Chapter 8. Water Quality Monitoring

8.1 EPA and Gulf Hypoxia Task Force Expectations

EPA Expectations for water quality monitoring are an implied component of all 8 elements in the Nutrient Reduction Framework, the Gulf Hypoxia essential elements, and related programs. Monitoring data are critical for targeting and prioritizing watersheds (Element 1), supporting determination of load reductions (Element 2), determining the effectiveness of permit programs (Element 3), understanding nutrient concentrations in agricultural areas (Element 4), documenting conditions in urbanized areas and from septic systems (Element 5), accountability and verification of efforts (Element 6), reporting (Element 7), and establishing numeric criteria for nutrients (Element 8). Other EPA programs, such the Section 319 Program for addressing nonpoint source pollution, also emphasize water quality monitoring of implementation projects. Simply stated, EPA expects Wisconsin to have an effective monitoring program as well as the capability to determine trends and implement a Nutrient Reduction Strategy.

8.2 Wisconsin's Approach – Surface Water

Extensive water quality monitoring has occurred in Wisconsin for decades. DNR is the lead state agency for surface water quality monitoring but other state agencies, including DATCP, the Department of Health Services (DHS) and the University of Wisconsin System also conduct monitoring activities. In addition federal agencies, including USGS and NRCS, counties through their Land & Water Conservation Departments or health departments), non-profit organizations, volunteers, and many other local partners conduct monitoring activities. Each agency and organization conducts monitoring designed to meet specific programmatic needs, resulting in a tremendous body of information about the status of Wisconsin's waters. A partial listing of programs is included in Table 8.1.

8.2.1 Coordination of water monitoring efforts

Wisconsin's multiple water quality monitoring efforts recognize the importance of effective monitoring to (1) calculate nutrient loads from major basins, (2) identify those basins with highest contributions (mass and yield), (3) determine trends, and (4) document progress. The workgroup assembled to address monitoring needs associated with the Nutrient Reduction Strategy identified opportunities for improving coordination and data management among Wisconsin's multiple monitoring efforts to support the strategy. Several key monitoring programs are discussed below.

8.2.2 Key Monitoring Program Components

DNR Long-Term Trend (LTT) River Monitoring

Wisconsin's Long Term Trend (LTT) River water quality monitoring network is maintained by DNR. The LTT River network consists of 42 sites, with a minimum of one site per major river basin, generally located near the mouth of each river, most often at a site of a USGS gaging station.[17] The sites are identified in Figure 8.1. Selection of the 42 trend monitoring sites considered different land coverage in the state varying from urban areas in the southeast, heavy agricultural use in central and southwest, and forest cover dominating the north. Just over half the sites (24) are sampled monthly and other sites quarterly. Monthly sites are generally located near the mouth of major rivers, whereas quarterly sites are often located at additional locations some distance above. DNR collaborates with other agencies that provide water quality measurements for some sites on the Mississippi River (e.g., Lock and Dams (LD) 3 and 4). Water quality samples are analyzed for nutrients, solids, specific conductance, pH, hardness, alkalinity, bacteria, and chlorophyll. Biannually they are analyzed for triazine herbicides during winter and summer. All analyses follow approved U.S. EPA methods.

Information from long-term trends sites has been used to calculate annual loads to the Great Lakes as part of EPA's reporting to the International Joint Commission. LTT River data have also contributed to background information for biennial Integrated Reports ("305b" Reports to US Congress), Wisconsin phosphorus rules, and development of current trends analysis (Robertson and Diebel, in preparation). Many LTT River sites are proposed to be included in a tributary load monitoring network for the Mississippi River. Information from these sites has also been used to calculate nutrient trends briefly described in Chapter 2.

DNR Watershed Rotation Water Quality Monitoring

The Watershed Rotation Water Quality Monitoring activity was initiated in 2006 to collect water chemistry information at the downstream location, "pour point," of each of 333 DNR watersheds (approximately HUC 10 size). If the watershed had multiple pour points, the largest stream was monitored. Water chemistry sampling was conducted at a monthly interval (e.g., every second Wednesday of the month) to avoid weather related bias. Field parameters included temperature, dissolved oxygen, pH and turbidity (using a transparency tube). Lab parameters include total phosphorus, ammonia-N, total Kjeldahl-N, nitrite-nitrate-N and suspended solids. This monitoring ended in September 2011. This information has been used in the targeting and priority setting analysis described in Chapter 1.

DNR TMDL Development

TMDL development across the state has resulted in an increased level of monitoring to help determine pollutant load reductions necessary to meet water quality criteria. The monitoring associated with each TMDL varies widely and depends on the pollutant(s) of concern, the existing monitoring data, the geographic scale of the TMDL, and other factors. Often, DNR leads the monitoring efforts associated with TMDL development but a number of other entities contribute

[17] from "Wisconsin's Long Term Trend Water Quality Monitoring Program for Rivers: July 2001-June 2005." Prepared by the DNR Bureau of Watershed Management River Long Term Trends Work Group. November 2006.

effort. County Land & Water Conservation Departments, USGS, wastewater treatment facilities, local citizen groups, and others have contributed to DNR or third party TMDL development efforts.

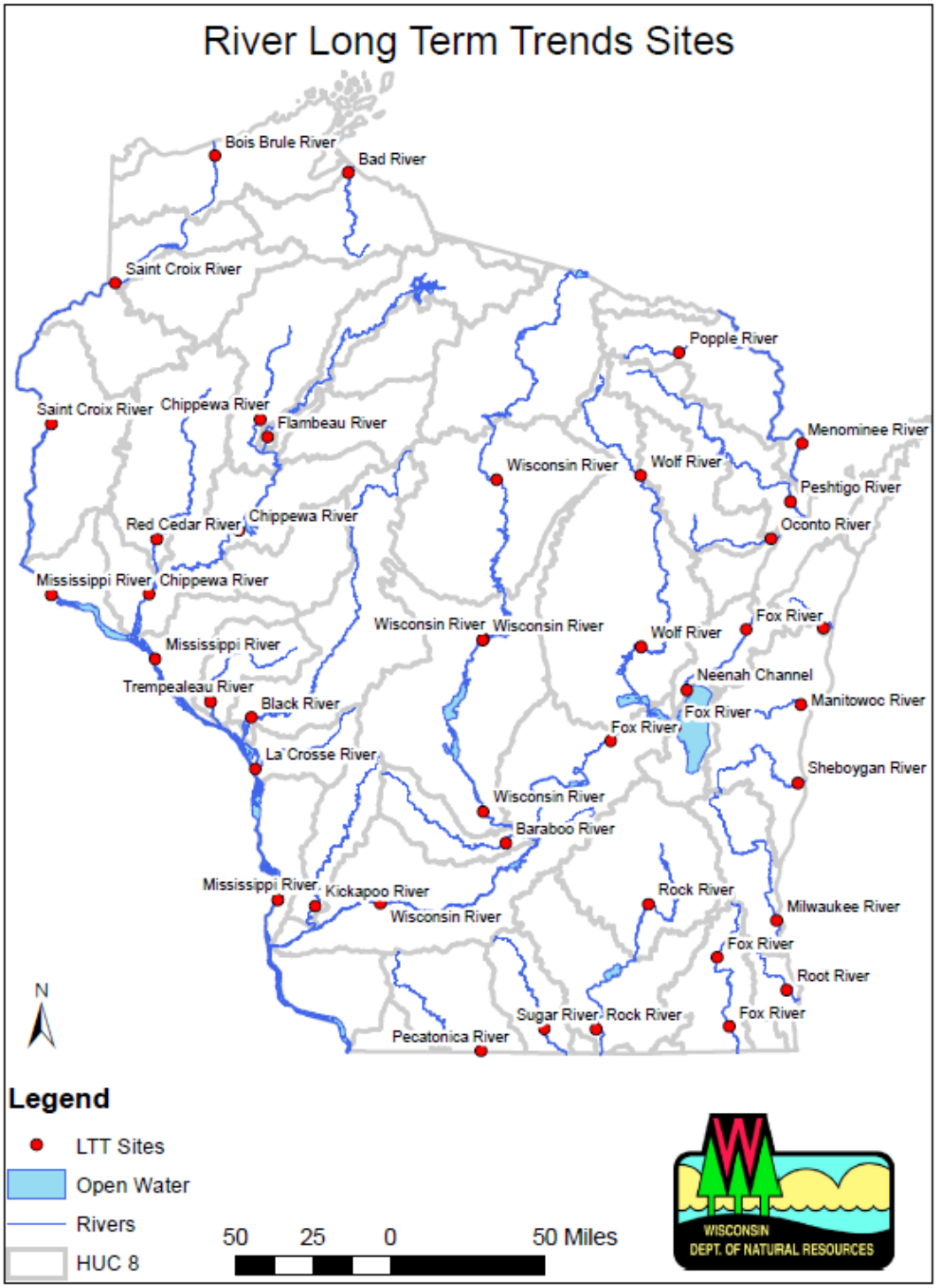

Figure 8.1 Wisconsin's River Long-Term Trend Monitoring Sites

USGS Flow Gaging and Water Quality Monitoring

The USGS is active in water quality monitoring and research across Wisconsin. USGS maintains a large network of flow gaging stations, including many long-term sites across the state that provide information used in a number of water quality programs, such as for calculating nutrient loads and point source permit effluent limits. Additional water quality monitoring sites are maintained through partnerships with DNR and others as part of various studies. These partnerships take advantage of USGS's equipment, expertise, and historical involvement in Wisconsin.

NRCS Monitoring

NRCS in collaboration with USGS, has organized monitoring efforts primarily through the Mississippi River Basin Initiative (MRBI). This three-tiered approach supports efforts to reduce nutrient loading from fields to waterways. The three tiers include edge-of-field monitoring, small watershed monitoring, and large watershed monitoring. These three tiers are intended to examine the impact field-level nutrient reduction practices have on loadings to adjacent waterways while also examining in-stream water quality at a number of scales. NRCS does not conduct monitoring itself but works with multiple partners to provide that service.

Multi-Partner Monitoring

A number of additional monitoring efforts that are collaborative between multiple agency and organizational partners generate substantial water quality data for Wisconsin. Two projects focus on the water quality trading and watershed adaptive management options for meeting nutrient standards (see chapter 5 of this document). Municipal wastewater treatment facilities often partner with county Land & Water Conservation Departments to conduct the monitoring for these projects. County Land & Water Conservation Departments also frequently partner with agencies for other water quality monitoring efforts, including for TMDL development. Permitted wastewater discharge facilities (municipal and industrial) individually collect water quality data, and as a group, they provide data for selected urban areas of the state. Another set of monitoring efforts that collectively provide water quality data for the state is the volunteer monitoring program guided by DNR and UW-Extension. Volunteers are trained in techniques to ensure that the data they collect adheres to agency standards and is pertinent to statewide monitoring goals. Volunteer monitoring is often conducted by non-profit groups and individuals. An additional outcome of volunteer monitoring programs is increased awareness of water quality issues statewide.

Table 8.1 Select water quality monitoring programs in Wisconsin

Monitoring Program	Water Quality Management Needs				
	Determine status/ impaired	Calculate Nutrient Loads	Identify High Yield Watersheds	Determine Trends	Document Progress
DNR					
River Long Term Trend		X	X	X	X
Great Lakes Tributary Nutrient Monitoring (LTT)		X		X	X
Mississippi River Basin Nutrient Analysis (proposed)		X		X	X
Watershed Rotation Water Quality			X	X	
TMDLs		X	X		
Impaired Waters Evaluation	X				X
Lake Long Term Trend		X	X	X	X
Lake Michigan Cladophora/Nutrient Study	X				X
NRCS					
Three-Tier Monitoring	X				X
USGS					
Rural Water Quality Research Studies		X			
Stream flow (gauge) sites		X		X	X
Cooperative Water Quality Studies	X	X	X		X
Metropolitan Sewerage Districts					
Green Bay Ambient Water Quality Monitoring		X		X	X
Milwaukee Water Quality Monitoring		X		X	X
Multi-Partner					
Adaptive Management		X			X
Water Quality Trading		X			X
Upper Mississippi River Long Term Resource Monitoring Program	X	X			X
Volunteer Lake and Stream Monitoring	X		X	X	X
Municipal/Industrial Discharge Monitoring		X			X
Other County monitoring					

8.3 Wisconsin's Approach – Groundwater and Drinking Water

Groundwater monitoring in Wisconsin occurs primarily through public water system testing associated with federal Safe Drinking Water Act (SDWA) requirements, private well testing for drinking water quality by individual homeowners, and formal monitoring programs conducted by DNR, DATCP, GNHS and USGS. The University of Wisconsin Stevens Point also maintains an extensive statewide database with water quality results from private wells and winter stream base-flow monitoring. The information collected from these efforts is used for various public health and environmental management purposes. Although groundwater monitoring programs frequently include nitrogen, phosphorus, due to the absence of human health concerns and low mobility in groundwater is rarely included.

None of the above programs is focused on characterizing statewide groundwater with respect to nutrients or other contaminants. Compared to surface water monitoring, groundwater monitoring is more difficult due to the expense of constructing wells and considerations of contaminant transport, travel times, depth, and aquifer type. Because of the expense and these considerations there is no ambient groundwater quality network in Wisconsin.

8.3.1 Coordination of water monitoring efforts

In 1983 the Wisconsin Groundwater Coordinating Council (GCC) was created to serve as a means of increasing the efficiency and facilitating the effective functioning of state agencies in activities related to groundwater management. The GCC is composed of representatives from six state agencies, the State Geologist and Governor's representative and advises and assists state agencies in the coordination of nonregulatory programs and the exchange of information related to groundwater.

One of the GCC's main concerns has been groundwater monitoring and research activities and through their efforts groundwater monitoring has improved due to increased communication and eliminated duplication of effort. The GCC has coordinated the Joint Solicitation for proposals to Wisconsin's Groundwater Research and Monitoring Program Since 1991 The DNR, UWS, DATCP, and Commerce have funded over 400 groundwater monitoring and research projects.

The GCC prepares a report each year that, among other thing, summarizes the condition of the groundwater resource. Nitrate, being a leading threat to groundwater, is discussed at length in the report at: http://dnr.wi.gov/topic/groundwater/documents/GCC/GwQuality/Nitrate.pdf

8.3.2 Key Monitoring Program Components

Wisconsin's multiple groundwater quality monitoring efforts recognize the importance effective monitoring to characterize the quality of the resource, respond to groundwater quality problems, and assess the effectiveness of management efforts.

DNR Public Water System Monitoring

The DNR's Bureau of Drinking Water and Groundwater implements and enforces the requirements of the Safe Drinking Water Act in Wisconsin. There are approximately 11,500 public water systems in the state and each must monitor the quality of the water it provides. These systems monitor for nitrate-nitrogen at least annually.

An example of recent use of public water supply data for resource monitoring purposes is DNR's "Wisconsin Safer Drinking Water Nitrate Initiative. The initiative is targeted at reducing nitrate levels in groundwater by making the most efficient use of nitrogen in agricultural production. Activities in project areas include measuring all current nitrogen inputs and baseline groundwater nitrate levels, calculate agricultural input and production costs, determine and implement best nitrogen management practices that optimize groundwater conditions and agricultural production efficiency, and measure whether predicted results are achieved. Target areas were selected by reviewing statewide at non-community public well data (see Figure 8.2). Project areas have been selected in Rock and Sauk Counties within subwatersheds with large numbers of public drinking water systems approaching unsafe levels of nitrate contamination. DNR is currently working with stakeholders to determine an optimal nitrogen management system. In the next phase of the project the nitrogen management system will be applied in one of the project areas. Monitoring of nitrogen inputs, groundwater nitrate levels, production costs will continue and costs of nitrogen management will be compared to water treatment costs.

Private Drinking Water Supply Well Monitoring

Regulations do not require that private water well be sampled for nitrate. However many well owners do have their well tested because of concerns about contamination. DNR, DATCP and UW-SP track this data where available. Since sampling is done for only a minority of wells the data is difficult to use to characterize the resource. However, DATCP has conducted 4 statewide surveys (1994, 1996, 2001 and 2007) using a stratified random sampling procedure that were used to represent groundwater accessible by private wells. The 2007 survey (http://datcp.wi.gov/uploads/Environment/pdf/ARMPub180.pdf) estimated that the proportion of wells that exceeded the 10 mg/l enforcement standard for nitrate-nitrogen was 9.0%. The UW-SP maintains a private well sampling program and a statewide database of private well water quality. The data is accessible through their Groundwater Quality Viewer (http://gissrv2.uwsp.edu/cnr/gwc/pw_web/) map viewer which displays groundwater quality information from private wells around the state.

Contaminated Site Monitoring

DNR, DATCP and DSPS monitor sites of groundwater and soil contamination for the purpose of implementing the groundwater standards contained in ch. NR 140, Wis. Adm. Code. Monitoring occurs at sites associated with: spills, hazardous substance release sites, abandoned containers, drycleaners, brownfields, leaking underground storage tanks, closed wastewater and solid waste facilities, hazardous waste corrective action and generator closures, and sediment cleanup actions, proposed, active, and inactive solid waste facilities and landfills, municipal and industrial wastewater discharges, by-product solids and sludge disposal from wastewater treatment systems, and wastewater land treatment/disposal systems. Many of these sites are monitored for nitrate and/or ammonia concentrations but the data is somewhat difficult to access.

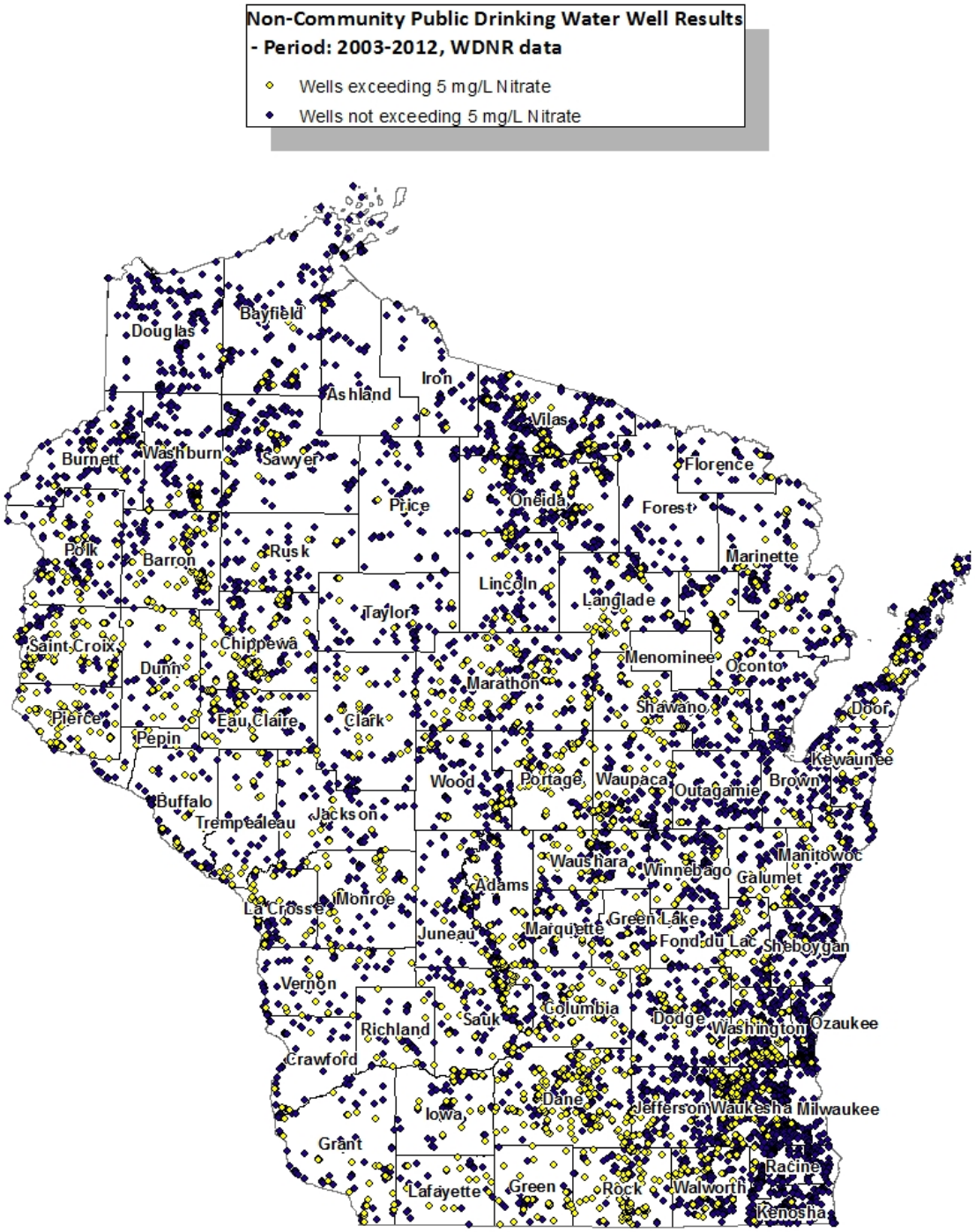

Figure 8.2 Non-community public wells with raw water samples exceeding 5 mg/L Data source: DNR Drinking Water System, 2013.

Groundwater Management Practice Monitoring Projects

DNR, UWS, DATCP and DSPS/Commerce/DILHR have funded over 400 Groundwater Research and Monitoring projects since 1983. Many of these projects have contributed to the understanding of nitrogen occurrence in Wisconsin's groundwater. A list of projects is here: http://dnr.wi.gov/topic/groundwater/documents/GCC/MonitoringResearch/AllProjects.pdf. A partial listing of groundwater monitoring programs is included in Table 8.2.

Table 8.2 Selected groundwater and drinking water quality monitoring programs

Monitoring Program	Objective	Agency	Identify High Yield Watersheds	Determine Trends	Document Progress
Public water system monitoring	Determine Compliance - SDWA requirements	DNR – DG	No	Yes	Yes
Private well monitoring	Determine compliance - bacteria	DNR-DG	Possibly	Possibly	In limited cases
Private well monitoring	Determine compliance – pesticides and nitrate	DATCP	Possibly	Possibly	In limited cases
Private well monitoring	Homeowner information	UW-SP	Possibly	Possibly	In limited cases
Landfill	Determine compliance – groundwater standards	DNR – WMM	Possibly	Yes	Yes
Contaminated and cleaned-up sites	Determine compliance – groundwater standards	DNR-RR	Possibly	Yes	Yes
Wastewater discharges, by-product solids, and sludge disposal	Determine compliance – Groundwater standards	DNR-WQ	Possibly	Yes	Yes
County monitoring	Various	Some Counties	Various	Various	Various
Management Practice Monitoring and Research	Evaluate effectiveness of management practices and various other	DNR, UWS, DATCP, USGS, WGNHS and others	Possibly	Possibly	Possibly

8.4 Future Directions for Monitoring Improvement

The multiple agency partners involved in developing this Nutrient Reduction Strategy are exploring opportunities to ensure that existing monitoring efforts are coordinated into an expanded framework for water quality monitoring. The workgroup determined that an improved state monitoring framework could enhance communication and coordination among monitoring entities, guide future monitoring efforts, and continue to meet the specific and multiple programmatic needs

for analysis and reporting. The vision for an improved monitoring framework involves coordinating existing efforts through multiple levels. There are three levels of monitoring for surface water and three levels for groundwater.

8.4.1 Surface Water Monitoring

The three levels of surface water quality monitoring coordination are described below. Together, they outline a structure to organize current monitoring efforts occurring across Wisconsin based on their goals, characteristics, and outcomes. The levels will be clarified and further refined as the Monitoring Work Group reviews details of monitoring efforts, such as scale, purpose, and potential for coordination.

Level 1 – A fixed statewide network to describe status and trends

The objective of Level 1 is to characterize nutrient concentrations and loads and quantify long-term nutrient trends from HUC 6 and HUC 8 watersheds. To best achieve this objective a spatially distributed network of fixed stations co-located with flow gaging stations would be operated over a long term. Sites within the Wisconsin network may also be part of multi-state networks for the Great Lakes or Mississippi River Basin. Water chemistry samples should be collected at least on a monthly basis and analyzed for nutrients, and suspended sediment/solids. Flow should be monitored on a continuous basis. The existing DNR River LTT network described above and the Great Lakes Nutrient Load monitoring with their associated USGS flow gaging stations fit into this level. Wisconsin will continue to conduct long-term trend monitoring through DNR LTT River network. Data will be used for trend analysis, the biennial Integrated Report, and more.

Level 2 – A flexible network to identify high nutrient concentration surface waters

The objective of Level 2 is to identify lakes, streams and rivers with high concentrations of nutrients that occur especially during the growing season (May through October). These waters will probably have high nutrient loadings. To best achieve this objective a spatially distributed network of stations corresponding to HUC 10s or HUC 12s is needed. Water chemistry samples for this objective should generally be taken on a monthly basis and analyzed for phosphorus, nitrogen and suspended sediment/solids. Given the size of such a network, continuous flow gaging is not practicable. The DNR Watershed Rotation Water Quality Monitoring activities fit into this level, and preliminary analysis is underway. More detailed monitoring would be needed – possibly in targeted HUC 10s – to best identify implementation projects at the HUC 12 scale. Sites in this network could be sampled on a rotational basis. Self help volunteer monitoring of lakes (for Secchi depth, total phosphorus, and cholorphyll a) and volunteer stream monitoring (for phosphorus) could also fit into this level. Data from Level 2 would also contribute to the biennial Integrated Report and to TMDL development and implementation.

Level 3 – Special projects to quantify surface water process and effects of management practices

Monitoring at this level addresses specific questions to determine cause and effect of implementing specific land use practices. Nutrient loads in surface water in watersheds of varying sizes across the state would be analyzed before and after implementation of the practices. Comparisons would be

made to determine the effects of the practices on nutrient loads. The spatial scale for this level is generally at HUC 12 or smaller, depending on the specific questions being answered. Flow and concentration measurements would be made to support load calculations. Depending on the duration of the effort, this level may support trend identification. The frequency of monitoring and other details would vary by project and often specified in a quality assurance program plan or the program's standard operating procedures. Several existing efforts fit into this level, including NRCS small watershed projects (e.g., East River, Dane Co projects), and UW projects including Pioneer and Discovery Farms, and volunteer monitoring within a specific watershed. An example of an emerging application for this level could be in-stream sampling by POTWs associated with trading or the Watershed Adaptive Management Option.

8.4.2 Groundwater Monitoring

The two levels of groundwater quality monitoring coordination are described below. Together, they outline a structure to organize current monitoring efforts occurring across Wisconsin based on their goals, characteristics, and outcomes. The levels will be clarified and further refined as the Monitoring Work Group reviews details of monitoring efforts, such as scale, purpose, and potential for coordination.

Level 1 – A fixed statewide network to describe status and trends

The goal at this level is to carry out regular monitoring of groundwater across the state to characterize the status and long-term trends of nitrate-nitrogen concentrations in Wisconsin's groundwater. As with surface water monitoring at this level, this would allow for patterns to be analyzed and areas flagged for further study if high concentrations are observed. Ideally, a network of fixed sites that are spatially and geologically distributed and representative of groundwater statewide is needed. These sites would be maintained over the long term and would be monitored semi-annually or annually. The three-dimensional nature of factors that affect groundwater pose challenges to developing a monitoring network at this level. Different geologic formations vary in their susceptibility to contamination and thus well depth and aquifer information are important considerations. A network of this type is currently far beyond the financial resources available.

In 2012-2013 the GCC's Research and Monitoring Subcommittee evaluated options for achieving this goal and arrived at three options: 1) using available private well data; 2) using a statistical approach similar to what DATCP published in 2008 sampling a relatively small number of private wells at strategic locations and settings; and 3) using non-community public water well data as shown in Figure 8-2. Option 1 is a good tool to address issues such as where and when wells have been drilled and abandoned and can add some insight to where nitrate is most prevalent but is fraught with problems related to the disparate nature of the data set. Option 2 is a solid, cost-effective approach but the budget of approximately $100,000 is currently out-of-reach. This leaves Option 3 as the best currently attainable method. The 2008 DATCP report is available here: (http://datcp.wi.gov/uploads/Environment/pdf/ARMPub180.pdf).

Level 2 – Identification of high nitrate concentration in groundwater using existing wells

Monitoring at this level addresses specific questions to determine cause and effect of implementing specific land use practices on water levels and nutrient concentration in groundwater as needed

across the state. Numerous Management Practice Monitoring Projects have monitored specific nitrogen-contributing agricultural or waste disposal practices to evaluate the effect of various geological conditions and management practices on nitrogen loading to groundwater. Another example of this kind of work is DNR's "Wisconsin Safer Drinking Water Nitrate Initiative" which is targeted at reducing nitrate levels in groundwater by making the most efficient use of nitrogen in agricultural production. By focusing on small project areas an optimal nitrogen management system is more likely to be effective.

8.4.3 Moving Forward

Agency partners have already identified many issues to address as part of their discussions exploring the potential for this tiered approach. Issues include identifying additional sites for the Long Term Trends (LTT) monitoring, identifying sampling frequency and methods for sites within various levels, and protocols for reporting and sharing data.

Table 8.3 Potential levels for coordinating water quality monitoring

Level	Spatial Scale	Key Measurements	Duration	Monitoring Goals	Trend Analysis	Monitoring Frequency	Lead Monitors
1 - surface	Approx. HUC 8	Flow and concentrations	Ongoing	Broad	Yes	Monthly	DNR/USGS
2 - surface	Approx. HUC 10 or 12	Concentrations	Periodic (perhaps every 5 years)	Inventory of conditions and for flagging waterways with high concentrations for follow up study.	Possibly, but would be at a coarse scale	Monthly for 12 months	DNR
3 - surface	Various scales, generally HUC 12 or smaller	Flow and Concentration	Variable	Answering specific questions; local interest	Variable, project specific	Variable, project specific	Variable, project specific. Volunteers, others, publically owned wastewater treatment systems
1 - ground	Statewide, stratified by geologic factors and land use	Nitrate concentrations	In develop-ment	Broad - identifying spatial patterns, problem areas	Yes	Annually at minimum	DNR/USGS/ WGNHS/DATCP
2 - ground	Localized	Nitrate concentration	Variable	Answering specific questions	Variable, project specific	Variable, project specific	Variable, project specific