

One component of Wisconsin's anti-degradation policy is the designation of Outstanding Resource Waters (ORW) and Exceptional Resource Waters (ERW). These are surface waters which provide outstanding recreational opportunities, support valuable fisheries and wildlife habitat, have good water quality, and are not significantly impacted by human activities. ORWs typically do not have any dischargers, while ERW designation offers limited exceptions for dischargers if human health would otherwise be compromised (e.g., expansion of wastewater treatment facilities to protect public health).

Inherent in the assessment and impaired waters listing process is the application of anti-degradation provisions. Anti-degradation is an important aspect of pollution control because preventing deterioration of surface waters is less costly to society than attempting to restore waters once they have become degraded.

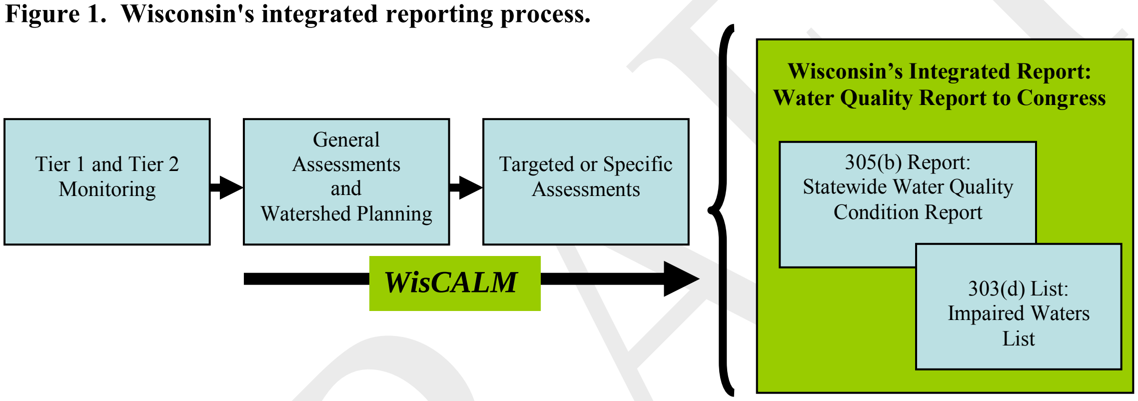
2.0 Wisconsin's Monitoring Program and Data Management

2.1 Three Tiers of Monitoring

Wisconsin DNR's Water Division Monitoring Strategy is available on WDNR's website at: http://dnr.wi.gov/topic/SurfaceWater/monitoring.html

WDNR's Surface Water Monitoring Strategy[3] directs monitoring efforts in a manner that efficiently addresses the wide variety of information needs, while providing adequate depth of surface water knowledge to support decision making. This monitoring strategy employs a three-tiered approach to information gathering to ensure that the status of Wisconsin's water resources can be determined in a comprehensive manner without depleting the capacity to conduct in-depth analyses and problem-solving where needed. The first two tiers of monitoring allow the state to assess waters and place evaluated waters into condition categories (excellent, good, fair and poor) as reflected in the Integrated Report, including the Impaired Waters List (Figure 1).

Figure 1. Wisconsin's integrated reporting process.



Three tiers of monitoring are incorporated into the Integrated Reporting Process:

Tier 1 – Statewide Baseline Monitoring: *Establishing Trends*
Under Tier 1 of the monitoring strategy, staff and partners collect baseline condition information to help satisfy Water Division information needs on a broad spatial scale. Tier 1or baseline monitoring helps obtain broad-scale, statewide assessments of Wisconsin's waters. This procedure is helpful when water resources are too numerous to evaluate individually. Wisconsin's over 84,000 stream miles, for example, call for this dispersed sampling effort which provides, through inference, technically rigorous and credible 'snapshot' of statewide water conditions. Baseline monitoring work provides core information for the state's Clean Water Act general assessment work (305(b)); however, the terms "Tier 1 monitoring" and "General Assessments" are not synonymous. A general assessment is simply reviewing existing data and consistently applying key parameters and minimum results to waters within a given area. This broad scale analysis identifies waters needing further evaluation or "specific assessments."

Under the tiered approach, metrics collected through Tier 1 monitoring include:

<u>Lakes</u>

Trophic Status Index (TSI)*
Aquatic Macrophyte Community Index (AMCI) *

[3] WDNR Water Division Monitoring Strategy, Nov. 2008. Wisconsin Department of Natural Resources, Madison, WI.

Contaminants in fish tissue—mercury and PCBs*
Pathogen indicators *
Game fish population dynamics

Streams and Rivers

Macroinvertebrate samples*
Fish assemblage characteristics*
Water chemistry*
Contaminants in fish tissue—mercury and PCBs *
Pathogen indicators*
Gamefish, Endangered, & Threatened species surveys
Habitat assessment

** Metrics used in the general assessment steps are described in chapter 4.2 and 5.2 of this report.*

Tier 2 – Targeted Evaluation Monitoring: *Site-specific Monitoring*
Sites on waterbodies identified under Tier 1 as potentially being impaired are prioritized based on professional judgment and available resources and may be monitored more intensively under Tier 2 monitoring. Tier 2 is often used to verify whether waterbodies should be placed on the Impaired Waters List and to develop comprehensive water quality management plans or Total Maximum Daily Loads (TMDLs). Under this tier, confirmation of the impairment is made, along with documentation of the pollutant and possible cause(s). For instance, Tier 2 monitoring might focus on resurveying 'flagged' Tier 1 sites and expanding monitoring along the waterbody to determine whether a problem really exists, and the extent of the problem. Or, Tier 2 monitoring might be used to determine what the cause of the impairment is. Thus, it is a more comprehensive evaluation of individual waterbodies, often requiring cross-program collaboration. Tier 2 monitoring may also provide baseline data to determine how well a waterbody responds to management, as evaluated under Tier 3.

Tier 3 – Management Effectiveness and Compliance Monitoring: *Determining effectiveness of management practices and permit conditions*
Tier 3 monitoring evaluates management practices that have been implemented through TMDL implementation or a nonpoint source nine key elements plan. Tier 2 monitoring may also provide information for evaluating permit compliance and effectiveness. Effluent monitoring helps WDNR determine whether permitted entities are meeting their permit conditions and state regulations, and to assess the health of waters receiving effluent. Monitoring of public drinking water wells is also carried out under Tier 3 to ensure that surface and groundwater meet federal public health standards for contaminants in drinking water. Effectiveness of water-specific management actions is determined using core indicators from the more intensive sampling designs under Tier 2 that are specific to the problem being addressed. The chosen indicators are compared before and after management actions are implemented.

2.2 Use of Monitoring Data from Other Sources

In addition to Department-generated data, WDNR biennially seeks information from partners and the public to use in its assessment of waterbodies. Partners include: the U.S. Geological Survey, EPA, U.S. Fish and Wildlife Service, other state agencies, universities, regional planning commissions and major municipal sewerage districts. Guidance is provided on how to submit third party data on the WDNR website. GovDelivery, a web-based service used by WDNR, was also used to solicit data from citizens. This service offers the public real-time updates on topics of interest via email or text messages, and is also used to provide information regarding the Integrated Reporting Process and Wisconsin's Impaired Waters Program.

As datasets are submitted, WDNR reviews the data and the procedures used to collect and analyze the data. WDNR will review information provided by any individual or group at any time; however, the data used for listing purposes must have been obtained using documented quality assurance procedures that meet WDNR procedures. WDNR has an internal website that outlines our State Quality Management Plan. Data submitters outside of WDNR are referred to EPA's site for questions on quality assurance project plans at http://www.epa.gov/QUALITY/qapps.html.

Agencies and individuals submitting data for assessment purposes must: meet minimum data requirements, demonstrate that sample collection occurred at appropriate sites, during appropriate periods, and use certified laboratories for sample analysis. If the quality assurance procedures are not adequate, staff may use this data to initiate further investigations by Department staff. If quality assurance procedures are adequate, WDNR may use this data to assess the water for possible impairment listing.

WDNR may assist outside groups in the design and implementation of data quality procedures necessary for data to be used for assessments. Department staff will consult with EPA water quality criteria guidance, state WQS, and use professional judgment to interpret the results of field sampling to determine whether or not WQS are achieved. Groups outside of WDNR who regularly collect and submit data to WDNR may work with staff at Central Office to upload data into the SWIMS database to be considered as part of our evaluation and assessment process.

WDNR also supports a Citizen Based Monitoring Program for rivers, streams and lakes. As stated in the WDNR's Water Resources Monitoring Strategy for Wisconsin, "If citizens follow defined methodology and quality assurance procedures, their data will be stored in a Department database and used in the same manner as any Department-collected data for status and trends monitoring defined in the Strategy." Citizen data are currently used for general water quality assessments, including broad-scale statewide assessments. If these data indicate a potential water quality problem at a specific site, additional data may be collected by Department staff to verify the extent of the problem and determine if a waterbody should be placed on the Impaired Waters List.

2.3 Quality Assurance and Laboratory Analysis

Information used for assessments must be consistent with the WDNR Quality Management Plan or have been obtained using comparable quality assurance procedures. For all Tier 1 (baseline) monitoring supporting general and statewide assessments, quality assurance measures are described within each applicable chapter of the *Wisconsin DNR Water Division Monitoring Strategy*. WDNR uses only certified laboratories sample analysis, primarily the State Lab of Hygiene and the University of Wisconsin Stevens Point Aquatic Entomology Laboratory. For targeted, or special, monitoring studies which are frequently used to discern impairment prior to listing a waterbody, quality assurance protocols, such as field blanks, duplicates or spikes, are incorporated as funds allow.

2.4 Data Management

Well organized and readily accessible data is fundamental to a smooth functioning, scientifically grounded water quality monitoring and assessment program. The WDNR has invested many resources into building and maintaining monitoring and assessment databases.

Monitoring Data –SWIMS

The Surface Water Integrated Monitoring System (SWIMS) (Figure 2) is a WDNR information system that holds chemistry (water, sediment), physical (flow), and biological (macroinvertebrate, aquatic invasive) data.

SWIMS is the state's repository for water and sediment monitoring data collected for Clean Water Act work and is the source of data sharing through the federal Water Quality Exchange Network, which is an online federal repository for all states' water monitoring data. WDNR Fisheries and Water Quality Biologists use the system to document monitoring stations for both Water Quality and Fisheries Program datasets, providing a gateway to fisheries management datasets housed at the U.S. Geological Survey.

Figure 2. SWIMS database sign in screen.

The SWIMS database supports Citizen Based Stream Monitoring (CBSM) Level 2 Program volunteers. Level 2 volunteers come into the program with previous water monitoring experience, most volunteers having participated in the CBSM Level 1 Program (Water Action Volunteers or WAV Program). The Level 2 training focuses on the proper use of WDNR field methods and specialized equipment, such as transparency tubes, DO and pH meters. The Level 2 Program Coordinator trains volunteers to properly calibrate the instruments, use and store the equipment, record the data, etc. Volunteers chose monitoring locations on nearby streams with input from WDNR staff. The data collected by Level 2 volunteers are entered into the SWIMS database and quality assured by WDNR staff. SWIMS also supports the Citizen Lake Monitoring Network (CLMN) datasets, which are collected by citizen volunteers and used directly for lake general assessment work.

Assessment Data -- WATERS

The Water Assessment, Tracking and Electronic Reporting System (WATERS) is a data system that includes the following water program items:

- Water Division Objectives, Goals, Performance Measures, and Success Stories
- Clean Water Act Use Designations and Classifications (chs. NR 102 and 104, Wis. Adm. Code)
- Outstanding and Exceptional Resource Waters Designations (ch. NR 102, Wis. Adm. Code)
- Clean Water Act assessment data, including decisions about whether a waterbody is meeting its designated use or is considered "impaired"
- impaired waters tracking information, including the methodology used for listing, the status of the TMDL creation, and restoration implementation work
- Fisheries Trout Classifications (s. NR1.02(7), Wis. Adm. Code)
- Watershed planning recommendations, decisions, and related documents

2.5 Data Requirements

By establishing data requirements, WDNR staff collect representative data as efficiently as possible with limited staff and fiscal resources and use those data in a manner that minimizes the chance of incorrectly characterizing the attainment status of a particular water. Extremely large datasets are neither available nor necessary for many water bodies in the state. Minimum data requirements have been established for indicators including:

- **Period of Record:** Generally, data from the most recent 10-year period may be considered when assessing waters to ensure that the data are representative of a wide range of factors that affect water quality (i.e., weather, flow)[4]. If staff determine that older data within the 10-year period are no longer representative of recent conditions, the period may be shortened to the most recent 5 years. To make such a determination department staff will consider whether significant changes in the watershed have occurred, such as changes in land use, nonpoint source controls, or the amount of pollutants discharged from point sources.

- **Sampling Period:** The WisCALM guidance document identifies the appropriate sampling period for each parameter and waterbody type. The determination of appropriate sampling period is based on seasonal variability in pollutant levels and corresponding ecological responses. Data from two sampling seasons will be needed for some assessments to account for sampling error or annual variation.

- **Representative Data:**

    - **Sampling Protocol**: Individual data points must have been collected according to parameter-specific protocols. Prescheduled sampling designs are often used for 305(b)/303(d)-related monitoring in order to randomly capture the range of conditions. In these cases, targeted samples that are collected for other purposes (e.g. monitoring targeted during runoff events) should not be incorporated into the 305(b)/303(d) assessment datasets. In other cases, weather and hydrography must match intended conditions specified in the sampling protocols. For example, biological samples should be collected during base flow, not following a runoff or scouring flow event, to ensure the sample is representative of normal conditions.

    - **Extreme Weather Years:** Chemical and biological parameters are likely to be affected by extreme weather conditions. If a prescribed sampling schedule falls during an extreme weather year, exhibiting unusual average air temperature, precipitation, stream flow or water levels, a determination should be made as to whether that year was an extreme weather year that resulted in unrepresentative conditions. As a very general guideline, an extreme weather year may be defined as a year where precipitation, flow, stage/elevation, and/or temperature are above the 90th or below the 10th percentile of the annual averages within the period of record. Staff may use a combination of the following sources to document their determination of whether the year qualifies as an extreme weather year:
        - Climate data from nearest regional weather station(s)
        - Regional stream stage/flow gage(s)
        - Indices of drought severity (e.g., Palmer Drought Severity Index, U.S. Drought Monitor)

[4] Total phosphorus and biological data (chlorophyll, macroinvertebrates and fish) from the most recent 5-year period are used to make impairment decisions. However, if insufficient data are available from the most recent 5-year period, data collected within the past ten years may be used.

If it is determined that a year was an extreme weather year resulting in unrepresentative conditions, that year's data points should not be excluded, but rather should be supplemented with data from an additional year of monitoring. In this case, combined data from a minimum of two years should be used for assessments to account for variability between years.

Best professional judgment may be used to determine whether data were collected from an extreme weather year and are considered unrepresentative of normal conditions. For instance, a region may be experiencing drought, but stream flow may not be impacted significantly for those streams that are dominated by groundwater flows.

- **"Evaluated" Information:** Information that is not considered representative of current conditions or was not collected according to WDNR's Quality Management Plan cannot be used in preparation of the Impaired Waters List. WDNR classifies these types of data as "evaluated" information, which may include:
  - Information provided by groups, other agencies or individuals where collection methods are not documented and thus the data quality cannot be assured
  - Projected surface water conditions based on changes in land use with no corresponding in-water data (i.e., desktop analyses or models)
  - Visual observations that are not part of a structured evaluation
  - Anecdotal reports

  Though not used directly to update the impaired waters list, "evaluated" data may potentially be used to identify areas where further monitoring may be needed for future assessment cycles.

- **Sample Type:** The indicator being evaluated will dictate what type of samples should be used for an assessment decision. In some cases, samples may be collected as instantaneous measurements vs. continuous measurements. In other cases, the choice may be between a grab sample and a composite sample. In either case, the selection of the values should result in using the most representative data available.

- **Sample Size:** This document outlines sample sizes that appropriately and efficiently represent existing and relevant conditions. Sample size requirements differ by water body type and parameter. The number of samples required is commensurate with the inherent sampling error and annual variation of the parameter measured. Available representative data should be reviewed to ensure that the minimum data requirements are met. However, a waterbody may be listed as impaired despite minimum sample size not being achieved if overwhelming evidence of impairment exists (see Ch. 7, Professional Judgment).

3.0 The Assessment Process: An Overview

3.1 General Condition Assessment

Data collected under WDNR's tiered monitoring strategy are used to identify where a specific waterbody falls on a continuum of water quality condition, which is the first step in assessing whether a waterbody is attaining its assigned designated uses.

WDNR uses four levels of condition to represent waters' placement in the overall water quality continuum (Figure 3). Waters assigned the condition category of *excellent* are considered to be attaining applicable WQS and ***fully*** *supporting* their assessed designated uses. Waters assigned the condition category of *good or fair* are *also* considered to be attaining applicable WQS and *supporting* their assessed designated uses. Waters assigned the *poor* condition category *may not be attaining* WQS or assessed designated use(s). Waters determined to be in poor condition based on Tier 1 monitoring data are further evaluated and may be selected for additional (Tier 2) monitoring or, if the limited dataset includes overwhelming evidence of impairment (e.g. large magnitude of exceedance), considered "impaired" and added to Wisconsin's Impaired Waters List.

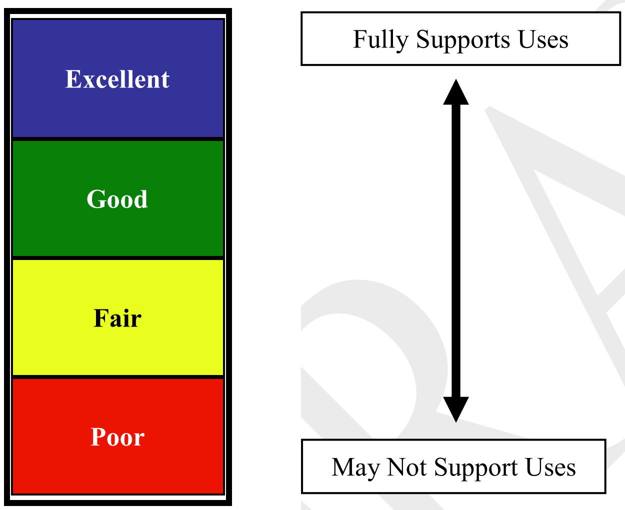


Figure 3. General water condition continuum.

3.2 Impairment Assessment

The assessment of whether a waterbody is meeting designated uses requires comparison to applicable water quality criteria, or, when numeric criteria do not exist, a well-defined reference condition or listing thresholds as a benchmark for comparison to narrative standards.

This section briefly outlines the concepts of indicators and associated thresholds to measure attainment status of Wisconsin lakes, rivers, and streams. For purposes of this guidance, the term "indicator" is used to describe the various measures of water quality, including those that represent physical, chemical, biological, habitat, and toxicity data. The term "threshold" is used to when referring to the numeric value or narrative description that distinguishes attainment of the WQS versus values that indicate impairment. In the simplest sense, a waterbody is defined as "impaired" when it is not meeting WQS, including its assigned designated uses.

Key Indicators for Assessments

Detailed assessments are tailored to the specific characteristics of a waterbody. Some assessments will focus upon one key indicator only, whereas others use multiple indicators. Furthermore, a stepwise process of indicator selection may be employed. For example, for assessment of total phosphorus impacts, biological confirmation (i.e. bioconfirmation) of impairment will be evaluated if moderate enrichment is apparent, but bioconfirmation is not necessary if phosphorus levels are exceedingly high. Assessment indicators are sub-divided into the following categories:

- Conventional physical-chemical
- Toxicity
- Biological

Other indicators, including habitat metrics, are also used for certain assessments.

Impairment Thresholds

Impairment thresholds are applied to determine whether waterbodies should be placed on the Impaired Waters List. These thresholds are usually expressed as ambient water concentrations of various substances based on numeric water quality criteria included in chs. NR 102-105, Wis. Adm. Code, WDNR technical documents, and federal guidance. In some cases, qualitative thresholds based upon narrative standards may be used to make impairment decisions. In those cases, a thoroughly documented analysis of the contextual information should be used in conjunction with professional judgment to collectively support a decision. Impairment thresholds outlined in WisCALM guidance must be in line with the intent of the water quality criteria in code. In some cases, WisCALM lists impairment thresholds for parameters for which water quality criteria have not been promulgated (e.g., macroinvertebrate and fish indices of biotic integrity and chlorophyll concentration) that may also be used as guidance for impairment listing decisions.

For some assessments methods, a single criterion or threshold may not be applicable across all the different waterbody types. For assessments of waters against the statewide total phosphorus criteria, for example, an initial waterbody classification analysis is required to ensure the assessment process applies the correct criteria. For other assessment methods, the WDNR applies the same water quality criterion or threshold across all resource types. An example is the use of the same fish tissue mercury concentration for all our lakes and rivers in the assessment of Fish Consumption Advisories as part of the Public Health and Welfare Use (chapter 6.1).

Exceedance Frequency

In the context of numeric water quality criteria, exceedance frequency refers to the number of times a criterion may be exceeded over a period of time before the water is no longer attaining the criterion and is considered impaired. Allowable exceedance frequencies for criteria contained in Wis. Adm. Code, are outlined in this WisCALM document. In addition, allowable exceedance frequencies for some water quality or biological thresholds that are not included in Wis. Adm. Code are provided in the Lakes and Rivers/Streams chapters.

4.0 Lake Classification and Assessment Methods

4.1 Lake Classification

WDNR classifies or groups similar lake types based upon physical data. Specifically, lake size, stratification characteristics, hydrology and watershed size are identified as the primary influences on a lake and, to a large degree, these characteristics determine the natural biological communities each lake type supports. Using this information, lakes should fall into one of ten natural community types (Table 1).

Table 1. Lake and reservoir natural communities and defining characteristics.

Natural Community	Stratification Status	Hydrology
Lakes/Reservoirs <10 acres – Small	Variable	Any
Lakes/Reservoirs ≥10 acres		
• Shallow Seepage	Mixed	Seepage
• Shallow Headwater	Mixed	Headwater Drainage
• Shallow Lowland	Mixed	Lowland Drainage
• Deep Seepage	Stratified	Seepage
• Deep Headwater	Stratified	Headwater Drainage
• Deep Lowland	Stratified	Lowland Drainage
Other Classification (any size)		
• Spring Ponds	Variable	Spring Hydrology
• Two-Story Fishery Lakes	Stratified	Any
• Impounded Flowing Waters	Variable	Headwater or Lowland Drainage

The WDNR recognizes that lakes may vary geographically. Spatial data are available for each of the lakes. Regional differences in soils, climate and land use may explain additional variation in the bio-indicator metrics used in the classification of lakes[5]. However, WDNR has determined that lake size, hydrology and depth are more critical factors for initial classification of lakes, and that regional differences are secondary.

For most lakes, the WDNR's automated data packages determine which natural community and which impairment thresholds are appropriate based on the parameters described below. However, if the biologist has information to suggest that a lake's automatically assigned natural community is inaccurate or not representative of the lake, a change to the natural community may be made if reasons for the change are documented. If a Partial Lake Listing is being considered, a different Natural Community may be assigned to the portion of the lake being considered for a Partial Lake Listing, based on site characteristics that are significantly different from those in the rest of the lake.

[5] Past Wisconsin studies have used eco-regions to explain landscape variability and EPA has proposed using this framework for assessment (Omernik 1987).

Reservoirs – Reservoirs are classified using the same classification schema as lakes, described below, though biologists may employ multiple sampling stations on reservoirs to provide more representative data. NR 102.06(2)(f) of Wis. Admin. Code defines a reservoir as "a waterbody with a constructed outlet structure intended to impound water and raise the depth of the water by more than two times relative to the conditions prior to construction of the dam, and that has a mean water residence time of 14 days or more under summer mean flow conditions using information collected over or derived for a 30 year period."

Size: Small vs. Large - Lake classification begins by first separating lakes into those 10 acres and greater and those less than 10 acres.

Small Lakes – Lakes less than 10 acres are classified into the Small Lake community. These lakes are uniquely different from communities in larger lakes but there is limited monitoring data available in Wisconsin. Because data for lakes less than 10 acres is so limited, it is difficult to set quality thresholds for assessment. Currently, there are very few thresholds set for water quality, fisheries, or aquatic plants for lakes less than 10 acres[6]. To address these small lakes in the future, Wisconsin may look to emerging wetland assessment tools for guidance.

Large Lakes – Lakes 10 acres or more are classified as Large Lakes. Large Lakes are further subdivided, by stratification status, hydrology, and watershed size, as shown below.

Stratification Status: Shallow (Unstratified or Mixed) vs. Deep (Stratified) – Lakes that are 10 acres or greater may be further characterized by their tendency to mix or stratify thermally. Stratification is an important factor in determining overall lake water quality and availability of suitable habitat for fish and aquatic life. An equation developed by WDNR Researchers (Lathrop and Lillie, 1980) is used by WDNR to identify whether a lake is categorized as Deep (Stratified) or Shallow (Unstratified or Mixed)[7]. Although this model is used to automatically generate lake classifications from the WDNR database, use of field data on depth, area, residence time, and temperature profiles to refine the model-based lake classifications is encouraged.

The Lathrop/Lillie equation is represented by a ratio calculated as follows:

$$\frac{\text{Maximum Depth (meters)} - 0.1}{\text{Log 10 Lake Area (hectares)}}$$

or

$$\frac{\text{Maximum Depth (feet)}*0.3048 - 0.1}{\text{Log 10 (Lake Area (acres)}*0.40469)}$$

Figure 4. Shallow, Mixed Lake

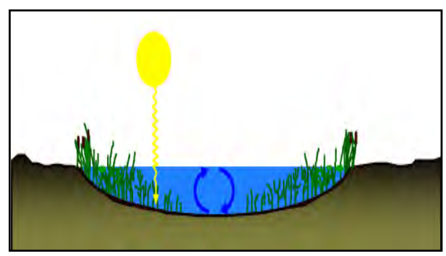
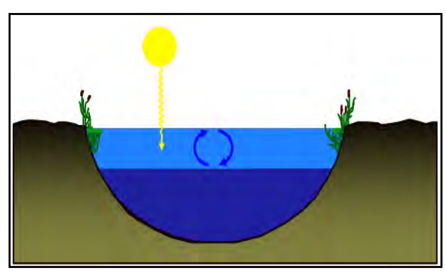


Figure 5. Deep, Stratified Lake



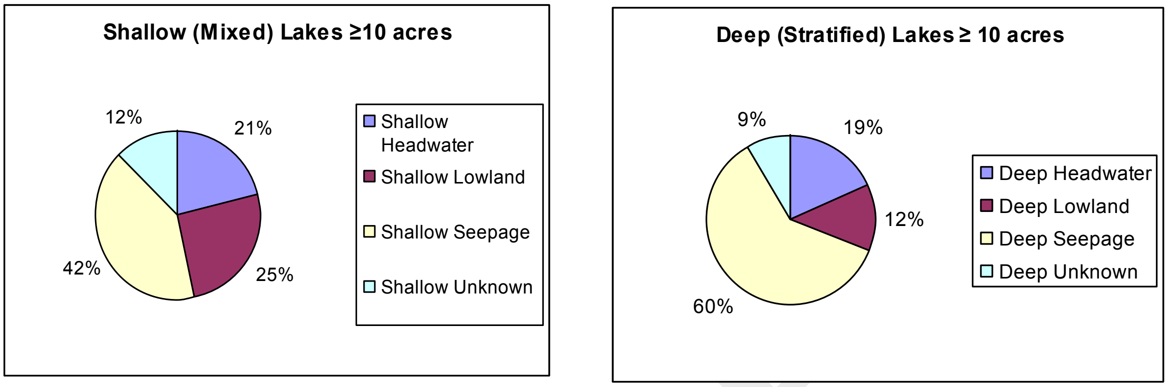
Shallow (Unstratified or Mixed) – When using the Lathrop/ Lillie Equation, any value less than or equal to 3.8 predicts a mixed lake, which is placed in the Shallow category. Mixed lakes tend to be shallow, well-oxygenated, and may be impacted by sediment re-suspension. In addition, shallow lakes have the potential to support rooted aquatic plants across the entire bottom of the lake (Figure 4).

[6] Total Phosphorus criteria apply to lakes of five acres and larger.

[7] WDNR's decision to use the Lillie/Lathrop equation to determine stratification status also examined several other models for predicting lake stratification based on depth and area. These included work by Emmons et al. (1999), the Osgood Index (Osgood 1988), a Minnesota "lake geometry ratio" (Heiskary and Wilson 2005) and a model by WDNR Researchers (Lathrop and Lillie, 1980). The Lathrop/Lillie Equation was selected because it better distinguishes between clearly stratified and mixed lakes.

Deep (Stratified) –When using the Lathrop/Lillie Equation, any value greater than 3.8 predicts a stratified lake, which is placed in the Deep category. Stratified lakes tend to be deep, with a cold water refuge for fish, and the potential for anoxic conditions (without oxygen) in the bottom layer which may release nutrients from sediments into the water column. Aquatic plants are typically confined to shallow (littoral) waters around the perimeter of the lake (Figure 5). Stratified lakes exhibit thermal layering throughout the summer or they undergo intermittent stratification.

Figure 6. Distribution of Shallow and Deep lake types (for lakes greater than 10 acres)



Hydrology and Watershed Size – Lake hydrology is the measure of the relative inflow/outflow of surface water compared to direct precipitation and groundwater inputs. Lake hydrology and lake watershed size are two other critical factors in lake classification. Both Deep and Shallow Lakes are further divided based on hydrology. The terms "seepage" or "drainage" are best used to describe the appropriate hydrologic category for lakes.

Seepage Lakes – A lake with no surface water inflow or outflow is considered a seepage lake (Figure 7). A seepage lake receives water from two sources: primarily from precipitation, both as overland sheet flow to the lake and directly onto the lake and seepage into the lake from groundwater. Seepage lakes tend to have lower nutrient concentrations, due to relatively small catchment areas, and may be poorly buffered against acid deposition.

Drainage Lakes – A lake with surface water inflow/ outflow from a river or stream is classified as a drainage lake (Figure 8). Drainage lakes tend to have more variable water quality and nutrient levels, depending upon the amount of land area drained by the lake's watershed. For this reason, watershed size also plays a key role in the classification of Drainage Lakes (Emmons, et al, 1999). Drainage lakes are subdivided by watershed size as follows:

- <u>Headwater Drainage Lakes:</u> If the watershed draining to the lake is less than 4 square miles, the lake is classified as a Headwater Drainage Lake.
- <u>Lowland Drainage Lakes:</u> If the watershed draining to the lake is greater than or equal to 4 square miles, the lake is classified as a Lowland Drainage Lake.

Figure 7. Seepage Lake

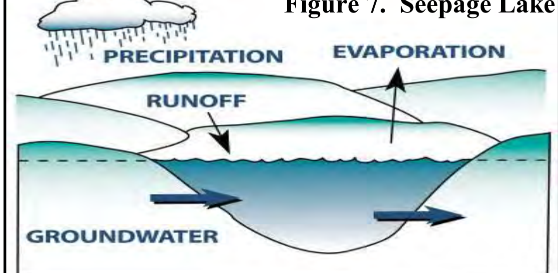
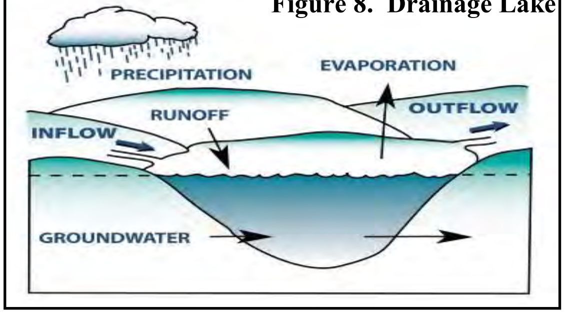


Figure 8. Drainage Lake



Other Classifications (any size) – Three other classes representing unique natural communities are recognized in this classification scheme: Spring Ponds, Two Story Lakes, and Impounded Flowing Waters.

Spring Ponds –Spring ponds typically contain cold surface water and support coldwater fish species and are most often shallow headwater lakes. In order to be included in this category there should be documentation of a current or historical cold water fishery (e.g., stream trout) and evidence of spring hydrology.

Two Story Fishery Lakes – Two-story fishery lakes are often more than 50 feet deep and are always stratified in the summer. They have the potential for an oxygenated hypolimnion during summer stratification and therefore the potential to support coldwater fish species in the hypolimnion. In order to be included in this category, a lake should meet the definition of “stratified” (Lathrop/Lillie equation value >3.8), be greater than five acres, and support a coldwater fishery. Supporting a coldwater fishery may either be demonstrated through documentation of a current or historical native cold water fishery (e.g., cisco, lake trout), or verification with DNR fisheries biologists that the lake is on a long-term stocking plan for coldwater species, where the individuals have good year-to-year survival.

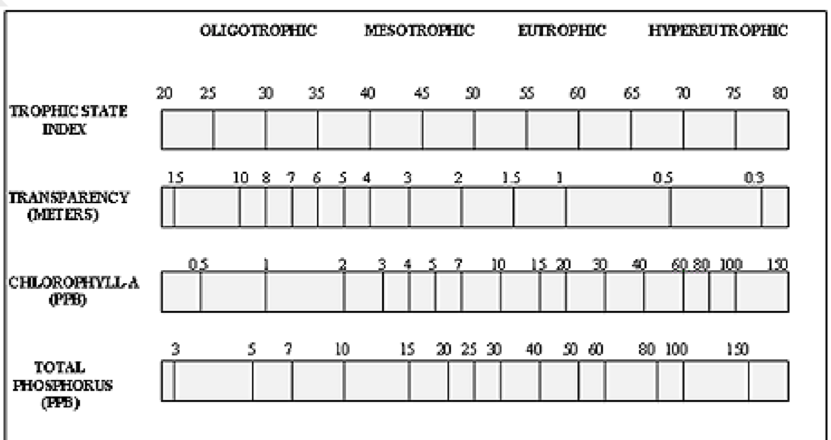
Impounded Flowing Waters—Rivers or streams that are impounded but do not meet the definition of reservoir above are considered to be “impounded flowing waters.” Impounded flowing waters are lotic in nature and should be evaluated using the river and stream criteria that apply to the primary stream or river entering the impounded water. Biological response metrics may also include metrics that are typically used for lakes, such as chlorophyll a, as deemed appropriate based on professional judgment.

4.2 Lake General Condition Assessment

The WDNR focuses on in-lake water quality metrics to assess a specific lake’s fish and aquatic life designated use. These in-lake parameters correlate strongly with fish and other aquatic life communities (macroinvertebrates, aquatic plants, etc.) within a lake.

Wisconsin bases its General Condition Assessment for lakes on the Carlson Trophic State Index (TSI). The Carlson TSI is the most commonly used index of lake productivity. It provides separate, but relatively equivalent, TSI calculations based on either chlorophyll *a* concentration (chl *a*, or CHL in the equation below) or Secchi depth (SD, for which Wisconsin also uses satellite clarity data as a surrogate)[8]. Because TSI is a prediction of algal biomass, typically the chl *a* value is a better predictor than Secchi or satellite data. Water clarity as measured by Secchi depth or satellite is a practical measure of algal

Figure 9. Continuum of lake trophic status in relation to Carlson Trophic State Index.



After Moore, L. and K. Thornton, [Ed.]1988. Lake and Reservoir Restoration Guidance Manual. USEPA>EPA 440/5-88-002.

8 Carlson also provides an equation to convert total phosphorus concentration to TSI, but WDNR is not using that equation for purposes of water quality assessments or 303(d) Impaired Waters Listing.

production and water color. Algal production is known to be highly correlated with nutrient levels (especially phosphorus). High levels of nutrients can lead to eutrophication and blue-green algae blooms. This limits the amount of available light to macrophytes and adversely affects other aquatic organisms. Information from each of these parameters is valuable because the interrelationships between them can be used to identify other environmental factors that may influence algal biomass.

TSI values range from low (less than 30), representing very clear, nutrient-poor lakes, to high (greater than 70) for extremely productive, nutrient-rich lakes (Figure 9). Very few lakes in Wisconsin would fall into the category of "very clear, nutrient poor lakes." The cutoff for excellent TSI values would certainly include these lakes (Table 2) but also includes some lakes in the mesotrophic category, based on sediment core data which indicates that some lakes are naturally more productive than others.

Data requirements

TSI is automatically calculated using a programming package (TSI Package) that draws from Department data in SWIMS. The rules used by the TSI Package are described below. These requirements are set to provide enough data to account for the average lake condition during the summer index period (when the lake responds to nutrient inputs and achieves maximum aquatic plant growth) over several years to account for unusual weather (dry, wet, hot, cold). Results from the TSI Package are provided to biologists to use in their assessments. Biologists may use professional judgment in assessing package results.

a) *Seasonal Range and Sampling Frequency.*

- For chl *a* and Secchi data, the TSI Package requires 2 samples per year in each of 3 different years. Samples should be collected between July 15 – September 15.
- For satellite clarity data, at least one satellite inferred clarity reading is required in each of 3 years (3 values minimum). Samples should be collected between July 1 – September 30.

b) *Sampling Depth.* Chlorophyll a samples taken from the top 2 meters of the lake will be used to calculate TSI (excluding grab samples collected at 0 m). Samples can be grab samples or integrated samples.

c) *Year Range.* Sampling data are used from within the most recent 5 years (2008-2012).

d) *Sampling and Analytical Methods.* Field collection, preservation and storage should follow procedures outlined in the WDNR Field Procedures Manual and the Citizen Lake Monitoring Manual (http://WDNR.wi.gov/lakes/CLMN/manuals/). Laboratory analysis should follow standard methods (WSLH 1993). Data collected using different protocols may be considered, with limitations, based upon professional evaluation.

Calculations

a) For each year with sufficient data, first all values are converted to TSI using the calculations below (calculate TSI *separately* for chl *a*, Secchi, and satellite data)[9]. (Note: Satellite readings are automatically converted to clarity values (equivalent to Secchi depth) in SWIMS.)

$TSI_{CHL} = 9.81 \ln(CHL) + 30.6$

$TSI_{SD} = 60 - 14.41 \ln(SD)$ (satellite inferred clarity data can also be used in lieu of Secchi data in this equation)

Where:

[9] Although Carlson's Trophic State Index also provides a calculation for TSI based on total phosphorus (TP), Wisconsin does not calculate TSI based on phosphorus for General Condition Assessments. TP concentrations are used to determine whether a waterbody exceeds thresholds for 303(d) listing as a pollutant.

TSI = Trophic Status Index
SD = Secchi depth (meters)
CHL= Chlorophyll *a* concentration (µg/L)
ln = natural log

b) For each year of data, an Annual Average is calculated from the data points within that year (Annual Averages are calculated separately for each parameter).

c) All available Annual Averages from the last 5 years are averaged together, to produce a Multi-year Average (Multi-year Averages are calculated separately for each parameter).

d) The TSI Package automatically prioritizes which TSI Multi-year Average to use in comparison against the General Condition Assessment Thresholds. Historically, there has been a tendency to average the three TSI values, but research suggests that this generally is not a good practice (Carlson and Simpson 1996). Therefore, Wisconsin has instituted a prioritization system for selecting which TSI score to use. When more than one Multi-year Average TSI score is available, whichever TSI score is based on the most direct measure of algal biomass will be used, as follows:

- TSI based on chl *a* will be used if available, since this is the most direct measure of trophic state.
- TSI based on measured Secchi data is the second preference; Secchi depth readings measures clarity as a surrogate for trophic state.
- TSI based on satellite data is the third preference, as it infers water clarity rather than measuring water clarity directly.

e) The final step in the General Assessment is to compare the lake-specific Multi-year Average TSI value to the lake general condition assessment thresholds shown in Table 2. As described previously, the lake condition assessment thresholds establish four categories for each Lake Natural Community: Excellent, Good, Fair, and Poor.

Table 2. Trophic Status Index (TSI) thresholds – general assessment of lake Natural Communities.

Condition Level	Shallow			Deep			
	Headwater	Lowland	Seepage	Headwater	Lowland	Seepage	Two-Story
Excellent	< 53	< 53	< 45	< 48	< 47	< 43	< 43
Good	53 – 61	53 – 61	45 – 57	48 – 55	47 – 54	43 – 52	43 – 47
Fair	62 – 70	62 – 70	58 – 70	56 – 62	55 – 62	53 – 62	48 – 52
Poor	≥ 71	≥ 71	≥ 71	≥ 63	≥ 63	≥ 63	≥ 53

Note: Although TSI thresholds are not yet available for three natural communities: 1) Small Lakes; 2) Spring Ponds; and 3) Impounded Flowing Waters, by default assessments are completed for the most similar natural community for which thresholds are currently available.

Derivation of TSI General Condition Thresholds

Excellent Condition

To establish the excellent range for TSI conditions, WDNR uses excellent or “reference” conditions inferred from total phosphorus (TP) values based upon preserved diatom communities from pre-settlement times found in lake bottom sediment cores.

Sediment cores measure fossilized diatom communities allowing a comparison of historical (pre-settlement) conditions and recent water condition. This allows the comparison of current water clarity measurements to historical conditions with changes represented by the changes in algae conditions over time. Diatoms are a type of algae containing siliceous cell walls that fossilize in lake sediments. Diatom taxa are known to prefer narrow ranges of water quality. Therefore, inferences about historical water condition can be made from fossilized diatom communities at the bottom of the sediment core. These inferred concentrations, when converted to TSI values using the Carlson equations, can be used as reference values. This approach will not work for most reservoirs, impounded flowing waters, or raised wetland lakes since these lakes are artificial and pre-settlement conditions do not exist. WDNR has not yet developed criteria specific to these artificially created waterbodies.

WDNR has sediment core data spanning each of the 6 natural lake community types (Table 3) and derives excellent TSI thresholds from these data (Garrison, unpublished data*). The transition between excellent and good for each natural community is based on the 75th percentile of the TSI values calculated from sediment core bottom inferred phosphorus concentrations.* The bottom sediment core values represent reference lake conditions and using the 75th percentile gives some margin for lakes to have changed since the bottom of the sediment core accumulated (Table 3).

Sediment cores are not available for small lakes or spring ponds and are not appropriate for impounded flowing waters. Since adequate sediment core data from two-story lakes is not available, the 75th percentile value for deep seepage lakes was used for the threshold between excellent and good condition (Table 2). Ideally, sediment core data should be collected whenever monitoring is conducted on two-story lakes.

Table 3. Mean and median inferred TP values calculated from top and bottom segments of sediment cores from 87 Wisconsin lakes (Garrison, unpublished data).

Lake Class	Natural Community	N	Mean TP (µg/L)		Median TP (µg/L)		75^{th} Percentile (µg/L) (Bottom	TSI Threshold
			Top	Bottom	Top	Bottom		
1	Shallow Headwater	17	27	24	26	19	30.3	53
2	Deep Headwater	19	24	18	21	14	20.5	48
3	Shallow Lowland	11	28	25	28	24	30.5	53
4	Deep Lowland	43	25	19	20	15	20.0	47
5	Shallow Seepage	15	17	16	16	14	17.0	45
6	Deep Seepage	29	15	13	12	11	15.3	43

Poor Condition

Setting the threshold for Poor Condition was approached differently for each lake type, as most appropriate for the specific conditions exhibited by those lakes:

Shallow Lakes: The transition between a fair and poor condition for shallow lakes was set at a TSI of 71 (corresponding to TP concentration of 100 µg/L) because this approximates TP concentrations that lead to a switch from aquatic plant dominated to algal dominated ecosystems in shallow lakes (Jeppesen et al. 1990). This represents a major ecosystem change and once it occurs, it is very difficult to restore to the aquatic plant dominated state.

Deep Lakes: The fair to poor transition threshold for deep lakes was set using a TSI value known to cause increased frequency of algal blooms, high amounts of blue-green algae and/or hypolimnetic oxygen depletion. A TSI of 63 (corresponding to TP of 60 µg/L) was chosen because it represents the threshold between eutrophic and hyper-eutrophic lakes (Carlson 1977).

Two-Story Lakes: TSI values that cause significant hypolimnetic oxygen depletion should be used as the threshold for two-story lakes since this habitat component is critical for maintaining coldwater fisheries. This value will be highly dependent upon the lake's morphometry. Hypolimnetic oxygen demand is largely from the sediment; therefore, the greater the ratio of *sediment area to hypolimnetic water volume* the higher the hypolimnetic oxygen demand. That makes setting this threshold very difficult. A conservative TSI value of 53 (corresponding to a TP of 30 µg/L) is recommended. Further research on these relationships is needed to derive accurate values for two-story lakes.

Good and Fair Condition
The transition value between the condition of "fair" and "good" for each natural community was selected as a mid-point between the excellent and poor TSI values (Table 2).

4.3 Lake Impairment Assessment: Selecting representative stations and which lakes to evaluate

Not all waters categorized as Poor in the General Condition Assessment should be considered Impaired or warrant 303(d) listing. Whether or not a waterbody should be listed as impaired is dependent on the strength of the data used to make the assessment. To submit a lake for the 303(d) List, it should exceed certain numeric listing thresholds or meet narrative listing criteria. A General Condition Assessment status of "Poor" or "Fair" based on TSI score serves as a flag that TSI values and other parameters such as TP, temperature, DO, and pH should be evaluated against the additional impairment thresholds outlined in Table 5A. In addition, best professional judgment may be needed for certain parameters (such as TSS and turbidity), or unique natural communities (such as two-story lakes or impounded flowing waters) for which there are currently no thresholds or criteria for certain parameters.

It is important to determine the relationship between the impairment and pollutant when placing a waterbody on Wisconsin's Impaired Waters List. There are a number of field-measurements that can be taken to more clearly define the condition of a lake and determine what specific impairments and pollutants may be present. Selecting the correct indicators is an important part of understanding the underlying causes of water quality problems. Collectively, the type of data collected and the frequency of sampling is critical for accurate listing and the development of a successful management strategy. Guidance on how to make attainment decisions for some of the more common pollutants or stressors observed in Wisconsin lakes is provided below.

Station Locations: Selecting representative stations for assessment
Most lakes will use only a single "Deepest Spot" site to characterize the status of the lake. By default, the TP and chl *a* Packages use those sites that are designated as "Deepest Spot" for assessments. If more than one station is designated as "Deepest Spot", the packages will use both. However, biologists can change which stations are selected by the package by using the checkbox in WATERS named "Use for TP/Chlorophyll?". They can select and unselect stations as needed to appropriately characterize the site.

Lakes with multiple stations: Reservoirs, multi-lobed lakes, and very large lakes may not have a Deepest Spot station and/or may need more than one sampling station to accurately characterize the lake's morphology and to assess the lake. In these cases, to determine which stations should be selected to use for assessments, use the following guidelines:

- Typically between two and five stations would be chosen to be representative of lake conditions, depending on the size and character of the lake.
- Select only 'active' stations that have data from within the past ten years.
- If there are stations that seem to be duplicative of the same location, contact SWIMS/WATERS support staff to determine whether those stations should be consolidated.
- For **very large lakes** (Figure 10), select well-spaced stations representative of the entire lake.
- For **reservoirs/flowages** (Figure 11), select stations that are roughly equally spaced along the thalweg (the deepest channel along the river line). Stations in flowing portions near the upstream entry point of the river may be eliminated.
- For **lobed lakes**,
    - if there are **multiple deepest spots** (Figure 12), select a station for each deep spot.

- if there is **one deepest spot** but it is not representative of the entire lake (Figure 13), select the deep spot as well as other stations to represent the other portions of the lake. It may be more difficult in these situations to determine which stations provide the best representation of the lake.

Once the biologist has selected which stations will be used to assess the lake, the additional stations should be indicated in WATERS. To do this, check the checkbox to the right of each station you wish to select[10]. These stations are then automatically represented in the TP and chl *a* Package results.

For lakes with multiple stations selected, the assessment results for each station will be shown individually.

Note: The maps below are for illustrative purposes only; the stations shown may not be the most representative stations available.

Figure 10. Large Lakes: Select well-spaced

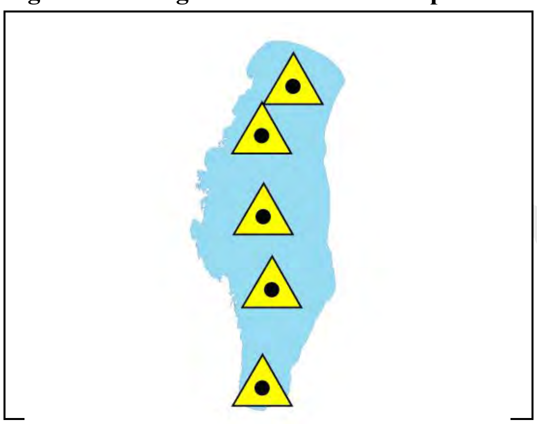


Figure 11. Reservoirs/Flowages: Select stations

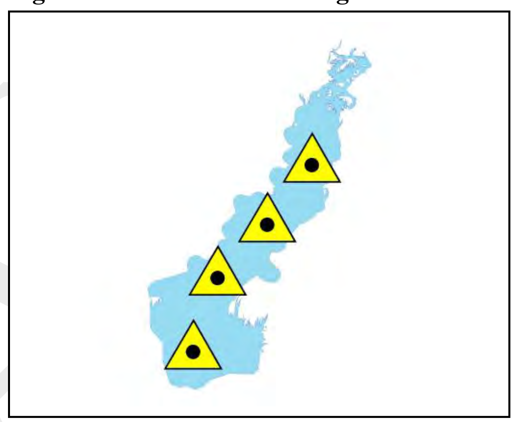


Figure 12. Lobed lakes with multiple deep holes: One station per deep hole.

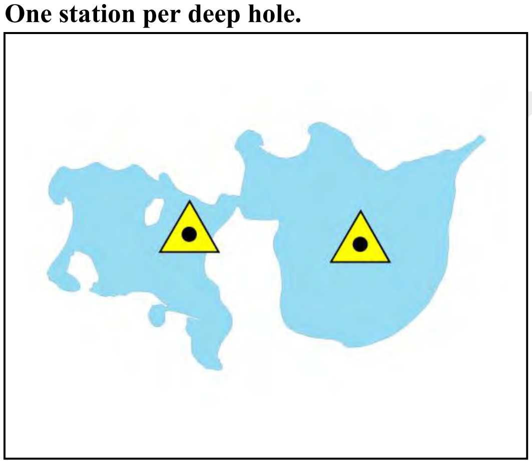
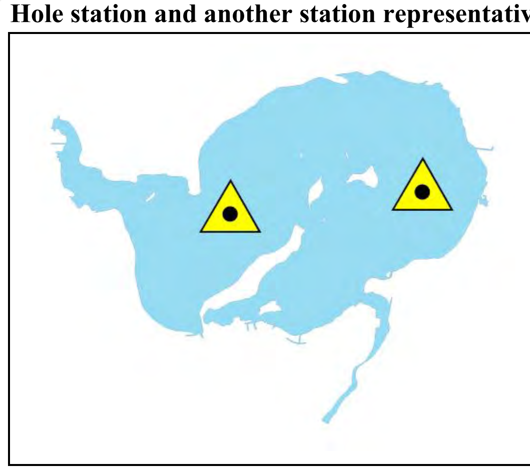


Figure 13. Lobed lakes with one deep hole: Use Deep Hole station and another station representative of County



[10] Data packages are updated every Friday evening. If new stations are selected, the biologist will need to re-run the packages the following week to incorporate the new information.

Whole Lake vs. Partial Lake Assessment

As a rule, a lake is a mixed system that functions as a single, contiguous unit. Therefore, in the vast majority of situations where there are multiple stations used for assessments, if one station is impaired on the lake, the whole lake would be listed as impaired. However, in cases where a known or suspected localized pollution source is believed to cause impairment in only one portion of a lake (such as an isolated bay or well-defined lobe), biologists may consider assessing and listing that portion as impaired separate from the larger lake.

In cases where Partial Lake Assessments and/or Partial Lake Impairment Listing are warranted, the portion of the lake under consideration should be delineated as a separate Assessment Unit to differentiate it from the larger part of the lake. This is typically warranted when the geography of the lake is such that there is a physical barrier separating most of one portion of the lake from the main portion. In such cases, the partial lake area will typically be assigned its own Natural Community, which may differ from the greater lake.

For Partial-Lake assessments, a sampling station should be added that is representative of the partial-lake area. Such a station should be situated in open water, so that samples are not taken near-shore or in an effluent plume but in ambient lake water within the vicinity of the suspected source of the problem.

Partial Lake Impairment Listings

In cases where a localized pollution source is believed to cause impairment in only one portion of a lake, as evidenced by a station's exceedance of an impairment threshold in only one area of a lake, biologists may consider listing only that portion of the lake as impaired using the appropriate Natural Community threshold. However, if, for instance, one area of a lake is experiencing high algae concentrations due to algae that are being produced throughout the lake but are blown by the wind to a particular area, this would be considered a whole lake problem and partial lake listing would not be appropriate.

4.4 Lake Impairment Assessment: Fish & Aquatic Life (FAL) Uses

Minimum data requirements and calculations for Pollutant and Impairment indicators
For all of the Lake Pollutant and Impairment Indicators, the following guidance on minimum data requirements apply for *Station Location, Year Range*, *Sampling and Analytical Methods,* and *Data Quality*. Guidance for frequency, seasonality, sampling depth, and any specific data quality notes are specific to different parameters and are provided under each Pollutant or Impairment Indicator. Some of the more common Pollutants and Impairments are described in the text below; these and others are also documented in Table 5A.

Station Location. See the "Station Location" section in chapter 4.3.

Sampling and Analytical Methods. Field collection, preservation and storage should follow procedures outlined in the WDNR Field Procedures Manual which is stored in the SWIMS system (http://WDNR.wi.gov/org/water/swims) and the Citizen Lake Monitoring Manual (http://WDNR.wi.gov/lakes/CLMN/manuals/). Laboratory analysis should follow standard methods[11] (WSLH 1993). Data collected using different protocols may be considered, with limitations, based upon professional evaluation of data.

Data Quality. Sample points may be excluded if there are quality control concerns or if the data were collected for specific studies that are not representative of overall lake conditions.

Total Phosphorus (TP) and Chlorophyll a (Chl)[12]
Phosphorus is one of Wisconsin's most common pollutants for lakes. In 2010, Wisconsin developed numeric criteria for TP and corresponding protocols for listing waterbodies for TP as a pollutant. Algal biomass, as measured by chlorophyll a concentrations, is one of the most common response metrics to increased phosphorus concentrations. For the purpose of assessing water quality against impairment thresholds, in-lake TP values and chlorophyll a concentrations are calculated using automated programming packages that draw from Department data in SWIMS (these packages are referred to as the TP Package and Chl Package). The rules used by these packages are described below. Results from the packages are provided to biologists to use in their assessments; biologists may use professional judgment in assessing package results.

**New in 2014:*

- *The automated assessment protocols ("Packages") for TP and chlorophyll a have changed significantly for the 2014 assessment cycle, in order to more appropriately assess water quality and to provide more consistency between lake and stream protocols.*
- *<u>Any</u> qualifying data from the period of record in the SWIMS database will be used, and the automated assessment package will provide statistical summary output whether or not the quantity of data points meets the assessment requirements. Including lake datasets that do not meet minimum requirements will allow biologists to review the available data and determine future monitoring needs. However, the automated assessment packages will indicate which stations do or do not meet the minimum data requirements for impairment assessment, and only those that do meet assessment requirements will be used for official assessment reporting.*

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[11] WSLH (Wisconsin State Laboratory of Hygiene). 1993. Manual of Analytical Methods. Environmental Science Section, Inorganic Chemistry Unit, Wisconsin State Laboratory of Hygiene, Madison, WI.

[12] Heiskary, S, and C. B. Wilson, 2005. Minnesota Lake Water Quality Assessment Report: Developing Nutrient Criteria, Third Edition. Minnesota Pollution Control Agency, September 2005.

TP and Chl have separate thresholds for Recreational (REC) impairments and for Fish & Aquatic Life (FAL) impairments. Therefore, there are four distinct packages that are run to report the needed calculations: TP REC, TP FAL, CHL REC, and CHL FAL. The calculations used are almost identical for TP REC, TP FAL, and CHL FAL. These protocols are described below. The protocols for CHL REC are slightly different and are described in the Lake chapter's *Recreational Uses* section. Once the package results are available, the TP and Chl results are assessed separately and *in combination with one another* to determine whether a lake should be listed as impaired, and if so, in what category. Because algae and aquatic plants are biological metrics that respond to phosphorus, they are used as biological confirmation of impairment related to phosphorus concentrations.

1. Select data to use

Period of record (for both TP & Chl a)
Data from the most recent 10 year period may be used, but data from the most recent 5 years is given preference, as it is more representative of current conditions. See "**Select appropriate year range to use**" (below) for more detail.

Seasonal range and frequency
For official assessment purposes, the goal of the DNR's lake monitoring program will be to have 3 samples per year for both TP and Chl a that meet the data requirements outlined below.

- One sample per month should be taken during the designated sampling season. They should be taken as close as possible to the middle of the month.
- Samples must be spaced at least 15 days apart, to evenly represent the season.
- For TP, the allowable date range is June 1 – Sept. 15, allowing for four monthly samples (June, July, August, Sept.). Only three samples are needed for the calculations, but more samples will be used if available. For Deep (stratified) Lakes, samples from May and/or late September may be manually added if it can be demonstrated that the lake is thermally stratified during that time period.
- For chlorophyll a, the target date range is July 15-Sept. 15[13], which should result in one sample for each of July, August, and September. However, if sampling within that window is not possible, data will be accepted if it is collected within one week of the sample season (i.e. July 8-Sept. 22).

Sampling protocols

- *Sampling and analytical methods:* Field collection, preservation and storage should follow procedures outlined in the WDNR Field Procedures Manual which is stored in the SWIMS system (http://WDNR.wi.gov/org/water/swims) and the Citizen Lake Monitoring Manual (http://WDNR.wi.gov/lakes/CLMN/manuals/). Laboratory analysis should follow standard methods[14] (WSLH 1993). Data collected using different protocols may be considered, with limitations, based upon professional evaluation of data.
- *Sampling depth:* Only surface samples taken from the top 2 meters of the lake will be used (excluding grab samples collected at 0 m because these may contain a scum layer). Samples can be grab samples or depth-integrated samples. (If samples were taken from more than one depth

[13] The sampling periods for TP and Chl are not identical. June samples are not used for Chl assessments because many lakes have a clear water phase in June due to food web dynamics. Therefore June samples do not appropriately represent lakes' summer chlorophyll conditions. However, for TP, June samples are included to reflect the range of summer conditions.

[14] WSLH (Wisconsin State Laboratory of Hygiene). 1993. Manual of Analytical Methods. Environmental Science Section, Inorganic Chemistry Unit, Wisconsin State Laboratory of Hygiene, Madison, WI.

within this zone at a single station on a single day, average the samples for that station for that day to produce the station's daily average.)

- *Data quality:* Sample points may be excluded if there are quality control concerns or if the data were collected for specific studies that are not representative of overall lake conditions. See Chapter 2.5 in WisCALM on *Data Requirements*.
- *Units:* Both TP and chlorophyll a values should be expressed in ug/L. This is consistent with phosphorus water quality criteria in ch. NR 102, Wis. Adm. Code.

Aggregating samples and determining "qualifying years"

- *Calculate Daily Mean:* Most lakes will have only one sample per day within the correct depth zone (0-2 m or 0-6 ft); in these cases that single sample serves as the daily mean. If there is more than one sample from a single station on a single day from within the correct depth zone, then these samples should be averaged into one, and flagged. Samples with no depth or wrong depth should be excluded.
- *Determine "Qualifying Years"*[15]*:* A "qualifying year" is one that has at least 2 daily means that are in different months of the appropriate date range and that are at least 15 days apart. Whether or not a year is a qualifying year is indicated by the assessment package output.
- *Calculate Monthly Mean:* For all years, regardless of whether they are qualifying years, calculate the monthly mean from the daily means. Most lakes will have only one daily mean per month; in these cases that single value serves as the monthly mean. If more than one daily mean are available for a given month, average them into a monthly mean.

Number of samples required to meet assessment requirements

- For TP, a minimum of 6 monthly means over at least two qualifying years are required.
- For chl a, the minimum number of monthly means and years required depends on whether the assessment is being used as a 'biology only' impairment listing for chl a, or whether it is being used as bioconfirmation of a TP impairment.
  - For a biology-only chl a impairment listing, a minimum of 6 monthly means over at least two qualifying years are required.
  - For chl a bioconfirmation on a waterbody that exceeds TP criteria, a minimum of 3 chl a monthly means from at least one qualifying year is required.
- If three monthly means during a year are not available, multiple years may be used to assemble the minimum number of data points.

Select appropriate year range to assess

- All data (that meets requirements for depth/dates/etc.) from the most recent 5 years will be used. If there are enough monthly means within the most recent 5 years to meet minimum data requirements (6 monthly means over at least 2 qualifying years), then only the most recent 5 years will be used.
- If there are not enough monthly means within the most recent 5 years to meet minimum data requirements, then the data package will go back year by year (up to 10 years) to include more months until the minimum data requirement is met, and then stop (i.e. will not use any additional months from the 5-10 year range once minimum data requirement is met).
- If there are not enough months with data from the whole 10 year period to meet the minimum data requirements, the package will still run the formulas and provide statistical summary output using the months available from that 10 year period, for informational purposes. However, the station will be flagged as not meeting assessment requirements.

[15] At this stage, biologists may also determine whether any years should be considered "Extreme Weather Years", as described in Chapter 2.5 in WisCALM on *Data Requirements*. If so, and if the biologist feels the extreme weather year resulted in data that would make the assessment result unrepresentative, the biologist may manually check to determine that at least one "normal year" was included in the assessment before making impairment decisions.

2. Compute confidence intervals and exceedance frequencies

The assessment packages run the following calculations on all stations that have any monthly data, regardless of whether they have enough data to meet the minimum data requirements for assessment purposes. However, stations that do not meet the minimum data requirements for an assessment are flagged (see section "**Indicate whether results meet assessment requirements**"). Years that did not have at least 2 monthly means are also flagged.

Along with the automated assessment packages, an Excel spreadsheet template is also available for performing the calculations described below manually. Manual calculations of the statistical values may be required to assess data that is not in the SWIMS database.

Calculate the grand mean[16] and related statistics

Take the average of monthly means across years to calculate each station's grand mean. Use monthly means from the 'appropriate year range' as described above. The grand mean is used for TP REC & FAL, and Chl FAL (not for Chl REC). The list of statistical values needed for this calculation and other values useful for assessment and reporting are:

- Applicable impairment thresholds for the lake type
- Grand Mean
- Min
- Max
- 90% CI –Lower (see formula below)
- 90% CI –Upper (see formula below)
- Standard Deviation
- # of data points used
- Period of Record (the most recent 10 year period, starting with the most recent **even numbered** year)
- Year range used from within the period of record
- Number of years used
- Number of monthly means used

Calculate confidence intervals for TP REC & FAL, & Chl FAL

The following statistical method applies to the Lakes TP package for both FAL and REC. For the Lakes chl a package, it applies for the FAL impairment assessment, but not REC.

The confidence interval (CI) around the mean is:

$$CI = exp\left(\bar{Y} \pm t_{1-\frac{\alpha}{2},N-1}\frac{S}{\sqrt{N}}\right)$$

where $\bar{Y}$ and S are the mean and standard deviation, respectively, of the natural logarithms of the measured values, N is the sample size, α is the desired significance level, and $t_{1-\alpha/2, N-1}$ is the 100(1-α/2) percentile of the t distribution with N - 1 degrees of freedom.

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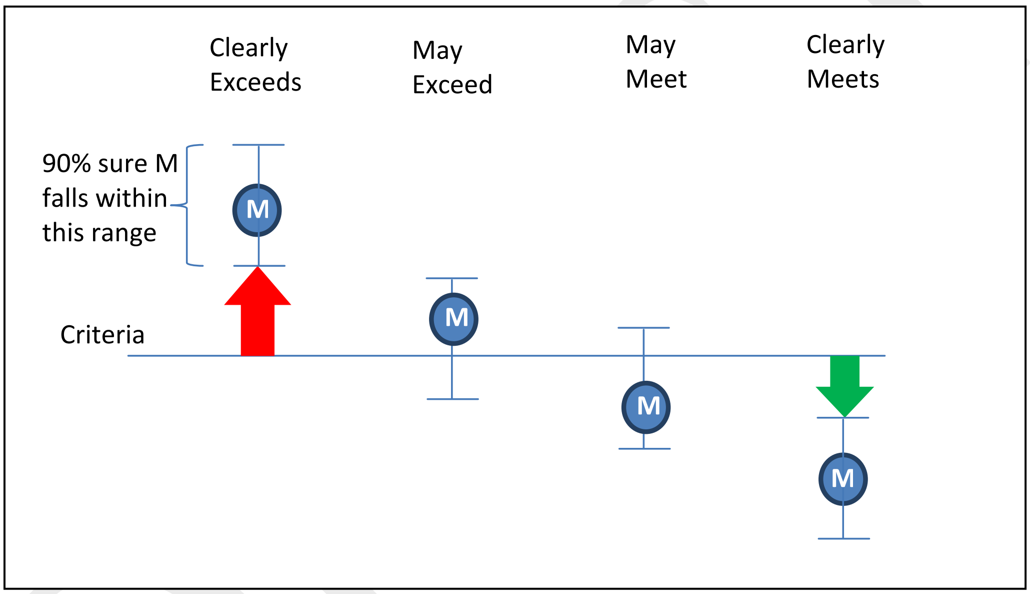
[16] This approach of calculating a grand mean differs from that used in 2012. In the 2012 WisCALM, annual averages were calculated and the number of annual averages that exceeded the applicable thresholds was used to determine impairment. For the 2014 WisCALM, all data points, from multiple years, that meet requirements are combined into a grand mean and its 90% confidence intervals, which are compared against listing thresholds.

3. Compare formula results to the applicable criteria/thresholds

For each of the formula runs above (TP REC & FAL, and CHL FAL), as well as the CHL REC described in the next chapter, compare the resulting Upper and Lower 90% Confidence Intervals to the applicable TP criteria and CHL thresholds for the lake type. The impairment criteria/thresholds for FAL are shown in Table 5 for FAL and in Table 6 for REC.

- If Lower 90% CI > criteria = the lake "Clearly Exceeds" the criteria.
- If Upper 90% CI > criteria = the lake "Clearly Meets" the criteria.
- If Grand Mean > criteria, AND lower CI < criteria, AND Upper CI > criteria = the lake "May Exceed" the criteria.
- If Grand Mean < criteria, AND lower CI < criteria, AND Upper CI > criteria = the lake "May Meet" the criteria.

Regardless of whether the decision was a "Clear" decision, the package will report the decision based upon the data points used to meet the minimum data requirements, rather than including older data that may be less representative[17].



4. Indicate whether the package results meet the assessment requirements

For TP results, indicate the following:

- Did the data meet the minimum data requirements for assessments? (Need at least 6 monthly means, from at least 2 qualifying years.)

For Chl results (both REC & FAL), indicate the following:

- Do the results qualify for a "bioconfirmation" assessment? (Need at least 3 monthly means, from at least 1 qualifying year.)
- Do the results qualify for a "biology-only" assessment? (Need at least 6 monthly means from at least 2 qualifying years).

[17] The Integrated Reporting workgroup discussed whether to include more data from earlier years to try to reach a more "Clear" decision, but decided against this. If the lake is trending better or worse over time, it is most appropriate to use the most recent data and recommend future monitoring to reach a more "Clear" decision rather than using older data. However, biologists may incorporate less recent data if they feel it is appropriate to do so.

5. Determine listing categories: Applying Bioconfirmation (a.k.a. Hierarchy of Indicators)

Once it has been determined that one or more metrics (TP and/or biological metrics such as chlorophyll or macrophytes) have exceeded an impairment threshold, the department looks at the results of both the TP and biological response indicators in combination to determine which listing category the lake should be placed into. There are several assessment paths that can lead to listing a lake as impaired for TP, chlorophyll a, or a combination of both.

- *TP Only—based on "Overwhelming TP exceedance":* If a lake's lower 90% confidence interval exceeds its phosphorus criterion by 1.5 times[18], it is considered to have an 'overwhelming exceedance' of the phosphorus criteria, and the lake can be listed as impaired based on phosphorus alone, in Category 5A. In this case, only one year of overwhelming exceedance is required if that year is not an extreme weather year (see Chapter 2.5 in WisCALM on *Data Requirements* for a definition of extreme weather year), and biological confirmation is not required (though can be included if available).
- *Biology Only—based on impairment of uses:* If a lake's phosphorus concentration does not exceed the criteria, but at least one biological metric is exhibiting impairment over two years, the lake can be listed for biology only. In these cases, the lake would be listed as having an impaired fish and aquatic life or recreational use under Category 5A, but the pollutant associated with this impairment may be listed as "Unknown" instead of as "Phosphorus". If it is believed that phosphorus is the causal factor in the biological impairment, the lake may be a good candidate for a more stringent site-specific phosphorus criteria.
- *TP & biology in combination—based on TP exceedance plus "bioconfirmation":* If TP exceeds the criteria but not by 1.5 times, biological confirmation will be used to determine what listing category is appropriate.
  - If at least one of the biological response metrics is poor for at least one year, the lake should be listed as impaired for fish and aquatic life and/or recreational uses under Category 5A, with phosphorus listed as the pollutant.
  - If either insufficient biological data are available to conduct bioconfirmation, or biological data are available and do not indicate an impairment, the lake will be placed in Category 5P. This category is a special category on the impaired waters list for waters exceeding TP criteria but without bioconfirmation of an impairment. More monitoring is needed, and/or other metrics may need to be considered. These lakes may be good candidates for site-specific phosphorus criteria.

Assessment scenarios incorporating TP and biological data are listed in Table 4.

[18] For lakes an "overwhelming exceedance" is defined as 1.5 times the phosphorus criteria; for rivers/streams, an "overwhelming exceedance" is defined as 2 times the phosphorus criteria.

Table 4. Assessing phosphorus and biology in combination to determine impairment status and pollutant.

	Biological Response Indicators	Overall Assessment Result & EPA Listing Category	Pollutant
Meets TP criteria	None indicate impairment	Not Impaired (Fully Supporting) Category 2	NA
	One or more indicate impairment	Impaired – Biology Only (Not Supporting) Category 5A	Unknown
Exceeds TP criteria (not an overwhelming exceedance)	One or more indicate impairment	Impaired – TP & Bioconfirmation (Not Supporting) Category 5A	TP
	None indicate impairment	Impaired – Exceeds TP but has insufficient or conflicting biological data (Not Supporting) Category 5P	TP
Exceeds TP criteria by an overwhelming amount	None needed	Impaired – TP Only (i.e. Overwhelming exceedance) (Not Supporting) Category 5A	TP

Dissolved Oxygen (DO)
Low DO can be used as an impairment indicator. This standard implies an activity that causes a change in DO above and beyond natural variability, or some uncontrollable factor (such as drought).

Minimum Data Requirements

a) *Seasonal Range and Sampling Frequency.* A minimum of 10 discrete values over a period of 5 years, collected on separate calendar days during the ice-free period are required from each assessment station. If more samples than the minimum are available, they will also be used in calculations unless excluded due to professional judgment.

b) *Sampling Depth.* Samples should be taken from the epilimnion. In the case of two-story lakes, samples should be taken from both the epilimnion and hypolimnion.

c) *Units.* DO values should be expressed in mg/L.

d) *Data Quality.* If data quality for any values is questionable, they should not be used for the calculations. Data should only be used from DO meters where calibration records are available, or from titration methods. (However, this information is all field-entered, so the data points are not automatically flags to indicate suspect data.)

Calculations and Exceedance Frequencies

a) *Calculations.* Data from the most recent 5-year period may be lumped together for this calculation (however, the data should all be from a single station). If 10% of values exceed DO criteria, the lake is not meeting criteria. Because low DO most commonly occurs in shallower portions of a lake, individual station data should be assessed separately to determine whether DO problems exist.

b) *Exceedance Frequency.* Compare data to the impairment threshold for DO listed in Table 5A. For all lakes except Two-Story Lakes, the threshold is less than 5 mg/L. For Two-Story Lake, the threshold is less than 5 for the epilimnion and less than 6 for the hypolimnion, where coldwater species may be found. If 10% or more of all DO values (from all assessment sites combined, cumulatively over the most recent five year period) are below the applicable thresholds, the impairment threshold is exceeded.

Macrophytes (aquatic plant metrics)

Aquatic plants respond to human disturbance (Lacoul & Freedman 2006, Wilcox 1995). Certain plant species are lost when nearshore areas are developed or when non-point source pollution, especially phosphorus, impacts water chemistry, triggering a response from aquatic plant communities. Plants can be used as a metric to signify ecological impairment, for example, due to eutrophication[19]. The department has employed a standardized point-intercept sampling method beginning in 2005 to make data more comparable across lakes and to gain lake-wide coverage of the entire aquatic plant community (Hauxwell et al. 2010, Mikulyuk et al. 2010). Methodological standardization has resulted in high among-lake comparability and robust estimations of species richness and frequency of occurrence.

In this assessment cycle, we are exploring how a combination of both multivariate and multi-metric methods can be used to assess aquatic macrophyte communities in lakes. Multivariate community analysis can be used to compare aquatic plant communities in assessment lakes to those in undisturbed reference sites. Lakes that have substantially different plant communities from reference lakes can be flagged for further investigation. The aquatic plant data from flagged systems can then be used to calculate a number of metrics that indicate human perturbation. Individual metrics can be combined into a comprehensive index score. One of these indices, called the Aquatic Macrophyte Community Index, or AMCI, decreases with increasing human disturbance. This multi-metric aquatic plant index was created by Nichols, Weber, and Shaw (2000) using data from transect-based plant surveys of Wisconsin lakes. Current analysis is underway to evaluate the component metrics of the AMCI and consider additional or alternative plant metrics that are most informative at identifying impaired lakes.

Because a waterbody's overall AMCI score reflects a wide range of stressors, WDNR researchers have determined that for purposes of impairment (303(d)) listing related to individual stressors such as phosphorus, it is more appropriate to use a combination of plant community information and individual plant metrics correlated to that stressor, instead of the overall AMCI score. For 2014, WDNR has developed protocols for assessing the following variables and metrics that correlate to elevated phosphorus levels and eutrophication impairments in Wisconsin lakes:

- Plant species abundance
- Plant community composition

[19] For 2014, plant metrics will be used primarily to assess eutrophication impacts to fish and aquatic life uses. In the future, they may also be used to assess habitat degradation or recreational use impairments.

- Relative % littoral area vegetated
- Relative % tolerant species
- Maximum depth of plant growth

Biological impairment will be analyzed using a reference condition approach. We selected a pool of reference lakes representing regional least-impacted conditions as defined by land-use at the watershed and local scale (100m shoreline buffer). The reference plant communities serve as benchmarks against which other plant communities may be compared. However, environmental factors not related to humans influence aquatic plant communities and also must be accounted for before making comparisons (Mikulyuk et al. 2011). Thus, we grouped reference lakes according to plant community composition. Lakes fell into three major groups that were best explained by latitude and substrate type (soft vs. sandy). The assessment procedure involves assigning category membership to new assessment lakes (based on latitude and substrate), and then comparing the test community to those communities in the appropriate reference group using multivariate methods (Reynoldson et al. 1995). If plant communities in comparison lakes are found to be significantly different, than an investigation into the possible sources of impairment proceeds first by evaluating the scores of individual impairment metrics.

The impairment indicated by different aspects of an aquatic plant community will vary. For example, maximum depth of plant growth (MDC) and relative frequency of tolerant species (TOL) both indicate a eutrophication impairment, while frequency of floating-leaf plants (FLOAT) signifies a habitat degradation impairment. The metrics that appear to be most strongly related to land-use disturbance are frequency of floating-leaf plants (buffer zone urban disturbance) and relative frequency of tolerant species (watershed agriculture disturbance).

For the 2014 cycle, the department has appointed an Aquatic Botanists Review Team. For lakes that biologists suspect that plant metrics may indicate impairment, the Aquatic Botanists Review Team will review the available data and make a determination based on their established protocols and best professional judgment as to whether Fish and Aquatic Life uses are impaired due to aquatic plants. Such a determination may also be used to corroborate total phosphorus exceedance.

Table 5A. Fish & Aquatic Life Use impairment thresholds for lake natural communities.

Indicators	Min. Data Requirement (see text for details)	Exceedance Frequency (see text for details)	Impairment Threshold - LAKES - Fish & Aquatic Life Use						
			Shallow			Deep			
			Headwater Drainage Lake	Lowland Drainage Lake	Seepage Lake	Headwater Drainage Lake	Lowland Drainage Lake	Seepage Lake	Two-story fishery lake
Biological indicators									
chl a	3 monthly values from each of two years[3] from the period July 15 – Sept. 15	Lower bound 90%CI of the mean exceeds threshold	≥60 ug/L (≥71 TSI)	≥60 ug/L (≥71 TSI)	≥60 ug/L (≥71 TSI)	≥27 ug/L (≥63 TSI)	≥27 ug/L (≥63 TSI)	≥27 ug/L (≥63 TSI)	≥10 ug/L (≥53 TSI)
Aquatic plant metrics	*Baseline aquatic plant survey*	*NA (1 survey)*	*(Data will be reviewed by DNR's Aquatic Botanist Review Team impairment assessments)*						
Conventional physico-chemical indicators									
TP	3 monthly values from the period June 1 –Sept. 15	Lower bound 90%CI of the mean exceeds threshold	≥100 ug/L	≥100 ug/L	≥100 ug/L	≥60 ug/L	≥60 ug/L	≥60 ug/L	≥15 ug/L
DO	10 discrete[1] epilimnetic values (ice free period, epilimnetic samples)	Greater than 10% of values	< 5 mg/L						
Temperature	20 discrete[1] values	Vary (see thresholds)	Daily (mean) and seasonal T˚ fluctuations (min. & max. daily mean) [2] not maintained; and Maximum T˚ increase exceeding 3˚F above natural temperature[2]						
pH	10 discrete[1] values	Vary (see thresholds)	- Outside the range of 6.0-9.0 - Change >0.5 units outside natural seasonal maximum (mean) & minimum (mean) [2]						
Turbidity	10 discrete[1] values	*(to be determined)*	*(reserved until sufficient data available)*						
TSS	10 discrete[1] values	*(to be determined)*	*(reserved until sufficient data available)*						
Aquatic Toxicity-based indicators									
Acute aquatic toxicity	2 values within a 3-year period	Maximum daily concentration not exceeded more than once every 3 years	≥ values provided in Tables A & B below						
Chronic aquatic toxicity		Maximum 4-day concentration not exceeded more than once every 3 years	≥ values provided in Tables A & B below						

(1) Discrete values refer to samples collected on separate calendar days. DO, temperature and pH criteria are taken from s. NR 102.04, Wis. Adm. Code, Water Quality Standards for Wisconsin Surface Waters.
(2) Based on historical data or reference site.
(3) For bio-confirmation of TP criteria exceedance, chlorophyll data from only one year is required.

Table 4B. Acute toxicity thresholds for lakes with toxicity related to hardness or pH. *

Substance	Acute Thresholds (ug/L) at various hardness (ppm) levels *		
	50	**100**	**200**
Cadmium, total recoverable			
- Lake Superior and Lake Michigan; and any lakes classified as "trout waters"	1.97	4.36	9.65
- All other lakes	4.65	10.31	22.83
Chromium $^{+3}$, total recoverable			
- All lakes	1022	1803	3181
Copper, total recoverable			
- All lakes	8.07	15.51	29.84
Lead, total recoverable			
- All lakes	54.73	106.92	208.9
Nickel, total recoverable			
- All lakes	261	469	843
Zinc, total recoverable			
- All lakes	65.66	120.4	220.7
	Acute Thresholds (ug/L) at various pH levels*		
	6.5	**7.8**	**8.8**
Pentachlorophenol			
- All lakes	5.25	19.4	53.01
	Acute Thresholds (mg/L) at various pH levels*		
	7.5	**8.0**	**8.5**
Ammonia			
- Lake Superior and Lake Michigan; and any lakes corresponding to "CW Categories 1 or 4"	13.28	5.62	2.14
- Any lakes corresponding to "CW Categories 2 or 3"	16.59	7.01	2.67
- All other lakes	19.89	8.41	3.20

* See Table 2 in s. NR 105.06, Wis. Adm. Code for calculation of acute thresholds with specific hardness or pH values
CW Category 1 = Default category of cold water classification. This category includes all fish. [Note: CW Category 1 is always applicable in Lake Superior, Lake Michigan, and Green Bay north of 44° 32' 30" north latitude.]
CW Category 2 = Inland lakes with populations of cisco, lake trout, brook trout or brown trout, but no other trout or salmonid species. This category excludes data on genus Onchorhynchus.
CW Category 3 = Inland lakes with populations of cisco, but no trout or salmonid species. This category excludes data on genera Onchorhynchus, Salmo, and Salvelinus.
CW Category 4 = Inland trout waters with brook, brown, or rainbow trout, but no whitefish or cisco. This category excludes data on genus Prosopium.
CW Category 5 = Inland trout waters with brook and brown trout, but no whitefish, cisco, or other trout or salmonid species. This category excludes data on genera Prosopium and Onchorhynchus.

Table 4C. Acute and chronic toxicity thresholds for lakes with toxicity unrelated to water quality.

Substance	Thresholds (ug/L)	
	Acute toxicity	Chronic toxicity
Arsenic $^{+3}$, total recoverable		
- Lake Superior and Lake Michigan; and lakes classified as "trout waters"	339.8	148
- All other lakes	339.8	152.2
Chromium $^{+6}$, total recoverable		
- All lakes	16.02	10.98
Mercury $^{+2}$, total recoverable		
- All lakes	0.83	0.44
Cyanide, free		
- Lake Superior and Lake Michigan; and lakes classified as "trout waters"	22.4	5.22
- All other lakes	45.8	11.47
Chloride		
- All lakes	757,000	395,000
Chlorine, total residual		
- All lakes	19.03	7.28
Gamma - BHC		.
- All lakes	0.96	n.a.
Dieldrin		
- Lake Superior and Lake Michigan; and lakes classified as "trout waters"	0.24	0.055
- All other lakes	0.24	0.077
Endrin		
- All lakes	0.086	0.072
Toxaphene		
- All lakes	0.73	n.a.
Chlorpyrifos		
- All lakes	0.041	n.a.
Parathion		
- All lakes	0.057	0.011

Table 4D. Chronic Toxicity Threshold for Lakes with Toxicity Related to Hardness or pH*

Substance	Chronic Thresholds (ug/L) at various hardness (ppm) levels *		
	50	**100**	**200**
Cadmium, total recoverable			
- All lakes	1.43	2.46	3.82
Chromium $^{+3}$, total recoverable			
- Lake Superior and Lake Michigan; and lakes classified as "trout waters"	48.86	86.21	152.1
- All other lakes	74.88	132.1	233.1
Copper, total recoverable			
- All lakes	5.72	10.35	18.73
Lead, total recoverable			
- All lakes	14.33	28.01	54.71
Nickel, total recoverable			
- All lakes	29.0	52.2	93.8
Zinc, total recoverable			
- All lakes	65.66	120.4	220.7
	Chronic Thresholds (ug/L) at various pH levels *		
	6.5	7.8	8.8
Pentachlorophenol			
- Lake Superior and Lake Michigan; and lakes classified as "trout waters"	4.43	14.81	40.48
- All other lakes	5.33	17.82	48.7
	Chronic Thresholds (mg/L) at various pH levels*		
	7.5	8.0	8.5
Ammonia			
All lakes (early life stages present) (1)			
- @ 25 ˚C	2.22	1.24	0.55
- @ 14.5 ˚C or less	4.36	2.43	1.09
All lakes (early life stages absent) (1)			
- @ 25 ˚C	2.22	1.24	0.55
- @ 7 ˚C or less	7.09	3.95	1.77

** See Table 4 (Cadmium), 4b (Ammonia) & 6 (all other substances) in s. NR 105.06, Wis. Adm. Code for calculation of thresholds with specific hardness or pH values*
(1) The terms “early life stage present” and “early life stage absent” are defined in subch. III of ch. NR 106, Wis. Adm. Code.

4.5 Lake Impairment Assessment: Recreational Uses

Recreational Use impairments for lakes are based primarily on both phosphorus and chlorophyll a levels, as chlorophyll a is a measure of algal concentrations. For the 2014 assessments, the protocols for assessing both phosphorus and chlorophyll have been revised significantly from 2012. The assessments now utilize a more sophisticated statistical approach that more appropriately accounts for the variability of water quality samples. As with Fish & Aquatic Life listings, once individual metrics for eutrophication are assessed, phosphorus results should be reviewed in combination with biological response indicators such as chlorophyll to make a determination as to which listing category the lake should be placed into. This is described in chapter 4.4 "Lakes Fish & Aquatic Life", under the subheading "Determine listing categories: Applying Bioconfirmation".

Total Phosphorus (TP)
For recreational uses, TP data are assessed in the same way as described in chapter 4.4, "Lakes Fish & Aquatic Life", but the resulting 90% confidence intervals are compared to different, lower thresholds, as shown in Table 6.

Algal blooms (chlorophyll a)
Algae, including blue-green algae, are naturally occurring organisms found throughout the state and are an important part of Wisconsin's freshwater ecosystem. However, excessive nutrient loading (particularly phosphorus) can cause algae populations to grow rapidly under certain environmental conditions and form "blooms" that can impact water quality and pose health risks to people, pets, and livestock. Blue-green algae pose the greatest nuisance and risk to those recreating. Most species of blue-green algae are buoyant and when populations reach bloom densities, they float to the surface where they form scum layers or floating mats. In Wisconsin, blue-green algae blooms generally occur between mid-June and late September, although in rare instances, blooms have been observed in winter, even under the ice.

Algae blooms can cause many water quality problems including: a) reduced light penetration affecting the ability of macrophytes to thrive; b) discoloration of water; c) taste and odor concerns, and d) reduced DO concentrations due to massive decomposition of the cells when they die-off. Another important consequence of blue-green algae is their ability to produce naturally-occurring toxins. Effects of algal toxicity and related thresholds are discussed further in the Public Health Uses chapter.

Calculating percent days with nuisance algal blooms and confidence intervals for Chl a
The assessment protocol for determining if chlorophyll *a* is exceeding a recreational use threshold is significantly different in 2014 than it was in 2012. In 2012, the threshold was a concentration threshold, similar to that used for TP. For 2014, the protocol has been changed to better reflect actual impairments of recreational uses, and to better capture the variability of chlorophyll in lakes. The protocol now uses the percent of days during the sampling season that a lake experiences nuisance algal blooms as its benchmark for assessments. Nuisance algal blooms are defined as exceeding 20 ug/L chl a. This was defined based on user perception surveys conducted in Minnesota. For deep lakes, the impairment threshold is 5% of days of nuisance algal blooms during the sampling season. For shallow lakes, the impairment threshold is 30% of days of nuisance algal blooms during the sampling season.

For Chl a recreational use assessments, the same protocols apply for data selection and calculating a grand mean as those described for chlorophyll in chapter 4.4 "Lakes Fish & Aquatic Life". However, the following statistical formula replaces that found under the subheader "Calculate confidence intervals for TP REC & FAL, & Chl FAL".

The statistical formula for Chl a recreational assessments determines the frequency that a lake exceeds a specific chlorophyll threshold, and also calculates the 90% confidence interval. This formula is difficult to run manually but can be done through use of a programming package such as “R” (http://www.r-project.org/). Use the following procedure to calculate the percent of days a lake is exceeding 20 ug/L chl a (P):

1. Using the chlorophyll sample values, calculate $= \frac{20-\bar{x}}{\sigma}$, where $\bar{x}$ is the sample mean and σ is the sample standard deviation.
2. Using the T table provided by the department[20], for each confidence level (lower 90%, Tlow; median, Tmed; and upper 90%, Thigh), and for the appropriate value of n (number of samples), find the value of T that is closest to the one calculated in step 1.
3. Report the value of P that is associated with the value of T that was selected in step 2.

In the absence of meeting minimum data requirements (for instance, nearshore data are available but not from the deep station), the professional judgment of the Regional Biologist should be used to consider listing any waterbody that experiences frequent and severe algal blooms where there is strong reason to believe that designated uses are impaired and nutrient levels may be contributing to such blooms. Information such as taste and odor complaints, documentation of toxin-producing bluegreen algae genera, and algal cell counts can be used as justification for impairment determinations based on best professional judgment.

[20] The department can provide the appropriate T table file upon request as a CSV file (Ttable.csv).

Table 6. Recreational impairment thresholds for lake natural communities

Note: For all parameters, the assessment period is the most recent 10 year period. For TP and chl *a*, data from within the most recent 5 year period are prioritized for impairment assessments.

Indicators	Min. Data Requirement (see text for details)	Exceedance Frequency (see text for details)	Impairment Threshold - LAKES - Recreational Use						
			Shallow			Deep			
			Headwater Drainage Lake	Lowland Drainage Lake	Seepage Lake	Headwater Drainage Lake	Lowland Drainage Lake	Seepage Lake	Two-story fishery lake
Conventional physico-chemical indicators									
TP	3 monthly values from the period June 1 –Sept. 15	Lower bound 90%CI of the mean exceeds threshold	≥40 ug/l	≥40 ug/l	≥40 ug/L	≥30 ug/L	≥30 ug/L	≥20 ug/L	≥15 ug/L
***Biological** indicators*									
chlorophyll *a* (1)	3 monthly values from each of two years(2) from the period July 15 –Sept. 15	Lower bound 90%CI of the mean exceeds threshold	> 30% of days in sampling season have “nuisance algal blooms (> 20 ug/L)			> 5% of days in sampling season have “nuisance algal blooms” (> 20 ug/L)			
Aquatic plant metrics*	Baseline aquatic plant survey	N/A (one survey)	*(reserved until guidance available)*						

(1) While the TP impairment thresholds for the Recreational Use are based on codified criteria, the chlorophyll *a* thresholds for impairment and plant metrics assessments protocols are not codified.

(2) For bio-confirmation of TP criteria exceedance, chlorophyll data from only one year is required.

Macrophytes (aquatic plants)
Although healthy aquatic plant communities are necessary for a good quality lake system, impacted lakes that receive high nutrient inputs may respond not with excessive algal blooms (and the associated high chl *a* values), but instead may exhibit very high macrophyte growth that is matted and densely topped out across the lake surface. This can impact recreational boating and swimming if it becomes a severe problem.

For 2014, the department has developed listing protocols based on macrophyte metrics for use in determining Fish & Aquatic Life use impairments, as described in chapter 4.4 "Lakes Fish & Aquatic Life". However, more research is needed to define how to appropriately conduct recreational use assessments based on macrophytes. WDNR recognizes the importance of developing such a protocol, and hopes to further investigate this issue through additional research and data review, for use in future listing cycles. Such research may investigate correlations between density of macrophytes or frequency of species occurrence with impacts such as inhibited recreational uses or increased issuance of Aquatic Plant Management permits.

Invasive species such as Eurasian Water Milfoil and Curly Leaf Pondweed often contribute to high macrophyte levels. However, Wisconsin does not list waters as impaired due to invasive species, as no guidance is yet available from EPA on how to do so.

Inland and Great Lakes Beaches
Many, but not all, beaches are evaluated for Recreational Uses in Wisconsin. Federal criteria for *Escherichia coli* (*E. coli*) are applicable to the open waters of the Great Lakes – including beaches. In Wisconsin, inland beaches follow the same monitoring and assessment protocol as the Great Lakes beaches. *E. coli* is a species of bacteria that serves as an indicator of the presence of fecal matter in the water – suggesting that there may be harmful bacteria, viruses, or protozoans present that elevate risk to humans.

Monitoring for *E. coli* at many public beaches along the shorelines of Lake Michigan and Lake Superior is conducted in accordance with the Beach Environmental Assessment and Coastal Health Act of 2000 (the BEACH Act). Since 2003, approximately 122 monitoring sites[21] at public beaches in Wisconsin are sampled for *E. coli* for implementation of the BEACH Act. Beaches included in the monitoring program get sampled between 1 and 4 times per week depending on the priority given to the beach. For more information on Wisconsin's Beach Program please visit: www.wibeaches.us.

Although *E. coli* may not be representative of the pathogen strains that result in illness to humans, its presence suggests that fecal matter may be in the water and that other pathogens may be present. It is often these and other pathogens that result in water borne illnesses in humans. Data from this effort are used to make decisions on which beaches are impaired – namely due to chronic closure problems due to the presence of high counts of *E. coli* bacteria.

EPA has established two different water quality criteria for *E. coli* – a single sample maximum of 235 colony forming units (cfu) /100 mL and a long-term geometric mean[22] maximum of 126 cfu/100 mL. Beach closure decisions are routinely made considering the single sample value. However, when evaluating *E. coli* data to determine if a beach should be included on the Impaired Waters List, WDNR relies on long-term data sets.

[21] A few beaches in Wisconsin have beaches large enough that multiple sites are sampled at the beach. In these cases, samples from multiple sites on one beach are often combined to make up a composite sample.
[22] A geometric mean is a measure of central tendency calculated by multiplying a series of numbers and taking the n^{th} root of the product, where *n* is the number of items in the series

To assess the attainment of recreational uses at Wisconsin beaches, WDNR aggregates by month all data collected from beaches during the "beach season" (defined as May 1 through September 30) over the past five years[23]. The data is aggregated by month because it more closely approximates the "five samples per month" requirement of the geometric mean criterion and recognizes that typical sampling frequencies are often less than five times per month. For example, Monthly aggregate data sets with fewer than five data points are considered insufficient for assessing recreational use support. If one or more of the monthly-aggregated geometric means exceeds the criterion of 126 cfu/100ml, the beach will be identified as not supporting its recreation use and placed on the Impaired Waters List. When a beach is included on the proposed Impaired Waters List, the pollutant is listed as *E. coli* and the impairment is identified as "Recreational Restrictions – Pathogens." WDNR will propose to remove a beach from the Impaired Waters List when the monthly-aggregated geometric means of data collected during the previous five years meet the criterion of 126 cfu/100 ml. WDNR believes this is an appropriate way of recognizing chronic risk to human health associated with recreational activities in water with long-term elevated levels of *E. coli.*

4.6 Lake Impairment Assessment: Public Health and Welfare Uses[24]

Harmful Algal Blooms- Blue Green Algal Toxin Health Risks

Algal toxins can be harmful to humans and animals alike through skin contact, inhalation, or ingestion. Some of the species commonly found in Wisconsin that produce algal toxins include *Anabaena* sp., *Aphanizomenon* sp., *Microcystis* sp., and *Planktothrix* sp. Where monitoring of blue-green algae occurs, notices are provided to local public health agencies when concentrations are presumed to exceed 100,000 cells/L. That value represents the threshold for high risk to humans as established by the World Health Organization (WHO) (Table 7). Illnesses related to blue-green algae can occur in both humans and pets. People may be exposed to these toxins through contact with the skin (e.g., when swimming), through inhalation (e.g., when motor boating or water skiing), or by swallowing contaminated water. In 2009, the Wisconsin Department of Health Services documented over 41 cases statewide of human health exposure related to blue-green algae blooms including respiratory ailments (coughing), watery eyes and rashes. Animals can be even more susceptible to risks by drinking water directly from water bodies with dense algal blooms or by licking their fur after swimming.

Biologists should use best professional judgment in determining whether the "High Risk" thresholds in Table 7 are exceeded on a regular basis. When a waterbody is proposed to be included on the Impaired Waters List due to frequent and elevated blue green algal cell counts or toxins, and data are available suggesting high TP concentrations, the Impairment should be identified as "Public Health-Harmful Algal Blooms." In the absence of meeting minimum data requirements for TP (for instance, nearshore data is available but not deep hole data), the professional judgment of the Regional Biologist should be used to consider listing any waterbody that experiences frequent and severe blue-green algal blooms or elevated levels of toxins where there is strong reason to believe that nutrient levels may be contributing to such blooms.

If data are frequently falling into the "Moderate Risk" category, the lake should be considered for Recreational Use listing based on the guidelines in that chapter.

[23] For example, the five year assessment period for the 2012 Impaired Waters List is January 1, 2006 through December 31, 2010.

[24] Although in the future, WDNR hopes to categorize impairments due specifically to Blue Green Algal Toxins under a Public Health & Welfare Use impairment category, for 2014 they will be categorized under Recreational Use Impairments.

Table 7. World Health Organization thresholds of risk associated with potential exposure to cyanotoxins.

Indicator (units)	Low Risk	Moderate Risk	High Risk
chl a (µg/L)	<10	10 - <50	>50
Cyanobacteria cell counts (cells/L)	< 20,000	20,000 - <100,000	≥ 100,000
Microcystin	<10	10 - ≤20	>20

5.0 Stream & River Classification and Assessment Methods

5.1 Stream and River Classifications

The condition of streams and rivers in Wisconsin are currently assessed for the following use designations: Fish and Aquatic Life, Recreational Use, Public Health and Welfare (Fish Consumption) and General Uses. The following provides details on the classifications and water quality goals against which waters are assessed.

Fish and Aquatic Life: Stream and River Classifications
Wisconsin's Fish and Aquatic Life (FAL) use designations for streams and rivers are categorized into the following subcategories as defined in s. NR 102.04(3), Wis. Adm. Code:

- **Coldwater (Cold) Community**: Streams capable of supporting a cold water sport fishery, or serving as a spawning area for salmonids and other cold water fish species. Representative aquatic life communities associated with these waters generally require cold temperatures and concentrations of DO that remain above 6 mg/L. Since these waters are capable of supporting natural reproduction, a minimum DO concentration of 7 mg/L is required during times of active spawning and support of early life stages of newly-hatched fish.

- **Warmwater Sport Fish (WWSF) Community**: Streams capable of supporting a warm water-dependent sport fishery. Representative aquatic life communities associated with these waters generally require cool or warm temperatures and concentrations of DO that do not drop below 5 mg/L.

- **Warmwater Forage Fish (WWFF) Community**: Streams capable of supporting a warm water-dependent forage fishery. Representative aquatic life communities associated with these waters generally require cool or warm temperatures and concentrations of DO that do not drop below 5 mg/L.

- **Limited Forage Fish (LFF) Community**: Streams capable of supporting small populations of forage fish or tolerant macroinvertebrates that are tolerant of organic pollution. Typically limited due to naturally poor water quality or habitat deficiencies. Representative aquatic life communities associated with these waters generally require warm temperatures and concentrations of DO that remain above 3 mg/L.

- **Limited Aquatic Life (LAL) Community**: Streams capable of supporting macroinvertebrates and/or occasionally fish that can tolerate organic pollution. Typically this category includes small streams with very low-flow and very limited habitat. Certain marshy ditches, concrete line-drainage channels, and other intermittent streams. Representative aquatic life communities associated with these waters are tolerant of many extreme conditions, and require concentrations of DO that remain above 1 mg/L.

Fish and aquatic life use designations for individual waters are defined in chs. NR 102 or 104, Wis. Adm. Code. In some cases, coldwater fish communities referenced in the 1980 Trout Book (Wisconsin Trout Streams – Publication 6-3600(80)) may be *codified by reference.* Waters that are not referenced in code are considered *default* FAL waters and are assumed to support either a coldwater community or warmwater community depending on water temperature and habitat.

Assignment of designated uses for the protection of fish and aquatic life has been an iterative process dating back to the late 1960's. Many of the designated uses that are included in the Wis. Adm. Code date back to the 1980's. While efforts are underway to revise FAL use subcategories, the current codified FAL use designation subcategories in ch. NR 102, Wis. Adm. Code will be used for evaluating WQS attainment status.

Natural Communities
Currently, streams and rivers are being evaluated for placement in a revised aquatic life use classification system, in which the new fish and aquatic life use subclasses are referred to as *Natural Communities*. Natural Communities are defined for streams and rivers using model-predicted flow and temperature ranges associated with specific fish and/or macroinvertebrate communities. This model, developed by the USGS and WDNR Science Services Research Staff, generated proposed stream natural communities based on a variety of base data layers at various scales, and was initially applied to the 1:100,000 scale NHD (National Hydrography Dataset) hydrography layer. The data was then extrapolated or "conflated" to the 1:24,000 scale WDNR hydrography layer (version 5). The Natural Communities data layer for Wisconsin rivers and streams identifies which fish index of biological integrity (F-IBI) to apply when assessing our waters. The following Natural Communities have been defined:

> *Macroinvertebrate* – very small, almost always intermittent streams (i.e., cease flow for part of the year, although water may remain in the channel) with a wide range of summer temperatures. No or few fish (< 25 per 100 m of wetted length) are present, but a variety of aquatic invertebrates may be common, at least seasonally.
>
> *Coldwater* – small to large perennial streams with cold summer water temperatures. Coldwater fish range from common to dominant (25-100% of individuals), transitional fish from absent to abundant (up to 75% of individuals), and warmwater fish from absent to rare (0-5% of individuals). Small-stream, medium-stream, and large-river fish range from absent to dominant (0-100% of individuals).
>
> *Cool-Cold Headwater* – small, usually perennial streams with cool to cold summer water temperatures. Coldwater fish range from absent to abundant, transitional fish from common to dominant, and warmwater fish from absent to common. Small-stream fish range from very common to dominant (50-100% of individuals), medium-stream fish from absent to very common (0-50% of individuals), and large-river fish from absent to uncommon (0-10% of individuals).
>
> *Cool-Cold Mainstem* – moderate to large but still wadeable perennial streams with cool to cold summer water temperatures. Coldwater fish range from absent to abundant, transitional fish from common to dominant, and warmwater fish from absent to common. Small-stream fish range from absent to very common, medium-stream fish from very common to dominant, and large-river fish from absent to very common.
>
> *Cool-Warm Headwater* – small, sometimes intermittent streams with cool to warm summer temperatures. Coldwater fish range from absent to common, transitional fish from common to dominant, and warmwater fish from absent to abundant. Small-stream fish range from very common to dominant, medium-stream fish from absent to very common, and large-river fish from absent to uncommon.

Cool-Warm Mainstem – moderate to large but still wadeable perennial streams with cool to warm summer temperatures. Coldwater fish range from absent to common, transitional fish from common to dominant, and warmwater fish from absent to abundant. Small-stream fish range from absent to very common, medium-stream fish from very common to dominant, and large-river fish from absent to very common.

Warm headwater – small, usually intermittent streams with warm summer temperatures. Coldwater fish range from absent to rare, transitional fish from absent to common, and warmwater fish from abundant to dominant. Small-stream fish range from very common to dominant, medium-stream fish from absent to very common, and large-river fish from absent to uncommon.

Warm mainstem – moderate to large but still wadeable perennial streams with warm summer temperatures. Coldwater fish range from absent to rare, transitional fish from absent to common, and warmwater fish from abundant to dominant. Small-stream fish range from absent to very common, medium-stream fish from very common to dominant, and large-river fish from absent to very common.

Large rivers – non-wadeable large to very-large rivers. Summer water temperatures are almost always cool-warm or warm, although reaches are identified based strictly on flow. Coldwater fish range from absent to rare, transitional fish from absent to common, and warmwater fish from abundant to dominant. Small-stream fish range from absent to uncommon, medium-stream fish from absent to common, and large-river fish from abundant to dominant.

5.2 Stream and River General Condition Assessment

Fish and Aquatic Life General Assessments
WDNR uses biological indices, including fish indices of biological integrity (F-IBI) and the macroinvertebrate index of biological integrity (M-IBI), to determine whether current water quality conditions support the Fish and Aquatic Life designated use.

Fish Indices of Biological Integrity
Multiple, peer-reviewed F-IBIs have been developed by WDNR research staff and are used to assess the biological health and quality of fish assemblages of streams and rivers (Lyons, Wang, and Simonson 1996; Lyons 1992, 2003, 2006, and 2012). F-IBIs have been customized to account for differences in stream morphology, water temperature and fish species associated with rivers and streams. A fish IBI has not been developed for any of the small streams lacking sufficient perennial flow to support a fish community. The indices use a large statewide database of standardized fish assemblage surveys from numerous reaches with different levels of human impact. An objective procedure was used to select and score the metrics that compose the various F-IBIs, choosing metrics that represent a variety of the structural, compositional, and functional attributes of fish assemblages (Table 8).

Table 8. Fish Indices of Biological Integrity for Wisconsin streams and rivers.

	Cold F-IBI (Lyons et. al, 1996)	**Warm F-IBI** (Lyons, 1992)	**Small F-IBI** (Lyons, 2006)	**Large River F-IBI** (Lyons et. al, 2001)	**Cool-Warm F-IBI** (Lyons, 2012)	**Cool-Cold F-IBI** (Lyons, 2012)
Temperature	Maximum daily mean <22° C	Maximum daily mean >22° C	Maximum daily mean >22° C	N/A	Maximum daily mean 22.6–24.6 °C	Maximum daily mean 20.7–22.5 °C
Applicable Stream Size & Location	Streams of any size or watershed area	Wadeable streams of a width between 2.5m and 50m, and depth of at least ~1.25m	Streams with watershed areas that are $4km^2$ to $41km^2$	Rivers with at least 3km of contiguous, non-wadeable channel	Scoring criteria depend on the watershed area ("large" is > 200 km^2 and "small" is ≤ 200 km^2) and latitude ("north" > 44.6◦N and "south" is ≤ 44.6◦N)	Scoring criteria depend on the watershed area ("large" is > 200 km2 and "small" is ≤ 200 km2) and latitude ("north" > 44.6◦N and "south" is ≤ 44.6◦N)
Individual Metrics	a) # intolerant species b) % tolerant species c) % top carnivore species d) % native or exotic stenothermal coldwater or coolwater species, e) % salmonid individuals that are brook trout	a) # native species b) # darter species c) # sucker species d) # sunfish species e) # intolerant species f) % tolerant species g) Percent omnivores h) % insectivores i) % top carnivores j) % simple Hthophils k) # of individuals per $300m^2$ l) % diseased fish	a) # native species b) # intolerant species c) # minnow species d) # headwater species e) Total catch per 100m, excluding tolerant species f) Catch per 100 m of brook stickleback g) % diseased fish	a) Weight Biomass PUE b) # native species c) # sucker species d) # intolerant species e) # riverine species f) % diseased fish g) % riverine h) % lithophils i) % insectivore j) % round suckers	a) # native minnow species b) # intolerant species c) % tolerants d) # benthic invertivore species e) % omnivores	a) # darter, madtom and sculpin species b) # coolwater species c) # intolerant species d) % tolerant species e) % generalist feeders

Macroinvertebrate Indices of Biological Integrity
Data derived from aquatic macroinvertebrate samples, combined with stream habitat and fish assemblages, provide valuable information on the physical, chemical and biological condition of streams. Most aquatic macroinvertebrates live for one or more years in streams, reflecting various environmental stressors over time. Since the majority of aquatic invertebrates are limited in mobility, they are good indicators of localized conditions, upstream land use impacts and water quality degradation.

WDNR uses the M-IBI developed by Weigel (2003) to assess wadeable streams. The M-IBI is composed of various metrics used to interpret macroinvertebrate sample data. The M-IBI was developed and validated for cold and warm water wadeable streams and cannot be used as an assessment tool for non-wadeable rivers or ephemeral streams. The following metrics are included in the M-IBI:

- Species richness
- Ephemeroptera–Plecoptera– Trichoptera (EPT)
- Mean Pollution Tolerance Value
- Proportion of Depositional Taxa
- Proportion of Diptera (Dipt)
- Proportion of Chironomidae (Chir)
- Proportion of Shredders (Shr)
- Proportion of Scrapers (Scr)
- Proportion of Gatherers (Gath)
- Proportion of Isopoda (Isop)
- Proportion of Amphipoda

A new macroinvertebrate IBI has been developed, validated, and applied to assess nonwadeable rivers (Weigel and Dimick 2011). Hester–Dendy artificial substrates were used to conduct a standardized macroinvertebrate survey at 100 sites on 38 nonwadeable rivers in Wisconsin. Ten metrics that represent macroinvertebrate assemblage structure, composition, and function constitute the IBI:

- Number of Insecta taxa
- Number of EPT taxa
- Proportion of Insecta individuals
- Proportion of intolerant EPT individuals
- Proportion of tolerant Chironomidae individuals
- Proportion of gatherer individuals
- Proportion of scraper individuals
- Proportion of individuals from the dominant 3 taxa
- Mean Pollution Tolerance Value
- Number of unique functional trait niches

Fish and macroinvertebrate data are used to calculate the appropriate F-IBI and M-IBI scores. Biological data collected within the last ten years are assessed. General biological condition assessments require at least one F-IBI value or one M-IBI value, whereas at least two values of a particular index are required for impairment assessments. Due to strong temporal variations in biological assemblage characteristics at degraded sites, more samples and a longer time frame are needed to determine biotic integrity at sites with human impacts than is needed at least-impacted sites (Lyons, et. al 2001). Natural Community classifications are used to determine which biological index to apply (Table 9).

Table 9. Modeled water temperature and flow criteria used to predict Natural Communities in healthy Wisconsin streams and the primary index of biotic integrity (IBI) for bioassessment associated with each Natural Community.

Natural Community	Maximum Daily Mean Water Temperature (˚F)	Annual 90% Exceedence Flow (ft^3/s)	Index of Biotic Integrity
Macroinvertebrate	Any	0.0 – 0.03	Macroinvertebrate
Coldwater	< 69.3	0.03 – 150	Coldwater Fish
Cool-Cold Headwater	69.3 - 72.5	0.03 – 3.0	Small-Stream (Intermittent) Fish
Cool-Cold Mainstem	69.3 - 72.5	3.0 – 150	Cool-Cold Transition (Coolwater) Fish
Cool-Warm Headwater	72.6 - 76.3	0.03 – 3.0	Small-Stream (Intermittent) Fish
Cool-Warm Mainstem	72.6 - 76.3	3.0 – 150	Cool-Warm Transition (Coolwater) Fish
Warm Headwater	> 76.3	0.03 – 3.0	Small-Stream (Intermittent) Fish
Warm Mainstem	> 76.3	3.0 – 150	Warmwater Fish
Large River	Any	> 150	River Fish

The biological indices respond to watershed scale impacts of agricultural and urban land uses, local riparian stressors, nutrient enrichment, and instream habitat degradation including sedimentation and scouring. In general, as the rate of stream degradation increases, a corresponding decrease in the number of environmentally-sensitive species and an increase in environmentally tolerant species are observed. These changes in aquatic community composition are scored relative to a reference or "least-impacted" condition, and are placed in a condition category based on the resulting score. The condition categories (excellent, good, fair, poor) and corresponding F-IBI scores are shown in Table 10, and the wadeable M-IBI and nonwadeable river M-IBI thresholds are given in Tables 11 and 12, respectively. To determine the biological condition of streams and rivers for assessments, the F-IBI or M-IBI values should be compared against thresholds established for each natural community class.

For general condition assessments, all waters scoring in the excellent, good, or fair categories are considered supporting the FAL use, unless corroborating physical or chemical data exceed impairment thresholds. Waters scoring in the poor condition category based on general assessments using one bioassessment result (available from Tier 1 monitoring) are flagged for follow-up (Tier 2) monitoring.

Table 10. Condition category thresholds for applicable fish indices of biotic integrity (IBI).

Natural Community	Fish IBI Type	Fish IBI	Condition Category
Coldwater	Coldwater Fish	81-100	Excellent
		51-80	Good
		21-50	Fair
		0-20	Poor
Cool-Cold or Cool-Warm Headwater	Small-Stream (Intermittent) Fish	91-100	Excellent
		61-90	Good
		31-60	Fair
		0-30	Poor
Cool-Cold Mainstem	Cool-Cold Transition Fish	61-100	Excellent
		41-60	Good
		21-40	Fair
		0-20	Poor
Cool-Warm Mainstem	Cool-Warm Transition Fish	61-100	Excellent
		41-60	Good
		21-40	Fair
		0-20	Poor
Warm Headwater	Small-Stream (Intermittent) Fish	91-100	Excellent
		61-90	Good
		31-60	Fair
		0-30	Poor
Warm Mainstem	Warmwater Fish	66-100	Excellent
		51-65	Good
		31-50	Fair
		0-30	Poor
Large River	River Fish	81-100	Excellent
		61-80	Good
		41-60	Fair
		0-40	Poor

Table 11. Condition category thresholds for wadeable stream macroinvertebrate index of biotic integrity.

Wadeable Stream M-IBI Thresholds	*Condition Category*
> 7.5	Excellent
5.0-7.4	Good
2.5-4.9	Fair
< 2.5	Poor

Table 12. Condition category thresholds for nonwadeable river macroinvertebrate index of biotic integrity.

River M-IBI Thresholds	*Condition Category*
>75	Excellent
50-75	Good
25-49	Fair
<25	Poor

5.3 Stream and River Impairment Assessment: Fish & Aquatic Life Uses

To make an impairment assessment, all available data over the last 10-year period are reviewed. If a stream or river general assessment category is 'poor', an impairment assessment is conducted. Data up to the past decade, preferably from within the past five years, can be used when conditions are confirmed to be stable throughout the assessment time period. Biological data alone can be used to list a water as impaired, as long as minimum data requirements are met. If corroborating water quality or physical habitat data exists, one 'poor' F-IBI or one 'poor' M-IBI may be sufficient for listing a water on the Impaired Waters List. Example: If the biological condition category is 'poor,' and minimum total phosphorous sampling requirements are met and the TP concentrations exceed the impairment threshold, the Impaired Waters Listing would be as follows: pollutant – "total phosphorus" and impairment – "degraded biological community."

Additional targeted monitoring may be needed to identify a particular pollutant/impairment combination and could include supplemental physical and chemical data, as well as biological data, at additional monitoring sites to obtain adequate coverage of extent of impairment (Table 13). WDNR Biologists have knowledge of the factors that influence community response in rivers and streams. Those insights should be considered when selecting indicators to collect or when scheduling supplemental monitoring. Potential stressors and habitat surveys can help choose the appropriate parameters to be monitored and evaluated to confirm the impairment and to define the associated pollutant. Field collection, preservation and storage should follow procedures outlined in the WDNR Field Procedures Manual and laboratory analysis should follow standard methods (Wisconsin State Lab of Hygiene, 1993).

Table 13. Additional parameters for river & stream impairment assessments.

Indicator	Indicator
Alkalinity	Nitrogen – (Nitrate & Nitrite)
Ammonia*	Organic Compounds*
Biochemical Oxygen Demand	Periphyton
Chlorides*	pH*
Dissolved Oxygen*	Phosphorus – Ortho
Exotic Species – Abundance	Phosphorus – Total*
Exotic Species – Presence/Absence	Sediment Chemistry
Flow	Solids – Total Suspended
Habitat – Qualitative	Solids – Settleable
Habitat – Quantitative	Specific Conductivity
Hardness	Temperature%
Heavy Metals*	Toxicity – Ambient*
Land Use	Toxicity – Sediment
Nitrogen – Total Kjeldahl	Transparency

* = Numeric Water Quality Criteria are available in chs. NR 102 or 105, Wis. Adm. Code

Specific Protocols and Indicator Thresholds for Impairment Decisions

Biological Indicators

As in general condition assessments, biological indicators are also used to assess attainment of WQS and determine whether the fish and aquatic life uses are supported. Section NR 102.01(2) of Wis. Adm. Code explains the goal of WQS is to "protect the use of water resource for all lawful purposes… which includes the protection of public health and welfare and the present and prospective uses of all waters of the state for public and private water supplies, propagation of fish and other aquatic life and wild and domestic animals, domestic and recreational purposes, and agricultural, commercial, industrial, and other legitimate uses. Chapter 102.04(1)d Wis. Adm. Code provides narrative standards for the protection of fish and other aquatic life in surface waters, stating "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." For streams and rivers, attainment of the narrative biological standards is assessed using the fish and macro-invertebrate indices described in the previous section. Biological indicator data collected from two or more sampling visits for a particular assessment unit (i.e. stream segment) are considered sufficient data to assess attainment of the narrative biological standards. The general condition category threshold for "poor" condition is used as the benchmark for evaluating attainment of WQS.

Total Phosphorus

For streams and rivers, TP can be linked as a pollutant causing biological impairment using WDNR's sampling protocol, which has been developed consistent with considerations of seasonality, timing and frequency of sample collection used by USGS for development of the TP criteria (s. NR 102.06(3), Wis. Adm. Code). Waters should be sampled monthly over a 6-month period from May through October, ideally within the same year. Each sample should be collected approximately 30 days apart, with no samples collected within 15 days of one another. If more than one sample is available per month, the sample closest to mid-month should be used in the analysis. If one or more monthly samples are missed within a year, additional samples may be collected in subsequent years corresponding with the missed months (e.g., if July and August samples were not collected in the first year, they could be collected in the second year to make a complete data set). If multiple years of data are available, the three most recent years of data should be used. TP data collected for study-specific purposes as part of a targeted monitoring design (e.g., storm event sampling or targeted flow regimes) are not appropriate for assessment of attainment of the applicable TP water quality criterion.

A parametric statistical approach is employed to assess stream TP data against the applicable water quality criterion found in NR 102.06 of Wis. Admin. Code. This approach involves the calculation of a 90% confidence limit around the median of a TP sample dataset. A confidence limit is calculated using measures of sample size and variation to suggest with a specified level of certainty that the true population statistic (e.g. median) falls within a specified range of values. This statistical approach is described in Gibbons (2003).

The 90% lower and upper confidence limits (LCL and UCL, respectively) on the 50th percentile (median) of a normal distribution are computed as:

$$LCL = \bar{x} - Ks$$
$$UCL = \bar{x} + Ks$$

Where $\bar{x}$ is the sample mean, s is the observed sample standard deviation, and K is the one-sided normal tolerance limit factor for the median with 90% confidence and *n* samples.

WDNR uses automated database assessment packages to perform the calculations for sampling stations that meet the minimum data requirements for assessment purposes. Along with the automated assessment packages, an Excel spreadsheet template is also available for performing the calculations manually. Manual calculations of the statistical values may be required to assess data that is not in the SWIMS database.

If the LCL of the phosphorus dataset from a particular stream site exceeds the applicable criterion, and those data were representative of normal weather and hydrology, then the corresponding stream segment is considered to be exceeding the TP criteria. Two assessment paths lead to listing a stream or river for the pollutant TP in the standard impaired waters category, Category 5A. If the LCL exceeds the applicable TP criterion by two-fold (i.e., "overwhelming exceedance"), then biological confirmation of impairment is not required. However, if the LCL exceeds the criterion less than two-fold (under normal weather and hydrologic conditions), a F-IBI or M-IBI score indicating 'poor' biological condition sufficiently corroborates the FAL use impairment. Waters that exceed TP criteria, but biological data are not available or the biological assessment does not indicate impairment, will be placed in an impaired waters subcategory, Category 5P. These waters are assigned a high priority for biological data collection to determine appropriate future management actions. These TP-related impairment listing scenarios are summarized in Table 4 of Section 4.4.

Other physical/chemical indicators
For other physical/chemical parameters listed in Table 14, monitoring data are evaluated against minimum data requirements, specific thresholds and allowable exceedance frequencies as indicated in the table. If readily available data for the parameters listed are evaluated and determined to be insufficient (i.e. does not meet minimum data quantity requirements), but the limited data indicates a potential use impairment, the waterbody may be a designated as a "Watch Water," and assigned a higher priority for monitoring in the near future.

Table 14A. Fish and aquatic life use impairment thresholds for rivers/streams.

Parameters	Minimum Data Requirement	Exceedance Frequency	Cold Waters	Warm Waters	Limited Forage Fish	Limited Aquatic Life
Conventional physical and chemical indicators						
Dissolved Oxygen	3 days of continuous measurements (no less than 1 sample per hour) in July or August collected from each of 3 separate calendar years.	Greater than 10% of values	<6.0 mg/L and <7.0 mg/L during spawning season	<5.0 mg/L	<3.0 mg/L	<1.0 mg/L
Temperature	10 discrete daily values[25] or days of continuous temperature data[26] collected within a given calendar month to assess against acute and sub-lethal criteria, respectively.	Greater than 10% of daily maximum values or any maximum weekly average temperature value in a calendar month exceeds acute criteria or sub-lethal criteria, respectively.	See Table 2 of NR 102.25(2) of Wis. Admin. Code for acute and sub-lethal temperature criteria by calendar month for non-specific waters			
pH	10 discrete daily values[25]	Greater than 10% of values within a continuous sampling period or for instantaneous w/in season	Outside the range of 6.0 to 9.0 standard units (SU), or change is > 0.5 SU outside natural seasonal maximum (mean) and minimum (mean)			
Total Phosphorus[27]	6 samples monthly from May through October	Lower 90% confidence interval of the sample median exceeds threshold	≥0.100 mg/l for rivers; ≥0.075 mg/l for streams			
Biological indicators						
Fish IBI	1 value for bio-confirmation of TP impairment. For a standalone bio-assessment, 1 value from each of 2 years within 5 years	1 value for bio-confirmation of TP exceedance. For a standalone FAL listing, average value from 2 samples across 2 years	See "poor" condition thresholds in Table 10			
Macroinvertebrate IBI	1 value for bio-confirmation of TP impairment. For standalone bio-assessment, 1 value from each of 2 years within 5 years	1 value for bio-confirmation of TP exceedance. For standalone FAL listing, average value from 2 samples across 2 years	See "poor" condition thresholds in Tables 11 and 12			

Note: Data are evaluated from within the most recent 10 year period for all parameters.

[25] Discrete values refer to samples collected on separate calendar days.
[26] To assess against the applicable sub-lethal temperature criterion, continuous temperature data should be collected at a frequency of no less than one sample per hour with a continuous recording thermistor.
[27] One 'poor' F-IBI or one 'poor' M-IBI is also required to corroborate the impairment of the FAL use for standard impaired waters Category 5A listings. Streams exceeding TP criteria alone will be placed in an impaired waters subcategory, Category 5P.

Table 14B. Aquatic toxicity-based indicator impairment thresholds for rivers/streams.

Aquatic Toxicity-Based indicators			
Acute aquatic toxicity indicators	**Minimum Data Requirement**	**Exceedance Frequency**	**Criteria Table Reference**
Cadmium*, Chromium$^{(3+)}$*, Copper*, Lead*, Nickel*, Zinc*, Pentachlorophenol, and Ammonia *(*total recoverable form)*	2 values within a 3-year period	Maximum daily concentration not exceeded more than once every 3 years	≥ values provided in Table A below
Arsenic$^{(+3)}$*, Chromium$^{(+6)}$*, Mercury$^{(+2)}$*, free Cyanide, Chloride, Chlorine (total residual), Gamma - BHC, Dieldrin, Endrin, Toxaphene, Chlorpyrifos, and Parathion (**total recoverable form)*			≥ values provided in Table B below
Chronic aquatic toxicity indicators			
Cadmium*, Chromium$^{(3+)}$ *, Copper*, Lead*, Nickel*, Zinc*, Ammonia and Pentachlorophenol *(*total recoverable form)*	2 values within a 3-year period	Maximum 4-day average concentration not exceeded more than once every 3 years	≥ values provided in Table C below
Arsenic$^{(+3)}$*, Chromium$^{(+6)}$*, Mercury$^{(+2)}$*, free Cyanide, Chloride, Chlorine (total residual), Dieldrin, Endrin, and Parathion (**total recoverable form)*			≥ values provided in Table B below

Table 14C. Acute Aquatic Toxicity Thresholds for Rivers & Streams with Toxicity Related to Hardness and pH*

Substance	Acute Thresholds (ug/L) at Various Hardness (ppm) Levels*		
	50	**100**	**200**
Cadmium, total recoverable			
- Cold Waters	1.97	4.36	9.65
- Warm Waters & Limited Forage Fish	4.65	10.31	22.83
- Limited Aquatic Life	13.03	28.87	63.92
Chromium $^{+3}$, total recoverable			
- All flowing waters	1022	1803	3181
Copper, total recoverable			
- All flowing waters	9.29	16.82	30.45
Lead, total recoverable			
- All flowing waters	54.73	106.92	208.9
Nickel, total recoverable			
- All flowing waters	642.7	1361	2219
Zinc, total recoverable			
- All flowing waters	65.66	120.4	220.7
	Acute Thresholds (ug/L) at various pH levels*		
	6.5	**7.8**	**8.8**
Pentachlorophenol			
- All flowing waters	5.25	19.4	53.01
	Acute Thresholds (mg/L) at various pH levels*		
	7.5	**8.0**	**8.5**
Ammonia			
- Cold Waters	13.28	5.62	2.14
- Warm Waters & Limited Forage Fish	19.89	8.41	3.2
- Limited Aquatic Life	30.64	12.95	4.93

* See Table 2 in s. NR 105.06, Wis. Adm. Code for calculation of acute thresholds with specific hardness or pH values

Table 14D. Acute, Chronic Toxicity Thresholds Rivers & Streams Unrelated to Water Quality

Substance	Thresholds (ug/L)	
	Acute toxicity	Chronic toxicity
Arsenic $^{+3}$, total recoverable		
- Cold Waters	339.8	148
- Warm Waters, Limited Forage Fish, & Limited Aquatic Life	339.8	152.2
Chromium $^{+6}$, total recoverable		
- All flowing waters	16.02	10.98
Mercury $^{+2}$, total recoverable		
- All flowing waters	0.83	0.44
Cyanide, free		
- Cold Waters	22.4	5.22
- Warm Waters, Limited Forage Fish, & Limited Aquatic Life	45.8	11.47
Chloride		
- All flowing waters	757,000	395,000
Chlorine, total residual		
- All flowing waters	19.03	7.28
Gamma - BHC		.
- All flowing waters	0.96	n.a.
Dieldrin		
- Cold Waters	0.24	0.055
- Warm Waters, Limited Forage Fish, & Limited Aquatic Life	0.24	0.077
Endrin		
- Cold Waters, Warm Waters, & Limited Forage Fish.	0.086	0.072
- Limited Aquatic Life	0.12	0.10
Toxaphene		
- All flowing waters	0.73	n.a.
Chlorpyrifos		
- All flowing waters	0.041	n.a.
Parathion		
- All flowing waters	0.057	0.011

Table 14E. Chronic Toxicity Threshold for Rivers & Streams with Toxicity Related to Hardness or pH*			
Substance	**Chronic Thresholds (ug/L) at various hardness (ppm) levels***		
	50	**100**	**175**
Cadmium, total recoverable (all flowing waters)	1.43	2.46	3.82
Chromium $^{(+3)}$, total recoverable			
Cold Waters	48.86	86.21	n.a.
Warm Waters, Limited Forage Fish, & Limited Aquatic Life	74.88	132.1	n.a.
Copper, total recoverable (all flowing waters)	6.58	11.91	n.a.
Lead, total recoverable (all flowing waters)	14.33	28.01	n.a.
Nickel, total recoverable (all flowing waters)	71.5	151.5	n.a.
Zinc, total recoverable (all flowing waters)	65.66	120.4	n.a.
	Chronic Thresholds (ug/L) at various pH levels *		
	6.5	**7.8**	**8.8**
Pentachlorophenol			
Cold Waters	4.43	14.81	40.48
Warm Waters, Limited Forage Fish, & Limited Aquatic Life	5.33	17.82	48.7
	Chronic Thresholds (mg/L) at various pH levels*		
	7.5	**8.0**	**8.5**
Ammonia			
Cold Waters and Warm Waters (early life stages present) (1)			
- @ 25 ˚C	2.22	1.24	0.55
- @ 14.5 ˚C or less	4.36	2.43	1.09
Cold Waters and Warm Waters (early life stages absent) (1)			
- @ 25 ˚C	2.22	1.24	0.55
- @ 7 ˚C or less	7.09	3.95	1.77
Limited Forage Fish (early life stages present) (1)			
- @ 27 ˚C	5.54	3.09	1.38
Limited Forage Fish (early life stages absent) (1)			
- @ 25 ˚C	6.69	3.73	1.67
- @ 7 ˚C or less	21.34	11.9	5.33
Limited Aquatic Life			
- @ 25 ˚C	14.5	8.09	3.62
- @ 7 ˚C or less	46.29	25.82	11.56

(1) The terms “early life stage present” and “early life stage absent” are defined in subch. III of ch. NR 106, Wis. Adm. Code.

5.4 Stream and River Impairment Assessment: Recreational Uses

Federal criteria for *E. coli* were developed after consideration of risk to the swimming public. All of the data used to establish the federal criteria were collected from swimming beaches. In general, flowing rivers and streams in Wisconsin do not provide comparable recreational activities for full body immersion. For those water bodies, WDNR utilizes that the long-standing water quality criterion for fecal coliform that is reflected in s. NR 102.04(5), Wis. Adm. Code. That section reads:

> (a) *Bacteriological guidelines.* The membrane filter fecal coliform count may not exceed 200 per 100 ml as a geometric mean based on not less than 5 samples per month, nor exceed 400 per 100 ml in more than 10% of all samples during any month.

When a flowing stretch of a river or stream is included on the proposed Impaired Waters List, the pollutant is listed as fecal coliform and the impairment is identified as "Recreational Restrictions – Pathogens." In many instances where fecal coliform counts are high, *E. coli* data or other pathogen data are also collected for streams and rivers and may be used in lieu of or supplementary to fecal coliform data to make best professional judgment decisions to list or not list the waterbody as impaired.

6.0 Public Health and Welfare Uses[28] applicable to all waterbody types

6.1 Fish Consumption Use Assessment

Waterbodies may be designated as impaired on the 303(d) list based on the level of fish consumption advice, which, in Wisconsin, is due primarily to mercury, PCBs, dioxin and furan congeners, and Perfluoroctane sulfonate (PFOS). In 1998, 241 waters were added to the 303(d) list in Category 5B[29], "Waters Impaired by Atmospheric Deposition of Mercury," because mercury-based fish consumption advisories had been issued for these specific waterbodies based on advisory protocols then used by Wisconsin (1985 and 1986 Mercury Protocols).

In 2001, Wisconsin adopted a statewide general advisory that applies to all (non-Great Lakes) waters of the state based on statewide distribution of mercury in fish and species differences in mercury concentrations. The statewide general advisory eliminated the need for many of the pre-2001 advisories because the equivalent of more stringent advice now applied through the general advisory. In addition to the statewide general advisory, some waters still required more stringent advice or exceptions to the general advisory. Exceptions to the general advice apply to some species of fish from specific waters where higher concentrations of mercury, PCBs or other chemicals require advice more stringent than the general advisory.

Since 2002, the 303(d) list has been updated based on changes made to the list of specific advisory waters. However, most of the pre-2001 specific advisory waters remain on the 303(d) list until re-sampling of these waterbodies occurs to confirm that the general advisory is adequate. If new data collected from a pre-2001 advisory water indicates that an exception to the general advisory is not necessary, the waterbody would be removed from the 303(d) list.

For the 2012 impaired waters update, a waterbody will be proposed for removal from the 303(d) list when the most recent advisory update indicates that only the statewide general advisory is necessary for

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[28] For the 2014 listing cycle, impairments related to algal toxins will be listed as Recreational Use impairments (see Lakes Assessment chapter). In the future, WDNR may associate impairment causes such as fish tissue contamination, contaminated sediment, and algal toxins with impairments to the Public Health and Welfare Use.
[29] See chapter 8 for an explanation of Integrated Report Assessment Categories.

concentrations of bioaccumulating chemicals that are of concern in Wisconsin fish. The waters defined as impaired waters are those with specific contaminant data for game and panfish species that require advice more stringent than the statewide general advice based on examination of data in conjunction with WDNR of Health Services. Appendix B lists the fish tissue contaminant thresholds that are used when developing fish consumption advisories.

Specific waters will be proposed for de-listing where fish samples are collected and tested for the appropriate chemicals and where the general statewide advisory is determined to be adequate and exceptions are not necessary based on an evaluation of the concentrations of mercury, PCBs, dioxin/furans, or other chemicals using Wisconsin's fish advisory protocols. The general fish consumption advisory will still apply to these waters, but they will no longer be included on the 303(d) list.

Wisconsin Departments of Natural Resources and Health Services jointly manage the fish contaminant monitoring and advisory programs. The monitoring strategy for fish contaminants varies by the pollutant and the waterbody (see Wisconsin's Water Division Monitoring Strategy). WDNR fisheries staff conducts the fish sampling supported by a variety of fisheries funds. The Wisconsin State Laboratory of Hygiene supports most chemical analyses through general revenue and an agreement with the WDNR. Some EPA funds are used for supplies, lab and freezer rentals, advisory publications, and special analyses.

More information about the specific consumption advisory can be found in the publication: Choose Wisely, A Healthy Guide for Eating Fish in Wisconsin (PUB-FH-824 2010 or subsequent years.) It is available on line at http://WDNR.wi.gov/fish/consumption/.

6.2 Contaminated Sediments

Waterbodies that have sediment deposits that are known to have toxic substances that exceed state water quality criteria for ambient water (as specified in ch. NR 105, Wis. Adm. Code) will be included on the Impaired Waters List. These waters may be identified through various monitoring activities, including routine water quality monitoring, sediment analysis, and collection of fish tissue. In addition to a comparison to the water quality criteria found in ch. NR 105, Wis. Adm. Code, WDNR compares the concentrations of commonly found, in place contaminants to the values outlined in a sediment quality guidance document *Consensus-Based Sediment Quality Guidelines, WT PUB- 732, 2003* (See Appendix C). *http://www.WDNR.state.wi.us/org/water/wm/sms/documents.html*. The guidance was developed through an assimilation of results from multiple published effects-based toxicity testing to freshwater benthos, and serves as part of a tiered approach to evaluating potential ecological and human health risks at sites under evaluation for various reasons.

7.0 Making a Decision to List or Delist Waterbodies

Once data have been assessed to determine whether any parameters indicate impairment of a waterbody, a decision to list a waterbody as impaired or to delist a waterbody should be made. There are several nuances to this decision that are discussed in this chapter. These include resolution of conflicting results from different parameters on a waterbody, identification of which Use Designations are impaired, determination of the appropriate EPA category, and identification of "Causes" and "Sources" of impairment.

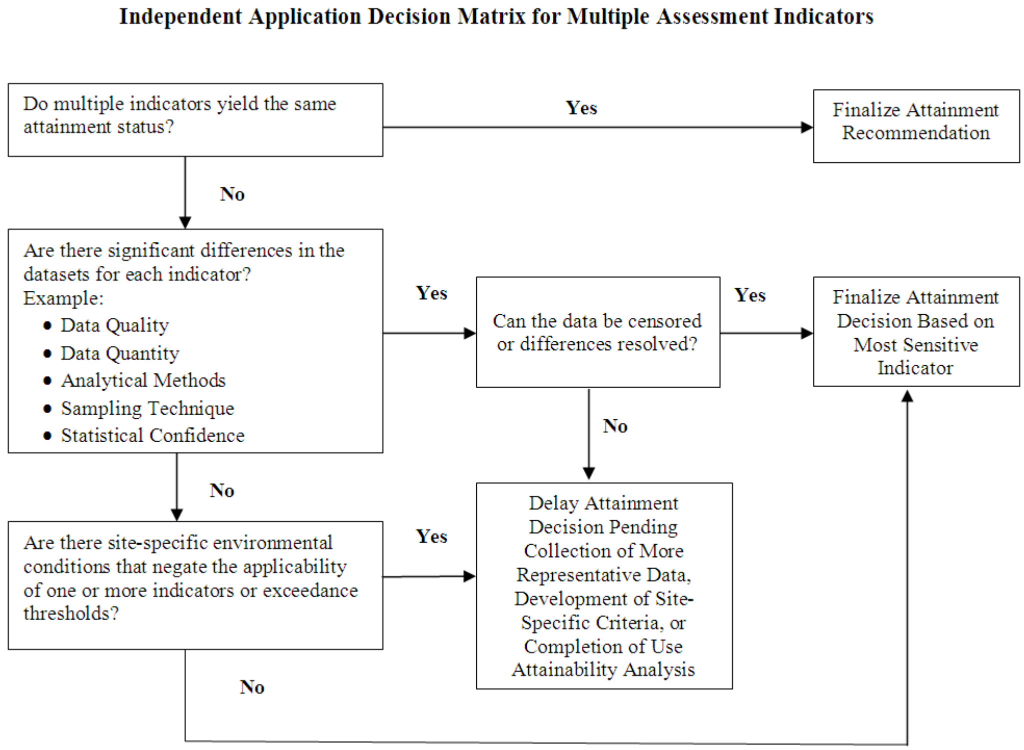
When minimum data requirements are met, an attainment decision should be made and documented. When a decision is made to not list a waterbody due to insufficient data, where limited data show criteria excursions, the water is identified as a "Watch Water" and prioritized highly for future monitoring allow in order to collect sufficient data for future assessment. All assessment results and impaired waters listing details are documented in the WATERS database.

7.1 Independent Applicability & Tools to Resolve Data Conflicts

Under Federal guidance, a water shall be listed on the Impaired Waters List if data is reflective of current conditions, data has met minimum data requirements, and the water does not meet WQS, including water quality criteria, designated uses, and/or antidegradation. This decision philosophy is referred to as *independent applicability,* consistent with the Clean Water Act that protects biological, chemical, and physical integrity of surface waters. However, EPA recognizes that there are certain situations in which factors beyond a strict interpretation of Independent Applicability should be considered to make the most appropriate listing decision. When assessing whether a water is attaining narrative WQS, for example, a suite of indicators are often used. Accordingly, EPA allows states to formulate specific decision rules pertaining to circumstances under which one type of parameter should be given a greater 'weight' than others. Wisconsin has developed decision rules that use a hierarchy of indicators for certain parameters, which are described within the Lakes and Rivers & Streams chapters of this guidance document.

If one of the WQS are not met, but multiple data sets produce conflicting results (some indicating impairment and some not), WDNR staff should review all available data to assist in making an attainment decision. There are several factors biologists may use to resolve these differences to arrive at a listing decision. A decision matrix is described in Figure 14 to describe the process for *not* making attainment decisions using independent application. Cases where this process is used will be rare and should be well documented for that water in the WATERS database.

Figure 14. Independent Application Matrix



Data quality differences

If one parameter indicates impairment but another does not, differences between the two data sets in data quality, data quantity, analytical methods, sampling technique or statistical confidence may provide reason to weight one set of data more heavily than another.

Site-specific factors

Natural background levels of a pollutant may be higher than impairment thresholds or uncontrollable factors may cause an exceedance of WQS. In these circumstances, WDNR will determine whether criteria exceedance are reasonably expected to be due to natural or uncontrollable causes, as defined in the "Six Factors" of Use Attainability Analysis (40 CFR 131.10(g)). If assessment documentation supports that impairment is due to natural or uncontrollable factors, a Use Attainability Analysis (UAA) should be pursued to modify the Designated Use and/or associated criteria. However, a water with suspected naturally occurring pollutant levels that exceed applicable water quality criteria should be placed on the Impaired Waters List under Category 5C, until the appropriate designated use and/or site-specific water quality criteria have been approved by WDNR and EPA. Category 5C waters are those that are identified as impaired, but the cause of the impairment may be attributed to natural or uncontrollable source(s) (see Table 15).

Weight of Evidence

In certain cases where data sets conflict with one another, states may apply a "weight of evidence" approach. This approach helps define the extent of the problem based on how it impacts the Designated Use, and allows biologists to consider aspects of the data that might indicate whether one data set should be weighted more greatly than another.

In all cases, Department staff will look for corroborating information, such as the various habitat and biological indices and water chemistry data. If the suite of available data does not suggest an evident impairment, then the water will not be listed, but will be recommended for additional monitoring as resources allow. WDNR will provide a rationale for those cases where data are available that show that a water quality criterion has been exceeded, but the water has not been recommended for the impaired waters list. In those cases, the indicator has not reached the magnitude, duration or frequency to warrant placing a waterbody on the list or the available data from a particular indicator are not representative of current conditions.

Hierarchy of Indicators
In some situations*, a hierarchy of the indicators may be appropriate*. For example, biological indicators (e.g., fish or macroinvertebrate IBI) for assessment of the fish & aquatic life use may have precedence over physical or chemical indicators in the impairment decision process, because they are direct measures of health of aquatic life. However, this hierarchical approach should be used with caution, knowing that exceedance of chemical indicators may correspond to a more recent event that was not reflected in the biological community data due to differences in collection periods or delays in community response. In such a case, a decision to rely on a hierarchical approach would be inappropriate.

When assessing waters against the applicable phosphorus criteria, biological data are used in combination with phosphorus data to determine whether the fish and aquatic life use is currently impaired. If biological impairment is observed, the water is placed in the standard impaired waters category (5A). If the water exceeds phosphorus criteria but biological impairment is not observed, the water is placed in an impaired waters subcategory (5P) that is given a lower priority for management actions, until biological impairment is confirmed.

7.2 Professional Judgment

WDNR staff most familiar with a waterbody should be directly involved in the assessment decision. Staff knowledge and experience along with the factors that influence water quality should be considered when reviewing and interpreting available data. Professional staff should explore a myriad of issues to determine the most relevant and appropriate data to use for attainment decisions, including: data quality, frequency and magnitude of exceedances, weather and flow conditions during sample collection, anthropogenic or natural influences on water quality in the watershed, etc. If any available data is not used because of professional judgment, clear documentation of the reasons for doing so should be included in the final attainment decision. Again, whether a waterbody is listed as impaired, or the decision has been made not to list a waterbody, all decisions should be *well documented* within the database and future management recommendations will be noted on waters that were not listed (for example, a formal use designation change is needed in order to list the water as impaired, and a recommendation would be made in WATERS to reflect this need).

Two specific review stages occur during the assessment process when regional water resource biologists review the preliminary assessment results. The first review is a data review of the automated database assessment packages. The package results include a series of downloadable reports and spreadsheet outputs for some assessment parameters, which are provided to biologists for review. At that time, reviewers may document justification for a different assessment result based on data quality, additional data and/or waterbody classification errors. After incorporating all assessment and listing modifications from the data review, a Professional Judgment Team will review the draft assessment results and make recommendations for any needed modifications. The following questions may be considered during the professional judgment review stage:

- Are the data from appropriate weather and flow conditions, or are they limited to critical hydrological regimes (low and high flows)? If data are available only from extreme weather years (as defined in Section 2.5), should that dataset be supplemented with data from current conditions before making an assessment decision?

- Are data representative of current water quality conditions?
- Have land uses or point sources changed substantially since the data were collected?
- If the minimum data requirements are not met, do the limited data provide overwhelming evidence of impairment (e.g., phosphorus dataset does not meet minimum data requirements, but biological impairment has been documented or the phosphorus criterion is exceeded by double).

7.3 Threatened Waters

Wisconsin recognizes *threatened* waters as defined by the United States Environmental Protection Agency (EPA):

> *Any waterbody of the United States that currently attains water quality standards, but for which existing and readily available data and information on adverse declining trends indicate that water quality standards will likely be exceeded by the time the next list of impaired or threatened waterbodies is required to be submitted to EPA.*

Waters identified as *threatened* waters become a formal part of the Impaired Waters List, with all of the ramifications associated with impaired waters. Currently no guidance exists on how to formally list *threatened* waters as impaired, waters that fall into this category may be evaluated on a case-by-case basis. A biologist would have to provide sufficient data and information (e.g., 5-10 years of data and multiple samples per year to run a regression analysis) that clearly shows a “declining trend” to predict that the water would be impaired by the next listing cycle. If such significant data exists, the water could be considered for listing as threatened on the Impaired Waters List.

7.4 Watch Waters

Watch Waters are those for which limited data indicate potential impairment, but insufficient data are available to make a final impairment decision, and, therefore, are identified for further monitoring. These waters are not included on the Impaired Waters List due of circumstances warranting further observation or evaluation.

For example, a water may be designated as a Watch Water if water quality data indicating impairment are were collected from unrepresentative “extreme weather” periods, as defined in Section 2.5, resulting in insufficient data to assess. Watch Water status is also designated when phosphorus data are assessed for a particular water but a “clear” decision cannot be made (i.e. 90^{th} percent confidence interval of the phosphorus sample concentration data overlaps the criterion). WisCALM guidance defines a “clear” exceedance of the phosphorus criteria as the lower 90^{th} percent confidence interval of a phosphorus sample concentration dataset that exceeds the applicable criterion. Conversely, the phosphorus criteria are “clearly met” when the upper 90^{th} percent confidence interval of the phosphorus sample concentration data is below the applicable criterion.

7.5 Identifying Sources of Impairment

When a water is deemed impaired, the potential source(s) causing the impairment should be identified. Impairment sources affect which parameters are monitored, what model should be used for analysis and what type of restoration activities would be best on that individual water. In the WATERS database, under the “WDNR Impaired Waters Category” sources may be entered. Some possible sources of impairment include:

Atmospheric Deposition: Waters with fish consumption advisories (FCAs) caused by atmospheric deposition of mercury. To a very limited extent, it may include waters with advisories due to polychlorinated biphenyls (PCBs) where no discrete contaminated sediment deposits exist.

Contaminated Sediment: Waters identified through various monitoring activities, sediment core analysis, and collection of fish tissue that exceed ambient water quality criteria for toxics as specified in ch. NR 105, Wis. Adm. Code. In addition this may include waters where contaminated sediments contain pollutant concentrations that will cause "probable effects" in biological organisms based on guidelines outlined in the "Consensus-Based Sediment Quality Guidelines: Recommendations for Use and Application (2002).

Physical Habitat: Waters where codified uses are not being met due to a physical structure, such as a dam (e.g., a downstream segment is deemed impaired due to the presence of a dam preventing fish movement).

Point Source Dominated: Waters are categorized as point source dominated when the impairment is a result of a current discharge from an existing point source. The Wisconsin Pollutant Discharge Elimination System (WPDES) Permit Program issues and evaluates permits for point sources to assure the attainment of standards at the time of permit issuance. Existing laws and administrative rules including the WQS and WPDES permit rules preclude the issuance of a permit if it will not attain WQS. Waters in this category are likely between permit cycles, or may have obtained a variance to the WQS under current law.

Nonpoint Source (NPS) Dominated: Waters in which the impairment is a result of nonpoint source runoff, including urban stormwater runoff.

Nonpoint Source/Point Source Blend: Waters are placed in this category when impairments exists due to both point source contributions and nonpoint source runoff. Listing a waterbody which is impacted by a point source does not imply that the source is not meeting all the requirements in its discharge permit, but only indicates that a TMDL is needed to determine relative contributions by each of the sources and what additional requirements may be needed.

7.6 De-listing Impaired Waters

Waters and/or associated pollutants and impairments are de-listed from the state's impaired waters list when the state determines and the EPA approves that the waters are no longer impaired or a particular pollutant impairment combination should be removed. A water will not be delisted until all previously listed pollutant/impairment combinations have been removed because applicable WQS are attained. WDNR proposes to de-list a waterbody and/or associated pollutants and impairments from the Impaired Waters List when contemporary, representative, and high quality data warrant de-listing. However, when a change to a water quality standard (e.g. site-specific criteria) has been approved by EPA and the waterbody now meets the revised criterion, WDNR may propose to remove the water and/or associated pollutants and impairments from future lists.

Water No Longer Impaired

WDNR de-lists waters that have been restored. New monitoring data will be collected through Tier 3 monitoring to evaluate the response of the waterbody to some sort of implementation or restoration strategy. Waters will be assessed through the same process identified as listing a waterbody on the 303(d) Impaired Waters List and must meet WQS to be removed from the list.

If a portion of a previously listed water is later determined to be no longer impaired, while other portions remain impaired, the originally listed water may be subdivided into multiple assessment units to account for these differences in attainment status.

Water Listing Validation Found No Impairment

WDNR has identified some waters on historical Impaired Waters Lists that may be inappropriately listed. Common reasons include improper documentation of a past assessment, misidentification of a waterbody, and/or incorrect description of the reach and its specific location within a watershed. In those cases, contemporary information will be documented and WDNR may propose to de-list those waters if the most recent assessment indicates all designated uses are achieved.

EPA Approved TMDL

When EPA approves a TMDL, the water pollutants covered by the TMDL are proposed for removal from EPA-approved list of impaired waters that require a TMDL (Category 5 waters). However, the water is still considered impaired until applicable WQS have been met. Waterbodies having completed TMDLs are moved to Category 4A (Table 15). Once the water is restored and meets applicable water quality criteria, it may be moved to Category 2.

7.7 Decision Documentation

A primary goal of the WDNR is to document all impaired waters decisions, verify the current impaired waters list, and make this information accessible to the public. It is critical that WDNR staff fully document their impaired waters listing recommendations, supporting materials, and justification of their decisions, including any professional judgment used to support those decisions. As a part of this process, it is also important to document assessment decisions for waterbodies that were evaluated but deemed fully supporting assessed uses. The WATERS data system for monitoring and assessment data provides WDNR staff with a systematic location and process for documenting assessment decisions.

Data contained in these data systems are available for the public via the WDNR Surface Water Data Viewer. Information such as monitoring stations, Impaired Waters, WPDES permits, etc. can be accessed from this site. WDNR also maintains dynamic webpages created for Impaired Waters where the public can find water quality monitoring data, pollutants/impairments of concern, TMDL status, and possible management solutions for improving the waterbody. The Impaired Waters Search Tool may be accessed at following website: http://dnr.wi.gov/water/impairedSearch.aspx.

Assessments of non-conventional parameters or those that deviate from standard WisCALM guidance should be documented on the standardized documentation form (Appendix A) and include a justification or case-specific reason for diverging from the assessment guidance. An electronic documentation form is available on request; please send requests to DNRImpairedWaters@wisconsin.gov.

8.0 Integrated Report Listing Categories

One of the elements of the Integrated Report (IR) is defining IR listing categories (Table 15) for each waterbody or assessment unit to communicate work conducted under the use designation, assessment and restoration elements of the WQS program. Wisconsin's IR listing categories loosely follow federal categories identified in the 2008 EPA Integrated Reporting Guidance document.

Table 15. Integrated Report (IR) Listing Categories

IR Category	How Categories Are Used in Wisconsin
Category 1	All designated uses are met, no use is threatened, and the anti-degradation policy is supported. This category requires that all designated uses have been assessed for a given water.
Category 2	Available information indicates one or more designated uses are met. This category is applied to waters that have been assessed and considered fully meeting one or more designated uses and is usually applied in Wisconsin to waters that have been restored and removed from the impaired waters list.
Category 3	There is insufficient available data and/or information to assess whether a specific designated use is being met or if the anti-degradation policy is supported. This category is also used for situations where the state has not yet had time or resources to analyze available data.
Category 4: Waters where a Total Maximum Daily Load (TMDL) is approved by EPA or not required.	
Category 4A	All TMDLs needed for attainment of water quality standards have been approved or established by EPA. This does not mean that all other designated uses have been evaluated and found to be meeting their designated use.
Category 4B	Required control measures are expected to achieve attainment of water quality standards in a reasonable period of time. Environmental Accountability Projects may be proposed as an alternative to TMDL development.
Category 4C	A waterbody where the impairment is not caused by a pollutant. Pollution is defined by EPA as the human-made or human-induced alteration of the chemical, physical, biological, and radiological integrity of water (Section 502(19)).
Category 5: Waters where a TMDL is required.	
Category 5A	Available information indicates that at least one designated use is not met or is threatened and/or the anti-degradation policy is not supported, and one or more TMDLs are still needed.
Category 5B	Available information indicates that atmospheric deposition of mercury has caused the impairment of the water. The water is listed for a specific advisory and no in-water source is known other than atmospheric deposition.
Category 5C	Available information indicates that non-attainment of water quality standards may be caused by naturally occurring or irreversible human-induced conditions.
Category 5P	Available information indicates that the applicable total phosphorus criteria are exceeded; however, biological impairment has not been demonstrated (either because bioassessment shows no impairment or because bioassessment data are not available).

Placing Assessment Units in Categories
Waters are placed in Category 3 unless additional data or information is available to move the water from a Category 3 to a different group. Waters that meet one or more designated uses -- and have no uses impaired will be included in Category 2. For example, if an assessment for fish and aquatic life results in the water being listed, restored, and removed from the impaired waters list, it may then be placed in Category 2, indicating that the water has been assessed and considered fully meeting one or more designated uses (with "unknowns" or no information available for the other use designations-unknowns could refer to unknown designated uses or pollutants/impairments). This category cannot be used for situations in which one or more use designations have been restored but other use designations remain impaired. Waters will be placed in Category 2 after WisCALM guidance has been applied and the water has been fully assessed through an impaired waters de-listing process and determined to be meeting applicable WQS.

WDNR assigns a listing category to both the overall water and individual pollutant/water combinations in our WATERS database. If one pollutant listing has been removed from a water (e.g., because the applicable criteria are now met for that pollutant) but additional pollutant listing(s) remain, the overall waterbody will remain in an impaired water category (i.e., Category 4 or 5) until all pollutant listings have been removed. Categories are also assigned to pollutant/water combinations, in part, to allow WDNR to track the TMDL status of each pollutant listing. For example, for a water with multiple pollutant listings, Category 4a is assigned to pollutant listings when a TMDL has been developed, while other pollutant listings that do not have a completed TMDL are assigned to Category 5.

Moving Assessment Units between Categories
Waters are moved from one category to another during updates to the assessment database by water quality biologists and program coordinators. Once an assessment has been conducted the water will be moved from Category 3, which is the state's default category, to the updated category. This process usually occurs once a year during the update of the state's water assessments during basin plan updates.

Assessment Units with multiple pollutant/impairment listings
Wisconsin uses one category per water, as opposed to tracking a category for each pollutant/impairment listing combination. Because of this, the water will be placed in the more protective or restrictive category available. If a waterbody is listed for two use designation pollutant/impairment combinations (Fish and Aquatic Life, and Recreation) and one of the two remain impaired and the other is restored, the water will remain in an impaired water "category" such as 5A, 5B or 5C, or if applicable, 4B or 4C.

8.1 Priority Ranking for TMDL Development

Waters on the Impaired Waters List will be ranked by priority for Total Maximum Daily Load (TMDL) development. A TMDL is an analysis that determines how much of a pollutant a waterbody can assimilate before it exceeds WQS. Federal law requires that TMDLs be developed for impaired waters.

Waters are ranked "high," "medium" or "low." Rankings are evaluated during each listing cycle to determine if TMDL development can be completed based on staff and fiscal resources. If a TMDL is in development, we will rank the waterbody as a "high" priority. A ranking of "medium" indicates that information is currently being gathered that may be used for future TMDL development. All Category 5B waters (waters impaired by atmospheric deposition of mercury) will be assigned a "medium" priority. A ranking of "low" indicates that a TMDL will be completed in the future.

The following factors are considered when selecting waters for TMDL development:

- **Availability of information**: Large amounts of data are needed to develop a TMDL. Some waters already have some water quality data that can be used while others have little to no data to determine pollutant sources or loading. Waters with readily available data will more likely be a candidate for TMDL development within two to five years and assigned a "medium" or "high" priority ranking.
- **Likelihood to respond:** WDNR may consider the likelihood of the water to respond to management actions when assigning a rank.
- **Severity of the impairment:** WDNR will also consider the severity of the impairment in assigning a priority. In some cases, extreme conditions may be present that need attention more quickly than those that are not so extreme. Waters with frequent fish kills or acute toxicity issues are examples of this concern.
- **Public health concerns:** Waters with issues that may affect human health can be considered "high" priority if development and implementation of a TMDL can result in improving water quality.

Environmental Accountability Projects (EAPs)
Alternatives to a TMDL can be prepared for waters on the 303(d) list. These alternatives are referred to as "Environmental Accountability Projects" or EAPs. These are any planned implementation actions on the impaired water that will result in that water meeting WQS. EAPs are commonly used when the source of an impairment and the appropriate management action are readily identifiable. EAP listings are designated when of the sources and pathways of pollutants do not require a TMDL analysis to identify management actions. Wisconsin currently has several projects that may have an EAP prepared to address specific pollutants and impairments (http://WDNR.wi.gov/org/water/wm/wqs/303d/TMDL.html).

9.0 Public Participation

WDNR recognizes the importance of public involvement in the assessment, restoration and protection of the state's water resources. Public involvement in the development of the state's Impaired Waters List is also required by the Clean Water Act. Several opportunities are provided for public comment on the water quality assessments related to the development of the Impaired Waters List and Integrated Report as it is developed, including the following:

- Calls for data as public noticed by WDNR.
- Statewide public informational meetings to discuss the draft list of impaired waters and the WisCALM document used to determine impairments.
- Informal meetings, as resources allow, with interested parties.
- Draft 305(b) report and 303(d) list as public noticed by WDNR with request for comments.
- Supporting assessment documentation provided upon request.
- Public comments must be sent to WDNR during the formal comment period to be considered in the listing decision submittal. However, comments may be sent to WDNR or directly to EPA about WDNR's Integrated Report at anytime during the process.

9.1 Requests for Data from the Public

The WDNR provides an opportunity for the public, partners and stakeholders to submit water quality datasets for inclusion in assessment of waters against water quality standards for the Integrated Report of Water Quality. For the 2014 listing cycle, public data was solicited during January and February, 2013.

9.2 Submittal of Wisconsin's Integrated Report to U.S. EPA

Wisconsin will provide the EPA with an integrated dataset, a narrative report, associated spatial data files, and a list of updates to the state's 2014 Impaired Waters List on or before April 1, 2014. When this occurs, the WDNR will post the final submittal package on the agency's website for public informational purposes.

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APPENDIX A. 2014 Impaired Waters Assessment Documentation Form

2014 Impaired Waters Documentation Sheet

Author:		Date Prepared:
Waterbody Name:		Segment:
WADRS ID:	WBIC:	Use i-SWDV (CRTL + Click) to find ID numbers

Choose from the following to indicate what you are recommending:

_____ Proposed new **impaired water** listing

_____ Proposed new **watch water** listing

_____ Proposed changes for water already on 303(d) list (check type of change below) ➔ TMDL ID #: _________

    _____ Proposed change to existing list (new pollutants, impairments, mileages, etc.)

    _____ Proposed for de-listing

    _____ General 303(d) documentation for water already on list

Description of waterbody segment

Start Mile: End Mile: Total miles: Lake Acres:	Detail (describe segment using road crossings, convergence with other waterbodies, etc.):

Use Designation Categories	List use designation & data source for each category.
Current (Existing) Fish & Aquatic Life Use:	
Attainable (Potential) Fish & Aquatic Life Use:	
Designated (Codified) Fish & Aquatic Life Use:	

Is it supporting its FAL Attainable Use? _____ Fully Supporting _____ Not Supporting _____ Not Assessed

Is it supporting its Recreational Use? _____ Fully Supporting _____ Not Supporting _____ Not Assessed

Does a *Specific* Fish Consumption Advisory Exist? _____ Yes _____ No _____ Don't know

If so, what is the specific advisory:

Pollutants & Impairments

Pollutants: (Place an X next to all pollutants that you are recommending for listing or de-listing, or "watch water" monitoring needs.)

Phosphorus	Sediment	Bacteria	PAHs	PCBs
NH_3 (Ammonia)	Thermal	Hg	Creosote	Metals
Unknown	Other Pollutants:			

Impairments: (Place an X next to all impairments that you are recommending for listing, de-listing, or "watch water" monitoring needs.)

Degraded Habitat	Eutrophication	Temperature
Contaminated Fish Tissue	Chronic Toxicity	Aquatic Toxicity
Unknown	Degraded Biological Community	

Specific causes of impairment: (Describe to the best of your ability what you think is contributing to the impairment.)

Information is based on:

Monitoring data collected on/after January 1, 2003? _____ YES _____ NO

If 'NO' then provide justification for using data from the long term record:

Monitoring & Listing Data

Monitoring Study, Date, Results. List water quality exceedances indicating magnitude, duration and frequency (attach additional sheets, if needed).

Monitoring Studies:

Exceedances:

Stations:

Parameters:

Database where data is stored (Fish Database, SWIMS, FishSED, Personal PC):

Narrative on why you are proposing this waterbody to be listed or de-listed?

List and attach any additional reports, updated watershed tables, analyses etc. including use designation survey.

1.

2.

3.

4.

APPENDIX B. Summary of Fish Tissue Criteria for Fish Consumption Advice

Summary of Fish Tissue Criteria for Fish Consumption Advice in Wisconsin 2008.

Summary of Mercury Advisory Guidelines (Rfd = 0.3 ug/kg/day and 0.1 ug/kg/day)
PPM **//---Statewide Safe Eating Guidelines-----------------------------------//** //--------Site Specific Only--------------//

	Unrestricted*	1 meal/week	1 meal/month	do not eat	1 meal/week	1 meal/month
men and older women	**<0.16**	**0.16-0.65**	**>0.65**		site specific ave >0.22 and max >0.33	site specific ave >0.65 and max >0.95
	panfish, bullheads, and inland trout	gamefish and other species	muskies		panfish, bullheads, and inland trout	gamefish and other species at a site ave >0.65
	Unrestricted	**1 meal/week**	**1 meal/month**	**do not eat**	**1 meal/month**	**do not eat**
Children and women of childbearing age	**<0.05**	**0.05 - 0.22**	**0.22-0.95**	**>0.95**	site specific ave >0.22 and max >0.33	site specific ave >0.65 and max >0.95
		panfish, bullheads, and inland trout	gamefish and other species	muskies	panfish, bullheads, and inland trout	gamefish and other species

Informational Item - Update on change in the fish consumption adivsory for mercury. February 2001. Department of Natural Resources. Natural Resources Board Agenda Item (Green Sheet). Also, 2007 Mercury Addendum.

Summary of PCB Advisory Guidelines (HPV = 0.05 ug/kg/day) **General vs Site Specific**
PPM

GL Tissue Criteria	Unrestricted	1 meal/week	1 meal/month		6 meals/yr	do not eat
Panfish, inland trout, bullheads	≤0.05 for GLs (General advice for inland waters)	0.06-0.22	0.22-1.0		>1- 1.99 ppm	≥ 2 ppm
Gamefish and others		0.06-0.22 for GLs (General advice for inland waters)				

Protocol For a uniform Great Lake Sport Fish Consumption Advisory. Great Lakes Sport Fish Advisory Task Force. September 1993.

Summary of Dioxin TEC Advisory Guidelines

	do not eat
sum only furan and dioxin congeners x EPA HH TEFs for total TEC	> 10 (ng/kg) ppt dioxin equvalents

June 20, 1990. Henry Anderson, MD, Department of Health and Human Services. Memo to Jay Hochmuth. Department of Natural Resources.

Summary of Chlordane Advisory Guidelines (HPV = 0.15 ug/kg/d -)

	Unrestricted	1 meal/week	1 meal/month		6 meals/yr	do not eat
Panfish, inland trout, bullheads	≤0.16 for GLs (General advice for inland waters)	0.16-0.66	0.66-2.82		2.83-5.62	>5.62 ppm
Gamefish and others		0.16-0.66 for GLs (General advice for inland waters)				

Hornshaw. 1999 Discussion Paper for Chlordane HPV. ILEPA.

Summary of PFOS advisory Guidelines

GL Tissue Criteria	Unrestricted	1 meal/week	1 meal/month		6 meals/yr	do not eat
Panfish, inland trout, bullheads	≤40 ppb for GLs (General advice for inland waters)	40-200 ppb	200-800 ppb			>800 ppb
Gamefish and others		40 - 200 pb for GLs (General advice for inland waters)				

APPENDIX C. Consensus-Based Sediment Quality Guidelines Recommendations for Use & Application