Wisconsin's Water Quality Monitoring Strategy 2021-2025

Photo of the St Croix River courtesy of WDNR, J Cunnigham

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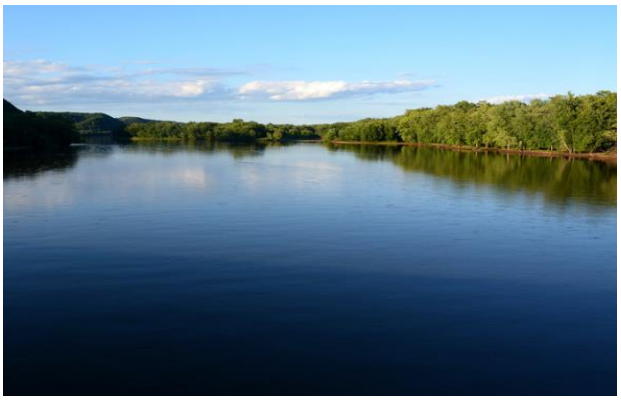
This document can be found on the WDNR Website at:
http://dnr.wi.gov/topic/surfacewater/monitoring.html

Executive Summary

Wisconsin's Water Quality Monitoring Strategy (2021-2025)



This 2021 update to Wisconsin's Water Quality Monitoring Strategy presents DNR's vision to fulfill Wisconsin's Clean Water Act (CWA) monitoring responsibilities. This strategy supports our statewide commitment to protecting and improving water quality through monitoring that is structurally integrated with waterbody assessments and management needs across multiple water programs. The 2015 update to the Monitoring Strategy provided many substantial changes to Wisconsin' Monitoring programs. This 2021 update provides refinements that build upon the 2015 version. Additionally, the 2021 update provides prioritized *"Strategic Shifts"* that outline key areas the Monitoring program will focus on implementing and improving over the next five years and form the basis for funding and staffing requests from internal and external sources.

Strategy Highlights

- → Continued emphasis on a "prescriptive" monitoring approach [Targeted Watershed Assessments and Directed Lakes] to complete waterbody assessments for integrated CWA reporting and address relevant management needs.
- → Greater emphasis on training, oversight, and follow up on staff procedures to ensure that monitoring study design, equipment, methods and analyses are completed and documented.
- → Significantly greater emphasis on linking monitoring, or data collection, with attainment decisions for Clean Water Act 305b/303d reporting and other science-based decisions for management actions.
- → Increased focus on monitoring that evaluates progress toward water quality improvement in watersheds with restoration work.
- → Increased focus working with partner agencies and citizen scientists to monitor, evaluate and manage ecosystems.
- → Continued emphasis on underrepresented media in monitoring and assessment, such as large river biological assemblages, wetlands and aquatic invasive species (AIS) pathways.
- → Increased emphasis on data collection efforts to support identifying and maintaining healthy waterbodies and healthy watersheds, as well as identifying emerging contaminants and tracking effects of a changing climate.
- → Development of online data visualization tools and reporting plans.

Strategy Structure

Chapter 1 provides an overview of the WDNR Monitoring Program and describes how we address the suggested elements of a State Monitoring Program and answer five key questions through implementation of the Strategy. Chapter 2 describes the DNR's organizational structure, funding, and annual work planning framework, including support for laboratory analysis. Chapter 3 provides details about each monitoring "study" or approach, organized by media type (lakes, rivers, streams, and wetlands), as well as AIS, citizen monitoring, and cross program monitoring support. Chapter 4 delves into database management and information technology support for water quality monitoring. Finally, Chapter 5 describes several "strategic shifts" that we have either already initiated or are planning to pursue in the next 5 years, as well as other opportunities to advance our monitoring capacity in Wisconsin.

Contents

Section 1.0 Monitoring Program Overview

Water Quality Program

The Wisconsin Department of Natural Resources, Water Quality Program provides science-based monitoring, analysis, and regulation of discharges to surface waters to protect and maintain the water quality in Wisconsin through management actions including discharge permits, aquatic plant management, aquatic invasive species initiatives, and lakes, rivers, and wetland grants and program implementation.

VISION & MISSION STATEMENTS

Our vision is a sustainable Wisconsin, made possible by clean water and water availability for wildlife, humans, and a vibrant economy through excellent environmental resource management.

Our mission is to protect and enhance our aquatic ecosystems, and to ensure clean, safe water by adhering to state and federal requirements for water quality and environmental protection.

Water Quality Monitoring Program

The Water Quality (WQ) monitoring program supports Department, Bureau and partner data needs that inform water resource management. The program implements the Water Quality Monitoring Strategy and annual monitoring workplans that incorporate baseline (status and trends), probabilistic, problem assessment, evaluation, and response monitoring needs in an efficient and cost-effective manner. The program is administered through the Central Office Monitoring Section, but field work is implemented by a combination of Central Office and District staff located in various offices across the State.

The Water Quality monitoring program, and by extension the Monitoring Strategy, covers wadeable streams, nonwadeable rivers, inland lakes and wetlands within the state. Other water resources such as the Great Lakes open water and coastlines and groundwater are covered by programs not within the DNR Water Quality Program (Office of Great Waters and Drinking Water and Groundwater Program, respectively). The WQ Program works closely with staff in these two other Programs within Wisconsin DNR through collaborative funding, staff assignments and technical assistance. However, they each have or are developing their own monitoring strategies and priorities that are not duplicated in this document.

VISION STATEMENT

Lakes, rivers, streams, and wetlands throughout the state are assessed using representative data collected with standardized biological, chemical, and physical metrics that inform science-based water resource management.

Monitoring Program Goals and Objectives

The objectives of the WQ Monitoring Program and Strategy is organized around the USEPA's Recommended Elements of a State Monitoring Program (https://archive.epa.gov/water/archive/web/html/elements.html), particularly the five questions described in section II:

1) What is the overall quality of waters in the State?
2) To what extent is water quality changing over time?
3) What are the problem areas and areas needing protection?

4) What level of protection is needed?
5) How effective are clean water projects and programs?

While each of these questions has long been an objective for the WQ Monitoring Program, the focus prior to 2015 was very heavily directed toward answering questions 1 and 2 (statewide water quality and trends). Starting with the 2015 Monitoring Strategy and continuing with this 2021 Update there is an increased focus on questions 3, 4 and 5. Recent monitoring has emphasized providing data for restoration and management with local and federal partners such as watersheds under US EPA's Nine Key Element Plans, NRCS's National Water Quality Initiative, and Lake and River Management Plans, among other restoration and watershed plans (Question #3). We are also increasing focus on protection of high-quality waters through the Healthy Watersheds, High Quality Waters (HWHQW) strategic plan aimed at protecting healthy waterbodies (https://dnr.wisconsin.gov/topic/SurfaceWater/HQW.html). The Monitoring Strategy supports this effort by increasing monitoring on healthy waterbodies and providing data that can be used for local management actions (Question #3). The WDNR TMDL monitoring program was a large component of the 2015 Monitoring Strategy and continues to be a large part of this Monitoring Strategy update (Question #4). There have been numerous large scale TMDLs with monitoring initiated and completed recently with more planned post-2020 (https://dnr.wisconsin.gov/topic/TMDLs). Lastly, evaluating the effectiveness of watershed/waterbody restoration efforts has been a major focus of the monitoring program and led to the creation of Targeted Watershed Assessments and Directed Lakes monitoring programs in 2015 (Question #5). In Section 3, where each of the monitoring programs is described, the objective of that project is described by which of the five questions the program is designed to answer.

Section 1.1 Monitoring Program Approach

The Strategy employs a stratified approach to meeting various monitoring objectives as follows:

"Baseline" – Statewide
"Prescribed" – Statewide and Local Collaboration
"Local Needs" – Staff Initiated

Baseline Monitoring – Statewide
Baseline Monitoring are projects that are carried out on waterbodies across the State with a consistent design, method, and monitoring frequency. These projects are typically coordinated by the Monitoring Section and the sampling is conducted by District staff assigned to each site based on their geographic coverage area, usually delineated by county boundaries. Some projects require specialized expertise and/or equipment and implementation may occur with a small set of experts or occur intensively in one geographic area at a time.

Baseline Monitoring consists of:

- Status Monitoring (Primary Objective: What is the overall quality of waters in the State?)
    - Large River Biological Monitoring
    - Remote Sensing Trophic State Monitoring (lakes)
    - Total Phosphorus Loading into Lake Michigan and Lake Superior
    - National Aquatic Resource Surveys (streams, rivers, lakes, wetlands and Great Lakes)

- Trend Monitoring (Primary Objective: To what extent is water quality changing over time?
    - Long Term Trend Rivers
    - Long Term Trend Lakes
    - Lake Level Monitoring
    - Stream Temperature Monitoring Network (streams)
    - Aquatic Invasive Species Long-Term Trends (streams, rivers and lakes)

- Reference sites (Primary Objectives: To what extent is water quality changing over time? And what level of protection is needed?)

    - Wadeable Stream Trend Monitoring
    - Regional Monitoring Network Lakes

Prescribed Monitoring – Statewide and Local Collaboration

Prescribed Monitoring is monitoring activities with common design and a suite of standardized monitoring procedures. This monitoring approach allows for a consistent methodology for sampling watersheds and waterbodies. However, the geographic location and intensity of each project varies on an annual or biennial basis. Prescribed monitoring is designed to meet statewide data needs through consistent data collection schemes and site selection priorities. Watershed/waterbody selection and monitoring intensity are developed by Districts to support local management needs, such as non-point source restoration monitoring. These projects are designed to provide data that will inform protection or restoration actions as well as collecting required data for waterbody impaired waters assessments. As WDNR field staff are distributed geographically across many field offices, this is the Monitoring Strategy's approach to getting new or contemporary data collected across the state. The two main programs that fall under the Prescribed Monitoring approach are Targeted Watershed Assessments (TWA) and Directed Lakes Studies.

Targeted Watershed Assessments

The Targeted Watershed Assessments (TWA) are a stream monitoring program that employs a standard suite of parameters and level of effort to assess a watershed effectively and efficiently, typically of the HUC12 size. Each TWA collect the minimum data requirements for TP and biological assessments at one downstream location in the watershed. The sampling design and intensity may be modified as necessary for project specific goals. TWAs are the major monitoring program that is utilized to assist local watershed management, such as watershed restoration and protection planning activities. For example, WDNR may develop a more intensive nutrient monitoring program to support the data needs necessary for county partners to develop a Nine Key Element Plan. Once approved WDNR may develop a more intense monitoring program including chemical, physical and/or biological monitoring in the same watershed over several years to assess any improvements due to watershed restoration efforts.

Directed Lakes Studies

Directed Lakes is a program that supports assessments and lake-specific management goals. Directed Lakes collects chemical, physical, and biological data using a standard set of monitoring protocols, and the monitoring design can be intensified if needed for management purposes. DNR staff select Directed Lakes for monitoring by considering data gaps and opportunities for engaging communities in lake management. The comprehensive information gathered on a lake can be used to develop a lake management plan or prioritize and implement specific protection and restoration actions. For example,

the lakeshore habitat survey identifies shoreline erosion problems and can be used to engage the county and landowners in shoreline restoration projects. DNR has successfully used Directed Lakes to build new partnerships with lake associations and other groups. DNR conducts the surveys and reports lake condition; partners commit to investing in protection and restoration actions.

TMDL Monitoring

The WDNR TMDL program has prioritized developing TMDLs for total phosphorus and total suspended solids on larger watersheds with multiple impairments (*Wisconsin's Water Quality Restoration and Protection Framework 2015).* The TMDL program has prioritized updating and finalizing modelling and allocations for two TMDLs. The program is currently working on the next 10-year vision for prioritization, the WQ Monitoring Strategy is built to be supportive of TMDL monitoring needs in the next 5-1- years. TMDL monitoring consists of a relatively standard monitoring protocol for collecting continuous discharge paired with grab sample water chemistry to estimate daily pollutant loads. TMDL monitoring is intensive in data collection, geographic scale, and staff time so that only one watershed at a time can be sampled with available staff and funding resources. TWAs are often included at high priority watersheds within TMDL watersheds to collect contemporary assessment data or collect pre-restoration data that can be used to plan or assess future restoration efforts.

"Local Needs" - Staff Initiated

Local needs monitoring is designed to address specific data gaps identified by staff, which could not be addressed through a Prescribed Monitoring project. Local Needs projects may be waterbody investigations that do not require the more extensive TWA or Directed Lakes assessment, investigations of unique stressors not typically monitored, assisting other WDNR cross-program management efforts with water quality data, among other small-scale issue-specific data needs. Every year money in the monitoring budget is reserved for Local Needs projects. Staff identify monitoring needs and write projects, the technical merit of each is reviewed by a media-specific technical review team (streams, lakes or wetlands). Projects funded under the Local Needs approach consist of the following (plus many others):

- Pollutant-specific impaired waters delisting efforts
- Site-specific criteria development
- Cross program support
- AIS response monitoring
- Aquatic plant management evaluation monitoring
- Unique waterbody assessments, such as large river backwaters
- Method development

Section 2.0 Water Quality Monitoring Program Operations

Staffing

The WQ Monitoring Program is administered through the Monitoring Section located in the Madison Central Office. The Monitoring Section consists of a Section Chief, several waterbody-type specific monitoring technical leads, and other specialist and generalist water quality monitoring experts. Among the many responsibilities of the Monitoring Section is to develop the Monitoring Strategy, implement

Figure 2.1. Coverage for Water Resources stream & river (left panel) and lake Biologists (right panel

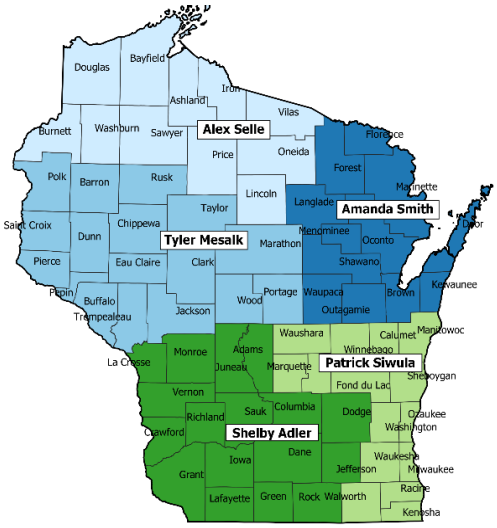


Figure 2.2. Coverage for WDNR Water Resources Aquatic Invasive Biologists.

annual/biennial monitoring workplans, technical improvements in filed and analysis methods, staff training, applied research, technical consultation with field staff among, other duties.

Implementation of water quality field monitoring is partially conducted by the Monitoring Section, Lakes and Rivers Section and other Central Office staff. However, the main portion of field monitoring is conducted by stream and lake biologists located in ~20 or so WDNR field offices throughout the state (Fig 2.1). The Department recently hired 5 aquatic invasive species biologists to implement AIS monitoring and support regional partners (Fig. 2.2). Generally, biologists are assigned monitoring coverage by county boundaries and waterbody type. While having ~25 permanent field biologists allows for extensive monitoring capabilities and flexibility, these staff are typically generalists with many other WQ Bureau responsibilities in addition to monitoring.

The DNR monitoring program is able to accomplish more than it ever could alone through partnerships with volunteers and citizen/community-based scientists. Two important citizen science operations, Citizen Lake Monitoring Network (lakes), and Water Action Volunteers (streams and rivers) are long standing partners in monitoring Wisconsin's surface waters. The CLMN program (https://dnr.wisconsin.gov/topic/lakes/clmn) consists of over 1,000 volunteers that collect lake data to inform lake management. Professional CLMN staff provide equipment and train volunteers in WDNR monitoring protocols that are used by WDNR biologists, research professionals, UW-extension staff and other individuals interested in lake water quality and ecosystem data. CLMN volunteers may monitor several parameters depending on their interest and training including water clarity, ice-on and ice-off records, water chemistry, aquatic invasive species detection among others.

Water Action Volunteers is a partnership between UW-Extension, WDNR and dedicated citizen scientists across the state (https://wateractionvolunteers.org/). Every year WAV monitor more than 600 unique stream locations throughout Wisconsin. WAV monitoring programs operate on a three-tier system. Tier 1 monitoring is introductory monitoring on baseline stream health such as water temperature, streamflow, habitat, AIS, macroinvertebrates among others. Tier II monitoring is status and trends nutrient monitoring using WDNR protocols and assessment methods to collect surface water chemistry data that is used in WDNR's impaired waters assessments. The monitoring locations are mainly directed by WDNR in as part TWA or Local Needs projects, while a small amount of funding is reserved for volunteer-initiated monitoring support. The third tier is special studies monitoring, where volunteers are trained in advanced methods as part of project such as invasive species extent monitoring, urban road salt runoff monitoring, temperature monitoring, among others

Section 2.1 Standard Laboratories

Wisconsin State Laboratory of Hygiene

The Wisconsin State Lab of Hygiene (WSLH) is the state's public health and environmental laboratory which performs a broad array of analysis for the WDNR including organic, inorganic, and toxicological testing for water, fish tissue, sediment, and environmental DNA. http://www.slh.wisc.edu/. The WSLH provides analytical services for multiple state agencies, local governments and private citizens.

The WSLH's Biomonitoring Laboratory, housed within the WSLH provides whole effluent toxicity (WET) testing, ambient (surface water) toxicity testing, and sediment toxicity testing at the request of DNR staff. WET (effluent) testing is normally conducted through the Bureau of Water Quality Wastewater program and is used to supplement existing permit data sets, support enforcement, document impacts of spills or other data collection needs. Ambient and sediment toxicity testing is most often performed, at the request of field biologists or other staff, in response to a known or suspected problem (suspected spills, illicit discharges, historical contamination sources, etc.) and may be conducted on source that is suspected of potentially causing toxicity. The WSLH now provides diatom taxonomic identification to support WDNR's growing need for assessing benthic diatoms for the Diatom Phosphorus Index.

The Environmental Health Diversion of the WSLH provides surface water organic and inorganic analytical services for the WDNR including nutrients, metals, pathogens, algal toxins, industrial chemicals, environmental DNA among others. The WR Program sends thousands of surface water samples to the WSLH organic and inorganic laboratories every field season. Lab sheets are printed in SWIMS, within the correct SWIMS project, with a database key that allows seamless data reporting from the WSLH. The

WSLH Lab Data Entry System (LDES) sends data results back to field staff via an automated email and sends results back to SWIMS using the database key requiring no extra steps by WDNR staff to associate chemistry data with the correct project, waterbody, assessment unit and SWIMS station.

University of Wisconsin – Stevens Point Aquatic Biomonitoring Laboratory

The Aquatic Biomonitoring Laboratory (ABL), affiliated with the Wisconsin Cooperative Fishery Research Unit [http://www.coopunits.org/Wisconsin_Fish/], is housed in the College of Natural Resources at the University of Wisconsin – Stevens Point. The ABL is the main laboratory used by WDNR for identification of aquatic macroinvertebrates. WDNR maintains a 5-year cooperative agreement with the ABL with a workplan mutually agreed upon annually. The ABL analyzes benthic macroinvertebrate samples to assess the ecological condition and environmental quality at sampled locations. The ABL was established in 1985 under the guidance of Dr. Stanley W. Szczytko (retired 2012) to provide benthic macroinvertebrate sample processing to the Wisconsin Department of Natural Resources and other regional resource management agencies. Jefferey Dimick supervises the Aquatic Biomonitoring Laboratory which also hires undergraduate and graduate students perform many of the sample processing services in the Aquatic Biomonitoring Laboratory. Student opportunities exist as direct employment, financial aid assistance through the work study program, for-credit experience and volunteerism. These opportunities develop settings to train future aquatic ecology professionals and conduct stream ecology research.

University of Wisconsin – Superior Entomology Laboratory

Dr. Schmude, Assistant Professor at the University of Wisconsin-Superior, conducts analysis of aquatic macroinvertebrates for the WDNR on a regular basis. Dr. Schmude often supports the analysis of special studies and partnership macroinvertebrate data collection and analysis work often including identification or the NARS NRSA. Dr. Schmude's research focuses on aquatic invertebrates, especially aquatic insects. Over the past 28 years, Dr. Schmude and his colleagues have completed research on a variety of subjects, bringing in several million dollars' worth of research funding, which has helped employ numerous student assistants on many projects. The research has included surveys for rare and endangered species in state-owned properties, biomonitoring streams, lakes, and wetlands and examining the effects of contaminants and other chemicals.

Other Laboratories

Dr. Ryan Thum, Assistant Professor at Montana State University, conducts genetic analysis of milfoil species for the WDNR on a regular basis. Dr. Thum supports the analysis of milfoil species. Dr. Nic Tippery Assistant Professor at the University of Wisconsin-Whitewater conducts genetic analysis of unknown invasive plant species.

Section 2.2 Funding

The WR Monitoring Program is funded through a combination of federal and state funds. For the breakdown of funds, we excluded permanent staff time required to complete monitoring. Due to the generalist staffing model for field biologists only a portion of their time is dedicated to monitoring, and the proportion of time each year may vary drastically based on annually work planning. Therefore, the estimates of monitoring is an underestimate of the true cost of monitoring. The federal proportion of

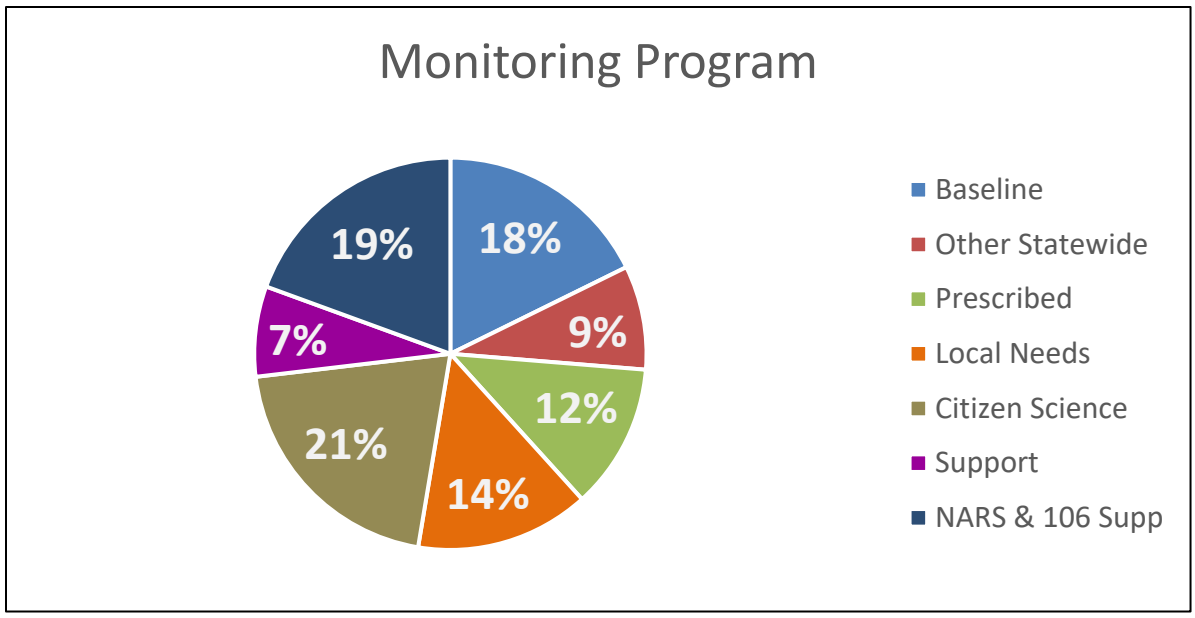


Figure 2.3. Monitoring program funding allocation by project type.

funding sources is probably a larger underestimate because most staff are funded through Federal Section 106 or 319 grants from US EPA for implementation of the Clean Water Act. The relative cost of different monitoring programs may still be fairly accurate (Fig 2.2).

The following analysis includes the average of the last five years of funding, excluding field season 2020 which was affected by COVID health and safety-based adjustments. By monitoring program type funding for Baseline, Prescribed, Local Needs and other Statewide projects, accounts for more than half of the monitoring budget. Baseline, Prescribed and Local Needs projects are described in detail in Section 3. Other Statewide projects includes Long Term Resource Monitoring Program on the Mississippi River, the Northeast Lakeshore and Fox/Des Plaines River TMDLs, satellite Trophic State Index monitoring and various other smaller multi-year projects. Citizen science comprises ~21% of monitoring effort as measured by funding and consists of contracts to UW-Extension and monitoring supplies for personal to run the Water Action Volunteers and Citizen Lake Monitoring Network citizen science programs. The Support portion is amalgamation of money that is annually reserved for equipment purchases and a contract to the UW-Stevens Point Aquatic Biomonitoring Laboratory for macroinvertebrate (assemblage-based assessments and AIS) taxonomic identification. Lastly, 19% of the overall funding is provided by the National Aquatic Resource Surveys (NARS) and the associated 106 Supplemental grant.

Most of the NARS funding is dedicated to a specific monitoring program run by US EPA and States are contracted, but part of the funds are used to increase the sample size for a state-specific survey. 106 Supplemental covers more than just monitoring programs, such as database development or enhancements, assessment methods etc., but we include it here as some of the money is dedicated to monitoring or monitoring adjacent activities every year.

A breakdown of monitoring effort by funding source reveals that more than half of the WR Programs funds come from the US EPA (Fig 2.4). But a further breakdown of sources is necessary as all monitoring funds have unique requirements for the type of activities they may support. The US EPA 106 grant is 18% of monitoring funding and is meant to support and maintain state water pollution control programs

and generally allow the most flexibility for the monitoring it can support. The US EPA Section 319 Program and Project (i.e. Nine Key Element) can be used for monitoring projects that support pollution control work in non-point source dominated watersheds. Lastly from US EPA the NARS funding and 106 Supplemental can be used to gather state-scale assessment of water resource condition and innovations that enhance the State's monitoring and assessment programs. General State funds at 17% make up a significant portion of the monitoring funding. These sources are funded by various state programs and distributed either very generally (e.g. lake monitoring efforts) or for very specific short-term (Northeast lakeshore TMDL legislative initiative) or long-term lifespans (Nearshore Great Lakes protection monitoring fund). The last State funding source is the State WSLH allocation (i.e. Basic Agreement) which is appropriated but the Wisconsin State legislature and sent directly to the Wisconsin State Lab of Hygiene. A portion of that funding is reserved specifically to support WDNR's analytical chemistry needs. The Basic Agreement supports regular organic and inorganic sample analysis and WET testing for the WDNR but may not be re-allocated to other funding sources or any savings be rolled over to a new state fiscal year.

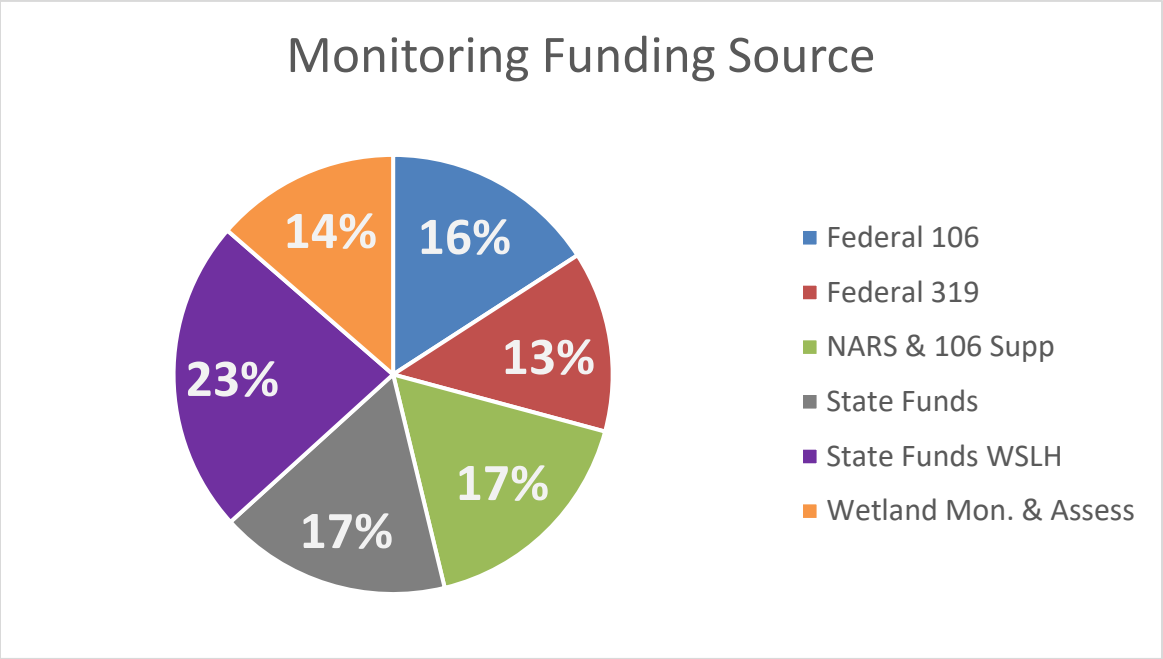


Figure 2.4 WDNR monitoring program relative contribution of different funding sources.

Section 2.3 Monitoring Work Planning and Oversight

The WR's Monitoring Program is administered by the Monitoring Section Chief and monitoring coordinators in the Central Office Monitoring Section and Lakes and Rivers Section. Most of the monitoring is implemented by District field staff with oversight by four District Supervisors and the Field Operations Director. Baseline and Prescribed Monitoring approaches are typically sampled by field staff while Local Needs, depending on the project, may be conducted by field staff, monitoring section staff or a combination thereof. Wetland monitoring is coordinated and mainly implemented out of the central office with field staff specialists hired on a grant or project specific need. Another newer

monitoring program, the Large River Biological Monitoring Rotational Watersheds, is coordinated by two field staff who cover that state along a rough north/south split.

Monitoring is planned on a five-year, two-year, and annual frequency. Every five-years the monitoring strategy is updated to reflect longer-term visions for the monitoring program. Many of the TWAs and Directed Lakes require two years to collect the necessary data. The oversight with these projects is nearly identical to the annual work planning activities. On an annual basis starting in December prior to field the season the Monitoring Section provides monitoring planning instructions to field staff. First monitoring funds are allocated to Baseline projects, then a second block of funds is sequestered for Prescribed Monitoring and the remaining funding is made available to Local Needs funding. Monitoring Section staff ensure all proposed TWAs and Directed Lakes project meet the requirements for each project type. Monitoring staff then perform only a minimal review of the projects monitoring design because the of the standardized nature of the protocols.

Local Needs projects go through an extensive review process annually. Due to the unique nature of these projects (e.g., unique stressors, method development, etc.) a thorough review is necessary to ensure likely project effectiveness, efficient use of funds and program priority. First, each proposed Local Needs project is reviewed by the appropriate Technical Team (lake, stream, river or wetland) and given a technical score. Second, projects are ranked within each District for priority by the District Supervisor. Finally, a Joint Review Committee consisting of monitoring coordinators and District Supervisors review all the projects and propose a list of approved projects based on technical merit score, program priority, staffing and funding levels. The final list is approved by the Water Resources Policy Management Team in April of each year as the official monitoring workplan for the upcoming field season.

Pictures from Large River Watershed Rotation surveys, courtesy of M. Sorge and R. Piette

Section 3.0 Resource or Media-Based Monitoring Study Descriptions

Section 3.1 Monitoring Strategy for Rivers

Table 3.1.1 River Monitoring Studies		
Study Name	**Purpose**	**Supports**
Long-Term Trend Water Quality Monitoring Network	Historic chemistry data at 42 (43rd site added in 2014) river sites. Provides large river water quality trends over time.	What is the overall quality of waters in the State? To what extent is water quality changing over time?
Large River Biological Monitoring	Collection of biological assessments (fish, macroinvertebrates and mussels) at large river sites on a watershed rotation schedule and at annual trend sites	What is the overall quality of waters in the State? What are the problem areas and areas needing protection?
U.S. EPA National Rivers and Streams Assessment	Evaluate river and stream condition using a probabilistic survey design to scale up to all rivers and streams in the state.	What is the overall quality of waters in the State? To what extent is water quality changing over time??
Total Maximum Daily Loads	Monitoring to support pollutant load and watershed modeling for TMDL development.	What level of protection is needed? What are the problem areas and areas needing protection?

Long Term Trend River Water Quality Monitoring Network

DESCRIPTION

The Long-Term Trends (LTT) Rivers monitoring program is a baseline monitoring activity conducted by the Wisconsin DNR Water Quality Bureau. The LTT Rivers program was developed to track and analyze water quality trends over time in Wisconsin's rivers. The current version of the network, initiated in 2001, now consists of 43 sites, with a minimum of one site per major river basin, located near the mouth of each river located at or near a USGS stream flow gauge. Some of the larger rivers will have one to three additional monitoring location located upstream where chemistry samples are collected quarterly. The upstream watersheds from each sampling point collectively cover ~80% of Wisconsin's land area. The LLT Rivers network not only detect trends in water quality in different river systems, but collective tell the story of water quality trends in the state.

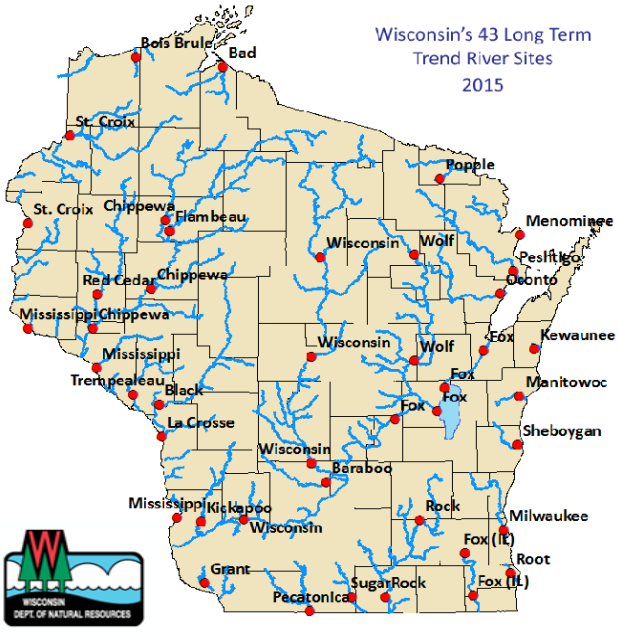


Figure 3.1.1 Location of the 43 Long-Term Trends River monitoring locations on the large river networks in Wisconsin.

Monitoring Objectives

- Collect basic water chemistry and discharge information on Wisconsin rivers.
- Establish long-term trends in ambient water quality across the state and regionally.
- Provide water quality information to support 305(b) reporting, 303(d) program and TMDLs or other restoration efforts.
- Inform progress on the Wisconsin's Nutrient Reduction Strategy and the State's contributions to the Gulf Hypoxia Task Force.

Monitoring Design

There are 43 LTT Rivers sites located throughout the state, generally at the mouth of larger rivers and as closer to the State boarder as practical. On the larger rivers additional site(s) are located upstream (e.g. Wisconsin River) as one location at these rivers would not adequately capture the changing condition of those rivers (Figure X). At each of the sampling stations Water Quality staff collect basic water chemistry data from grab samples or instantaneous water quality probes. Each of the sites is collocated with a USGS streamflow gauge that allows for the easy calculation of loads or flow-weighted concentrations. At most sites the USGS gauge was established first so that WDNR did not have autonomy when selecting specific locations, but the USGS site selection process merges well with the LTT Rivers objectives.

Sampling Frequency

Field sampling for the LTT Rivers occurs on a monthly basis for ~3/4 of the sites and quarterly at ~1/4 of the sites. Sampling for this program consists solely on water quality parameters including chemistry grabs and field measurements. Some water quality parameters at select sites are collected on a sub-monthly/quarterly frequency (e.g. *E. coli*). Sampling is scheduled at least one week in advance to avoid bias from weather conditions. Samples are collected during the second week of the month for the monthly and quarterly scheduled sampling locations. Monthly samples are collected at 30-day intervals while quarterly sampling occurs in January, April, July and October to roughly coincide with seasonality.

WATER QUALITY INDICATORS

Parameter	Analysis Location	Database
Field Data: Dissolved Oxygen, Temperature, pH, Conductivity and Transparency Tube, Invasive Species	In-field analysis	SWIMS
Nutrients: Ammonia, Nitrate + Nitrite, Total Kjeldahl Nitrogen, Total Phosphorus and Ortho Phosphorus Sediments: Total Suspended Solids, Turbidity Bioindicators: Suspended Chlorophyll a, E. coli Low Level Metals: Cadmium, Copper and Mercury Other: Chloride, Alkalinity, Hardness, Silica, Triazine	State Laboratory of Hygiene	SWIMS
Continuous Discharge	USGS	USGS National Water Information System

Large River Biological Monitoring

DESCRIPTION

The Large River Biological Monitoring program aims to assess biological communities, specifically fish, macroinvertebrate, and mussel assemblages across Wisconsin's large river ecosystems. The project is the first water quality monitoring program to comprehensively assess biological integrity in all of Wisconsin's large river systems.

MONITORING OBJECTIVES

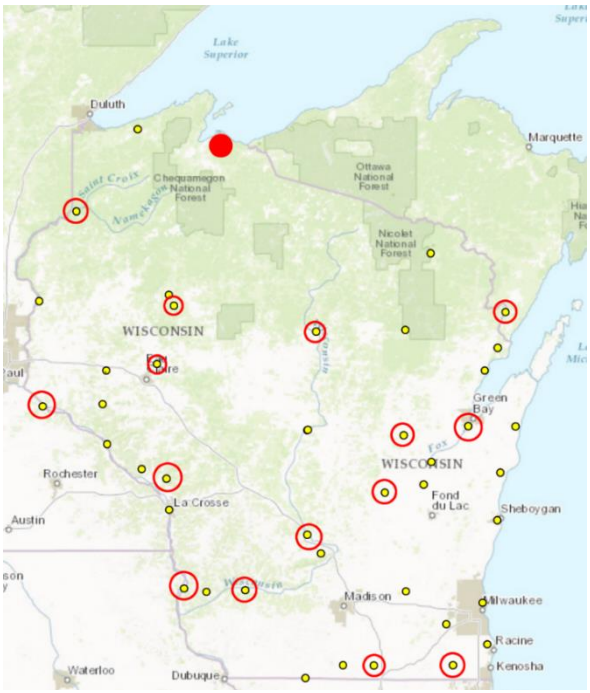
- Collect fish, macroinvertebrate and mussel assemblage data in Wisconsin's large river systems
- Provide information to support 305(b) reporting, 303(d) program and TMDLs or other restoration efforts on Large River Fish and Large River macroinvertebrate indices of Biotic Integrity
- Establish long-term trends in fish assemblages at a subset of sites in estimate temporal variability
- Develop program capabilities to collect and assess mussel assemblages in large rivers
- Detections of new AIS may trigger response actions and management planning.

MONITORING DESIGN

Using a rotational basin monitoring plan, two major basins (and their sub-basins), selected along a rough north-south statewide split would be sampled each year along with a set of annual sites to monitor large rivers fish assemblages. In addition to fish, a subset of sites within the basin would also be surveyed for freshwater mussels and benthic macroinvertebrates. The annually sampled trend sites allow for an estimation of temporal variability among fish assemblages and associate Large River Fish IBI scores. Additionally, each of these sites are collocated with the LTT Rivers sites so temporal variability can be correlated to changing discharge, water temperature and/or water chemistry. This project divides the state into ten basins based on network connectivity, proximity and attempts to balance workload (i.e. number of sampling sites) so that after five years the entire state will be sampled intensively.

Table 3.1.2 The larger river rotation watersheds and locations of 15 trend sites that are sampled annually (Fig 3.1.2, right).

Year	Monitoring Unit 1	Monitoring Unit 2
2017	Menominee Oconto, Peshtigo	Rock, Pecatonica, Sugar, Fox, Grant
2018	Upper Wisconsin Eau Claire, Tomahawk	Lower Wisconsin Kickapoo, Baraboo
2019	Fox /Wolf Embarrass, Waupaca	Black La Crosse, Trempealeau
2020	St. Croix Yellow, Namekagon	Chippewa/Flambeau Red Cedar
2021	Lake Michigan and Superior Tributaries	Mississippi



Sampling Frequency

Samples are collected once per year from each site in the network (trend or rotational). However, this may involve multiple field visits as fish and mussel assemblages are done in a partial day during a mid-summer index period. Macroinvertebrates are deployed on a Hester-Dendy sampler over a ~6-week period requiring two visits early summer to early fall. Chemistry sampling at the trend sites are part of the LTT Trends sites and not included here.

Water Quality Indicators

Parameter	**Analysis Location**	**Database**
Fish Assemblage Composition and Index of Biotic Integrity	In-field taxonomy	Fisheries Management Database
Macroinvertebrate Assemblage Composition and Index of Biotic Integrity	UW-Stevens Point Aquatic Biomonitoring Laboratory	SWIMS
Mussel Assemblage Composition	In-field taxonomy	WI Mussel Monitoring Program Database

National Rivers and Streams Assessment – Probabilistic Survey

DESCRIPTION

NRSA is a collaborative effort among state and federal agencies, and tribes, led by the U.S. Environmental Protection Agency and is designed to:

- Assess the condition of the Nations perennial streams and rivers;
- Assess the extent and impact of major environmental stressors of flowing water;
- Evaluate changes in conditions of the Nation's rivers and streams over time:
- Help build State and Tribal capacities for monitoring and assessment and promote collaboration across jurisdictional boundaries.

MONITORING OBJECTIVES

The primary objectives of the NRSA surveys are to generate statistically-valid evaluations of the conditions of the Nation's streams and rivers, identify key factors (stressors) impacting the physical, chemical, and biological conditions of flowing waters in the U.S., and assess changes in the condition of these resources over time. Detections of new AIS may trigger response actions and management planning.

MONITORING DESIGN

The NRSA uses nationally – consistent site selection, field sampling, sample analysis, data interpretation, and data reporting protocols. Sampling locations are selected using a probability-based sample design, where every perennial river and stream reach in the contiguous U.S. has a known probability of being selected for sampling. The sample selection process is weighted by waterbody size and geographic location to provide balance in the number of river and stream sites surveyed across the U.S. This design provides sufficient numbers of survey sites to characterize resource conditions within each of 9 ecoregions that encompass the lower 48 states. The survey design ensures that the results reflect the full range in waterbody types and variation among flowing waters across the U.S. The survey is not designed to characterize resource conditions of individual states, so the department samples additional randomly selected stream and river reaches to have a sufficient state sample population for a statistically robust evaluation of Wisconsin's flowing waters.

SAMPLING FREQUENCY

The NRSA has been conducted on a 5 – year cycle, since 2008, with the most recent survey being done in 2018 – 2019. All boatable river and wadeable stream sites are sampled once during each survey.

WATER QUALITY INDICATORS

Parameter	Analysis Location	Database
Physical habitat (in-stream and riparian)	Field	SWIMS
Water temperature, pH, conductivity, and dissolved oxygen	Field	SWIMS
Water chemistry grab samples (nutrients, sediment, etc.)	Field	SWIMS
Benthic macroinvertebrates	UW Superior Lake Superior Research Institute	SWIMS
Fish assemblage data	Field and Fisheries Management Database	Fisheries Management
Algal toxins (*Microcystin*)	State Laboratory of Hygiene	SWIMS
Fecal Indicators (*Enterococci*)	U.S. EPA Contract Lab	U.S. EPA NARS
Fish Tissue Plugs (methylmercury)	U.S. EPA Contract Lab	U.S. EPA NARS
Whole Fish (legacy pollutants such as poly-chlorinated biphenyls)	U.S. EPA Contract Lab	U.S. EPA NARS
Invasive species	Field	SWIMS

Total Maximum Daily Load Monitoring

DESCRIPTION

The WDNR TMDL program has prioritized developing TMDLs for total phosphorus and total suspended solids on larger watersheds with multiple impairments (*Wisconsin's Water Quality Restoration and Protection Framework 2015).*

MONITORING OBJECTIVES

To collect quality high frequency data on pollutant concentrations and discharge for the purpose of developing accurate pollutant loading models.

MONITORING DESIGN

Typically monitoring consists of grab samples for total phosphorus and total suspended solids either collocated with a USGS gauge or a WDNR pressure transducer for capturing continuous discharge. Instantaneous discharge is collected using either wadeable or nonwadeable methods & equipment. Additional chemical parameters may be collected such as dissolved reactive phosphorus or the nitrogen series. TMDL watersheds will typically be paired with a subset of TWA watersheds to collect detailed information on watershed and waterbody condition in advance of potential improvements from source or point source pollutant reductions.

SAMPLING FREQUENCY

Water chemistry samples are collected twice per month during from April to October and collected once per month the reaming months over a minimum two-year period. Additionally, runoff or very low flow samples are collected when these situations occur, especially during the early spring runoff events. Instantaneous discharge is collected in at least 10 separate events, targeting the entire range of expected flows.

WATER QUALITY INDICATORS

Parameter	Analysis Location	Database
Total phosphorus, total suspended solids & other chemical parameters	Wisconsin State Laboratory of Hygiene	SWIMS
Continuous discharge	USGS	NWIS
Instantaneous discharge	Field	SWIMS
Continuous pressure recording	Field & Desktop	SWIMS

Section 3.2 Monitoring Strategy for Streams

Table 3.2.1 Stream Monitoring Studies		
Study Name	**Purpose**	**Supports**
Wadeable Stream Trend Network	Measure variation in biological indices over time at reference sites to understand natural variation and broad scale impacts of climatic extreme events on biological communities.	To what extent is water quality changing over time? What level of protection is needed?
Natural Community Stratified Random Sample Design	Provide an estimate of the physical, chemical & biological quality of the overall population of wadeable, perennial streams across the State.	What is the overall quality of waters in the State? To what extent is water quality changing over time?
Stream Temperature Monitoring Network	Measure long-term changes in stream temperature in response to climate change across different stream types, regions and land uses.	To what extent is water quality changing over time? What level of protection is needed?
Targeted Watershed Assessments	A HUC12 size monitoring program applied to prioritized watersheds consisting of water chemistry, biological assessments and physical habit at 6-12 locations depending on watershed size and complexity.	What are the problem areas and areas needing protection? How effective are clean water projects and programs?
U.S. EPA National Rivers and Streams Assessment	Provide an estimate of the physical, chemical & biological quality of the overall population of wadeable, perennial streams across the U.S, and state.	What is the overall quality of **flowing** waters in the U.S.? What anthropogenic factors are impacting flowing waters in the U.S.? To what extent is water quality changing over time?
Water Action Volunteers	Volunteer monitoring is conducted to provide educational benefits to participants, identify new problem areas and help fill gaps for monitoring as needed, for example, for phosphorus and invasive species assessments.	What are the problem areas and areas needing protection? How effective are clean water projects and programs?

Wadeable Stream Trend Network

Description

The Wadeable Stream Trend Network monitoring program samples regionally based least-disturbed stream locations distributed throughout the State. In 2008 and 2009 the WDNR Water Quality Bureau, in collaboration with the USGS, undertook a monitoring program intended to identify regionally-based reference sites and sample those sites to understand the biological conditions under least disturbed conditions. The explicit purposes for the 2008-09 reference site project was to monitor sites using consistent screening criteria to select reference sites that could then be used for multiple purposes (e.g., refining expectations, understanding variation, etc.). A subset of these sites was select to be sampled annually as the WSTN starting in 2010.

Monitoring Objectives

The major goal of this monitoring program is to track long term variation in biological indices over time at least-disturbed sites to understand natural variation and impacts of climatic extreme events on biological communities. Secondarily, a suite of physical and chemical parameters are monitored over time to understand natural variation and their relationship to biological variation. Detections of new AIS may trigger response actions and management planning.

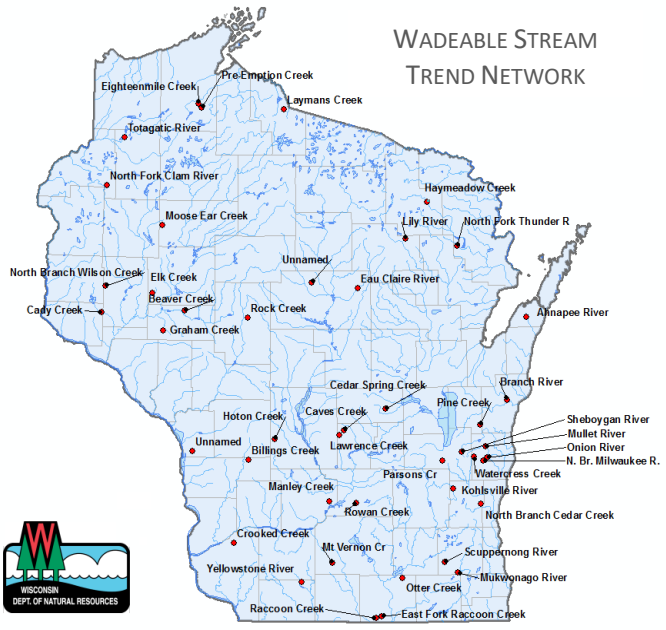


Figure 1.2.1 Location of the 44 monitoring sites in the Wadeable Streams Trend Network.

Monitoring Design

Regionally based least-disturbed sites were selected to cover ergographic stream types, as defined by Omernik Ecoregion, and stream temperature by stream size classifications (e.g. the stream Natural Community model). Final determination of "least-disturbed" status was made by a GIS-based disturbance model then field biologist on-site inspection of stream and watershed condition. At each of the 44 sites staff collect fish, macroinvertebrate and diatom assemblages, quantitative physical habitat, water chemistry and continuous stream temperature.

Sampling Frequency

Samples are collected once per year at each of the WSTN sites, but requires multiple visits depending on index periods for the specific water quality parameters. Fish, diatoms, quantitative physical habitat, water chemistry are collected during a mid-summer index period and macroinvertebrates are collected during a fall index period.

WATER QUALITY INDICATORS

Parameter	Analysis Location	Database
Nutrients: Ammonia, Nitrate + Nitrite, Total Nitrogen and Total Phosphorus **Sediments:** Total Suspended Solids **Other:** Chloride	State Laboratory of Hygiene	SWIMS
Field Data: Dissolved Oxygen, Conductivity, pH, Transparency Tube, Invasive Species	In-field analysis	SWIMS
Continuous Stream Temperature	SWIMS	SWIMS
Macroinvertebrate Assemblage	UW Stevens Point Entomology Laboratory	SWIMS
Fish Assemblage	In Field and Fisheries Management Database	Fisheries Management Database
Quantitative Habitat metrics and Index, Invasive Species	In Field and Fisheries Management Database	Fisheries Management Database
Diatom assemblages and Diatom Phosphorus Index	State Laboratory of Hygiene	SWIMS*

Natural Community Stratified Random Monitoring Program

DESCRIPTION

The Natural Community Stratified Random Monitoring program is a probabilistic survey designed provide statistically valid estimates of conditions large, hard to sample resources with a known confidence. These designs were first developed for aquatic resources by the US EPA National Aquatic Resource Surveys (NARS). The NCSR in a Wisconsin-specific version of the EPA NARS program that uses Wisconsin's monitoring protocols to estimate broad scale condition estimates for Wisconsin's streams.

MONITORING OBJECTIVES

The NCSR program aims to estimate the condition of Wisconsin's streams in both aquatic health and water quality stressors. The goal so the program is to provide statistically valid, but easily understood and communicated condition results for the entire population of Wisconsin's ~45,000 miles of perennial wadeable streams. Detections of new AIS may trigger response actions and management planning.

MONITORING DESIGN

Monitoring sites are selected using a stratified random selection procedure producing a new set of stream sites to sample every two years. Sites are stratified by geographic location which is defined as the Water Resources Program's four District boundaries (North, East, South and West) and stream temperature by size classifications (e.g. Natural Community Model). The program samples 100 sites per analysis cycle, which is evenly split over two years.

Sampling Frequency

Samples are collected once per year at each of the NCSR sites, but requires multiple visits depending on index periods for the specific water quality parameters. Fish, quantitative physical habitat, water chemistry are collected during a mid-summer index period and macroinvertebrates are collected during a fall index period.

Water Quality Indicators

Parameter	Analysis Location	Database
Nutrients: Ammonia, Nitrate + Nitrite, Total Nitrogen and Total Phosphorus Sediments: Total Suspended Solids Other: Chloride	State Laboratory of Hygiene	SWIMS
Field Data: Dissolved Oxygen, Conductivity, pH, Transparency Tube, Invasive Species	In-field analysis	SWIMS
Macroinvertebrate Assemblage	UW Stevens Point Entomology Laboratory	SWIMS
Fish Assemblage	In Field and Fisheries Management Database	Fisheries Management Database
Qualitative Habitat Metrics and Index	In Field and Fisheries Management Database	Fisheries Management Database

Stream Temperature Monitoring Network

Description

The Stream Temperature Monitoring network is a program that collects continuous temperature at 100 sites across the state to assess the impacts of climate change on stream temperature regimes. Many of these sites have longer periods of record as they were part of older monitoring projects (e.g. WTSN, WR 5-year temperature study, WAV, etc.) but many were added specifically as part of this study starting in field season 2021.

Monitoring Objectives

The goal of the project is to track statewide long-term (~30 years) changes and possible trends in stream temperature. Secondarily, a subset of sites (44 WTSN sites) also collect biological assemblages so that the impact of any stream temperature regime changes on biological assemblages, and the tools WDNR uses to assess those assemblages, can be observed.

Monitoring Design

The Stream Temperature Monitoring Network (STMN) will monitor ~100 stream sites by deploying continuous temperature loggers and recording data all year. 44 of these sites are collocated with the WTSN locations to additionally assess change in stream temperature and its effects on biological assemblages. The STMN includes another ~60 sites to the network that solely monitor temperature.

Sites were selected to cover the range of current stream temperature classes (cold, cold transition, warm transition and warm) and the range of factors shown to be important in determining stream temperature through the first iteration of the statewide model temperature model (land use, watershed size, soil properties, watershed slope, etc.)

Sampling Frequency

Temperature loggers record data at 30-minute intervals, but site visits are only required two times per year to check logger deployment, download data and redeploy.

Water Quality Indicators

Table 6: Stream Temperature Monitoring Network		
Parameter	**Analysis Location**	**Database**
Continuous Stream Temperature	SWIMS	SWIMS

Targeted Watershed Assessments

Description

Targeted Watershed Assessments (TWA) are a monitoring framework that is designed to be deployed in prioritized watersheds providing a consistent funding and basic monitoring level of effort, while bring flexible enough to add parameters or increase intensity based on site-specific data needs.

Monitoring Objectives

TWAs meet multiple monitoring objectives, but most often TWAs are selected to provide pre and post restoration data for multiple watershed planning efforts such as US EPA Nine Key Element, WNDR Water Quality Planning or NRCS National Water Quality Initiative. TWAs are also used to investigate watersheds where poor biology was unexpectedly discovered (i.e. identify unique or ephemeral stressors) or to provide data in support of WDNR healthy waters initiatives. Additionally, TWAs are used as a tool for collecting sufficient data for waterbody impaired waters assessments at unassessed waterbodies or those that require contemporary assessments. TWAs are usually conducted on the HUC12 scale, occasionally TWAs may cover the HUC10 scale at a less spatially intense scale before identifying smaller HUC12s that require more intense monitoring for impaired waters assessments and/or providing data for restoration or protection activities. Detections of new AIS may trigger response actions and management planning.

Monitoring Design

TWAs generally include 6-12 monitoring locations in a HUC 12 size watershed, although exceptions can be made because of watershed size, shape or complexity. Each site typically receives a biological and habitat assessment as well as at least single grab sample for multiple water chemistry measures. At a minimum the downstream pore point location will receive six monthly grab sample total phosphorus samples to meet WisCALM impaired waters minimum data requirements, although usually many more sites in the watershed also have increased frequency of water chemistry samples.

Sampling Frequency

Sampling frequency is determined by parameter specific data requirements, which may include a single site visit or up to monthly water chemistry grab samples. Typically, TWAs are conducted over the course of a single field season, but high intensity sampling requirements may necessitate a two-year project window for some TWAs. As continuous loggers became less expensive and more reliable WNDR staff are collecting more continuous data, which may require many site visits over the course of the TWA project.

Water Quality Indicators

Parameter	Analysis Location	Database
Nutrients: Ammonia, Nitrate + Nitrite, Total Nitrogen and Total and Dissolved Phosphorus Sediments: Total Suspended Solids Other: Chloride	State Laboratory of Hygiene	SWIMS
Field Data: Dissolved Oxygen, Conductivity, pH, Transparency Tube, Invasive Species	In-field analysis	SWIMS
Continuous Stream Temperature	SWIMS	SWIMS
Macroinvertebrate Assemblage	UW Stevens Point Entomology Laboratory	SWIMS
Fish Assemblage	In Field and Fisheries Management Database	Fisheries Management Database
Quantitative Habitat metrics and Index	In Field and Fisheries Management Database	Fisheries Management Database
Diatom assemblage	State Laboratory of Hygiene	SWIMS

Water Action Volunteers - Stream Monitoring

Description

Water Action Volunteers is a partnership between UW-Extension, WDNR and dedicated citizen scientists across the state (https://wateractionvolunteers.org/). Every year WAV monitor more than 600 unique stream locations throughout Wisconsin.

Monitoring Objectives

The WAV program aims to preserve, protect and restore Wisconsin's 86,000+ miles of streams and rivers by educating and empowering volunteers to gather high-quality stream data useful for decision-making and natural resource management, and share their data and knowledge. Objectives for each monitoring program are defined on a project specific basis.

Monitoring Design

WAV monitoring programs operate on a three-tier system. Tier 1 monitoring is introductory monitoring on baseline stream health such as water temperature, streamflow, habitat, macroinvertebrates among others. Status and Trends Nutrient monitoring uses WDNR protocols and assessment methods to collect surface water chemistry data that is used in WDNR's impaired waters assessments. The monitoring locations are mainly directed by WDNR in as part TWA or Local Needs projects, while a small amount of funding is reserved for volunteer initiated monitoring support. The third tier is special studies monitoring, where volunteers are trained in advanced methods as part of project such as invasive rusty crayfish monitoring, urban road salt runoff monitoring, among others

Sampling Frequency

WAV monitoring frequency many occur on many deafferent levels depending on the particular Tier (1,2 or 3) and the objectives of the project. Sampling may be a one-time visit, six-monthly grab samples for nutrient assessments or anything in-between.

Water Quality Indicators

WAV Program Description			
WAV Level	**Parameter**	**Analysis Location**	**Database**
Level 1: Introductory Monitoring	Dissolved Oxygen (DO)	In Field	Water Action Volunteers Project in SWIMS database
	Temperature		
	Transparency		
	Streamflow		
	Macroinvertebrates (WAV Index)		
	Habitat		
	Invasive Species		
Level 2: Status and Trends Monitoring	Dissolved Oxygen (DO)	In Field	SWIMS
	pH		
	Temperature (point in time)		
	Transparency		
	Continuous Temperature	SWIMS	
Level 3: Special Projects Monitoring	Specific Conductance	In Field	SWIMS
	Total Phosphorus	WI State Lab of Hygiene	
	Chloride	WI State Lab of Hygiene	
	Invasive Species	In Field	

Section 3.3 Monitoring Strategy for Lakes

Table 3.3.1 Lake Monitoring Studies		
Study Name	**Purpose**	**Supports**
U.S. EPA National Lakes Assessment	Evaluate lake condition using a probabilistic survey design to scale up to all lakes in the state.	What is the overall quality of waters in the State?
Long-Term Trend (LTT) Lakes	Document long-term trends in lake water quality, provide context for other lakes, answer questions from the public, and evaluate long-term effectiveness of management actions.	To what extent is water quality changing over time?
Regional Monitoring Network	Long-term, high-frequency monitoring to evaluate trends over time in water temperature, water levels, and other water quality indicators in response to warming air temperature and changing precipitation patterns.	To what extent is water quality changing over time?
Satellite Secchi Monitoring	Infer lake water clarity from satellite data to estimate general lake condition on thousands of lakes in the state, especially lakes where other data do not exist. Used for 305(b) reporting.	What is the overall quality of waters in the State? What are the problem areas and areas needing protection?
Directed Lake Surveys	Collect lake information needed for assessment (e.g., 303(d) reporting) and lake management (e.g., aquatic plant management, AIS detection, shoreland zoning). Use baseline data to drive protection and restoration projects (e.g., lakeshore habitat restoration).	What is the overall quality of waters in the State? What are the problem areas and areas needing protection?
Citizen Lake Monitoring Network	Collect water quality and AIS information on many lakes and engage/educate the public.	To what extent is water quality changing over time? What are the problem areas and areas needing protection? How effective are clean water projects and programs?
Lake Level Monitoring	Long-term monitoring to understand natural fluctuations in lake levels and guide lake management, particularly regarding groundwater withdrawals and climate.	What level of protection is needed? To what extent is water quality changing over time?

National Lakes Assessment - Probabilistic Survey

DESCRIPTION

The National Lakes Assessment (NLA) is a statistical survey of the condition of our nation's lakes, ponds, and reservoirs led by the Environmental Protection Agency (EPA). It is designed to provide information on the extent of lakes that support healthy biological condition and recreation, estimate how widespread major stressors are that impact lake quality, and provide insight into whether lakes nationwide are getting cleaner.

MONITORING OBJECTIVES

The objective of the probabilistic survey is to determine statewide lake condition across all lake types and sizes. By repeating the survey over time, tracking changes in statewide lake condition and the rate of AIS spread are also determined.

MONITORING DESIGN

Fifty lakes are sampled once within a single summer field season, which is a sufficient sample size for a statewide assessment. Natural lakes, ponds, and reservoirs > 1 meter deep, > 1 hectare area, and with at least 0.1 hectare of open water are randomly selected from a sample stratified by ecoregion and weighted by lake size. Sampling for water chemistry, zooplankton, and other parameters occurs at the deepest point of the lake and sampling for physical habitat and benthic macroinvertebrates occurs at 10 sites located equidistant to one another along the lake shoreline.

SAMPLING FREQUENCY

The NLA is conducted once in a 5-year period (2007, 2012, 2017, 2022, etc.).

WATER QUALITY INDICATORS

Parameter	Analysis Location	Database
Secchi depth	Field	SWIMS
Vertical Profiles: temperature, dissolved oxygen, specific conductivity, and pH	Field	SWIMS
Water Chemistry: Ca, Mg, K, Na, Al, alkalinity, pH, conductivity, chloride, silica, sulfate, dissolved organic carbon, color, total suspended solids, ammonia, nitrate, nitrite, total nitrogen, total phosphorus, chlorophyll *a* Algal Toxins: microcystin and cylindrospermopsin Pesticides: atrazine	State Laboratory of Hygiene	SWIMS

Species Assemblages: benthic macroinvertebrates and zooplankton	EPA National Laboratory	None, available on National Aquatic Resource Surveys (NARS) website
Physical Habitat: variety of indicators describing habitat in the riparian and littoral zones	Field and EPA Office of Research and Development	None, available on National Aquatic Resource Surveys (NARS) website
Other: research indicators change with each survey and have included sediment contaminants, sediment total organic carbon, sediment grain size, fish environmental DNA, dissolved gases, fish contaminants (mercury, PCB's, PFAS), aquatic plants, AIS, E. coli, enterococci	Various	Various

Long Term Trend Lakes (LTT Lakes)

DESCRIPTION

The water quality of sixty-two lakes has been monitored annually as part of the LTT Lakes program since approximately 1986. Some lakes have records dating back to 1968 whereas others were added more recently (as late as 2000).

MONITORING OBJECTIVES

The primary objective of LTT Lakes monitoring is to document long-term trends in lake water chemistry. This data set also provides context for water chemistry in other lakes in terms of intra and inter-annual variability. Given that many lakes were initially included in the program due to a management action, data may also be used to evaluate management action effectiveness.

MONITORING DESIGN

These lakes are distributed across all four ecoregions, all five DNR management regions (west central, south east, south central, north, northeast), and most lake natural communities. "Small lakes" (< 10 acres area) are not represented. The smallest, median, and largest LTT lakes are 38, 382, and 132,000 acres in area, respectively. The LTT lakes were not chosen to be reference lakes with minimal human disturbance. Rather, most lakes were chosen based on societal value and management actions taking place. All sampling occurs at the deepest spot of the lake.

SAMPLING FREQUENCY

Lakes are sampled once during spring turnover and three times during the stratified period in summer.

WATER QUALITY INDICATORS

Parameter	Analysis Location	Database
Secchi depth	Field	SWIMS
Vertical Profiles: temperature, dissolved oxygen (preferred: specific conductivity, and pH)	Field	SWIMS
Water Chemistry: total phosphorus, chlorophyll *a*, Total Kjeldahl Nitrogen, nitrate+nitrite, color, conductivity, pH, alkalinity, calcium, magnesium	State Laboratory of Hygiene	SWIMS

Regional Monitoring Network for Climate Change

DESCRIPTION

The Regional Monitoring Network (RMN) on lakes is similar to Long Term Trend Lakes in purpose and design but makes use of continuous loggers to obtain high-frequency data and collects more parameters. It also aims to include lakes with minimal human disturbance. This effort is being carried out in other states in EPA Region 5 and Region 1. Data across the regions can be collated and analyzed in the future.

MONITORING OBJECTIVES

Monitor and detect long-term trends in water temperature, dissolved oxygen, water levels, ice cover, and other water quality indicators, particularly on lakes with minimal human disturbance, to better understand and track how warming air temperatures and changing precipitation patterns affect lakes.

MONITORING DESIGN

We selected lakes that already have long term water quality records, either because they were part of the Long-Term Trend Lakes effort monitored by DNR staff or part of the Citizen Lake Monitoring Network. Most lakes also have good water quality and minimal human disturbance in the watershed and around the lake, but some lakes included in the RMN have agricultural and developed lands in the watershed and in the riparian area. We also selected lakes to represent different geographic regions of Wisconsin and different lake types. Two categorical lake types represented include whether the lake mixes year-round or stratifies and whether the lake is connected by a stream. Three aspects of lake characteristics that describe a continuum include trophic status, color, and alkalinity. We did not include eutrophic lakes in the network. Some monitoring has occurred on all of the lakes below, but none have attained full monitoring status as described below in sampling frequency and indicators. Dimictic, seepage, and mesotrophic lakes are the most common lake types represented in the network.

Table 3.3.2. Lake characteristics of the eight candidates for inclusion in the Lake Regional Monitoring Network. Trophic status, color, and alkalinity are continuous gradients, but categories are used to describe lake types.

Stratification[1]	Hydrology[2]	Trophic Status[3]	Color[4]	Alkalinity[5]	Lakes
Dimictic	Seepage	Oligotrophic	Clear	Neutral	Lost
Dimictic	Seepage	Mesotrophic	Clear	Acidic	Devils, Franklin
Dimictic	Seepage	Mesotrophic	Moderate	Neutral	Axhandle, Anvil
Polymictic	Seepage	Mesotrophic	Clear	Acidic	Snipe
Dimictic	Drainage	Mesotrophic	Moderate	Alkaline	Pewaukee
Dimictic	Drainage	Mesotrophic	Brown	Neutral	Mineral

[1]Dimictic lakes stratify in summer and winter; polymictic lakes are shallow enough to mix in summer
[2]Hydrology describes lakes as seepage (no outlet) or drainage (stream outlet)
[3]Trophic status is defined using chlorophyll *a* data
[4]True color was used to define lakes as clear, moderate, or brown
[5]Alkalinity was categorized as acidic, neutral, or alkaline

Sampling Frequency

There is flexibility in the frequency at which parameters are collected. For details, please reference RMN materials from EPA. Here, we describe the frequency we aim to attain in Wisconsin, but this has not yet been achieved. Secchi depth will be sampled once in spring and three times in summer with a goal of achieving monthly sampling or more during the open-water season. Continuous temperature loggers will be deployed at multiple depths year-round; dissolved oxygen loggers will eventually be deployed at fewer depth locations due to limited funds. Total phosphorus will be sampled once in spring and three times in summer, with a single bottom sample if the lake stratifies. Chlorophyll *a* will be sampled three times in summer. All other chemistries will be sampled once in mid-summer (July 24-August 7). The goal is to deploy continuous water level loggers on all lakes to record hourly, but the effort may begin with weekly to monthly measurements. Currently, lake level monitoring only occurs at a few sites. Ice on/off dates will be recorded annually at a minimum with an ultimate goal of obtaining daily images to estimate percent ice cover. General assessments will occur once per year. To date, continuous temperature loggers, Secchi depth and chemistry monitoring according to the LTT Lakes protocol have occurred in part but monitoring the other parameters has not yet begun. Temperature logger chains have been installed on some lakes, but equipment will soon need to be replaced.

WATER QUALITY INDICATORS

Parameter	Analysis Location	Database
Secchi depth	Field	SWIMS
Continuous Vertical Profiles: temperature and preferably dissolved oxygen, hourly	Field	none
Water Chemistry: total phosphorus, chlorophyll *a*, total nitrogen, nitrate+nitrite, ammonia, dissolved organic carbon, color, total suspended solids, conductivity, pH, alkalinity, calcium, magnesium, chloride, sulfate, sodium, potassium, dissolved silica	State Laboratory of Hygiene	SWIMS
Water Level	Field	SWIMS
Ice Cover	Field	SWIMS
General Assessment	Field	none

Satellite Monitoring – Water Clarity and Trophic Status

DESCRIPTION

Lake water clarity is inferred from Landsat satellite imagery.

MONITORING OBJECTIVES

Assess lake water clarity and the Trophic State Index on approximately 8000 lakes in Wisconsin using satellite imagery. This data is used for 305(b) reporting of lake condition, but not for impairment listings. Remote sensing fills a monitoring gap by obtaining water clarity estimates on thousands of lakes that DNR staff and volunteers do not have the capacity to monitor in-situ.

MONITORING DESIGN

Satellite imagery is used in conjunction with Secchi depths to develop models that estimate water clarity in lakes > 5 acres statewide. Clear imagery is required for calibrating and predicting water clarity. At least two water clarity values from within a 3-year period in summer are averaged to determine lake trophic status.

SAMPLING FREQUENCY

Images are processed to obtain annual estimates for each lake.

WATER QUALITY INDICATORS

Parameter	Analysis Location	Database
Secchi depth	Field and remote sensing	SWIMS
Trophic State Index	Field and remote sensing	SWIMS

Directed Lake Surveys

DESCRIPTION

Directed Lakes collects biological, physical, and chemical data on lakes where information is completely absent or where there are data gaps. This monitoring contributes to assessments and may address local lake management issues including aquatic plant management, AIS, shoreland zoning, high capacity wells, lake restoration projects, dam regulations, blue green algae blooms, and other issues. Lakes are selected both for protection and restoration.

MONITORING OBJECTIVES

Strategically collect holistic lake information needed for assessment (305(b) and 303(d) reporting), AIS and lake management. Comprehensive baseline data will enable informed decision making for protection and restoration actions and is needed for lake management plans.

MONITORING DESIGN

At a minimum, monitoring surveys include water chemistry samples, an aquatic plant point-intercept survey, a shoreland habitat survey, and an aquatic invasive species (AIS) early detection survey. Lakes with no or little existing recent data are the first priority for selection. Additional characteristics related to lake size, accessibility, overlap with other data sets, and AIS risk also help prioritize which lakes to select. At the local level, the opportunity to engage communities in protection or restoration activities provides strong incentive for selecting an individual lake. At a statewide level, lakes chosen should help achieve statewide water quality objectives, represent a variety of lake natural communities, and fill data gaps. Lakes with public access of 5-acre area or larger are prioritized first.

SAMPLING FREQUENCY

Water chemistry is monitored for two consecutive years with three samples collected during the stratified period each summer. Aquatic plant, lakeshore habitat, and AIS surveys are conducted once over the 2-year time frame.

WATER QUALITY INDICATORS

Parameter	Analysis Location	Database
Secchi depth	Field	SWIMS
Vertical Profiles: temperature, dissolved oxygen, (specific conductivity, and pH preferred)	Field	SWIMS
Water Chemistry: total phosphorus, chlorophyll *a*, total nitrogen, nitrate+nitrite, color, dissolved organic carbon, conductivity, pH, alkalinity, hardness as $CaCO_3$ (which includes calcium and magnesium), chloride	State Laboratory of Hygiene	SWIMS
Aquatic Plant Point Intercept Survey: frequency of occurrence by plant species and other metrics	Field	Aquatic Plant Database
Lakeshore Habitat Survey: riparian and littoral habitat metrics at parcel scale, coarse woody habitat locations and density	Field	In progress, Lakes and AIS Mapping Tool
Aquatic Invasive Species Early Detection Surveys: presence/absence and estimate of abundance of AIS	Field	SWIMS

Citizen Lake Monitoring Network

DESCRIPTION

The Citizen Lake Monitoring Network goals are to collect high-quality data, to educate and empower volunteers and to share data and knowledge. Volunteers collect most of Wisconsin's available water clarity and water chemistry data on lakes. Volunteers also monitor temperature, dissolved oxygen, and ice cover. This data is used to make management and watershed decisions and to track long-term trends in water quality. They also identify and map native aquatic plants and monitor new or documented populations of aquatic invasive species like zebra mussels and Eurasian watermilfoil. Most AIS discoveries in lakes are found by CLMN volunteers. The work done by CLMN volunteers is woven through every aspect of lake work.

MONITORING OBJECTIVES

Educate and empower volunteer participants, collect a variety of high-quality data, and broadly share volunteer-collected data with local communities and beyond.

MONITORING DESIGN

Lake selection is primarily driven by volunteer interest. Approximately 600 lakes are monitored each year for Secchi depth, 550 lakes for water chemistry, 350 lakes for dissolved oxygen, 100 for ice on/off, 30 for water levels, 70 for AIS, and 1 for native plants. Water chemistry lakes range in area from 6 – 23,000 acres, with a median area of 213 acres. All volunteers collecting Secchi depth, dissolved oxygen, ice on/off, AIS, water levels, and native plant data should continue their efforts as long as possible.

Given the costs associated with water chemistry analysis, not all lakes enrolled in CLMN can be monitored for water chemistry long-term. A subset of lakes will continue monitoring indefinitely for evaluating long-term trends. The remaining lakes are committed for three years of sampling with the possibility to extend monitoring for more years if a specific management action is being evaluated or if continued monitoring is warranted for another reason such as a lack of data from a specific lake type.

Lakes are prioritized for chemistry monitoring following these criteria:

- The volunteer has monitored Secchi depth for at least 1 year.
- The lake has not been assessed for total phosphorus and chlorophyll a per WisCALM guidance within the past 5 years.
- A volunteer has been recruited to help the local lake biologist monitor a Long-Term Trend Lake.

If further prioritization is needed in any given year, the following criteria are applied:

- "New citizen engagement" - By enrolling a volunteer in chemistry monitoring, he/she and possibly the greater lake group will learn more about the lake and become more engaged in the management and stewardship of the lake.
- "Demonstrated citizen engagement" – These are lakes where one or more volunteers are active stewards of their lakes, and they regularly share lake monitoring data with others, including at meetings of the lake association/district or town/county board.
- "Lake management" – Lakes where additional chemistry data would aid decisions about protection or restoration management actions or lakes that should be monitored to evaluate the results of nutrient-related management practices.
- "Lake Classification" – Lake types that exist on the landscape but are rarely monitored. Some lake characteristics considered include: 1) drainage vs. seepage lakes, 2) shallow, mixed lakes vs. deep, stratified lakes, 3) trophic status (nutrient richness), 4) color (clear to brown), and 5) alkalinity (soft to hard water).
- **"**Long-Term Record" - The lake has a long-term record (> 10 years) and has improved/new capacity to restart the long-term record. The lake is also important to fulfill the statewide monitoring plan to represent different lake types.

Sampling Frequency

Secchi depths are taken every 10 to 14 days April through September and possibly into October, primarily focused in July and August. Phosphorus is sampled within two weeks of ice-off; phosphorus and chlorophyll-a are sampled the last two weeks of June, July, and August. Temperature and dissolved oxygen profiles are taken at the same time as the four phosphorus samples. Some volunteers collect additional temperature and/or dissolved oxygen data during water clarity monitoring events. Water levels are ideally monitored weekly during the ice-free season, but may be monitored monthly. The remaining indicators are monitored annually.

WATER QUALITY INDICATORS

Parameter	Analysis Location	Database
Secchi Depth	Field	SWIMS
Total Phosphorus, chlorophyll *a*, and water temperature	Field and State Laboratory of Hygiene	SWIMS
Dissolved Oxygen	Field	SWIMS
Ice on/off	Field	SWIMS
Water Levels	Field	SWIMS
Aquatic Invasive Species	Field	SWIMS
Native Plants	Field and CLMN Educator	none

Lake Level Monitoring

DESCRIPTION

Water levels in lakes are monitored during the ice-free season using a staff gauge.

MONITORING OBJECTIVES

Monitor statewide lake levels over time to address growing concern related to changing water levels due to drought, flooding, changing climate, and groundwater withdrawals.

MONITORING DESIGN

In 2015, DNR added lake level monitoring to the Citizen Lake Monitoring Network. Lakes were initially prioritized for lake level monitoring based on the following criteria: 1. seepage lakes, 2. regions with little to no existing lake level monitoring data, 3. regions vulnerable to groundwater withdrawal (deep layers of sand and gravel), and 4. lakes monitored by volunteers or DNR for other parameters. More lakes are added to the network each year if volunteers contract a surveyor and obtain their own staff gauge.

SAMPLING FREQUENCY

Professionals (e.g., county surveyors) survey and install staff gages to lakes shortly after ice-out in spring and then survey and remove staff gages in late fall. Volunteers record and report lake levels preferably weekly, but at least monthly.

WATER QUALITY INDICATORS

Parameter	Analysis Location	Database
Staff Gauge Reading	Field	SWIMS
Survey Information: benchmark locations and elevations, derived elevation of staff gauge spring and fall	Field	SWIMS

Pictures from various WDNR monitoring studies, courtesy of C. Hein, S. Jarosz.

Section 3.4 Monitoring Strategy for Wetlands

Table 3.4.1 Wetland Monitoring Studies		
Study Name	**Purpose**	**Supports**
Wetland Condition Assessment/Floristic Quality Assessment (FQA)	Site Level Biological Condition. Intensive, expert–based, assessment of the floristic quality of a given wetland site to document the biological condition of the wetland, based on its plant community. Floristic quality benchmarks can be used based on community type and location in the state.	What is the overall quality of waters in the State? What level of protection is needed?
Wetland Function and Value Assessment	Site Level Rapid Assessment. Provides a standardized process to evaluate the extent to which a specific wetland performs a given function, and evaluate condition, using a stressor checklist. The method is primarily used to support regulatory decision making.	What is the overall quality of waters in the State? What level of protection is needed?
U.S. EPA National Wetland Condition Assessment	Randomly assess wetland vegetation, soils, hydrology, and general condition every 5 years as part of the EPA National Aquatic Resource Assessments.	What is the overall quality of waters in the State? To what extent is water quality changing over time?
Reference Wetland Hydrology Monitoring	Long-term monitoring of reference-quality wetland sub-surface hydrologic conditions to better understand typical community-specific hydroperiods of different communities in different regions of the state.	To what extent is water quality changing over time? How effective are clean water projects and programs?
Wetland - Targeted Watershed Approach	An intensive survey of a subset of all wetlands within a single HUC12 or group of HUC12 watersheds. Usually focuses on floristic quality and/or functional values of the wetlands.	What are the problem areas and areas needing protection? What level of protection is needed?

Floristic Quality Assessment (FQA) and Benchmark Surveys

DESCRIPTION

A Floristic Quality Assessment allows for an intensive, expert-based, assessment of the floristic quality, or biological condition, of a given wetland plant community. It is based on the assignment of a coefficient of conservatism to the vascular plant species found in Wisconsin. Most commonly, FQA data is gathered by utilizing the Timed Meander Survey protocol – a plotless vegetation survey method that involves randomly walking through a single wetland community (or Assessment Area) and identifying all

plants that are observed and then assigning each species a cover value. The method requires a high degree of plant identification skill to correctly inventory the site. The DNR has also create the FQA Calculator to be used in conjunction with a Timed-Meander Survey that can auto-calculate various FQA metrics including the weighted mean coefficient of conservatism value.

From this data, the DNR generated floristic quality benchmarks which serve as a statistically valid, cost-effective, and repeatable approach that allows for relative comparisons across sites and time and at most scales of interest. Benchmarks have been set for most commonly occurring, native wetland communities found in Wisconsin. They are broken out by NHC-determined wetland communities and by Level 3 Omernik Ecoregions.

Monitoring Objectives

The FQA protocol is used to gather widespread baseline data throughout the state. This data is used and will continue to be developed to inform wetland water quality standards, regulatory decision making, functional value assessments and AIS detection and management. FQA metrics lend themselves nicely to be used as before-and-after metrics and should be incorporated into future long-term trend monitoring. As additional FQA data is collected, the FQA Benchmarks will continue to be developed to better inform future decision making and assessments of wetland health.

Monitoring Design

Currently, FQA surveys are conducted opportunistically or as needed for special projects. Occasionally FQA surveys are associated with targeted sampling efforts or grant efforts and may be concentrated in a given watershed (such as associated with a Targeted Watershed Assessment) or to develop additional benchmarks (such as grant efforts associated with the FY19/20 Wetland Program Development Grant to assess rare and unique wetland communities).

Water Quality Indicators

Parameter	Analysis Location	Database
Mean Coefficient of Conservatism	Field	TBD; Access
Functions and Values Score	Field	TBD; Sharepoint (Water Reg)
Benchmark Score	Watershed	TBD; Access
Invasive species	Field	SWIMS

Wetland Function and Value Rapid Assessment

Description

The Wisconsin Wetland Rapid Assessment Methodology version 2 (hereafter "WRAM") is the most updated functional and value assessment tool developed by the DNR; as of 2021, an update to this tool is being planned. The WRAM is a qualitative method developed to provide a standardized process for the professional to evaluate the extent to which a specific wetland performs a given function. The full range of wetland functions and values are covered. The presence or absence of specific characteristics is used to determine the importance of each functional value for a site. The method documents the best professional judgment of the evaluator and requires one or more field visits. This tool is utilized primarily for assessment of a wetland's functions and values for consideration in wetland permitting decisions.

Monitoring Objectives

The WRAM protocol is used to assess individual wetland site conditions. This data is used and will continue to be developed to inform regulatory decision making and functional value assessments. In future, with better data management and improved protocol methodologies, this data can be summed by watershed to get a better picture of watershed health, identify restoration targets, and better understand the intersection between functional values and other landscape metrics such as urban development or wetland community type.

Monitoring Design

The WRAM is primarily used for regulatory decisions and permitting by the DNR Waterways Program. It is also used in conjunction with some wetland monitoring and assessment protocols to look for relationships between WRAM findings and FQA findings as floristic quality is often utilized as a representative metric for many wetland functions and values (e.g. if floristic quality is high, it is assumed that the wetland will also rank high for wildlife habitat or erosion control).

Sampling Frequency

WRAMs are only completed on an as-needed basis for wetland permits or specific projects. WRAMs are also completed as spot-checks for the GIS-based Wetland Function and Value Assessment (see below).

Water Quality Indicators

Parameter	Analysis Location	Database
Functions and Values Score(s)	Field	TBD; SharePoint (Water Reg)

National Wetland Condition Assessment (NWCA)

Description

The NWCA is designed to answer basic questions about the extent to which our nation's wetlands support healthy ecological conditions and the prevalence of key stressors at the national and regional scale. It is intended to complement and build upon the achievements of the U.S. Fish and Wildlife Service Wetland Status and Trends Program, which characterizes changes in wetland acreage across the conterminous United States. Paired together, these two efforts provide government agencies, wetland scientists, and the public with comparable, scientifically-defensible information documenting the current status and, ultimately, trends in both wetland quantity (i.e., area), quality (i.e., ecological condition) and AIS distributions.

Monitoring Objectives

The NWCA objective is to create a nation-wide look at wetland conditions on a five-year recurring survey.

Monitoring Design

The sampling design for the NWCA is a probability-based network that provides statistically-valid estimates of ecological condition for a population of wetlands with known confidence. Sample points are selected at random to represent the condition of wetlands across the country. The survey design is developed in partnership with the US FWS Wetlands Status and Trends Program.

The NWCA sampling is comprised of all wetlands of the conterminous U.S. The survey encompasses both tidal and nontidal wetlands ranging from the expansive marshes of our coasts to the forested swamps, meadows, and waterfowl-rich prairie potholes of the interior plains.

Sampling Frequency

NWCA surveys are typically completed once every 5 years as part of the National Aquatic Resource Survey rotation.

Water Quality Indicators

Parameter	Analysis Location	Database
Vegetation	Field; Lab	EPA Exchange Network
Soil	Lab	EPA Exchange Network
Hydrology	Field	EPA Exchange Network
Water Chemistry	Lab	EPA Exchange Network
Algae	Lab	EPA Exchange Network
Buffer Characteristics	Field	EPA Exchange Network
Invasive species	Field	SWIMS

Reference Wetland Hydrology Monitoring

Description

This survey is designed to better characterize reference-quality wetland communities' hydrologic regimes – the natural fluctuation of sub-surface and standing-water to normal climatic changes. The survey is divided by natural wetland communities' times and Level 3 Omernik ecoregions.

Monitoring Objectives

The objective is to more-accurately characterize wetland hydrologic regimes by wetland community and region to better inform wetland restoration targets; specifically, to better inform wetland compensatory mitigation expectations. Often a reference wetland is chosen from a nearby and similar reference-quality wetland but when no such wetland is available, this data could be utilized instead. Wetland hydrology is foundational to wetland health and by better understanding the nuance of wetland hydrology, we will be able to make more informed decisions about restoration efforts, permit decisions, and overall wetland functional values.

Monitoring Design

At this time, only southern sedge meadow and wet-mesic prairie communities in the southern two ecoregions have been surveyed with 19 reference wetlands surveyed (11 sedge meadow communities and 8 wet-mesic prairie communities). As the opportunity (and funding) is available, the intent is to expand the community types and regions included in these surveys and to extend the survey period to more than 2 years; long-term data sets are better able to capture the full range of conditions from dry and wet years to include more "normal" years.

Sampling Frequency

An EPA Wetland Program Development Grant funded two field-season years' worth of data collection for 20 reference wetland sites (2020 and 2021). If staff time allows, we intend to re-deploy those for more than 2 years to gather more data. At this time, expansion of this assessment protocol will occur opportunistically.

WATER QUALITY INDICATORS

Parameter	Analysis Location	Database
Depth to groundwater	Field	TBD

Wetland - Targeted Watershed Assessments

DESCRIPTION

Targeted Watershed Assessments (TWA) are a monitoring framework that is designed to be deployed in prioritized watersheds providing a consistent funding and basic monitoring level of effort, while bring flexible enough to add parameters or increase intensity based on site-specific data needs.

MONITORING OBJECTIVES

TWAs meet multiple monitoring objectives, but most often TWAs are selected to provide pre and post restoration data for multiple watershed planning efforts such as US EPA Nine Key Element, WNDR Water Quality Planning or NRCS National Water Quality Initiative. TWAs are also used to investigate watersheds where poor biology was unexpectedly discovered (i.e., identify unique or ephemeral stressors), provide data in support of WDNR healthy waters initiatives or AIS management monitoring.

MONITORING DESIGN

TWAs generally include 20-30 wetlands of various structural types (e.g., shallow open water, herbaceous, shrub, or forested) in a HUC 12 size watershed, although exceptions can be made because of watershed size, shape or complexity. Each site typically receives a level 3 floristic quality assessment and functions and values assessment and may also include water and/or soil samples for analysis. Sites may be selected through a probabilistic approach or targeted selection. Ideally, the TWA watershed has updated wetland mapping available.

SAMPLING FREQUENCY

Sampling frequency is determined by parameter specific data requirements, which may include a single site visit or 2 to 3 follow up visits. Typically, TWAs are conducted over the course of a single field season, but high intensity sampling requirements may necessitate a two-year project window for some TWAs.

Pictures from various WDNR wetland monitoring studies, courtesy of S. Jarosz.

WATER QUALITY INDICATORS

Parameter	Analysis Location	Database
Mean Coefficient of Conservatism	Field	TBD; Access
Functions and Values Score(s)	Field	TBD; Sharepoint (Water Reg)
Invasive species	Field	SWIMS

Section 3.5 AIS

During 2010-2015, a project was implemented to evaluate the rate of spread of invasive species in Wisconsin lakes. This project developed a constant protocol for lakes that was later adapted to invasive species monitoring in streams and wetlands. In 2016, AIS monitoring was integrated with the National Aquatic Resources Surveys (NARS) to continue the rate of invasive species spread assessment. At that time, AIS monitoring was also integrated with routine water quality sampling on lakes, streams, and wetlands to increase early detection and distribution information. Field staff funded through the Great Lakes Restoration Initiative and segregated AIS monitoring funds assisted this integration. In addition, about half the monitoring is completed by partners (counties) and citizen volunteers. Efforts were also made to target early detection monitoring at priority access points and/or entire waterbodies. Emphasis was placed on response monitoring following new discoveries and the opportunity to integrate with local needs projects. Moving forward, AIS monitoring will include early detection monitoring at priority locations based on high risk to invasion based on pathways and response monitoring (further described below).

Our overall goal is for DNR, partners and citizens to monitor over 1,000 sites annually. About half those fieldwork events are by citizens and the rest split between partners and DNR staff. Citizens tend to monitor lakes where they live or when species are incidentally discovered. Partners work to fill gaps that are aligned with DNR has priorities. DNR staff will prioritize response monitoring and implement early detection monitoring once response monitoring is complete. Districts request additional LTE support through local needs, if AIS response monitoring is expected to exceed the district's AIS monitoring activity allotment. Grant-funded partners and citizen volunteers provide major contributions to accomplish monitoring goals.

Moving forward, DNR AIS Monitoring will include (further described below):
Planned AIS Monitoring

- Data management (data entry, QA/QC, verification)
- Targeted early detection monitoring (pathways)
- Opportunistic AIS monitoring through incident reports and integrating with routine water quality monitoring, including CLMN and WAV
- Rate of spread study through the National Lake, Stream and Wetland Assessment
- AIS long term trends to understand specific species population dynamics over time (Eurasian water milfoil, starry stonewort, zebra mussels, spiny waterflea)

Local Need Monitoring (see local needs section for details)

- Response monitoring to delineate/evaluate population extent (could be standard field collections or eDNA screening).
- Response monitoring to determine genetics for species and hybrid identification.

- Response monitoring for treatment evaluation monitoring (point-intercept surveys)
- Response monitoring for treatment evaluation monitoring (herbicide concentration surveys)

Table 3.5.1 Aquatic and Wetland Invasive Species Monitoring		
Study Name	**Purpose**	**Supports: Wildlife, Fisheries, Habitat, Recreation**
Aquatic and Wetland Invasive Species Early Detection	Identify presence of NR 40 AIS in the state through surveys of lakes, streams, wetlands and monitoring other pathways.	What are the problem areas and areas needing protection? What level of protection is needed?
AIS Response	Delineate population extent and assess management.	What are the problem areas and areas needing protection? What level of protection is needed?
Incident Report	Report invasive species detected outside of planned monitoring.	What are the problem areas and areas needing protection? What level of protection is needed?
EWM and SSW Long-Term Trend Monitoring	Understand long-term population dynamics of specific invasive species (milfoil starry stonewort) and native plant communities across different management regimes and invasion trajectories	What are the overall trends in invasive and native aquatic plant frequency and abundance over time? To what extent do environmental factors drive observed changes in plant communities over time?
Zebra Mussel Long-Term Trend Monitoring	Understand zebra mussel population abundance over time.	To what extent is water quality changing over time?
AIS Rate of Spread Surveys - National Aquatic Resource Surveys	Understand rate of invasive species spread	What is the overall quality of waters in the State? To what extent is water quality changing over time?
AIS Snapshot Day	Detect presence/absence of invasive species at predetermine locations.	What are the problem areas and areas needing protection? What level of protection is needed?
Project Riverine Early Detectors	Detect presence/absence of invasive species at predetermined locations.	What are the problem areas and areas needing protection? What level of protection is needed?

Aquatic and Wetland AIS Monitoring

DESCRIPTION

DNR, partners and volunteers monitor and report invasive species in lakes, streams, wetlands. This is accomplished through targeted search efforts that target specific stations with high-risk pathway introductions and integrated with routine water quality sampling. It is also accomplished by integrated efforts between routine water quality and AIS monitoring.

MONITORING OBJECTIVES

DNR, partners and volunteers collect data to understand distribution of invasive species and initiate appropriate response action.

MONITORING DESIGN

Sampling timeframe is generally May 15 to September 15 with broader timelines for some species. Staff, partners, and citizens collectively monitor about 1,000 locations annually using studies based on the baseline AIS monitoring protocols developed for lakes, streams, and wetlands.

SAMPLING FREQUENCY

Sampling frequency is determined by parameter specific data requirements, which may include a single site visit. Typically, invasive species monitoring events are conducted over the course of a single field season.

WATER QUALITY INDICATORS

Parameter	Analysis Location	Database
Invasive species	Field	SWIMS
Genetic identification	Genetics lab (WSLH, UW Whitewater, Montana State University, University of Illinois)	LDES and SWIMS
Mussel veliger	Field, WSLH	LDES and SWIMS
Waterflea	Field, WSLH	LDES and SWIMS

AIS Response Monitoring

DESCRIPTION

Staff, partners, and volunteers monitor for invasive species following new detection to delineate population extent. This monitoring includes the parameters assessed during targeted early detection monitoring and further explore pathway movement to determine locations for potential spread. Response monitoring utilizes species-specific detection tools such as eDNA, drones, conservation canines. Treatment evaluation may also be assessed with point-intercept plant surveys and herbicide concentration monitoring. Response monitoring falls under the Local Needs category as these activities might need to seek additional funding then routine planned monitoring.

Monitoring Objectives

DNR, Partners and volunteers collect data to understand distribution of invasive species and evaluate management.

Monitoring Design

Sampling timeframe is generally May 15 to September 15 with broader timelines for some species. Monitoring generally includes the newly colonized location, proximal suitable locations and other locations based on potential pathway dispersion. Lakewide aquatic plant point-intercept surveys can be conducted for response monitoring associated with invasive aquatic plants. Annual counts are included within the 1,000 sites monitored of invasive species. Response monitoring are conducted in a single day or multiple days/years.

Sampling Frequency

Sampling frequency is determined by the parameter specific data requirements, which may include a single site visit or multiple visits.

Water Quality Indicators

Parameter	Analysis Location	Database
Invasive species	Field	SWIMS
Mussel veliger	Field & WI State Lab of Hygiene	LDES and SWIMS
Waterflea	Field & WI State Lab of Hygiene	LDES and SWIMS
Genetic identification	Genetics lab (WSLH, UW Whitewater, Montana State University, University of Illinois)	LDES and SWIMS
Invasive species eDNA	State Lab of Hygiene and other genetic labs	SWIMS, LDES, genetic lab
Canine scent detection	Field, Conservation Dogs Collective	SWIMS, TBD
Aerial surveillance	Field, DNR Aeronautics	SWIMS, GIS
Treatment evaluation - Aquatic Plant Point Intercept Survey: frequency of occurrence by plant species and other metrics	Field	Aquatic Plant Database
Treatment evaluation – Herbicide concentration	Field & WI State Lab of Hygiene	LDES and SWIMS

Incident Report

Description

DNR, partners and volunteers report invasive species in lakes, streams, wetlands when detected outside of planned monitoring. These opportunistic reports account for about ¼ of AIS fieldwork events each year.

Monitoring Objectives

Document reports of invasive species populations to understand distribution of invasive species and possibly initiate appropriate response action.

Monitoring Design

Incidental reports are opportunistic reports submitted when staff, partners and citizens observe AIS when not intentionally looking for AIS. Reporting timeframe is year-round and most concentrated during growing season (May to October). Up to 200 incident reports are submitted each year. All reports are vetted by DNR for verification. Most are either not new reports or are incorrect; however, many NR40 Prohibited Species and uncommon species are reported through incident reports each year which highlight the value of this program.

Sampling Frequency

Incidental reports occur in one day, though follow up can take additional trips for verification.

Water Quality Indicators

Parameter	Analysis Location	Database
Invasive species	Field	SWIMS

Eurasian Water Milfoil (EWM) and Starry Stonewort (SSW) Long Term Trend Monitoring

Description

The Department conducts lake-wide aquatic plant surveys on the same lakes over time to document long-term trends in populations of non-native invasive aquatic plants (i.e., Eurasian watermilfoil & starry stonewort) and native plant communities.

Monitoring Objectives

Long-term data on aquatic plant communities is collected and analyzed to better understand invasive species population dynamics and provide context when developing both local and statewide management plans. This long-term data is also used to better understand the environmental conditions which may drive variation observed in aquatic plant community frequency and abundance over time.

Monitoring Design

Aquatic plant point-intercept surveys have been conducted on a subset of 28 waterbodies located across the state where EWM has been verified. This sub-set of lakes is split into lakes which are actively managing EWM, and those which are not actively managing EWM. These lakes are further grouped into waterbodies where EWM has been well-established for numerous years, as well as waterbodies where EWM had been newly discovered. Lake wide aquatic plant point-intercept surveys are also conducted on a regular basis on 16 waterbodies where SSW has been verified.

Sampling Frequency

Lake wide aquatic plant surveys are conducted once per year between June 15 - Sept 15. Surveys are scheduled so that they are completed during approximately the same time each season. Priority is given to monitoring unmanaged lakes in years when all study lakes cannot be monitored due to lack of staff or resources. Larger waterbodies may also need to be sampled every other year if staff time and resources do not allow for an annual survey.

Zebra Mussel Long-Term Trend Monitoring

Description

The UW Extension Citizen Lake Monitoring Program has been using substrate samplers to evaluate zebra mussel population dynamics in lakes. There has been little engagement with volunteers collecting zebra mussel trend data, so UW Extension Department worked with DNR to simplify the method for volunteers. We hope to increase engagement to better understand zebra mussel population dynamics within and among Wisconsin Lakes. This will be piloted in 2022.

Monitoring Objectives

Evaluate zebra mussel population densities annually to determine change in population abundance over time.

Monitoring Design

We aim to recruit a volunteer from at least one lake in each district. Each year volunteers check substrate samplers monthly to estimate zebra mussel abundance over time. Data will be recorded in SWIMS to estimate population density.

Sampling Frequency

Annually monitor zebra mussel abundance on substrate samplers monthly from June to September or October.

Water Quality Indicators

Parameter	Analysis Location	Database
Invasive species	Field	SWIMS

Aquatic Invasive Species Trend Monitoring

Description

The National Assessment Long-Term Trends (LTT) monitoring programs are a baseline monitoring activity conducted by the Wisconsin DNR Water Quality Bureau on lakes, streams, rivers in coordination with the US EPA 106 Supplemental grant. The NARS program was developed to track and analyze water quality trends over time in water throughout the nation, including Wisconsin's water. Wisconsin has incorporated invasive species surveys with NARS to assess evaluate invasive species distribution and rate of spread over time.

Monitoring Objectives

Track species-specific trends for managed/unmanaged populations
Evaluate effectiveness of outreach aimed at stopping the spread
Identify relationships between AIS presence and water quality.

MONITORING DESIGN

Invasive species LTT assesses invasive species presence/absence per site during routine LTT assessments. Logistic regression will be used to evaluate changes in the AIS rate of spread. See specific LTT design above.

SAMPLING FREQUENCY

Each LTT occurs on a 5-year basis.

WATER QUALITY INDICATORS

Parameter	Analysis Location	Database
Aquatic plants	Field	Aquatic Plant Database
Invasive species	Field	SWIMS

AIS Snapshot Day

DESCRIPTION

This event is coordinated by the University of Wisconsin-Extension Water Action Volunteers program in cooperation with the Wisconsin Citizen Lake Monitoring Network and Wisconsin DNR.

MONITORING OBJECTIVES

Engage citizens to detect pioneer invasive species populations at suspected or high-risk locations. Detections of new AIS may trigger response actions and management planning.

MONITORING DESIGN

Local site leads identify rendezvous location and works with Regional DNR AIS Coordinators to select locations to be monitored. Citizens receive training from local site lead are provide maps and equipment to monitor the pre-determine locations, collect specimens/photographs and return to the rendezvous site to report.

SAMPLING FREQUENCY

One day in late summer is selected for a statewide snapshot day. There are also events hosted outside the statewide effort.

Parameter	Analysis Location	Database
Invasive species presence	In Field	SWIMS

Project Riverine Early Detectors

DESCRIPTION

This program is coordinated by the River Alliance of Wisconsin in coordination with county and local partners and the Wisconsin DNR.

MONITORING OBJECTIVES

Engage citizens to detect invasive species along rivers and streams. Detections of new AIS may trigger response actions and management planning.

MONITORING DESIGN

Local coordinators recruit and train citizen volunteers and select locations to be monitored. Citizens collect specimens/photographs and submit to the regional Project RED coordinator and regional DNR AIS Coordinator for verification.

SAMPLING FREQUENCY

Sporadically May through September.

Parameter	Analysis Location	Database
Invasive species presence	In Field	SWIMS

Section 3.6 Cross Program Monitoring

Cross program monitoring is monitoring activities in conjunction with other partners that help the Program fulfill monitoring strategy goals. The partner may be internal WDNR programs that have overlapping responsibilities or programmatic goals that align with the WR Program, such as the Drinking water and Groundwater Program or Office of Great Waters. Other partners are external to WDNR, but work in collaboration to protect and restore Wisconsin's waterbodies, such as county governments and lake management associations. Below is a non-exhaustive list of the most common cross-program monitoring that helps fulfill the Monitoring Strategy.

Springs – Water Use

As part of the Water Use Section's monitoring needs assessment the Section identified springs monitoring as a needed programmatic element. Springs, a reflection of groundwater intersecting the land surface, are unique natural resources that supply water for streams, lakes and wetlands. A spring is defined in s. 281.34 (1) (f), as "an area of concentrated groundwater discharge occurring at the surface of the land that results in a flow of at least one cubic foot per second at least 80% of the time." Springs create habitat that often harbor endangered or threatened species. Springs indicate areas of concentrated groundwater discharge and are convenient places to measure groundwater elevation. The WR Program partnered with Water Use Section to assume responsibility for six reference springs to be sampled quarterly for long term trends in chemistry and discharge. Water Use provides funding and WR field staff are responsible for completing monitoring program.

FERC

As part of issuing a state water quality certification, WDNR is responsible for determining whether it has reasonable assurance that the Federal Energy Regulatory Commission (FERC) facility will comply with water quality standards, the public interest and public rights. The development and implementation of a water quality monitoring plan provides the information necessary for the department. Monitoring the water quality and biology of impounded areas increases understanding of these waterbodies individually and as a group. Collecting WQ data within the impoundment and in the river stretches downstream and upstream of the dam helps identify problems and help the facility and DNR work collaboratively towards management solutions. The WDNR recommends that facility staff work with DNR staff before developing the first draft of their monitoring plans and throughout the process. DNR can provide the facility with useful information on monitoring locations, existing data, and recommended parameters and sampling frequency for the site. The WQ Bureau developed a guidance document in 2021 for roles and responsibilities for monitoring at FERC facilities, the monitoring program supports those efforts with technical guidance, SOPs, data management or in some cases, monitoring support.

Nearshore Great Lakes

Nearshore Great Lakes monitoring consists of monitoring to conduct (i) AOC status and remediation monitoring each year; (ii) probabilistic assessment of Great Lakes nearshore waters every five years as part of the National Coastal Condition Assessment; and (iii) targeted studies designed to answer focused management questions. AOC monitoring projects include verification monitoring, BUI assessments, and pre- and post-project (restoration or remediation) monitoring projects. AOC monitoring projects are typically funded through AOC-designated GLRI money, but state funding is also used. Monitoring is done by WDNR staff, other federal agencies, local municipalities, or contracted through universities or consultants depending on the specific project and capacity with WDNR and partners. The National Coastal Condition Assessment is EPA-funded, and follows a similar format to other NARS surveys, with some enhancements specific to Great Lakes coastal habitats. Targeted studies done on the Great Lakes (e.g. Harmful Algal Bloom monitoring on Lake Superior, CSMI-funded work, habitat assessments) are typically funded through GLRI-focus area funds or Great Lakes Protection Funds and are often confined monitoring projects with specific questions in mind and short-term (one to a few years) monitoring duration.

Major gaps for Great Lakes nearshore monitoring include lack of overall Great Lakes nearshore monitoring strategy, need for a water quality monitoring plan for the Lower Fox River, post-AOC delisting long-term monitoring plans for Areas of Concern, and monitoring plan to assess nearshore sediments for beneficial use of dredged material. Additional information on Great Lakes monitoring can be found in the Office of Great Waters Monitoring Strategy.

Mississippi River

Monitoring on the Mississippi River is done by WDNR staff and federal partners to add to the collective knowledge and resource management by interstate program managers on the Mississippi River. Primary long-term monitoring projects include LTT monitoring; LTRM program, zebra mussel monitoring, macroinvertebrate monitoring, and CWA monitoring. LTT monitoring occurs at three sites along the river to provide site specific condition assessment and attainment as well as long-term views of major constituent loadings on the river. The Long-Term Resource Monitoring program (LTMR) consists of bimonthly and monthly fixed station sampling and quarterly stratified random sampling in Pool 8. Monitoring components include water quality, fish, invertebrates, and aquatic vegetation. Evaluation of habitat rehabilitation projects constructed as part of Environmental Management Program and Channel Maintenance Plans are also conducted using general limnological and hydrologic monitoring principles.

Detailed information on Mississippi River monitoring programs and projects can be found in the Office of Great Waters Monitoring Strategy.

Beaches and HABs

Authority for beach monitoring, issuing beach advisories, and beach closures lies with local public health agencies. Most local public health agencies lack the capacity for developing their own monitoring program, so they rely on DNR and the Wisconsin Department of Health Services for technical expertise for both E. coli and HAB monitoring DNR has the authority for monitoring beaches at State Park and State Forest properties.

Beach monitoring for E. coli is done to manage risk of human illness associated with exposure to pathogens and recreational water use and to determine whether water quality beaches attain recreational use criteria. Coastal beach monitoring in Wisconsin is funded through the BEACH Act, and DNR receives funds, which pass through to local public health agencies to monitor approximately half of all Wisconsin coastal beaches. Some local entities supplement BEACH Act funding with local funds to increase monitoring. All monitored beaches are monitored at least one time per week, and monitoring frequencies are determined by WDNR in collaboration with local public health departments. Monitoring partners follow WDNR and EPA guidance in terms of monitoring and lab protocols and beach advisory and closure standards. For Great Lakes waters, the "advisory" standard is 235 CFU/100mL, and the "closure" standard is 1000 CFU/100mL (also called Beach Action Values). Monitoring data and advisories are entered into the Wisconsin Beach Health database as they are analyzed by participating local public health departments and university labs. Wisconsin prepares an annual report summarizing program activities and results as part of BEACH Act grant reporting. DNR has authority for monitoring beaches and posting advisories and closures on State property. DNR Parks staff collect water samples following the same protocols as for Great Lakes coastal beaches, and samples are sent to the WSLH. Data is transmitted to LDES and then to the Wisconsin Beach Health database where advisory or closure status is automatically posted following beach action values of 235 CFU/mL for an advisory and 1000 CFU/mL for a closure. External Services and the WDNR Beach program regularly evaluate monitoring frequencies and funding allocations for State beaches, with minimum monitoring frequencies of 1x per week for monitored beaches. Limited DNR funding also exists for monitoring of non-State inland water access points by local health departments. This program operates the same as the State-inland beaches, with data collected by local public health departments, analysis by WSLH, and advisories following Great Lakes Beach Action Values. All data is also transmitted to LDES and the Wisconsin Beach Health database.

For Harmful Algal Blooms: While DNR staff may implement informal strategies for beach monitoring and beach closures at State properties, there is a need for development of a formal HAB monitoring program that can be implemented at State property beaches. That program can be used as a model to support monitoring and public health protection activities at non-State properties, where the authority for beach monitoring, issuing advisories, and beach closures lies with local public health agencies.

Nine Key Element Plan Development

EPA's Nine Key Elements provide a framework for improving water quality in a holistic manner within a geographic watershed. The nine elements help assess the contributing causes and sources of nonpoint source pollution, involve key stakeholders and prioritize restoration and protection strategies to address water quality problems. Surface water monitoring contributes to Nine Key Element watersheds in two ways. The monitoring strategy encouragers Water Resources staff to support partners in developing Nine Key Element plans by providing water quality data and technical resource expertise. These

monitoring efforts can be funded by base program funds but are not yet eligible for 319 Project funding. Once the watershed has an approved Nine Key Element plan, at the biologist's discretion, a monitoring project can be developed to collect pre-implementation data. This may consist of additional chemical monitoring or resource condition monitoring such as biological assessments and/or physical habitat evaluations. Staff may develop low intensity continuous monitoring efforts for long periods of time, or high intensity efforts pre and post watershed restoration to evaluate any improvements that may or may not have occurred within the targeted waterbodies. Developing a Nine Key Element plan does not commit WDNR staff to future monitoring in that watershed. Each watershed needs to be evaluated on the likelihood of large-scale watershed restoration and finally the total amount of activities that have been applied on the landscape to determine probability of detecting improvements in surface waters.

Wetland Monitoring (with Waterways program)

The Waterways Program (DNR Division of External Services) is charged with collecting wetland condition assessments for most, if not all, proposed wetland impact permit sites through the use of a Wetland Rapid Assessment Methodology. These surveys are utilized to assess wetland functions and values as it pertains to wetland permitting. At his time, the results of these wetland assessments are not collected as data, only used as defense for permit decisions. With the overhaul of the Waterways permit database and the wetland water quality database, the goal is to better capture this data to be utilized for wetland water quality assessment purposes. In addition, an effort is underway as of late 2021 to overhaul the WRAM that would assist in making data collection and utilization more efficient and streamlined.

Aquatic Plant Management

The Department's Aquatic Plant Management (APM) program is charged with protecting diverse and stable communities of native aquatic plants and preventing the spread of invasive aquatic plants. A major component of the APM program is the review and approval of permits which are submitted to the Department to control nuisance causing aquatic plants in waters of the state. These control activities consist of chemical, mechanical, manual, physical, and biological approaches. When new or novel management activities are proposed on a waterbody, there is oftentimes a lack of scientific information available on efficacy of target species control as well as potential non-target impacts to other organisms. The Department's APM Technical Team regularly meets and identifies management techniques where scientific information is lacking and strives to fill in these data gaps in scenarios where a new or novel approach is permitted to occur. This monitoring data includes, but is not limited to lake wide aquatic plant surveys, pre- and post-treatment sub-PI surveys, meander AIS mapping surveys, and laboratory analysis of herbicide concentrations present in water following chemical treatments. This APM evaluation data is currently available in the statewide aquatic plant database as well as SWIMS. Monitoring data is collected by a wide variety of external partners, with much of this monitoring effort being implemented through the Department's Surface Water Grant program. Department staff may also assist in conducting these APM evaluation activities as part of local needs efforts or other broader monitoring efforts.

Surface Water Grants

DNR Surface Water Grants allocate funding for aquatic invasive species, planning, protection and restoration, land/easement acquisition which all include monitoring components that bolster DNR efforts. Grantees upload their raw monitoring data and associated reports to the Surface Water Integrated Monitoring System (SWIMS) database. Monitoring data collected as part of these surface water grant projects includes but is not limited to: Clean Boats Clean Waters (CBCW), Citizen Lake Monitoring Network (CLMN) data, Water Action Volunteer (WAV) data, AIS early detection surveys,

aquatic plant point-intercept surveys, pre/post aquatic plant management surveys, herbicide concentration monitoring, and other water quality data.

The surface water grant program provides cost-sharing grants for surface water protection and restoration. Funding is available for education, ecological assessments, planning, implementation, and aquatic invasive species prevention and control. With many different projects eligible for grant funding, you can support surface water management at any stage: from organization capacity development to project implementation.

Pictures from WDNR wetland monitoring studies, courtesy of S. Jarosz.

Pictures from Kewaunee River, courtesy of M. Gansberg.

Section 4.0 Databases and Information Technology

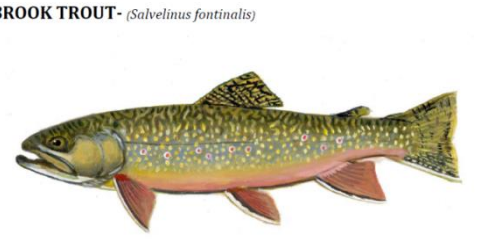
Section 4.1 Summary of Existing Databases

Data from WDNR water monitoring programs are stored in several databases, most of which are accessible to the public via the internet. The primary database for WR monitoring data is stored in the Surface Water Integrated Monitoring System (SWIMS). Since the development of the previous Monitoring Strategy 2015-2020 WDNR has continued to develop web-based spatial data displays (hereafter called Viewers) that are developed for specific Water Quality programs (TMDLs, WPDES, etc.). This section describes SWIMS and other databases currently used by the WR Monitoring program, including those managed by partner programs.

Surface Water Integrated Monitoring System (SWIMS)

The Surface Water Integrated Monitoring System (SWIMS) enables all staff, as well as the public, to access comprehensive sets of data for each waterbody, and to view monitoring results geographically using Web mapping applications called Surface Water Data Viewer (SWDV). Users can access the system via the Internet using a user ID and password. SWIMS consolidate many monitoring tasks by creating projects that store multiple data types into one place, printing field forms with automated database keys, automatic generation of station numbers, automatic generation of some biological metrics/indices, data flow integration with the UW-Stevens Point Aquatic Biomonitoring Laboratory and State Lab of Hygiene, and enables timely entry of results into the EPA Water Quality Exchange (WQX) Network. Datasets stored in SWIMS includes organic and inorganic water chemistry, sediment chemistry, continuous monitoring data, lake profiles, satellite water clarity estimates and biological taxonomic data such as aquatic invasive species, aquatic macroinvertebrates, aquatic macrophytes among other data.

More information about SWIMS is available on the internal WDNR website at:
http://dnr.wi.gov/topic/surfacewater/swims/



Fisheries Management Database

The Fisheries Management Database (FMDB, formally the Statewide Fish and Habitat Biology Database) is a centralized database for all statewide fish surveys, wadeable stream habitat surveys, fish propagation information, fishing tournament permits, and fish kill investigations. Raw data and summary reports are available for exporting and analysis. The FMDB is the main storage hub for WR monitoring data fish taxonomy, calculation of the fish Index of Biotic Integrity (IBI) metrics and indices and stream physical habitat data, metrics and indices.

The FMDB is accessible to all DNR staff and analyzed data in the form of reports are available to the public. DNR staff has access to the data entry forms and reports on the internal website. The public website is available for other state agency staff and members of the public. Statewide data are also available upon request from the database manager, and regional fisheries data requests are handled by district fisheries biologists. The database can be accessed at:
https://infotrek.er.usgs.gov/wdnr_biology/metadata.htm

WDNR 24K Hydrography Layer

The WDNR 1:24,000 scale Hydrography layer is the base spatial water resources data structure. All water resources data collect related to surface water is located against this structure, with the exception of wetland data. Wetland data is not spatially joined to other data and is a stand-alone dataset. The Hydrography layer is a digital representation of lines and polygons that represent surface water on the USGS 7.5 minute topographic maps. The 24K Hydrography data layer:

- Serves as the spatial representation for locating all of our water related data such as monitoring locations, assessment units, outfalls, engineering studies, dams etc.
- Serves as the base surface water layer for all mapping applications (i.e. web-based Viewers)
- Enhances our ability to communicate/share information with others who use our hydrography layer for their activities (e.g. counties, Regional Planning Commissions, federal agencies, etc.).

Wisconsin Hydrography Dataset Plus (WHDPlus)

The WHDPlus is a Wisconsin-specific waterbody and watershed attribute table stored in a geodatabase following the National Hydrography Dataset data model. The WHDPlus provides hundreds of physical attributes for each of the ~160,000 WHD stream reaches and lake features throughout the state (Menuz et al. 2013, Ruesch et al. 2013). Stream reaches in WHD are inter-confluence segments from WDNR's 1:24k hydrography layers, which were digitized from USGS 1:24k topographic maps. Contributing watershed areas for each stream reach were delineated using the 10 meter resolution National Elevation Dataset. WHD stream reaches and their contributing drainage areas are typically small, with a mean length of 0.8 km and a mean drainage area of 0.9 km_2. WHD hydrography layers and WHDPlus attributes are available for download and public use at: ftp://dnrftp01.wi.gov/geodata/hydro_va_24k/.

Wetland Spatial Layers

The Wisconsin Wetland Inventory (WWI) feature classes show graphic representations of the type, size and location of wetlands in Wisconsin. This data has been prepared from the analysis of high-altitude imagery in conjunction with soil surveys, topographic maps, previous wetland inventories and field work. Recent efforts by the Department were completed to overhaul the way wetlands are mapped in Wisconsin with a few pilot watersheds being completed; those will be available to the public in 2021.

The Potentially Restorable Wetlands (PRW) dataset was last updated in July 2016. It is derived, in part, from the SSURGO soil surveys, a compound topographic layer derived from the statewide 10m DEM, Wisconsin 24K Hydro Layer, Wisconsin Wetlands Inventory, and the Restoration Database. The extraction of soil polygons is based on two fields and is refined by the CTI values of 10 or greater. All polygons that were greater or equal to 75% hydric were automatically selected for consideration. In addition, Soil Polygons that had a Percent Hydric from 1 - 74 were also selected, and all polygons that were not in these two sets that had a PWSL value between 1 - 80 and <null> were also considered. Soil units with 75% or greater Percent Hydric were automatically added to the penultimate dataset, and rest were only considered based on the CTI values of 10 or greater inside their respective units.

The Wetland Indicators dataset shows the intersect of hydric soils mapped by the USDA Natural Resources Conservation Service and topography indicative of a wetland landscape position based on 10 m USGS topographic data. Mapped hydric soils are typically found within areas designated as wetlands. Intersecting soils information and landscape position can identify potential wetlands. For more information on the mapped soil types, please use the Identify tool and link to the USDA Natural Resources Conservation Service Web Soil Survey. The Maximum Extent Wetland Indicators layer does not include the Wisconsin Wetland Inventory Layer and therefore, the Maximum Extent Wetland

Indicators layer and the Wisconsin Wetland Inventory layer should be used in conjunction to identify potential wetlands on the landscape.

Register of Waterbodies (ROW)
The Register of Waterbodies is the database that manages inventory information about our state's surface water. Unique numeric identifiers called waterbody ID codes (WBICs) are assigned to each stream/river, lake, pond, reservoir etc. as it is defined by users. WBICs are used by monitoring databases to associate data to waterbodies and for linking data across tabular datasets. WBICs are also encoded into the state 24K Hydrography layer.

Water Assessment Tracking and Electronic Reporting System (WATERS)
WATERS, an intranet-based tabular and spatial assessment database, supports implementation and reporting under the Federal Clean Water Act. This database holds Clean Water Act Section 305(b) and 303(d) data, designated uses, assessment units, assessment status, codified uses, and other data describing the quality of Wisconsin's rivers, lakes, and Great Lakes shoreline. WATERS uses the table structure and the reporting requirements identified in USEPA's integrated reporting strategy and programmed into the ADB V 2.0 and includes additional enhancements specific to the state's water management needs. Data from this system is sent to EPA periodically in fulfillment of Clean Water Act 305(b), 303(d), and 314 grant reporting requirements. WATERS can be accessed internally at: http://dnrx.wisconsin.gov/wadrs/

System for Wastewater Applications, Monitoring, and Permits (SWAMP)
The SWAMP is an Oracle-based computer system designed to assist with management of the Wisconsin Pollutant Discharge Elimination System (WPDES) Permit Program. This system has the capability to generate WPDES permit applications, store facility information, generate and issue WPDES permits, determine whole effluent toxicity requirements, generate monitoring forms, store permittee monitoring data and analyze compliance, generate/store permit-related documents, track compliance events, and calculate annual environmental fees based on reported discharges. The database became active in January 1999; permitting capability became active in 2000.

For monitoring purposes, SWAMP has the capability to track sample point and monitoring requirements, display data and documents, compare reported data to reporting requirements and display apparent violations, warnings, and exceedance, and produce reports. Discharge, groundwater, sludge, and land application self-monitoring data are stored and available for downloading. Electronic reporting of discharge data is currently being implemented. Monitoring data that is held in SWAMP is downloaded, manipulated, and displayed as annual loading in the FACTs system, available on the WDNR website.

Surface Water Data Viewer (SWDV)
The Surface Water Data Viewer is an interactive web mapping application that serves GIS data to DNR staff and the public. The incredibly popular and heavily used SWDV has multiple themes that support a broad range of programs including of datasets dam safety, floodplain management, fish consumption advice, construction permits, designated waters review and wetland and wetland indicators. The data viewer can be found at: http://dnrmaps.wi.gov/sl/?Viewer=swdv

Water Condition Viewer (WCV)
The Water Condition Viewer is designed to supplement the SWDV by providing summary assessment data and various themes related to Water Quality program-specific functions including Clean Water Act assessments, watershed and quality planning, targeted watershed assessments, monitoring studies and

results, and fisheries, macroinvertebrate and habitat index assessments. The Water Condition Viewer can eb found at: http://dnrmaps.wi.gov/sl/?Viewer=Water Condition Viewer

Watershed Restoration Viewer (WRV)
The Watershed Restoration Viewer is an online interactive map that displays geospatial layers associated with Total Maximum Daily Load (TMDL) development and implementation, adaptive management and water quality trading, watershed planning, and 9-Key Element Plans. The web-based version of the Pollutant Load Estimation Tool (PRESTO), referred to as PRESTO-Lite, has been added to the viewer to allow for quick watershed delineation and automate water quality reporting for any spatial location interactively selected on the map.

Lakes and AIS Viewer (LAV)
The Lakes and AIS Viewer is a web mapping viewer that allows users to view data derived from water quality, shoreland and AIS monitoring. This includes information pertaining to water quality, aquatic & wetland invasive species presence, shoreland habitat, volunteer lake monitoring efforts and Surface Water Grants. The Viewer also displays supportive data layers such as the DNR 24k Hydrography, Wisconsin Wetlands, geographic and political boundaries as well as other water related datasets.

Wisconsin Beach Health Database
The Wisconsin Beach Health Database is an online database that allows local beach monitoring partners and WDNR staff to enter *E. coli* data, beach sanitary survey information, and beach advisories for public health notifications and for submittal to EPA as part of WDNR's BEACH Act funding. The database also serves as a web mapping viewer and online report viewer that allows members of the public to view beach monitoring data at all Great Lakes coastal beaches, all State Parks beaches, and at participating inland beach locations. The database links with LDES so that data collected at State Parks beaches and DNR-funded inland beaches are automatically uploaded to the Wisconsin Beach Health Database. Data is also uploaded from Wisconsin Beach Health into SWIMS and to EPA's BEACON system at the end of each beach season.

Pictures from McNaughton Creek, Oneida County, courtesy of J Klosiewski.

Section 5.0 Future Directions

These sections highlight areas that DNR has modified or expanded since 2015, or plans to work on and improve upon in the next five years. An implementation strategy and prioritization framework does not yet exist for most of these items. The next monitoring strategy update will review progress toward these recommended changes and will describe the decisions made going forward.

Section 5.1 Changes during the life of the previous Strategy

Emphasized Monitoring Programs

Over the course of the 2015 Water Monitoring Strategy several programs have been expanded, including TMDL monitoring, Large River Biological Monitoring, continuous stream temperature and PFAS Monitoring.

In 2015, WDNR adopted a TMDL prioritization framework that identified a few larger watersheds that were primed for the next TP/TSS TMDL development. The exact timeline for each was not identified as much of the work depends on funding and staff workload. Through an EPA Monitoring Initiative Grant in 2016 WDNR began building capacity to complete TMDL monitoring and development completely in-house, significantly reducing the cost to develop new large scale TMDLS. Since then WDNR has completed monitoring for the Northeast Lakeshore TMDL (https://dnr.wisconsin.gov/topic/TMDLs/NELakeshore.html) and is in the process of monitoring for the Fox and Des Plaines river TMDLs. In 2015 monitoring for TMDL development was not considered as large of a part of the monitoring program as it is today. The TMDL program is in the process of updating the prioritization framework and the updated Monitoring Strategy reflects the current emphasis towards TMDL monitoring, for whichever watershed(s) is prioritized over the next 5 years.

In 2015, the Water Monitoring Strategy reflected the limited ability to collect assemblage-level data on large river ecosystems. The program consistently collected macroinvertebrates but only had limited capacity of trained staff and equipment to collect large river fish assemblages for impaired waters assessments. WDNR used funding from the NARS NRSA to purchase a new electrofishing boat specifically for large river work and hired a Large River Monitoring Coordinator dedicated to building program capacity. WDNR now has a program that collects large river macroinvertebrate, fish and select mussel assemblage data at fixed sites and following a watershed rotation program. Field season 2021 will mar the final year of a 5-year rotation to complete large river biological assessments for the State. Afterwards a program evaluation will be conducted and any adjustments to the plan will be implemented in field season 2022.

A section of the previous strategy that was underdeveloped was emerging contaminants and climate change monitoring. While emerging contaminants was part of WDNR monitoring strategy, specifically monitoring for Per- and Polyfluoroalkyl Substances (PFAS) has become a significant aspect of the program. Since 2015 WDNR built surface water monitoring capacity by developing an SOP, conducting staff training on field methods, working with the WSLH on laboratory methods and increasing frequency of fish tissue collection for fish consumption advisories. The WDNR has been monitoring is surface waters for PFAS along three concurrent paths, investigating potentially contaminated sites, paired surface water and fish tissue samples to aid in criteria development and a completed project to sample

at all of the Long Term Trend River sites (n=44) to understand ambient concentrations is Wisconsin's surface waters (https://dnr.wisconsin.gov/topic/PFAS/SWFish.html). The WDNR also hired two emerging contaminant scientists, one specifically for surface waters, that will help guide the program in future monitoring and research efforts.

Wisconsin also developed a long-term stream temperature monitoring program to track the effects of climate change on Wisconsin's wadeable streams. There were earlier statewide efforts to collect continuous temperature for the creation of the Wisconsin Stream Model and subsequent Natural Community classification system. A 5-year project recently completed that was intended to collect stream temperature over a longer period of time and collect under-represented stream types for an update to the Wisconsin Stream Model. A subset of these sites (n = 56), plus all the sites in the Wadeable Stream Trend Network (WSTN, n=44) were selected as the Stream Temperature Monitoring Network to collect continuous temperature for at least 30 years. For sites part of the WSTN we will also have co-collected biological assemblage data to measure the implications of climate change on community composition.

De-Emphasized Monitoring Programs

Two monitoring programs described in the 2015 Water Monitoring Strategy have been significantly reduced or eliminated altogether.

The Follow Up monitoring program was devised to return to locations where there was some data suggesting an impairment, but the minimum data requirements had not yet been met. This program filled a gap because WDNR spent a lot of time getting to as many sites as possible, usually in a single year of monitoring. This often fell short of minimum data requirements for chemical and biological assessments in streams, rivers and lakes. Instead of continuing this program the strategy put a larger emphasis on TWAs and Directed Lakes which focus more intensive monitoring on fewer waterbodies/watersheds. This resulted in fewer monitoring locations with too sparse of data for impaired waters assessments, so the Follow Up program was dropped.

The Natural Community Stratified Random program is Wisconsin's version of the NARS NRSA. The benefit to Wisconsin is that the methods and assessments are appropriate for WDNR's biological assessments (i.e. IBIs) and that cycle is completed every two years using 100 sites allowing for more frequent assessment of condition and future state-scale changes in condition. This program was dropped in field seasons 2020 and 2021 as COVID protocol's made traveling and working in larger crews more difficult. WDNR is also considering dropping this program permanently and relying solely on state enhancements of the NARS programs to get state-scale condition assessments.

Section 5.2 Data Analysis and Reporting Goals

While developing the 2021 Update to the Monitoring Strategy, program gaps surrounding data display and reporting were identified. We have prioritized working on data display and reporting over the next 5years and aim to have solutions identified by the time the 2025 Monitoring Strategy is developed. Particularly the Monitoring Section plans to:

- Develop performance metrics for the monitoring program that can be reported annually/biennially to assess the short and long-term performance of Baseline, Prescribed and Local Needs monitoring.
- Develop a long-term reporting schedule for each of the Baseline monitoring programs. This may consist of smaller annual reporting and larger 5 to 10-year comprehensive reports.
- Develop data visualization tools and procedures for display and dissemination of Baseline trend and other monitoring programs.

Section 5.3 Strategic Shifts Over the Next Five Years

The Water Resources Monitoring Strategy Review Team conducted a gap analysis, listing 59 data needs and monitoring gaps that the team would like to address as part of the monitoring strategy update (Appendix A). The team then narrowed this list to the top ten priorities to address in the next five years that will require a change in daily operations to accomplish. We describe those ten priorities below. Note that many of the items listed in Appendix A that did not make the top ten list can still be addressed by the monitoring technical teams. Each of the individual priorities will have unique timeline to achieve full implementation. It may not be feasible to fully implement the data need, but making progress on the item will be a priority for the Program over the next five years.

Formalize and fully implement Regional Monitoring Network for climate change

GOAL

By 2025, the WR Monitoring program is monitoring eight lakes according to the full Regional Monitoring Network protocol collaboratively developed by EPA Region 5 and Region 1 state and federal staff. In addition to purchasing and replacing equipment, this effort also requires staff time for monitoring and development of a data management procedure for continuous data in lakes.

JUSTIFICATION

Air temperatures are warming, and precipitation patterns are changing in Wisconsin. Climate change is affecting lakes in many ways: increased likelihood of harmful algal blooms, habitat threats to cold-water fish, changing assemblages of aquatic biota, changing threats of AIS, flooding, drought, and more. Long-term monitoring specifically designed to track how Wisconsin lakes are changing in response to changing temperature and precipitation patterns will help DNR better manage lakes into the future. Wisconsin's Long-Term Trend Lakes monitoring can be used to evaluate trends in trophic status, but temperature monitoring is not frequent enough to track how lake thermal regimes are changing over time. Other important metrics like water levels are not part of the Long-Term Trend Lake monitoring design. The Regional Monitoring Network design fills a gap in our monitoring program by enhancing the Long-Term Trend Lake protocol with more parameters monitored at higher frequency. By joining efforts with other states, we can better evaluate trends over time and differences between lake types and regions.

Expand partner monitoring of E. coli at beaches by local health departments and partners

GOAL

By 2025, the beach monitoring program has increased partner monitoring and reporting to the Wisconsin Beach Health database of *E. coli* at beaches by local health departments by 10% compared to 2020 numbers. This effort will support public health protection measures and increase data available for making impaired waters determinations at beaches. For Great Lakes beaches, IT costs savings have opened additional money for monitoring. For inland lakes beaches, additional OGW and External Services staff time will be needed for these outreach efforts as well as increased basic agreement allotment to inland lake beach monitoring

JUSTIFICATION

Most beaches in the state are unmonitored for *E. coli*, which presents a public health risk to many participants of in-water recreation. Authority to close public beaches lies with local health departments, so most monitoring is done by those organizations at a minimum frequency of once per week. EPA funding exists, through the BEACH Act to monitor *E. coli* at Great Lakes beaches, but funding only covers costs at approximately half of Great Lakes beaches. Some local health departments (e.g. Door County Public Health and City of Milwaukee Health Department) supplement BEACH Act funds to increase monitoring locally. New upgrades to the Wisconsin Beach Health database have reduced costs and will allow for increased monitoring of coastal beaches starting in the 2022 beach season.

There is limited DNR funding for monitoring done at inland water bodies at State Parks and by local health departments at non-State water access points. We have an opportunity to use the new Wisconsin Beach Health database and website upgrades, in addition to newly promulgated *E. coli* water quality criteria, as means to expand partner monitoring of *E. coli* to other inland beaches throughout the state. The WDNR Beach Program is actively working with DHS, External Services, and local public health agencies to evaluate state level funding for inland *E. coli* monitoring and reprioritize funding allocations to expand the number of beaches that participate in WDNR funded monitoring. We are also working with DHS and External Services to increase outreach to local public health departments that have capacity to do monitoring in house to increase monitoring efforts and to have them start entering their data into our Wisconsin Beach Health database.

Develop strategy and protocols for HAB monitoring by DNR and partners

GOAL

From 2020 to 2025 several harmful algal bloom (HAB) monitoring efforts are proposed for development:
Monitoring protocol development for beaches at state parks and state forests, with applicability to beaches monitored by local health agencies. State properties will be ranked or prioritized to target beach monitoring to HAB-impacted water bodies.
Developing financial, logistical, and data-sharing support for monitoring buoy deployment by partners.
Supporting development of automated remote sensing monitoring of HABs using new remote sensing products and future enhancements of current products.
Developing HAB monitoring and reporting protocols for DNR staff and Citizen Lake Monitoring Network volunteer monitors.

JUSTIFICATION

Monitoring for harmful algal blooms and their toxins is not currently implemented at a statewide level. Bloom reporting to DNR by the public has helped to document where HABs are recurring issues, but we still lack a synoptic view of HAB occurrence in the state due to monitoring data gaps. HAB monitoring is

also needed at State Park and State Forest properties to protect public health. Support for monitoring buoys is needed for monitoring source water for public water utilities on Lake Winnebago, and for monitoring other sites on inland and Great Lakes waters.

Develop a nearshore Great Lakes monitoring strategy

GOAL

By 2025 the OGW monitoring program will develop and begin implementing a Great Lakes nearshore monitoring framework. This enhanced monitoring will support OGW strategic plan and Lake Michigan and Lake Superior LAMP goals. OGW and WR Monitoring Section staff time will be needed to help develop the monitoring framework. Funding for increased monitoring will likely come from the nearshore monitoring account and a potential increase in OGW basic agreement allotment. FTE staff time for monitoring is already covered through GLRI funding.

JUSTIFICATION

To date, the WDNR has done little monitoring of the Great Lakes nearshore waters. Some monitoring occurs during NCCA years in both Great Lakes and within Wisconsin's Areas of Concern to assess beneficial use impairments, but WDNR does not monitor in the nearshore outside of NCCA years; federal agencies do not monitor nearshore as part of lake-wide assessments; and there is limited monitoring by other agencies and partners. As such, assessing the health of nearshore waters and evaluating effectiveness of management actions on the landscape is difficult.

The OGW Strategic Plan and the OGW Monitoring Strategy both identified the development and implementation of a monitoring strategy for Great Lakes nearshore waters as a top priority. This strategy will provide data that can allow OGW to better assess the health and changes in water quality of our nearshore waters. The nearshore monitoring strategy will consider current monitoring underway (e.g. NCCA) and determine what monitoring objectives, design, indicators, and frequency is needed to meet OGW management needs.

Collect data on nitrogen and ecosystem impacts to inform department Clean Water Initiatives

GOAL

By 2025 the WR Monitoring program has fully implemented nitrogen data needs identified by the Nitrogen Pre-Criteria Team (subset of the Nitrogen in Surface Waters Team). This enhanced monitoring will support nitrogen criteria development and/or nitrogen criteria assessment. In addition to monitoring appropriate forms of nitrogen, ancillary parameters needed for criteria will also be monitored (e.g. dissolved organic carbon).

JUSTIFICATION

Eutrophication from excess nitrogen and phosphorus can have moderate to severe impacts on ecosystem and human health. Wisconsin has developed criteria for P, which drives a large percentage of the work for WR, WW and RM. Nitrogen in surface waters has increased in Wisconsin. The WQ Standards program has prioritized development of N surface water criteria, which would help develop consistent targets and focus implementation. We recommend updating the monitoring program to provide data needed for nitrogen criteria development, including potential biological endpoints and tracking N reductions in waterbodies Monitoring for these purposes will likely require a shift in monitoring locations (representing different waterbody types), ancillary data (dissolved organic carbon) and monitoring endpoints (HABs, benthic algae, etc.). Once N criteria are developed, the monitoring strategy will also need to be adjusted to ensure necessary data is collected to complete assessments.

The WDNR Water Initiatives Steering Committee (WISC) has identified addressing nitrogen in surface and ground water as one of its main priorities. A sub-group of WISC, the Nitrogen Pre-Criteria Team is assessing WDNR's readiness to pursue nitrogen criteria in lakes & reservoirs, streams & rivers, Mississippi River and the Great Lakes. Part of the Team's assessment will be cataloguing the current nitrogen and nitrogen-specific endpoints required for stressor response modeling, other data analysis to be used in criteria development. The updated Monitoring Strategy should reflect the recommendations form the Nitrogen Pre-Criteria workgroup and implement adjustments to current monitoring programs, or the development of new monitoring programs to fulfill the identified data gaps.

Operationalize wetland monitoring and assessments to routine efforts by Water Resources and Partners.

GOAL

Through the 2020-2025 period of this effort, the goal is to complete a handful of new monitoring and assessment protocols that will enable more staff to be complete wetland assessments. During this period, Water Quality staff, working with Waterways wetland staff, will build a wetland database for information to be stored and grow the wetland assessment trainings. The aim is to be able to expand data collection to external partners and more Department staff though new tools, updated trainings, and better data capture by 2025.

JUSTIFICATION

For decades, the Department of Natural Resources has monitoring the State's water quality by monitoring and assessing lakes, streams, and rivers. Over the last few years, the Water Quality program has been developing wetland monitoring and assessment protocols. To date, the wetland program has developed multiple Level 2 and Level 3 wetland monitoring assessment tools. The natural next step is to roll these tools out to be used for baseline monitoring, wetland quality assessment, and watershed monitoring.

To grow the wetland monitoring program, we propose to identify partners and/or Department staff who are able to grow routine wetland monitoring efforts including, but not limited to, creating routine long-term trend wetland monitoring sites, establishing a targeted watershed assessment program for wetlands, expand the collection of routine wetland floristic quality assessment samples, and to develop a more robust database. A database is needed to capture and query all the multiple layers of information that is acquired through the multiple wetland monitoring and assessment protocols.

The 2025-2030 monitoring strategy should then tackle how to design routine monitoring efforts and identify which partners (if any) to begin collaboration with, to expand the wetland monitoring and assessment program.

Build capacity of the Lake Monitoring and Protection Network

GOAL

Increase capacity of partners engaged in the water quality and invasive species monitoring programs by providing funding to eligible applicants to conduct volunteer training and recruitment, implement and submit monitoring data for water quality, aquatic invasive species presence and prevention activities, and other activities.

JUSTIFICATION

The Department's Water Quality and Aquatic Invasive Species Monitoring programs have incorporated citizen and partner data collection for decades. About half of the annual 1,000 fieldwork events are generated by partners and citizens, many of who are engaged through the surface water grant program, NR193. NR193 was recently updated to incorporate contracts with eligible sponsors (counties) to support statewide coordination of lake protection activities, including the collection and reporting of data on the use and condition of lakes and lake ecosystems. Activities include watercraft inspection, monitoring, early detection of AIS, and other activities related to lake protection and AIS prevention. See surface water grant Section 5.2 (Limitations and Opportunities)

Enhance monitoring of invasive species pathways

GOAL

Identify and stop invasive species introduction and spread by stopping the vectors or pathways that move/introduce them.

JUSTIFICATION

The Department's AIS Management Plan identifies and describes 7 pathways (Table 5.1) that introduce and move invasive species. State and Federal Agencies, Maritime Commerce an Organisms in Trade are vectors for the most species introduced to the state and State and Federal Agencies, Canals, Dams & Diversions, and Recreational Boaters are vectors for the most species moved within the state. Many of our surface water monitoring strategies inadvertently assess locations where these pathways could introduce species. However, we are not actively monitoring the pathways before species arrive to surface water.

Our existing monitoring and outreach strategy prioritize AIS early detection monitoring in the field at publicly accessible lakes, rivers and wetlands and outreach at public events, direct contacts through trusted spokesperson/social influencers (i.e. bait shop staff, professional anglers, gardening experts, etc.) or through passive outlets (i.e. new releases, brochures, presentations, etc.). We are adding a new element to the existing strategy by integrating pathways into monitoring site selection and outreach to target audiences. Monitoring pathways may appear abstract in comparison to traditional water quality sampling, though it is serving an equally important purpose. A core team identified a process to outline the steps to consistently prioritize, inventory, evaluate and educate to stop invasive species transport through these pathways. The Department will proactively implement this pathway intervention to evaluate pathways that introduce AIS to the Great Lakes and the state.

Table 5.1. Risk for each pathway to introduce and spread 90 different invasive species. Based on risk assessments from the USGS, USFWS, and GLANSIS. Primary dispersal is the pathway that provided the initial introduction and secondary is how the species moves following initial introduction. The counts in the table are count of number of species moved by that pathway as referenced in USGS NAS and GLANSIS risk assessments.

Dispersal	Roadside Maintenance & Transport Corridor	State & Federal Agencies	Maritime Commerce	Canals, dams, & diversions	Recreational Activities & Service Providers	Non-recreational Fishing & Aquaculture	Organisms in Trade
Primary	1	18	20	2	4	6	32
Secondary	1	17	2	17	24	4	6

Explore and develop real-time high frequency data instrumentation opportunities

GOAL

By 2025, Wisconsin will have at least 10 highly instrumented buoys deployed on inland waters, as well as 10 USGS "supergages" on major river systems where we are implementing large-scale TMDL's. We will also have institutional support for satellite remote sensing technology.

JUSTIFICATION

Wisconsin has often been a leader in innovation for use of remote sensing and other remote tools for water monitoring, often in conjunction with Federal and University partners. We have also invested in several Monitoring Initiative projects over the past decade to help explore these new innovations. In addition, USGS and other entities will be deploying real-time sensors on Great Lakes waters and Illinois River system as part of NGWOS over next decade. This information has potential to be extremely useful in tracking progress toward water quality improvement, especially if can be designed to communication real-time information to public and partners. WDNR will be developing budget initiatives and seeking grant and partnership opportunities over the next 5 years to deploy buoys and gages.

Incorporate Environmental Justice principles and actions into monitoring program

GOAL

By 2025, an analysis of DNR's monitoring strategy in terms of environmental justice will be complete and steps to modify monitoring designs will already be underway. For example, who completes the monitoring, where monitoring takes place, and what parameters are measured may all be modified to better represent the interests and concerns of underrepresented communities. Substantive changes that cannot be addressed by 2025 will become part of the 2025-2030 strategy.

JUSTIFICATION

Water quality is an environmental justice issue; black, indigenous, people of color and other underrepresented communities are more likely to be exposed to or affected by polluted waters, contaminated fish, flooding, and other water quality concerns. However, these groups are not always involved in developing water quality standards, prioritizing where monitoring occurs, or engaged in volunteer monitoring efforts. For example, most Citizen Lake Monitoring Network volunteers own land along lake shorelines, and lakefront property owners typically represent a small portion of the state's population as affluent white people. To ensure that the interests of people of color are represented in monitoring, DNR should develop and work with focus groups to better understand water quality needs and concerns. DNR would then be better poised to prioritize monitoring parameters and locations using an environmental justice lens (e.g. monitoring to help preserve wild rice and high-quality walleye habitat, to ensure safe beaches for swimming, and warn of E. coli contamination). Another opportunity for enhancing diversity in DNR's monitoring efforts is to engage more diverse volunteers in CLMN and WAV, possibly even develop new programing to target different aspects of water quality.

Section 5.4 Budget, Staff, and Operation Initiatives Needed to Further Wisconsin's Monitoring Strategy

The future directions described in sections 5.1 to 5.3 can be accomplished with DNR's current resources and overall operating structure. Section 5.4 focuses on three areas strongly needed to further the monitoring program that require further budget and staffing investments and/or changes to operations. These three limiting areas include: 1) operations and workload limits, 2) information technology staff, and 3) staff with expertise in remote sensing technology. In each of these three areas, we describe the limitation and offer potential solutions. We highlight these as opportunities to pursue should new budget, staff, or grant initiatives arise. We also offer operational solutions so that we can continue to further our strategy even if we cannot procure more resources.

1) Field Staff Workload Limitations and Operational Solutions

The formation of the monitoring section in 2013 recruited dedicated staff to Wisconsin's water quality monitoring strategy and implementation. Since then, DNR has developed and begun implementing many new monitoring efforts, growing new programs and expanding upon long-standing monitoring programs. Some examples on lakes include lakeshore habitat, lake levels, Directed Lakes, continuous temperature and DO loggers on buoys, and several new methods for detecting various AIS (i.e. eDNA, canines, etc.). Examples on streams include large river mussels, large river discharge, targeted watersheds, and SOP's for continuous temperature and water level loggers. Some examples on wetlands include targeted watershed wetland surveys, use of provisional floristic wetland condition benchmarks, probabilistic wetland surveys, wetland diatom surveys, and rapid wetland assessments. District staff who typically conduct monitoring show interest and willingness to learn new techniques, but monitoring is just one of many tasks that fill their time. The development of new monitoring efforts represented an expansion in what DNR can learn about water quality in Wisconsin, not a transition away from some activities and toward new ones. This expansion reflects water quality challenges: new and emerging threats develop (e.g., PFAS), but old threats take a long time to solve (e.g. nutrient pollution) and cannot be ignored. While our expansion of monitoring efforts should be celebrated, the number of staff able to conduct monitoring has not grown. Thus, this monitoring strategy is attempting to evaluate and generate new ideas on who can contribute to monitoring in addition to what, where, and how to monitor. Below, we discuss ideas for re-evaluating our DNR staff model and partnering with externals to conduct DNR monitoring protocols.

Revisiting the Generalist Monitoring Staff Model

The WDNR WQ Monitoring Program has long operated under a "generalist" staffing model. Where, typically, each lake-specific and stream-specific staff member is assigned several counties where one of their many responsibilities is to perform monitoring activities in their assigned work area. This model results in field staff that are especially well educated in the local water resources. This also results in 10-12 individuals for lakes and streams that must have monitoring expertise (e.g. non-game fish field identification). Besides expertise, each individual must have specialized monitoring equipment required to carry out various tasks, such as boats, electrofishing gear, water quality sondes, etc. Under this model collecting sparse amounts data across a wide geographic distribution is relatively easy as the staff are dispersed geographically, and resources can be allocated evenly. Collecting an intensive amount of data in a small geographic area (such as a TMDL) becomes difficult as the local field staff has many other responsibilities.

A more centralized and/or specialized monitoring staffing model would provide some advantages to the distributed generalist model. Many of the other EPA Region 5 States operate under a fully or partially

(one central location or 2-3 field offices) centralized staffing model with experts whose time is mostly dedicated to monitoring activities. Additionally, WR has adopted this model on project-specific basis and has seen some success. For example, point-intercept macrophyte surveys have been conducted by two specialized crews because of the required field identification expertise. Large river fish monitoring is centralized in two field offices with two specialized watercrafts and staff with boat operation and fish identification expertise. Centralized monitoring crews have also been effective at carrying out specific projects such as the National Aquatic Resource Surveys and wetland monitoring method development. A review of the current monitoring staffing model could reveal small or large-scale changes that could improve the efficiency of the monitoring program and benefit other programs in Water Resources that compete for the same limited staff time and capacity. Water Resources will explore alternative staffing options for at least some monitoring activities and consider the benefits and drawbacks on a project specific basis.

Further Integrating Partners and Volunteers in DNR Monitoring

DNR has a long history of engaging partners and volunteers in monitoring efforts. The Citizen Lake Monitoring Network, Water Action Volunteers, and the Surface Water Grant Program are all prime examples, and these programs clearly show that the number of sites reached goes far beyond what could be accomplished with DNR staff alone. Here, we suggest looking closely at these existing ways of incorporating partners to help accomplish our monitoring needs and possibly broadening how and who we engage as monitoring partners.

The benefits of engaging external partners are clear: it accomplishes a lot more monitoring work and educates and involves others in water quality. Monitoring can initiate partner engagement and result in partners committing to and even leading protection and restoration projects. The biggest challenges are ensuring high quality data and staffing enough people for program development and support. Monitoring efforts that engage externals require the same elements as those that involve DNR staff: training, coordination, data entry, a database ready to receive data, quality assurance, and data retrieval/display. To ensure the previous list of items is fully met, DNR must devote enough staff time for coordination and IT support.

The program will continue to evaluate who our partners are and make sure that diverse groups of partners are contacted and encouraged to collaborate with DNR, specifically including partners that represent communities of color, tribes, and other under-represented groups. Below, we discuss how the following external partners could be further integrated into DNR's surface water quality monitoring:

Surface Water Grants

Projects funded by DNR must collect and submit data using many of DNR's protocols. Surface Water Grants are contributing water chemistry, lakeshore habitat, aquatic plant, AIS, and other data. Some grant recipients are explicitly carrying out the full suite of Directed Lakes and AIS monitoring. About half of the 1,000 annual fieldwork events for invasive species are generated through surface water grant projects. There is also an AIS Research grant category to support research that could benefit monitoring, prevention and assessing impacts. The recently deployed Lake Monitoring and Protection Network program establishes contracts with interested/eligible sponsors (i.e. counties) to implement methods. The ranking process should be reviewed to fully leverage the grant program in helping to fulfill monitoring strategy goals. DNR should continue ensuring that DNR protocols are used and data is submitted in the proper format. More work is needed to improve and streamline training, data submittal, retrieval, and tracking processes.

Citizen Lake Monitoring Network & Water Action Volunteers
DNR started prioritizing new chemistry monitoring requests to fulfill data needs. DNR could also begin recruiting volunteers on high-priority lakes (e.g., finding more volunteers to conduct most of the Long-Term Trend Lake monitoring). DNR should also consider new CLMN and WAV programming to meet new data needs (e.g., nitrogen and dissolved organic carbon samples, buoys with temperature loggers, AIS early detectors, temperature logger deployment) or fill in for DNR staff in new ways (e.g., collect full list of parameters for midsummer LTT Lake sampling event). DNR may also strategically recruit volunteers for lake level monitoring, Regional Monitoring Network lakes and Targeted Watershed Assessments.

AIS Snapshot Day
Under a Surface Water Grant, River Alliance of Wisconsin developed AIS Snapshot Day. This event selects a single day where local site leads trains and deploys volunteers to search for AIS. The program has evolved to include lakes and wetlands, incorporated DNR guidance on site selection and even partners with Minnesota. In 2021, the program was integrated into the DNR contract with UW Extension.

U.S. Forest Service
DNR should better integrate with water quality monitoring efforts conducted by the U.S. Forest Service. The Forest Service conducts its own surface water monitoring, and this data may help fill gaps in DNR's monitoring strategy. The Forest Service and DNR will partner to sample lakes for the 2022 National Lakes Assessment, and the Forest Service has started monitoring its own Regional Monitoring Network Lakes in Wisconsin. There is great potential for growing this partnership.

United States Geological Survey
USGS is skilled at high frequency data collection, particularly for water levels. DNR contracts USGS to maintain staff gauges on 10 lakes, and USGS would like to instrument more of those sites with continuous sensors. An increase in contract dollars would be necessary. DNR should further consider how USGS monitoring efforts overlay with DNR monitoring strategy goals and how to best leverage USGS partnerships.

Counties
Many counties contribute a wide breadth of water quality monitoring information through Surface Water Grants and other means. Counties are conducting Directed Lakes Surveys, AIS, and other monitoring. Some county surveyors are installing and surveying staff gauges for lake level monitoring. And some counties are conducting wetland surveys. Still, many counties are not involved in water and wetland quality monitoring. DNR should evaluate how to possibly involve more counties and how to support and expand monitoring partnerships with counties that are actively monitoring.

Water Resource Utilities
Many water resource utilities conduct water quality monitoring throughout the watershed and initiate programs to improve water quality. DNR should make efforts to inventory these entities' monitoring plans and, in cases where programs use field and lab methods compatible with DNR methods and WisCALM guidance, encourage facilities to submit their water quality results to SWIMS.

Federal Energy Regulatory Commission
Dams regulated by the Federal Energy Regulatory Commission conduct water quality monitoring as part of their license requirements. DNR could establish guidelines on the monitoring conducted throughout

the term of the license. DNR is also working to ensure that data collected by these entities is submitted to SWIMS.

Universities
University of Wisconsin-Madison maintains the North Temperate Lakes Long Term Ecological Network, which conducts long-term monitoring on lakes in Dane and Vilas counties. DNR should use information from this valuable data set as needed and incorporate into designs for long-term monitoring. Many opportunities for partnering with universities have not been explored, and the newly formed Freshwater Collaborative could provide a great opportunity to incorporate DNR monitoring protocols and data collection into course curricula statewide.

Tribes
DNR should better integrate with tribal monitoring strategies and partner where possible. For example, Red Lake Nation in Minnesota sought funding for deploying temperature loggers on tribal lakes throughout EPA Region 5 and included Lac Courte Oreilles in the proposal. Lac Courte Oreilles is also a high priority lake for high-frequency temperature and dissolved oxygen monitoring to DNR because of its cold-water fishery. Tribal nations and DNR can apply for funding separately and could potentially accomplish more monitoring by planning together.

Consultants
Consultants contribute a lot of monitoring data to DNR, especially through the Surface Water Grant Program. DNR should evaluate the data generated by consultants to ensure that the monitoring they conduct is desired, follows DNR protocols, quality assurance criteria are in place and met, and data is properly submitted (see Surface Water Grants Program). In addition, DNR should consider consultants as yet another partner for adding new monitoring elements to meet future monitoring strategy needs.

Other DNR Programs
DNR Water Resources should seek help from other divisions and bureaus within the agency to further the monitoring strategy. Examples include Water Use section monitoring springs and water levels, Watershed monitoring wetlands, and Fisheries potentially contributing to lakeshore habitat monitoring.

2) Information Technology Workload Limitations and Solutions
As the monitoring program adopts new monitoring protocols and technology such as continuous sensors, new data management systems must also be put into place. Obtaining, storing, and querying data are all important steps in any monitoring program. The monitoring section is also trying to develop web interface tools to ease data visualization and interpretation, which could enormously reduce staff time. Staff can then more efficiently obtain, analyze, and graph data for reports and also more easily convey how the public can access information.

DNR has limited information technology staff and therefore, furthering existing and new monitoring data products is hampered. Below, we list potential solutions:

- Hire FTE's, LTE's and interns to work on Information Technology. Find ways to expand IT capabilities in strategic hiring plans.
- Make use of free and available software to enable staff to complete more data management tasks.
    - Train interested staff to use SQL Developer and/or R.
    - Ensure field staff are trained to create and manage their projects and data in SWIMS, reserving more time for SWIMS data managers to focus on development.

    - Train specific staff to use SQL Developer to query SWIMS (e.g., statewide coordinators and staff conducting analyses). Only a limited number of staff have training and licenses for TOAD, so only a couple of IT staff can currently handle large queries.
    - Adopt R Shiny (or other software) as a tool for data display. Using open-source software enables many staff to develop tools for data display rather than being limited by contractor time. Many R Shiny display tools have already been developed but await department-level approval to be hosted online and shared internally and externally.
- Continue development of forms for online data collection that can be used with smartphones or tablets.
- Set stringent data submittal requirements for externals to minimize troubleshooting and data cleaning steps that DNR staff conduct after receiving data.

3) Technological Advances in Remote Sensing Offer Opportunity Despite Loss of In-House Expertise

DNR uses remote sensing to infer water clarity on approximately 8000 lakes each year (see Section 3.3). This information is used for 305b reporting and other applications seeking baseline information. DNR no longer employs remote sensing experts, but this information is extremely valuable and remains an important element of DNR's monitoring strategy. Additionally, remote sensing technology is rapidly advancing. The launch of the Sentinel 2 satellite promises to make it possible to infer additional water quality information on lakes from satellite imagery including: colored dissolved organic matter, chlorophyll *a*, and harmful algal blooms. These added parameters will allow DNR to better interpret water clarity information and may even allow for 303d impairment assessments in the future. Is low water clarity due to naturally high levels of CDOM staining the water brown or is it due to high concentrations of algae? With the advent of Google Earth Engine, image processing can also be computerized with water quality indicators estimated as close as two days after the image was taken. Although this would not be fast enough for closing beaches vulnerable to algal toxins, this high frequency data will advance Harmful Algal Bloom research and management. In addition, two research groups are using Wisconsin's lake level data and water quality data to advance the use of remote sensing for inferring changes in lake levels, area and volume over time and for studying how winter drawdown affects harmful algal blooms. DNR is a co-principal investigator or collaborator on both grants (National Aeronautics and Space Administration and the Northeast Climate Adaptation Science Center).

DNR should use this staffing transition as an opportunity to re-evaluate how to obtain water quality and quantity information derived from remote sensing technology and adopt the latest advancements in the field. Below, we list potential options for the future, all of which will require financial resources.

1. Staff an LTE to continue processing satellite imagery as DNR has done in the past and involve IT staff as needed. Requires a 6-month LTE position each year and results in annual water clarity estimates for thousands of lakes. Water clarity estimates can be generated one to two years after the image was taken.
2. Contract researchers to develop tools for automated image processing through Google Earth Engine near real-time (water clarity, CDOM, chlorophyll *a*, and HABs). Data could be generated as often as every 5 days, but cloud cover will reduce the temporal frequency for any given waterbody.
3. Create an FTE scientist position to develop and implement Wisconsin-specific algorithms that make use of the latest remote sensing technology. Same output as item 2.

DNR should pursue grants and partnerships to share costs for item 2. Minnesota has already developed algorithms to use the latest remote sensing technology. Wisconsin could partner with Michigan and potentially other Midwestern states to develop algorithms for the region, building on the work that has already been completed in Minnesota. Fisheries and other DNR programs also have interest in these enhanced lake water quality parameters. Possible funding sources include the Midwest Glacial Lakes Partnership and the new Midwest Climate Adaptation Science Center. These grants also require state dollars as match. By partnering with other DNR programs, states and universities, DNR could obtain the latest technology for Wisconsin.

Pictures from WDNR lake monitoring, courtesy of C. Hein.

Appendix A

Detailed gap analysis identified from the Water Resources Monitoring Strategy Review Team. Each of these detailed data needs/gaps was identified as an important need, but only the highest priorities were selected as Strategic Shifts (Section 5.1).

DATA NEEDS/DATA GAP ANALYSIS	CATEGORY	STRATEGIC SHIFT	STREAMS/ RIVERS	LAKES	WETLANDS	TIMELINE
AIS CONTROL STRATEGIES	AIS		X	X	X	Long
HIGH WATER/CLIMATE MONITORING IMPACTS TO AIS	AIS		X	X	X	Long
AIS IMPACTS TO WATERBODIES	AIS	X	X	X	X	Long
AIS DETECTION, ER & DISINFECTION	AIS		X	X	X	Short
WHO DOES AIS MONITORING	AIS	X				Long
SLOW THE SPREAD OF AIS & ASSESS PATHWAYS	AIS	?				Long
VERIFICATION OF AIS SAMPLES	AIS		X	X	X	Short
RATE OF SPREAD (NATIONAL ASSESSMENTS)	AIS		X	X	X	Long
ALGAL BLOOM STRATEGY FOR MISSISSIPPI RIVER	Algae		X		X	Short/Long
HOW TO MONITORING HABS FOR PUBLIC HEALTH	Algae	X	X	X		Long
APM LONG TERM TREND	APM			X		Current
UNDERSTAND LONG-TERM TRENDS	Baseline		X	X	X	Current
NCSR OR NARS ENHANCEMENTS OR BOTH	Baseline		X			Short
USE LTT STREAMS BIOLOGY TO SET EXPECTATIONS	Baseline		X			Long
LTT STREAM ASSESSMENT	Baseline		X			Short
EXPAND LTT STREAM SITES	Baseline		X			Short
REVISIT ROTATION HUC 10 SITES	Baseline	X	X			Short
CLIMATE CHANGE/HIGH WATER MONITORING	Climate	X	X	X	X	Long
MONITORING DESIGN AND IMPACTS OF METALLIC MINING	Cross Program		X	X	X	Long
IMPLEMENTING THE OGW MONITORING STRATEGY	Cross Program	X	X	X	X	Long
ROTATION WATERBODIES/UPDATED WATERSHED ASSESSMENTS	Design	X	X	X	X	Short
EVALUATING WETLAND STATUS TRENDS/CHANGE OVER TIME	Design	X			X	Long
WETLAND HEALTHY WATERS/RESTORATION/IMPAIRED	Design		X	X	X	Long
COLLECTING CONTEMPORARY DATA ON MORE WATERBODIES	Design		X	X	X	Short
MONITORING DESIGN FOR LAKES IN FOREST MANAGEMENT	Design			X		Long
9 KEY ELEMENT PLAN MONITORING DESIGN	Design		X	X		Long
EMERGING CONTAMINANTS STRATEGY	EC	X	X	X		Long
PFAS MONITORING STRATEGY AND ASSESSMENTS	EC		X	X		Short

FERC MONITORING, PROTOCOLS, TRAINING AND DATA REQUIREMENTS	FERC	X	X	X	X	Long
ID HIGH QUALITY WATER, VULNERABLE – HEALTHY WATERS	HW		X	X	X	Short
IMPROVED DATA MANAGEMENT SWIMS	IT		X	X	X	Long
DATA ENTRY: REMOTE, SYNC WITH DATABASES, UPLOAD GIS DATA	IT		X	X	X	Long
MAKE SUITABILITY MODEL AVAILABLE ON WEBSITE	IT				X	Long
MUSSEL MONITORING EXPERTISE	Large River	X	X			Long
LARGE RIVER BIOLOGY ASSESSMENTS	Large River		X			Short/Long
MONITORING TO INFORM NITROGEN/NITRATE/DIN SW CRITERIA	Nutrients		X	X		Short/Long
P BUDGETS, LEGACY P AND SEDIMENTS	Nutrients	X	X	X	X	Long
ALUM TREATMENT MONITORING SOP FOR ADAPTIVE MANAGEMENT	Nutrients			X		Short
NEW RESPONSE INDICATORS TO MEASURE EUTROPHICATION	Nutrients		X	X	X	Long
DATA TO SUPPORT RESTORATION PLANNING & TRACK PROGRESS	TMDL/Restoration		X	X	X	Current/Long
TMDL MONITORING/EPA EXPECTATIONS & PACE	TMDL/Restoration	X	X	X		Short
MONTHLY/QUARTERLY MONITORING FOR TRENDS/TMDL	TMDL/Restoration		X	X		Long
TMDL TARGETS FOR BIOLOGY	TMDL/Restoration		X	X		Short
LEVEL OF EFFORT TO MEASURE WQ IMPROVEMENT	TMDL/Restoration		X	X		Long
PROCESS FOR MONITORING 9KE/RESTORATIONS	TMDL/Restoration		X			Long
TRACK LAND USE TO DETERMINE IF WQ IMPROVEMENTS ARE LIKELY	TMDL/Restoration		X	X		Long
SOCIAL SCIENCE TO IMPROVE CITIZEN ENGAGEMENT	TMDL/Restoration		X	X	X	Long
LAKE-WIDE MACROPHYTE RESTORATION STRATEGY	TMDL/Restoration			X	X	Long
COASTAL WETLANDS FOR PROTECTION AND RESTORATION	TMDL/Restoration			X	X	Short
WETLAND PROTECTION AND RESTORATION HELP WATER QUALITY	TMDL/Restoration	X	X	X	X	Long
LONG TERM RESTORATION MONITORING	TMDL/Restoration		X	X	X	Long
CAN WE TRACK TRENDS WITH BIOLOGY	Tools		X	X	X	Short/Long
SEDIMENT AND PHOSPHORUS FINGERPRINTING	Tools					Long
ID STRESSORS CAUSING BIOLOGICAL IMPAIRMENTS	Tools		X	X	X	Long
MONITOR SHALLOW LAKES, INCLUDING WILD RICE COMMUNITIES	Tools			X		Long
TRAINING & JOB SHADOWING	Training	X	X	X	X	Long
CRITICAL HABITAT DESIGNATION	Policy		X	X		Long
ANTI-DEGRADATION MONITORING	Policy		X	X	X	Long
REVISE ALLOCATION OF MONITORING RESOURCES	Policy		X	X	X	Current

Appendix B

Table indicating which parameters are commonly sampled and if these parameters are used in impaired waters assessments. **(Green** (In WisCALM), **Yellow** (prioritized future WisCALM update), **Blue** (additional contextual data)). "X" indicates fully meets WisCALM data requirements, and "P" means that the program partially meets data requirements or that the program may collect the parameter but does not always do so. Waterbodies with insufficient data (i.e. "P") are flagged and prioritized for additional monitoring by other Directed Lakes and Targeted Watersheds.

	Total Phosphorus	Total Nitrogen	Chlorophyll *a*	Secchi Depth	Chlorides	TSS	Continuous DO	Cont. Temperature	Dissolved Oxygen	Temperature	pH	Qualitative Habitat	Quantitative Habitat	Macroinvertebrates	Fish Community	Mussel Surveys	Diatoms	Aquatic Plants	Aquatic Invasive Spp	Flow Monitoring	E. coli	Zooplankton
Rivers																						
Long Term Trend River Water Quality Monitoring Network	X		X		P	P		X	P		X										X	
Large River Biological Monitoring														P	P							
TMDL Development Monitoring	P					P																
National Rivers and Streams Assessment – Probabilistic Study	P		P		P	P					P										P	
Streams																						
Wadeable Trend Reference Streams	P		P			P	P	X	P		P		X	X	X		X					
Natural Community Stratified Random Monitoring Program	Replaced by NRSA																					
Targeted Watershed Approach – Streams	X		P			P	P	X	P		P		P	P	P		X					
Water Action Volunteers - Stream Monitoring	X				X			X														
Stream Temperature Monitoring Network								X														
Lakes																						
Probabilistic Survey (National Lakes Assessment)	P		P	P					P	P	P	P		X								
Long Term Trend Lakes (LTT Lakes)	X		X	X					X	P	X	X						P				
Aquatic Plant Reference Lakes				X														X				
Citizen Lake Monitoring Network^	X		X	X					X	P												
Satellite Monitoring - Secchi~				X																		
Directed Lake Surveys (and follow-up monitoring)	X		X	X					P	P	P	X						X				
Wetlands																						
Floristic Quality Assessment (FQA) Monitoring																						
Watershed Approach Wetland Functional Assessment (WAWFA)																						

Appendix C

Evaluation of Monitoring Strategy and USEPA 10 Key Elements

USEPA 10 Elements of a State Water Monitoring Program

1. Monitoring Program Strategy
2. Monitoring Objectives
3. Monitoring Design
4. Core Indicators of Water Quality
5. Quality Assurance
6. Data Management
7. Data Analysis/Assessment
8. Reporting
9. Programmatic Evaluation
10. General Support and Infrastructure

First Element: Monitoring Strategy

Self-Assessment:

Wisconsin's vision is that water quality is comprehensively measured to protect beneficial uses and that protection and restoration efforts are adequately evaluated. This requires a comprehensive strategy to meet the water quality management needs of the state waters including streams, rivers, lakes, reservoirs, Great Lakes shorelines, groundwater, and wetlands.

The monitoring strategy outlines a framework that can be extended to a long-term plan with a 5 to 10-year schedule for complete implementation. The strategy covers monitoring objectives, study design, water quality indicators, quality assurance, data management, data analysis/assessment, reporting, programmatic evaluation and general support.

Second Element: Monitoring Objectives

Self-Assessment:

Wisconsin's Water Monitoring Team has identified a set of monitoring objectives based on the range of regulatory responsibilities and water quality programs with special emphasis on trend monitoring, impaired waters assessment, TMDL development and supporting partner management plans (USEPA 9KE plans, NRCS NWQI, lake management plans). In 2008, the Water Division Monitoring Team (a precursor to the Water Resources Monitoring Team) identified monitoring objectives critical to the design of a monitoring program that is efficient and effective in generating data that serve management decision needs. Improvements could be made in documenting when, where and the level of effort which DNR supports partners with providing monitoring data and other technical expertise.

Monitoring objectives include:

- Establishing, reviewing and revising water quality standards,
- Determining water quality standards attainment,
- Determining water quality status and trends,
- Identifying impaired waters,
- Identifying causes and sources of water quality problems,
- Implementing water quality management programs, and
- Evaluating program effectiveness.

Third Element: Monitoring Design

Wisconsin's strategy reflects media-specific variable designs to maximize the state's ability to meet monitoring objectives with existing resources. The primary design frameworks utilized include:

- Statewide status and trends data collection through long-term trend and reference-site based networks;
- Random stratified sample designs by participating in USPEA NARS for all media types;
- Prescriptive monitoring designs (targeted watershed assessments, directed lakes, runoff management/319 studies, and local monitoring needs);
- Monitoring to initiate TMDL model development.
- Watershed condition monitoring to support integrated reporting and watershed planning.
- Site-specific monitoring to identify and characterize water quality problems;
- Evaluation monitoring to determine the effectiveness of best management practices or restoration progress outlined in resource recovery initiatives.

Wisconsin DNR monitoring is designed to be able to answer the US EPA's five questions a state monitoring program should be able to answer

- What is the overall quality of waters in the State?
- To what extent is water quality changing over time?
- What are the problem areas and areas needing protection?
- What level of protection is needed?
- How effective are clean water projects and programs?

These key study designs are supplemented by data gathering from lake and stream monitoring volunteers, whose data efforts have grown and evolved into gap filling and key assessment data collection work. The monitoring program could be improved by including more prescriptive monitoring measure for stressor identification and improved monitoring and assessment for wetlands and nearshore coastal areas.

Fourth Element: Water Quality Indicators

Wisconsin has a variety of aquatic condition indicators used in various program areas. This strategy inventories what indicators are fully functional and which indicators need more research, development and implementation. Over the course of the previous strategy the monitoring and standards and assessment programs adopted new indicators for assessing aquatic macrophytes, benthic diatoms and suspended chlorophyll *a* to protect recreation uses.

Our vision is to develop a complete set of monitoring indicators and assessment tools with clearly articulated thresholds (measurable standards that we must meet or exceed) to track the status and trends of water quality and to evaluate the effectiveness of management actions to improve water quality in the state. These indicators must be site specific yet reflective of a population of resources geographically and/or categorically.

The Water Quality Program uses water quality standards impaired waters assessments conducted for the biennial Water Quality Report to Congress ("Integrated Reporting for Sections 305b/303d") to

provide statewide summaries of overall condition. Refinements or creation of key indicators within each of these designated use assessments could be developed and advanced on a more fine-scale basis for condition assessments for water type statewide, regionally, and at a local level.

Fifth Element: Quality Assurance

Quality assurance covers a broad range of activities from the inception of the study design to the final report write up and publication. The following key areas cover quality assurance aspects throughout the life cycle of study proposal through data sharing and data delivery.

A number of quality assurance elements are in place in Wisconsin's Monitoring Program. However, several enhancements can be incorporated into ongoing activities to improve the value of monitoring data for long-term DNR and data sharing with other agencies and partners. Quality assurance is covered in greater detail in the body in the document and in the appendix. The monitoring program received a grant from US EPA to update monitoring procedures and accessibility. The program developed and internal webpage called the "WR Handbook" that stores monitoring SOPs, baseline monitoring project designs and technical reports commonly used by DNR staff. The monitoring program has also developed a 2-day spring training program for all field staff for hands-on training refreshers for current methods and introduction to methods/procedures. Field-based quality assurance could be improved by institutionalizing regular training and auditing of field staff conducting monitoring, especially for field-based taxonomic identification (e.g. macrophyte, wetland flora and fish assessments).

Quality assurance project plans (for large studies) or quality assurance checklist (to be developed) could be submitted with project proposals as a prerequisite for funding. The quality assurance program plan may solicit input from partner groups including other state programs, non-profit environmental organizations, and USEPA Region V. The quality assurance program plan should be flexible and well documented and in place for the Surface Water Integrated Monitoring Program (SWIMS), the Fish Management Data base (FMDB), and other relevant database systems.

Sixth Element: Data Management

DNR's vision is to make credible ambient monitoring data available to all customers, stakeholders, and partners in a timely manner. Multiple databases support the state's monitoring and assessment work including:

- Fish Management Database
- Fish Contaminants Database → *SWIMS*
- Bio monitoring Toxicity Laboratory Data → SWIMS
- Sediment chemistry → SWIMS
- Microbiology →SWIMS
- Habitat/biological data → Fish and SWIMS
- Aquatic Invasives→ SWIMS

→ Water Quality Exchange → **USEPA STORET**

All tables in systems that hold monitoring data should have appropriate metadata (consistent with recommendations of the National Water Quality Monitoring Council) and geo-locational standards. DNR oracle systems conduct "journaling" to provide greater auditing functionality; enhanced security for backend users of database tools; and more frequent backups to restore data in the case of catastrophic data loss. Specific emphasis on communication between data systems has been enhanced over the years, due to mutual dependencies surrounding shared datasets.

Surface Water Integrated Monitoring System

The Wisconsin DNR stores its ambient water quality data in its Surface Water Integrated Monitoring System (SWIMS), a project based, comprehensive data system which holds chemical, physical, habitat water and sediment chemistry, and aquatic invasive and macroinvertebrate data (and more). Detailed documentation of the SWIMS system is available upon request. The SWIMS Team has several ongoing sub team initiatives to enhance the quality and completeness of this work including:

- Outreach, help guidance and support team.
- Data integrity and quality assurance.
- System enhancement technical design sub team.
- Short-term user interface improvement team to help with ease of system use.
- Long-term vision team to modernize and enhance system accessibility including mobile options, tablet forms, infield data entry, topical search and display and more.

Water Assessment Tracking and Electronic Reporting System

The Water Assessment Tracking and Electronic Reporting System (WATERS) stores water quality standards, trout classifications, O/ERW designations, and assessment information for Clean Water Act Section 305(b) reports and 303(d) reporting. Additional fields include narratives regarding basin, watershed and waterbody narratives, priorities and goals for management, and recommendations for management actions. The (GIS) Geospatial data for stations and for assessment units is stored in Wisconsin's GIS Spatial Database Engine "SDE" environment. The SDE environment includes sufficient descriptive metadata for the data to be shared and compared among managers and the public.

Fish Management Database

The Fisheries Management Database holds a variety of fish, habitat and physical data relating to fisheries surveys. The database is hosted by USGS and is interconnected with the SWIMS system through sharing stations, fish kill locations, and fish stocking sites. The fish program creates parameter calculations that are critical for Clean Water Act reporting and serves those data up through a query tool.

Seventh Element: Data Analysis/Assessment

Wisconsin DNR's goal is to provide a consistent defensible framework for the evaluation of monitoring data relative to state and regional standards, the protection of water quality standards and beneficial uses, and for tracking the effectiveness of management actions. Water Quality Biologists and central office professional staff are responsible for preparation of technical reports that summarize the findings of watershed assessments and special studies. The Water Management structure transmits these reports

to the USEPA for certification as part of the state's Areawide Water Quality Management Plan after a required public review and comment period. The Water Monitoring Section staff is responsible for technical reports that summarize the findings of statewide assessments.

This information is used in the preparation of Wisconsin Water Quality Report to Congress through the "Integrated Reporting Process" under the Clean Water Act Section 305(b) reports and 303(d) listings. The Water Quality Bureau biennially publishes updates to its Wisconsin Consolidated Assessment and Listing Methodology (WisCALM) which may change to reflect new scientific findings or other changes required by state resources or USEPA. WisCALM outlines how to assess attainment of water quality standards based on analysis of various types of data (chemical, physical and biological) from various sources, for all state waters. The Water Evaluation Section through WisCALM establishes listing and delisting criteria for the Section 303(d) list of Impaired Waters. The WES Section also contains criteria to assist in establishing priorities for developing total maximum daily loads, guidelines for acceptability of data, and other measures necessary to facilitate the completion of total maximum daily loads.

Eighth Element: Reporting

Wisconsin's vision is to provide all collected data in a usable format, and in a timely and publicly accessible manner. A variety of reports are used to convey the results of Wisconsin's work by the Water Monitoring, Evaluation, and Implementation Program projects.

Most reports are available to the public in electronic format online. The types of reports include fact sheets, monitoring study summary reports, data downloads and reports, quality assurance reports, interpretative reports, and the 305(b)/303(d) Integrated Report.
https://dnr.wisconsin.gov/topic/SurfaceWater/Congress.html

These reports provide analyses and interpretation of the data collected. The technical reports have written descriptions of the study design, methods used, graphical, statistical, and textual descriptions of the data, and interpretation of the data including comparisons to relevant water quality goals. These reports are available to all interested parties through the DNR's website "Explore Wisconsin's Water" at http://dnr.wi.gov/water/

The state has worked to produce timely, complete, and technically valid water quality reports and lists called for under the Clean Water Act Sections 305(b) and 303(d). The current emphasis on updating the state's strategic monitoring plan. The Water Quality program provides multiple avenues for public participation with WisCALM and Triennial Standards Reviews public comment periods. The state also submits monthly data submittals through the Water Quality Exchange Network to STORET in support of the federal Clean Water Act 106 grant. The monthly transfer of monitoring data to the national STORET database via the Wisconsin Environmental Data Exchange Network satisfies this requirement.

Ninth Element: Programmatic Evaluation

Wisconsin intends to conduct periodic reviews of each aspect of the monitoring program to evaluate its scientific validity, whether the program is being implemented as designed, and how well the program serves water resources decision needs of the state. This update to the Monitoring Strategy was planned after 5-years as the previous strategy was a major change for the

program. This strategy update is nearly 7 years since the adoption of the previous strategy which puts the program behind schedule.

Study Design Documentation – Protocols, Methods, Procedures

A major element of Monitoring Strategy implementation work will involve completion of an ongoing inventory and strategic gap analysis of monitoring protocols, methods and procedures. The monitoring program plans to address gaps identified in this report through applying for US EPA Monitoring Initiative grants, seeking additional funding and positions from the State of Wisconsin and periodically reviewing the current structure and allocation of resources.

Tenth Element: General Support and Infrastructure

Wisconsin's vision is to provide funding and support needed to implement a coordinated and comprehensive monitoring and assessment program conducted by citizens, state staff, stakeholders, and federal and state agency partners. Wisconsin receives a mix of federal and state funding that is used for monitoring and analysis work. This annual allocation covers everything from lab analysis for chemical, biological, toxicological data to data interpretation and research of satellite data to funding USGS gage stations, LTE support, equipment, supplies and travel.

The following items are listed as monitoring program needs based on the lack of a reliable or stable funding source or have been listed due to historical budget reductions. These items are not listed in priority order.

Mississippi River CWA Collaborative Interstate

This initiative is a one-time pilot-project to implement portions of the UMR CWA monitoring strategy and would be coordinated with similar efforts proposed by the Minnesota Pollution Control Agency. This proposal builds on existing Mississippi River budget allocations and is tiered to allow flexibility in allocation of budget resources.

Citizen-based Water Quality Monitoring Data

Provide stable funding and support for volunteer water monitoring to ensure that the data being collected are useful for Department decision-making. This work is currently supported by LTE employees through the EPA Monitoring Initiative funding.

Water Resources Monitoring Technicians

- This request would create 4 new technician level positions to conduct baseline and targeted monitoring of lakes, wetlands, streams, and rivers throughout the state.
- Having dedicated permanent staff to develop expertise and capacity to conduct monitoring activities where needed will provide efficiency, consistency and quality assurance, free up time for biologists to be project managers, and reduce the need for LTE retraining. This funding would supplement or replace current spending on LTEs.

Support for Water Quantity Information

- Support existing contracts with USGS, UW Extension volunteer monitoring programs to increase the capacity for lake and wetland water level and stream flow monitoring and identify and upload historical data.
- This funding would build capacity for water quantity information required under the Great Lakes Compact and to assist with water withdrawal permitting decisions - water levels, stream flows and springs)

Water Information Systems enhancements

- Fund programming support to implement needed integration and upgrades to core water information systems used for federal and state reporting, permit decisions, and condition information (SWIMS, WATERS, SWDV)
- Supplemental to existing funding (WWI) which has been static and not keeping up with increased demands.