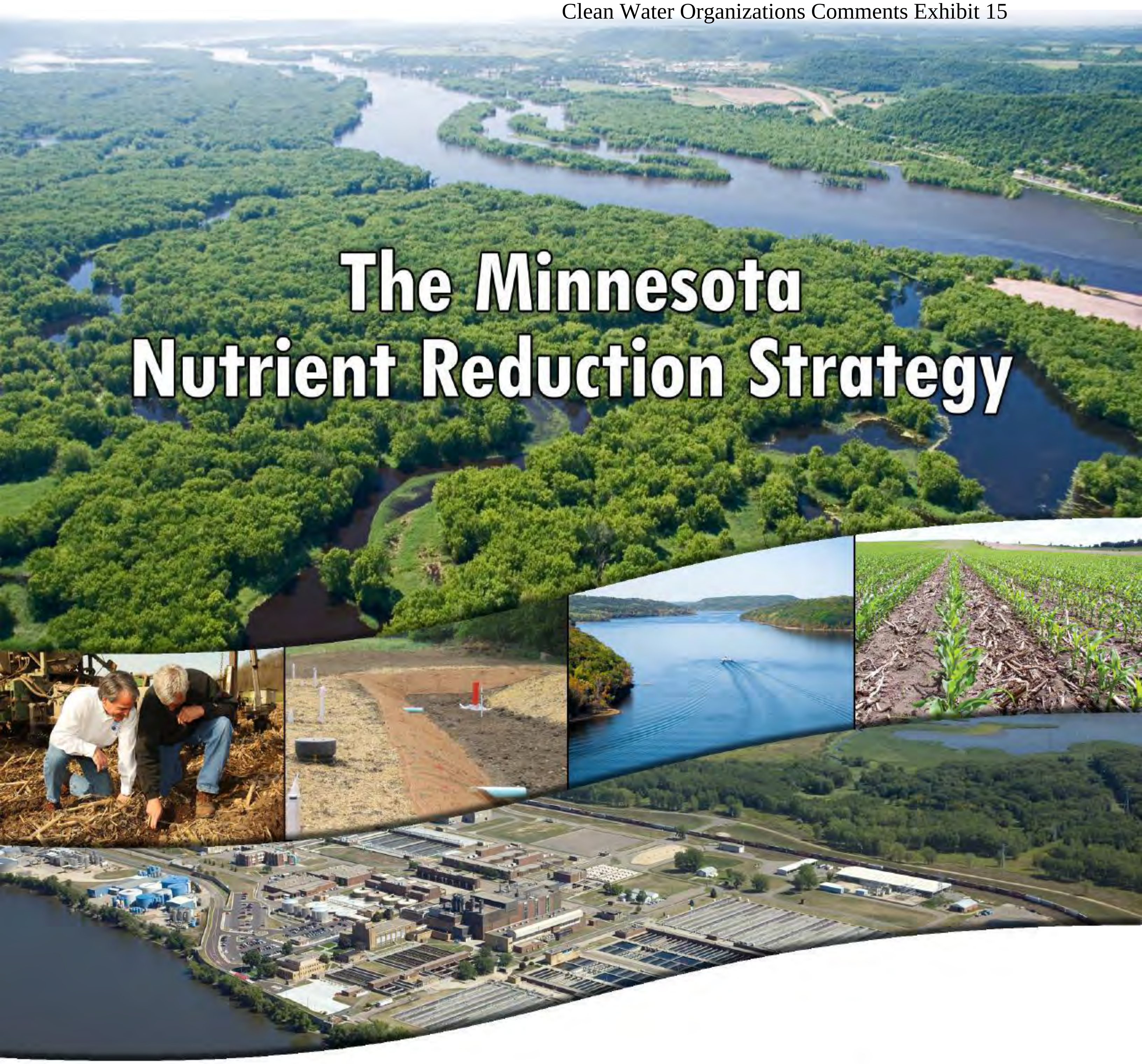
The Minnesota Nutrient Reduction Strategy



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The Minnesota Nutrient Reduction Strategy report was created in cooperation with the following partners:

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Acronyms and Abbreviations

Amendment	Clean Water, Land and Legacy Amendment
BMP	Best Management Practice
BWSR	Board of Water and Soil Resources
CAFO	Concentrated Animal Feeding Operation
CAWT	Commercial Animal Waste Technicians
CDL	Cropland Data Layer
CEAP	Conservation Effects Assessment Project
CGP	Construction General Permit
CHF	Central Hardwood Forest
Chl-a	Chlorophyll-a
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
CSP	Conservation Security Program
CStP	Conservation Stewardship Program
CTI	Compound Topographic Index
CWA	Clean Water Act
CWLA	Clean Water Legacy Act
CWSEC	Manitoba Conservation and Water Stewardship and Environment Canada
DNR	Minnesota Department of Natural Resources
DO	Dissolved Oxygen
EBI	Environmental Benefits Index
ELM	Environmental Learning in Minnesota
EPA	U.S. Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
FANMAP	Farm Nutrient Management Assessment Program
Framework	Minnesota Water Management Framework
FSA	Farm Service Agency
FWMC	Flow Weighted Mean Concentration
HUC8	8-digit Hydrologic Unit Code
ICT	Interagency Coordination Team
ITPHS	Imminent Threat to Public Health or Safety
IRRB	International Red River Board

LGU	Local Governmental Unit
LSTS	Large Subsurface Sewage Treatment System
MCES	Metropolitan Council Environmental Services
MDA	Minnesota Department of Agriculture
MDH	Minnesota Department of Health
Metro Area	Twin Cities Metropolitan Area
MIDS	Minimal Impact Design Standards
MN P Index	Minnesota Phosphorus Index
MnTap	Minnesota Technical Assistance Program
MPCA	Minnesota Pollution Control Agency
MRB	Mississippi River Basin
MRB3	Major River Basin 3
MRBI	Mississippi River Basin Initiative
MS4	Municipal Separate Storm Sewer System
N	Nitrogen
NASS	National Agricultural Statistics Survey
NBMP	Nitrogen Best Management Practice Watershed Planning Tool
NFMP	Nitrogen Fertilizer Management Plan
NGP	Northern Glaciated Plains
NLF	Northern Lakes and Forest
NO3+NO2-N	Nitrate plus Nitrite Nitrogen
NO_3-N	Nitrate-Nitrogen
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
NRS	Minnesota Nutrient Reduction Strategy
NWQI	National Water Quality Initiative
P	Phosphorus
RIM	Reinvest in Minnesota
RRBC	Red River Basin Commission
SWCD	Soil and Water Conservation District
SDS	State Disposal System
SPARROW	Spatially Referenced Regressions on Watershed
SSTS	Subsurface Sewage Treatment System
SWAT	Soil and Water Assessment Tool
TKN	Total Kjeldahl Nitrogen

TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WCP	Western Cornbelt Plains
WDIP	Watershed Data Integration Project
WPLMN	Watershed Pollutant Load Monitoring Network
WQBEL	Water Quality-Based Effluent Limit
WRAPS	Watershed Restoration and Protection Strategy
WRP	Wetland Reserve Program
WWTP	Wastewater Treatment Plant

Executive Summary
Minnesota Nutrient Reduction Strategy

The *Minnesota Nutrient Reduction Strategy* (*NRS*) will guide the state in reducing excess nutrients in waters so that in-state and downstream water quality goals are ultimately met.

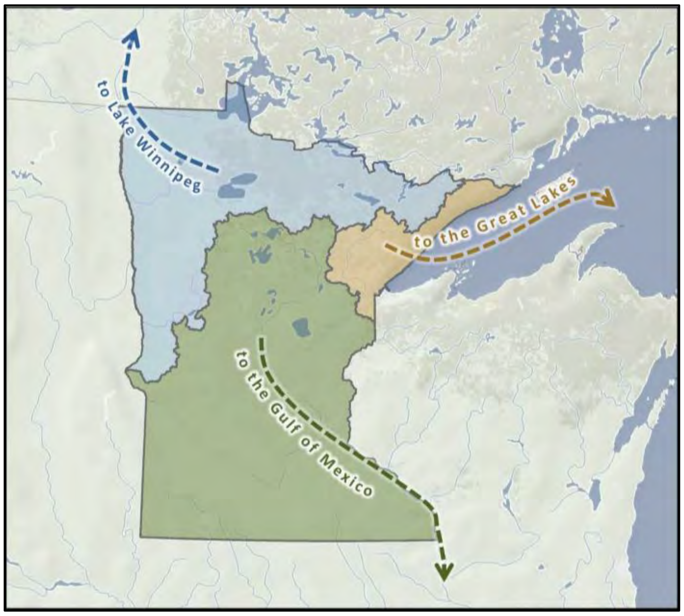


Figure 1. Major drainage basins in Minnesota.

Nutrient impacts are widespread. Excessive nutrients pose a significant problem for Minnesota's lakes, rivers, and groundwater, as well as downstream waters including the Great Lakes, Lake Winnipeg, the Mississippi River, and the Gulf of Mexico. Nutrients are important for human and aquatic life; however, when levels exceed normal conditions, problems can include excessive algae growth, low levels of oxygen, toxicity to aquatic life and unhealthy drinking water.

Substantial nutrient reductions are needed across much of Minnesota. For example, in 433 Minnesota lakes with impairments related to nutrients, an average of 45 percent phosphorus reduction is needed to meet water quality standards. Phosphorus levels in 48 river stretches exceeding the pending river eutrophication standards need an average 41 percent reduction. Many of these rivers flow toward the Mississippi River and into Lake Pepin, where similar levels of phosphorus reduction are needed to achieve a healthy lake. Nitrate, a dominant form of nitrogen in polluted waters, commonly exceeds the levels established to protect drinking water, especially in wells located below sandy soils and shallow soils above fractured bedrock. Nitrate levels are high enough to harm the food chain for fish in some rivers and streams fed by groundwater and drainage ditches.

This NRS is driven by the environmental needs of both waters within Minnesota and waters downstream of Minnesota, including Lake Winnipeg, the Gulf of Mexico and Lake Superior. In-state lake standards and pending river eutrophication standards, as well as planning goals for downstream waters, have clearly defined the magnitude of needed reductions. The timing of NRS development also aligns with several other supportive efforts, some of these efforts are described below:

- The 2009 Minnesota *Clean Water, Land and Legacy Amendment* provides additional funding for water quality protection and restoration until 2034.
- Along with 11 other states represented on the Gulf of Mexico Hypoxia Task Force, Minnesota committed to develop a NRS to protect in-state waters and the Gulf of Mexico.
- The Minnesota Water Management Framework developed in 2014 lays out the state's approach for implementing watershed-based planning that will sustain a 10-year statewide cycle of locally-led water quality improvement plans.
- The Minnesota Department of Agriculture updated its *Nitrogen Fertilizer Management Plan* in 2014 for protecting groundwater from nitrate pollution.
- The legislature directed the Minnesota Pollution Control Agency (MPCA) to develop nitrate standards which will eventually increase protection of Minnesota aquatic life from the toxic effects of high nitrate.
- Manitoba, North Dakota and Minnesota are working together to update plans for protecting Lake Winnipeg from severe algae blooms.

The overall theme of the NRS is ***A Path to Progress in Achieving Healthy Waters***. The NRS guides activities that support nitrogen and phosphorus reductions within Minnesota water bodies. In addition, nutrient reductions will also benefit the Gulf of Mexico hypoxia problem and other waters downstream of Minnesota including Lake Winnipeg and Lake Superior. Fundamental elements of the NRS include:

- Defining progress with clear goals
- Building on current strategies and success
- Prioritizing problems and solutions
- Supporting local planning and implementation
- Improving tracking and accountability

Successful implementation of the NRS will require broad support, coordination, and collaboration among agencies, academia, local government, and private industry. An interagency coordination team, representing 11 agencies, helped develop the draft NRS. Public input was sought and used by the interagency coordination team to produce the final NRS.

Goals and Milestones

The NRS includes nutrient reduction goals and milestones at several levels. For individual water bodies in Minnesota, state water quality standards define the goals. For major basins, such as Lake Winnipeg and the Mississippi River/Gulf of Mexico, planning goals for reducing Minnesota's nutrient contributions were developed (Table 1). These major basin goals are intended to be measured where the basin waters leave the state (e. g., Mississippi River Basin where it leaves Minnesota at the Iowa border). Nutrient reduction targets have been previously developed for major drainage basins and provide a suitable framework for NRS load reduction goals. In addition, the NRS includes a groundwater/source water protection goal to address groundwater as a drinking water source.

Table 1. Major basin-wide nutrient reduction goals

Major basin	Phosphorus reduction goal	Nitrogen reduction goal
Lake Superior [a]	Maintain 1979 conditions	Qualitative – continued implementation of specific nutrient management programs
Lake Winnipeg [b]	10% reduction from 2003 conditions	13% reduction from 2003 conditions
Mississippi River [c]	45% reduction from average 1980–1996 conditions	45% reduction from average 1980–1996 conditions
Statewide Groundwater/ Source Water	Not applicable	Meet the degradation prevention goal of the Minnesota Groundwater Protection Act

a. Great Lakes Water Quality Agreement of 1978, amended by a protocol signed November 18, 1987.
b. 2003 Lake Winnipeg Action Plan. Goals to be updated after completion of the Red River/Lake Winnipeg strategy. Lake Winnipeg Goals are expected to change in the near future, resulting in additional load reduction needs.
c. 2008 Gulf Hypoxia Action Plan; Provisional goal; also includes drainage associated with Missouri, Des Moines, and Cedar rivers.

Milestones provide a realistic and meaningful benchmark of progress toward meeting major basin goals for nutrient reduction. They also establish a point in time to adapt strategies as necessary based on the rate of progress and changes in factors such as land uses, climate, regulatory environment, and technologies. A nitrogen reduction milestone was established for the Mississippi River because the final goals were determined to be impractical at this time. Additional research should enable feasible approaches for achieving the long-term nitrogen reduction needs. The nitrogen milestone for the Mississippi River is set at a 20 percent reduction by 2025. A provisional target date for reaching the 45 percent reduction goal for nitrogen in the Mississippi River is set at 2040, allowing time for the needed research and subsequent demonstration and promotion of new practices. Additional milestones can be added as new nutrient reduction goals are set for downstream waters or as new research and policies inform planning and decision-making. Figure 2 summarizes the timeline for achieving the Mississippi River phosphorus goal and nitrogen milestone.

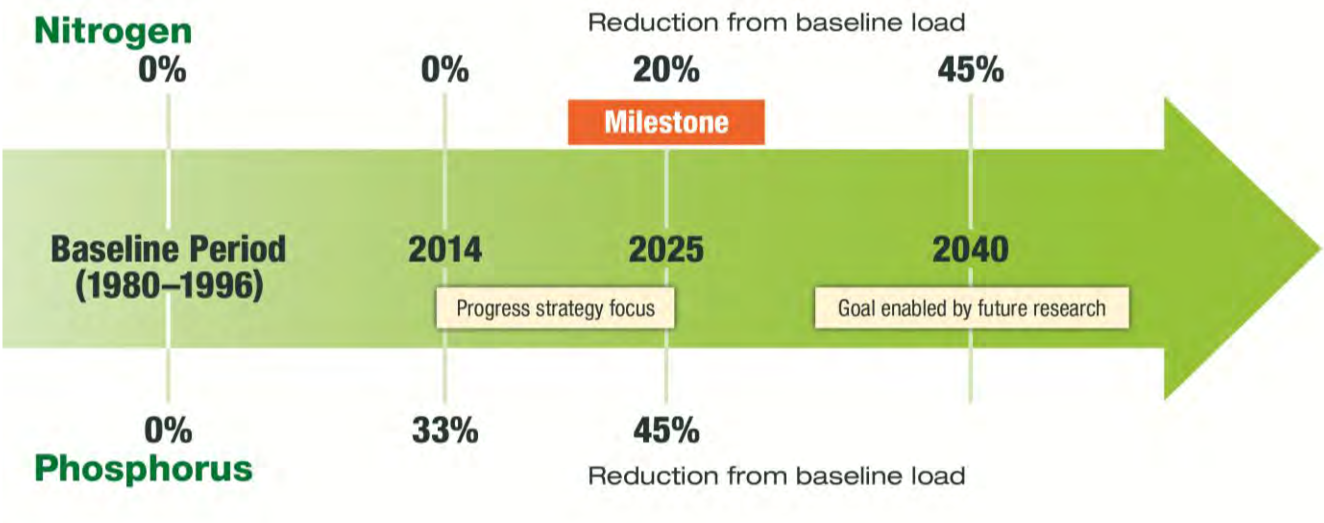


Figure 2. Timeline for achieving the Mississippi River milestone and goal.

Minnesota is implementing a watershed approach that assesses, restores and protects waters under the umbrella of the Minnesota Water Management Framework. This approach sets a 10-year cycle of water assessments, watershed restoration and protection strategy (*WRAPS*) development at the hydrologic unit code 8 (HUC8) watershed level, and local water planning (e. g., *One Watershed One Plan*). The NRS provides the information and collective objectives needed to address watershed nutrient goals downstream of the HUC8 watersheds. These downstream objectives can then be integrated with needs and prioritized actions within the HUC8 watershed. HUC8 watershed goals and milestones should be developed so that cumulative reductions from all watersheds will achieve the goals and milestones in waters downstream.

Water Quality Standards

Nutrient related water quality standards and drinking water *standards* are an important part of the water quality policy framework in Minnesota and nationally. Both lake and pending river eutrophication standards in Minnesota include phosphorus, but they do not include nitrogen. Eutrophication standards were set for lakes in 2008, and finalization of the river eutrophication standards is expected by Fall 2014. Nitrate standards to protect aquatic life in Minnesota surface waters are anticipated in the next few years. Phosphorus loading is often directly related to total suspended solids in rivers, especially during moderate to high flow events. Minnesota has existing standards for turbidity and plans to replace the turbidity standards with total suspended solids standards.

An evaluation of monitoring data indicates that meeting in-state lake and pending river eutrophication standards will likely result in meeting the major basin goals for phosphorus reduction. For example, Lake Pepin, a riverine lake on the Mississippi River, requires a greater phosphorus load reduction from this point in time than reductions needed to meet the Gulf of Mexico hypoxia goal. However for nitrogen, current in-state standards will not drive enough change to sufficiently address Minnesota's share of nitrogen to the Gulf of Mexico and Lake Winnipeg. Future nitrate standards to protect aquatic life will also necessitate nitrate reductions in some waters of the state, but we will not know the effect of those standards on downstream loading until they are established.


Headwaters to the Mississippi River
Photo Credit: MPCA

Evaluating Progress Since the Baseline Period

In developing the NRS, an assessment of recent progress to reduce nutrients in waters was conducted using available government program data. Each of the major basins in Minnesota has a reduction goal that is established according to a designated baseline period when that goal was established. For the Mississippi River, the National Hypoxia Task Force established the load reduction goals based on average conditions that occurred from 1980 -1996. Estimates of recent progress based on best management practice (BMP) adoption were then validated with river monitoring results.

Several regional, state, or federal programs were identified as key nutrient-reducing programs in Minnesota. Program staff provided input on quantifying outputs or outcomes of program implementation. Data from the Natural Resource Conservation Service Environmental Quality Incentives Program (EQIP), Reinvest in Minnesota Program (conservation easements), Minnesota's eLINK database which tracks state-funded nonpoint source BMPs, MPCA's Feedlot Program, and estimated phosphorus reduction from septic system improvements and the statewide lawn phosphorus fertilizer ban were compiled from 2000 to present. Reductions in wastewater nutrients were also quantified. Table 2 summarizes the load reductions that were quantified as part of this effort. While the assessment of progress from BMPs and changes since 2000 does not incorporate all BMPs and land management changes, river monitoring results generally support the magnitude of estimated recent progress.

Table 2. Summary of recent progress by sector as compared to overall load in each major basin.
The load reductions in this table represent estimated load reductions that will occur at the state border as a result of practices since 2000.

	Percent in load change by cropland BMPs		Percent in load change by certain misc. source BMPs		Percent in load change by wastewater		Recent progress (as % of total load delivered)	
Major basin	P	N	P	N	P	N	P	N
Mississippi River	-8%	-2%	-1%	NA	-24%	+2%	-33%	0%
Lake Winnipeg	-3.7%	0%	-0.3%	NA	-0.3%	0%	-4.3%	0%
Lake Superior	-0.7%	NA	-1.3%	NA	+2.8%	NA	+0.8%	NA

Note: P=phosphorus; N=nitrogen. A negative number indicates reduction; a positive number indicates an increase.

The greatest progress during recent years has occurred with phosphorus reductions in the Mississippi River, where the estimated phosphorus reduction is 33 percent since 2000. Mississippi River monitoring showed a similar reduction (31 percent) in Red Wing after accounting for changes in flow conditions. Estimated Mississippi River phosphorus and nitrogen reductions achieved during recent years is shown in Figure 3 and Figure 4, as compared with baseline loads and milestone and goal loads. The NRS addresses the gap between current conditions (which includes quantified recent progress) and goals and milestones.

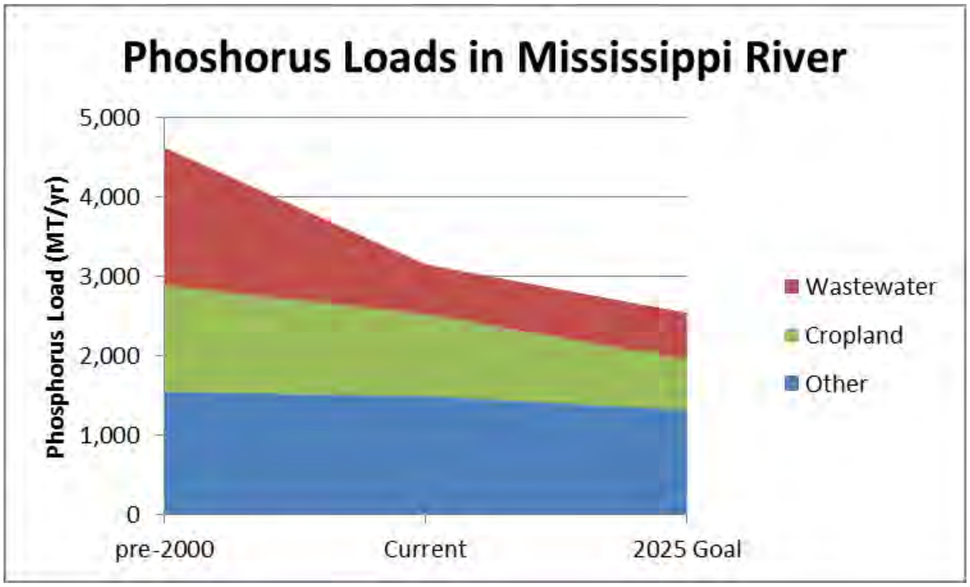


Figure 3. Minnesota's annual phosphorus loading in the Mississippi River at the state border during an average flow year in the past, current and NRS projected future. Other sources include atmospheric deposition, urban runoff, non-agricultural rural runoff, streambank erosion, barnyard runoff and septic systems.

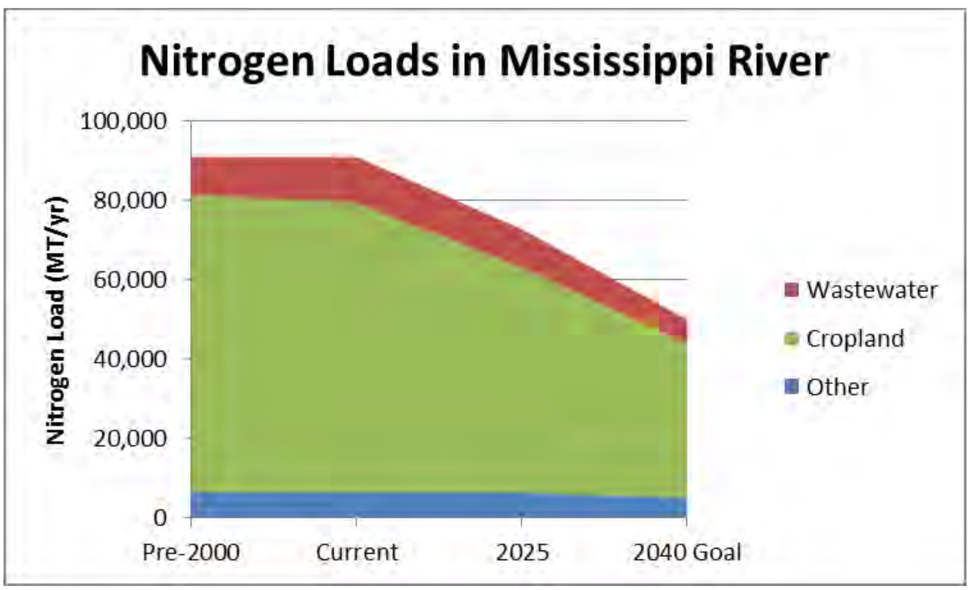


Figure 4. Minnesota's annual nitrogen loading in the Mississippi River at the state border during an average flow year in the past, current and NRS projected future. Other sources include atmospheric deposition, forest, urban runoff, and septic systems.

The full effects of these reductions have not yet been observed in river monitoring at the Minnesota/Iowa border. Lake Pepin and Mississippi River backwaters are likely recycling historically deposited phosphorus, thereby masking the full downstream effects of the load reductions. Evaluation of NRS progress will include a combination of monitoring and modeling at different points along the state's rivers, and will consider such effects as lag time and climate.

Metropolitan Wastewater Treatment Plant
Photo Credit: Metropolitan Council

Priority Management Areas

State level priority sources and major watersheds are based on the highest nutrient-loading to waters. Identifying priority areas within major watersheds occurs through local watershed planning such as "One Watershed, One Plan" and as part of WRAPS. It is important to recognize that while prioritization is an effective management tool for directing limited resources, nutrient reductions needed to meet the NRS goals cannot be achieved through implementation in a limited number of high-priority watersheds. BMP adoption is needed on millions of acres, and thus reductions are needed for priority sources in most watersheds.

Priority sources (Table 3) are determined on the basin scale, although it should be noted that different sources might be more or less important at the local scale. Priority sources could differ depending on the scale at which reductions are needed and could be adjusted through local and regional planning processes. The NRS does not consider sources that cannot be greatly reduced by local or regional implementation activities which include atmospheric deposition and loads from forested areas as reduction priorities.

Table 3. Priority sources for each major basin

Major basin	Priority phosphorus sources	Priority nitrogen sources
Mississippi River	Cropland runoff, wastewater point sources, and streambank erosion	Agricultural tile drainage and other pathways from cropland
Lake Superior	Nonagricultural rural runoff [a], wastewater point sources, and streambank erosion	Wastewater point sources
Lake Winnipeg	Cropland runoff and nonagricultural rural runoff	Cropland

a. Includes natural land cover types (forests, grasslands, and shrublands) and developed land uses that are outside the boundaries of incorporated urban areas.

Priority watersheds have the highest nutrient yields (loads normalized to area), and also include watersheds with high phosphorus levels in rivers. Figure 5 identifies major watershed priorities.

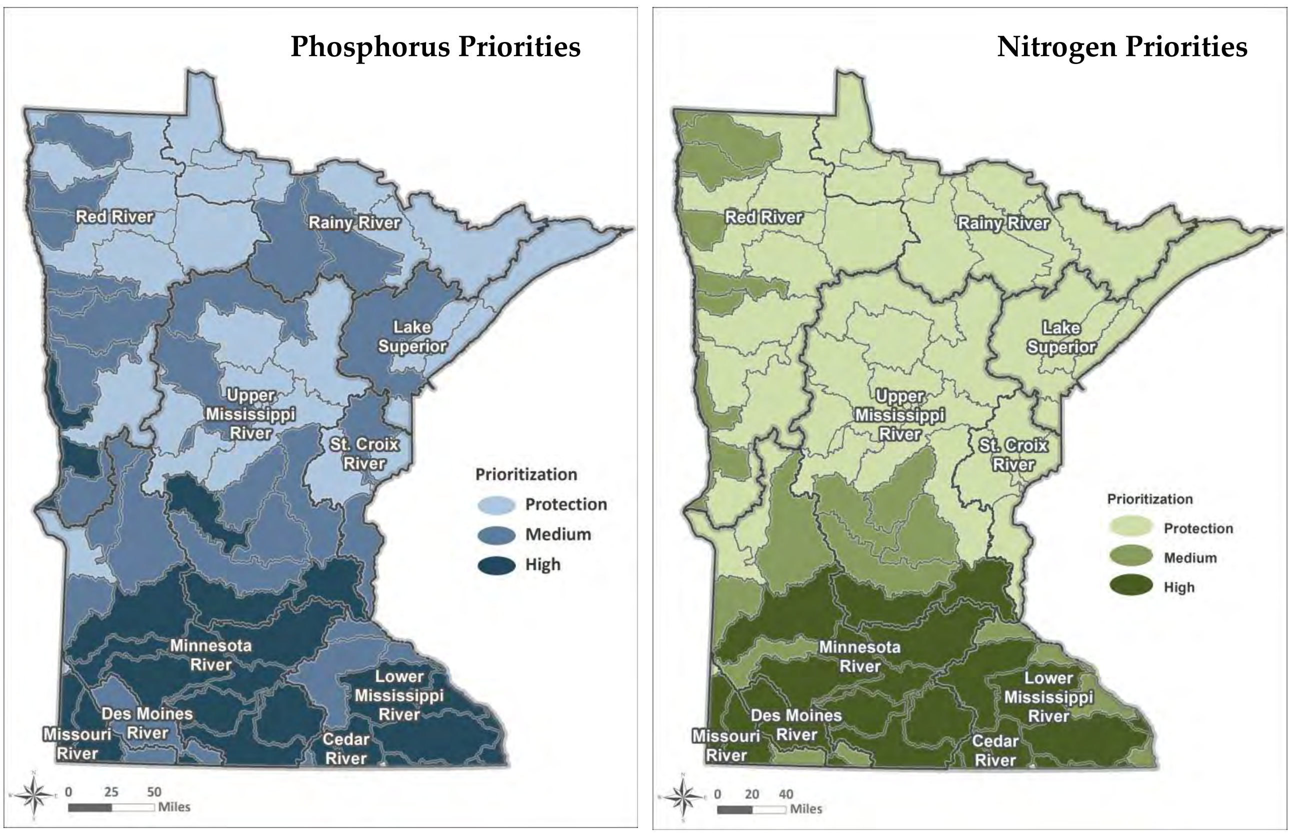


Figure 5. HUC8 watershed priorities.

Nutrient Reduction Strategies

No single solution exists for achieving the level of nutrient reductions needed to meet goals and milestones. It will take many actions and BMPs implemented over large areas of the state. To support the needed widespread change, the NRS includes two overarching strategies:

Develop a Statewide NRS Education/Outreach Campaign. Develop and implement a coordinated NRS outreach campaign that integrates with other efforts to promote statewide stewardship of water resources. This statewide campaign is responsible for raising general public awareness about the need to reduce nutrients in Minnesota waters and will support BMP specific education activities.

Integrate Basin Reduction Needs with Watershed Planning Goals and Efforts. As part of Minnesota's Water Management Framework, ensure that downstream nutrient reduction needs are addressed by cumulative local level efforts. Watershed restoration and protection strategies and accompanying comprehensive watershed management plans (e.g., One Watershed One Plan) should be developed to not only have the goal of protecting and restoring water resources within the watershed, but to also contribute to nutrient reductions needed for downstream waters both within Minnesota and those downstream of the state border. The *Minnesota Nutrient Planning Portal* was recently developed for accessing watershed nutrient-related information. It includes information on nitrogen and phosphorus conditions and trends in local waters, nutrient modeling, local water planning, and other nutrient information. Information from this portal can be used when developing local plans and strategies to reduce nutrient losses to local and downstream waters.

Wastewater Strategies

The current Phosphorus Rule and Strategy has, and will continue, to address phosphorus reductions in wastewater. The adoption of river eutrophication standards in 2014 is expected to result in additional wastewater phosphorus reductions in certain watersheds.

The history of phosphorus management at wastewater treatment facilities in Minnesota starting in 2000 is an example of a successful program to reduce a pollutant of concern. Several steps used in the successful Phosphorus Strategy (MPCA 2000) are also proposed for nitrogen:

- Influent and effluent nitrogen monitoring at wastewater treatment facilities
- Nitrogen management plans for wastewater treatment facilities
- Nitrogen effluent limits

- Add nitrogen removal capacity with facility upgrade
- Point source to nonpoint source trading

An approximate 20 percent reduction in wastewater nitrogen loads, along with reductions from other sources, will enable achievement of the nitrogen milestone for the Mississippi River. Until research and testing are complete, wastewater treatment facilities may be limited in their nitrogen removal achievements. This will be evaluated as more information is gathered throughout the life of the NRS and may result in modification of the nitrogen reduction milestones. As facilities complete these steps, assessment will help to identify changes needed to existing treatment processes and technologies. Major changes to treatment plants will require significant timeframes for design and construction.

Cropland Strategies

The NRS includes select cropland BMPs and treatment options to guide implementation; however, any combination of BMPs and treatment options that achieve the load reduction goals can be used. As new research occurs, additional BMPs and treatment options will likely become part of the NRS.

Agricultural BMPs recommended for the NRS are grouped into the following four categories:

1. Increase fertilizer use efficiencies, emphasizing:
    a. Nutrient management through reduction of nitrogen losses on corn following soybeans
    b. Switch from fall to spring fertilizer applications (or use nitrification inhibitors)
    c. Application of phosphorus in accordance with precision fertilizer and manure application techniques, including applications based on soil test results and University of Minnesota recommendations
2. Increase and target living cover, emphasizing:
    a. Cover crops on fallow and short season crops such as sweet corn, corn silage, peas, small grains, and potatoes
    b. Perennials in riparian zones and on marginal cropland
    c. Research and development of marketable cover crops to be grown on corn and soybean fields
    d. Research and development of perennial energy crop(s)
3. Field erosion control, emphasizing:
    a. Tillage practices that leave more than 30 percent crop residue cover or alternative erosion control practices that provide equivalent protection

   b. Grassed waterways and structural practices for runoff control

4. Tile drainage water quality treatment and storage, emphasizing:
   a. Constructed and restored wetlands
   b. Controlled drainage when expanding or retrofitting drainage systems
   c. Water control structures
   d. Research and development of bioreactors, two-stage ditches, saturated buffers and other ways to store and treat drainage waters

Example BMP scenarios to achieve the nutrient reduction goals and milestones in each major basin were developed. In general, the conceptual strategy for nitrogen includes increasing fertilizer and manure use efficiency through nutrient management, treating tile drainage waters, and implementing living cover BMPs. NRS phosphorus reductions from cropland are based largely on precision use of fertilizer and manure, reducing soil erosion, and adding riparian buffers and other living cover on the landscape.

Residue Management
Photo Credit: NRCS

Increased adoption of agricultural BMPs is critical to implementing the NRS and achieving goals and milestones. The NRS provides many recommendations on how to increase BMP adoption and recognizes that new ideas and strategies are also needed to achieve the high level of BMP adoption. Key cropland strategies include:

- Advance the use of vegetative cover through riparian buffers and adoption of cover crops on short season crops, while working to advance cover crop and perennial crop options for Minnesota's climate and markets for perennials.
- Work with farmers to improve soil health, which will include more crop residue and soil erosion control, especially for protection of soil during the increasing frequency of high intensity rains.
- Work with co-op agronomists, certified crop advisers, and agricultural producers on an educational campaign to achieve greater nutrient efficiencies. Provide greater confidence in reducing rates by offering crop nutrient insurance for reduced fertilizer rates and other self-demonstration projects.
- Increase education and outreach on water quality issues and BMPs needed to reach nutrient reduction goals. Encourage participation and provide education through the Agricultural Water Quality Certification Program. Develop recognition programs for excellent nutrient management such as Watershed Heroes.
- Develop strong public-private partnerships to support increased delivery of voluntary BMPs and optimize opportunities to improve the rate of BMP adoption in targeted areas. Increase demonstrations, promotion and incentives for implementing tile drainage management, wetland construction and other practices to reduce nutrients from tile drainage waters.
- Provide the necessary research and demonstration that will lead to increased adoption of cropland BMPs.

Miscellaneous Source Strategies

Phosphorus reductions from miscellaneous sources such as streambank erosion, subsurface sewage treatment systems, stormwater, and feedlots are needed to meet the overall goals and milestones in the Mississippi River and Lake Winnipeg major basins. Strategies already being used will further the progress toward reducing these nutrient loads. Existing programs have strategies that allow for systematic reductions in loads from subsurface sewage treatment systems, stormwater, and feedlots.

A large-scale strategy is also under development to address sediment reduction. The strategy will help address sediment-related nutrient load reductions. In addition, implementation of Total Maximum Daily Loads (TMDLs), particularly for turbidity-impaired streams, will likely address sediment-bound phosphorus sources that are a result of bank and channel erosion.

Protection Strategies

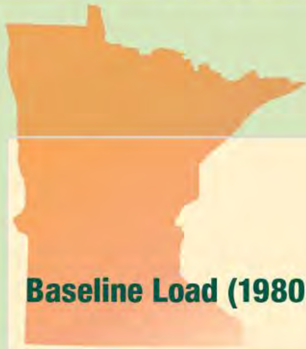
Protection strategies are needed in watersheds facing development pressures and changes in agricultural and land use practices, as well as in areas with vulnerable groundwater drinking water supplies. The Minnesota Water Management Framework requires protection strategies as part of WRAPS development, and therefore should address the potential for increased nutrient loads at a watershed scale. In addition, protection strategies should consider mitigation measures to address increases in Red River Basin tile drainage.

Specific to groundwater protection, the MDA is completing its Nitrogen Fertilizer Management Plan during 2014. The strategies outlined in that plan serve as the NRS's strategies for groundwater protection and include implementation of BMPs which protect groundwater resources, wellhead protection planning and implementation, a broad education and BMP promotion component, and a phased mitigation strategy to reduce groundwater nitrate concentrations to drinkable conditions in high nitrate zones.

Quantified Overview of Nutrient Reduction Strategy

The following figures for the Mississippi River Major Basin summarize the overall strategies to achieve the phosphorus goal and nitrogen milestone. Similar figures have also been developed for the Red River Basin (see Chapter 5). Each of the figures includes suggested reductions by source for each of the key BMP categories. The figures are organized to provide the baseline load by sector (agricultural, wastewater, and miscellaneous), quantified progress since baseline, and the breakdown of BMPs and implementation activities that are needed to meet the goals and milestone.

45% Reduction — Mississippi River Phosphorus



	Source: Agricultural	Wastewater	Miscellaneous	Total
Baseline Load (1980–1996) Units = metric tons (MT) per year	1,337	1,739	1,551	4,627
Progress Since Baseline	356	1,113	51	1,519
Recommended Strategy Reductions				
Increasing Fertilizer Use Efficiencies on 2.2 Million Acres ▪ Recommended fertilizer rates ▪ Placement and timing of application ▪ Reducing soil P levels ▪ Livestock feed management	238			
Increase and Target Living Cover on 1.2 Million Acres ▪ Cover crops ▪ Perennial buffers ▪ Forage and biomass planting ▪ Perennial energy crops ▪ Conservation easements and land retirement	53			
Field Erosion Control on 4.5 Million Acres ▪ Conservation tillage and residue management ▪ Terraces/grassed waterways ▪ Sediment control basins	57			
Urban Stormwater + Other Sources			180	
Wastewater Treatment		37		
Total Reductions	348 +	37 +	180 +	1,519 = Total 2,084

Goal **45%** from Baseline Load = 2,084 Metric Tons Reduced

Progress Since Baseline 1,519 + **Additional Reductions 565** = **Goal 2,084 MT Reduced = 45% by 2025**

1,000 kg = 1 MT

Figure 5. Phosphorus goal reductions for Mississippi River Major Basin.

20% Reduction Milestone

Mississippi River Nitrogen

	Source			
	Agricultural	Wastewater	Miscellaneous	Total
Baseline Load (1980–1996) Units = 1,000 metric tons (MT) per year	75.0	9.6	6.4	91
Progress Since Baseline	2	-2	0	0
Recommended Strategy Reductions				
Increasing Fertilizer Use Efficiencies on 11.2 Million Acres ▪ Recommended fertilizer rates ▪ Placement and timing of application ▪ Nitrification inhibitors	11			
Increase and Target Living Cover on 1.6 Million Acres ▪ Cover crops ▪ Perennial buffers ▪ Forage and biomass planting ▪ Perennial energy crops ▪ Conservation easements and land retirement	4.0			
Drainage Water Retention and Treatment for 0.6 Million Acres ▪ Constructed wetlands ▪ Controlled drainage ▪ Bioreactors ▪ Two stage ditches	1.2			
Wastewater Treatment		1.9		
Total Reductions	16.2 +	1.9 +	0 +	0 = Total 18.2

Milestone Target **20%** from Baseline Load = 18,200 Metric Tons Reduced

Progress Since Baseline 0 + **Additional Reductions** 18,200 = **Milestone** 18,200 MT Reduced = **20%** by **2025**

1,000 kg = 1 MT

Figure 6. Nitrogen milestone reductions for Mississippi River Major Basin.

Adaptive Management and Tracking Progress

Progress towards goals and milestones will be tracked over time to determine if strategies are successful and where additional work is needed. To understand the level of nutrient reduction progress being achieved and ensure that on-the-ground implementation is on pace with the NRS goals and milestones, it is important to evaluate both changes in the adoption of BMPs (our actions) and water quality monitoring information (environmental outcomes). The basic components of the NRS's adaptive management plan are as follows:

- Identify data and information needed to track progress toward NRS goals and milestones.
- Create a system or approach for collecting data and information needed to track progress toward NRS goals and milestones.
- Evaluate trends as well as relationships between actions and outcomes.
- Adjust the NRS as necessary.

Implementation tracking will be done through both land management and water quality data. Program implementation data provides early indicator information about nitrogen and phosphorus reductions that, over time, should translate to in-stream nutrient reductions. An integrated and streamlined approach to track BMP implementation should be a priority. The NRS contains a suite of program measures that can be used to measure progress including various implementation activities. It is important to note that the selected program measures reflect government programs and do not capture industry-led conservation activities. As a result, while the selected program measures are strong indicators of program implementation trends, they are conservative indicators of statewide BMP adoption. BMP implementation that is occurring outside of government assistance is likely the largest gap in measuring success of the NRS. Comprehensively determining outcomes will require measuring conservation practices and farming activities that are not funded and tracked through government programs.

Future water quality evaluations will rely upon the Watershed Pollutant Load Monitoring Network and statewide water quality modeling. Many other local, regional, statewide, and national monitoring programs will inform water quality evaluations. No single water quality metric, monitoring site, or period of monitoring will provide the needed information to evaluate environmental outcomes. When monitoring data from multiple sites is used, along with periodic modeling and evaluation of anticipated lag times, then progress toward NRS goals and milestones can be more accurately assessed.

Water quality outcome measures will include the following:

- Trend in actual load
- Trend in flow weighted mean concentration
- Extent of river and lake eutrophication impairments
- Statistical comparisons of baseline loads and concentrations at low, medium, and high flow periods with comparable flow periods during recent years
- Extent of groundwater nitrate above drinking water standards in high-nitrate areas, including those watersheds where nitrate coming from groundwater impairs surface waters

The NRS centers on a series of goals and milestones and targeted actions identified to achieve those goals and milestones over time, with periodic reevaluation and reassessment. Tracking and reporting will occur at 2-year, 5-year, and 10-year intervals. There is currently no integrated reporting, data management and report generating system that will allow for automated tracking of NRS output and outcome information to assess progress over time. The approach for tracking progress requires the development of a system to ensure the efficiency and reliability of progress tracking. Developing a tracking system of this nature will be a multi-agency undertaking that must take into consideration the existing data management approaches used by numerous programs within several agencies.

The NRS provides for accountability, incorporates adaptive management, and ensures that Minnesota stays on the ***Path to Progress in Achieving Healthy Waters***.

Lake Superior
Photo Credit: MPCA

Chapter 1

Development of the Minnesota Nutrient Reduction Strategy

Minnesota's state, federal, and regional partner agencies along with the University of Minnesota have collaborated to provide a statewide strategy to reduce levels of phosphorus and nitrogen, collectively referred to as *nutrients*. The public provided comments and suggestions which helped to create this final strategy. Minnesota will use the statewide strategy as a guide for reduction of nutrients. Excessive nutrient levels pose a substantial threat to Minnesota's lakes and rivers, as well as downstream waters including the Great Lakes, Lake Winnipeg, the Mississippi River, and the Gulf of Mexico.

The *Minnesota Nutrient Reduction Strategy* (NRS) will guide Minnesota to achieve nitrogen and phosphorus reductions within Minnesota surface waters to enhance the health of aquatic life, protect public health and safety, increase the recreational potential of Minnesota's numerous lakes, rivers, and streams. The NRS also addresses groundwater protection as it relates to nitrate in drinking water. In addition, nutrient reductions will benefit the Gulf of Mexico hypoxia problem and other waters downstream of Minnesota including Lake Winnipeg and Lake Superior. The theme of the overall NRS is ***A Path to Progress in Achieving Healthy Waters*** (Figure 1-2).

Figure 1-1. Major drainage basins in Minnesota.

The Minnesota Water Sustainability Framework (University of Minnesota 2011) surveyed Minnesotans' attitudes and beliefs about water. Based on more than 4,500 surveys and 9 listening sessions around the state, the team concluded:

- Minnesotans consider providing drinking water to be the most important use of water, followed by providing ecological services, offering recreational opportunities, and meeting the needs of agriculture.
- Minnesotans rank chemical pollution; nutrients; and non-native plant, animals, and diseases the three most serious problems facing Minnesota's waters.
- Minnesotans understand that we need to change our behavior in order to reverse the trend toward reduced water quality.
- Minnesotans equally value improving polluted lakes and rivers and protecting healthy waters.
- Minnesotans place equal importance on investing in groundwater and investing in surface waters.
- Minnesotans want to address the most serious water problems first, rather than place priority on distributing funding equitably across the state.
- Minnesotans want quantifiable measures of water quality to be communicated and accessible.

Figure 1-2. Pathways to progress.

The mission of the NRS is to recognize the importance of nutrients in protecting water quality whether sources are nearby or many miles upstream. As such it provides a roadmap to address both Minnesota's nutrient contribution to downstream waters, and, at the same time, add value for those who work on local and regional land and water nutrient-related issues within Minnesota. More specifically, the NRS mission includes the following:

1. **Complement Existing State-Level Strategies** – Several state-level plans and strategies for Minnesota water issues have been developed during recent years, and are in various stages of implementation. One goal of the NRS is to add further focus to those efforts, specifically on nutrients, thereby supplementing and coordinating among these other plans and not supplanting.

2. **Work toward Progress in Downstream Waters** – By the time nutrient problems show up in resources downstream of Minnesota such as the Gulf of Mexico or Lake Winnipeg, the contributions can be very large. Rather than comprehensively addressing the long-term goals in these downstream waters, it is beneficial to focus on making incremental progress toward restoring these waters. Minnesota is one of 12 states that have committed to develop state level nutrient reduction strategies. Even with all of these states contributing to load reductions, the level of reduction needed from any individual state can still be significant. Minnesota is approaching this challenge by establishing milestones and providing a plan to reach these meaningful interim goals. Meaningful and achievable nutrient load reduction milestones are developed that allow for better understanding of incremental and adaptive progress toward final goals. Milestones target load reductions from point and nonpoint sources impacting the Gulf of Mexico, Lake Winnipeg, Lake Pepin, Mississippi River backwaters, Lake Superior, and other downstream waters.

3. **Work toward Progress on Meeting In-state Nutrient Criteria** – Meeting Minnesota's beneficial use water quality standards is critical to protecting the waters that Minnesotans value. Whether for recreation, consumption or other uses, Minnesota identifies with its waters in important ways. The NRS complements existing efforts to make progress toward meeting in-state nutrient criteria and proposed standards for Minnesota's lakes and streams, and additionally provides protection to water bodies not yet assessed, or assessed as threatened (or needing protection) by nutrients or eutrophication.

4. **Prioritize and Target** – Major watersheds (i.e., 8-digit hydrologic unit code [HUC8]) are prioritized on a statewide basis relative to nutrient loads and impacts, and implementation activities are targeted to ensure efficient use of resources. Geographic, land use, and best management practice (BMP) priorities are established through technical analyses, resulting in recommended reductions of phosphorus and nitrogen that account for the most substantial impacts to receiving surface waters and groundwater.

5. **Build from Existing Efforts** – Many ongoing efforts are moving the state in the right direction, however the magnitude of these efforts is not sufficient to address the loading reductions needed. At the same time other factors might be contributing toward increased loads. The NRS identifies ways to build on successes of current programs and activities so that we can achieve our local and downstream water quality goals. The NRS is a unifying and organizing step to align goals, identify the most promising strategies, and coordinate the collective activities around the state working to achieve these common goals. The intent is to simplify and support, not complicate. A successful NRS will support and work within the Minnesota Water Management Framework, total maximum daily loads (TMDLs), Agricultural Water Quality Certification, the Nitrogen Fertilizer Management Plan, as well as local and regional planning efforts.

6. **Lead to Effective Local Implementation** –The NRS is directly applicable to state, federal, and regional agencies and organizations to focus and adjust state-level and regional programs, policies, and monitoring efforts. Those agencies often have the local watershed managers and water planners as a key customer focus; therefore the NRS is intended to focus at the state level but be relevant at the local level. These customers will take the large-scale data, priorities, and recommendations and consider that information when developing localized implementation plans (i.e., for HUC8 watershed scale and smaller). Efficiencies will be gained by making large-scale information available to local watersheds. This NRS will enhance and not replace the planning work needed at the HUC8 and finer watersheds scale.

1.1 Driving Forces

The need for a statewide nutrient reduction strategy in Minnesota is driven by a number of federal, regional, and state initiatives coalescing at this particular point in time. At the federal level, Environmental Protection Agency's (EPA) focus on statewide nutrient reduction planning has served as a key driving force for Minnesota's NRS development. Regionally, Minnesota's involvement in the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force has also served as a driving force. In the past decade, nutrient issues downstream of Minnesota have reached critical levels, including the effect of nutrients in the Gulf of Mexico which has resulted in hypoxia (low levels of oxygen), eutrophication problems in Lake Winnipeg, and nutrient concerns in the Great Lakes. Several state-level initiatives and actions have highlighted the need for a statewide strategy that ties separate but related activities together to demonstrate integration toward nutrient reductions. The following sections contain a brief discussion of each primary federal, regional, and state driving force.

Hypoxia Action Plan

The Mississippi River/Gulf of Mexico Watershed Nutrient Task Force developed a *Hypoxia Action Plan* in 2001, which was revised in 2008 and describes a national strategy to reduce, mitigate, and control hypoxia in the northern Gulf of Mexico and improve water quality in the Mississippi River Basin. The Action Plan identified the following action to help achieve nutrient reduction in the Mississippi River/Gulf of Mexico watershed and work toward meeting the goals for reduction in the hypoxia zone in the Gulf of Mexico:

> *Complete and implement comprehensive nitrogen and phosphorus reduction strategies for states within the Mississippi/Atchafalaya River Basin encompassing watersheds with significant contributions of nitrogen and phosphorus to the surface waters of the Mississippi/Atchafalaya River Basin, and ultimately to the Gulf of Mexico.*

This action calls for state-level nutrient reduction strategies by 2013. The strategies are intended to be collaborative, support both current and new nutrient reduction efforts, identify available funding, and specify funding needs (Mississippi River/Gulf of Mexico Watershed Nutrient Task Force 2008). EPA has provided funding and assistance to many of the states to help develop these strategies, including Minnesota. The NRS applies to the entire state, a large part of which includes the basins flowing into the Mississippi River.

EPA Memo on State Nutrients Framework

A *memo* issued by EPA on March 16, 2011, urged states to accelerate nutrient reduction and provided "Recommended Elements of a State Nutrients Framework" to help guide state planning activities related to nutrient reduction. Framework elements include:

1. Prioritize watersheds on a statewide basis for nitrogen and phosphorus loading reductions
2. Set watershed load reduction goals based upon best available information
3. Ensure effectiveness of National Pollutant Discharge Elimination System (NPDES) point source permits in targeted/priority subwatersheds
4. Agricultural areas
5. Stormwater and septic systems
6. Accountability and verification measures
7. Annual public reporting of implementation activities and biannual reporting of load reductions and environmental impacts associated with each management activity in a targeted watershed
8. Develop a work plan and schedule for numeric criteria development

This NRS strives to address each of the framework elements.

In-State Surface and Groundwater Water Quality Issues

Excessive levels of phosphorus and nitrogen present a substantial threat to Minnesota's lakes and rivers, as well as downstream water bodies. These threats are not only to the environment, but also to drinking water and public health. Minnesota promulgated lake and reservoir eutrophication standards in 2008 and is in the process of promulgating proposed *river and stream eutrophication standards* in 2014. Both sets of standards include phosphorus as the cause variable along with response variables that demonstrate that phosphorus has manifested as excess algal levels. Based on the 2012 Impaired Waters List, almost 20 percent of Minnesota lakes and river segments have been assessed as impaired due to excess nutrients or nutrient-related parameters (see Chapter 2). These water bodies will be the subject of TMDL studies and individual restoration plans designed to help achieve state water quality standards. These listings do not reflect the proposed river eutrophication standards; therefore, many more streams and rivers are anticipated to be added to future impaired waters lists.

The Minnesota Pollution Control Agency (MPCA) has assessed many Minnesota lakes and categorized them as impaired for excess nutrients (e.g., phosphorus). Sixty-five percent of the state of Minnesota is located upstream of a lake impaired by excess nutrients. As a result, MPCA is developing individual restoration plans that are designed to bring local waters into compliance with state water quality standards.

Nitrate concentrations in Minnesota groundwater also present a threat to safe drinking water supplies. Groundwater supplies drinking water to about 75 percent of all Minnesotans and almost all of the water used to irrigate the state's crops. The inflow of groundwater also is important to maintain the water level, pollution assimilative capacity, and temperature in Minnesota's streams, lakes, and wetlands. Central and southern Minnesota has the highest groundwater nitrate concentrations, predominantly in areas of karst as well as shallow sand and gravel aquifers. Minnesota is currently developing nitrate toxicity standards to protect aquatic life in surface waters of the state. The state is working toward adoption of these standards in about 2015.

Confluence of Dry Weather Creek and Chippewa River Photo Credit: MPCA

Clean Water Land and Legacy Amendment

On November 4, 2008, Minnesota voters approved the *Clean Water, Land and Legacy Amendment* (Amendment) to the constitution to protect drinking water sources; to protect, enhance and restore wetlands, prairies, and forests, as well as fish, game, and wildlife habitat; to preserve arts and cultural heritage; to support parks and trails; and to protect, enhance and restore lakes, rivers, streams, and groundwater. The Amendment increased the sales and use tax rate by three-eighths of one percent on taxable sales, starting July 1, 2009, continuing through 2034. Of those funds, approximately 33 percent are dedicated to a Clean Water Fund to protect, enhance, and restore water quality in lakes, rivers, streams, and groundwater, with at least 5 percent of the fund targeted to protect drinking water sources. Approximately $152 million was invested in the Clean Water Fund in the first 2 years for water management activities such as monitoring, planning, and on-the-ground restoration and protection activities.

Minnesota agencies that receive Clean Water Fund dollars have released *two collaborative reports*, most recently in 2014. Overall, the report shows the state is on track with its investments, though challenges remain. The 25 measures in the report provide a snapshot of how Clean Water Fund dollars are being spent and the progress being made. The measures are organized into three sections: investment, surface water quality, and drinking water protection. These are just some of the measures that will be used to consistently track and report clean water outcomes over the life of the Amendment. Each measure has a status ranking and trend information.

Minnesota's Clean Water Road Map was released in 2014 and is "a set of goals for protecting and restoring Minnesota's water resources during the 25-year life of the Clean Water, Land and Legacy Amendment. Clean Water Roadmap goals are based on currently available data and are intended to be ambitious, yet achievable. Progress in meeting these goals will require significant investment from the Clean Water Fund established by the Amendment, combined with historical water resource funding from other sources." Goals are provided for four high-level indicators that describe surface water quality, groundwater quality, and groundwater quantity.

Minnesota Water Management Framework – Watershed Approach to Protecting and Restoring Water Quality in Minnesota's Watersheds

The Minnesota Water Management Framework (Framework) lays out the state's plan to implement watershed-based planning efforts that will over the next 10 years result in locally-led water quality improvement plans. The Framework is a high-level, multi-agency, collaborative perspective on managing Minnesota's water resources.

Minnesota's water resource management efforts are tied to the goals of the 1972 Clean Water Act (CWA) for restoring and protecting the multiple beneficial uses, including recreation, drinking water, fish consumption, and ecological integrity of America's waters. The CWA requires states to do the following:

- Assign designated beneficial uses to waters and develop water quality standards to protect those uses.
- Monitor and assess their waters.
- List waters that do not meet water quality standards.
- Identify pollutant sources and reductions in pollution discharges needed to achieve standards.
- Develop a plan to implement water restoration and protection activities.

The passage of Minnesota's Clean Water Legacy Act (CWLA) in 2006 provided a policy framework and resources to state and local governments to accelerate efforts to monitor, assess, and restore impaired waters, and to protect unimpaired waters.

The CWLA and the recently established Clean Water Fund has changed how Minnesota approaches water quality, allowing a systematic approach in addressing impaired waters and protection efforts in unimpaired waters. Minnesota's watershed program has rapidly evolved from a singular focus on TMDLs to a watershed approach that will lead to comprehensive restoration and protection strategies for each of the state's major (HUC8) watersheds described in comprehensive watershed management plans (e.g., *One Watershed One Plan*). The Framework describes how Minnesota agencies aim to streamline water management by systematically and predictably delivering data, research, and analysis and empowering local action (Figure 1-3).

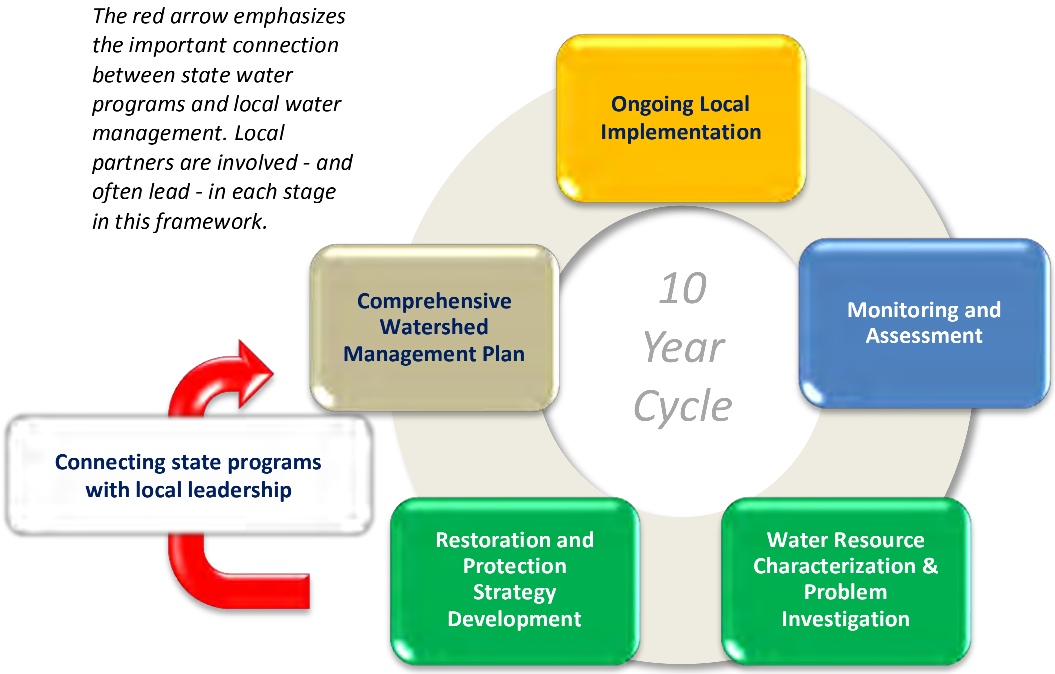


Figure 1-3. Minnesota Water Management Framework

Ongoing Local Implementation is at the heart of the state's overall strategy for clean water. Actions must be prioritized, targeted, and measurable in order to ensure limited resources are spent where they are needed most. The rest of the cycle supports effective implementation.

Monitoring and Assessment determines the condition of the state's ground and surface waters and informs future implementation actions. The state's "watershed approach" systematically assesses the condition of lakes and streams on a 10-year cycle. Groundwater monitoring and assessment is more varied in space and time.

Water Resource Characterization and Problem Investigation delves into the science to analyze and synthesize data so that key interactions, stressors, and threats are understood. In this step, watershed and groundwater models and maps are developed to help inform strategies.

Watershed Restoration and Protection Strategies (WRAPS) and Groundwater Restoration and Protection Strategies include the development of strategies and high level plans, "packaged" at the 8-digit HUC scale (81 major watersheds in Minnesota). These strategies identify priorities in each major watershed and inform local planning.

The **Comprehensive Watershed Management Plan** is where information comes together in a local commitment for prioritized, targeted, and measurable action. Local priorities and knowledge are used to refine the broad-scale WRAPS and other assessments into locally based strategies for clean and sustainable water.

The NRS provides recognition that many of the watershed nutrients manifest as problems downstream of the HUC8 watersheds in regional lakes, reservoirs, national waters and international waters. It is important, therefore, that comprehensive watershed management plans address the contribution of nutrients to waters within their HUC8 watershed as well as downstream waters.

What is a Watershed Restoration and Protection Strategy (WRAPS)?

MN Statute 114D.15, Sec. 12, Subd. 13 defines a WRAPS as:

[A] document summarizing scientific studies of a major watershed no larger than a hydrologic unit code 8 including the physical, chemical, and biological assessment of the water quality of the watershed; identification of impairments and water bodies in need of protection; identification of biotic stressors and sources of pollution, both point and nonpoint; TMDLs for the impairments; and an implementation table containing strategies and actions designed to achieve and maintain water quality standards and goals.

Groundwater Protection and the Nitrogen Fertilizer Management Plan

The Comprehensive Groundwater Protection Act of 1989 (Minnesota Statute § 103H) provided direction and authority for water resource protection in Minnesota and especially with regard to nitrogen fertilizer management in Minnesota. This was a result of three separate but related components of the Act: (1) development of a groundwater protection goal; (2) enhanced regulatory authority for fertilizer practices within the Minnesota Department of Agriculture (MDA); and (3) development of a *Nitrogen Fertilizer Management Plan* (NFMP) by MDA.

The NFMP is the state's blueprint for prevention or minimization of the impacts of nitrogen fertilizer on groundwater. The plan must include both voluntary components and provisions for the development of nitrogen fertilizer use restrictions if the implementation of BMPs proves to be ineffective.

Many aspects of the NFMP have been implemented since the adoption of the original NFMP in 1990. In 2010 the MDA began a process to revise the plan to reflect current activities and interagency water protection planning and implementation work, and to better align it with current water resource conditions and program resources.

The following are excerpts from the Draft Plan's Executive Summary written by MDA (2013):

> *The intent of the Nitrogen Fertilizer Management Plan is to prevent, evaluate, and mitigate nonpoint source pollution from nitrogen fertilizer in groundwater. The plan must include components promoting prevention and developing appropriate responses to the detection of nitrogen fertilizer in groundwater. The strategies in the NFMP are based on voluntary BMPs, intended to engage local communities in protecting groundwater from nitrate contamination.*
>
> *The general approach to addressing nitrate in groundwater in Minnesota is to: (1) promote nitrogen fertilizer BMPs to protect groundwater with greater efforts in vulnerable areas to prevent groundwater problems from occurring (ongoing); (2) monitor private wells on a township scale over a 10-year period or use existing monitoring data to identify areas with nitrate concerns; (3) conduct a detailed assessment of water quality in these areas to determine the severity and priority of the problem; and, 4) conduct mitigation actions in high-priority areas using a phased approach starting with voluntary actions and progressing to regulatory actions if necessary.*
>
> *Prevention is significantly emphasized because once groundwater is contaminated; it can be extremely difficult, expensive, and very slow to remediate. Prevention activities within the NFMP are ongoing regardless of the status of mitigation for nitrate in groundwater. A variety of activities can be utilized in order to achieve the NFMP prevention goal including BMPs, alternative management tools, wellhead protection, education and promotion, and local water plans. A Nitrogen Fertilizer Education and Promotion Team will be developed to assist MDA with the coordination of prevention activities and programs.*
>
> *The goal of mitigation is to minimize the source of pollution to the greatest extent practicable and, at a minimum, to reduce nitrate contamination to below the drinking water standard (10 milligrams per liter or 10 mg/L) so the groundwater is not restricted for human consumption. The mitigation strategy is based on the prevention strategy, but implemented over a defined area and at a higher level of effort and intensity. It is intended to have significant local involvement and leadership, especially through the participation of local farmers.*

Red River and Lake Winnipeg Nutrient Strategy

The International Red River Board (IRRB) recognized that excessive nutrients such as phosphorus and nitrogen are one of the greatest water quality issues facing the international Red River watershed and Lake Winnipeg. While all jurisdictions within the watershed have various regulatory frameworks, plans, and approaches in place to reduce the contribution of nutrients to water, the development of an enhanced, coordinated, and systematic strategy across jurisdictional boundaries is desirable. Working with the Red River Basin Commission (RRBC), the IRRB has convened a group to coordinate development of a nutrient strategy that encompasses the three jurisdictions that cover the majority of the Red River basin: Minnesota, North Dakota and Manitoba. The goal is to attain water quality in the Red River that meets the needs of all of the jurisdictions. Implementation of the strategy will be done separately in each jurisdiction, but coordinated through the IRRB and the RRBC. Implementation in Minnesota will be guided by the NRS. Communication between those working on Minnesota's NRS and those working on the IRRB's strategy has ensured compatibility between the two efforts. Communication and coordination will continue as the strategies are implemented within the basin.

Red River at Fargo/Moorhead Photo Credit: MPCA

1.2 Collaborative Process

Interagency Coordination Team

Successful implementation of the NRS will require broad agency support, coordination, and collaboration. An interagency coordination team (ICT) supported development of the NRS and is expected to support its implementation. The ICT consists of representatives from various agencies and organizations that administer key nutrient reduction programs or implement programs that support decisions affecting nutrient loads. The ICT structure includes a high-level Steering Committee composed of senior agency managers and a work group composed of agency program managers. Two sector-specific focus groups were also formed to provide input and direction on NRS development. The Agricultural Sector group includes representation from MDA, Natural Resource Conservation Service (NRCS), Board of Water and Soil Resources (BWSR), MPCA, and University of Minnesota. The Point Source Sector group includes representation from MPCA and Metropolitan Council. Each of these groups met twice to identify potential strategies for nutrient reduction.

ICT Representation

- Minnesota Pollution Control Agency
- Minnesota Department of Agriculture
- Minnesota Department of Natural Resources
- Minnesota Department of Health
- Minnesota Department of Employment and Economic Development
- Board of Water and Soil Resources
- Natural Resource Conservation Service and Farm Service Agency
- United States Geological Survey
- University of Minnesota
- Metropolitan Council

Public Involvement

Public input on the draft NRS was obtained through a formal public comment period which began on October 7, 2013 and extended through December 18, 2013. Outreach activities included draft NRS availability through the *project website* along with summary facts sheets, a series of open houses, presentations, question and answer sessions, and one-on-one discussions. Hundreds of interested residents, agency and other governmental staff, elected officials, and advisors attended over 25 different events during the public comment period which provided the opportunity to learn about the NRS and provide input. A total of 85 comment letters were submitted by individuals or organizations. Many changes were made to update the NRS based on input by commenters.

1.3 Building Blocks

This NRS was developed from several existing foundational efforts which estimated the river nutrient loads, nutrient sources, and effectiveness of BMPs for nutrient reductions. Below are some of these key technical building blocks:

- Phosphorus Source Assessment
- Nitrogen in Minnesota Surface Waters, Conditions, Trends, Sources, and Reductions Report
- Spatially Referenced Regressions on Watershed (SPARROW) Modeling
- Conservation Effects Assessment Project
- Major Watershed Load Monitoring Network
- Major River Monitoring by Metropolitan Council Environmental Services, Manitoba and U. S. Geological Survey (USGS)
- BMP Effectiveness Manuals and Models

Phosphorus Source Assessment

In 2003 concerns about the phosphorus content of automatic dishwashing detergents prompted the passage of legislation requiring a *comprehensive study* of all of the sources and amounts of phosphorus entering publicly owned treatment works and, ultimately, Minnesota surface waters. The assessment conducted for the MPCA by Barr Engineering (2004), with assistance from the University of Minnesota and others, estimated how much phosphorus enters Minnesota's lakes, wetlands, rivers and streams, and where it comes from in each of the state's 10 basins.

The detailed assessment of phosphorus sources report, along with two updates to the study, was used for certain parts of NRS development. In 2007 the phosphorus atmospheric deposition amounts were updated (Barr Engineering 2007), and in 2012 the MPCA updated the phosphorus wastewater point source discharge amounts based on wastewater discharge monitoring reports.

Nitrogen in Minnesota Surface Waters Report

In 2013 the MPCA released *Nitrogen in Minnesota Surface Waters, Conditions, Trends, Sources, and Reductions* describing the nitrogen conditions in Minnesota's surface waters, along with the sources, pathways, trends, and potential ways to reduce nitrogen in waters (MPCA 2013a). The report was developed in response to concerns about nitrogen in Minnesota's surface waters, including: (1) toxic effects of nitrate on aquatic life, (2) increasing nitrogen concentrations in the Mississippi River combined with nitrogen's role in causing the hypoxic zone in the Gulf of Mexico, and (3) the discovery that some Minnesota streams exceed the 10 milligrams per liter (mg/l) standard established to protect potential drinking water sources. The report was developed by the MPCA, University of Minnesota, and USGS. Several parts of the report were used in the NRS, including the nitrogen sources to surface waters assessment, river nitrogen load based on monitoring and modeling, and practices to reduce nitrogen in waters.

SPARROW Modeling

Results from the SPARROW model, which the USGS developed and maintained, was used for this study to estimate nitrogen and phosphorus loads and to estimate nutrient contributions from different sources in Minnesota. The *Nitrogen in Minnesota Surface Waters, Conditions, Trends, Sources, and Reductions* report (MPCA 2013a) contains a chapter on SPARROW modeling for nitrogen in Minnesota.

The SPARROW model integrates water monitoring data with landscape information to predict long-term average constituent loads that are delivered to downstream receiving waters. The SPARROW models are designed to provide information that describes the spatial distribution of water quality throughout a regional network of stream reaches. SPARROW also tracks the attenuation of nutrients during their downstream transport from each source. Models are developed by statistically relating measured stream nutrient loads with geographic characteristics observed in the watershed.

Nutrient estimates for Minnesota were based upon the SPARROW Major River Basin 3 (MRB3) model that Robertson and Saad (2011) developed. The authors used water quality data from 1970 to 2007 to estimate representative loads expected in 2002 at each site. The SPARROW model for the Upper Midwest (Robertson and Saad 2011) incorporates five different nutrient sources, five climatic and landscape factors that influence delivery to streams, and nutrient removal in streams and reservoirs.

SPARROW results were used in certain parts of the NRS to provide comparable watershed nutrient yield and loading data, inform sources of nutrients, and estimate loading in the Lake Superior and Rainy River watersheds.

Conservation Effects Assessment Project

The U. S. Department of Agriculture NRCS Conservation Effects Assessment Project (CEAP) estimated the benefits of the 2002 Farm Bill's increase in conservation funding at a national, regional, and watershed scale. The Upper Mississippi River Basin was one of 13 basins studied in the CEAP. Total nitrogen and phosphorus loading values were estimated for five scenarios: background (no cultivated land), current conditions (2003–2006), no conservation practices, treatment of critical undertreated cropland, and treatment of all undertreated cropland conditions. The latter two scenarios dealt with increasing treatment for undertreated areas and, more specifically, simulated the effects of structural conservation practices, residue and tillage management, and nutrient management.

The recommendations from the CEAP analysis help to inform the general approach to the NRS. Compared to current conditions (based on a 2003 to 2006 operator survey), the study recommends a greater focus on applying conserving practices to undertreated land. The study also recommends complete and consistent use of nutrient management, including appropriate rate, form, timing, and method of application, especially for nitrogen loss in subsurface flows (USDA 2012a).

Watershed Pollutant Load Monitoring Network

The *Watershed Pollutant Load Monitoring Network* (WPLMN) is a multi-agency effort led by the MPCA to measure and compare regional differences and long-term trends in water quality among Minnesota's major rivers including the Red, Rainy, St. Croix, Minnesota, and Mississippi and the outlets of major HUC8 tributaries draining to these rivers. The network was established in 2007. Site-specific streamflow data from USGS and Minnesota Department of Natural Resources (DNR) flow gauging stations is combined with water quality data that the Metropolitan Council Environmental Services, local monitoring organizations, and MPCA staff collected to compute annual pollutant loads at river monitoring sites across Minnesota.

The WPLMN has been collecting water quality at an increasing number of locations since 2007, reaching 79 monitoring sites by 2010. The design scale is focused toward, but not limited to, monitoring HUC8 watershed outlets within the state. Strategic major river mainstem sites are included to determine basin loads and assist with statewide mass balance calculations. Annual water quality and daily average discharge data were coupled in the Flux32 pollutant load model, which Dr. Bill Walker originally developed and the U.S. Army Corps of Engineers and MPCA recently upgraded, to create concentration/flow regression equations to estimate pollutant concentrations and loads on days when samples were not collected. Primary output includes annual and daily pollutant loads and flow weighted mean concentrations (pollutant load/total flow volume). Loads and flow weighted mean concentrations are calculated annually for total suspended solids (TSS), phosphorus, dissolved orthophosphate , nitrate plus nitrite nitrogen (NO3+NO2-N) and total Kjeldahl nitrogen (TKN). The NO3+NO2-N is added to TKN to represent total nitrogen.

These data were compared to SPARROW model results, but were not used directly in NRS development. These data will be critical to future iterations of the NRS as long-term monitoring data become available for the majority of HUC8 major watersheds.

Major River Monitoring by Metropolitan Council Environmental Services, Manitoba, and USGS

Long-term monitoring of nutrients in rivers by three agencies was used for calculating nutrient loads. Table 1-1 summarizes these long-term monitoring efforts. Chapter 3 summarizes these data. Each of these efforts continues to collect data, and therefore newer data are available than presented in the NRS.

Table 1-1. Major river monitoring efforts

Monitoring program	Lead agency	Watershed/stream locations	Years	Load estimation methods
Long-term Resource Monitoring Program	USGS	Mississippi River Upstream and Downstream of Lake Pepin; Mississippi River near Iowa at Lock and Dams 7 and 8	1991–2010	MPCA used multiple year regressions in Flux32.
Metropolitan Council Major Rivers Monitoring Program	Metropolitan Council Environmental Services	Mississippi River at Anoka and Prescott; Minnesota River at Jordan; St. Croix River at Stillwater	1980–2010	Met Council used 1-year concentration/flow data and a single year's flow to calculate loads in Flux32.
Red River	Manitoba Conservation and Water Stewardship and Environment Canada (CWSEC)	Emerson Manitoba	1994–2007	Manitoba CWSEC used monthly water quality and flow data (average of daily) for full period to estimate monthly and annual loads.

Mississippi River at St. Cloud Photo Credit: MPCA

Best Management Practices for Nutrient Reduction

The effectiveness of BMPs and conservation practices for reducing nutrient loads to surface waters was evaluated from several sources. Three key sources of information for agricultural BMPs included: (1) Minnesota AgBMP Handbook; (2) Iowa State University literature review; and (3) University of Minnesota Nitrogen Best Management Practice watershed planning tool (NBMP).

MDA's Clean Water Research Program funded the *Minnesota AgBMP Handbook* (Miller et al. 2012). The handbook describes different BMPs and associated research findings concerning the effect that individual BMPs can be expected to have on reducing pollutants to surface waters, including nutrients.

Iowa recently completed an extensive review of Upper Midwest studies on the effectiveness of nitrogen removal when using various individual and collective BMPs (Iowa State University 2013). This report, part of the *Iowa Nutrient Reduction Strategy*, was developed by a team of scientists led by Iowa State University.

The University of Minnesota developed the *NBMP tool* to enable water resource planners developing either state-level or watershed-level nitrogen reduction strategies to gauge the potential for reducing nitrogen loads to surface waters from cropland, and to assess the potential costs of achieving various reduction goals. The tool merges information on nitrogen reduction with landscape adoption limitations and economics. The tool allows water resource managers and planners to approximate the percent reduction of nitrogen entering surface waters when either a single BMP is applied across the watershed or a suite of BMPs is adopted at specified levels across the watershed. The tool also enables the user to identify which BMPs will be most cost-effective for achieving nitrogen reductions. The spreadsheet was not designed for individual land owner decisions, but rather for large-scale watershed or state-level assessments.

Chapter 2

Setting Goals and Milestones

The *Minnesota Nutrient Reduction Strategy* (NRS) includes goals and milestones for nutrient reduction at multiple scales including supporting goals and objectives for protecting and restoring nutrient sensitive waters within the state, and expected outcomes at the major basin (e.g., Mississippi River Major Basin at the state line) and major watershed (e.g., 8-digit hydrologic unit code [HUC8] watershed) outlets. Progress toward goals and milestones can be tracked over time to determine if strategies are successful and where additional work is needed. The following definitions apply throughout the NRS document:

- **Goal** – Ultimate nutrient reduction desired for water quality improvement, expressed as a percent reduction in load. Goals are expected to be updated as new information becomes available in the various major basins.
- **Milestone** – An interim goal to be achieved, expressed in terms of load reduction. Milestones are used in this NRS to define loading reductions that represent environmental progress.
- **Baseline** – Represents initial time period against which goals are compared and trends in water quality and programmatic implementation are evaluated.

Identifying and integrating downstream needs and objectives with nutrient reduction goals at various watershed scales is an important part of the NRS intended to create a win-win approach for water quality improvement and protection. Downstream needs include total maximum daily loads (TMDLs) for phosphorus-impacted in-state rivers, regional lakes and reservoirs, along with both nitrogen and phosphorus reduction needs for the Gulf of Mexico, Lake Winnipeg, and other out-of-state waters.

2.1 Major Basin-Wide Goals and Milestones

Several existing efforts establish nutrient reduction targets for large drainages within Minnesota and provide a suitable framework for load reduction goals. Individual nutrient reduction goals (phosphorus and nitrogen) in this NRS are included for the following three major river basins (Figure 2-1):

- Mississippi River Major Basin (including the Missouri River, Cedar River, and Des Moines River basins)
- Lake Superior Major Basin
- Lake Winnipeg Major Basin (including the Red River and Rainy River basins)

In addition, a groundwater/source water protection goal is included to address groundwater as a drinking water source. Nutrient reduction needed to improve in-state rivers, lakes, and reservoirs is described in Section 2.2.

Figure 2-1. Minnesota's major basins and basins.

The NRS is based on load reduction goals that have previously been stated in applicable plans or policies. Goals are expressed as a percent reduction from loads during a baseline time period. Table 2-1 presents the goals, which are derived from existing planning goals as found in the following references:

NRS Goals

NRS goals for reductions to Major Basin Waters such as the Mississippi Basin/Gulf of Mexico are based on load reduction goals or water quality targets that have previously been stated in plans or policies.

- **Lake Superior** – Great Lakes Water Quality Agreement of 1978, amended by a protocol signed November 18, 1987.
- **Lake Winnipeg** – The Manitoba Water Stewardship Division developed the Lake Winnipeg Action Plan in 2003. The International Red River Board is currently working on developing nutrient reduction goals, expected to be completed in 2014 or 2015. Goals associated with the 2003 reference are included as provisional goals and are expected to be higher as a result of the International Red River Board plan.
- **Mississippi River (Gulf of Mexico)** – The Mississippi River/Gulf of Mexico Watershed Nutrient Task Force developed the 2008 Gulf Hypoxia Action Plan. Minnesota has assumed a nutrient reduction goal that is proportional to the load reductions needed in the Gulf of Mexico drainage area as a whole, as a percentage of baseline loads. In the future, it is possible that states could be allocated a nutrient load to meet the Gulf of Mexico goals. In the meantime, Minnesota will strive to reduce nutrient loads applying an equitable "fair-share" approach using a proportional reduction of the baseline load. Goals associated with this reference are included as provisional goals since the authorities for downstream waters may adjust the overall goals at some time in the future. Other states are concurrently developing their goals and strategies. It is the mission of the Hypoxia Task Force to coordinate these strategies.
- **Statewide Groundwater/Source Water** – Minnesota Groundwater Protection Act. The 1989 Act's degradation prevention goal states, "It is the goal of the state that groundwater be maintained in its natural condition, free from any degradation caused by human activities. It is recognized that for some human activities, this degradation prevention goal cannot be practicably achieved. However, where prevention is practicable, it is intended that it be achieved. Where it is not currently practicable, the development of methods and technology that will make prevention practical is encouraged."

Table 2-1. Major basin-wide nutrient reduction goals

Major basin	Phosphorus reduction goal	Nitrogen reduction goal
Lake Superior [a]	Maintain 1979 conditions	Qualitative – continued implementation of specific nutrient management programs
Lake Winnipeg [b]	10% reduction from 2003 conditions	13% reduction from 2003 conditions
Mississippi River [c]	45% reduction from average 1980–1996 conditions	45% reduction from average 1980–1996 conditions
Statewide Groundwater/ Source Water	Not applicable	Meet the degradation prevention goal of the Minnesota Groundwater Protection Act

a. Great Lakes Water Quality Agreement of 1978, amended by a protocol signed November 18, 1987.
b. 2003 Lake Winnipeg Action Plan; Provisional goal, milestones to be revised upon completion of the Red River/Lake Winnipeg strategy. Lake Winnipeg Goals are expected to change in the near future, resulting in additional load reduction needs which could approach a 50 percent reduction.
c. 2008 Gulf Hypoxia Action Plan; Provisional goal; Also includes drainage associated with Missouri, Des Moines, and Cedar rivers.

In addition to goals, milestones serve as interim measures of progress and were developed as part of the NRS. Milestones provide a step-wise approach to meeting major basin goals for nutrient reduction and can adapt to the changing landscape, regulatory environment, and suitability of available BMPs.

Milestones are an important component of the NRS because of a variety of factors, including the following:

- The adoption of future water quality standards will drive point source reductions in some watersheds; the timing of standards adoption is critical to long-term planning.
- Additional research and successful pilot demonstrations are required for several types of point and nonpoint source BMPs before widespread adoption.
- Effective nitrogen reductions at wastewater treatment facilities require several years of planning.

Milestone Foundation

The basis for milestone selection is the balancing of meaningful environmental outcomes with achievable actions working together across all sectors. Achieving milestones represents progress toward the goals for nutrient reduction.

Milestones are phased over time, depending on parameter and major basin. One milestone is included in the NRS to address nitrogen reductions in the Mississippi River Major Basin. Milestones for the Lake Winnipeg Major Basin are anticipated in future revisions of the NRS along with higher reduction goals being developed as part of a Red River/Lake Winnipeg strategy to reduce nutrient loading. The International Red River Basin Water Quality Committee has suggested that revised goals for the Red River may be as high as a 50 percent nutrient reduction (IIRB Water Quality Committee meeting June 23, 2014).

Mississippi Nitrogen Milestone–While progress can be made with existing BMPs for nitrogen reduction, achieving nitrogen goals for the Mississippi River will also require research and development of new BMPs and adjustment to some current BMPs to make them more widely applicable. As a result, a longer timeframe is proposed for nitrogen reduction implementation. In addition, nitrate standards for aquatic life that are currently being considered will require several years for approval and implementation. For nitrogen in the Mississippi River Major Basin, a milestone reduction of 20 percent is established with a target date of 2025. Future milestones for nitrogen reduction will be established based on progress toward the milestone, along with adaptations that integrate new knowledge and needs for continued improvement. The timeframe for achieving the provisional goal is likely between 2035 and 2045 and will be refined after the success of future BMP research is evaluated, and as the Gulf of Mexico Hypoxia Task Force further considers timeframes for reaching goals. For now, a projected target date for achieving the NRS provisional goal of 45 percent reduction is 2040.

Table 2-2 presents the target dates for goals and milestones, which are based on reducing major basin outlet loads. Strategies and target dates for goals and milestones will be adjusted through an adaptive management process.

Table 2-2. Timeline for reaching goals and milestones

Major basin	Pollutant	2010 - 2025	2025 - 2040
Mississippi River (Includes the Cedar, Des Moines, and Missouri Rivers)	Phosphorus	Achieve 45% reduction goal	Work on remaining reduction needs to meet water quality standards
	Nitrogen	Achieve 20% reduction from baseline	Achieve 45% reduction from baseline
Lake Winnipeg [a] (Red River Only)	Phosphorus	Achieve 10% reduction goal	Achieve any additional needed reductions identified through international joint efforts with Canada and in-state water quality standards
	Nitrogen	Achieve 13% reduction goal	
Lake Superior	Phosphorus	Maintain goals, no net increase	
	Nitrogen	Maintain protection	
Statewide Groundwater/ Source Water	Nitrogen	Meet the goals of the 1989 Groundwater Protection Act	

a. Timeline and reduction goals to be revised upon completion of the Red River/Lake Winnipeg strategy.

To track progress toward goals and milestones, a series of action and outcome metrics will be needed to maintain appropriate management and adaptation during the implementation of this *Path to Progress* strategy. The Clean Water Accountability Act of 2013 will guide tracking efforts, and might include programmatic annual or biennial reporting. Chapter 7 describes the NRS's adaptive management process in greater detail and highlights reporting on and evaluating progress toward goals and milestones.

2.2 Watershed Load Reductions

Major basin-wide goals are further refined for waters within Minnesota based on meeting state water quality standards. The specific load reductions that are needed at the basin and major watershed scale will be determined by existing or future TMDLs and as part of watershed planning activities (e.g., watershed restoration and protection strategy [WRAPS] and One Watershed One Plans) that will help to focus nutrient reduction activities at the major watershed level. While the NRS is not assigning required load objectives to the HUC8s within Minnesota, local planning that is consistent with the NRS is a key to achieving the goals for waters at the HUC8 outlets and downstream. The NRS includes two guides to determine appropriate HUC8 outlet nutrient reductions that are considered consistent with the NRS goals and milestones. One guide is based on proportional reductions applied across all major watersheds. Another guide adjusts possible reductions for BMP land suitability. Detailed HUC8 reductions are discussed further in Chapter 6.

For many of the Mississippi River Major Basin major watersheds, downstream impacts mean meeting goals at regional waters such as Lake Pepin or Lake St Croix. In the case of Lake Pepin, upstream major watersheds will need to integrate local and downstream reduction needs of lakes and streams undergoing eutrophication and also consider meeting their part of the reduction needs of Lake Pepin at their outlets. These local and regional goals need to be met in addition to meeting the major basin goals and milestones. Comparing phosphorus percent reductions needed at each local resource to downstream goals is beyond the scope of this document. General comparisons of percent reductions are made in Section 2.3.

Water quality standards are used to do the following:

1. Protect beneficial uses, such as healthy fish, invertebrates (bugs), and plant communities, swimming and other water recreation, and human consumption of fish.
2. Evaluate water monitoring data used to assess the quality of the state's water resources.
3. Identify waters that are polluted, impaired, or in need of additional protection.
4. Set effluent limits and treatment requirements for discharge permits and cleanup activities.
5. Serve as the target for TMDLs designed to reduce pollution from all sources to meet designated uses of a given water resource.

Rush River, Tributary to Minnesota River Photo Credit: MPCA

The federal Clean Water Act (CWA) requires states to designate beneficial uses for all waters and develop water quality standards to protect each use. Water quality standards include the following:

- **Beneficial uses** — identification of how people, aquatic communities, and wildlife use our waters.
- **Numeric standards** — allowable concentrations of specific pollutants in a water body, established to protect the beneficial uses.
- **Narrative standards** — statements of unacceptable conditions in and on the water.
- **Nondegradation** — extra protection for high-quality or unique waters and existing uses.

Explicit in the CWA is the presumption that a water body should attain healthy aquatic life and recreation uses unless proven unachievable. Minnesota's rules provide a framework that broadly protects aquatic life and recreation, as well as the following additional uses: drinking water (domestic consumption), industry, agriculture, navigation, and aesthetic enjoyment. Waters not meeting the minimal aquatic life uses are known as *limited resource value waters*, and might have modified standards, but are still protected for the multiple beneficial uses above.

Water quality standards including the beneficial uses of waters, the numeric and narrative criteria to protect beneficial uses, and antidegradation provisions, are included in Minnesota Rules Chapters 7050 and 7052. These water quality standards serve as the basis for wastewater treatment effluent limits to protect receiving water quality. Federal Regulations and Minnesota Rules Chapter 7053 serve as the basis for minimum wastewater treatment requirements and technology-based effluent limits. This NRS only refers to use of the term *water quality standard* as it applies to the conditions of the water resources.

A water body is impaired if it fails to meet one or more water quality standards. Impaired waters are addressed through TMDL studies that set pollutant reduction goals needed to restore those waters.

Relationship Between State Standards and Downstream Goals

Minnesota's existing and forthcoming eutrophication and aquatic toxicity nitrate water quality standards will lead to a reduced load of nutrients to downstream waters, including the Gulf of Mexico. Minnesota is not proposing additional nutrient water quality standards specifically for meeting suggested goals in the Gulf of Mexico. Where water quality standards are established, the standards development process is an independent effort that is not affected by this strategy's analysis. Restoring and protecting the Gulf of Mexico requires a multi-state approach. Minnesota is committed to participating in setting the appropriate targets and loads necessary to meet the hypoxia objectives in the Gulf of Mexico. Rather than iterate specific targets that must be met within Minnesota in relationship to the Gulf of Mexico, this NRS identifies planning goals for downstream waters and shows how progress can be made in reducing nutrient delivery to downstream waters.

The question sometimes arises, "Once we meet all Minnesota water quality standards, will we also be fully addressing the downstream needs in the Gulf of Mexico and Lake Winnipeg?" In-state reductions of phosphorus will be substantial to meet in-state eutrophication and turbidity/total suspended solids standards, and these reductions might be sufficient to meet downstream targets for the Mississippi River. The reduction requirements to meet future in-state nitrogen aquatic life standards are less certain.

Nitrate and eutrophication water quality standards for protection of Minnesota's water resources are important components of the NRS. Both the existing lake and pending river eutrophication standards in Minnesota include phosphorus, but they do not include nitrogen. Eutrophication standards were promulgated for lakes in 2008 and river eutrophication standards are expected to be finalized in 2014. Nitrate toxicity standards to protect aquatic life in surface waters are under development and expected in the next few years.

Phosphorus loading is often directly related to total suspended solids (TSS) in rivers, especially during moderate to high flow events. Minnesota has existing standards for turbidity and plans to replace the turbidity standards with TSS standards. Current TMDLs for turbidity have a TSS surrogate to facilitate the calculation of load allocations.

Promulgation of numeric water quality standards will provide more tools to protect and restore Minnesota's waters and make progress toward meeting goals to reduce Minnesota's contribution of nutrients into downstream waters such as the Gulf of Mexico and Lake Winnipeg. Minnesota's NRS takes into consideration the state-level programs, efforts, and goals which can aid local governmental units in addressing nutrients and thereby achieve these multipurpose goals.

Addressing the mutually beneficial goals of meeting state standards and protection and downstream goals will strengthen local, regional, state, and federal partnerships. This will in turn bring more resources to solving the problems. Additionally, motivation for adopting nutrient reduction measures could increase when these improvements are viewed as benefiting both local and downstream waters.

Reducing nutrient loads in all watersheds, regardless of localized impairments or eutrophication issues, will be necessary to protect many of our in-state and out-of-state downstream waters. Cumulative reductions, if limited to only those changes needed to meet local TMDLs (e.g., at the HUC8 scale) will often not be sufficient to meet regional and downstream needs (e.g., Lake Pepin, Gulf of Mexico).

The following sections describe the potential broad scale nutrient load reductions that can be expected from the following standards:

- Current Drinking Water Nitrate Standards
- Future Aquatic Life Nitrate Toxicity Standards
- Lake Eutrophication Standards
- River Eutrophication Standards
- Turbidity/TSS Standards

2.2.1 Current Drinking Water Nitrate Standards

Streams

Reductions in nitrate loads to achieve surface water drinking waters standards will be needed in a relatively small portion of Minnesota's surface waters. The 10 mg/l drinking water standard applies to cold-water streams (trout streams) in Minnesota. The overall stream miles covered by the existing standard are a relatively minor portion of the total stream miles in Minnesota (Figure 2-2). Several streams in the karst region of southeast Minnesota need nitrate reductions to meet the 10 mg/l standard.

Few streams have been listed on the State's Impaired Waters List for exceeding the 10 mg/l nitrate threshold (Figure 2-2). In 2011 the Impaired Waters List noted 15 cold-water streams in Minnesota as not meeting the 10 mg/l nitrate water quality standard established to protect potential drinking water supplies. Twelve of the fifteen were in southeastern Minnesota. Because nitrate-impaired watersheds are of limited geographic extent, nitrate reduction measures implemented to meet these standards are not expected to result in substantial annual nitrogen load reductions to the Mississippi River.

Surface waters are important drinking water sources for many Minnesotans, including the citizens of Minneapolis and St. Paul. Roughly 23 percent of Minnesotans get their drinking water from surface water supplies, primarily the Mississippi River. Fortunately, nitrate levels in the Mississippi River near the direct or indirect intakes for these cities are approximately 1 mg/l or less, so reductions are not currently needed to protect human health. However, protection of surface waters for nitrate is still important to ensure safe supplies of drinking water into the future.

Groundwater

Seventy-seven percent of Minnesota's population gets its drinking water from groundwater. Groundwater is an important source of drinking water throughout most of Minnesota, including many areas where aquifers have nitrate that exceeds the drinking water standard of 10 mg/l. Nitrate in groundwater used as a drinking water source is a concern in several areas in Minnesota that are susceptible to contamination (Figure 2-3).

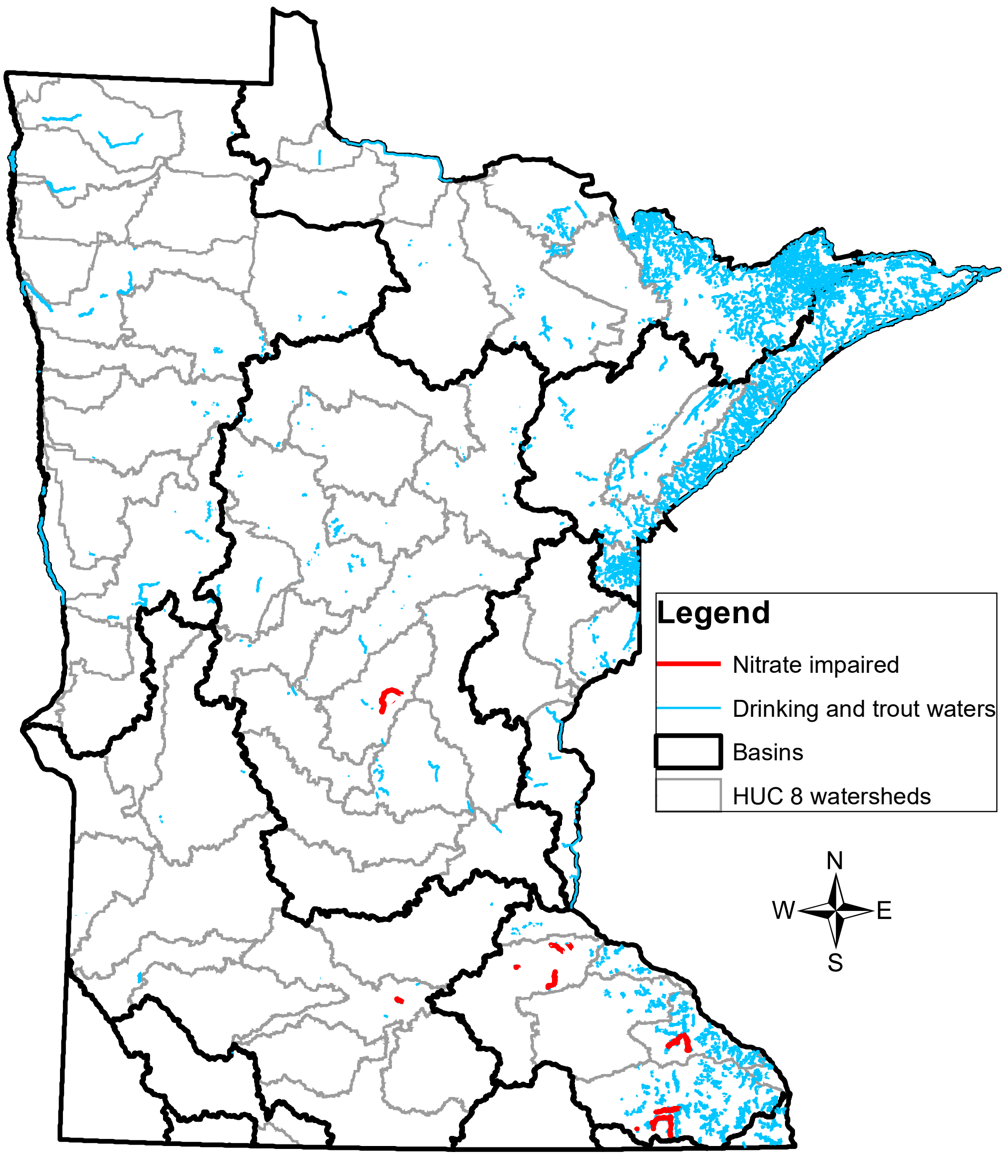


Figure 2-2. River and stream reaches protected as drinking water sources, including cold-water streams. The blue waters have a 10 mg/l nitrate drinking water standard and the red waters have a nitrate impairment based on exceedances of the drinking water standard.

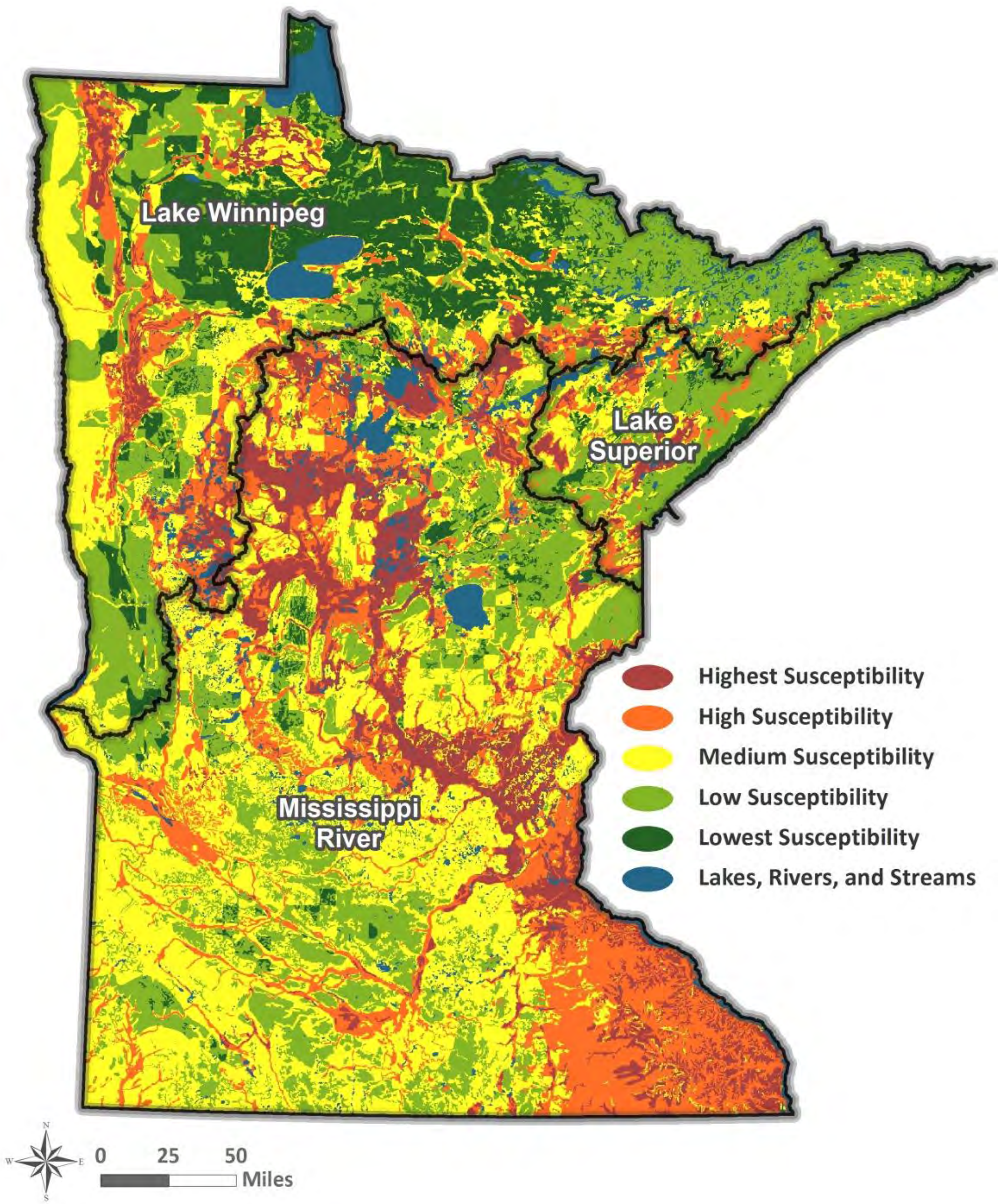


Figure 2-3. Groundwater susceptibility to contamination (MPCA 1989).

2.2.2 Future Aquatic Life Nitrate Toxicity Standard

Toxicity studies to determine safe levels of nitrate for aquatic life will inform the nitrate aquatic life standard rule-making process. Future aquatic life nitrate toxicity standards will be developed based on protecting designated uses of surface waters. The nitrate standard development process is independent from the NRS. Analyses conducted for this strategy will not be used to establish numeric nitrate standards.

Future Aquatic Life Nitrate Toxicity Standard and the NRS

Aquatic life nitrate toxicity standards will be developed based on protecting designated uses of Minnesota's surface waters.

Since ambient stream conditions have higher nitrate levels in the southern part of the state, it is anticipated that a nitrate aquatic life standard might have a larger influence in this area. In the Minnesota River Basin, nitrate levels are generally highest in May and June when flow is elevated. If the state standard for nitrate is exceeded during this high loading period, then reduction strategies to meet state standards will combine with the state-level *Path to Progress* strategy to reduce downstream loads. The potential for downstream reductions due to the forthcoming standard is not known at this time, since the nitrate standard for warm-water streams (Class 2B) has not been established. A standard as low as 5 mg/l nitrate would require reductions in annual loading of roughly 50 percent throughout much of southern Minnesota, whereas a standard greater than 15 mg/l would require only minor reductions over much smaller geographic areas. Much of the northern half of the state would not need to reduce nitrate levels, even for a nitrate standard set as low as 5 mg/l. Wastewater reductions required by a new standard will also depend on the concentration of the standard. Preventing elevated nitrate in watersheds where nitrate is generally low currently should be a point of emphasis in addition to reducing downstream loads.

2.2.3 Lake Eutrophication Standards

With lake eutrophication standards in place and river eutrophication standards are pending final approval, Minnesota is better positioned to evaluate the relationship between in-state phosphorus reduction needs and corresponding downstream phosphorus reduction potential. Both lake and river eutrophication standards in Minnesota include phosphorus, but they do not include nitrogen. Direct comparisons of phosphorus reduction needs for distant downstream water resources can be challenging due to the timing of peak phosphorus loads and temporal responses to phosphorus loading in resources being compared. Fortunately, modeling results exist for high phosphorus-loading areas such as the Minnesota River Basin.

Currently, 520 lakes (including bays of lakes) and reservoirs are listed as impaired due to eutrophication based on the standards in Table 2-3. While most of the drainage areas for lakes are quite small, there are reservoirs, flowages and regional lakes such as Lake Pepin with very large watersheds. These waterbodies have watersheds that receive water from more than 70 percent of Minnesota's land area (Figure 2-4). The spatial, seasonal, and annual distribution of phosphorus loadings within these watersheds is variable. Individual or watershed TMDLs will identify where phosphorus reductions are needed, sometimes at very large scales, within a watershed. Several TMDLs have been initiated or completed for lakes with the largest watersheds (Table 2-4).

The percent reductions for in-lake phosphorus concentration in impaired lakes needed to meet state-applicable standards varies throughout the state. The overall average percent reduction needed is 45 percent from 2002–2011 concentrations for the lakes with sufficient data (Figure 2-4 and Table 2-5). Lake Pepin, a flowage or riverine lake on the Mississippi River, requires an approximate 43 percent phosphorus load reduction compared to pre-2006 conditions to meet a proposed site-specific standard for the lake. Both of these reduction percentages are comparable to the 45 percent phosphorus reduction needed to meet long-term goals established for the Gulf of Mexico. However, the baseline period for measuring progress towards Gulf of Mexico hypoxia goals (1980–1996) is much earlier than the baseline for reductions for Lake Pepin (2006) and other in-state needs. Because progress was made toward achieving the goals after the Gulf of Mexico hypoxia baseline but before the Lake Pepin and other later baselines, there are some needed in-state reductions that are greater than the NRS goal for the Gulf of Mexico.

Table 2-3. Minnesota's lake eutrophication standards. A lake must exceed the cause variable (phosphorus) and one of the response variables chlorophyll-a (chl-a) or transparency (Secchi)) to be considered impaired.

Ecoregion (classification)	Phosphorus (ug/L)	Chl-a (ug/L)	Secchi (m)
NLF – Lake trout lakes	≤12	≤3	≥4.8
NLF – Stream trout lakes	≤20	≤6	≥2.5
NLF – Deep and shallow lakes	≤30	≤9	≥2.0
CHF – Stream trout lakes	≤20	≤6	≥2.5
CHF – Deep lakes	≤40	≤14	≥1.4
CHF – Shallow lakes	≤60	≤20	≥1.0
WCP & NGP – Deep lakes	≤65	≤22	≥0.9
WCP & NGP – Shallow lakes	≤90	≤30	≥0.7

Notes: Northern Lakes and Forest (NLF), Central Hardwood Forest (CHF), Western Cornbelt Plains (WCP) and Northern Glaciated Plains (NGP).

Lake Pepin Photo Credit: Guy Schmickle

Table 2-4. Key eutrophication-impaired lakes with large watersheds in Minnesota (phosphorus reductions)

Lake Pepin (48,634-square-mile watershed)

- Draft phosphorus reductions needed from contributing watersheds to meet standard in Lake Pepin
  - 50% in Minnesota River
  - 20% in St. Croix River
  - 20% in Upper Mississippi River
  - 50% in Cannon River
  - Reduced point source loads
- Hundreds of impaired lakes within Lake Pepin watershed
  - **Lake St. Croix** (contributing watershed: 7,674 square miles)
  - **Lake Byllesby** (contributing watershed: 1,116 square miles)

Lake of the Woods (Contributing watershed: 26,930-square-mile watershed)

- Approximately 10% reduction needed

Lake Zumbro (845-square-mile watershed)

- Approximately 40% reduction needed

South Heron Lake (467-square-mile watershed) and **Talcot Lake** (519-square-mile watershed)

- Approximately 80% reduction needed for both lakes

Table 2-5. Percent phosphorus reduction from average monitored condition (2003–2012) to meet applicable standards for impaired lakes with sufficient data to make calculations

Basin	Minimum	Average	Maximum	Count (number of lakes in dataset)
Cedar	48%	62%	73%	6
Des Moines	23%	47%	81%	13
Lower Mississippi	29%	67%	95%	36
Superior	11%	36%	90%	7
Minnesota	<5%	47%	95%	93
Missouri	20%	49%	73%	5
Red River	<5%	32%	71%	23
Rainy River	<5%	27%	55%	5
St. Croix	<5%	45%	88%	50
Upper Mississippi	<5%	42%	95%	195
Statewide average/total	**45%**			**433**

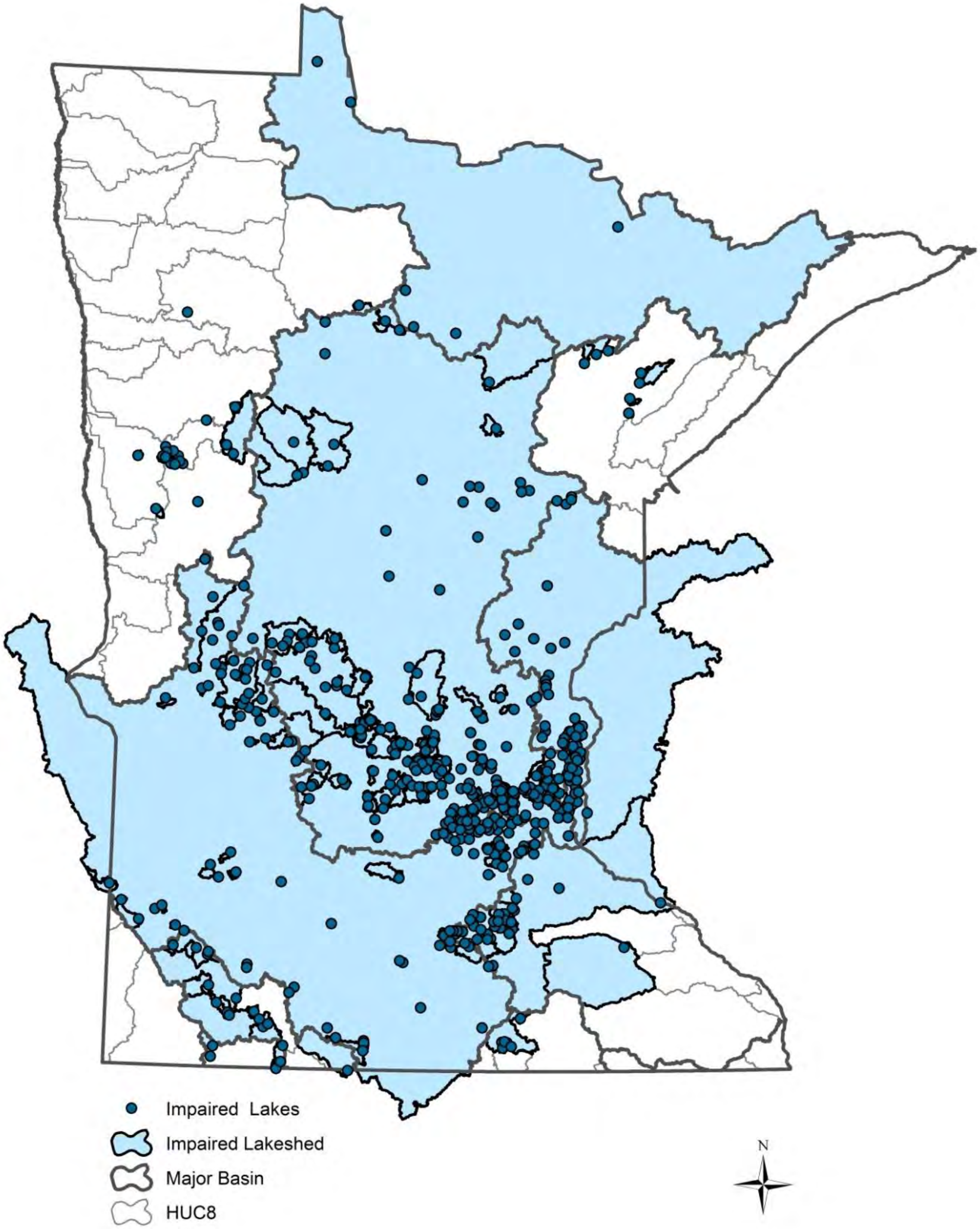


Figure 2-4. Contributing watersheds of lakes and reservoirs impaired due to eutrophication.

Note: Some watersheds of impaired lakes are very small and might not be visible on this graphic.

2.2.4 River Eutrophication Standards

Table 2-6 and Table 2-7 show Minnesota's pending river eutrophication standards, which are pending final approval at the time of this NRS. The phosphorus reductions needed to meet river eutrophication standards are highly variable throughout Minnesota based on data from the past 10 years. Only phosphorus and chlorophyll-a (chl-a) were assessed for the purposes of NRS development. Approximately 38 percent of streams and rivers in the state with 12 or more observations of both phosphorus and chl-a are meeting both the total phosphorus and response variable criteria as included in the pending river eutrophication standards (Figure 2-5). Eighteen percent of rivers with sufficient data exceed both the cause (phosphorus) and response (chl-a) variable of pending river eutrophication standards. These watersheds will need to reduce phosphorus loads to meet standards. The remaining 44 percent of rivers with sufficient data exceed the phosphorus variable of eutrophication standards, but do not exceed the chl-a response variable in the local reach. Some of these river reaches are upstream of other reaches impaired for river eutrophication standards or lake eutrophication standards. For example, the Minnesota River Basin has 21 reaches that are not locally impaired for river eutrophication standards, but would need reductions to meet standards at the Lower Minnesota River at Jordan, Minnesota (projected to be impaired for river eutrophication standards), and Lake Pepin (impaired for lake eutrophication standards). Other river reaches, such as several of those in the Red River of the North Basin, have elevated phosphorus, but specific eutrophication concerns have not been identified, except for the downstream Lake Winnipeg. Reduction targets from Minnesota rivers upstream of Lake Winnipeg are not well refined at this time, so it is difficult to project the load reduction needed.

The phosphorus load reductions from existing conditions needed to meet pending river eutrophication standards in the potentially impaired rivers average 41 percent for potentially impaired rivers (Table 2-8). These reductions are similar to both average phosphorus reductions needed to meet standards for lakes (45 percent) and Mississippi River (Gulf of Mexico) phosphorus reduction goals (45 percent from the baseline). While these phosphorus reduction needs are similar in percentage reduction, the process of crediting implementation activities towards progress will depend on when the actitivy occurred relative to the designated baseline period. All nutrient reduction activities that have occurred since the 1980-1996 baseline time period for the Mississippi River Major Basin goal can be used to show progress towards meeting that goal. However, those same activities may not be credited toward meeting pending river eutrophication standards or TMDLs that have been established more recently (much later than the 1980-96 baseline period for the Gulf of Mexico).

Table 2-6. Pending river eutrophication standards by river nutrient region for Minnesota

Region	Causal variable (nutrient) Phosphorus µg/L	Response variables Chlorophyll-a µg/L	Dissolved oxygen flux mg/l	5-day biochemical oxygen demand mg/l
North	≤50	≤7	≤3.0	≤1.5
Central	≤100	≤18	≤3.5	≤2.0
South	≤150	≤35	≤4.5	≤3.0

Table 2-7. Draft criteria for mainstem rivers, Mississippi River pools, and Lake Pepin. Concentrations expressed as summer averages. Assumes aquatic recreational and aquatic life uses are maintained if phosphorus and chlorophyll-a are at or below criteria levels.

River/Pool	Site	Data source	Phosphorus µg/l	Chlorophyll-a µg/l
Rivers				
Mississippi River at Anoka[1]	UM-872	MCES	100	18
Lake St. Croix[3]	SC-0.3	MCES	40	14
Minnesota River at Jordan[1]	MI-39	MCES	150	35
Pools and Lake Pepin				
Pool 1[2]	UM-847	MCES	100	35
Pool 2[4]	UM-815	MCES	125	35
Pool 3[4]	UM-796	MCES	100	35
Pepin (Pool 4)[5]	Four fixed sites	LTRMP	100	28
Pools 5-8[6]	Near-dam	LTRMP	100	35

Notes: MCES - Metropolitan Council Environmental Services; LTRMP - Long-Term River Monitoring Program
1. River eutrophication criteria-based. Based on modeling UM-872 and MI-3.5 criteria will meet Pepin requirements.
2. Minimize frequency of severe blooms. Upstream criteria provide additional protection for Pool 1.
3. Minnesota lake eutrophication criteria-based. Based on modeling St. Croix outlet (SC-0.3) would meet Pepin requirements.
4. Minimize frequency of severe blooms and meet Pepin requirements.
5. Phosphorus consistent with Wisconsin standard. Lake Pepin criteria assessed based on mean from four monitoring sites.
6. Minimize frequency of severe blooms; upstream phosphorus requirements benefit lower pools. Wisconsin standard of100 µg/L could apply to Pools 5—8.

Table 2-8. Preliminary analysis of all available phosphorus and chl-a levels in river and stream reaches in Minnesota compared to pending river eutrophication standards. Monitoring data are from 2003–2012. Percent reduction is the average reduction to meet phosphorus variable of river eutrophication standards.

	Elevated phosphorus and chlorophyll-a		Meets standard		Elevated phosphorus only		Total stream reaches
Basin	Count	% phosphorus reduction	Count	% phosphorus reduction	Count	% phosphorus reduction	
Cedar	3	52%	2	NA	3 [a]	42%	8
Des Moines	2	39%	--	--	1 [a]	91%	3
Lower Mississippi	5	63%	9	NA	29 [a]	52%	43
Minnesota	20	35%	3	NA	21 [b]	42% [b]	44
Missouri River	--	--	--	--	2 [a]	42%	2
Rainy River	--	--	10	NA	8 [b]	12% [b]	18
Red River	2	62%	22	NA	18 [a]	36%	42
St. Croix	2	19%	2	NA	1 [b]	9% [b]	5
Superior	--	--	9	NA	--	--	9
Upper Mississippi	14	42%	43	NA	34 [b]	37% [b]	91
Grand Total	**48**	**41%**	**100**	**NA**	**117**	**40%**	**265**

Note – This chart is only for streams with sufficient phosphorus and chl-a data (minimum 12 observations each).
a. Downstream resources might be beyond state boundaries.
b. Stream reaches with elevated phosphorus will only need to reduce if a downstream water exceeds response variable.

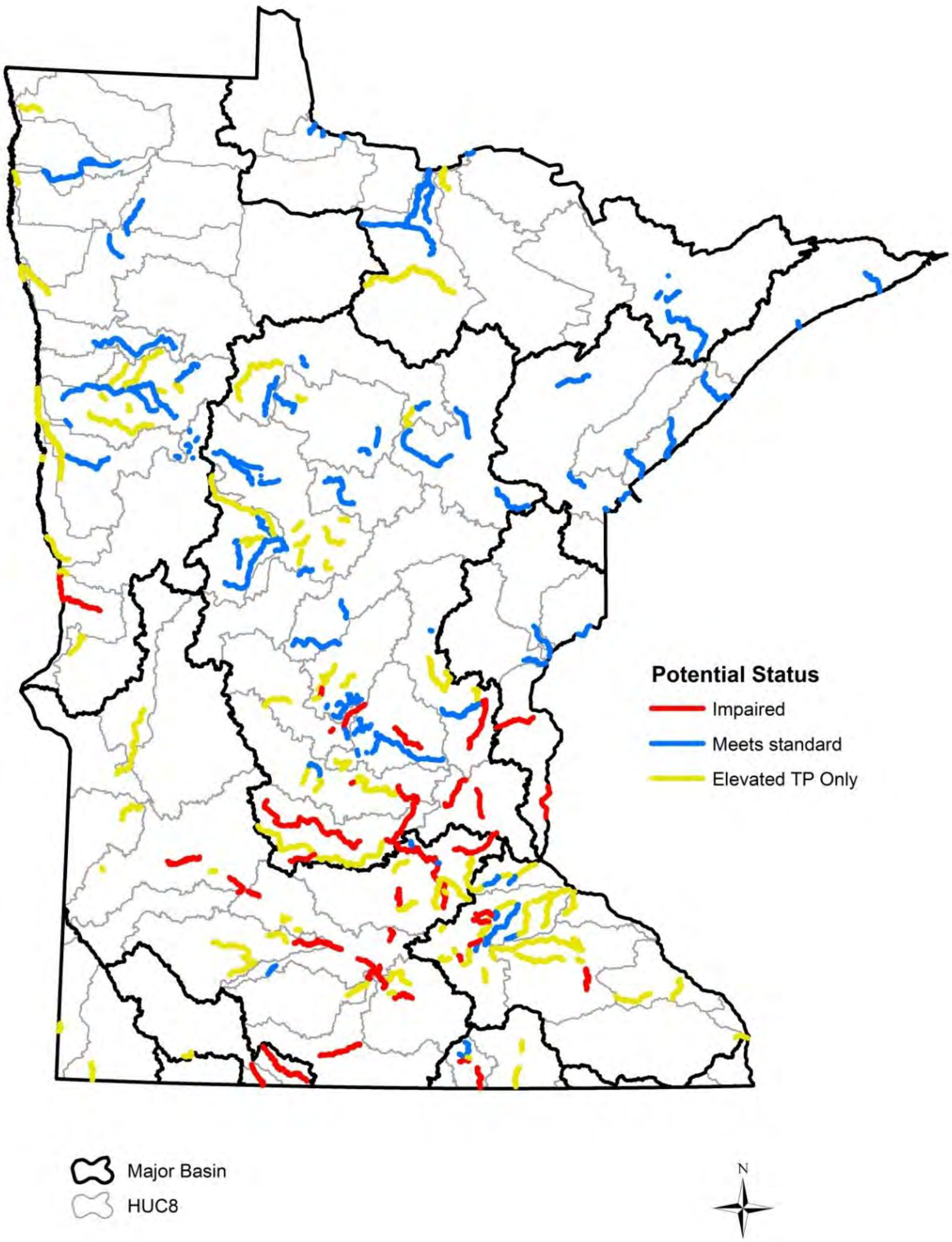


Figure 2-5. Projected status of assessed rivers potentially impaired by the pending river eutrophication standards (red) and rivers that exceed the phosphorus part of the standard, but do not also exceed the chl-a response variable (yellow).

2.2.5 Turbidity/TSS Standards

Phosphorus is typically attached to suspended particles in river systems. Minnesota has many streams and rivers listed on the Impaired Waters List due to excess turbidity (Figure 2-6). As previously noted, TSS is often used as a surrogate for turbidity to facilitate load calcuations for TMDLs. In some cases, high turbidity has resulted in diminished light penetration, making this a co-limiting factor for eutrophication. Increasing light penetration could increase the effect of phosphorus on eutrophication. It should be noted that suspended algae (measured via chlorophyll-a) need longer residence times and lower flow/velocity conditions to develop higher levels. Even though the TSS levels in many of the state's rivers are eleveated during high flows, TSS often drops during lower flows and algae levels can increase dramatically during low flows. The Minnesota River is an excellent example of a river with high TSS levels during higher flows and high algae levels during lower flows.

Reducing turbidity/TSS could result in lower phosphorus levels in streams, especially during high flows. Reductions in turbidity/TSS will be an important driver for phosphorus reductions in areas where response variables for lake and river eutrophication standards are not exceeded. For instance, there is limited algal growth in portions of the mainstem of the Red River of the North. Thus, nutrient reductions might not be needed for meeting lake or river eutrophication standards. In this river, reductions for turbidity and TSS may be the main driver for phosphorus reductions, along with eutrophication considerations for Lake Winnipeg.

The turbidity standard will also be important in rivers exceeding the pending river eutrophication standards, since river eutrophication standards only apply from June through September. There is substantial loading of phosphorus associated with TSS during March through May. This timeframe is extremely important to downstream loading and it can be the driver of internal loading in some downstream lakes. The proposed TSS standards will apply from April to September. The current turbidity standard applies to the entire year.

MPCA has extensive watershed modeling results for the Minnesota River Basin to demonstrate the impact of TSS (surrogate for turbidity) reductions on phosphorus concentration and loads. Multiple scenarios of various combinations of BMPs were simulated to determine if a given set of BMPs could meet TSS standards throughout the Minnesota River Basin. Results show that a 27 percent reduction in annual phosphorus load will be achieved in the lower Minnesota River if an aggressive set of sediment reduction BMPs were adopted throughout the Minnesota River Basin. Further reduction of TSS would still be required, and could be achieved through stabilization of streambanks, streambeds, and bluffs. Therefore, meeting the TSS standard will likely achieve a more than a 27 percent reduction in phosphorus.

In summary, reductions to meet turbidity and future TSS standards will result in reduced loads of phosphorus during moderate to high flows in rivers. Therefore phosphorus reductions will be realized through TSS reductions in streams which do not exceed river eutrophication standards, but which have elevated phosphorus and TSS. TSS and associated phosphorus reductions will be most important for downstream resources such as Lake Pepin and the Gulf of Mexico. Lake and river eutrophication standards will be important for limiting phosphorus at average to low flows during the summer, when algal production in rivers and lakes is most problematic.

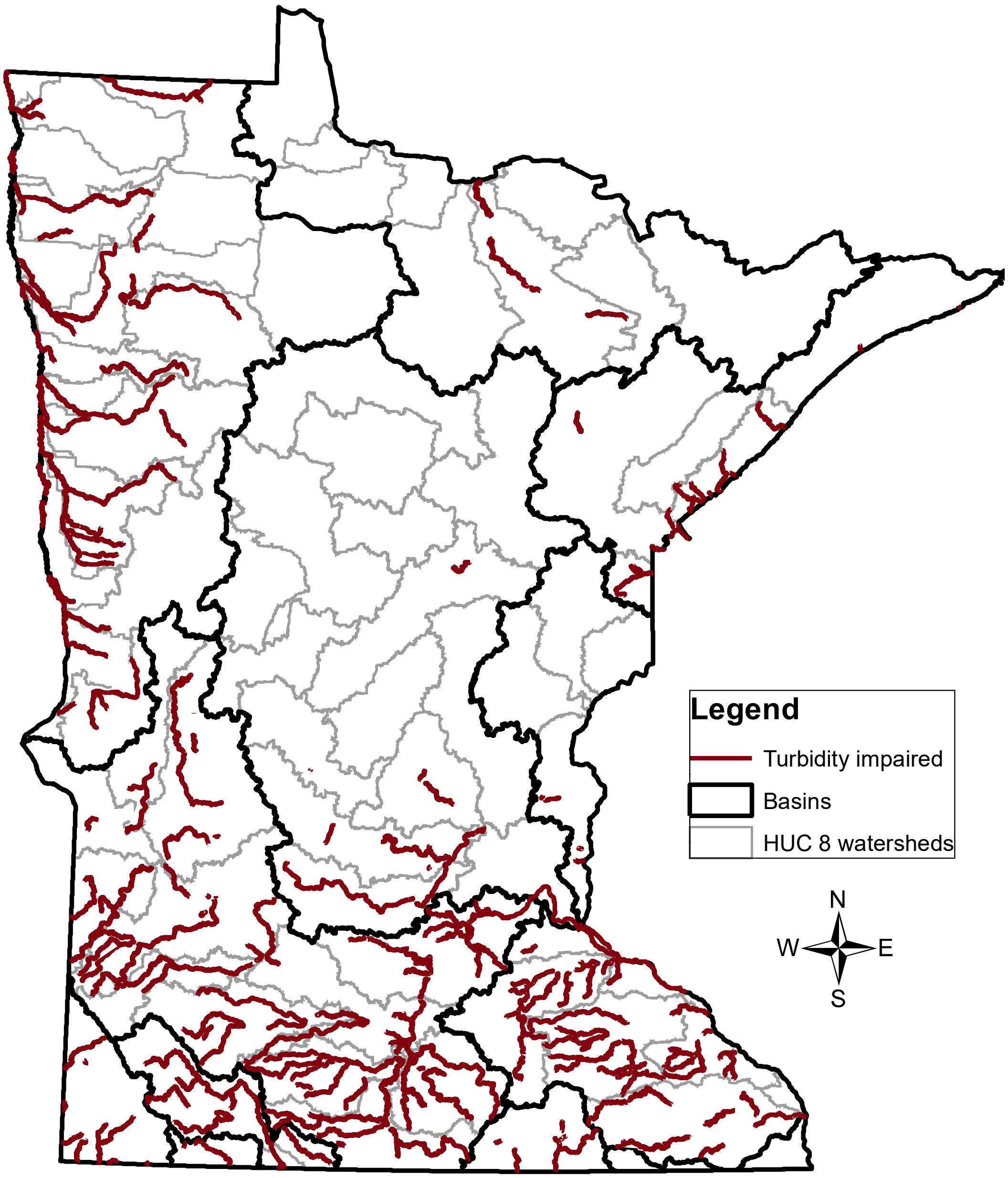


Figure 2-6. Turbidity-impaired streams included on 2012 Impaired Waters List.

The Lower Minnesota River Dissolved Oxygen TMDL

In addition to impaired lakes, streams and rivers can also be impaired due to nutrients, even without river eutrophication standards. For example, a river can be impaired due to low dissolved oxygen (DO) and a TMDL is developed to reduce phosphorus and achieve the DO criterion. The largest and most relevant example in the state is the Minnesota River.

The Lower Minnesota River Dissolved Oxygen TMDL established a phosphorus loading capacity during the 61-day critical low flow period (MPCA 2004). This loading capacity represents a reduction of 29,751 pounds from the "current day" loading estimate of 75,620 pounds (1988 critical low flow period with 1999–2000 land use and point source loading), which is a 39 percent reduction in load within this time period. The Dissolved Oxygen TMDL has been very successful for reducing wastewater point source loads, which are a major factor during low flow periods.

2.3 Basin Scale Comparison of Local and Downstream Reductions Needs

Eutrophication and TSS impairments are a common issue in central and southern Minnesota (Figure 2-7). In this area of the state, both lakes and rivers need improvement. The north-central and northeastern areas of the state need less reduction of phosphorus. Moderate reductions are necessary in the northern portions of the Lake St. Croix and Lake Pepin watersheds. The Lake of the Woods watershed will also require some targeted reductions. Far fewer rivers and lakes in this area of the state have elevated phosphorus compared to proposed and existing standards.

As the following sections describe, a focus on state phosphorus-related standards and protection for major rivers and regional lakes and reservoirs will likely result in long-term, out-of-state downstream needs being met. Basin and major watershed planning activities (e.g., WRAPS and comprehensive watershed management plans) will help focus phosphorus reduction activities at the smaller watershed level. For nitrogen, the NRS focuses on downstream waters, since at this time existing local surface and groundwater standards will not sufficiently reduce nitrogen loads going to out-of-state waters. The following section discusses the downstream effects of meeting existing lake standards and proposed river standards in each individual basin.

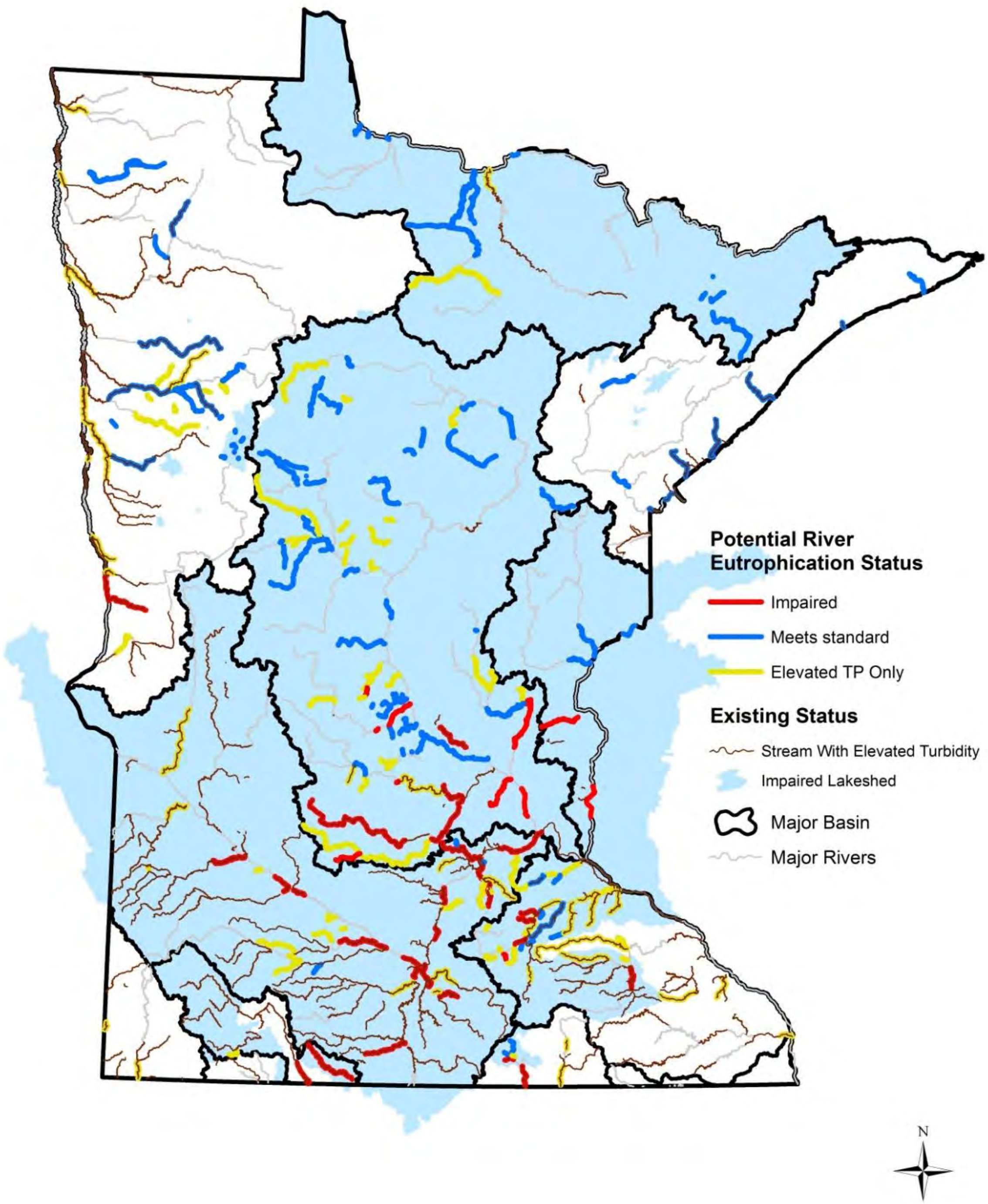


Figure 2-7. Summary of turbidity-impaired streams, streams with potential eutrophication impairments, and watersheds of eutrophication-impaired lakes in Minnesota. Note: Not all water resources in Minnesota have sufficient data to assess for eutrophication and turbidity.

2.3.1 Mississippi River/Gulf of Mexico Major Basin

Upper Mississippi River

The Upper Mississippi River Basin transitions from watersheds with limited eutrophication issues in the northern portion of the basin to watersheds with more eutrophication issues in the southern portion of the basin. Unlike the lower Minnesota River, which clearly exceeds the pending river eutrophication standards, the Mississippi River at Anoka is essentially at the pending river eutrophication standards. Therefore, the downstream driver for phosphorus reductions is Lake Pepin, which is outside the basin. Pool 2 of the Mississippi River is close to exceeding the proposed chl-a threshold. Key major watersheds for phosphorus reductions include the South Fork Crow River, North Fork Crow River, and Sauk River. As with the Minnesota River, management to meet phosphorus targets at the major watershed outlets could be an approach to meeting the target for the downstream resource.

Portions of this basin have high densities of lakes. This basin has the most eutrophication-impaired lakes in the state, including key lakes such as the Horseshoe Chain (near the outlet of Sauk River watershed), Big Sandy Lake, and several others. Management in the watersheds of these lakes will be important to both local and downstream eutrophication issues. The average percent reduction needed for eutrophication-impaired lakes in the basin is 42 percent.

Minnesota River

Forty-four reaches in the Minnesota River Basin had sufficient data to determine if a given stream reach would exceed the pending river eutrophication standards. These reaches included the majority of the major watershed outlets in the Minnesota River Basin. Of the 44 reaches in the Minnesota River Basin, 20 have chl-a levels above the pending river eutrophication standards. The average reduction to meet the local eutrophication standard (phosphorus equals 150 ug/L) for these waters is 35 percent. There are 21 additional reaches with elevated phosphorus, but these reaches do not exceed the chl-a variable of the pending river eutrophication standards. If it is assumed that these reaches need reductions to meet the local TP standard to protect downstream waters despite the lack of local response, then these reaches would need to be reduced by 44 percent. Of the 44 reaches, only 3 actually meet both the phosphorus variable and response variables of the pending river eutrophication standards. The downstream reach of the Minnesota River at Jordan and Lake Pepin have total phosphors (nutrient/cause variable) and chl-a (response/stressor) levels above the pending river eutrophication standards and existing lake standards, respectively, and therefore there are downstream needs to reduce phosphorus from the entire Minnesota River Basin. A proposed approach to managing phosphorus in the Minnesota River Basin would be to meet the 150 µg/l phosphorus target at the major watershed outlets (HUC8s) including the Lower Minnesota River major watershed. There are some additional considerations for the metropolitan portion of the Minnesota River such as the low dissolved oxygen TMDL and Lake Pepin, but these have/will be addressed in a basin-wide TMDL , such as the Lake Pepin TMDL.

Currently completed assessments show that there are also 112 lakes in the Minnesota River Basin that need in-lake concentrations reduced by an average of 47 percent from average phosphorus concentration monitored from 2003–2012 for each individual lake. While the number of lakes identified with phosphorus-based impairments is likely to increase, the watersheds for the smaller lakes are relatively small themselves, so the impact of meeting lake standards in the basin will not be nearly as large as meeting river standards. Reducing loads to lakes will be important to local watershed efforts and provide some load reductions at the major watershed scale.

Reductions needed throughout the Minnesota River Basin for turbidity/TSS impairments, lake eutrophication standards, and river eutrophication standards will conservatively result in loading reductions from 30 to 50 percent. Annual phosphorus loads in the lower Minnesota River are projected to be reduced by greater than 27 percent from turbidity BMPs based on modeling runs. Improvements in wastewater point source loads have occurred throughout the basin due to a low DO TMDL, along with additional requirements for Lake Pepin. Key major watersheds that contribute to downstream loading include the Greater Blue Earth River and Lower Minnesota River. These major watersheds have greater water and phosphorus yields than the western portion of basin due to higher levels of precipitation.

Lower Mississippi River

There have been fewer studies of the Mississippi River in Minnesota downstream of Lake Pepin (Lower Mississippi River). Wisconsin has a 100 µg/l phosphorus standard for the Mississippi River downstream of Lake Pepin and Minnesota has proposed eutrophication standards of 100 µg/l phosphorus and 35 µg/l chl-a. The Lower Mississippi River currently exceeds 100 µg/l phosphorus, but it is uncertain if the chl-a target is exceeded at any of the Dams 5–-8. The water coming out of Lake Pepin plays a critical role in driving the concentration of the Lower Mississippi River, since it is approximately 74 percent of the drainage area of the Mississippi River at Lock and Dam 8. The phosphorus standards for the Wisconsin tributaries to the Lower Mississippi River are 100 µg/l phosphorus for larger rivers such as the Chippewa River and 75 µg/l for wadeable streams. Minnesota has proposed eutrophication standards of 100 µg/l phosphorus and 18 µg/l chl-a for the tributaries of the Lower Mississippi River.

Turbidity impairments are prevalent in the Lower Mississippi Basin. A large portion of the basin is in the driftless area ecoregion, which has steeper slopes that are vulnerable to erosion. Management of turbidity/TSS impairments throughout the basin will be critical to reducing phosphorus during high flows. Local turbidity protection will result in downstream phosphorus load reductions.

Key lakes in the Lower Mississippi Basin include Lake Pepin, Lake Byllesby in the Cannon River watershed, and Lake Zumbro. Reductions to meet lake eutrophication standards, along with reductions to meet river standards in Wisconsin will likely result in achieving the 100 µg/l phosphorus standard in the Lower Mississippi. The Root River watershed is one watershed that might not exceed the response variable of river eutrophication standards, and thus local reductions will not be necessary. Some streams in the Root River watershed do not exceed the phosphorus variable of the river eutrophication standards during summer. High levels of phosphorus in the Root River watershed are mostly linked to excess turbidity so reducing phosphorus will be linked to meeting the turbidity standard.

Cedar, Des Moines, and Missouri Rivers

The Cedar River Basin has both lake and river eutrophication drivers. Reductions needed in the Shell Rock River range from 36 to 69 percent. This is also one of the few basins where wastewater point sources of phosphorus have not been reduced in the past 10 years. The cities of Albert Lea and Austin represent large phosphorus sources in this basin.

The Des Moines Basin has both lake and river eutrophication drivers. Meeting all applicable lake eutrophication standards, river eutrophication standards, and turbidity/TSS standards will result in substantial reductions of downstream phosphorus loads. Key lakes draining over half of the basin are Heron Lake and Talcot Lake. Both of these lakes need 80 percent phosphorus reductions from current levels to meet lake eutrophication standards. Two potentially impaired river reaches will need a 39 percent reduction to meet river eutrophication standards. One of these river reaches is the outlet of the Des Moines River Basin.

Turbidity/TSS reductions will be the main driver in the Missouri River Basin to reduce downstream phosphorus loads. Rivers and streams in the basin are relatively small, which limits production of suspended algae.

St. Croix River

Lake St. Croix is located at the outlet of this basin. A TMDL has been completed for the lake, which requires a 20 percent reduction of phosphorus from levels observed over the past 10 years. This reduction, along with other proposed reductions in other basins, is sufficient to meet the reduction needed for the draft Lake Pepin TMDL. Reductions in select watersheds in the southern portion of the St. Croix River Basin to meet local lake and river eutrophication standards will be key to meeting standards in Lake St. Croix and Lake Pepin. The northern portion of the basin has fewer eutrophication and TSS impairments. Any slight reductions needed in the northern portion of the basin will have limited impact on downstream loading.

St. Croix River Photo Credit: MPCA

2.3.2 Winnipeg Major Basin

Red River

Phosphorus is high in the Red River Basin, but there are relatively few local impacts. There are some lake and river eutrophication issues in the headwaters of the basin. Once phosphorus loads enter the mainstem of the Red River, turbidity limits algal production. Reductions in TSS should help dramatically lower phosphorus loads, benefitting downstream Lake Winnipeg. Downstream goals for Minnesota that are needed to protect Lake Winnipeg are expected to change in the near future.

Rainy River

The Rainy River Basin generally meets the applicable lake and river eutrophication standards. The main driver for phosphorus reductions in this basin is Lake of the Woods, which is impaired due to eutrophication. None of the river reaches with adequate data exceed the chl-a variable of the pending river eutrophication standards. River reaches that exceed the proposed phosphorus variable of river eutrophication standards in the basin would need an average reduction of 12 percent. The Lake of the Woods TMDL will ultimately determine the best approach to reducing phosphorus loading in the basin.

2.3.3 Lake Superior Major Basin

Rivers and lakes in the Lake Superior Major Basin are also in relatively good condition concerning phosphorus levels. The phosphorus and nitrogen levels in Lake Superior are low, and the goal is to maintain these low levels while vigilantly monitoring nutrient source contributions as well as river and lake trends.

Chapter 3

Water Quality Evaluation

Water quality in the three major basins was evaluated to assess the sources of nutrients and to support implementation planning. This chapter begins with a discussion of factors that affect nutrient loads. The chapter continues with discussions of sources of nutrients, nutrients in groundwater, and nutrient concentration and load trends in major basins.

3.1 Environmental and Land Use Factors Affecting Nutrient Loading

Several factors influence nutrient loading to waters. Some key factors include climate, land use and management. Long-term trends reflect changes in these factors over time. An understanding of these factors provides important perspective on the causes and solutions to reduce loadings and interpreting observed changes in loading over time. The following sections briefly review statewide information on changes in climate, urban development, and agricultural practices, with a focus on large changes within the major basins.

3.1.1 Climate

Climate and its impact on precipitation, runoff, and streamflow plays an important role in evaluating pollutant loadings. A snapshot of water quality data from a certain time period may suggest a change in loading is due to a change in sources while examination of precipitation over that same period may show this trend to be due to an increased level of precipitation and streamflow. Figure 3-1 displays annual precipitation averaged for the entire state of Minnesota for the period 1890 to 2010. It suggests the following regarding the different baseline periods for each of the major basins:

- Lake Superior (1979): wet year (near the 75th percentile)
- Lake Winnipeg (2003): dry year (below the 25th percentile)
- Mississippi River (1980 to 1996): four dry years, five relatively average years, and eight wet years suggesting that, overall, this period may have been somewhat wetter than the long-term average

These findings should be kept in mind as one compares future years to the loads for these time periods, and is one reason that flow-adjusted approaches (i.e., flow weighted mean concentrations [FWMCs]) are proposed for tracking progress over time.

In addition to the natural impact that weather has on year-to-year variability in pollutant loads, the long-term climate records show higher precipitation in recent decades as compared to historical precipitation. In Minnesota, the last three decades have been the wettest in more than 100 years and the annual number of large storm events has doubled in the past century. Since the *Minnesota Nutrient Reduction Strategy* (NRS) was developed with data from the past three decades, the river flows and precipitation evaluations in the strategy reflect the more recent climate situation rather than the pre-1980 historical climate. Trends in nutrient loading for the last century are difficult to assess except for those observed in sediment core studies such as those on Lake Pepin (Engstrom et al. 2009). Reducing loads and discerning trends in the face of such large-scale changes are important challenges to be addressed as we evaluate environmental progress of this NRS and future iterations of the NRS. It should be noted that current flows are similar to or less than baseline flows (the flows recorded during the goal setting periods) in all three major basins. Predicting future trends in flow is beyond the scope of the NRS, but it is an active area of research and debate in Minnesota.

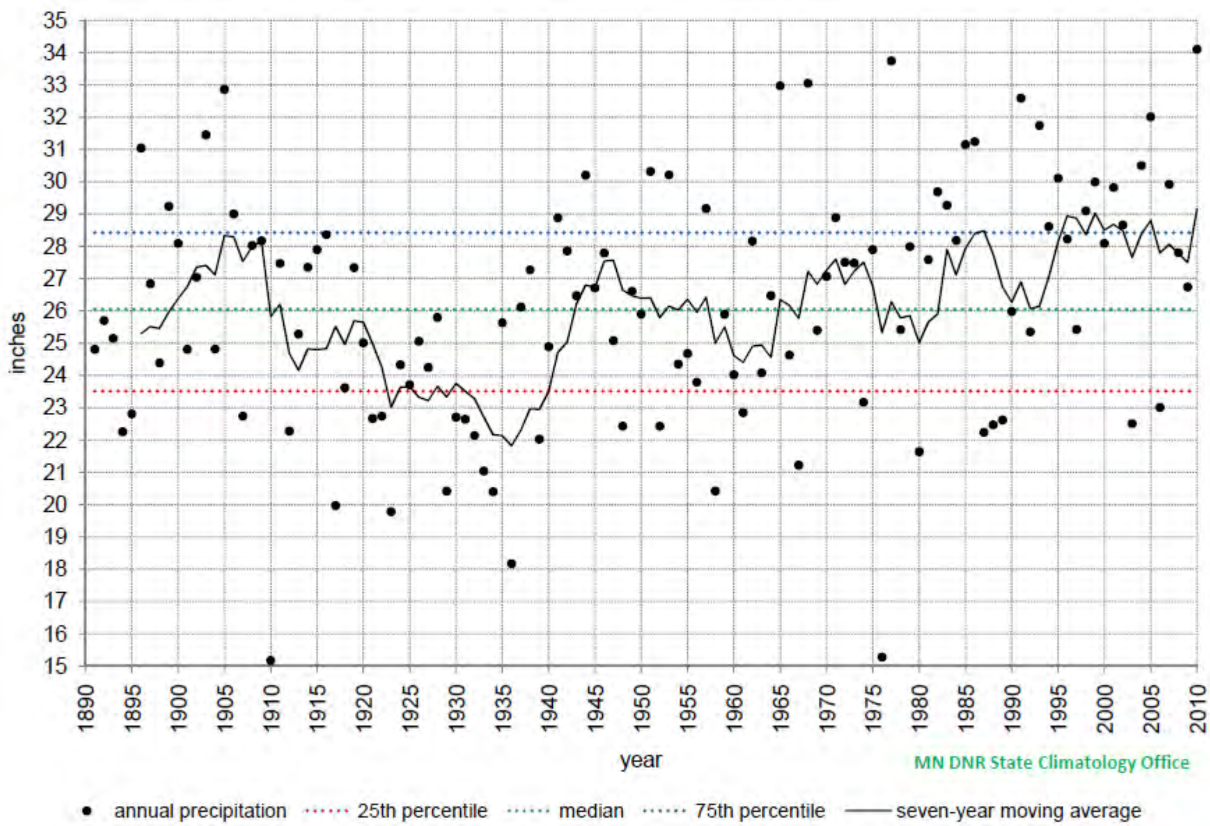


Figure 3-1. Minnesota state-averaged annual precipitation (Minnesota Climatology Working Group 2013).

3.1.2 Urban Development

Urban areas within Minnesota have grown over the past decade as the statewide population has increased from 4.9 million in the year 2000 to 5.3 million in the year 2010 (U.S. Census Bureau 2013). According to the National Land Cover Database, urban area in the state has increased from about 5.3 percent in 2001 to 5.4 percent in 2006 (the most recent year for which statewide data are available); similarly, impervious area has increased from about 1.0 to 1.1 percent. Figure 3-2 displays the population change by county between the 2000 and 2010 censuses. The greatest population increases by county occurred within the Mississippi River Major Basin, and all three major basins have experienced a consolidation in population from rural to more urban areas. The growth in land under urban development has increased the amount of stormwater runoff produced, although these increases are relatively small at the statewide level and have been mitigated, in part, by stormwater management and other nutrient reduction activities. Trends in wastewater flows are variable and have been reduced in some areas with improved collection systems that limit inflow and infiltration from groundwater into collection systems. A dramatic reduction in the statewide load of total phosphorus from wastewater has been achieved in the past 14 years (see Chapter 5). Loads of total nitrogen from wastewater have remained relatively stable.

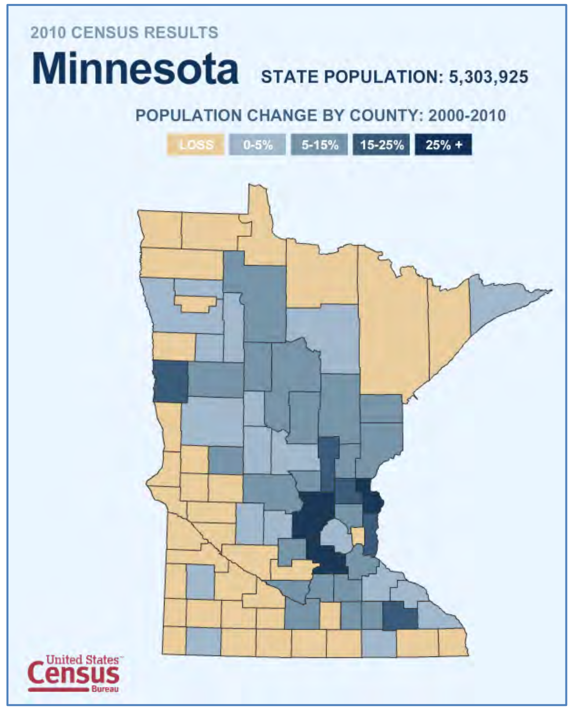


Figure 3-2. Population increase in Minnesota by county (Minnesota State Demographic Center 2013).

3.1.3 Agricultural Practices

Agricultural activities are expected to have a strong influence on nutrient loading in the Lake Winnipeg and Mississippi River major basins and less of an impact in the Lake Superior Major Basin. Across the entire state, about 50 percent of Minnesota's land is used for agriculture (USDA 2011). The greatest number of agricultural acres are used for our two most produced crops, corn and soybeans, although Minnesota is also known for its production of sugar beets, wheat, potatoes, dry beans, and other specialty crops. Agricultural practices in Minnesota began with corn and wheat production in the mid-1800s, and then wheat and small grain production began to shift to soybeans at the beginning of the 20th century (MDA 2008). Crop demands associated with World War I and World War II, as well as the

Great Depression and Dust Bowl, had significant impacts on Minnesota row crops; however, since the 1950s Minnesota's most valuable crops have been corn, soybeans, and wheat (MDA 2008).

Fluctuations and some marked changes in agricultural activities have occurred over the past few decades. From 1974 to 2002, the number of hogs and poultry raised within the state generally increased, while the number of cattle decreased. Livestock on farms has gone through a period of consolidation resulting in fewer livestock farms with larger livestock enterprises. Table 3-1 provides select historical acreages from the *Census of Agriculture* (USDA 2012b). Land enrolled in the Conservation Reserve, Wetlands Reserve, Farmable Wetlands, or Conservation Reserve Enhancement Programs dropped considerably between 2007 and 2012.

Table 3-1. Historical acreages from the Agricultural Census, Minnesota (USDA 2012b). See *http://agcensus.usda.gov/Publications/2012*.

Sector	Millions of acres			
	1997	2002	2007	2012
Land in farms	27.6	27.5	26.9	26.0
Harvested cropland	19.8	19.4	19.3	19.8
Permanent pasture	1.0	1.2	1.5	1.3
All pasture	2.9	2.6	2.7	1.9
Woodland used as pasture	0.8	0.6	0.5	0.4
Land enrolled in Conservation Reserve, Wetlands Reserve, Farmable Wetlands, or Conservation Reserve Enhancement Program	1.5	1.6	1.9	1.3

Recent Agricultural and Rural Land Changes

While statewide agricultural statistics capture overall trends, valuable insight can also be gained using satellite imagery for land use and land cover. Note, however, that statewide and large scale data summaries do not always reflect the changes occurring regionally or at the watershed level.

A shift from grassland to corn/soybean production is evident in a comparison of Cropland Data Layer from the U.S. Department of Agriculture (USDA) National Agricultural Statistics Service from 2006 to 2011 (Wright and Wimberly 2013). Grassland was converted to corn/soybean at a rate of 1.0 percent to 5.4 percent annually from 2006 through 2011 in the Western Corn Belt, which includes North Dakota, South Dakota, Nebraska, Iowa, and Minnesota; the conversion occurred as commodity prices and biofuel subsidies incentivized the switch from native grasslands and pasture to cultivated crops

(Wright and Wimberly 2013). For example, incentives for ethanol production began in the 1980s through the Minnesota Ethanol Program (MDA 2012).

The net loss of grassland to corn/soybean production in Minnesota from 2006 to 2011 was approximately 196,000 acres (Wright and Wimberly 2013). A summary of Conservation Reserve Program (CRP) data between 2007 and 2013 is available from the Farm Service Agency (FSA) (*CRP summary data*) and is summarized in Figure 3-3 and Figure 3-4. Statewide enrollment has been declining; the majority of CRP acres lost during 2012 and 2013 were in the Red River Valley. An additional 700,000 acres are expected to expire between 2014 and 2018. While the exact fates of the CRP-expired lands are unknown (i.e. converted to cropland or developed lands), based on the recent grassland-to-corn/soybean conversion rates it is likely that many CRP-expired lands will be converted into agricultural production. This has important implications for nutrient loading; since in general, cropland generates larger loads of phosphorus and nitrogen than grassland.

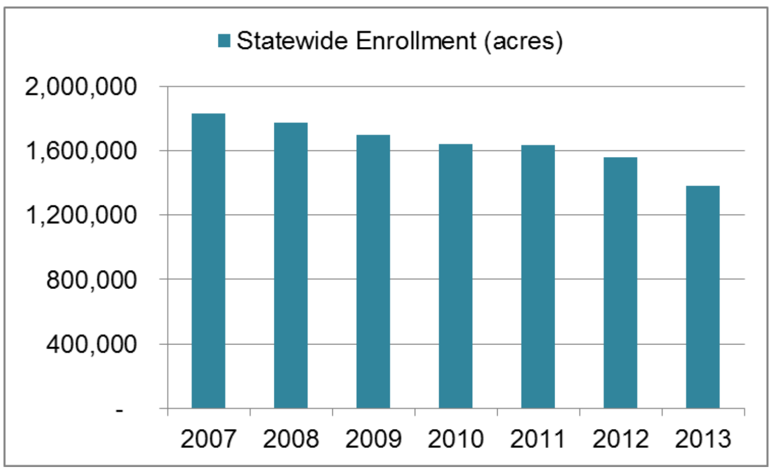


Figure 3-3. Total statewide enrollment in CRP.

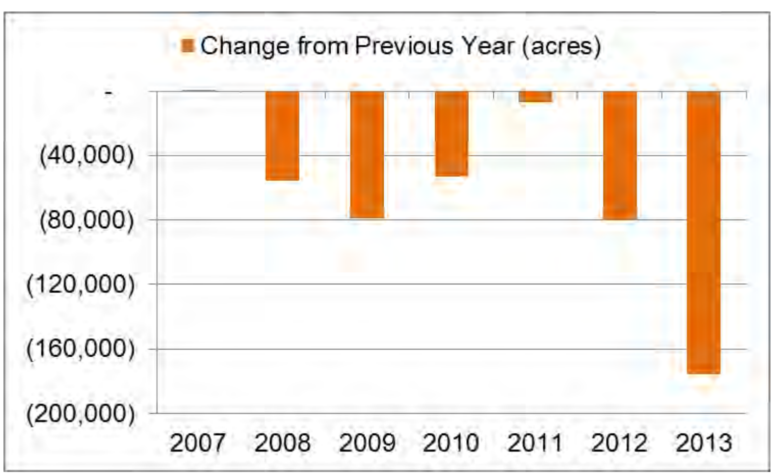


Figure 3-4. Annual net gain or loss of CRP acres.

Spring Corn Field in Minnesota Photo Credit: MPCA

Trends in crop genetics and in the use of agricultural drain tiles also have the potential to impact nutrient loads. Crop genetics has resulted in increased efficiency of corn and soybeans such that greater production has occurred per acre of farmland and per unit of fertilizer. The glacial processes that shaped the Upper Midwest left the area with highly productive but very poorly drained soils that require artificial drainage assistance to increase yields (Sands 2010). Tile drains were introduced to the American Midwest in the early- to mid-1800s, which supported the growth of corn and wheat production in Minnesota (Sands 2010). However, tile drains reduce surface runoff, increase subsurface runoff, and can expedite transport of soluble nutrients to waters, especially inorganic nitrogen. Inadequately designed or installed tile drain outlets are also sometimes associated with gully formation that erodes soil and contributes associated nutrients. In Minnesota it is estimated that about 20 to 30 percent of agricultural soil is tile-drained (Sands 2010). In some areas, such as the eastern portion of the Minnesota River Basin, a high percentage of row crop agriculture uses tile drains. Controlling nutrient loads from tile-drained lands will be a critical aspect of meeting the NRS's goals.

3.2 Sources and Pathways of Nutrients in Minnesota Waters

Sources of nutrients to Minnesota waters have been studied in depth over the past 15 years. Efforts have been made to quantify the nutrient loads associated with different sectors and activities, as well as to quantify nutrient loads spatially throughout the state. These efforts form the basis of this source assessment. Specific source loading information is not available for all evaluation time periods. The source data presented in this section represent research compiled since 2000 and land use information is generally from 2009 to 2010.

The phosphorus source assessment summary is based on the *Detailed Assessment of Phosphorus Sources to Minnesota Watersheds* (Barr Engineering 2004) and associated updates for wastewater point sources and atmospheric contributions. Atmospheric deposition loads were updated in 2007 and wastewater data have been updated to reflect 2011 conditions. The loadings do not represent the sources of phosphorus reaching the major basin outlets, but rather the sources of phosphorus to waters in each major basin. Atmospheric deposition values were further adjusted in 2012 by subtracting the phosphorus load directly to wetlands due to uncertainty about releases to downstream waters and to provide comparable results with the nitrogen source assessment.

The following are sources of phosphorus to surface waters (Table 3-2):

- Cropland and pasture runoff
- Atmosphere (including redeposited sediment from wind erosion)
- National Pollutant Discharge Elimination System (NPDES) permitted wastewater discharges
- Streambank erosion
- Urban runoff
- Nonagricultural rural runoff
- Individual sewage treatment systems
- Agricultural tile drainage
- Feedlots
- Roadway deicing chemicals

Historical phosphorus accumulations in Minnesota lakes are an important factor affecting water quality. Phosphorus that was historically deposisted in lake sediments can be released into the water column for decades through physical processes such as wind and wave action and as a result of anoxic conditions (lack of oxygen). In addition, bottom-feeding fish such as carp and bullhead can also cause suspension of sediment and subsequent release of phosphorus into the water column. Aquatic plants such as curly-leaf pondweed (*Potamogeton crispus*) can also contribute to phosphorus levels in lakes, especially in shallow lakes. Generally, internal loading is most important to local resources during July and August and a lesser source during higher flow periods from mid-March through June. In-lake treatment of legacy phosphorus and internal loading with alum has been effective in some lakes of Minnesota. Fish removal and aquatic vegetation management has also been effective in some lakes in

Minnesota. In-lake management techniques improve conditions during the summer for the local resource, but will not likely result in large downstream load reductions.

The Minnesota Pollution Control Agency (MPCA) has completed a *Nitrogen Study* (MPCA 2013a) that comprehensively assesses the science concerning nitrogen in Minnesota waters and characterizing nitrogen loading to Minnesota's surface waters by assessing conditions, trends, sources, pathways, and potential ways to reduce nitrogen loads. The nitrogen study is the basis for the nitrogen source assessment summary.

The following are sources of nitrogen to Minnesota waters (Table 3-2):

- Agricultural cropland via tile drainage
- Agricultural cropland via groundwater (nitrogen leached to groundwater beneath cropland, which later reaches surface waters through groundwater baseflow)
- Agricultural cropland via runoff over the soil surface
- NPDES permitted wastewater discharges
- Atmospheric deposition into lakes, rivers, and streams
- Forest runoff
- Individual sewage treatment systems
- Urban runoff and leaching
- Feedlot runoff (manure spreading to cropland is part of the cropland/agricultural categories.)

Within each major basin, the distribution of nutrient sources is unique. Table 3-2 provides a summary of the sources from Minnesota major basins associated with both phosphorus and nitrogen; the table is color coded to indicate the higher loading sources relative to other sources in the same major basin (green) and sources that contribute smaller load percentages (yellow). Each source will potentially require a different set of implementation activities to achieve reductions.

Table 3-2. Minnesota phosphorus and nitrogen sources by major basin, average conditions [a]

Nutrient source	Mississippi River		Lake Superior		Lake Winnipeg	
	P	N	P	N	P	N
Cropland runoff	35%	5%	6%	2%	42%	11%
Atmospheric [b]	8%	6%	7%	10%	18%	21%
NPDES permitted wastewater discharges [c]	18%	9%	24%	31%	11%	6%
Streambank erosion	17%	--	15%	--	6%	--
Urban runoff and leaching	7%	1%	10%	1%	2%	0%
Nonagricultural rural runoff [d]	4%	--	32%	--	15%	--
Individual sewage treatment systems	5%	2%	3%	4%	3%	2%
Agricultural tile drainage	3%	43%	0%	5%	0%	7%
Feedlot runoff	2%	0%	0.1%	0%	0.3%	0%
Roadway deicing	1%	--	2%	--	2%	--
Cropland groundwater [e]	--	31%	--	9%	--	35%
Forest runoff	--	4%	--	38%	--	19%

Notes: P = phosphorus; N = nitrogen

a. Source estimates are based on Barr Engineering (2004) with more recent MPCA updated wastewater (2011 conditions) and atmospheric deposition sources (2007). Source percentages do not represent what is delivered to the major basin outlets, but what is delivered to local waters.

b. Atmospheric deposition is to lakes and rivers (atmospheric deposition to wetlands is not reflected in this table).

c. Nutrient loads in the Lake Superior Major Basin are lower than other major basins in the state and therefore wastewater is a larger portion of the overall sources. Western Lake Superior Sanitary District (Duluth area) accounts for more than 50 percent of the wastewater phosphorus load in the major basin.

d. Includes natural land cover types (forests, grasslands, and shrublands) and developed land uses that are outside the boundaries of incorporated urban areas.

e. Refers to nitrogen leaching into groundwater from cropland land uses.

Scale: Low — High

Phosphorus findings:

- The primary sources of phosphorus transported to surface waters are cropland runoff, atmospheric deposition, permitted wastewater, and streambank erosion. These four sources combined are 71 percent, 76 percent, and 83 percent of the statewide phosphorus load under dry, average, and wet years, respectively.

- During dry conditions, NPDES permitted wastewater discharges and atmospheric deposition become more prominent sources of phosphorus. Under wet conditions, streambank erosion becomes the most significant source of phosphorus in the state.

- The most significant phosphorus sources by major basin during an average precipitation year include cropland runoff, wastewater point sources, and streambank erosion in the Mississippi River Major Basin; streambank erosion, nonagricultural rural runoff, and wastewater point sources in the Lake Superior Major Basin; and cropland runoff, atmospheric deposition, and nonagricultural runoff in the Lake Winnipeg Major Basin. These sources do not necessarily represent the proportion of nutrient sources at the major basin outlets.

Nitrogen findings:

- Cropland nitrogen losses through agricultural tile drainage and agricultural groundwater make up the majority of nitrogen sources, contributing 51 percent, 68 percent, and 73 percent of the nitrogen load under dry, average, and wet years, respectively.
- During wet years, cropland nitrogen losses through tile drainage in the Minnesota River Basin have the single highest contribution to nitrogen loading.
- The most significant nitrogen sources by major basin include agricultural tile drainage and cropland groundwater in the Mississippi River Major Basin; forest and wastewater point sources in the Lake Superior Major Basin; and cropland groundwater, forest, and atmospheric deposition and in the Lake Winnipeg Major Basin. These sources do not necessarily represent the proportion of nutrient sources at the major basin outlets.

3.3 Nitrogen in Groundwater

Groundwater is monitored in Minnesota by a number of agencies and organizations. The MPCA maintains an Ambient Groundwater Monitoring Network that monitors the aquifers that are most likely to be polluted with nonagricultural chemicals. The Minnesota Department of Agriculture (MDA) monitors aquifers that agricultural chemicals are likely to impact. In southeastern Minnesota, a large amount of groundwater quality data has been collected by a Volunteer Nitrate Monitoring Network. The MPCA recently authored a report entitled *The Condition of Minnesota's Groundwater, 2007–2011* (MPCA 2013b), which includes a summary of nitrogen monitoring data. Figure 3-5 presents the nitrate concentrations in groundwater. It is important to note that these data represent many different aquifers and depths of wells. The Minnesota Department of Health also monitors the condition of groundwater in public water supply wells, however these data were not included in the MPCA's (2013b) report.

The following excerpt summarizes the key findings from the 2013 MPCA report:

> *The groundwater in the shallow sand and gravel aquifers in selected parts of Minnesota continues to be impacted by high nitrate concentrations. The shallow sand and gravel aquifers contained the highest median nitrate concentrations compared to all of the other aquifers assessed in this report. The highest nitrate concentrations occurred in the aquifers in Central and southwestern Minnesota. In Central Minnesota, about 40 percent of the shallow sand and gravel aquifer wells contained water with nitrate*

concentrations that were greater than the Maximum Contaminant Level (MCL) of 10 milligrams per liter (mg/L) set by the U.S. Environmental Protection Agency (USEPA) for drinking water. The limited available data in southwestern Minnesota showed that about 20 percent of the shallow sand and gravel aquifer wells contained water with nitrate concentrations that exceeded the MCL of 10 mg/L.

Some wells installed in the uppermost bedrock aquifers in southeastern Minnesota had nitrate concentrations that exceeded the MCL of 10 mg/L. These high concentrations occurred in selected wells in the Upper Carbonate, St. Peter, Prairie du Chien, and Jordan aquifers, and all occurred in areas where the aquifers are naturally susceptible to contamination.

Nitrate concentrations in the sand and gravel aquifers varied with land use and depth. The groundwater underlying both agricultural and urban lands contained higher nitrate concentrations compared to the groundwater underlying undeveloped land. The highest nitrate concentrations observed in this investigation typically were in the shallow groundwater underlying agricultural lands. The median concentration in the shallow groundwater underlying agricultural areas was about 9 mg/L; whereas, the median concentration in the groundwater underlying a variety of urban land uses ranged from 2-3 mg/L. Data from the MDA suggested the high nitrate concentrations in the state's sand and gravel aquifers may be restricted to the uppermost parts. In deeper parts of the sand and gravel aquifers, the nitrate may be removed by a natural, microbially-mediated processed called denitrification, or the groundwater in these parts of the sand and gravel aquifers may be so old that nitrate contamination that originated from the land surface has not yet percolated down to these depths.

The amount of nitrate contamination in Minnesota's groundwater generally has not changed over the last 15 years. There was sufficient data to quantify trends from about 90 wells, which primarily were sampled from 1997-2011. Nitrate concentrations did not significantly change in the majority of the wells.

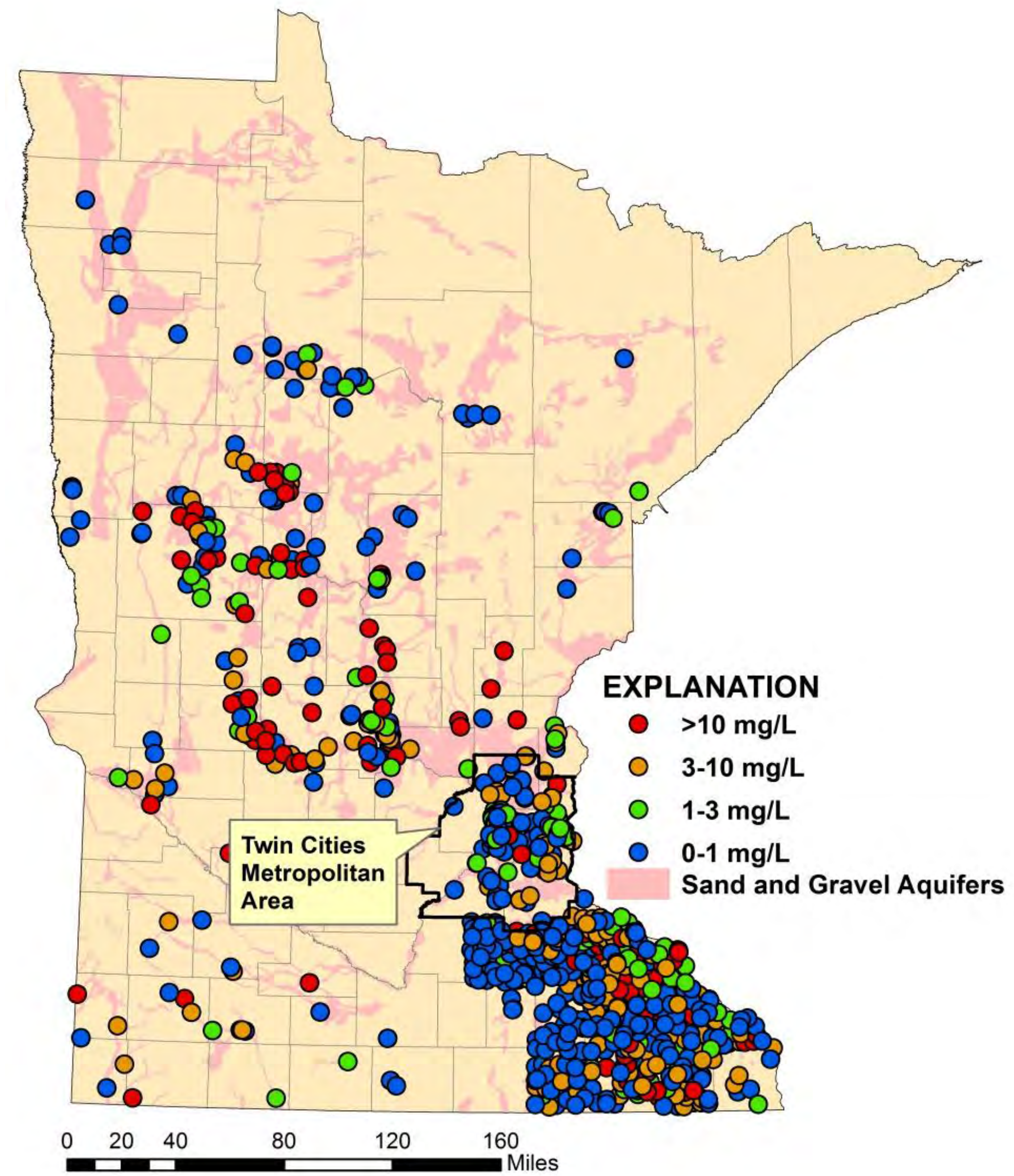


Figure 3-5. Nitrate concentrations in Minnesota's ambient groundwater, 2007–2011 (MPCA 2013b).

3.4 Surface Water Loading Analysis

Information on historic loading, water quality, and program implementation data were evaluated to inform changes in conditions since the baseline period. The purpose of this analysis was to assess potential trends in conditions that could have important implications on the NRS.

Potential trends were evaluated in four different ways:

- **Loads[1].** Nutrient loads were calculated as 5-year rolling averages of annual phosphorus and nitrogen loads using available flow and water quality data. These averages represent the arithmetic mean of the calculated annual loads for 5 consecutive years; for example, a 5-year rolling average of 1993 is the arithmetic mean of the annual loads from 1989, 1990, 1991, 1992, and 1993. Five-year rolling averages were used to smooth large variations in annual loads caused by flow variability, although flow still has an important impact on the load calculations.
- **Flow weighted mean concentrations (FWMC).** A FWMC is simply the annual load divided by the annual flow. Flow normalized values like FWMC provide a useful evaluation of long-term trends by removing variability in flow from annual averages of load. It is a good estimate of average concentration during moderate to high flows which dominate the annual load.
- **Program quantification of BMPs.** Quantification of BMP adoption and management change as represented in select program data and surveys is intended to provide an assessment of the recent progress achieved through implementation of best management practices (BMPs) and wastewater treatment. This metric, often referred to in the NRS as "program quantification," relies on inventorying the activities that have occurred over a period of time to reduce nutrient loads, and then estimating the reduced load using known information on the effectiveness of each practice (e.g., cover crops are reported to reduce phosphorus loading by 29 percent [Iowa State University 2013]).
- **Flow.** Trends in flow were not statistically analyzed in this effort, but this important variable was graphed for visual inspection since it is a fundamental driver to loads (Load = FWMC x Flow).

Careful examination of all four variables collectively will be needed to assess trends in each major basin. Loads measure the amount of nutrients delivered to a downstream water body, and as such provide a direct measure of the goals. However, trends in loads are difficult to determine because of a variety of factors, including variability in flows; insufficient data; lag times between BMP implementation and water quality response; and the impact of in-stream settling, resuspension, sediment release, etc. FWMCs are an in-stream measure and help to address the issue of flow variability, but determining trends can still be difficult if there are inadequate data, lag times, multi-year precipitation departures, and in-stream transformations. Program quantification provides a

[1] The most appropriate data to represent the major basin outlets were selected for evaluation. The available data varied, ranging from both annual and monthly loads for both nitrogen and phosphorus, to only annual loads for phosphorus or nitrogen. Limited data were available for the Lake Winnipeg Major Basin; data at Emerson in Manitoba generally represent the in-stream load in the Red River at the U.S.-Canada border. Except for SPARROW loading data, no known loading data were available that provided annual estimates based on observed data for the Lake Superior Major Basin or the Rainy River portion of the Lake Winnipeg Major Basin. Considerable nutrient processing occurs after the Rainy River flows into Lake of the Woods, which makes it difficult to assess the ultimate impact of the Rainy River on Lake Winnipeg.

simplified picture of BMP implementation and associated load reductions using available program data. However, it also relies on adequate data, is not a measure of actual in-stream conditions, and is subject to the uncertainties associated with quantifying the effectiveness of different practices. The approach to program quantification also does not account for BMPs that are adopted independent of state and federal programs and does not incorporate the effects of land use and management changes which can occur independent of BMP implementation (i.e., changing crops or tile drainage).

The following sections discuss the results of the loading and FWMC analysis, and Section 4.4 presents the program quantification analysis. In some cases, the results from each measure generally agree, whereas in other cases they do not. As discussed in Chapter 7, no one measure is considered the best and the NRS will ultimately be successful when they are all moving in the same direction.

3.4.1 Statewide SPARROW Results

The Spatially Referenced Regressions on Watershed (SPARROW) model integrates water monitoring data with landscape information to reflect long-term average constituent loads that are delivered to downstream receiving waters. The model also approximates nonpoint source loading for the 2000–2002 period. Loads reflect the wastewater point source update, which incorporates updated wastewater data from MPCA (updated for 2005–2006 for nitrogen and 2005–2009 for phosphorus) and is assumed to approximate current wastewater point source loading.

Results are independent of year-to-year variability in flow. SPARROW utilizes a mass-balance approach with a spatially detailed digital network of streams and reservoirs to track the attenuation of nutrients during their downstream transport from each source. Robertson and Saad (2011) developed the Major River Basin 3 (MRB3) SPARROW model for use in simulated nutrient loading in Minnesota. A primary advantage of the SPARROW model is that it provides statewide estimates of nitrogen and phosphorus for the same time periods and based on one methodology. Results from the Watershed Pollutant Load Monitoring Network (WPLMN) can be used to describe nutrient loads between 2007 and 2011 for many major watersheds. However, because long-term monitoring averages are not available at this time for all 8-digit hydrologic unit code major watersheds, analyses for NRS relied more heavily on SPARROW model outputs. Future revisions to the NRS should incorporate the WPLMN generated load data.

Estimates of transported phosphorus load in MRB3 depend on the following:

- Point source loads (excluding regulated stormwater)
- Manure production
- Fertilizer use on farms
- Forest area
- Urban area
- Soil permeability
- Tile density
- Travel time in stream
- Presence of lakes or reservoirs in stream network

Transported nitrogen load estimates depend on similar factors, with the addition of the following:

- Atmospheric nitrogen deposition rates
- Average annual precipitation
- Air temperature
- Clay content of soil
- Area of watershed in agricultural land use, as a proxy for other agricultural sources
- Presence of lakes or reservoirs in stream network

Use of these factors provides reasonable estimates of average annual load, but the model does not address a number of other factors. Notably, there are no measures of soil erodibility. There is also no correction for the extent of adoption of agricultural management practices. Therefore, the agricultural nonpoint load estimates are essentially a function of agricultural area, fertilizer use, and manure production. Given these conditions, the precision of the model is limited and used within the NRS primarily to assess the relative difference in loads by source categories and spatial differences in total loads across the state's watersheds.

Figure 3-6 and Figure 3-7 show the modeled yields by major watershed. Yields are used to understand the relative differences in loading between the major watersheds and are a product of land cover, land use, precipitation, and flow conditions.

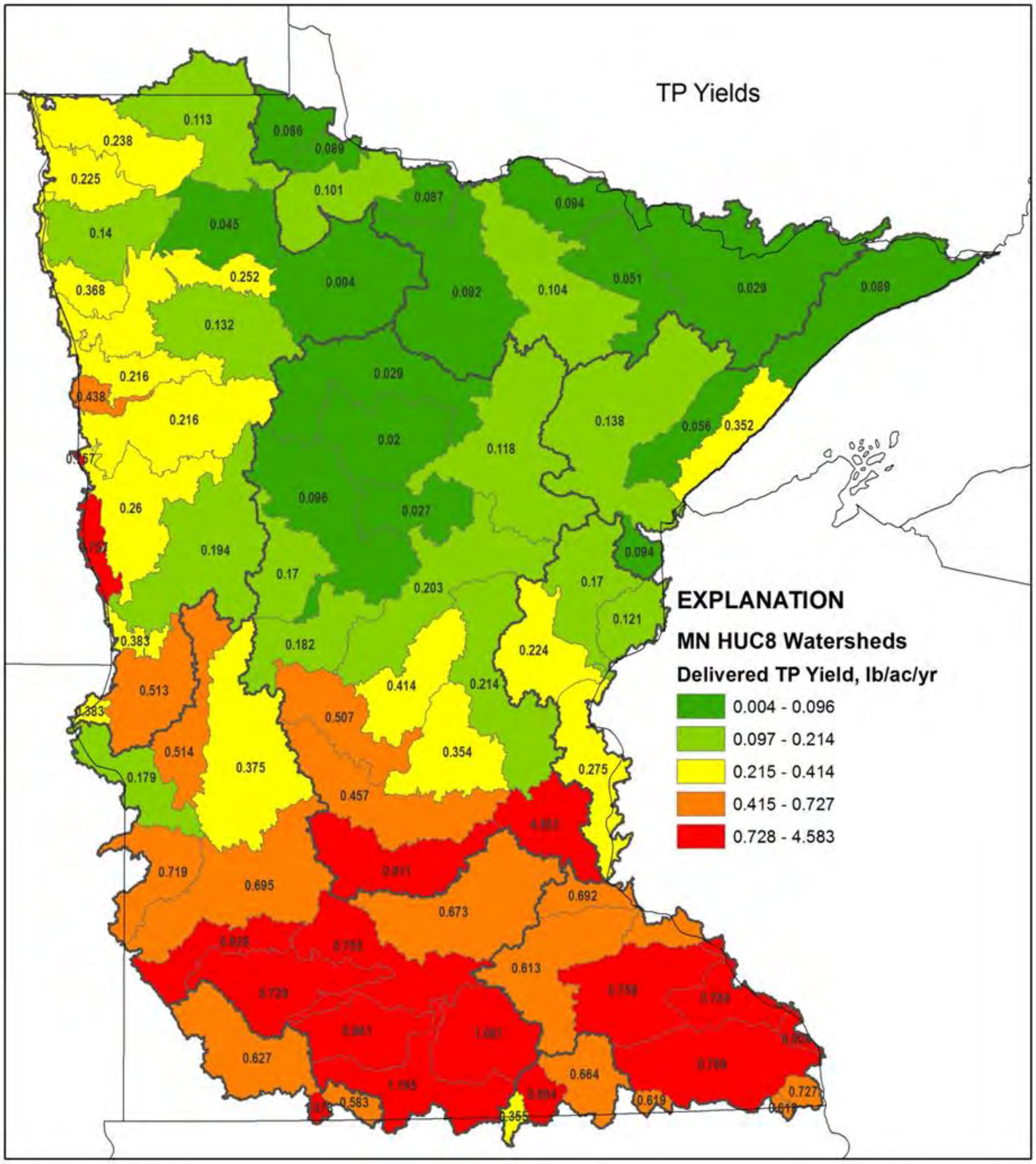


Figure 3-6. Annual phosphorus yield delivered to major watershed outlets in pounds/acre/year (Robertson and Saad 2011).

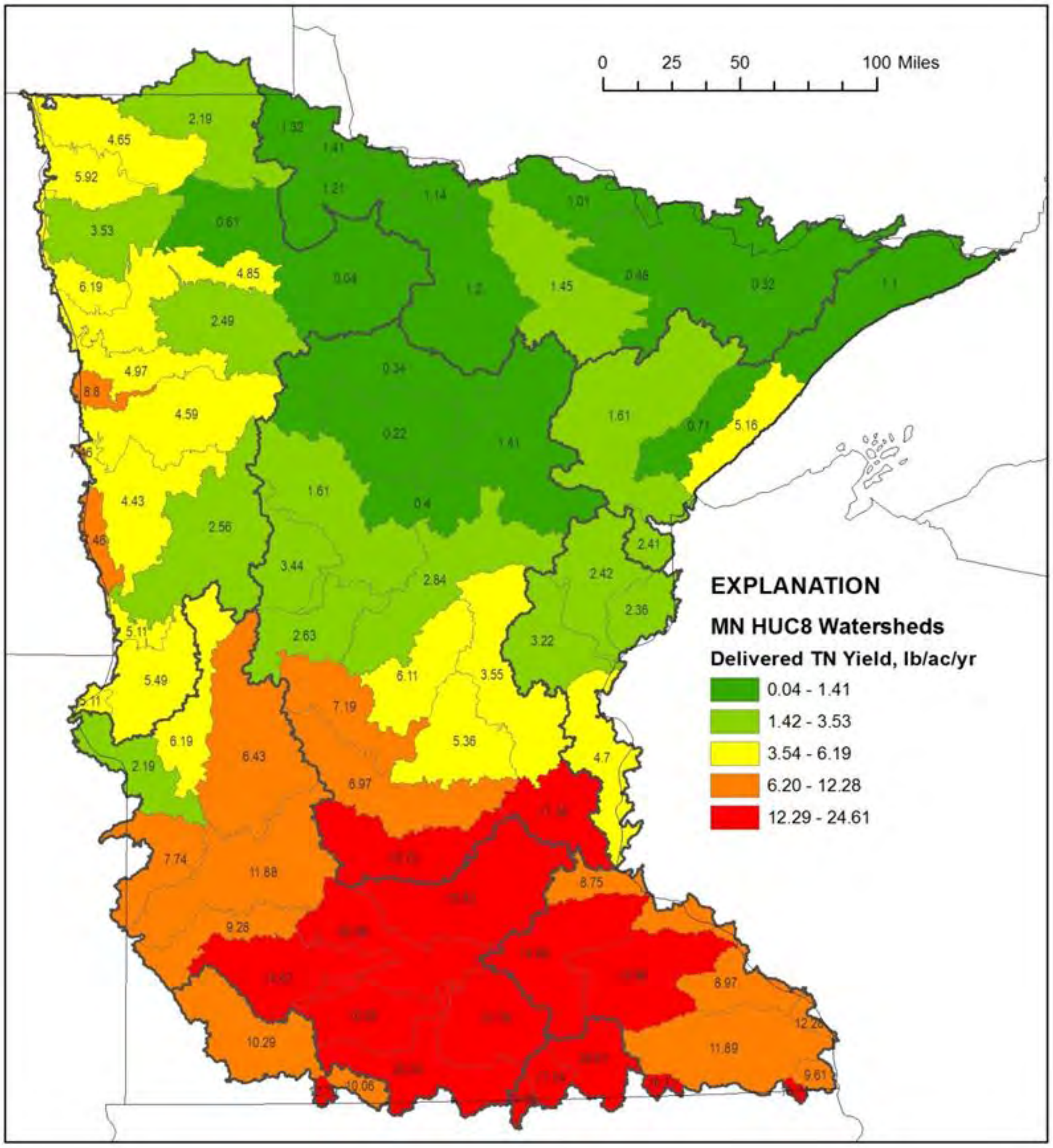


Figure 3-7. Annual nitrogen yield delivered to major watershed outlets in pounds/acre/year (Robertson and Saad 2011).

3.4.2 Lake Superior Major Basin

The Lake Superior Major Basin in northeastern Minnesota is approximately 6,200 square miles. Major watersheds include the Cloquet, Nemadji, and St. Louis River systems, as well as the North Shore tributaries to Lake Superior. Over 93 percent of the major basin is forest, wetlands, and open water. Duluth and the surrounding area comprise the majority of the urban development in this major basin.

Open-pit mining is common along the major basin divide between Hibbing and Virginia. Many high-quality streams and large forested areas, along with Lake Superior, provide significant recreational opportunities.

Excess nutrients within this major basin are primarily derived from anthropogenic sources in the developed areas, including wastewater from both municipal treatment systems and individual sewage treatment systems and runoff. Industry within the major basin may also contribute to excess nutrients.

Phosphorus bound to sediment is also an important source in North Shore streams. The University of Minnesota completed a study in 2013 *Lake Superior Stream Sediment Assessment: Phase 1* that begins work to study the major causes of erosion and sediment transport, excessive turbidity levels and their impacts on North Shore streams (Lahti et al. 2013). Anthropogenic stressors and natural variables were evaluated. Roads were identified as the most widespread anthropogenic stressor and areas along the channel mainstems have the greatest potential to impact water quality. Channel stability and the potential for channel erosion were also evaluated.

In-stream monitoring was insufficient for this major basin during the baseline timeframe (1979) to quantify nutrient loads to Lake Superior. Therefore, the 2002 USGS SPARROW modeling results were used to evaluate nutrient loading. Because land uses in this major basin have not changed substantially since the late 1970s and early 1980s, SPARROW results were determined to adequately approximate loads during the 1979 baseline condition in this basin. The SPARROW results with wastewater point sources updated in 2011 were used for the current conditions load. Table 3-3 provides phosphorus loading results for the Lake Superior Major Basin.

An approximate goal of 248 metric tons/year of phosphorus is proposed to represent "holding the line" at 1979 conditions. No new reductions are proposed based on the modeled current condition, the difference between the modeled baseline and current condition is within the range of uncertainty regarding the actual load. The nitrogen loading goal for the Lake Superior Major Basin is qualitative (no specific load reductions identified) and, therefore, nitrogen loading was not evaluated.

Table 3-3. Phosphorus loading results, Lake Superior (metric tons/year)

Data set	Modeled baseline ~1979	Goal load (no increase in 1979 loads)	Modeled current conditions 2006-2010 [a]	Notes
SPARROW Model Results	248	248	255	Minnesota drainage area only; delivered to lake

Current conditions in the Lake Superior Major Basin are represented by SPARROW as updated with wastewater point source data in 2011.

NPDES wastewater sources contribute the majority of anthropogenic phosphorus and nitrogen to the Lake Superior Major Basin. Thus, controlling wastewater sources is important to prevent load increases to Lake Superior. In addition, stormwater runoff and streambank erosion are important sources due to the developed nature of Duluth and surrounding areas, as well as flashy flows common in North Shore streams. Management needs to address all flow regimes.

3.4.3 Lake Winnipeg Major Basin

The Lake Winnipeg Major Basin includes both the Red River of the North Basin and the Rainy River Basin. The Minnesota portion of the Red River Basin covers about 37,100 square miles in northwestern Minnesota in all or part of 21 counties and flows to Lake Winnipeg. It is home to about 17,842 miles of streams and 668,098 acres of lakes including Upper and Lower Red Lakes. This basin is characterized by intensive agricultural land uses within the flat topography east of the river, rolling uplands full of trees and lakes in the east-central portion of the basin, and extensive wetlands in the northeast. The Rainy River Basin is home to some of the state's finest forest and water resources and flows to the Winnipeg River in Canada, which discharges into Lake Winnipeg. The Minnesota portion of the basin includes approximately 11,000 square miles and consists predominantly of forests, wetlands, and lakes, including Lake of the Woods. Voyageurs National Park and the Boundary Waters Canoe Area Wilderness are located within the Rainy River Basin, as are several of Minnesota's most famous walleye fisheries and many high-quality trout streams. Other prominent uses of natural resources in the basin are forestry, mining, and various forms of recreation.

Excess nutrients within this basin are primarily derived from agricultural activities and wastewater point sources within the Red River Basin. In-stream loading estimates were not available for the Rainy River Basin, and because there are limited anthropogenic sources of nutrients in this basin and likely substantial nutrient losses in Lake of the Woods, loading analysis concentrated on the Red River. Lake of the Woods is impaired due to eutrophication therefore reductions upstream of this valuable resource will be more important to an in-state water than Lake Winnipeg.

In-stream monitoring data collected in Emerson, Manitoba, and loading analysis provided by Manitoba Conservation and Water Stewardship and Environment Canada (CWSEC) were used to evaluate the flow trends, load (using 5-year rolling average), and FWMC in the Red River. For phosphorus, Figure 3-8 compares in-stream load, FWMC, and flow in the Red River near Emerson, Manitoba. Despite the lower flows, phosphorus loads in the Red River have not decreased since 2000. While the phosphorus 5-year rolling average load is relatively stable, the FWMC has been gradually increasing, indicating that progress toward long-term load reduction has not been achieved. The FWMCs show a smooth curve for phosphorus, with the exception of a high value in the low flow year of 2003, which may reflect a strong influence of wastewater point sources under low flow conditions.

To illustrate progress needed to achieve the load reduction goal, the dashed lines in Figure 3-8 represent the estimated outcome of a 10 percent provisional reduction in baseline conditions load. While the in-stream loading goal is achieved during 2 years with lower flows, on average, the goal based on the FWMC is not achieved during the entire period of record. If loading conditions remain similar to current conditions, high flow years are likely to show loading above the in-stream load goal.

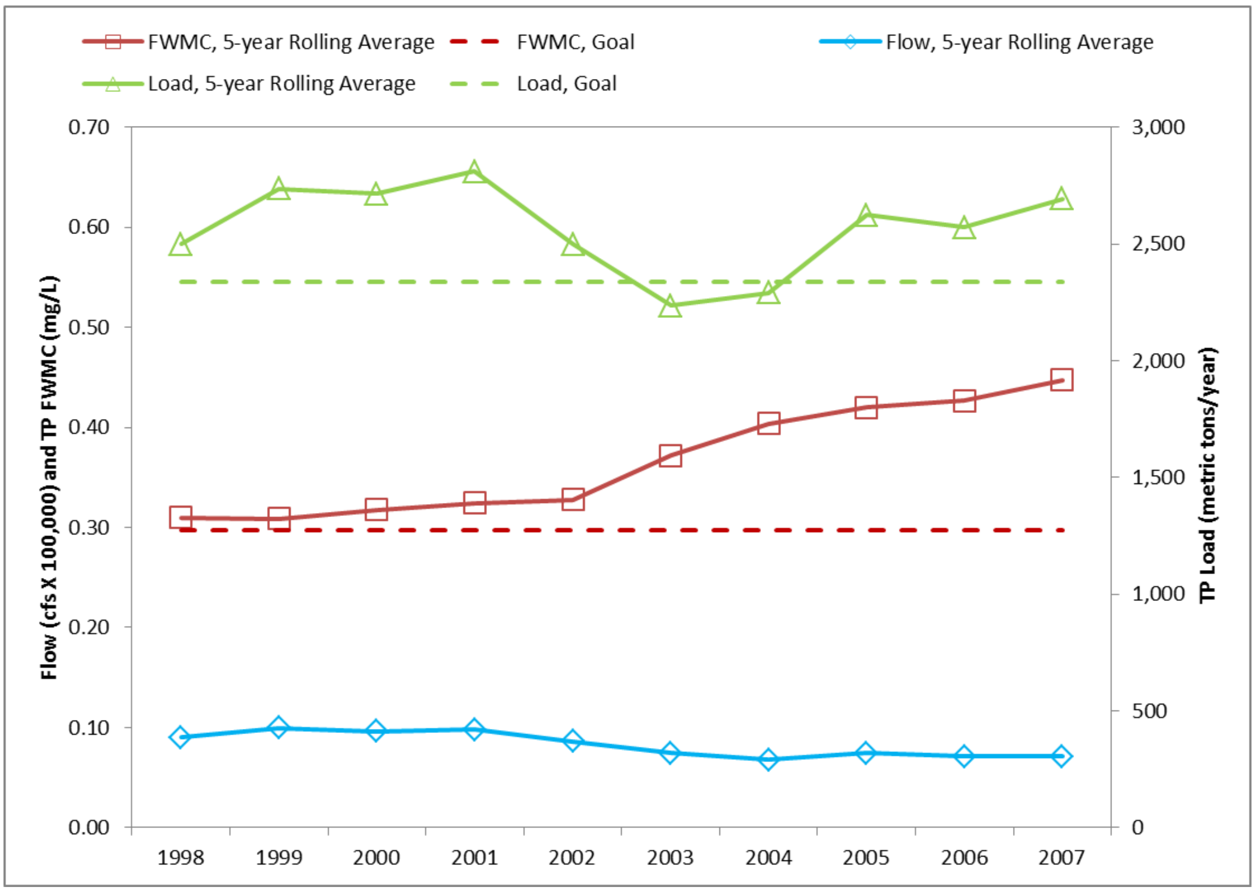


Figure 3-8. Phosphorus loading analysis, Red River near Emerson, Manitoba.

Data are the result of in-stream monitoring, and include out-of-state drainage area.

Table 3-4 presents the available phosphorus annual average load and FWMC estimates, summarized by time period. The goal load of 2,340 tons of phosphorus per year and the FWMC of 0.30 mg/l phosphorus correspond to the goals for the Lake Winnipeg Major Basin. An 11 percent reduction from current conditions would be required to achieve the loading goal, and a 32 percent reduction would be required to achieve the FWMC goal. When only in-stream loads from the Minnesota drainage area are considered, the load goal is 1,123 tons of phosphorus per year.

Table 3-4. Phosphorus loading results, Lake Winnipeg (concentration in mg/l; loads in metric tons/year)

Data set	Baseline 1999–2003	Goal (10% reduction from baseline)	Current conditions 2006–2010	Notes
FWMC (Red River only)	0.33	0.30	0.44	Based on in-stream loads; includes out-of-state drainage area
In-stream Loads[a] (Red River only)	2,600	2,340	2,633	In-stream loads; includes out-of-state drainage area
Total Minnesota Load to the Red River	1,248	1,123	1,264	An estimated 48% of River loads are from in-state (MN) watersheds

a. Calculated as the average of the 5-year rolling averages across the time period.

Figure 3-9 compares nitrogen in-stream load, FWMC, and flow in the Red River near Emerson. Nitrogen load has decreased since 2001. However, flow has also decreased during that same time period. The FWMC has remained relatively stable over time, possibly with a slight increase as flows have decreased. This suggests that apparent improvements in loading since 2001 are mostly due to lower flows rather than a true reduction in loads from nitrogen sources.

To illustrate progress needed to achieve the load reduction goal, the dashed lines represent the estimated outcome of a provisional 13 percent reduction in nitrogen from baseline conditions. Although some 5-year rolling average loads are less than the goal, both the in-stream load and FWMC measures indicate that the load reduction goal is not being met on an average basis.

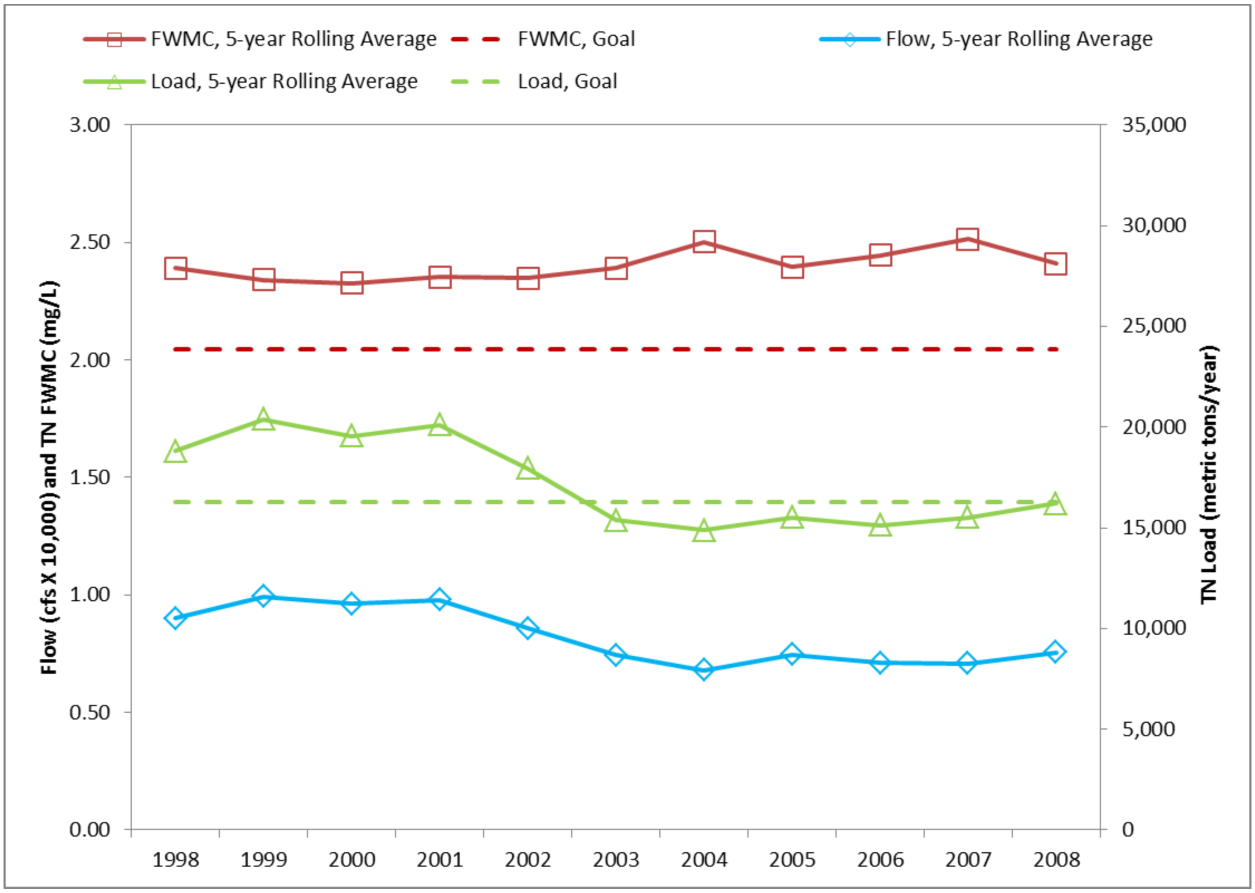


Figure 3-9. Nitrogen loading analysis, Red River near Emerson, Manitoba.

Data are the result of in-stream monitoring, and include out-of-state drainage area.

Table 3-5 presents the nitrogen FWMC and load estimates, summarized by time period. The proposed goals represent a 13 percent reduction from the baseline conditions. While the current conditions average load is less than the goal load, the analysis of flow trends indicates that this is likely due to lower flows under current conditions compared to baseline conditions. Future monitoring can confirm the status of nitrogen load across long-term conditions and not just within the current conditions time period. The FWMC goal represents a 17 percent reduction from current conditions. The goal load of 16,258 metric tons of nitrogen per year and the FWMC of 2.05 mg/l are the provisional nitrogen goals for the Lake Winnipeg major Basin. The goal load estimated for the Minnesota portion of the major basin can be used to assess reductions achieved within Minnesota as a secondary measure of achieving the loading goal. When only in-stream loads from the Minnesota drainage area are considered, the load goal is 7,804 tons of nitrogen per year.

Table 3-5. Nitrogen loading in the Red River near the Minnesota-Manitoba border (concentration in mg/l; loads in metric tons/year)

Data set	Baseline 1999–2003	Provisional Goal (13% reduction from baseline)	Current conditions 2006–2010	Notes
FWMC (Red River only)	2.35	2.05	2.46	Based on in-stream loads; includes out-of-state drainage area
In-stream Loads[a] (Red River only)	18,687	16,258	15,624	In-stream loads; includes out-of-state drainage area
Total Minnesota Load to the Red River	8,970	7,804	7,500	An estimated 48% of River loads are from in-state (MN) watersheds

a. Calculated as the average of the 5-year rolling averages across the time period.

3.4.4 Mississippi River Major Basin

The Mississippi River Major Basin covers 60 percent of the state and includes the following seven basins: Upper Mississippi River, Minnesota River, St. Croix River, Lower Mississippi River, Cedar River, Des Moines River, and Missouri River. The Upper Mississippi River Basin contains the headwaters to the Mississippi River near Itasca and includes a mixture of forest, prairie, agriculture, and urban land areas. The majority of the Twin Cities Metropolitan Area (Metro Area) is also located in this basin. The Minnesota River discharges to the Mississippi River near Fort Snelling and drains approximately 16,770 square miles. This basin contains very fertile soils and is predominantly agricultural upstream of the Metro Area. Sediment and nutrient reduction has been a focus in this basin for several decades and a phosphorus total maximum daily load (TMDL) was approved in 2012. The St. Croix River Basin is approximately 3,500 square miles in Minnesota and includes the state's only National Wild and Scenic River (St. Croix River). The basin is typically forested with lower intensity livestock agriculture in the upper portion and agriculture becoming more prominent in the lower portion. The Lower Mississippi River Basin is characterized by a mix of agriculture, bluffs, springs, caves, and many cold-water streams. Lake Pepin is a natural lake along the Mississippi River within this basin and has been the subject of many studies. A TMDL is being developed to address excessive nutrients (phosphorus) in Lake Pepin. Agriculture is the predominant land use in this basin. Agriculture accounts for 84 percent of land use in the combined Cedar River, Des Moines River, and Missouri River basins.

To evaluate major basin loading, loading data were obtained for a variety of locations (Table 3-6 and Figure 3-10). Data for the Mississippi River provide a reasonable span of years to cover most of the time periods. The most relevant data for goal setting were for sampling stations located at Lock and Dam 7 and 8, the most downstream locations in Figure 3-10. In addition, Lock and Dam 3 contains the longest period of record and is therefore also an important monitoring station. Its location upstream of Lake Pepin and many of the Wisconsin tributaries eliminates these complicating factors from annual loading evaluations. A review of average statewide precipitation indicates that the baseline period of 1980–1996 may have been wetter than the long-term average in Minnesota. However, the average annual load from this period is very similar to the average annual load from the 1998–2002 time period for both phosphorus and nitrogen.

Table 3-6. Mississippi River annual loading data

Location	Source agency	Nitrogen (annual loads available)	Phosphorus (annual loads available)
Mississippi River			
Above Lock and Dam 3 (UMR 796.9)	MCES	1980–2010[a]	1980–2010
Lake Pepin outlet (M764)	USGS/MPCA	1992–2008	1985–1996[c]
Gage 05378500, at Winona, Minnesota (60001)	USGS[b]	1975–1993	1975–1993
At Winona, Minnesota	MPCA	2009[a]	2009
Lock and Dam 7 (M701)	USGS/MPCA	1990–2010	1990–2010
Lock and Dam 7 + Root River	USGS/MPCA	--	1991–2010
downstream of Lock and Dam 7 (80009)	USGS[b]	1991–1997	1991–1997
Near Lock and Dam 8 (80011)	USGS/ MPCA	1990–2010	--
Near Lock and Dam 8	USGS[b]	1991–1997	1991–1997

Additional data available but are not included in the analysis below.
MCES = Metropolitan Council Environmental Services; USGS = United States Geological Survey.
a. Results are for total Kjeldahl nitrogen (TKN) and nitrate; the results are summed to represent nitrogen.
b. Upper Mississippi River Basin Loading Database (Sediment and Nutrients).
http://www.umesc.usgs.gov/data_library/sediment_nutrients/sediment_nutrient_page.html
c. Additional data are available for this site; however, loads were not available at the time of this report.

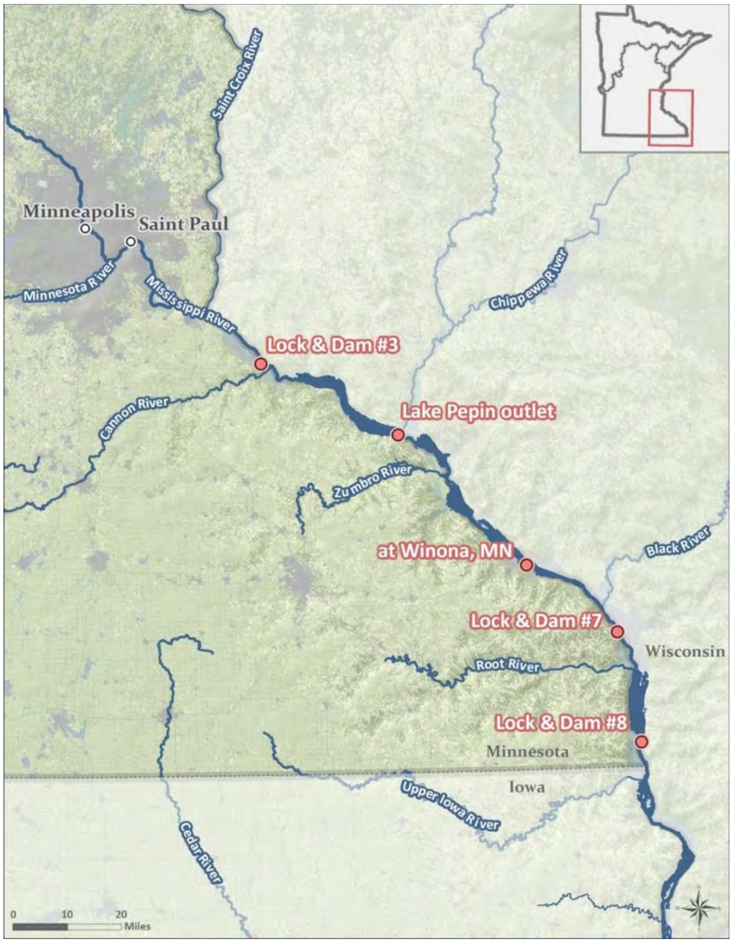


Figure 3-10. Monitored locations with available nutrient load estimates.

The loading analysis for the Mississippi River Major Basin involved evaluations of flow, load (using 5-year rolling average), and FWMC. Loading is estimated proportionally by area for the Cedar, Des Moines, and Missouri River basins from the Mississippi in-stream load associated with Minnesota.

Figure 3-11 compares in-stream load, FWMC, and flow in the Mississippi River near the state border. The dashed lines represent the estimated outcome of a 45 percent reduction in baseline conditions load. Analysis of load and flow for phosphorus indicate that phosphorus load reductions have been documented within the recent decade and between baseline and current conditions in the Mississippi River near the state border, with the exception of 2010 (a high flow year). While total load and flow have shown a decreasing trend, FWMC has remained fairly constant. These findings suggest that limited long-term progress has been made in reducing phosphorus loads to the Mississippi River near the state border. In contrast to this conclusion, substantial phosphorus reductions have been measured upstream of Lake Pepin at Lock and Dam 3, where additional monitoring data are available. Based on the results at Lock and Dam 3 and other more direct measurements, there is likely a lag time response at the state border for phosphorus. Lake Pepin, pools behind locks and dams, and backwaters of the Mississippi River likely affect the lag time.

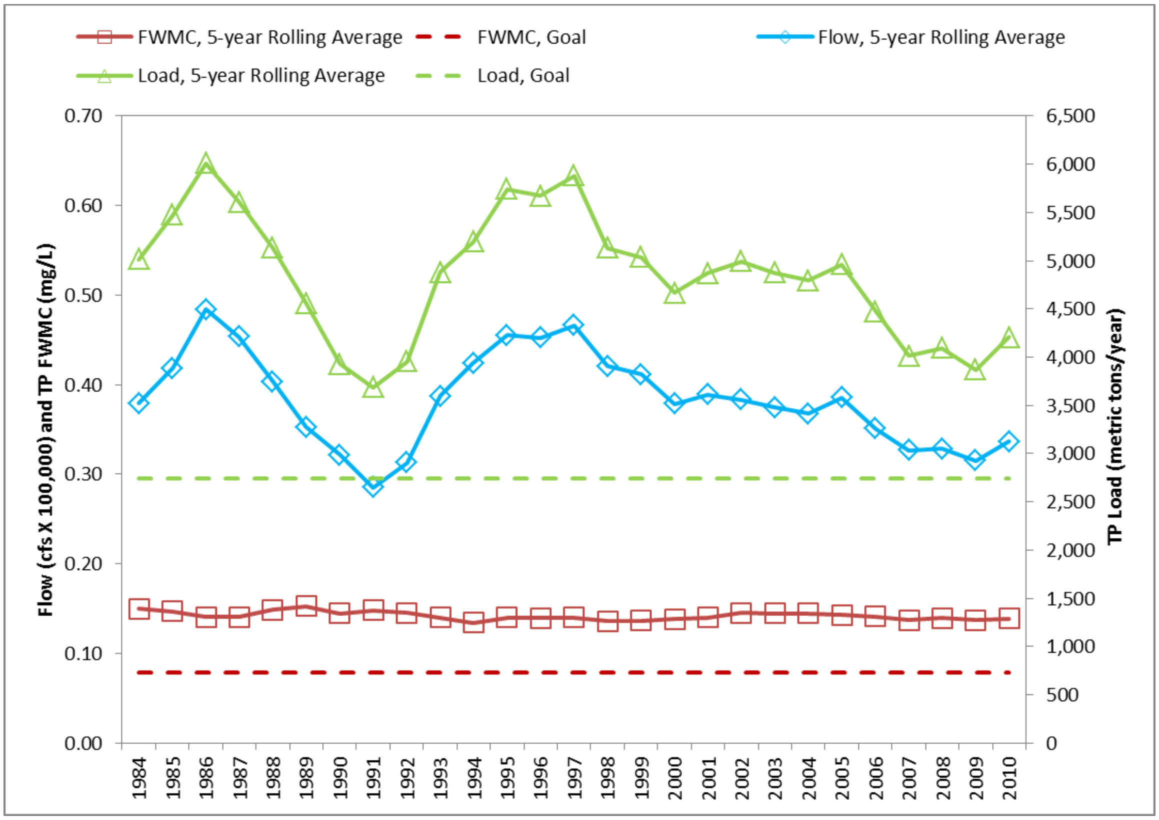


Figure 3-11. Phosphorus loading analysis, Mississippi River near the Minnesota border.

Data are the result of in-stream monitoring, and include out-of-state drainage area.

Table 3-7 presents the phosphorus load and FWMC estimates available at the state border, summarized by time period. The goals represent a 45 percent reduction in load from the baseline conditions. An in-stream load of 2,737 metric tons of phosphorus per year and a FWMC of 0.08 mg/l are proposed as the goals for the Mississippi River Major Basin. The goal load estimated for the Minnesota portion of the major basin (2,107 metric tons of phosphorus per year) can be used to assess reductions achieved within Minnesota as a secondary measure of achieving the loading goal. Since long-term annual loading data were not available for the Cedar, Des Moines, and Missouri River basins, the approximate load for these small basins was proportioned from the Mississippi in-stream loads (Minnesota portion which excludes areas in the Dakotas, Iowa, and Wisconsin as estimated using SPARROW). The goal load (437 metric tons of phosphorus per year) can serve as a nutrient reduction goal until more reliable loading data are available. When the load estimates for the Mississippi, Cedar, Des Moines, and Missouri Rivers are combined and only loads from the Minnesota drainage area are considered, the load goal is 2,544 tons of phosphorus per year.

As noted earlier and described in more detail later in this chapter, considerable progress has been made in reducing phosphorus loads to the Mississippi River, even though the monitoring-based load calculations at Lock and Dam 8 do not show the full extent of the reductions.

Table 3-7. Phosphorus loading results, Mississippi River (concentration in mg/l; loads in metric tons/year)

Data set	Baseline 1980–1996	Goal (45% reduction from baseline)	Current conditions 2006–2010	Notes
FWMC (Mississippi River near State Border)	0.14	0.08	0.14	Based on in-stream loads; includes out-of-state drainage area
In-stream Loads (Mississippi River near State Border)[a]	4,976	2,737	4,084	In-stream loads; includes out-of-state drainage area
In-stream Loads (Mississippi River near State Border, MN portion)	3,832	2,107	3,145	An estimated 77% of River loads are from in-state (MN) watersheds
Cedar, Des Moines, and Missouri River (proportional load based on Mississippi load, Minnesota portion)	795	437	658	MN drainage area only
Total Minnesota Load to the Mississippi River near State Border including the Cedar, Des Moines, and Missouri River loads	4,627	2,544	3,803	MN drainage area only

a. Calculated as the average of the 5-year rolling averages across the time period.

Figure 3-12 presents nitrogen in-stream load, FWMC, and flows for the Mississippi River near the state border. To illustrate reductions needed to achieve goals, the dashed lines represent the estimated outcome of a 45 percent reduction in baseline conditions load. The data indicate an overall decrease in nitrogen load within the past decade and between baseline and current conditions. The decrease can be mostly attributed to corresponding reductions in flow during this time period, with the exception of 2010 (a high flow year). FWMC has remained relatively constant, with a slight decrease over the period of record. Nitrogen loading appears to be strongly tied to flow, and future increases in flow would likely lead to increases in load, all other factors remaining constant.

Monitoring further upstream at Lock and Dam 3 has not shown nitrogen reductions when comparing baseline and recent periods during various flow conditions. This further substantiates that flow-adjusted nitrogen loads have not reduced appreciably in the Mississippi River since the baseline period.

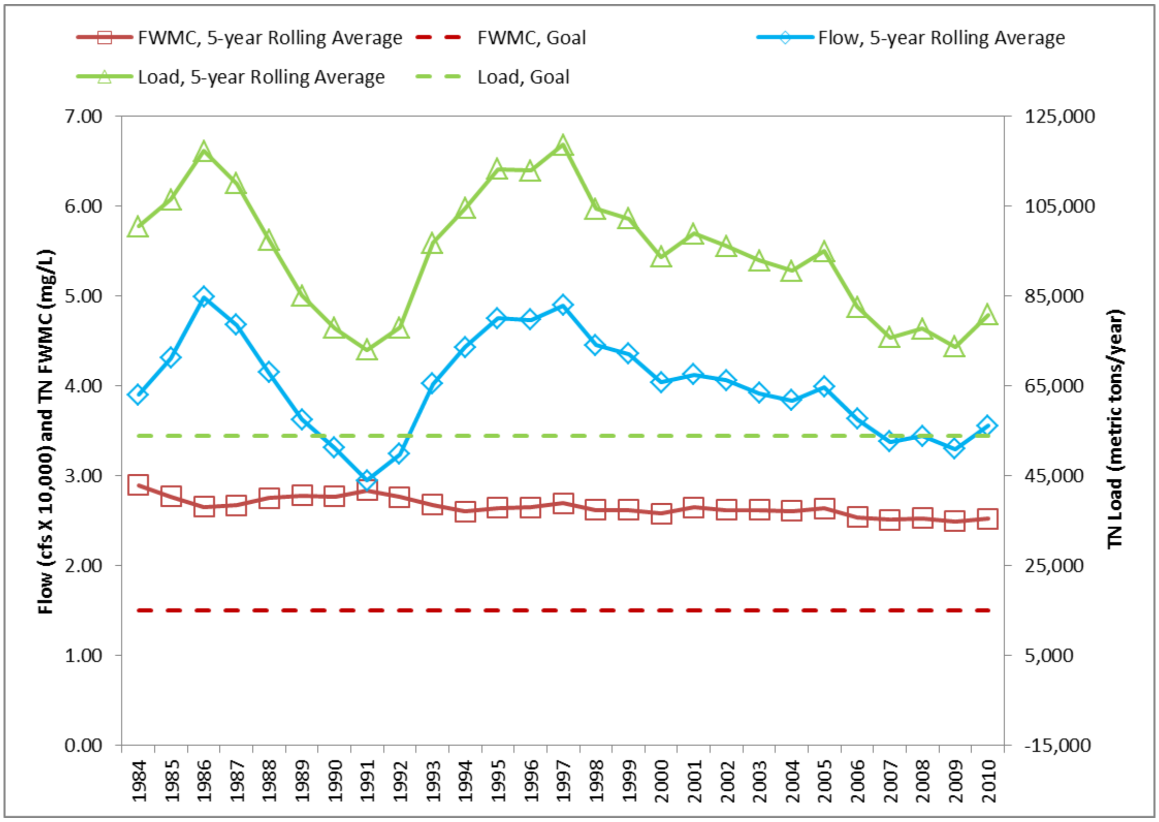


Figure 3-12. Water Quality Measures Comparison: Nitrogen, Mississippi River near the Minnesota border.
Data are the result of in-stream monitoring, and include out-of-state drainage area.

Table 3-8 presents the nitrogen load and FWMC estimates available, summarized by time period. The goals represent a 45 percent reduction in load from the baseline conditions. The goal load of 53,989 metric tons nitrogen per year and the FWMC of 1.5 mg/l are proposed as the goals for the Mississippi River Major Basin. The goal load estimated for the Minnesota portion of the major basin (41,502 metric tons of nitrogen per year) can be used to assess reductions achieved within Minnesota as a secondary measure of achieving the loading goal. The Cedar, Des Moines, and Missouri River basins' goal load (8,587 metric tons of nitrogen per year) can serve as a nutrient reduction goal until more reliable loading data are available. When the load estimates for the Mississippi, Cedar, Des Moines, and Missouri Rivers are combined and only loads from the Minnesota drainage area are considered, the load goal is 50,088 tons of nitrogen per year.

Table 3-8. Nitrogen loading results, Mississippi River (concentration in mg/l; loads in metric tons/year)

Data set	Baseline 1980–1996	Goal (45% reduction from baseline)	Current conditions 2006–2010	Notes
FWMC (Mississippi River near State Border)	2.73	1.50	2.58	Based on in-stream loads; includes out-of-state drainage area
In-stream Loads (Mississippi River near State Border)[a]	97,996	53,898	78,211	In-stream loads; includes out-of-state drainage area
In-stream Loads (Mississippi River near State Border, MN portion)	75,457	41,502	60,223	An estimated 77% of River loads are from in-state (MN) watersheds
Cedar, Des Moines, and Missouri River (proportional load based on Mississippi load)	15,612	8,587	12,460	MN drainage area only
Total Minnesota Load to the Mississippi River near State Border including the Cedar, Des Moines, and Missouri River loads	91,069	50,088	72,682	MN drainage area only

a. Calculated as the average of the 5-year rolling averages across the time period.

Headwaters to the Mississippi River Photo Credit: MPCA

Nutrient Reductions Upstream of Lake Pepin - A Closer Look at Lock and Dam 3

Data at Lock and Dam 3 show different results than Lock and Dam 8, likely due to its location which is upstream of Lake Pepin (impaired for eutrophication), several pools and backwaters of the Mississippi River, and several tributaries from Wisconsin. Recent (2009–2011) monitoring data from the Mississippi River at Lock and Dam 3 indicates that the average flow normalized phosphorus load has been reduced 31 percent from the 1980–1996 baseline level. Data from the recent period was used to calibrate the FLUX loading model developed by the U.S. Army Corps of Engineers, and this calibration was applied to historical flows. This technique was used to normalize flow since short-term variability in weather may impact average load when examining short periods of record such as the recent period.

Phosphorus concentrations at Lock and Dam 3 in recent (2009–2011) years are lower than the baseline period (1980–1996) (Figure 3-13). This is especially true during lower flows when wastewater point sources generally have the most impact on phosphorus concentration. Major wastewater reductions upstream of this station started in 2003 and stabilized from 2009–2011. Between 2000 and 2010, phosphorus loads from wastewater point sources upstream of Lock and Dam 3 reduced from 1,653 to 445 metric tons per year. Monitored nitrogen concentrations at Lock and Dam 3 also show a decrease under low flows (Figure 3-14). Two load estimates were compared to determine if the concentration changes in the recent period would result in lower loads if flows were identical to the baseline conditions (Figure 3-15 and Figure 3-16). Loading estimates were calculated by calibrating flow verses concentration relations during monitored dates and applying the calibration for all dates of interest to estimate the load for a given time period. The baseline loads are derived from monitored data collected between 1980 and 1996.

The recent calibration applied to the baseline flows predicts that average annual phosphorus load at Lock and Dam 3 would be 31 percent less than the baseline load. This analysis indicates that progress toward the NRS phosphorus goals has been made on a portion of the Mississippi River mostly due to phosphorus reductions in Minnesota. The baseline nitrogen loads are similar to the loads based on a 2002–2011 calibration applied to the baseline flows.

This analysis is a more effective method of removing flow bias than the flow-weighted mean or load estimation techniques used elsewhere in the NRS. Unfortunately, water quality data sets needed to similarly evaluate these trends are not available at the outlets of the state’s three major basins.

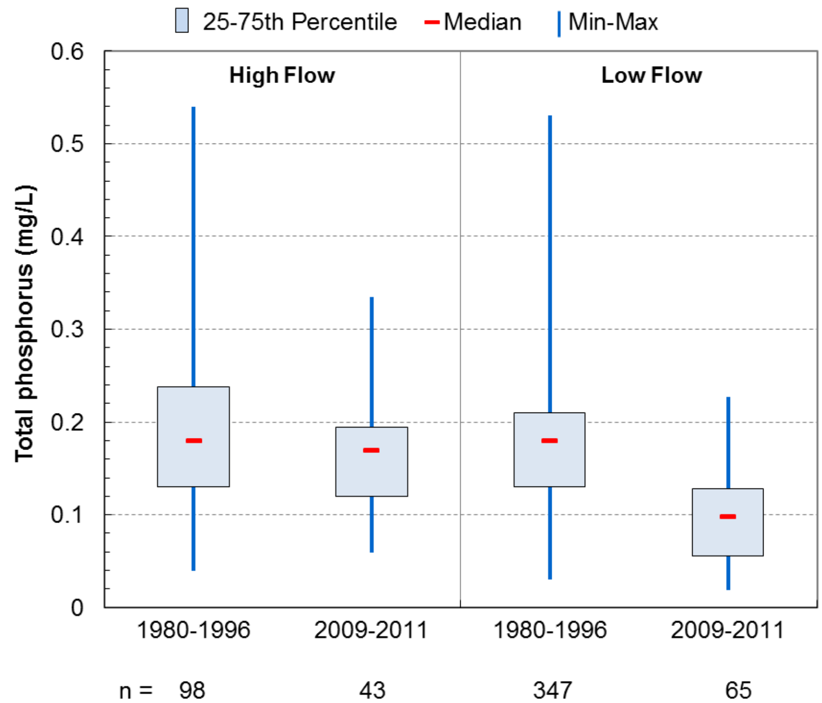


Figure 3-13. Monitored phosphorus concentration at Lock and Dam 3 during baseline (1980–1996) and recent conditions (2009–2011) for three flow conditions. *High Flow* represents flows that are exceeded from 0–20 percent of the time; *Low Flow* represents flows that are exceeded 21–100 percent of the time.

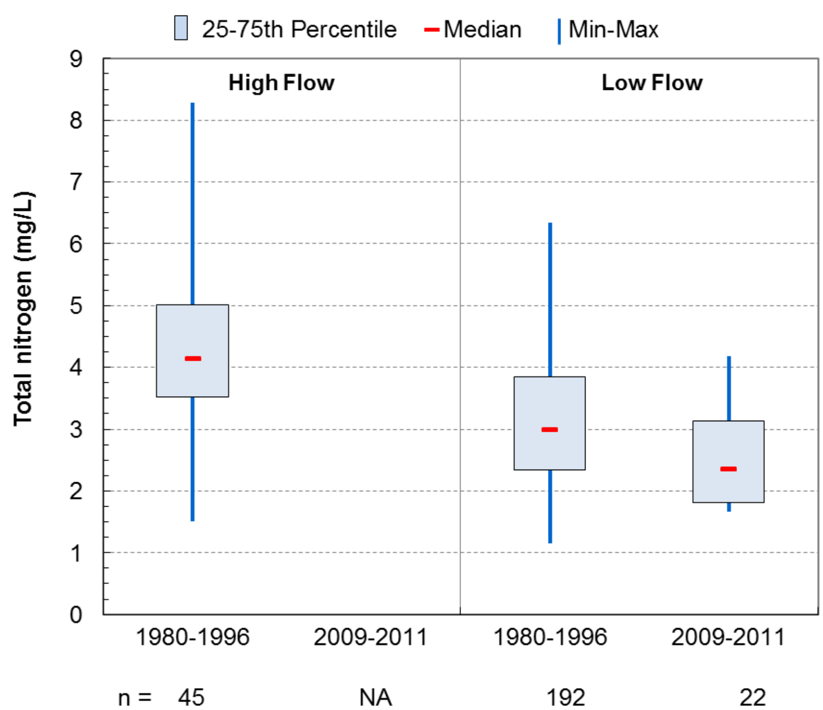


Figure 3-14. Monitored nitrogen concentration at Lock and Dam 3 during baseline (1980–1996) and recent conditions (2009–2011). *High Flow* represents flows that are exceeded from 0–20 percent of the time; *Low Flow* represents flows that are exceeded 21–100 percent of the time.

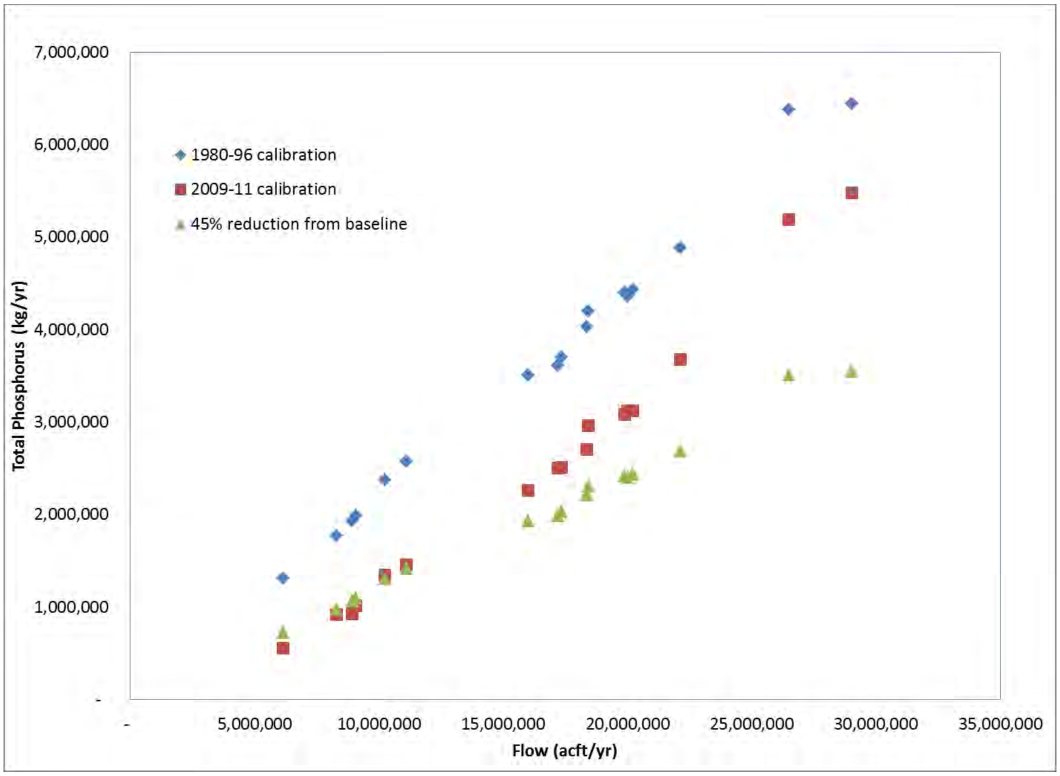


Figure 3-15. Estimated annual phosphorus loads for baseline years based on baseline and recent calibration verses observed flow.

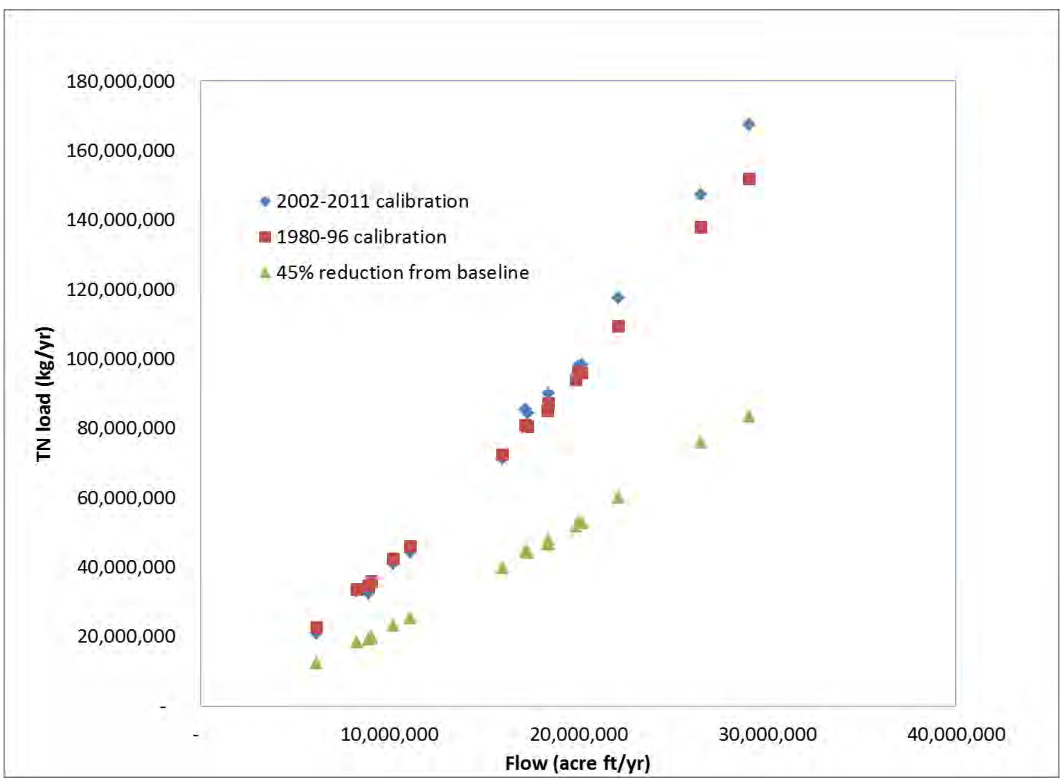


Figure 3-16. Estimated annual nitrogen loads for baseline years based on baseline and recent calibration verses observed flow.

3.4.5 Load Reduction Summary

Table 3-9 and Table 3-10 summarize the proposed water quality targets needed to meet goals (see Chapter 2). Future monitoring efforts will track changes in load, FWMC, and flow. These three variables are not independent and fluctuate annually. Achieving the ultimate goals in this NRS will be based on long-term evaluations that account for changes in river flow conditions.

Table 3-9. Summary of proposed in-stream FWMC targets (mg/l)

Major basin	Goal	FWMC target		Notes
		P	N	
Lake Winnipeg (Red River Only)	10% and 13% reductions from 2003 conditions for phosphorus and nitrogen, respectively	0.30	2.05	In-stream loads; includes out-of-state drainage area
Mississippi River near State Border	45% from average 1980–1996 conditions	0.08	1.50	In-stream loads; includes out-of-state drainage area

Note: P = phosphorus, N = nitrogen

Table 3-10. Summary of proposed in-stream load targets (metric tons per year)

Major basin	Goal	Load target		Notes
		P	N	
Lake Superior	Maintain loading at 1979 conditions	248	NA	MN drainage area only; delivered to lake
Lake Winnipeg (Red River Only)	10% and 13% reductions from 2003 conditions for phosphorus and nitrogen, respectively	2,340	16,258	In-stream loads; includes out-of-state drainage area
		1,123	7,804	In-stream loads; MN drainage area only
Mississippi River near State Border	45% from average 1980–1996 conditions	2,737	53,898	In-stream loads; includes out-of-state drainage area
		2,107	41,502	In-stream loads; MN drainage area only
Cedar, Des Moines, and Missouri River (sum of loads to state border)	45% from average 1980–1996 conditions	437	8,587	MN drainage area only
Total Minnesota Load to the Mississippi River near State Border including Cedar, Des Moines, and Missouri Rivers	45% from average 1980–1996 conditions	2,544	50,088	MN drainage area only

Note: P = phosphorus, N = nitrogen

Chapter 4 provides further analysis to determine reductions needed to meet milestones that take into consideration recent progress from known BMP implementation in the state. BMP implementation data, which are supported by upstream in-stream measurements, are used to quantify recent progress due to the limitations of current in-stream data at the Iowa border. However, in order to achieve milestones, all three measures (FWMC, in-stream loading, and BMP implementation) should be considered when evaluating progress toward milestones and goals.

Chapter 4

Management Priorities and Recent Progress

A function of the *Minnesota Nutrient Reduction Strategy* (NRS) is to identify the nutrient reduction goals and milestones and provide a path to achieve those reductions over time. Accomplishing the goals in an effective and efficient manner requires an understanding of the priority geographic areas within the state where nutrient reductions are most needed, priority nutrient sources, and key programs for delivering those reductions. This chapter describes the NRS's watershed prioritization process and presents a list of key regional, state, and federal nutrient reduction programs to address key nutrient sources. This chapter also presents the results of a program quantification analysis to assess recent progress in nitrogen and phosphorus source load reduction. Ultimately, the NRS should provide the information necessary to align priority major watersheds and priority programs to help programmatic staff at the local, state, and federal levels to better target key program resources.

4.1 Major Watershed Priorities

Comparing watershed nitrogen yields (i.e., lbs/acre of nitrogen and phosphorus) using the Spatially Referenced Regressions on Watershed (SPARROW) model provided the basis for major watershed nitrogen priorities. SPARROW modeling, which has been widely used to compare watershed nutrient loads throughout the country, is further described in Chapter 5. SPARROW modeled yields along with a comparison of available data to the pending river eutrophication standards, serve as the foundation for major watershed phosphorus prioritization. SPARROW reports an 8-digit hydrologic unit code (HUC8) yield as delivered to the state border, which takes into account attenuation of that load as it moves downstream from HUC8 pour point to the state border. This yield is used to determine which HUC8s have the highest nutrient loading per acre that ultimately reaches the state border. Major watersheds (HUC8s) with higher nutrient loading per acre are considered higher priority over lower yielding major watersheds. It is important to recognize that, while prioritization is a beneficial management tool for directing limited resources, significant reduction targets to meet the goals of the NRS—especially in the Mississippi River Major Basin and the Lake Winnipeg Major Basin—cannot be achieved through implementation in a limited number of high-priority major watersheds.

In addition to the SPARROW yield data, an analysis of available monitoring data (minimum 12 samples per reach) was used to determine which stream reaches would be likely determined impaired if the pending river eutrophication standards were in place. While the river eutrophication standards require both the phosphorus concentration and a response variable to exceed the pending water quality criteria for eutrophication in streams, the prioritization process assigns a high-priority ranking to major watersheds that have phosphorus concentrations higher than the pending river eutrophication standards, even when the eutrophication response variable may not be exceeded. This is because even where local waters are not sensitive to high nitrogen or phosphorus loads, downstream waters can still be sensitive to the added nutrients. For those major watersheds without monitoring data, prioritization is based on the SPARROW-modeled yields alone.

The prioritization process occurs at a state level so as to help state programs identify the largest loading major watersheds. A hierarchy of nutrient contributions can be identified for managers within the three major basins. Since priority rankings are assigned to major watersheds with the highest yields statewide, most of the priorities are located in the Mississippi River Major Basin. Table 4-1 summarizes the prioritization criteria and Figure 4-1 presents the results based on phosphorus and nitrogen.

Table 4-1. Major watershed prioritization criteria

<table>
<tr><th colspan="2">Nutrient yield</th><th>Anticipated exceedance of river eutrophication standards</th><th>Prioritization</th></tr>
<tr><td>Highest (upper 25%) yielding nitrogen or phosphorus HUC8s</td><td rowspan="2">OR</td><td>Phosphorus priorities only - HUC8s with greater than or equal to 50% of the monitored reaches estimated as not meeting pending river eutrophication standards.</td><td>High</td></tr>
<tr><td>HUC8s with high (25%–50%) yielding nitrogen or phosphorus</td><td>Phosphorus priorities only - Of the remaining HUC8s with monitoring data (those not already prioritized as High), greater than or equal to 50% of the reaches have elevated phosphorus levels (no elevated response variable).</td><td>Medium</td></tr>
<tr><td colspan="3">All remaining HUC8 major watersheds</td><td>Protection</td></tr>
</table>

Note: Based on additional review from Minnesota Pollution Control Agency (MPCA) technical staff, the following changes were made to the systematic screening approach to prioritization: Lower Minnesota from Medium to High and Lower St. Croix from High to Medium.

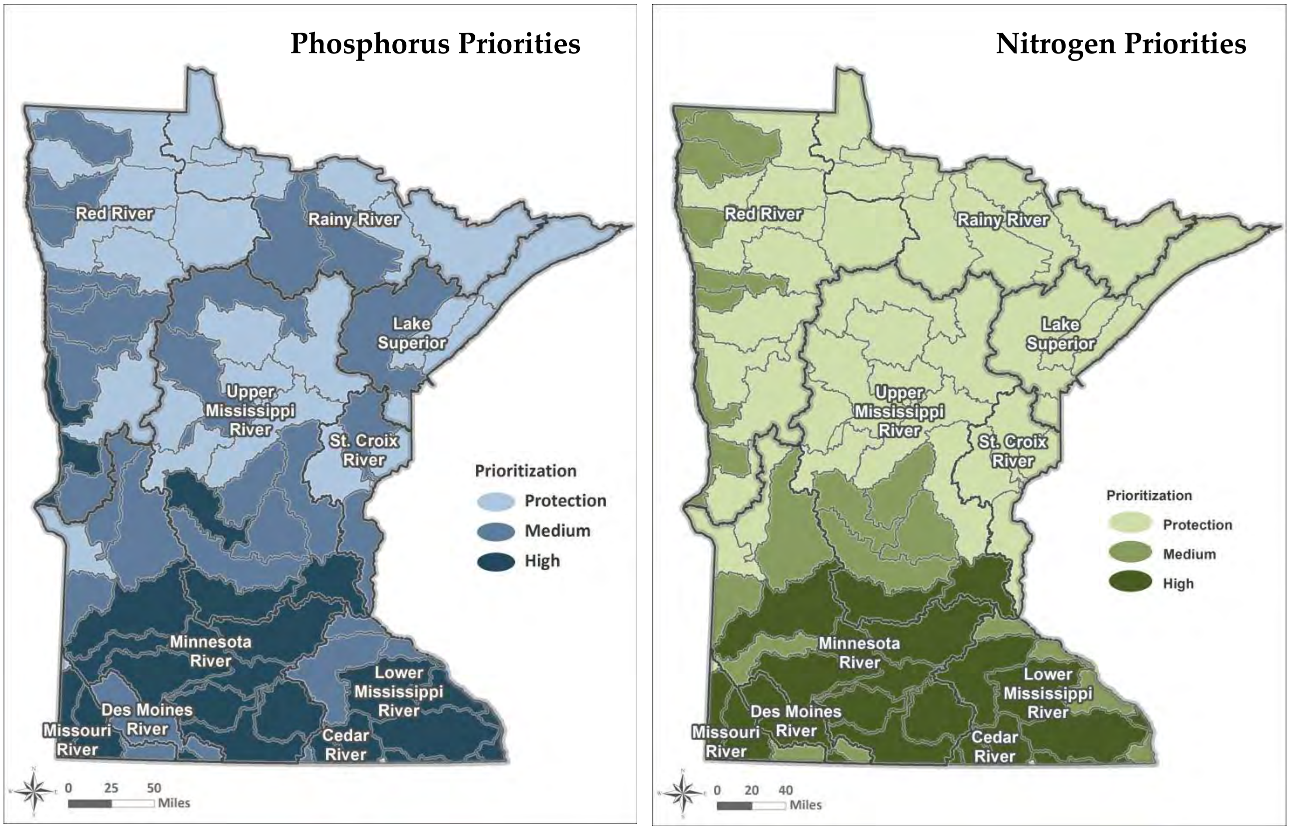


Figure 4-1. HUC8 major watershed priorities for phosphorus loading (left) and nitrogen loading (right).

Areas with a higher vulnerability for groundwater nitrate pollution are shown in Figure 4-2. Townships identified as vulnerable to groundwater contamination have a combination of greater than 20 percent row crops and a high geologic vulnerability. In 2013, groundwater supplies in 22 vulnerable townships were sampled under the leadership of Minnesota Department of Agriculture (MDA). In 18 of those townships at least 10 percent or more of the sampled wells were greater than or equal to 10 mg/l nitrate, which is the nitrate drinking water standard. Many areas of the state that are vulnerable for groundwater nitrate are located in areas with a lower priority for surface water nitrogen. Therefore prioritization efforts to reduce nitrate leaching should consider both surface water and groundwater loads and vulnerability.

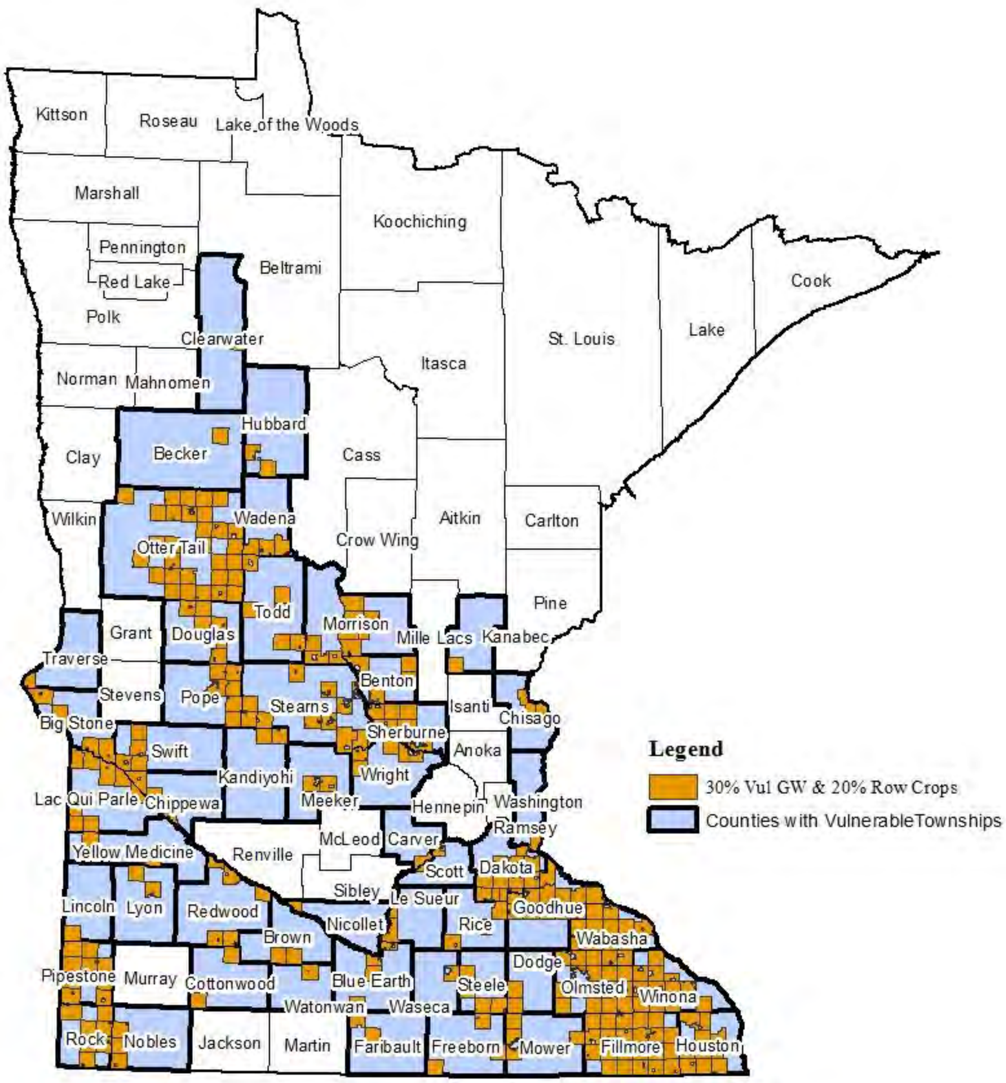


Figure 4-2. Priority groundwater areas (map provided by MDA).

The surface water analysis focuses mostly on priorities based on contributions to downstream loads, considering also potential river eutrophication standards impairments. The priority areas for groundwater protection from nitrate pollution are somewhat different compared to surface water protection priorities since the groundwater priorities are affected by areas of sandy soils which can create high nitrate levels in drinking water wells, but are not dominant enough across the watershed to create high loadings in surface water. Additionally, priorities for protection of overall water quality may be different than nutrient reduction priorities, since many lakes and streams currently have relatively small nutrient loads, but are highly sensitive to new loads if not protected. Some major watersheds also have numerous individual lakes impaired by eutrophication, but they do not contribute appreciably to downstream nutrient loads. Such major watersheds may be a higher priority when considering lake protection and restoration at a smaller scale.

Prioritizing areas at a smaller watershed scale is deferred to development of Watershed Restoration and Protection Strategies (WRAPS) and comprehensive watershed management planning initiatives. WRAPS and watershed plans (e.g., One Watershed One Plan) are developed for each HUC8 in the state according to a rotating schedule. Lower priority HUC8 watersheds can still have subwatersheds with high nutrient yields and may be considered high priority in local water plans. The *Clean Water Legacy Act* (CWLA) requires that WRAPS summarize priority areas for targeting actions to improve water quality, identify point sources, and identify nonpoint sources of pollution with sufficient specificity to prioritize and geographically locate watershed restoration and protection actions. In addition, the CWLA requires including an implementation table of strategies and actions that are capable of cumulatively achieving needed pollution load reductions for point and nonpoint sources. Because many of the nonpoint source strategies provided in WRAPS rely on voluntary implementation by landowners, land users, and residents of the watershed, civic engagement is required as part of WRAPS development in order to create social capital (trust, networks, and positive relationships) with those who will be needed to voluntarily implement best management practices (BMPs).

4.2 Source Priorities

The source assessment presented in Chapter 3 identifies the most significant sources of reducible nutrients in Minnesota (Table 4-2). These sources generally reflect 2009-2011 nitrogen conditions and a hybrid timeframe for phosphorus consisting of 2003 conditions for nonpoint source phosphorus and 2011 phosphorus loads from treated wastewater (reflecting the large reductions in wastewater phosphorus accomplished since 2003). Priority sources are determined on the major basin scale, although it should be noted that different sources may be more or less important at the local scale. Priority sources at the HUC8 scale or smaller will be determined through watershed planning efforts. For example, individual sewage treatment systems are not identified as a significant source of nutrients at the major basin scale but can contribute to lake eutrophication, potentially resulting in water body impairment. Each source will require a different set of implementation activities to achieve nutrient reductions.

Table 4-2. Priority sources

Major basin	Priority phosphorus sources	Priority nitrogen sources
Mississippi River	Cropland, wastewater point sources, and streambank erosion	Agricultural tile drainage and cropland
Lake Superior	Nonagricultural rural runoff [a], wastewater point sources, and streambank erosion	Wastewater point sources
Lake Winnipeg	Cropland and nonagricultural rural runoff	Cropland

a. Includes natural land cover types (forests, grasslands, and shrub-lands) and developed land uses that are outside the boundaries of incorporated urban areas.

Priority sources may differ depending on the scale at which reductions are needed and may be adjusted through local and regional planning processes. There are also sources that cannot be reliably reduced by local or regional scale implementation activities, including atmospheric deposition and loads from forested areas. These sources are therefore not considered priorities in this NRS. It is possible with additional research that a portion of the atmospheric deposition phosphorus load will be attributed to local wind-blown particulates. In this case, implementation of activities aimed at reducing wind-blown sediment could potentially reduce the atmospheric deposition phosphorus load. At this time, research is not available to make this distinction.

4.3 Nutrient Reducing Programs

Nutrient management efforts have been ongoing for several decades. Within the past 15 years, these efforts have increased in number and scope. Table 4-3 provides an overview of key regional, state, and federal nutrient-reducing programs in Minnesota with the initial year of program operation and a brief description of program activities. Most of the nutrient reduction efforts are statewide in scope, although each program has specific eligibility or regulatory requirements that narrow the geographic scope.

Regional, state, and federal programs only account for a portion of the nutrient reduction activities in the state. For example, agricultural producers are implementing BMPs without participating in cost-share programs that allow for tracking of BMP implementation. These activities, likely privately funded, are not tracked or quantified at a statewide level. However, it is probable that there are a significant number of BMPs implemented in this manner that warrant inventorying with assistance from partners at the local level, such as Soil and Water Conservation Districts (SWCDs). For example, two studies recently completed in the Chesapeake Bay watershed identified BMP adoption rates 30 to 50 percent higher than those identified through tracking of BMPs adopted through government programs (Maryland Department of Agriculture 2011).

For certain BMPs, we have existing methods to track the influence of combined government and private actions. The MDA, in partnership with the National Agricultural Statistics Service (NASS) and University of Minnesota, conduct *surveys of nitrogen fertilizer practices* on a regional and statewide scale. Both of these surveys should reflect BMP adoption as influenced by both government and private sector.

In addition, analysis (see Appendix A) of land cover data within a 30-meter buffer zone of all streams in Minnesota reflects a combination of buffers from both government program-influenced and private action (30 meters is beyond most regulatory requirements, but was used to represent a highly protective BMP scenario). The analysis indicates that within the Red River and Minnesota River basins streams have perennial vegetation within 50 and 57 percent of the buffer area, respectively. Figure 4-3 summarizes the percent of buffer area within each HUC8 major watershed that is recorded as perennial vegetation in the 2012 Cropland Data Layer. This level of implementation is not reflected in the quantifiable BMPs tracked as part of existing databases and programs.

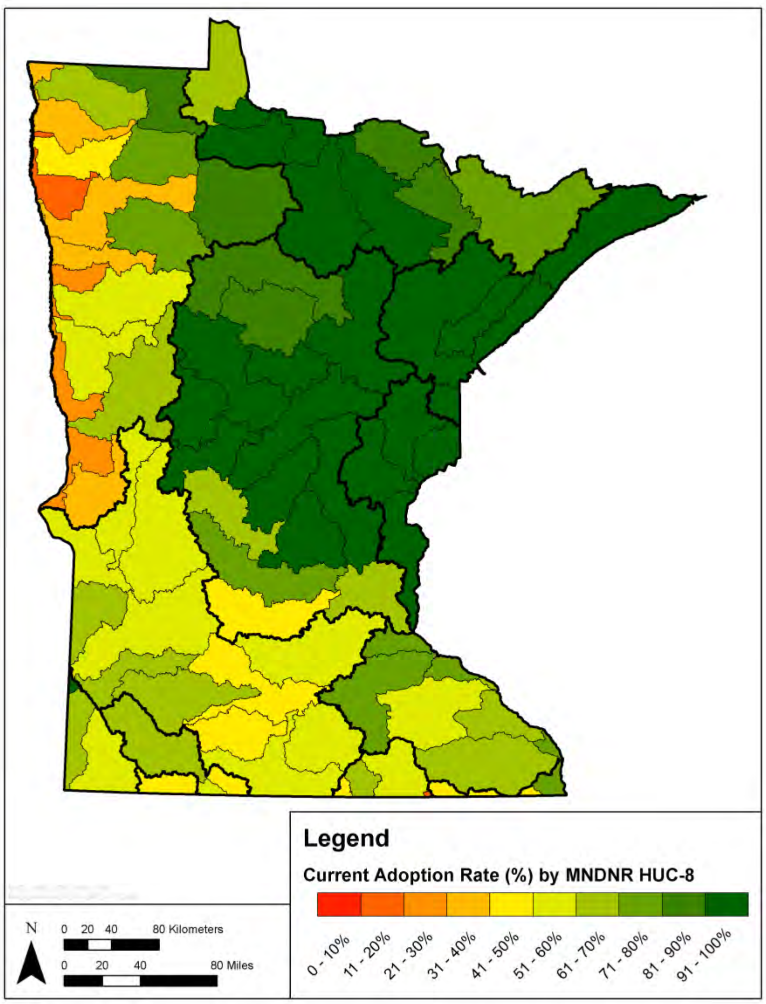


Figure 4-3. Statewide buffer analysis, percent of 30-meter riparian buffer (based on DNR 24K streams) in perennial vegetation.

Examples of some nongovernmental organization and industry-led initiatives include the fertilizer industry Four Rs Program for efficient fertilizer use, Minnesota Agricultural Water Resource Center Discovery Farms, Farm Bureau Green Farm Planning, Dairy Industry Livestock Environmental Quality Assurance, Pork Industry Quality Assurance, Farmland Trust, BMP Challenge, and many others. Nutrient planning is frequently provided through independent or cooperative crop advisors, and conservation tillage equipment advice is typically provided by equipment dealers in many cases without government program assistance. There are many other organizations that either help to support these programs or private advice networks (e.g., University of Minnesota Extension [*http://www1.extension.umn.edu/*]), or work to implement the program requirements and recommendations (e.g., counties, watershed districts [*www.mnwatershed.org*], and private industry). Water quality implementation work has also been occurring for the past three decades by cities, counties, and the Minnesota Department of Transportation, resulting in thousands of BMPs that help mitigate the effects of stormwater. Much of this work predates urban stormwater regulatory permits or programs at the state or federal levels. These entities are not specifically identified in the NRS; however, their actions are critical to implementation.

Nutrient Reduction in Action

Nitrate Reduction Efforts to Protect Groundwater

In response to elevated nitrate levels in its water, Cold Spring, Minnesota has been working with local landowners and others to reduce nitrogen fertilizer applications. In addition to area farmers, the central Minnesota city has partnered with the Minnesota Department of Health (MDH), the Minnesota Department of Agriculture, Minnesota Rural Water Association (MRWA), Stearns County, and the Natural Resource Conservation Service and has benefited from a grant from the Clean Water Fund.

After studying the issue, the wellhead protection team prioritized fields where recharge to public water supply wells was likely occurring and then worked with area farmers and landowners to reduce the nitrate levels. Cold Spring purchased nitrification-inhibitor products from the local co-op, which applied the products to farmers' fields to more efficiently use the nitrogen fertilizer that was being applied to the fields. As a result, farmers reduced their levels of fertilizer by 8 to 16 percent of their current application. The use of nitrification inhibitors, combined with the additional reduction in applied fertilizer, resulted in a decrease of 4,100 pounds of nitrogen applied on 277 acres.

Cold Spring also created a turf management demonstration project in a residential development near the public supply wells to demonstrate to landowners the proper rates and timing of nitrogen fertilizer applications. Beyond reducing the nitrogen fertilizer being applied, the partnership has increased the trust and cooperation between the city and local farmers and landowners, a relationship that had been strained in the past. The partnership, aided by funds from the Clean Water Fund, has improved vital relationships while making safer the water that Cold Spring is supplying to its 4,100 residents.

Monitoring wells have been installed to measure the effectiveness of the program and develop information about the source of contaminated groundwater now supplying the city's wells.

The City of Cold Spring was awarded the Source Water Protection Award by MRWA and MDH in 2013.

Other such efforts are described at:
http://www.mda.state.mn.us/en/protecting/waterprotection/drinkingwater.aspx

Table 4-3. Key regional, state, and federal nutrient-reducing programs

Program (date of program initiation)	Program activities
Metropolitan Council Environmental Services (MCES)	
Point Source Reduction Activities (1967)	MCES collects and treats wastewater at its seven regional treatment plants. It also develops plans to preserve and manage the region's water resources. Under the Point Source Program, MCES reduces nutrient loads through wastewater treatment plant (WWTP) technology upgrades and has phosphorus removal technologies at six of its seven plants that have greatly reduced contributions of phosphorus to the major receiving waters (Mississippi, Minnesota, and St. Croix). MCES develops monthly discharge monitoring reports, in response to permit requirements; WWTP load information available upon request. More information is available at *http://www.metrocouncil.org/environment/AboutMCES/index.htm*.
Nonpoint Source Pollution Management	To help achieve federal and state water quality standards, provide effective water pollution control, and help reduce unnecessary investments in advanced wastewater treatment, the MCES provides technical assistance to address nonpoint source pollution. These efforts include working with partners by providing the technical expertise and water quality and quantity information needed to develop TMDLs for several Metropolitan Area watersheds, conducting research and study on the control and prevention of water pollution (MN Statute 473.244), reviewing local surface water management plans (MN Statute 103B.231, Subd. 7), and providing technical assistance for local management of nonpoint source pollution control.
Water Quality Monitoring and Assessment (Streams – 1989; Rivers – 1930s; Lakes – 1980)	MCES supports several water monitoring programs that collect a variety of data for regional rivers, streams, lakes, WWTPs, and industrial dischargers. MCES is in the process of finalizing a comprehensive stream report that includes loading and trend information for the streams monitored in the metro area. Information on stream, river, and wastewater treatment loads are available on the Council's web site at *http://es.metc.state.mn.us/eims/index.asp* .
Minnesota Board of Water and Soil Resources (BWSR)	
Clean Water Land and Legacy Program (2008)	BWSR uses appropriations from the Clean Water Fund—one of four funds established through the Clean Water, Land, and Legacy Constitutional Amendment approved by voters in 2008—to implement a number of clean water easement programs and the Clean Water Fund Competitive Grant Program, as well as the Feedlot Water Quality Management Program. The goal of the Clean Water Fund directed to BWSR is to reduce nonpoint source pollution by providing Clean Water Fund dollars to local government units for on-the-ground activities, many of them installed on private lands that will result in improved and protected surface and ground water. BWSR requires Clean Water Fund awardees to use the eLINK reporting program to track all Clean Water Fund grant-related projects. BWSR's Annual Report on Clean Water Fund Appropriations for the state legislature (*http://www.bwsr.state.mn.us/cleanwaterfund/2012_BWSR_CWF_Legislative_Rpt-rev4.13.12.pdf)* contains a detailed description of the easement programs receiving funding and the qualitative information on outcomes and effectiveness. More information is available at *http://www.bwsr.state.mn.us/cleanwaterfund/*.

Program (date of program initiation)	Program activities
Erosion Control and Water Management Program/State Cost-Share Program (1978)	The Erosion Control and Water Management Program, commonly known as the State Cost-Share Program, provides funds to Soil and Water Conservation Districts to share the cost of systems or practices for erosion control, sedimentation control, or water quality improvements that are designed to protect and improve soil and water resources. Reductions in erosion and sedimentation from agricultural lands will also result in a reduction of nutrients. Eligible practices that also have implications for controlling nutrients include filter strips, grassed waterways, and wastewater and feedlot runoff controls. BWSR requires the use of the eLINK reporting program to track all cost-share funded projects. More information is available at *http://www.bwsr.state.mn.us/cs/index.html*.
Feedlot Water Quality Management Grant Program (2010)	Clean Water Feedlot Water Quality Management Grant funds provide financial assistance to landowners with feedlot operations less than 300 animal units in size and located in a riparian area or impaired watershed. Technical staff and engineers from local government units and private contractors work with the landowner to develop and implement a pollution control system that protects the environment and maintains the economic viability of the farm.
Regional and Local Resource Management and Planning Programs (1982, 1989)	A number of programs are included under the umbrella of regional and local resource management and planning programs, including comprehensive local water management that focuses on the adoption and implementation of local water management plans linked to land use decisions; watershed planning, including Metro Area surface water management, that focuses on adoption and implementation of local water plans based on watershed district and watershed management organization priorities; Soil and Water Conservation District comprehensive planning that involves review from BWSR; and Metro groundwater planning. Through these programs, BWSR addresses nutrient load reductions by implementing regulations, developing plans, engaging the public, and funding BMPs. More information is available at *http://www.bwsr.state.mn.us/planning/index.html*.
Reinvest in Minnesota (RIM) Reserve Program (1986)	The Reinvest in Minnesota (RIM) Reserve program compensates landowners for granting conservation easements and establishing native vegetation habitat on privately-owned lands that are economically marginal, flood-prone, environmentally sensitive, or highly erodible. The program permanently restores wetlands, adjacent native grassland wildlife habitat, and creates permanent riparian buffers. The RIM Reserve program is implemented in cooperation with county SWCDs. The land remains in private ownership and the landowner retains responsibility for maintenance and paying applicable real estate taxes and assessments. Through the RIM Reserve program, land is retired from production and restored back to its pre-altered state. Once production of agricultural commodities ceases, the stabilized hydrology from the site reduces runoff, thereby reducing sedimentation and nutrients in sediment or soluble forms. Nutrient reductions from the RIM Reserve program would be limited initially during construction periods through full establishment of native vegetation (1-3 years). More information is available at *http://www.bwsr.state.mn.us/easements/rim/index.html*.

Program (date of program initiation)	Program activities
Minnesota Department of Agriculture (MDA)	
Agricultural Best Management Practices (AgBMP) Loan Program (1995)	The AgBMP Loan Program is a water quality program that provides low interest loans to farmers, rural landowners, and agriculture supply businesses. The purpose is to encourage agricultural BMPs that prevent or reduce runoff from feedlots, farm fields, and other pollution problems identified by the county in local water plans. More information is available at *http://www.mda.state.mn.us/en/grants/loans/agbmploan.aspx.*
Nitrogen Fertilizer Management Plan (NFMP) (1990 and updated in 2014)	The NFMP is a strategy for protecting Minnesota's water resources from nitrogen fertilizer use. Originally developed in 1990 and updated in 2014, the plan promotes voluntary nitrogen fertilizer BMPs, evaluates BMP use and effectiveness, and includes response strategies when BMPs are not used or are found to be ineffective. A key component of the NFMP is voluntary nitrogen BMPs based on University of Minnesota field research organized for the five regions of the state. More information is available at*http://www.mda.state.mn.us/en/chemicals/fertilizers/nutrient-mgmt.aspx*.
Farm Nutrient Management Assessment Program (FANMAP) (1993)	This MDA developed diagnostic tool called FANMAP is used to get a clear understanding of existing farm practices regarding agricultural inputs such as fertilizers, manures, and pesticides. Results can be used to design focused water quality educational programs and as a baseline to assist in determining if voluntary BMPs are being adopted. More information is available at *http://www.mda.state.mn.us/en/protecting/soilprotection/fanmap.aspx*
Nutrient Management Initiative (2006)	In cooperation with individual farms and certified crop consultants, the Natural Resources Conservation Service (NRCS), and University of Minnesota, MDA provides technical and financial assistance for on-Farm Evaluation of Nitrogen and Phosphorous Nutrient Management. Field plots are established to track different fertilizer rates and measure resulting yields. More information is available at *http://www.mda.state.mn.us/nmi*
Laboratory Manure Testing Certification (1996)	In response to a need for farmers to test manure for nutrients, MDA assists and validates agricultural laboratories in their manure testing and nutrient management services. More information is available at *http://www.mda.state.mn.us/licensing/licensetypes/mnrcertfaq.aspx*
Agricultural Fertilizer Research and Education Council (2008)	A farmer-led program to advance soil fertility research, technology development, and education that is environmentally and economically sound. More information is available at *http://www.mda.state.mn.us/chemicals/fertilizers/afrec.aspx*
Phosphorus Lawn Fertilizer Law (2002/2005/2007 [full implementation])	The Minnesota Phosphorus Lawn Fertilizer Law regulates the use of phosphorus lawn fertilizer with the intent of reducing unnecessary phosphorus fertilizer use and preventing enrichment of rivers, lakes, and wetlands with the nutrient phosphorus. The law prohibits use of phosphorus lawn fertilizer unless new turf is being established or a soil or tissue test shows need for phosphorus fertilization. This prohibition went into effect in 2004 in the Twin Cities metro area and statewide in 2005. The law also requires fertilizer of any type to be cleaned up immediately if spread or spilled on a paved surface, such as a street or driveway. A report on the effectiveness of this law was completed in 2007 which indicated that phosphorus fertilizer has decreased. More information is available at *http://www.mda.state.mn.us/phoslaw.*

Program (date of program initiation)	Program activities
Certified Animal Waste Technician Licensing (CAWT) (2000)	Minnesota law requires Commercial Animal Waste Technicians (CAWT) to obtain a state license. This license applies to those who apply or manage manure on a for-hire basis, although it does not apply to farmers who apply manure to their own fields. Licensing requires passing a test that is based on proper animal waste management and application. Training manuals and resources for two levels of manure applicators (senior applicators and field hands) have been developed. Education manuals and continuing education for manure applicators are developed through collaboration with the University of Minnesota. More information is available at *http://www.mda.state.mn.us/licensing/licensetypes/cawt.aspx*.
Minnesota Department of Health (MDH)	
Source Water Protection Program (Triggered by 1986 Safe Drinking Water Act amendments)	MDH's Source Water Protection Program contains three components: wellhead protection, source water assessments, and protection of surface water intakes. Under the provisions of the 1986 amendments to the federal Safe Drinking Water Act, states are required to have wellhead protection programs. MDH administers the state wellhead protection rule Minnesota Rules, Chapter 4720.5100–4720.5590 that sets standards for wellhead protection planning. A capture zone for the well (called the wellhead protection area) is designated and a plan is developed and implemented for managing potential contamination sources within the wellhead protection area. The 1986 Safe Drinking Water Act amendments also require states to develop source water assessments. Source water assessments identify potential sources of contamination to a well, lake, or river, and identify strategies for managing contamination. MDH completed assessments for the over 7,000 public water systems in the state. MDH provides source water protection grants using Clean Water Legacy funds to help local water suppliers to implement source water protection activities. Many of these grant funded activities help to reduce nutrient contributions, particularly nitrogen, to source water supplies. Surface water intake protection planning efforts are voluntary for the public water supplies. More information is available at *http://www.health.state.mn.us/divs/eh/water/swp/index.htm*.

Program (date of program initiation)	Program activities
Minnesota Pollution Control Agency (MPCA)	
Feedlot Program (Rules revised in 2014)	The MPCA Feedlot Program implements the MN Feedlot Rules that regulate the collection, transportation, storage, processing, and use of animal manure and livestock operation wastes. The program also provides assistance to counties and the livestock industry. Specific program activities and requirements that reduce agricultural runoff from transporting nutrient-rich manure to streams and lakes include the following: reducing feedlot runoff, improved construction methods and standards, soil testing for the majority of fields receiving manure application, manure application setbacks and rate restrictions, manure nutrient testing, nutrient planning, and enforcement actions. The Feedlot Program has provided oversight for various Clean Water Act (CWA) Section 319 grants that provided money for publications, training sessions, and other outreach that targeted land application activities. A key element of the Feedlot Program is the county feedlot program, a cooperative arrangement between the MPCA and county government to administer Minnesota's feedlot rule. This cooperative program is known as "county delegation" or the "county feedlot program." County feedlot programs are responsible for the implementation of feedlot rules and regulations for many of the feedlots in 54 Minnesota counties, including most of the major feedlot counties. More information is available at *http://www.pca.state.mn.us/index.php/topics/feedlots/index.html*.
Septic Systems or Subsurface Sewage Treatment System Program (SSTS) (1996; current regulations in place since 2011)	Under the SSTS Program, MPCA issues a license to SSTS businesses that design, inspect, install, pump, or site evaluate SSTSs. The SSTS program also provides a registration program for SSTS professionals who have completed training, taken an exam, and have experience in the SSTS field. The program also focuses on outreach, rule interpretation, and education through training and site visits. In 2004, MPCA prepared a 10-year plan to identify, upgrade, and ensure compliance for SSTSs. Regulations restrict nitrate leaching from large systems. More information is available at *http://www.pca.state.mn.us/index.php/water/water-types-and-programs/wastewater/subsurface-sewage-treatment-system-ssts/minnesotas-subsurface-sewage-treatment-systems-program-ssts.html*.

Program (date of program initiation)	Program activities
Industrial/Municipal Wastewater NPDES Permitting (Pretreatment final rules 2008; Minnesota River Basin General Phosphorus Permit – Phase I (Permit) 2005)	National Pollutant Discharge Elimination System (NPDES) permits regulate wastewater discharges to lakes, streams, wetlands, and other surface waters. State Disposal System (SDS) permits regulate the construction and operation of wastewater disposal systems, including land treatment systems. Together, NPDES/SDS permits establish specific limits and requirements for municipal and industrial WWTPs to protect Minnesota's surface and ground water quality for a variety of uses, including drinking water, fishing, and recreation. NPDES/SDS permit requirements may include monitoring, limits, and management practices designed to protect surface and ground water quality. MPCA requires a phosphorus technology based effluent limit of 1 mg/l for new and expanded WWTPs above 1,800 pounds/year. MPCA includes water quality based effluent limits (WQBELs) for phosphorus in permits for WWTPs that contribute to downstream eutrophication impairments; when permits expire, MPCA typically updates WQBELs. In addition, MPCA uses TMDLs to calculate and refine WQBELs. For WWTPs with permits that do not contain phosphorus effluent limits, MPCA includes Phosphorus Management Plans in permits. Nitrogen loads from WWTPs, which would be expected to increase with population increases, were likely reduced through pre-treatment programs over the past several decades. Most facilities in the state have not monitored influent or effluent for nitrogen; however, monitoring data for nitrogen from the state's largest discharges are available. More information is available at *http://www.pca.state.mn.us/index.php/water/water-types-and-programs/wastewater/index.html*.
NPDES/SDS Regulated Stormwater (1994 for Phase I MS4s, construction, and industrial; 2005 for Phase II regulated small MS4s)	The NPDES/SDS Stormwater Program administered by MPCA permits stormwater discharges associated with municipal separate storm sewer systems (MS4s), eleven categories of industrial activities, and construction activities. Most stormwater permits contain narrative effluent limitations expressed as BMPs that contribute to nutrient load reductions, with MS4 permittees required to develop and implement stormwater management programs, and industrial and construction permittees required to develop and implement stormwater pollution prevention plans. Stormwater discharges to or near impaired waters require additional controls or an individual permit. Stormwater permits provide additional nutrient load reductions. For example, the MS4 permit includes a volume control requirement that will reduce total loading to receiving waters and, as a result, reduce nutrient loads. In addition, the construction stormwater general permit requires permittees to design projects such that the water quality volume of one inch of runoff from the new impervious surfaces created by the project is retained on site (i.e. infiltration or other volume reduction practices). More information is available at *http://www.pca.state.mn.us/index.php/water/water-types-and-programs/stormwater/index.html*.

Program (date of program initiation)	Program activities
Nonpoint Source Management Program (Section 319) (1988)	The State of Minnesota Nonpoint Source Management Program Plan (NSMPP) allows Minnesota to receive nonpoint source (NPS) grant funds from the US Environmental Protection Agency under Section 319 of the CWA. The 2008 NSMPP sets Minnesota's Statewide NPS goals and provides a statewide multi-year approach for addressing water quality problems from NPS pollution. Nonpoint source water pollution control proposals submitted to MPCA must be cited in the NSMPP to be considered for Section 319 funding. During 2011, Section 319 funds were used for developmental, education, and research projects and total maximum daily load implementation projects. More information is available at *http://www.pca.state.mn.us/index.php/water/water-types-and-programs/water-nonpoint-source-issues/clean-water-partnership/more-about-the-section-319-program.html*.
Phosphorus Strategy (2000)	Adopted in March 2000 by the MPCA Citizens' Board, the Phosphorus Strategy focuses on addressing phosphorus in NPDES permits through the development of Phosphorus Management Plans. The purpose of Phosphorus Management Plans is to help WWTP operators and managers understand the inputs of phosphorus to, and treatment capabilities of, their facilities, and evaluate pollution prevention and WWTP optimization options that can reduce the amount of phosphorus discharged to Minnesota waters. The strategy also requires effluent limits for new and expanding facilities discharging greater than 1,800 lbs/yr. This portion of the phosphorus strategy was adopted into state rule in 2008. More information is available at *http://www.pca.state.mn.us/index.php/water/water-monitoring-and-reporting/water-quality-and-pollutants/phosphorus/mpca-phosphorus-strategy.html*.
Impaired Waters/Total Maximum Daily Loads (TMDL) Program (1998, first TMDLs approved in 2002)	Water bodies that do not meet Minnesota water quality standards are listed as impaired and require the development of a total maximum daily load (TMDL). Through the Impaired Waters/TMDL Program, MPCA monitors and assesses water quality, lists impaired waters, and develops or oversees development of TMDLs in Minnesota. TMDLs are the comprehensive identification of pollutant sources and assignment of allowable pollutant loads that can be discharged to a water body while still meeting designated uses and water quality standards. The agency also coordinates closely with other state and local agencies on restoration activities. Approximately 27 percent of Minnesota's impaired waters are listed due to nutrients. This number will likely increase with the adoption of nutrient criteria for river eutrophication and aquatic life toxicity. More information is available at *http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/minnesotas-impaired-waters-and-total-maximum-daily-loads-tmdls.html*.

Program (date of program initiation)	Program activities
Watershed Management Program (2007)	The MPCA Watershed Management program provides watershed planning and integrates program-level technical assistance. A key aspect of the program is the watershed approach, described in Chapter 1. Under the Watershed Management Program, MPCA oversees contract and grants management for nonpoint programs including Section 319 Grants, Clean Water Partnership, and Clean Water Fund (Watershed Restoration and Protection Planning and Surface Water Assessment). In addition, the Watershed Management Program participates in statewide projects that set state-level policy and program goals that align with other state agency water programs including the Nitrogen Loading Study, the Nonpoint Source Management Program Plan, and Statewide Measures. More information is available at *http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/index.html.*
Water Quality Standards	The Clean Water Act requires states to designate beneficial uses for all waters and develop water quality standards to protect each use. Water quality standards include beneficial uses, narrative and numeric standards, and nondegradation. MPCA is in the process of developing amendments to Minnesota's water quality standards to address numeric river eutrophication standards for rivers, streams, the Mississippi River pools, and Lake Pepin. A nitrate toxicity standard is also being developed, but it will not be adopted into rule until after river eutrophication standards are adopted. More information is available at *http://www.pca.state.mn.us/index.php/water/water-permits-and-rules/water-rulemaking/water-quality-standards.html.*
Department of Natural Resources (DNR)	
Programs within Divisions of Fish & Wildlife and Ecological and Water Resources	DNR drafts forest harvest guidelines in riparian zones as part of the Forest Product Certification process. These guidelines were developed specifically to reduce pollution inputs to forest streams. The DNR's Wetlands Program is responsible for the development of a statewide comprehensive wetlands management plan which sets direction for managing and regulating the state's wetlands.
Shoreland Rules	Currently, MN Rules 6120.3300 require 50-foot buffers planted with perennial vegetation along public waters in agricultural lands in the state, unless the areas are part of a resource management systems plan. DNR drafts the state's shoreland zoning rules and implementation is the responsibility of the local government unit.
Farm Service Agency (FSA)	
Conservation Reserve Program (CRP) (1986)	CRP is a program for agricultural landowners. Through CRP, agricultural landowners receive annual rental payments and cost-share assistance to establish long-term, resource conserving covers on eligible farmland. Offers for CRP contracts are ranked according to the Environmental Benefits Index (EBI). FSA collects data for each of the EBI factors based on the relative environmental benefits for the land offered. EBI factors include water quality benefits from reduced erosion and runoff. The timeframe for CRP contracts is approximately 10 to 15 years. Commodity prices versus CRP rental rates affect enrollment in the program. Information on CRP enrolled acreage is available on a county-by-county basis. More information is available at *http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp*.

Program (date of program initiation)	Program activities
Conservation Reserve Enhancement Program (CREP) (1998)	CREP is a conservation easement program that helps agricultural producers protect environmentally sensitive land, decrease erosion, restore wildlife habitat, and safeguard ground and surface water. According to MN FSA, the last active CREP agreement was in 2005. County data on CRP (see above) takes CREP acreage into account.
Natural Resources Conservation Service (NRCS)	
Environmental Quality Incentives Program (EQIP) (1996)	EQIP is a voluntary program for agricultural working lands that provides financial and technical assistance to agricultural producers through contracts up to a maximum term of ten years in length. These contracts provide financial assistance to help plan and implement conservation practices that address natural resource concerns and for opportunities to improve soil, water, plant, animal, air, and related resources on agricultural land and nonindustrial private forestland. More information is available at *http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip*.
EQIP National Water Quality Initiative (NWQI) (2012)	The NWQI works in a limited number of select priority watersheds to help farmers, ranchers, and forest landowners improve water quality and aquatic habitats in impaired streams, while measuring the effects from field to streams. NRCS helps producers implement conservation and management practices through a systems approach to control and trap nutrient and manure runoff. Qualified producers receive assistance for installing conservation practices such as cover crops, filter strips, and terraces. NWQI watersheds include the Chippewa River, Seven Mile Creek, and Elm Creek. More information is available at *http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/landscape/?cid=stelprdb1047761*.
EQIP Mississippi River Basin Healthy Waters Initiative (MRBI) (2010)	MRBI's primary goals are to improve water quality, improve habitat, and restore wetlands through partnership projects in a limited number of select priority watersheds in the Mississippi River Basin. NRCS plans to achieve this goal primarily by working with producers to avoid, control, and trap nutrient and sediment runoff, and maintain or improve agricultural productivity. Reducing nutrients and sediment losses in MRBI project areas will improve local water quality and may demonstrate a pathway for addressing larger issues such as hypoxia in the Gulf of Mexico. NRCS and its partners are providing additional financial and technical assistance to help producers use agricultural nitrogen and phosphorus most efficiently and reduce nonpoint source pollution. Monitoring and modeling are being used to evaluate the effectiveness of conservation practices on agricultural land in the basin. A three-tiered monitoring and evaluation approach will be used strategically to assess water quality at the edge-of-field, in-stream, and on a watershed scale. Several watersheds are selected as MRBI priority watersheds in Minnesota including the Root River, Upper Cedar, Sauk River, and Middle Minnesota River, along with subwatersheds within the Vermillion River and Upper Minnesota River watersheds. More information is available at *http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/mn/programs/landscape/?cid=stelprdb1048200*.

Program (date of program initiation)	Program activities
Conservation Security Program (CSP) (2004)	Authorized under the 2002 Farm Bill, but not reauthorized under the 2008 Farm Bill, CSP was a voluntary program that provided financial and technical assistance to promote the conservation and improvement of soil, water, air, energy, plant and animal life, and other conservation purposes on tribal and private working lands. The Conservation Stewardship Program (see below) is very similar to this program. The CSP started in Minnesota in 2004 and although it is no longer in existence, there are existing CSP contracts in Minnesota. According to the NRCS, there are 690 CSP contracts (active or completed) representing 218,329 acres. Program name changes may occur with the 2014 Farm Bill. More information about this former program is available at *http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/programs/?&cid=stelprdb1047061*.
Conservation Stewardship Program (CStP) (2008)	CStP is a voluntary program that encourages producers with tribal and private agricultural land and nonindustrial private forest land to install and adopt additional conservation activities, and improving, maintaining, and managing existing activities. NRCS makes CStP available on a continuous application basis. The program started in Minnesota in 2008. To date, there are 3208 active contracts with 2,100,421.7 acres across the state. CStP contracts last five years. More information is available at *http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/csp/*.
Wetland Reserve Program (WRP) (1990)	WRP is a voluntary program offering landowners the opportunity to protect, restore, and enhance wetlands on their property. NRCS provides technical and financial support to help landowners with their wetland restoration efforts. The goal is to achieve the greatest wetland functions and values, along with optimum wildlife habitat, on every acre enrolled in the program. This program offers landowners an opportunity to establish long-term conservation and wildlife practices and protection. Minnesota has about 1000 WRP contracts covering approximately 100,000 acres. Approximately 37,112 acres of Minnesota's wetlands have been restored through the program. More information is available at *http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/easements/wetlands/?&cid=nrcs143_008419*.
Collaborative Plans/Initiatives	
Minnesota Agricultural Water Quality Certification Program (2014 pilot)	A new state and federal partnership intended to enhance Minnesota's water quality by accelerating the voluntary adoption of on-farm conservation practices. The program is staffed principally by MDA, and collaborators include MPCA, BWSR, DNR, NRCS, and U.S. EPA. More information is available at *http://www.mda.state.mn.us/en/protecting/waterprotection/awqcprogram.aspx*.
One Watershed One Plan (2014 pilot)	A campaign rooted in work that was initially done by the Local Government Roundtable and BWSR in 2011 which recommended that the various local governments charged with water management responsibility should organize and develop focused implementation plans on a watershed scale. One Watershed One Plan will build off of existing local water management plans and priority concerns, existing TMDLs, WRAPS, and other agency related plans. One Watershed One Plan will address the need for watershed based and focused implementation plans that will be prioritized, targeted, and measurable. More information is available at *http://www.bwsr.state.mn.us/planning/1W1P/index.html*.

Program (date of program initiation)	Program activities
Nonpoint Priority Funding Plan for Clean Water Implementation Funding (draft 2014)	The Nonpoint Priority Funding Plan is developed by BWSR every two years beginning in 2014 as required by the 2013 Clean Water Accountability Act. The Nonpoint Priority Funding Plan aims to provide state agencies with a systematic, coordinated and transparent process to provide assurance that clean water funding allocations are targeted to cost-effective actions with measurable water quality results. The process may also help agencies identify gaps in programming needed to accelerate implementation. Under the Nonpoint Priority Funding Plan, state agencies will use a set of criteria to tie funding decisions to cost-effective water quality outcomes. This will improve Clean Water Fund accountability. Over time, it may also provide local water management authorities with more predictability as they plan, and seek funding for, restoration and protection efforts. The draft Plan is currently under review.

4.4 Progress from Key Programs

As Chapter 3 describes, in-stream nitrogen levels at the Minnesota state line have not shown improvement relative to baseline conditions. Improvements due to implementation of agricultural BMPs focused on nitrogen may be partially offset by changes such as increased corn production and tile drainage, and wastewater point source loads of nitrogen have likely increased slightly over time. Also, where groundwater pathways of nitrogen transport to streams are dominant, the full benefits of BMPs will not show up in the rivers for years. In the case of phosphorus, there have been many known reductions in both agricultural and wastewater loads, some of which can be seen at monitoring stations located upstream of the state border (e.g., Lock and Dam 3). Because elevated soil phosphorus concentrations will take time to decrease after instituting better fertilization practices and because significant amounts of phosphorus can be stored and recycled in flood plains and stream sediments, as well as in Lake Pepin and Mississippi River backwaters, it will take time to see the full benefit of land and water management at the state border. For the Mississippi River, monitoring phosphorus at the state border is further complicated by missing data prior to 1992, as well as loads derived from Wisconsin watersheds.

Quantification of program data is meant to provide an estimate of the recent progress that has been achieved, in terms of nitrogen and phosphorus source load reduction, through implementation of BMPs and wastewater treatment. This recent progress (occurring since 2000) can be applied to meeting major basin reduction goals and milestones. Appendix B provides detailed methods and assessment results from the government program quantification.

The key nutrient-reducing programs identified in Table 4-3 implement or fund numerous structural and nonstructural BMPs. The Natural Resource Conservation Service (NRCS) and Farm Service Agency (FSA), along with the Board of Water and Soil Resources (BWSR) offer a long list of BMPs (see Appendix C for NRCS/FSA BMPs) that are beneficial to nutrient reduction. Not all programs had data that could be translated into spatially quantified nutrient load reductions. As a result, program quantification for assessing recent progress only addresses those programs with applicable data on a HUC8 scale and includes the following:

- Nutrient management (NRCS EQIP)
- Forage and biomass planting (NRCS EQIP)
- Residue management (NRCS EQIP)
- Conservation easements (BWSR Reinvest in Minnesota [RIM])
- Nonpoint source BMPs (as reported in BWSR's eLINK, not including feedlot BMPs)
- Septic system improvements (MPCA Subsurface Sewage Treatment System Program)
- Feedlot projects (MPCA Feedlot Program)
- Phosphorus lawn fertilizer ban

Conservation Tillage in Rice County Photo Credit: USDA NRCS

Data for nutrient management, forage and biomass planting, and residue management were obtained from EQIP, while data for conservation easements were obtained from the BWSR RIM program. Data for nonpoint source BMPs were provided primarily through the eLINK system, which BWSR maintains. The eLINK system allows users to input pollutant reduction estimates. BWSR does provide tools to users for estimating pollution reductions on the field scale but also allows for users to input estimates based on locally derived data from other models if they are available. BWSR staff review data input entered into the system for reasonableness but have no mechanism to evaluate pollutant reduction numbers entered. When analyzing data, BWSR does remove extreme outliers. Therefore, some caution should be used when using pollutant load reductions directly from eLINK.

Data for septic system improvements were based on the estimated number of septic systems that had been identified as an imminent threat to public health or safety and had been brought into compliance. Data for feedlots were derived from the MPCS's Feedlot Program information. A 10 percent reduction in phosphorus loading from urban areas was assumed to have resulted from the statewide phosphorus fertilizer ban; this percent reduction was estimated from research completed in Minnesota (Vlach et al. 2010), Michigan (Lehman et al. 2009), and the Chesapeake Bay watershed (Schueler and Lane 2013).

In addition to the cropland and miscellaneous source BMPs, recent trends in wastewater point source loads were also quantified. Recent trends in point source loads (wastewater) were quantified based on monitored data provided as part of the SPARROW model inputs (Appendix B). The difference in wastewater loads from 2002 and 2005–2006 for nitrogen and 2005–2009 for phosphorus were used to calculate the relative percent change in phosphorus and nitrogen loading from point sources that has recently occurred. The reductions as a percentage were then compared to baseline conditions (e.g., 1980–1996 for the Mississippi River Major Basin), which Table 4-4 presents.

Table 4-4. Summary of recent progress by sector as compared to overall load in each major basin. The load reductions in this table represent estimated load reductions that occur at the state border.

	Percent in load change by cropland BMPs		Percent in load change by certain misc. source BMPs		Percent in load change by wastewater		Recent progress (as % of total load delivered)	
Major basin	**P**	**N**	**P**	**N**	**P**	**N**	**P**	**N**
Mississippi River	-8%	-2%	-1%	NA	-24%	+2%	-33%	0%
Lake Winnipeg	-3.7%	0%	-0.3%	NA	-0.3%	0%	-4.3%	0%
Lake Superior	-0.7%	NA	-1.3%	NA	+2.8%	NA	+0.8%	NA

Note: P=phosphorus; N=nitrogen. A negative number indicates reduction; a positive number indicates an increase. Recent progress represents progress since 2000.

Available data indicate that wastewater nitrogen loads in the Lake Superior Major Basin have increased by 411 metric tons (over 12 percent increase) since 2000; however, there is a high level of uncertainty with these data that requires additional analysis and monitoring to verify.

Data are limited for evaluating the reductions resulting from nutrient management BMPs, and the estimates used for nutrient reductions likely underestimate the total reductions. Yet, the water quality findings in the Mississippi River south of the Twin Cities are generally consistent with what is expected due to the estimated reductions from documented BMPs. It may be that the additional BMPs not accounted for in this analysis were offset by other changes in the watersheds. Efforts between 2000 and present have resulted in significant progress in reducing phosphorus loads in the Mississippi River Major Basin, due to BMPs and wastewater treatment plant upgrades. There have also been reductions in phosphorus load to the Lake Winnipeg Major Basin, while estimated loads in the Lake Superior Major Basin (which wastewater point sources dominate) are estimated to have remained relatively stable. In contrast, little to no progress has been made in reducing nitrogen loads across all major basins, which is consistent with in-stream water quality data.

Interim tracking of progress toward the 2025 goals and milestones will be conducted in accordance with Chapter 7 and consistently with the Clean Water Fund Performance reporting. For the Mississippi River Major Basin, interim tracking will ensure environmental progress between recent conditions and the nitrogen milestone and provisional phosphorus load reduction goals. For Lake Winnipeg and Lake Superior, the milestones are equal to the current goal or provisional goals. For phosphorus, there has been strong recent progress toward the goals, but additional strategies will be necessary to reduce loading from all sources to achieve the goal. For nitrogen, there has been some recent progress in agriculture, but wastewater point source loads have generally increased with increasing population. A new focus on reducing nitrogen loads from both agriculture and wastewater point sources will be necessary to achieve the nitrogen milestone.

Chapter 5

Point and Nonpoint Source Reductions

Chapter 2 presented the *Minnesota Nutrient Reduction Strategy* (NRS) goals and milestones which are also in Table 5-1. Achieving the goals and nitrogen milestone by 2025 will depend on increased implementation of ongoing programs and practices by key sectors in targeted areas. This chapter describes practices and technology that can be used to reduce phosphorus and nitrogen inputs to waters from key sources and presents example scenarios projected to meet the nutrient reduction milestones.

Table 5-1. Goals and milestones

Major basin	Pollutant	2015 to 2025	2025 to 2040
Mississippi River (Includes the Cedar, Des Moines, and Missouri Rivers)	Phosphorus	Achieve 45% reduction goal (12% from current conditions)	Work on remaining reduction needs to meet water quality standards
	Nitrogen	Achieve 20% reduction from baseline (20% from current conditions)	Achieve 45% reduction from baseline
Lake Winnipeg [a] (Red River Only)	Phosphorus	Achieve 10% reduction goal (6% from current conditions)	Achieve any additional needed reductions identified through international joint efforts with Canada and in-state water quality standards
	Nitrogen	Achieve 13% reduction goal (13% from current conditions)	
Lake Superior	Phosphorus	Maintain goals, no net increase	
	Nitrogen	Maintain protection	
Statewide Groundwater/ Source Water	Nitrogen	Meet the goals of the 1989 Groundwater Protection Act	

a. Timeline and reduction goals to be revised upon completion of the Red River/Lake Winnipeg strategy.

To reach the 2025 goals and milestones, and eventually basin-wide goals, additional best management practices (BMPs), wastewater treatment, and other nutrient reduction activities will be needed. . The NRS includes select BMPs and treatment options to guide implementation; however, any combination of BMPs and treatment options that achieve the load reduction goals can be used. As new research is done, additional BMPs and treatment options are expected to become part of the NRS. Research is important to improving the current technologies and will be particularly critical to achieving nitrogen load reduction progress beyond the milestone target. As new technologies are made available and ongoing evaluation of progress toward goals is conducted, future adaptations to the NRS strategies will be needed.

5.1 SPARROW Model

U.S. Geological Survey (USGS) Spatially Referenced Regressions on Watershed (SPARROW) modeling provides a common reference point for evaluating loads from different source categories at major watershed outlets and in the state's rivers. SPARROW is based on land use conditions of 2002 (with a subsequent update for wastewater point source loads). SPARROW addressed land use decisions but does not allow quantification of the effects of specific BMPs or changes in water quality over time. However, the model is used to support calculating nutrient load reduction percentages based on the effects of BMPs quantified through separate efforts.

A spreadsheet tool was developed to evaluate phosphorus reduction scenarios for cropland, incorporating BMP efficiencies based on research, spatial data, SPARROW model outputs, and other information. The 2002 SPARROW results were used to provide a common reference point for the evaluation of watershed loads and the percent of change caused by various nutrient load reductions. Table 5-2 summarizes the loading results from SPARROW, both as an estimate of local stream loads aggregated at the Basin Scale which is labeled as "subwatershed", and as delivered downstream at the state line (measured at De Soto, Wisconsin). The "delivered" loads represent the loads at the state line, accounting for attenuation due to decay, settling, and other mechanisms as SPARROW specifies. The difference between subwatershed and delivered loads to state line reflects estimated transport losses occurring in the streams and rivers within Minnesota.

Table 5-2. SPARROW loading results by basin

Basin	Nitrogen subwatershed load (metric tons/year)	Nitrogen load, delivered, state line (metric tons/year)	Phosphorus subwatershed load (metric tons/year)	Phosphorus load delivered, state line (metric tons/year)
Cedar River	7,216	6,918	246	242
Des Moines River	5,726	4,507	367	251
Lake Superior	3,774	3,656	263	255
Mississippi River	116,200	99,441	6,351	5,553
Missouri River	6,617	5,208	424	290
Rainy River	3,791	2,606	301	204
Red River of the North	20,770	16,822	1,243	949

Notes:
Subwatershed loads include surface and subsurface transport to the SPARROW subwatershed stream reach and transport through half of the stream reach, representing the cumulative loads in the subwatershed near the sources.
Delivered loads represent the loads at the state line, accounting for attenuation due to decay, settling, and other mechanisms.

SPARROW load estimates are based on the following assumptions:

- The SPARROW model approximates nonpoint source loading for the 2000–2002 period.
- These loads reflect the wastewater point source update, which incorporates updated data from the Minnesota Pollution Control Agency (MPCA) (updated to 2005–2006 for nitrogen and 2005–2009 for phosphorus) and is assumed to approximate current wastewater point source loading.
- The Mississippi River Basin loads are tabulated at De Soto, Wisconsin, just downstream of the Minnesota-Iowa state line.
- The Cedar River and Des Moines River do not drain to the Mississippi River at the Minnesota state border. Rather, their basins ultimately drain to the Mississippi River farther downstream. For this analysis, the basin loads delivered to either the 8-digit hydrologic unit code (HUC8) outlets or the state line (the more upstream location) are used for Cedar and Des Moines, since the HUC8 outlets roughly correspond to the state line.
- Several HUC8 watersheds in Minnesota are not modeled in SPARROW. These include the following:
  - 04020300 (Lake Superior – HUC8 that only includes the lake)
  - 07080102 (Upper Wapsipinicon – Part of the Cedar River Basin, does not meet the Cedar until much farther downstream in Iowa; very small portion in Minnesota)
  - 10170202 (Missouri River – Upper Big Sioux)
  - 10170203 (Missouri River – Lower Big Sioux)

- 10170204 (Missouri River – Rock River)
- 10230003 (Missouri River – Little Sioux)

Loading for the Upper Wapsipinicon HUC8 was estimated by calculating the average unit area loading for the remaining Cedar River HUC8s from SPARROW and multiplying the unit area load by the HUC8 area. Similarly, the Des Moines River HUC8 loadings were used for approximating loading for the Missouri River HUC8s.

The SPARROW results can be used to estimate the proportion of delivered nutrient loads associated with different major source categories; however, communicating this must be done with some caution. For example, SPARROW provides estimates of delivered load associated with agriculture based on the regression model that includes manure, farm fertilizers, and fraction of catchment with tiles as parameters. However, SPARROW does not separate a number of the individual sources identified in the *Detailed Assessment of Phosphorus Sources to Minnesota Watersheds* (Barr Engineering 2004). Most notably, SPARROW does not separately account for the portion of phosphorus load due to streambank erosion and atmospheric deposition, estimated as 17 percent and 8 percent, respectively, of the total phosphorus load in the Mississippi River Basin (Table 3-2). The SPARROW estimates of agricultural load generalize the loads and implicitly include streambank erosion and atmospheric deposition in agriculturally dominated landscapes. The scenario analyses provided in the NRS require identification of the fraction of nonpoint loading that is attributable to those upland agricultural practices that can be controlled by BMPs. Therefore, we recalculate the upland agricultural fraction of load from the SPARROW results based on Table 3-2.

As indicated in Table 3-2, agricultural sources (cropland runoff and agricultural tile drainage combined) account for an estimated 38 percent of the total load in the Mississippi River Major Basin and 42 percent of the total load in the Lake Winnipeg Major Basin (sum of cropland runoff and agricultural tile drainage proportions). These percentages represent the baseline time period. As included in Table 3-2, point sources (NPDES permitted wastewater discharges) contribute 18 percent and 11 percent of the total phosphorus load in the Mississippi and Lake Winnipeg major basins, respectively. A refined estimate was used to determine the agricultural fraction of SPARROW loads by selecting 38 percent of the non-wastewater SPARROW load. Wastewater point source loads and agricultural loads are described further in Sections 5.2 and 5.3, respectively.

5.2 Recommended Wastewater Reductions

There has been a focus on wastewater treatment for phosphorus in Minnesota since 2000 with the adoption of the Phosphorus Strategy. While phosphorus loads from wastewater have reduced dramatically since 2000, nitrogen loads have remained constant or increased. Wastewater phosphorus and nitrogen loads account for approximately 16 percent and 8 percent of the total statewide loads delivered to the state border, respectively, based on USGS SPARROW outputs. Recommended reductions are provided below to achieve the goals and milestones.

5.2.1 Wastewater Technologies

Additional nutrient load reductions from wastewater are also needed to achieve milestones and goals. No new technologies are necessary for phosphorus removal. The majority of the municipal wastewater volume has already been treated to reduce phosphorus using biological phosphorus removal at the state's largest facilities and a mix of biological and chemical addition at other facilities. The majority of the state's municipal wastewater plants are stabilization ponds, which typically discharge at half the effluent concentration of mechanical facilities without phosphorus limits. Several smaller to larger sized mechanical facilities will still be required to reduce phosphorus discharges due to continued application of state and federal regulations. It is anticipated that biological chemical removal technologies will be used at these wastewater facilities. Some facilities might add effluent filters to achieve effluent limits less than 0.6 mg/l phosphorus consistently.

In the past, wastewater treatment technologies for nitrogen focused on converting ammonia plus ammonium-nitrogen to nitrate-nitrogen, to reduce aquatic toxicity and oxygen demand. Nitrate removal will be a new treatment consideration for most of Minnesota. Some facilities in Minnesota are required to meet a 10 mg/l nitrogen effluent limit to protect sources of drinking water. These facilities are relatively small in size and few in number.

The primary method for nitrogen removal from wastewater is biological nitrification/denitrification. Biological nitrification/denitrification is achieved by utilizing aerobic reactors to oxidize the influent ammonia nitrogen to nitrate, and anoxic reactors to reduce the resulting nitrate to nitrogen gas. Utilizing biological nitrification/denitrification, over 70 percent of the total nitrogen can be removed from the influent stream, depending upon the process flow design, temperature, and other factors. Adequate detention time is a key factor in biological nitrogen removal. A wastewater treatment plant (WWTP) utilizing a single anoxic reactor can achieve effluent total nitrogen concentrations of 6 to 8 mg/l. With multiple anoxic reactors, effluent nitrogen concentrations of under 3 mg/l can be achieved (EPA 2009, EPA 2010). If all WWTPs in Minnesota treated effluent down to a discharge concentration of

10 mg/l, a 41 percent reduction in wastewater nitrogen loads is estimated. If all WWTPs in Minnesota treated effluent down to a 6 mg/l effluent concentration, an estimated 62 percent reduction in wastewater nitrogen loads could be achieved.

As an alternative to utilizing multiple anoxic reactors, nitrate removal can be achieved by incorporating aerobic reactors with denitrification filters. The use of chemical addition, breakpoint chlorination, or ion exchange has diminished in recent years due to the effectiveness of achieving low total nitrogen effluent concentrations using biological treatment.

5.2.2 Phosphorus Wastewater Reductions to Achieve Goals

Substantial progress has been made in reducing wastewater loads of phosphorus in the Mississippi River Major Basin, particularly in the Minnesota River Basin and in the Metro Area Major Watershed. The focus now is to move forward to achieve the goal by pursuing additional wastewater reductions in the remaining basins with particular attention on the Cedar, Des Moines, Lower Mississippi, and Red River Basins, as well as further decreasing agricultural and miscellaneous sources by the year 2025.

Minnesota has established wastewater effluent limitations for phosphorus since the early 1970s for cases:

> *Where the discharge of effluent is directly to or affects a lake or reservoir, phosphorus removal to one milligram per liter shall be required… In addition, removal of nutrients from all wastes shall be provided to the fullest practicable extent wherever sources of nutrients are considered to be actually or potentially detrimental to the preservation or enhancement of designated water uses.*

This rule, referred to as the "Phosphorus Rule," had historically applied to discharges up to 50 miles upstream from the nearest lake or reservoir. This rule did not affect the majority of wastewater facilities in Minnesota during the Mississippi River baseline time period, since most facilities discharge to rivers. On March 28, 2000, the MPCA's Citizens' Board adopted *a strategy for addressing phosphorus in National Pollutant Discharge Elimination System (NPDES)* permits, which established a process for the development of 1 mg/L phosphorus limits for new and expanding WWTPs that had potential to discharge phosphorus in excess of 1,800 pounds per year. It also established requirements for other WWTPs to develop and implement Phosphorus Management Plans. The MPCA's Phosphorus Strategy was formally adopted as *Minnesota Rule Chapter 7053.0255* in 2008.

Implementation of MPCA's Phosphorus Strategy and Minnesota Rule Chapter 7053.0255 has resulted in significant wastewater effluent phosphorus load reductions since the year 2000 (Table 5-3). The modeled effects of these reductions at the state border are presented in Chapter 4.

Table 5-3. Statewide wastewater phosphorus effluent loading (metric tons/year)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Industrial Wastewater	214	196	177	163	162	187	182	185	184	186	194	180	152
Domestic Wastewater	1,975	1,923	1,813	1,379	1,123	927	897	873	816	676	657	659	546
Total	2,189	2,119	1,990	1,542	1,285	1,114	1,079	1,058	1,000	862	851	839	698

The loads presented in this table are derived from facility monitoring data and do not represent load delivered to the state line. See Chapter 4 for a summary of modeled loads delivered to the state line.

The accuracy of phosphorus load estimates from wastewater has improved since the year 2000 because of an increase in monitored effluent concentrations requiring fewer assumed values for effluent concentration (Figure 5-1).

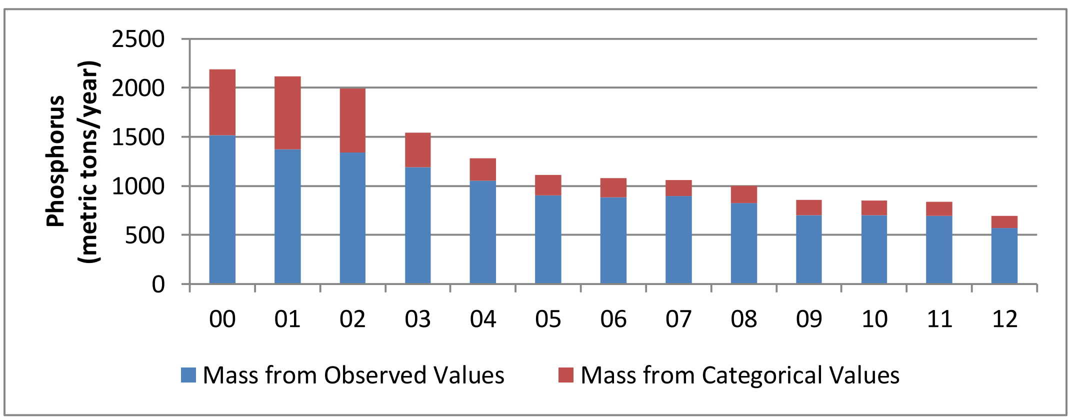


Figure 5-1. Confidence measure for effluent phosphorus data by year.

Mass estimates derived from categorical values (red) have less certainty than the mass based on observed monitoring results (blue).

The majority of effluent phosphorus loads generated are from domestic wastewater treatment facilities (Table 5-4, Figure 5-2), but the percentage of industrial phosphorus loading has increased in proportion to phosphorus reductions achieved by municipal wastewater treatment facilities.

Table 5-4. Proportion of wastewater phosphorus loading

	2000–2002 percent of total (%)	2010–2012 percent of total (%)
Industrial Wastewater	9%	22%
Domestic Wastewater	91%	78%
Total	100%	100%

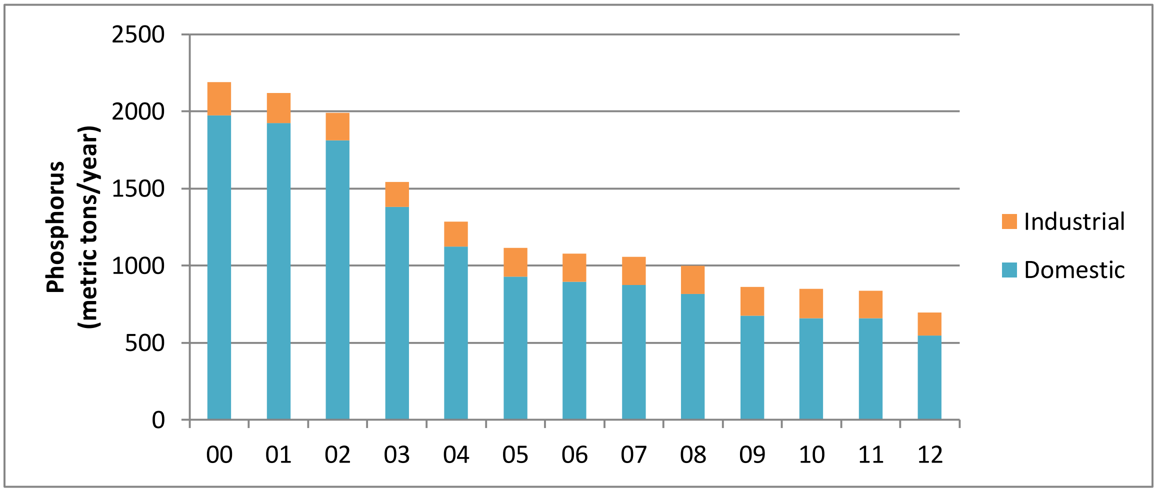


Figure 5-2. Comparison of annual industrial and municipal wastewater phosphorus loads.

Reduction percentages were calculated from 3-year loading averages to account for annual flow variability. The baseline load for the 2000–2002 period was 2,099 metric tons per year and the load for the 2010–2012 period was 796 metric tons per year, representing a 62 percent reduction in statewide wastewater phosphorus loading since 2000 (Table 5-5, Figure 5-3).

Table 5-5. Statewide wastewater effluent phosphorus percent reduction estimates

	Average 2000–2002 (MT/year)	Average 2010–2012 (MT/year)	Percent reduction (%)
Industrial Wastewater	196	175	11%
Domestic Wastewater	1,903	621	67%
Total	2,099	796	62%

Statewide NPDES wastewater effluent phosphorus load reductions are estimated at 1,303 metric tons per year (reflects facility discharge, not load delivered to the state line) since the MPCA's adoption of its Phosphorus Strategy in 2000. Figure 5-3 charts effluent phosphorus loads since 2000 (yellow line). The red line represents an estimate of increasing wastewater phosphorus loading based on an average effluent concentration of 4 mg/l and an annual effluent flow increase due to a 1 percent per year population growth. The blue horizontal line estimates the wastewater loading goal for full implementation of the state's existing phosphorus rule. The orange and purple lines represent a phase-in period and full implementation of the existing phosphorus rule. Compliance with existing rules includes water quality-based effluent limits for facilities upstream of impaired lakes such as Lake Pepin. The previously referenced "within 50-mile rule" no longer applies to discharges upstream of lakes. Thus, many facilities are receiving new limits based on Lake Pepin. Future adoption of river eutrophication standards will likely result in additional wastewater effluent load reductions.

Table 5-6 summarizes the anticipated phosphorus load reductions associated with permitted wastewater until the year 2025. Projected future loading is estimated based on the application of Lake Pepin Total Maximum Daily Load (TMDL)-style categorical effluent limitations to all wastewater dischargers in the state. Permitted loading assumptions were made on the basis of concentrations related to facility size, as well as type and flow related to currently reported values. Reductions were assumed to occur over a phase-in period ending in 2020. From then on, flows and loading are assumed to increase based on a natural population growth rate of 1 percent per year.

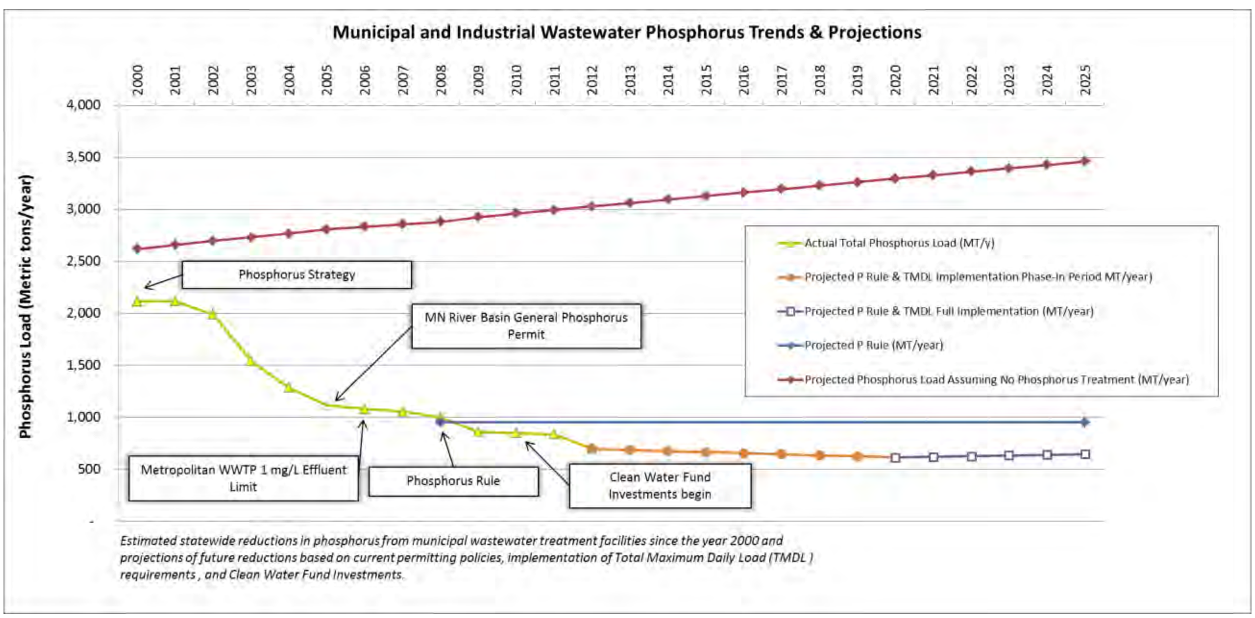


Figure 5-3. Domestic and industrial wastewater phosphorus loading trends and projections.

Table 5-6. Domestic and and industrial wastewater phosphorus loading trends and projections by basin (metric tons/year)

Basin	2000	2005	2010	2015	2020	2025
Lake Superior	36	49	42	52	48	51
Upper Mississippi	1,191	357	240	198	199	209
Minnesota	448	258	193	144	163	171
St. Croix	14	16	12	13	13	13
Lower Mississippi	272	219	115	82	74	77
Cedar	35	78	102	59	16	17
Des Moines	62	14	20	13	9	10
Red	31	51	51	32	22	24
Rainy	51	63	67	67	67	70
Missouri	18	8	9	5	4	5
Total	**2,158**	**1,114**	**851**	**667**	**615**	**647**

The loads presented in this table are derived from facility monitoring data and do not represent loads delivered to basin outlets. See Chapter 4 for a summary of modeled loads delivered to the state line.

Table 5-7 presents planned reductions in phosphorus loads from WWTPs, as included in the NRS. Values in this table represent loads delivered to the state line. The phosphorus load reductions were calculated by comparing the projected 2025 loads with the most recent (2012) monitored loads at the HUC8 level. The load reduction at the HUC8 level was then converted to an equivalent load reduction at the state line by applying the percent attenuation (between the HUC8 and state line) as calculated from SPARROW.

Table 5-7. Summary of expected wastewater phosphorus reductions for goal implementation

Major Basin	NRS wastewater phosphorus load reductions for goal (metric tons)
Mississippi River	37.2
Lake Winnipeg	14.9
Lake Superior	NA

5.2.3 Nitrogen Wastewater Reductions to Achieve Goals and Phase 1 Milestone

Municipal and industrial wastewater facilities contribute 9 percent of the nitrogen load to the Mississippi River Basin, 31 percent of the nitrogen load in the Lake Superior Major Basin, and 6 percent of the nitrogen load in the Lake Winnipeg Major Basin. Municipal facilities account for 86 percent of statewide wastewater nitrogen load. The 10 largest point sources, as measured by annual average nitrogen load, collectively amount to 67 percent of the load from point sources statewide.

Limited influent and effluent nitrogen concentration data are available. Table 5-8 represents current assumptions about effluent total nitrogen concentrations discharged by Minnesota wastewater treatment facilities and are based on a combination of effluent data from Minnesota and Ohio WWTPs. Increased effluent nitrogen monitoring frequencies are needed to validate current assumptions and understand the variability in wastewater effluent concentrations and loads. WWTP influent nitrogen monitoring is needed to develop an understanding of the magnitude and variability of loads and sources as a basis for development of nitrogen management plans.

Table 5-8. Nitrogen concentrations for treated municipal wastewater

Category	Concentration assumptions (mg/L) nitrogen
Class A municipal – large mechanical	19
Class B municipal – medium mechanical	17
Class C municipal – small mechanical/pond mix	10
Class D municipal – mostly small ponds	6

There are five municipal wastewater facilities in Minnesota that are required to reduce nitrogen loads through effluent limits (three WWTPs and two industrial dischargers). Table 5-9 provides a summary of the estimated existing nitrogen loads from point sources as reported in SPARROW (delivered to the state line).

Table 5-9. Wastewater loads by major basin, derived from SPARROW

Major Basin	Wastewater nitrogen delivered to state line (metric tons/yr)
Mississippi River [a]	9,363
Lake Winnipeg	304
Lake Superior	1,212
Total	**10,879**

a. SPARROW did not include the Missouri River Basin; therefore, wastewater loads for the Missouri River Basin are derived from MPCA estimates.

It is estimated that a 20 percent cumulative reduction in wastewater nitrogen loads, along with load reductions achieved for other sectors including agriculture, will achieve the goal in the Lake Winnipeg Major Basin and the Phase 1 nitrogen milestone in the Mississippi River Major Basin. Table 5-10 summarizes the anticipated load reductions by basin. Values in this table represent loads delivered downstream of Minnesota. Additional data from increased monitoring frequencies and nitrogen management knowledge gained in the coming years will allow for reevaluation of the goal's attainability in the future.

Table 5-10. Summary of 2025 wastewater nitrogen reductions

Major Basin	2025 wastewater nitrogen load reductions (metric tons)
Mississippi River	1,872.6
Lake Winnipeg	60.8
Lake Superior	NA

5.3 Recommended Agricultural Reductions

In 2004, cropland and pasture runoff plus tile drainage contributed an estimated 29 percent of the statewide phosphorus load in an average flow year (Table 3-2). This percentage has increased to an estimated 32 percent since 2003 due largely to the major phosphorus reductions accomplished in wastewater since 2004. A large part of the remaining nonpoint phosphorus load is due to near channel sources such as stream channel erosion, much of which is indirectly affected by an increase in erosive stream and river flows and atmospheric deposition, some of which is due to wind erosion. The *Nitrogen in Minnesota Surface Waters* study (MPCA 2013a) estimated that agriculture contributes 73 percent of the statewide nitrogen load in a typical year. Because agricultural sources contribute the bulk of the statewide nitrogen load and a substantial portion of the phosphorus load, nitrogen and phosphorus reductions from agricultural sources are key to successfully achieving the milestones. Recommended agricultural BMPs to address phosphorus and nitrogen are provided below.

Treatment Wetland under Construction Photo Credit: Tetra Tech

5.3.1 Agricultural Best Management Practices

A variety of management practices (Appendix C) are available to address agricultural nutrient loads. Selection of BMPs should be based on the specific characteristics of individual watersheds and fields as well as producer farming systems. Similarly, the performance of individual BMPs can vary widely depending on local soils, slopes, and other conditions. A challenge for developing a statewide NRS is describing approximate representations of the efficacy of BMPs across the entire state.

Phosphorus in fields is predominantly attached to soil particles, and measures that reduce soil erosion will also reduce phosphorus loading. Because phosphorus doesn't leach as readily as nitrogen, it tends to be persistent and can build up in soil. Where soil phosphorus concentrations are very high, soluble phosphorus can leach from fields and be transported with surface runoff or in drain tile water. Past over-application of phosphorus is especially likely to occur when manure is not credited for fertilizer value, or rates are based only on crop nitrogen needs without regard to potential over-application of phosphorus. Such practices can result in elevated soil phosphorus concentrations that can increase phosphorus loading rates for years. As a result, BMPs to reduce phosphorus loads from agriculture focus on increasing fertilizer use efficiency to maintain optimal soil phosphorus concentrations and decreasing soil erosion to reduce the risk of sediment and phosphorus loading from fields to water bodies.

Various tools can be used to estimate the risk of phosphorus loss from cropland, ranging from complex to simple models. Minnesota has a Rapid Phosphorus Index, which is a simple screening tool that helps determine when to apply the more complex Minnesota Phosphorus Index (MN P Index). The MN P Index incorporates multiple aspects of phosphorus management, and estimates the risk of phosphorus loading based on soil phosphorus concentrations, erosion risk (crops, soils, slope, and tillage), and phosphorus fertilizer and manure rate and method. The MN P Index estimates phosphorus loss risk through three major surface pathways: erosion, rainfall runoff, and snowmelt runoff. A first step in agricultural management for phosphorus loading is to encourage wider use of the MN P Index. While phosphorus is a necessary nutrient for plant growth, it can also be a pollutant in lakes and rivers that can cause degraded water quality and impairments. The management challenge for producers is the need to maintain adequate, but not excessive, soil phosphorus concentrations while minimizing erosion risk. Achieving an appropriate soil phosphorus concentration depends on fertilization practices over time that account for preexisting natural soil phosphorus levels and historical buildup of soil phosphorus due to livestock, green manures, and fertilization.

Like phosphorus, nitrogen is also a critical nutrient for plant growth. However, there are fundamental differences in the behavior of nitrogen and phosphorus in the environment that influence the performance of individual BMPs and also affect the evaluation of that performance. Unlike phosphorus that is conserved in the environment, nitrogen tends to be more mobile, and cycles within the air, land and water. The inorganic forms in particular are predominantly soluble. This means that much of the nitrogen load moves with water. For example, 6 percent of the statewide nitrogen load to rivers moves with cropland surface runoff, but 67 percent moves with drain tiles that collect and redirect subsurface flows to surface waters in areas that are naturally poorly drained, or to groundwater beneath cropland where soils are naturally drained. Because nitrate-nitrogen leaches from the soil, is taken up by the crop, or is lost to the atmosphere, it has low persistence in soil and cropping requires frequent replenishment by soil nitrogen mineralization and fertilization. As a result, nitrogen loading to surface waters is largely determined by hydrology; types of vegetation; and the form, rate, timing, and method of nitrogen fertilizer application. Management practices that reduce nitrogen application rates, remove dissolved nitrogen from soil and groundwater stores, modify hydrology, or trap and treat tile discharges. Most of these BMPs can be summarized in terms of nutrient load reduction efficiencies; however, actual removal efficiencies for nutrient management practices will depend on the difference between typical current practice and optimum fertilizer form, rate, timing, and method. The Watershed

Nitrogen Reduction Planning Tool (Lazarus et al. 2014) when used at the watershed or state level scale summarizes the efficacy of most of the well-developed BMPs available for nitrogen removal.

Potential agricultural BMPs selected for the NRS were identified from the *Nitrogen in Minnesota Surface Waters* study (MPCA 2013a), the Iowa Nutrient Reduction Strategy (Iowa Department of Agriculture and Land Stewardship et al. 2013 and Iowa State University 2013), the AgBMP Handbook (Miller et al. 2012), literature on the MN P Index (Moncrief et al. 2006), and the Lake Pepin implementation planning work (Tetra Tech 2009). BMPs were evaluated to determine which would be most likely to help achieve the nutrient reduction goals of the NRS. BMPs are grouped into the following four categories:

1. Increasing fertilizer use efficiencies (nutrient management practices)
2. Increase and target living cover
3. Field erosion control (for phosphorus reduction)
4. Drainage water retention for water quality treatment (for nitrogen reduction) and for control of erosive flows (to help address phosphorus loads from near-channel erosion, ravines, and streambanks)

Appendix C includes additional agricultural BMPs that could be used for reducing nutrients. A more complete listing of nitrogen fertilizer BMPs is provided at *http://www.mda.state.mn.us/protecting/bmps/nitrogenbmps.aspx* and at *http://www.extension.umn.edu/agriculture/nutrient-management/nitrogen/*.

Effectiveness and cost of BMPs depends on many site-specific factors. Representative values are used for this statewide analysis. These averaged results are approximations only, and BMP planning and efficacy is expected to vary significantly at the local scale. Iowa State University (2013) provided standard deviations for studied nutrient removal efficiencies. BMPs for both phosphorus and nitrogen included a high standard deviation; for example, the phosphorus removal efficiency of buffers is presented as 58 percent reduction with a standard deviation of 32.

The cost estimates for agricultural BMPs focused on estimating the net cost or cost-savings to the producer for the purpose of estimating the relative change in costs that would occur through implementation of the NRS. Cost data for construction and operation costs are readily available and provide a metric for gaging the financial impact of the NRS. The costs estimates were limited to readily available data and do not include costs relating to the government's role in implementation or land acquisition. Additional factors that were not considered quantitatively include monetary and non-monetary impacts to the public related to current agricultural incentives and other policies. Cost savings were assumed only where available quantitative information was relevant to the practices and geographic area considered. Some BMPs, like cover crops, may provide additional benefits to producers such as through improved soil quality, however these benefits were not estimated in this analysis. Due to these limitations, the cost estimates are provided as approximate measures and as a tool for comparing order of magnitude differences across the BMPs. As strategy recommendations are assessed in more detail at the community or site-scale, a more comprehensive cost-benefit analysis may be warranted.

Annualized cost per acre was obtained first from Lazarus et al. (2013), and then from Iowa State University (2013) for the remaining BMPs. Negative costs reflect a net return on investment (e.g., farmers can save money by reducing application of nitrogen fertilizer to economically optimal rates). The annualized costs, or lifecycle costs, reflect the cost per year (Table 5-11), that if held constant, would pay for both the upfront establishment and overall operation costs for the design life of the practice. Table 5-11 includes costs and effectiveness for various example BMPs.

Table 5-11. Representative BMP summary, including nutrient load reduction efficiencies in the BMP-treated area. Costs are approximate and change with changing markets and other factors.

BMP	Lifecycle cost ($/acre/year)	Nitrogen reduction efficiency	Phosphorus reduction efficiency	Notes
Increasing Fertilizer Use Efficiencies (Nutrient Management Practices)				
Nitrification inhibitors	($3) [2]	14%[1]	NA	Nitrogen removal efficiency based on average of literature reviews.
Reduced rates to MRTN (corn after soybeans and proper manure crediting)	($15-19)[3]	16%[1]	17%[2]	For phosphorus, based on no phosphorus applied until soil test phosphorus drops to optimum.
Shift fall application to spring and sidedresswith rate reduction	($7-26)[3]	26%[1]	NA	Efficiency applies only to fields currently using fall fertilization.
Phosphorus incorporated using subsurface banding	$15[2]	NA	24%[2]	Compared to surface application without incorporation.
Increase and Target Living Cover				
Cover crops (with establishment success)	$53[3]	51%[1]	29%[2]	See discussion of success rate below

BMP	Lifecycle cost ($/acre/year)	Nitrogen reduction efficiency	Phosphorus reduction efficiency	Notes
Perennial energy crops	$30[2,]	95%[1]	34%[2]	
Perennial buffers in riparian areas (replacing row crops)	$30-300[2,3]	95%[1]	58%[2]	See discussion of area treated in below.
Hayland in marginal cropland (replacing row crops)	$30-110[3,2]	95%[1]	59%[2]	
Conservation easements and land retirement	$6-110[3,2]	83%[2,6,7]	56%[2,6,7]	Average of values based on Upper Midwest research.
Field Erosion Control				
Conservation tillage and residue management	($1)[2]	NA	63%[2,4,5]	Average of Midwest and Chesapeake Bay studies.
Drainage Water Retention and Treatment				
Constructed wetlands	$6-18[3]	50%[1]	Drainage water retention can indirectly help mitigate phosphorus load through reduction of erosive flows; however, it is not possible to assign general reduction efficiency.	Wetlands not applicable for permanent phosphorus removal unless sediments cleaned out and vegetation harvested.
Controlled drainage	$9[3]	33%[2]-44%[1]		Nitrogen treatment applicable to tile-drained fields.
Bioreactors	$18[3]	13%[1]	NA	Net nitrogen reduction efficiency accounts for reduced treatment during spring flows.

[1]MPCA (2013a); [2]Iowa State University (2013); [3]Lazarus et al. (2013); [4]Miller et al. (2012); [5]Simpson and Weammert (2009); [6]Barr Engineering (2004); [7]MPCA (2013a); NA: BMP is not applicable to this nutrient. Parentheses indicate negative costs, which represent net dollar savings.

Increasing Fertilizer Use Efficiencies (Nutrient Management Practices)

Nitrogen

Corn and soybean cropping systems are inherently vulnerable to nitrogen losses, particularly during times of the year when row crop roots are not established enough to capture and use soil nitrate. Other crops can also affect nitrate losses to waters including potatoes, sugar beets and dry beans. Corn receives over 90 percent of Minnesota's nitrogen fertilizer additions to row crops; therefore the NRS focuses largely on fertilized corn, specifically corn following soybeans. The primary nitrogen efficiency goal is to reduce nitrogen losses on corn following soybeans, resulting from an industry average of fertilizer nitrogen (and manure on some farms) that has recently been estimated to be at least 30-40 pounds/acre higher than the mid-range of the University of Minnesota recommendations. The University of Minnesota recommended nitrogen fertilizer rates can be found at: *http://www.extension.umn.edu/agriculture/nutrient-management/nutrient-lime-guidelines/docs/corn-fertilization-2006.pdf*.

Improving the efficiency of nutrient applications by crediting all sources and adjusting rates, timing, forms, and placement of nitrogen can improve efficiency, resulting in better environmental and economic performance for these row crop systems. Using economically optimal application rates is a key nutrient management practice for nitrogen. Lazarus et al. (2013) provide a recommended "BMP target" nitrogen fertilizer rate based on current University of Minnesota recommendations. This rate is based on the maximum return to nitrogen and depends on the price of both corn and nitrogen fertilizer. At the time of this study, Lazarus et al. (2013) assumed a price ratio of nitrogen to corn of 0.11 (based on 55-cent nitrogen and $5 corn). This results in a nitrogen need for the corn following corn rotation of 141 pounds per acre (lbs/acre). The commercial fertilizer application target for corn following soybeans is equal to about 105 lbs/acre. It should be noted that these rates represent an average recommended fertilizer rate, and modifications (increases or decreases) might be required based on different site-specific considerations.

Data on nitrogen fertilizer rates are available through Bierman et al. (2011) and a companion study by the Minnesota Department of Agriculture (MDA) based on the 2009 growing season (MDA 2011). The 2009 survey of nitrogen fertilizer use on corn in Minnesota was collected from 1,496 farmers distributed across all corn-growing regions in the state, with their total acreage representing about 7 percent of the corn acres harvested in Minnesota in 2009. Data are provided by county and represent recent nitrogen fertilizer rate (lbs/acre) for fields growing corn. In 2009 there were 1,119 fields with corn following soybean surveyed across the state (MDA 2011). The highest reported county average nitrogen fertilizer rate in 2009 was 162 lbs/acre (Chisago County), and the lowest average rate was 111 lbs/acre (Clay County), with an overall state average of 141 lbs/acre.

The target average fertilizer rate of 105 lbs/acre, based on the mid-range of University of Minnesota recommendations, was subtracted from the current average fertilizer rate to determine the rate reduction needed to meet the mid-range of the recommended rate for corn following soybeans. Seventy-five percent of fields reported corn following soybean fields, while corn following corn and corn following other crops represented 19 percent and 4 percent of fields, respectively. Therefore corn following soybeans is the dominant rotation; but the cropping systems fluctuate and Minnesota also has a fairly large fraction of land in continuous corn.

Key Nitrogen Reduction Finding

By reducing rates to the mid-range of the University recommended rates (closer to 105 lbs/acre), many corn/soybean fields can potentially gain greater fertilizer and economic efficiencies, and at the same time reduce nitrate losses to waters.

The Bierman et al. (2011) survey results suggest that Minnesota nitrogen fertilizer rates are reasonably close to the University of Minnesota recommendations for corn following corn, but that greater fertilizer efficiencies can potentially be gained by bringing down the rate on corn following legumes. The University of Minnesota recommendations do not provide a single rate recommendation, but rather a range of recommended rates. For corn following soybeans, 2009 average fertilizer rates were higher than the top end of the University of Minnesota recommended rate range. By reducing rates to near the mid-range of the University recommended rates resulting in a statewide average of 105 lbs/acre), many corn/soybean fields can potentially gain greater fertilizer and economic efficiencies, and at the same time reduce nitrate losses to waters.

A recently published *updated fertilizer use survey* (MDA 2014) showed an average fertilizer rate of corn following soybeans in the 2010 cropping year of 148 lbs/acre, allowing an additional 8 lbs/acre reduction potential as compared to the 2011 Bierman report and the assessment developed for this NRS. Table 5-12 summarizes the reported fertilizer application rates compared to University of Minnesota recommended rates.

Table 5-12. Recommended nitrogen fertilizer rates and reported 2009 and 2010 rates

	Reported application rates (lbs/acre)		Maximum Return to Nitrogen - University of MN recommended rates for high productivity soils	
			N fert. price to corn value ratio	
	2009 cropping year [a]	2010 cropping year [b]	0.15	0.10
Corn following soybeans (no manure)	140	148	100	110
Corn following corn (no manure)	145	161	130	140
Corn following alfalfa (no manure)	97	115	30	40
Corn with manure (average of all rotations – fertilizer plus manure)	not reported	173	<130	<140

a. Bierman et al. 2011 and MDA 2011
b. MDA 2014

An additional component of nitrogen management efficiencies includes shifting from fall to spring or spring/sidedress applications on corn, along with a corresponding nitrogen rate reduction. Increased acreages of spring or sidedress applications and greater nutrient efficiencies from more precise crediting of nitrogen applications made through manure spreading are considered as part of the nitrogen load reduction scenarios. Manure nitrogen represents about 25 percent of the combined additions of manure and commercial fertilizer.

Nitrogen reduction estimates from reduced fertilizer rates and changed timing of fertilizer application were developed using the NBMP tool (Lazarus et al. 2014). Based on comparison of nitrogen fertilizer use from surveys and University of Minnesota recommendations, the NBMP tool provides results for the recent corn rotations in Minnesota, including mostly corn following soybeans, corn following corn and corn following alfalfa.

Phosphorus

For phosphorus, the assumed fertilizer application rate depends on the existing phosphorus concentration in the soil (soil test phosphorus) such that above a certain phosphorus concentration, additional fertilizer should not be applied. The MN P Index can serve as a measure of phosphorus loss potential and help identify areas where certain types of phosphorus management BMPs might be effective. The MN P Index depends on both soil test phosphorus and erosion risk. To reduce phosphorus export, the goal is to achieve a low MN P Index while maintaining minimum soil test phosphorus in order to maintain adequate crop growth.

There was no available statewide coverage of soil test phosphorus levels or the MN P Index for this analysis. An approximation of the potential role of increased fertilizer use efficiencies was therefore made through a back calculation of the MN P Index from SPARROW agricultural loading rates. Barr Engineering (2004, Appendix C) reports that Bray-1 soil test phosphorus can be related to the MN P Index by a factor of 0.75 and provides a conversion between the P Index and edge-of-field phosphorus loss rates such that loss rates in kg/ha/yr are equal to the P Index divided by 65. Therefore, a Bray soil test phosphorus of 21 ppm corresponds to a MN P Index of approximately 16. SPARROW agricultural loading rates that imply that the MN P Index is greater than 16 in a given HUC 8 were assumed to be reducible by better phosphorus fertilization practices.

As described above, the MN P Index depends on both soil test phosphorus and erosion risk. Representative BMPs are used to derive the phosphorus load reduction associated with achieving the target MN P Index. Subsurface banding of phosphorus serves as a representative BMP for fertilization practices, while conservation tillage (greater than 30 percent residue) is used as a representative BMP for erosion control (see Field Erosion Control below).

Existing Adoption Rates

There are no data available on a consistent HUC8 scale that shows how much increased adoption in nitrogen or phosphorus fertilizer management has occurred since the baseline time periods. Through farmer surveys and interviews, as reported in the Farm Nutrient Management Assessment Program (FANMAP) and by Bierman et al. (2011), evidence suggests that many farmers are already implementing fertilizer BMPs, but that there is still room for improvement on many farms.

The Nitrogen Fertilizer Management Plan (MDA 2013) shows a steady increase in nitrogen fertilizer use efficiency (nitrogen fertilizer used per bushel of grain) since the early 1990s across the state. However, some of the positive effects of such progress on the environment (lbs of nitrogen in the water per acre of cropland) can be masked by increased planting densities and changes in grain protein content. The BMPs and crop genetics leading to this increased efficiency may also be somewhat offset by reductions in legume crops, small grains, set-aside lands, and non-tiled lands, coupled with changing precipitation patterns. The combined effects of all these changes have not been determined. Water quality response to changes has an inherent lag time between the time of BMP adoption and improvements in monitored waters. For example, while the Mississippi River nitrogen levels have not shown decreases, much of the River's flow comes from groundwater which has a long travel time to the river. Further tracking of BMP adoption rates is needed.

Increase and Target Living Cover

Living cover BMPs selected for analysis include riparian buffers, cover crops, and conservation reserve areas. In addition to these specific BMP types, numerous other BMPs can be used to achieve the same or similar benefits such as forage, extended rotations including alfalfa, prairie strips and grassed waterways.

Riparian buffers described in the NRS include 30 meters on either side of all perennial and intermittent streams in the Minnesota Department of Natural Resource's 1:24,000 scale maps. A 30-meter buffer represents a highly protective scenario that minimizes the risk of channelized flow through the buffer. A statewide analysis of riparian buffers areas was conducted to determine the current presence of buffers and the suitable acres that could be converted into buffer. The 2012 Cropland Data Layer (CDL) was used to evaluate the presence of perennial vegetation in the buffer. The 2012 CDL datasets are derived from satellite imagery at a 30-meter (0.22 acres per pixel) resolution; therefore error is expected when evaluating a buffer strip that is 30 meters wide. Existing buffer data that were derived from high resolution photo interpretation by the Minnesota Center for Environmental Advocacy and the Cannon River Watershed Partnership were used to calibrate an analysis of riparian vegetation using the 2012 CDL. Appendix A further describes the buffer analysis.

The reduction for nitrogen only applies to the area of the buffer itself and is a result of less nitrate leaching in the footprint of the land conversion (from cropland to perennials) to create the buffer. For phosphorus, the percent reduction applies to the area of the buffer itself, as well as the immediate drainage area to the buffer. The drainage area being treated for phosphorus is assumed to be 3 times the area of the buffer. This ratio is set based on the ability of sheet flow to be maintained as runoff passes through the buffer.

Cover crops are also considered under this heading. A study of cover crops in the U.S. corn belt by Singer et al. (2007) reported that 5.1 percent of surveyed Minnesota farmers planted a cover crop in 2005 and that 10 percent of surveyed farmers planted a cover crop in five preceding years. The 2012 Census of Agriculture included a question on cropland area planted to a cover crop; these results will be available in 2014 for inclusion in future NRS updates. An existing adoption rate for cover crops was not estimated, therefore all current agricultural land was considered potentially available for cover crops.

Cover crops can be challenging in the Minnesota climate due to low success rates for establishment with aerial seeding onto traditional corn and soybean fields. Lazarus et al. (2013) suggested that success rates may be as low as 20 percent for typical corn and soybean fields. However, it is believed that higher success rates can be achieved depending on cropping system. For the NRS, cover crops were considered in two categories, those with a high seed germination success rate that are typically planted after shorter season crops and those with a low success rate. Cover crops with a high potential for success (80 percent success rate assumed) are those that follow early season harvest crops, and for this analysis were assumed to include peas, sweet corn, fallow, sugar beets, corn silage, or wheat, where applicable areas are determined based on the 2012 CDL. Cover crops with a lower potential for success at this time (40 percent success rate assumed, based on the possibility of improved seed establishment techniques potentially available by 2020) are assumed to include those that follow corn grain, soybean, dry bean, potato, or sorghum. However, in practice some early harvest varieties of dry beans and potatoes could also be included in the shorter season crop category.

Conservation reserve or land use retirement can be considered in scenarios as an alternative to nutrient control BMPs. The intention of evaluating land retirement is not to suggest that large acreages of existing cropland be permanently removed from production (which could have negative economic and other impacts), but rather to provide an argument for the implementation of innovative BMPs at this time, while working on research for long-term economically viable land use change possibilities.

There are several different management actions that could qualify as land use change. Some represent true land use change scenarios (e.g., perennial energy crops, land retirement), while others could be considered as adjustments to existing management practices (e.g., perennial buffers replacing row crops, hayland in marginal cropland). For this analysis, perennials are assumed to replace row crops (corn, sorghum, soybeans, sweet corn, sugar beets, potatoes, peas, and dry beans) only in targeted areas.

Field Erosion Control

Field erosion control is one of the most effective practices for limiting export of cropland phosphorus, although it does not affect loading of dissolved phosphorus. Barr Engineering (2004) reported that there is a strong linear correlation between the generalized MN P Index values Birr and Mulla (2001) reported and the observed phosphorus export (in kg/ha/year) at the field scale. Conservation tillage is used in this scenario as a generally accepted practice that can be effective for mitigation of phosphorus load by reducing net soil erosion rates from runoff, although conservation tillage can have additional benefits of reducing wind erosion and subsequent atmospheric phosphorus deposition. Data describing existing conservation tillage implementation (acres) and total planted acres are available through the Minnesota Tillage Transect Survey Data Center for 2007. Data are summarized by county and converted to the HUC8 level to incorporate into the analysis. Conservation tillage is assumed to have minimal net impacts on nitrogen export.

Conservation tillage reduces erosion by maintaining at least 30 percent residue cover on the surface. Reducing erosion reduces the transport of adsorbed phosphorus, although conservation tillage can also have an adverse effect on total phosphorus load if the practice results in less soil mixing and greater phosphorus concentrations near the surface, which can increase dissolved phosphorus export in runoff. The relatively high efficiency for reducing phosphorus export assigned to conservation tillage (63 percent) is realistic only if the practice is combined with other management practices that control surface soil phosphorus concentrations. Based on the literature, phosphorus reductions in the Midwest can range from 30 percent to greater than 90 percent depending on tillage method, fertilizer management, and other site specific conditions.

For the NRS, the recommended average phosphorus removal efficiency of conservation tillage is assumed to apply to high residue crops including corn, soybeans[1], sorghum and small grains based on the 2012 CDL. However, achieving this efficiency will only occur if conservation tillage is combined

[1] Soybeans are not typically referred to as a high residue crop; however the 2007 Tillage Transect Survey in Minnesota has documented greater than 30 percent residue on a significant number of soybean fields.

with other practices to manage excess soil phosphorus concentrations. Thus reductions, attributed in this NRS to conservation tillage, actually represent a combination of erosion reduction and nutrient management practices. Accordingly, the reduction efficiencies (and costs) associated with conservation tillage have been used in the analysis, but have re-apportioned part of the resulting phosphorus reduction to the fertilizer use efficiency category. Specifically, the portion of the reduction ascribed to conservation tillage that reduces the estimated P Index to the recommended level (as described above in the section on Increasing Fertilizer Use Efficiencies) is credited to the fertilizer use efficiency category while the remainder is tabulated as due to field erosion control. This approach is a rough approximation of the complexities involved in managing soil phosphorus concentrations over time and controlling phosphorus losses; however, it appeared to be the best option available for broad scale, statewide analysis given the unavailability of comprehensive data on soil test phosphorus distributions.

Drainage Water Retention and Treatment

Both constructed wetlands and controlled drainage were evaluated as practices to reduce nitrogen loading. Wetland treatment is not assumed to permanently reduce annual phosphorus loads unless sediments are cleaned out and vegetation is harvested and removed, which is not anticipated in the rural, agricultural region where these BMPs would be applied. In addition to wetland construction and restoration, additional nutrient reductions could also be achieved using other BMPs which provide short and long term storage.

Applicable areas assumed for wetland treatment (provided by the University of Minnesota) are based on an intersection of high Compound Topographic Index (CTI) and cultivated soils. Lands suitable for wetlands were assessed by first using a logistic regression model based on CTI. Once these areas were identified, the layer was further refined by intersecting likely historic wetlands with likely tile-drained lands, isolated by finding 2009 CDL crops that are likely drained (corn, beans, wheat, sugar beets) and intersecting them with SSURGO poorly drained soils on slopes of 0–3 percent.

Suitable acres for controlled drainage (provided by the University of Minnesota) are first determined by intersecting areas with poorly drained soils; 0–3 percent slope; and corn, soybeans, wheat, or sugar beet crops based on the 2009 CDL. This analysis is used to approximate acres of tile-drained lands, and is then intersected with lands having slopes less than 1 percent to identify appropriate controlled drainage locations. Controlled drainage is used in the analysis since it is shown to be more cost effective than some other treatment technique, but other techniques such as bioreactors could also be suitable for nitrogen removal from tile drainage, potentially in areas where slope make controlled drainage impractical. Another challenge with the use of controlled drainage can be difficulty in retrofitting fields with existing drainage where tile slope management was not a design priority. Pattern tiles designed to facilitate drainage flow controls holds the most promise for new tile installation, but can also be used in many situations for retrofitting existing tile systems.

BMP Opportunities

Suitable acres for each BMP category and current adaption rates are summarized in Table 5-13. Suitable acres were determined as described above. Existing adoption rates were calculated as the total BMP acres already established divided by the total suitable acres.

Table 5-13. Summary of suitable acres and existing adoption rates, total suitable acres includes all available land where that BMP can be applied, taking into account existing BMP adoption.

BMP Category	Example BMP	*Mississippi River*		*Lake Winnipeg (Red River Only)*	
		Total Suitable Acres	Existing Adoption Rate	Total Suitable Acres	Existing Adoption Rate
Increasing Fertilizer Use Efficiencies	Achieve target soil test phosphorus	*Suitable area includes all agricultural lands where Bray soil-test P exceeds recommended 21 ppm (Barr 2004)*			
	Subsurface banding	7,659,000	*Not quantified*	1,063,000	*Not quantified*
	Nitrogen fertilizer rate reduction (on corn) [a]	6,977,000 each year	*Average rates from survey*	740,000 each year	*Average rates from survey*
	Spring applications and rate reduced	3,000,000 each year	*Not quantified*	70,000 each year	*Not quantified*
Increase and Target Living Cover	Riparian buffers	442,000	70%	245,000	68%
	Cover crops [b] (short season crops)	751,000 – 1,051,000	*Not quantified*	1,575,000 – 1,628,000	*Not quantified*
	Cover crops [b] (grain corn and soybeans)	12,261,000	*Not quantified*	3,118,000	*Minimal*
	Conservation reserve (row crops) [c]	12,854,000	*Implicit in suitable acres*	3,506,000	*Implicit in suitable acres*
	Conservation reserve on marginal corn cropland	1,237,000		418,000	
Field Erosion Control	Conservation tillage [d]	8,354,000	38%	3,876,000	17%
Tile Drainage Treatment	Wetland construction/restoration	1,559,000	*Minimal*	Unknown [e]	*Minimal*
	Controlled drainage	1,321,000		Unknown [e]	

a. The fertilizer use efficiency BMP corn land which could receive optimal nitrogen fertilizer and manure rates and timing based on University of Minnesota recommendations. The total acres for fertilizer use efficiency BMPs represent the corn acreage during a given year, multiplying corn acreage by two is an approximation of total corn acres during a two-year period which can be used to estimate corn acres in rotation. It includes both existing corn land using the BMP rates/timing along with new land using the BMPs. The nitrogen fertilizer BMP is an approximate 35 pound average reduction of industry average nitrogen fertilizer rates on corn following soybeans and additionally meeting University of Minnesota recommended rates for corn following alfalfa and corn following corn.

b. Cover crop acres assume area where cover crops can be potentially seeded. Short season crops include peas, sweet corn, fallow, sugar beets, corn silage, or wheat for the low range; and peas, sweet corn, fallow, sugar beets, corn silage, wheat, dry edible beans, and potatoes for the high range.

c. Row crops are defined as corn, sorghum, soybeans, sweet corn, sugar beets, potatoes, peas, and dry beans.

d. Conservation tillage applied to high residue crops including corn, soybeans, sorghum and small grains.

e. The Red River Valley has historically had relatively little tile drainage. However, large acreages of tile-drained croplands are being added each year to the Red River Valley in recent years. The extent of this change is not well documented and is in a state of flux. Controlled drainage should be a suitable BMP for much of the added tile drainage acreage, but is less suitable for retrofitting existing tile drainage.

Nutrient Reduction in Action

Minnesota Farmer Recognizes Benefits of Vegetated Buffers and Easements Go Beyond Water Quality

For some Minnesota farmers, the reason to plant vegetated buffers between cropland and local rivers and streams goes beyond doing the right thing to protect water quality. These buffers can provide habitat for wildlife, translating to improved aesthetics and recreational opportunities. Steve Madsen, a lifelong farmer in Renville County, raises corn and soybeans on 1,000 acres of his 1,100 acre farm. The remaining 100 acres is planted in prairie grasses, tree windbreaks, and shelterbreaks using financial incentives provided through USDA's Conservation Reserve Program (CRP) and BWSR's Re-Invest in Minnesota (RIM) program.

While these natural areas help to capture and filter runoff, the primary focus of the incentive programs, Madsen sees other benefits. He planted a windbreak of red cedar and lilac in recent years along Highway 71 and installed a small corn crib to feed pheasants. Madsen said of the project, "It's a nice conservation project to stop the water erosion, and some wind erosion, too. And it's a benefit to the wildlife."

Some of the inspiration to participate in the conservation programs came from an example over the fence line. In the mid-1990s, the Department of Natural Resources acquired 320 acres to the west of the Madsen farm. Restored wetlands and prairie soon bustled with deer, pheasants, and other wildlife. "I saw how it worked out, how it stopped erosion," Madsen says. "And I really liked the wildlife." According to Madsen, those 100 acres will remain in trees and grasses, and they become the focus after harvest, when hunting season begins.

Increased adoption of vegetated buffers and conservation easements through CRP and RIM will not only provide nutrient reductions needed to achieve NRS goals and milestones, but these practices will also generate additional benefits for farmers who enroll. And, similar to the manner in which the DNR example inspired Madsen to adopt these practices on his own property, increased adoption might create a ripple effect throughout Minnesota.

(Adapted from MPCA's Minnesota Water Story series, "Prairie grass buffers a sign of efforts to keep soil and nutrients on cropland" available at *http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/minnesota-water-stories/water-story-soil-conservation.html*)

5.3.2 Agricultural BMPs to Achieve Phosphorus Goals

As Chapter 4 discussed, recent efforts by both nonpoint sources and wastewater treatment facilities have resulted in substantial phosphorus load decreases in the Mississippi River Major Basin, although further progress is needed to achieve the ultimate reduction goals for both local and downstream waters. The Red River Basin has not made similar progress, and new reduction targets are being considered to protect and improve Lake Winnipeg.

Existing phosphorus goals can be achieved by various combinations of BMPs. Example BMP scenarios to achieve the goals were developed, with the selection of BMPs and adoption rates generally maximizing the combination of both BMP effectiveness and cost. In general, the conceptual strategy for phosphorus has the following priority order:

1. Optimize fertilizer and manure rates based on soil test phosphorus (estimated to provide a net savings to producers).
2. Increase use of conservation tillage with at least 30 percent residue where conservation tillage is not already being used (estimated to provide a net savings to producers).
3. Use precision application techniques such as subsurface banding (net cost uncertain).
4. Add living cover BMPs such as riparian buffers and cover crops that currently have a net cost to producers.

An example scenario was created to investigate what it would take to achieve the 45 percent reduction goal for phosphorus in the Mississippi River Major Basin, assuming recent progress accounts for approximately 33 percent reduction and that reductions will be made in both the wastewater and miscellaneous source sectors. Additionally, a scenario was developed to provide an indication of the level of agricultural BMP adoption needed to reach a 10 percent reduction in the Red River portion of the Lake Winnipeg Major Basin. Agricultural strategies are of lesser importance in the Lake Superior Major Basin where agriculture contributes only about 6 percent of the phosphorus load.

The example scenario was developed based suitable acres and current adoption rates for each BMP category (Table 5-13). Table 5-14 summarizes the results of this analysis, which suggest that the phosphorus goals can be achieved, but only through a combination of BMPs. Specifically, for the Mississippi River Major Basin the goal (45 percent reduction from baseline conditions) could be achieved if 55 percent of the applicable agricultural land instituted at least 30 percent residue conservation tillage where not already employed, assuming also that soil test phosphorus levels are also reduced to recommended levels. Additionally, to meet the phosphorus goals, 30-meter buffers would also be needed on both sides of 25 percent of the non-buffered perennial and intermittent streams, along with an increase in conservation reserve lands.

The net increase in BMP application area (after accounting for recent progress) is approximately 8 million acres in the Mississippi River Major Basin. Alternatively, some of the reduction in agricultural load could be achieved through greater application of BMPs, such as conversion to perennial energy crops. Substantially lower levels of effort will be necessary in the Lake Winnipeg Major Basin to achieve a 10 percent reduction. In part this is because soil test phosphorus concentrations are low in many parts of this basin, which is also the reason why there is little incremental gain from increasing fertilizer use efficiency for phosphorus in this basin.

Table 5-14. Example BMP scenario for achieving the phosphorus goals through cropland BMPs

BMP category	Example BMP	*Mississippi River*		*Lake Winnipeg (Red River Only)*	
		Future adoption rate	Total new acres (million acres)	Future adoption rate	Total new acres (million acres)
Increasing Fertilizer Use Efficiencies	Achieve target soil test phosphorus and use subsurface banding	55%	2.2	0%	0.0
Increase and Target Living Cover	Riparian buffers	78% (25% of existing non-buffered acres)	0.1	71% (10% of existing non-buffered acres)	0.02
	Cover crops (short season crops)	50%	0.3	50%	0.6
	Cover crops (grain corn and soybeans)	10%	0.5	0%	0
	Conservation reserve (row crops)	3% (32% of marginal corn cropland)	0.3	0.5% (15% of marginal corn cropland)	0.02
Field Erosion Control	Conservation tillage	72% (55% of available acres)	4.5	26% (10% of available acres)	0.4

Notes:
Future adoption rates are expressed as a percentage of the total area on which a practice is applicable. Riparian buffers and conservation tillage also express the percent of currently available acres which excludes land currently using the BMP.
Acreage from program quantification for 2000–2013 is excluded from total new acres where applicable. Total new acres represent the new area that would require the BMP.

It is important to note that approximately 17 percent of the total phosphorus load and 20 percent of the nonpoint phosphorus load in the Mississippi River Major Basin is derived from streambank erosion under average conditions (see Table 3-2). Mitigating streambank erosion is not considered in the agricultural BMP scenario described above, but could be an important part of the ultimate solution. Another 8 percent of the total phosphorus load is estimated to come from atmospheric deposition of dust. The extent to which atmospheric deposition of phosphorus can be reduced through better agricultural cover and tillage practices within Minnesota is not known. An *assessment* of atmospheric deposition conducted in 2007 (Barr Engineering 2007) evaluated available data and literature on atmospheric deposition as a source of phosphorus in Minnesota. The assessment identified the potential for wind erosion in agricultural areas as potentially contributing to atmospheric deposition loads; however a detailed analysis was not completed.

Figure 5-4 presents the percentage of total phosphorus reduction attributed to each of the basins in the Mississippi River Major Basin. The Minnesota River Basin is the largest source of phosphorous to the Mississippi River, and therefore also contributes the greatest load reductions.

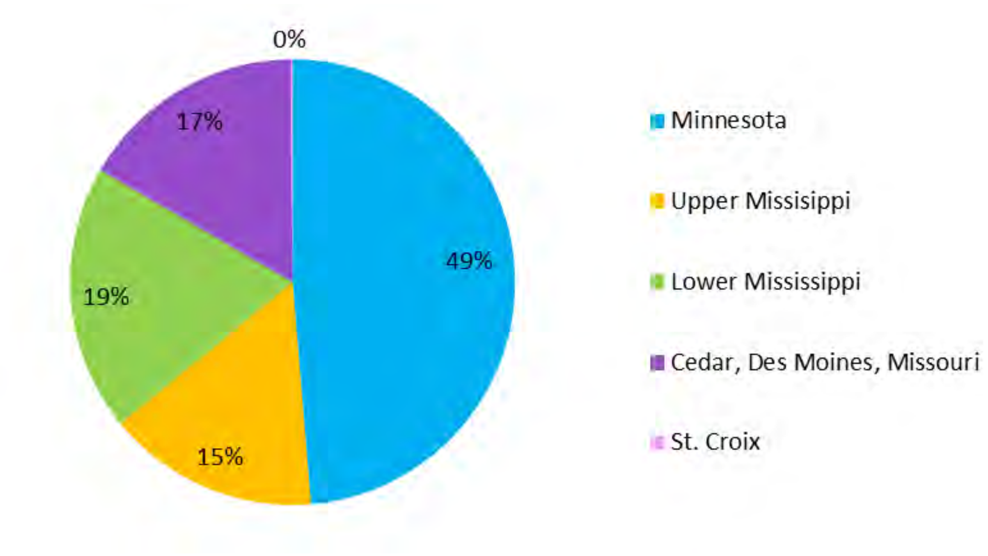


Figure 5-4. Percent of total reduction in Mississippi River Major Basin attributed to each basin.

High Island Creek in Spring, Tributary to Minnesota River Photo Credit: MPCA

Conservation Effects Assessment Project

The USDA NRCS Conservation Effects Assessment Project (CEAP) estimated the benefits of the 2002 Farm Bill's increase in conservation funding at a national, regional, and watershed scale (Appendix D). The Upper Mississippi River Basin was one of 13 basins studied by CEAP. Two nutrient loading scenarios in the CEAP study dealt with increasing treatment for undertreated areas and, more specifically, simulated the effects of structural conservation practices, residue and tillage management, and nutrient management. Similar to the NRS load reduction estimates, the practices used for simulation were selected as example practices that represent the broader range of practices available to operators. While using different analysis methods as compared to this NRS, the CEAP study showed that there is considerable room for improvement in reducing cropland nutrient transport to waters in Minnesota and neighboring states. By treating critical undertreated areas, the CEAP study estimated a 6 percent reduction of overall phosphorus loss to waters from all sources (12 percent reduction of the cropland only losses).By treating all undertreated areas the CEAP study estimated that phosphorus losses to water could be reduced by 17 percent or more (30 percent reduction in the cropland only losses).

The NRS goal of reducing Mississippi River phosphorus by 7.5 percent through cropland BMPs is within the 6 to 17 percent reduction range that the CEAP study determined possible through BMP adoption on some or all of the undertreated areas. The CEAP study supports the achievability of this NRS's recommendations for additional phosphorus loss reductions in the Mississippi River using traditional cropland conservation BMPs.

5.3.3 Agricultural BMPs to Achieve Nitrogen Goals and Phase 1 Milestone

As Chapter 4 discussed, while recent efforts by agricultural sources are estimated to have achieved a slight nitrogen reduction, the net reductions from improved fertilizer planning are offset by additional row crop acreage and tile drainage increases and are considerably smaller than those made for phosphorus. These losses have also been offset by slight increases in nitrogen from wastewater (due to population increases). The focus for nitrogen remains on the Phase 1 milestone for the Mississippi River Major Basin (20 percent reduction) and meeting the provisional goals in the Lake Winnipeg Major Basin. There are no goals for nitrogen reductions in the Lake Superior Major Basin.

An example scenario was created by an expert panel using the Watershed Nitrogen Reduction Planning Tool (Lazarus et al. 2014) to investigate what it would take to achieve the goals and milestones through more intensive application of agricultural BMPs after accounting for planned changes in wastewater discharges that include significant reductions in nitrogen loads. The example scenario was developed based on of suitable acres and current adoption rates for each BMP category summarized in Table 5-13.

The implementation of riparian buffers, cover crops, and conservation reserve is constrained to approximately match the phosphorus scenario, except that additional cover crops were needed to meet the nitrogen reduction targets (above the acreage needed to meet phosphorus reduction goals). The phosphorus scenario requires a relatively high rate of adoption of riparian buffers and cover crops to achieve phosphorus reduction goals in the Red River because soil test phosphorus concentrations are already low.

Table 5-15 summarizes the results of this analysis, which suggest that the Phase 1 Milestone could be achieved in the Mississippi River Major Basin (including the Cedar, Des Moines, and Missouri basins) with a mix of BMPs. The BMP application area in the Mississippi River Major Basin amounts to several million acres. Reduced fertilizer rates on corn, along with shifting fall fertilizer applications to spring, account for an estimated 13.6 percent reduction from all nonpoint source nitrogen loads to the Mississippi River. The addition of constructed wetlands and controlled drainage BMPs adds another 1.4 percent reduction, and another 5 percent of the nonpoint nitrogen load can be reduced through the vegetative cover BMPs.

Tile drainage is expected to increase rapidly in the Red River Valley. As a result, an increasing load of nitrogen is anticipated. Achieving the milestone for the Red River portion of the Lake Winnipeg Major Basin will require a focus on reducing baseline loads of nitrogen through increased fertilizer efficiency, as well as a strategy that includes wetland treatment and controlled drainage to offset new sources. Protection strategies are needed in the short term to mitigate new sources of nitrogen in the Red River Valley.

Table 5-15. Example BMP scenario for achieving nitrogen Phase 1 Milestone through cropland BMPs

BMP category	Example BMP	Mississippi River		Lake Winnipeg (Red River Only)	
		2025 adoption	New total acres (million acres)	2025 adoption	New total acres (million acres)
Increasing Fertilizer Use Efficiencies	Use recommended fertilizer rates/timing (corn only)	80%	See footnote a	80%	0.7
Increase and Target Living Cover	Cover crops (short season crops)	50%	0.7	50%	0.7
	Cover crops (grain corn and soybean)	10%	0.5	0%	0.0
	Riparian buffers	78% (25% of non-buffered acres)	0.1	60.8% (10% of non-buffered acres)	0.02
	Conservation reserve	3% (32% of marginal corn cropland)	0.3	0.5% (15% of marginal corn cropland)	0.02
Drainage Water Retention and Treatment	Wetlands	20%	0.5	New tile drainage [b]	0.01
	Controlled drainage	20%	0.1		0.01

Notes:

Future adoption rates are expressed as a percentage of the total area on which a practice is applicable. Riparian buffers also express the percent of currently available acres which excludes land currently using the BMP. Wetlands and controlled drainage adoption rates are expressed as the percentage of total drainage area to the practice.

a. Available data do not indicate how many acres are already using the reduced rates, but instead provide industry averages. The scenario assumes that the industry average for 11.2 million acres of corn following soybeans is reduced from about 140 lbs/acre to the Maximum Return to Nitrogen Rate, which is currently around 105 lbs/acre.

b. The Red River Valley has historically had relatively little tile drainage. However, large acreages of tile-drained croplands are being added each year to the Red River Valley in recent years. The extent of this change is not well documented and is in a state of flux and therefore the percent change for the added 0.01 million acres is also unknown.

Mississippi River Major Basin Nitrogen Goal Scenario – 45 Percent Reduction

Two hypothetical scenarios will achieve a 45 percent reduction of total nitrogen from cropland sources in the Mississippi River, assuming research can advance the success of cover crops in Minnesota. The two scenarios include:

(1) Use same adoption rates as for the Phase 1 Milestone except that cover crops are established on 80 percent of corn grain, soybean, dry bean, potato, and sorghum acres by improving the success rate on crops with current low establishment success from 40 to 80 percent.

(2) Increase adoption rates of the BMPs used for the Phase 1 Milestone to 100 percent of suitable acreages for those BMPs, and additionally increase cover crops from 10 to 60 percent of the corn grain, soybean , dry bean, potato, and sorghum acres (with current low establishment success) and improve establishment success to 60 percent.

If wastewater sources also make comparable percentage reductions, the long-term goal of a 45 percent reduction can potentially be achieved.

5.4 Recommended Miscellaneous Reductions for Phosphorus Goals

Miscellaneous sources (neither wastewater nor agricultural cropland) represent 48 percent of the statewide phosphorus load and 7 percent of the statewide nitrogen load in a typical year, as delivered to the state line. Much of this miscellaneous load will be addressed by existing programs and requirements, however, a third of this phosphorus load is a result of streambank erosion, which may be linked to erosive stream flows caused by natural and anthropogenic conditions and changes. In addition, atmospheric deposition also accounts for approximately 8, 7, and 18 percent of the loads in the Mississippi River, Lake Superior, and Lake Winnipeg major basins, respectively. A 12 percent reduction in total load from miscellaneous sources is assumed for phosphorus in the Mississippi River Major Basin, and one percent reduction in total load is assumed for the Red River Basin. Reductions in phosphorus from miscellaneous sources including streambank erosion, urban runoff, subsurface sewage treatment systems (SSTS), and feedlots are needed to reach the phosphorus goals in each of the three major basins. Control of nutrients from SSTS and feedlots in Minnesota are regulated by existing statute and rule, discussed in Chapters 4 and 6.

5.4.1 Streambank Erosion

Erosion of streambanks, bluffs, and ravines contribute to sediment and associated phosphorus loading. These loads can be reduced by watershed BMPs such as those included in Section 5.3 as well as stabilization or restoration of the channel, bluff, or ravine itself. BMPs which promote retention or detention of surface runoff or tile drainage can be used to help control downstream flows and potentially reduce streambank erosion.

Within the near channel area, various practices can be used for restoration and improvement including:

- Install buffers and perennial vegetation
- Armor slopes
- Restore sinuosity
- Reconnect floodplain
- Reduce upstream flow volume and velocity
- Riparian and upland forest management
- Streambank, gully, and bluff stabilization

The cost and effectiveness of these BMPs vary depending on the project and geographic location. A combination of activities will be needed to meet the miscellaneous source reductions.

5.4.2 Urban Runoff

Treatment of urban runoff from developed areas in the state is helpful to meet phosphorus reduction goals. The *Minnesota Stormwater Manual* provides detailed information related to stormwater management in Minnesota and includes descriptions of various structural and non-structural BMPs that can be used to address pollutant load reductions from urban runoff. The effectiveness of structural and non-structural stormwater BMPs vary. Examples of structural BMPs include:

- Bioretention
- Infiltration basin and trench
- Stormwater pond and wetland
- Green roof
- Permeable pavement
- Filtration including the iron enhanced sand filter (Minnesota Filter)

Examples of non-structural BMPs include pollution prevention, better site design, and education.

A combination of activities will be needed to meet the miscellaneous source reductions. These reductions rely predominantly on existing permit and program requirements, and therefore costs are not included in this analysis.

5.5 Nutrient Reduction Summaries

The overall practices to achieve nutrient reduction goals and milestones in the Mississippi River Major Basin and Red River Basin are summarized in Figure 5-5 through Figure 5-8. Each of the graphics includes suggested reductions by source for each of the BMP categories, urban stormwater and other sources, and wastewater treatment, as described in the preceding sections. Goals and milestones are presented in Chapter 2, baseline loads are presented in Chapter 3, progress since baseline is summarized in Chapter 4, and recommended NRS reductions are summarized above in Chapter 5.

45% Reduction — Mississippi River Phosphorus

	Agricultural	Wastewater	Miscellaneous	Total
	Source			
Baseline Load (1980–1996) Units = metric tons (MT) per year	1,337	1,739	1,551	4,627
Progress Since Baseline	356	1,113	51	1,519
Recommended Strategy Reductions				
Increasing Fertilizer Use Efficiencies on 2.2 Million Acres ▪ Recommended fertilizer rates ▪ Placement and timing of application ▪ Reducing soil P levels ▪ Livestock feed management	238			
Increase and Target Living Cover on 1.2 Million Acres ▪ Cover crops ▪ Perennial buffers ▪ Forage and biomass planting ▪ Perennial energy crops ▪ Conservation easements and land retirement	53			
Field Erosion Control on 4.5 Million Acres ▪ Conservation tillage and residue management ▪ Terraces/grassed waterways ▪ Sediment control basins	57			
Urban Stormwater + Other Sources			180	
Wastewater Treatment		37		
Total Reductions	348 +	37 +	180 +	1,519 = Total 2,084

Goal **45%** from Baseline Load = 2,084 Metric Tons Reduced

Progress Since Baseline 1,519 + **Additional Reductions 565** = **Goal 2,084 MT Reduced = 45% by 2025**

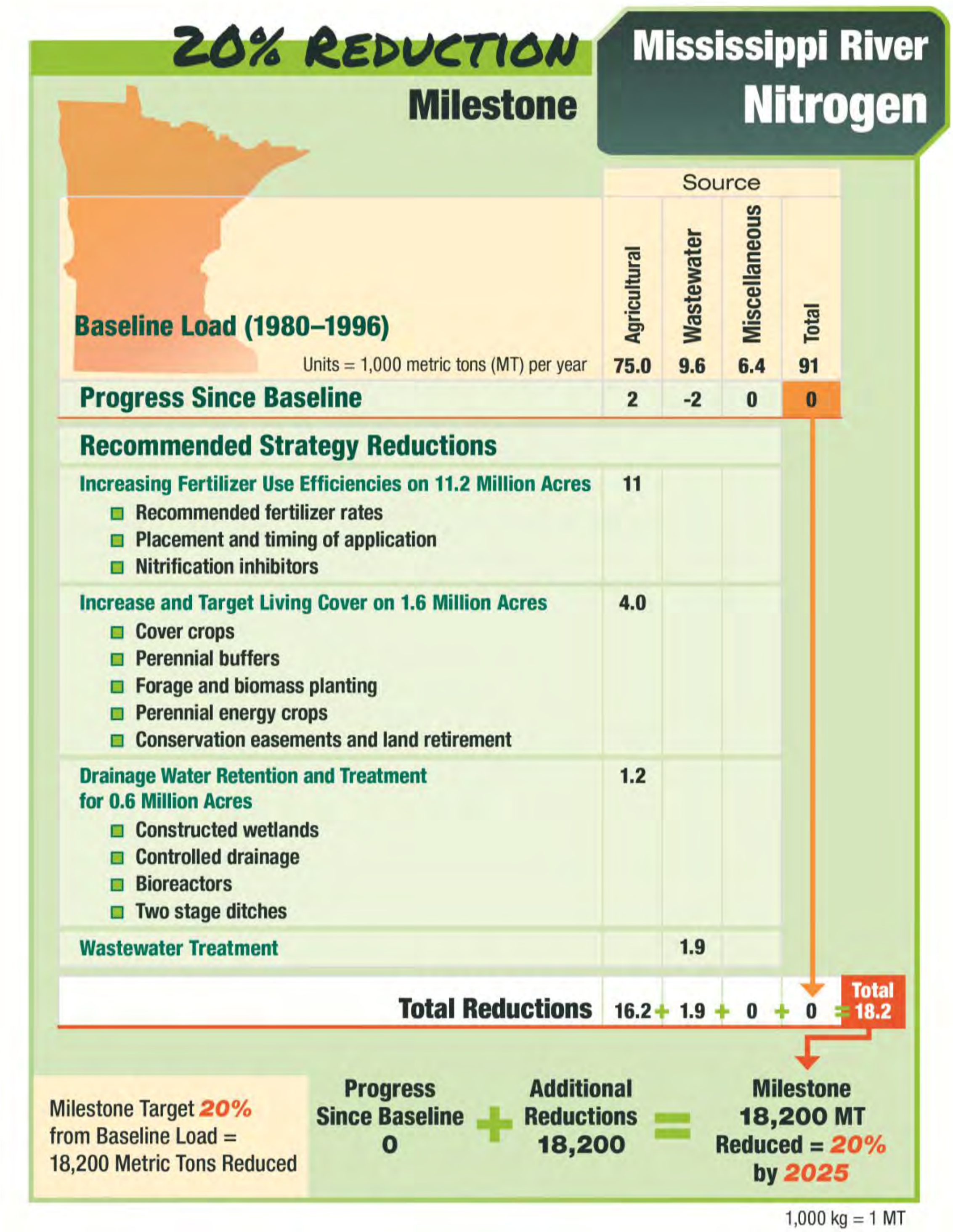
1,000 kg = 1 MT

Figure 5-5. Phosphorus goal reductions for Mississippi River Major Basin.

Notes:

Increasing Fertilizer Use Efficiency - In addition to load reductions gained from phosphorus banding, this load reflects the load reduction from applying conservation tillage that is attributable to fertilizer use efficiency. The area of conservation tillage listed under field erosion control in Table 5-14 is estimated to achieve load reductions from increased fertilizer efficiency and field erosion control.

Field Erosion Control - This load reflects the load reduction from applying conservation tillage that is attributable to field erosion control as opposed to fertilizer use efficiency.



20% Reduction Milestone

Mississippi River Nitrogen

	Source			
	Agricultural	Wastewater	Miscellaneous	Total
Baseline Load (1980–1996) Units = 1,000 metric tons (MT) per year	75.0	9.6	6.4	91
Progress Since Baseline	2	-2	0	0
Recommended Strategy Reductions				
Increasing Fertilizer Use Efficiencies on 11.2 Million Acres ■ Recommended fertilizer rates ■ Placement and timing of application ■ Nitrification inhibitors	11			
Increase and Target Living Cover on 1.6 Million Acres ■ Cover crops ■ Perennial buffers ■ Forage and biomass planting ■ Perennial energy crops ■ Conservation easements and land retirement	4.0			
Drainage Water Retention and Treatment for 0.6 Million Acres ■ Constructed wetlands ■ Controlled drainage ■ Bioreactors ■ Two stage ditches	1.2			
Wastewater Treatment		1.9		
Total Reductions	16.2 +	1.9 +	0 +	0 = Total 18.2

Milestone Target 20% from Baseline Load = 18,200 Metric Tons Reduced

Progress Since Baseline 0 + Additional Reductions 18,200 = Milestone 18,200 MT Reduced = 20% by 2025

1,000 kg = 1 MT

Figure 5-6. Nitrogen milestone reductions for Mississippi River Major Basin.

10% Reduction

Red River (Lake Winnipeg Basin) Phosphorus

Units = metric tons (MT) per year

	Source: Agricultural	Wastewater	Miscellaneous	Total
Baseline Load (2003)	422	58	768	1,248
Progress Since Baseline	47	4	4	55
Recommended Strategy Reductions				
Increasing Fertilizer Use Efficiencies ■ Recommended fertilizer rates ■ Placement and timing of application ■ Reducing soil P levels ■ Livestock feed management	0			
Increase and Target Living Cover on 640,000 Acres ■ Cover crops ■ Perennial buffers ■ Forage and biomass planting ■ Perennial energy crops ■ Conservation easements and land retirement	20			
Field Erosion Control on 400,000 Acres ■ Conservation tillage and residue management ■ Terraces/grassed waterways ■ Sediment control basins	22			
Urban Stormwater + Other Sources			13	
Wastewater Treatment		15		
Total Reductions	42 +	15 +	13 +	55 = Total 125

Goal ***10%*** from Baseline Load = 125 Metric Tons Reduced

Progress Since Baseline 55 + **Additional Reductions 70** = **Goal 125 MT Reduced = *10%* by *2025***

1,000 kg = 1 MT

Figure 5-7. Phosphorus goal reductions for Red River/Lake Winnipeg Major Basin.

Notes:

Increasing Fertilizer Use Efficiency - This load reflects the load reduction from applying conservation tillage that is attributable to fertilizer use efficiency as opposed to field erosion control. The area of conservation tillage listed under field erosion control in Table 5-14 is estimated to achieve load reductions from increased fertilizer efficiency and field erosion control.

Field Erosion Control - This load reflects the load reduction from applying conservation tillage that is attributable to field erosion control as opposed to fertilizer use efficiency.

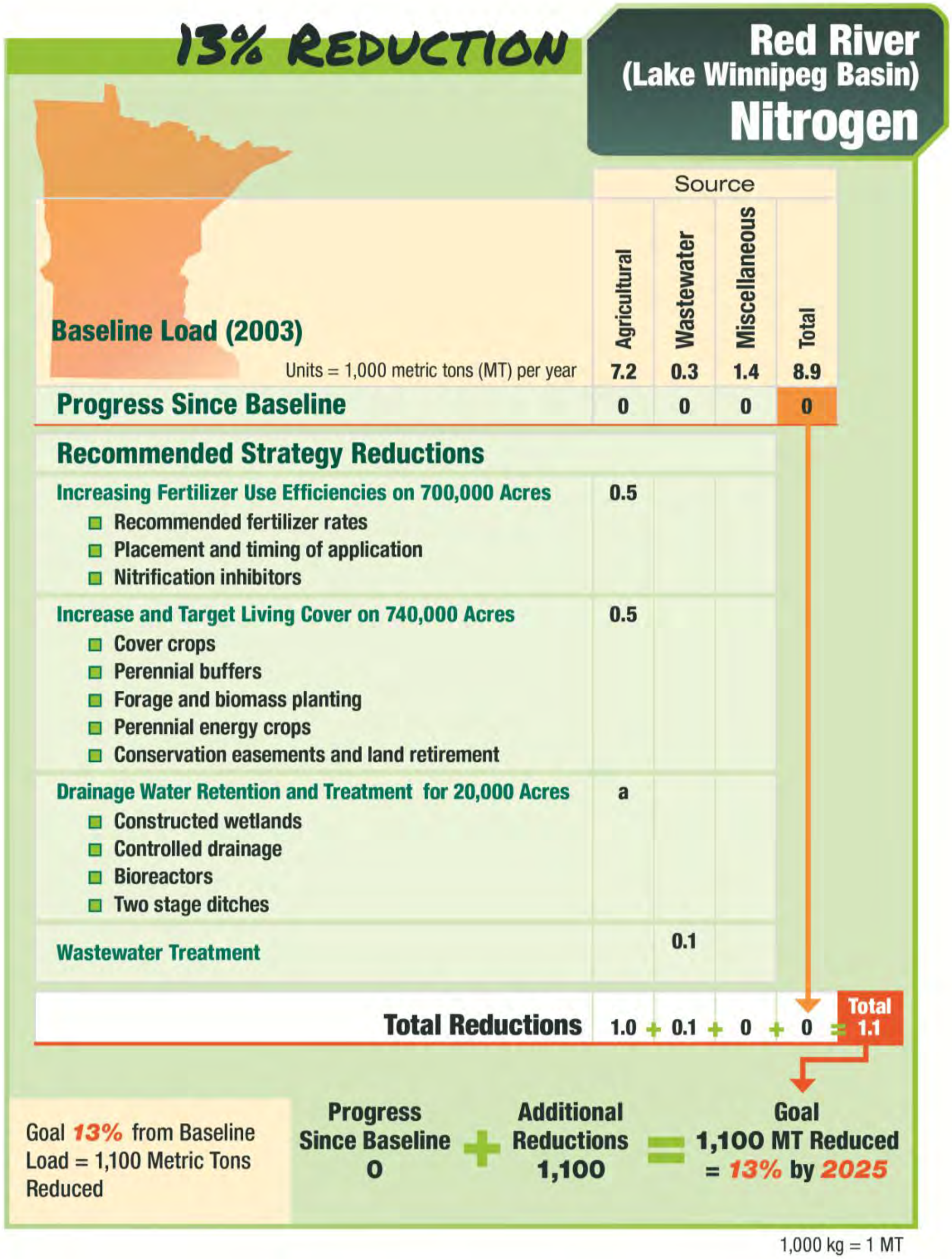


Figure 5-8. Nitrogen goal reductions for Red River/Lake Winnipeg Major Basin.

a. There is very little tile drainage during baseline period in this basin. BMPs are needed to mitigate increases from new tile installation.

5.6 Cost Analysis

An analysis of costs is provided below for both wastewater nutrient removal and agricultural BMP implementation. Costs are not presented for nitrogen removal costs in wastewater due to limited data. Literature sources were used for the agricultural BMP costs, which are documented in Section 5.3.

5.6.1 Wastewater Treatment

Costs for the vast majority (over 90 percent) of residents receiving municipal wastewater treatment range from $7 to $11 per pound of phosphorus removed to reach 1 mg/L concentration phosphorus in the effluent. However, removal costs escalate sharply with declining effluent concentration targets. Costs range from $39 to $175 per pound for removal to a 0.8 mg/L concentration and $91 to $344 per pound for removal to a 0.1 mg/L concentration. Table 5-16 presents the annual removal costs to treat wastewater (assumed influent concentrations of 4.5 mg/L) to 1.0 mg/L, 0.8 mg/L, and 0.1 mg/L effluent concentrations. These phosphorus removal cost estimates represent chemical phosphorus treatment by mechanical municipal wastewater treatment facilities only. Stabilization pond and industrial WWTP phosphorus removal costs are not included in these estimates.

Table 5-16. Summary of wastewater annual removal costs for phosphorus (MPCA calculations derived from Thorson 2011).

Design flow (mgd)	Population [a] (pop)	Annual removal cost to 1.0 mg/L [b] ($/year)	Annual removal cost to 0.8 mg/L [c] ($/year)	Annual removal cost to 0.1 mg/L [a] ($/year)
0.20 - 0.49	120,386	$3,575,501	$5,086,379	$13,660,247
0.50 - 0.99	194,117	$3,104,411	$4,665,486	$14,351,246
1.00 - 4.99	432,637	$5,436,306	$9,758,993	$25,349,659
5.00 - 9.99	225,393	$2,059,766	$2,869,941	$7,003,206
10.00 - 19.99	180,851	$1,446,127	$2,085,178	$4,900,305
20.00 - 39.99	506,769	$4,052,244	$5,812,076	$13,916,565
40.00 - 99.99	386,265	$3,529,904	$4,847,735	$12,178,169
100+	1,800,000	$14,393,224	$17,902,429	$37,861,033
	Total	**$37,597,483**	**$53,028,216**	**$129,220,430**

a. Population data derived from 2010 census; assumed flows of 100 gallons/capita/day.
b. Includes both capital and operations and maintenance costs.
c. Does not assume any additional capital costs.

Dividing these dollars per pound totals by the total population served by wastewater treatment facilities that discharge to surface waters (approximately 3.86 million) yields the following:

- Cost for phosphorus removal to a 1 mg/L concentration = $10/capita/year
- Cost for phosphorus removal to a 0.8 mg/L concentration = $14/capita/year
- Cost for phosphorus removal to a 0.1 mg/L concentration = $34/capita/year

5.6.2 Agricultural BMPs

The cost-benefit results for agricultural BMPs are presented both as annualized values. With the exception of conservation reserve values, MPCA (2013a) and Iowa State University (2013) developed the annualized values by calculating the net present value of the monetary costs and benefits associated with each practice from the producer's point of view. Costs included upfront establishment and operation costs. Benefits included any increases in production or cost savings to the producer gained by implementing the practice. For the conservation reserve values, an average of the costs from MPCA (2013a), Iowa State University (2013), and Miller et al. (2012) was used, which reflects the average across differing assumptions for site and program-specific details.

While an individual practice at the site-scale may change within 10 to 15 years, the NRS assumes, on average, that the acreages of BMPs implemented will be maintained in the long-term. The costs assume typical equipment replacement or other long-term maintenance requirements where appropriate.

The annualized value represents the net cost (or benefit in some cases) for the practice if it were paid in constant annual payments for the lifetime of the practice. The annualized value provides a means for comparing practices with different timing of costs and benefits (e.g., more upfront, less operation costs versus less upfront, more operation costs) or different time periods. These annualized values were referred to as lifecycle costs in Table 5-11 and presented there in terms of annualized costs per acre. The annualized values per acre were then applied to the acres of BMPs to calculate the cost per year to achieve the goals and milestone (Table 5-17).

The breakdown in costs by BMP category relate directly to the load reductions presented in Section 5.5. For example, the cost of the load reductions from increasing riparian buffer is estimated to achieve the reported load reductions for both nitrogen and phosphorus.

Table 5-17. Cost estimates by BMP, presents as a range of annualized values. Costs estimates will vary considerably with changing technologies, changing markets, new information and other changes. Parentheses indicate cost savings.

BMP category	Example BMP	Mississippi River Major Basin (per year)	Lake Winnipeg Major Basin (per year)
Increasing fertilizer use efficiencies	Nitrogen rates in accordance with the Maximum Return to Nitrogen	- ($80,000,000 - 95,000,000)	-($9,000,000 - 11,500,000)
	Achieve target soil test phosphorus and use subsurface banding	-(33,000,000 - $48,000,000)	$0
Increase and target living cover	Cover crops [a]	$42,400,000 - $63,600,000	$31,800,000 - $37,100,000
	Riparian buffers	$3,000,000 - $30,000,000	$600,000 - $6,000,000
	Conservation reserve	$1,800,000 - $33,000,000	$120,000 - $2,200,000
Drainage water retention and treatment	Wetlands and controlled drainage	$3,900,000 - $9,900,000	$150,000 - $270,000
Field erosion control	Conservation tillage	-($4,000,000 - $5,000,000)	-($375,000 - $425,000)
Cost of agricultural BMPs		**$51,100,000 - $136,500,000**	**$32,670,000 - $45,570,000**
Net cost (after subtracting savings)		**-($65,900,000 - $11,500,000)**	**$23,295,000 - $33,645,000**

a. Seed establishment cost estimates are based on aerial seeding for corn/soybean fields and no-till drill for short season crops. .

The results indicate that a net cost would be realized in the Mississippi River and Lake Winnipeg major basins. BMPs providing increased fertilizer use efficiencies are estimated to provide the greatest net benefit, while cover crops are estimated to provide the greatest net cost. In the Mississippi River Major Basin, the cost savings from the increased fertilizer use efficiency and conservation tillage BMPs offset greatly the net costs of the other BMPs. For an individual farm, the results would vary depending on which BMPs were implemented.

Increasing fertilizer use efficiency has a strong influence over the cost-benefit results. This BMP is estimated to provide a net cost savings, or benefit, due to reduced fertilizer costs. This value estimate assumes that the current nitrogen fertilizer application rate is above the recommended rate (on average) for the land where these practices would be implemented. Individual watersheds can use the NBMP tool to further evaluate the cost-effectiveness of numerous cropland BMPs adopted for nitrogen reduction to waters in a given watershed or basin (see Lazarus et al. 2014). The cost per pound of nitrogen prevented from entering waters for each BMP type is provided as an output of the NBMP tool (Table 5-18).

Table 5-18. Cost per pound of nitrogen reduced (Lazarus et al. 2014)

BMP	Cost per pound of nitrogen prevented from entering surface water in Mississippi Basin
Nitrogen rates in accordance with the Maximum Return to Nitrogen	(4.11) savings
Cover crops (short season crops)	$13.88
Cover crops (grain corn and soybean)	$8.90 to $31.80
Riparian buffers	$14.43
Conservation reserve on marginal cropland	$6.97
Wetlands	$1.59
Bioreactors	$14.66
Saturated buffers	$1.24
Controlled drainage (as a retrofit)	$2.40

Chapter 6

Nutrient Reduction Strategies

The *Minnesota Nutrient Reduction Strategy* (NRS) is intended to provide a roadmap as to the type of implementation activities that could be used to achieve the goals and milestones for reducing excess phosphorus and nitrogen in the waters of Minnesota and reducing Minnesota's contributions to downstream water quality problems. It is not intended to prescribe site specific best management practices (BMPs) and management actions. As a roadmap, the NRS acknowledges that additional planning activities will be necessary to support implementation actions for key strategies. In many cases this additional planning should integrate state level support and local implementation. This chapter identifies pathways for achieving nutrient reductions. Many of the strategies are contingent on a variety of factors, such as the collection of appropriate data, available financial and staff resources, and timing with other key initiatives and regulatory actions. As a result, an adaptive management approach to implementing the strategies will be used to guide and adjust implementation efforts over time. Chapter 7 of the NRS provides more detail on the adaptive management approach for gauging implementation progress as all stakeholders work toward meeting the goals.

6.1 Recommended Overarching Actions to Support Nutrient Reduction Strategy Implementation

The NRS builds on previous implementation efforts in the state. Working toward the goals and milestones will require a significant amount of coordination and communication at a statewide level. Infrastructure will be necessary to support coordination and communication among the various local, state, and federal partners. The first set of recommended strategies focus on developing and sustaining the necessary infrastructure to support coordinated implementation and communication on progress over time.

Strategy: Develop a Statewide NRS Education/Outreach Campaign. A significant portion of the nutrient reductions to be achieved through the NRS rely on voluntary actions from key sources, such as the agricultural community, and broad support from water users across the state. The NRS, and the scientific studies and other efforts that preceded it, expands conversations about the importance of reducing excess nutrient loss to waters and the most effective solutions available to meet nutrient reduction goals and milestones. Ongoing education and outreach are key to raising awareness about the need to reduce excess nutrient loss and to continue to make progress toward these reductions.

As a result, effective education and involvement are imperative to the success of the overall NRS. A multi-agency team of communications specialists, working with environmental educators and non-governmental stakeholder organizations, should develop and implement a coordinated NRS outreach campaign that integrates with other efforts to promote statewide stewardship of water resources. For example, the Draft *Nitrogen Fertilizer Management Plan* (NFMP) calls for a Nitrogen Fertilizer Education and Promotion Team to develop a prevention strategy to promote groundwater protection BMPs associated with nitrogen fertilizer use.

A Stakeholder Involvement and Education Plan to guide communication activities, crafted as part of the NRS development process, can serve as a foundation for outreach and education efforts. As the NRS moves into the implementation phase, the existing Stakeholder Involvement and Education Plan can evolve to identify outreach and involvement activities to communicate NRS -related messages and information to key audiences. Communication tools should inform, motivate, and assist with implementation of the nutrient reduction strategies. One of several tools could include a statewide coordinated advertising campaign intended to target nutrient behaviors from key target audiences, such as the Thank A Farmer! billboard campaign used in the Hinkston Creek (Kentucky) Watershed Project (Figure 6-1). The campaign could also include the development and distribution of nutrient reduction success stories and an associated awards program for the most successful nutrient reduction projects from across the state.

Figure 6-1. The Thank A Farmer! billboard campaign was used in the Hinkston Creek (Kentucky) Watershed Project to create a positive message for farmers about the use of grassed waterways.

Friendship Tours: Since some of the implementation actions needed are meant to help reduce impacts that are beyond the HUC8 watershed planning area, efforts should be made to increase direct interaction of local watershed managers with communities downstream that are being impacted. The Lake Pepin, Minnesota River and Mississippi River users and farther downstream, the Gulf of Mexico and Lake Winnipeg users, depend on local action far upstream. Friendship Tours which involve direct interactions of these upstream and downstream folks have been shown to help create the "small world" community perspective needed to make good stewardship decisions. Facilitation of these interactions may be needed to make this possible.

Basin Educators: As presented in the Minnesota Water Sustainability Framework (University of Minnesota 2011), Minnesota could consider funding basin educators through University of Minnesota Extension to work within the major river basins, focusing on the priority watersheds, to provide and coordinate water resources education and citizen engagement. This will increase capacity at both the state and local levels.

Strategy: Integrate Basin Reduction Needs with Watershed Planning Goals and Efforts. An expected outcome of Minnesota's Water Management Framework (described in Chapter 1) includes strategies for nutrient reduction, which are tailored to the 8-digit hydrologic unit code (HUC8) major watersheds and local water resources. The watershed restoration and protection strategy (WRAPS) for each HUC8 watershed includes such elements as timelines, interim milestones, and responsible governmental units for achieving the needed pollutant reductions. A comprehensive water management plan (e.g., One Watershed One Plan) is locally developed, which further defines the more specific actions, measures, roles, and financing for accomplishing the water resource goals.

While many major watersheds have nutrient impacted waters, in some cases the nutrient impacts to waters are greater downstream than at the local level, and in a few cases nutrient concerns are not evident until they show up in downstream waters. The WRAPS and associated comprehensive watershed management plan should be developed to not only have the goal of protecting and restoring water resources within the watershed, but to also contribute to nutrient reductions needed for downstream waters (in-state and out-of-state). For the WRAPS and watershed plans to achieve the downstream goals of this NRS, aggregated watershed reductions need to contribute to the overall milestones and goals.

A set of possible major watershed nutrient reduction targets is provided in Appendix E as a guide to collectively reach NRS goals and milestones. Watershed planning that addresses downstream needs should consider a proportional reduction from all anthropogenic sources based on the major basin goal or milestone (i.e., 20 percent nitrogen reduction for watersheds draining to the Mississippi River). Since the feasibility of BMP implementation practicality varies according to local conditions HUC8 watershed level reductions should also be guided by BMP implementation suitability in the watershed. Appendix E provides the HUC8 watershed nutrient reductions that would collectively achieve the goals and the Phase 1 nitrogen milestone for (a) all sources based on SPARROW modeling loads at the outlets of HUC8 watersheds, and (b) cropland sources alone based on the amount of land that is suitable and available for agricultural BMPs in each watershed as described in Chapter 5. Reductions are not expected for undisturbed landscapes such as undisturbed forests and grasslands; however preventative attention should be given to activities resulting in land disturbances.

Watershed modeling and local water planning through One Watershed One Plan can be used to develop the best scenario for BMPs in individual watersheds. The *Minnesota Nutrient Planning Portal* has been developed for accessing watershed nutrient-related information and includes information on nitrogen and phosphorus conditions and trends in local waters, nutrient modeling, local water planning, and other nutrient information. The information from this portal can be used when developing local plans and strategies to reduce nutrient losses to local and downstream waters.

Downstream Minnesota waters may require further evaluation to determine if additional nutrient reductions are needed, such as those reductions needed to meet approved total maximum daily loads (TMDLs) or downstream water quality standards (e.g., Lake Pepin). It is likely that future revisions of the NRS will include additional analysis of watershed-specific reductions undertaken to determine the most cost-effective approaches, especially when considering efforts to move toward final goals.

6.2 Strategies to Implement Wastewater Reductions

The current Phosphorus Strategy and Rule has and will continue to address phosphorus reductions in wastewater. The expected adoption of river eutrophication standards in 2014 is expected to result in additional wastewater phosphorus reductions in certain watersheds.

The history of phosphorus management at wastewater treatment plants (WWTPs) in Minnesota starting in 2000 is a relevant example of a successful program to reduce a pollutant of concern (Section 5.3.1). Several successful techniques utilized in the Phosphorus Strategy are proposed for nitrogen. An important caveat related to nitrogen removal is that nitrogen and phosphorous biological reduction can be competing processes depending on the facility type, and implementation of biological nutrient removal could compromise phosphorous removal efficiencies. Additional research and testing is necessary to develop cost-effective solutions for both phosphorus and nitrogen removal from wastewater. Until research and testing is completed, wastewater treatment facilities may be limited in their nitrogen removal achievements. This will need to be evaluated as more information is gathered and may result in modification of the nitrogen reduction milestones.

A series of steps are provided for the wastewater component of the NRS; and it is anticipated that the steps would be completed in sequential order. The steps described below are intended to build the knowledge base and generate the data necessary to support informed decisions and investments. The first step is to better understand nitrogen sources and concentrations in the wastewater influent and effluent. This step will provide information to support nitrogen management plan development. As a first step to reduce nitrogen in influent, facilities will identify high nitrogen contributors to the facility, if any, and target important nitrogen sources. Using information on nitrogen sources, facilities should develop optimization options for treatment processes that will enhance nitrogen removal without compromising phosphorus removal. As facilities complete these steps, the assessment will help to identify major changes needed to existing treatment processes and technologies. Major changes to treatment plants will require significant timeframes for design and construction.

Metropolitan Wastewater Treatment Plant Photo Credit: Metropolitan Council

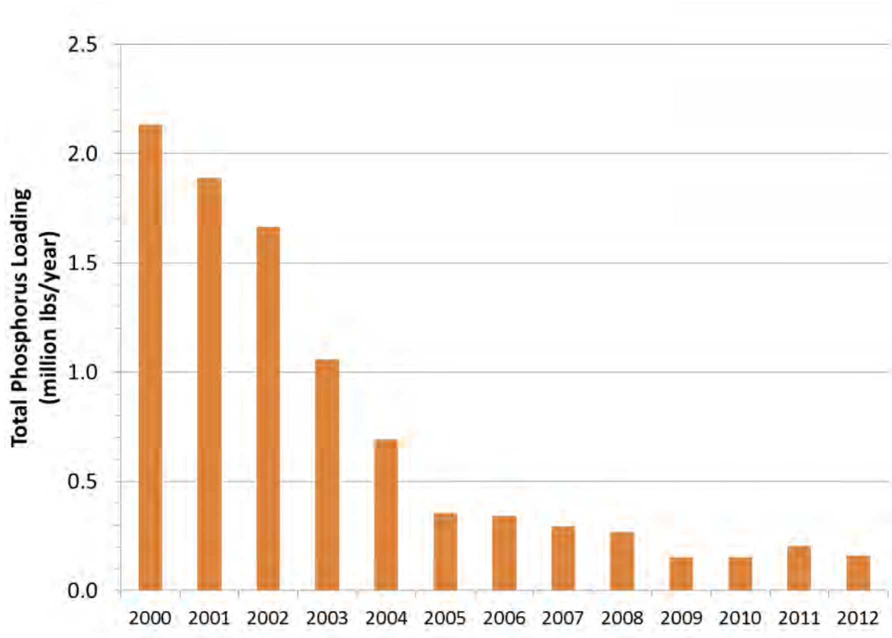
Nutrient Reduction in Action

Wastewater Treatment Success in the Metropolitan Area

The Metropolitan Council and its predecessor agencies have played a critical role in restoring the health of the Mississippi River in the 40 years since the passage of the Clean Water Act. Technology upgrades at WWTPs and partnerships with industry have greatly reduced pollutants such as phosphorus, mercury and other metals, suspended solids and ammonia-nitrogen in the river.

The Metropolitan WWTP is located on the Mississippi River in St. Paul, and is the largest wastewater treatment facility in Minnesota. When it opened in 1938, it was the first plant in a metropolitan area on the Mississippi River. Today it is among the nation's largest serving 1.8 million people.

Significant reductions in phosphorus loading from the Metro WWTP have occurred since 2000. The WWTP now consistently achieves less than 1 mg/l total phosphorus in the effluent.



Metro WWTP Phosphorus Loadings

Data provided by Metropolitan Council

Wastewater Strategy Step 1: Influent and Effluent Nitrogen Monitoring at WWTPs. Increase nitrogen series monitoring frequencies for all dischargers, including industrial facilities, starting with permits issued in 2014.

In the past, WWTPs in Minnesota have not regularly collected data on both influent and effluent nitrogen concentrations. Monitoring has been limited to ammonia primarily due to permit requirements. Those facilities with ammonia concentration or load requirements provide treatment to convert ammonia to nitrate-nitrite nitrogen, but do not reduce nitrogen loads in the effluent. Monitoring additional forms of nitrogen beyond ammonia is needed to more fully understand loading from WWTPs.

Nitrogen series (nitrate, total Kjeldahl nitrogen, ammonia) effluent monitoring is currently required twice per year for all dischargers with design flows over 0.1 million gallons per day. Influent monitoring should be added for municipal wastewater facilities and effluent monitoring frequency should be increased based on discharge type and size to obtain more data about point source nitrogen dynamics. More frequent data collection will help establish a better understanding of the variability in point source nitrogen discharges, and the comparison of influent and effluent nitrogen concentrations will allow for the development of nitrogen management plans and identification of dischargers with unusual (high or low) influent and effluent concentrations.

Monitoring also allows for information exchange among MPCA, operators, and consultants. Data could be used as background information for developing performance standards for various facility types.

Wastewater Strategy Step 2: Nitrogen Management Plans for Wastewater Treatment Facilities. Require nitrogen management plans for all major facilities and those facilities above certain effluent concentrations, except for industries such as power generation, which have limited potential to discharge new nitrogen to surface waters. Work with various organizations and existing programs to support nitrogen reduction planning for wastewater facilities, including the Minnesota Technical Assistance Program (MnTap), and identify possible funding and technical assistance. MnTap is a University of Minnesota organization whose mission is helping Minnesota businesses develop and implement industry-tailored solutions that prevent pollution at the source, maximize efficient use of resources, and reduce energy use and costs to improve public health and the environment. Their website contains more information: *http://www.mntap.umn.edu/*.

Historically, pollutant management plans have been developed for phosphorus and mercury. These plans were developed prior to, or in lieu of, implementing a permit limit. The plans identify cost-effective pollutant reductions depending on the facility, often targeting pollutant sources in influent. A nitrogen management plan could range from simple data analysis to complex engineering plans that reduce nitrogen at a given facility. Plans can allow a facility to identify cost-effective reductions that could be implemented in the near term and without the burden of effluent limits. The costs of such plans are relatively minor compared to a facility upgrade; however, if a facility upgrade is the only solution for nitrogen reduction, the plans might be unnecessary.

Timing of plan development is dependent upon monitoring data collection. Monitoring is anticipated to take a minimum of three years with plan development following. The first round of nitrogen management plans could be completed by 2020.

Wastewater Strategy Step 3: Nitrogen Effluent Limits as Necessary. After nitrate standards are adopted for protection of aquatic life, as currently required by 2010 legislation, begin incorporating water quality-based effluent limits (WQBELs) based on the new nitrogen standards for protection of aquatic life, as necessary.

The existing drinking water standard of 10 mg/l has resulted in very few nitrogen effluent limits. There are likely additional WWTPs in southern Minnesota that might need nitrogen WQBELs in the future, depending on the size of the discharge and the dilution of the receiving water during critical conditions. However, the number of WWTPs needing nitrogen WQBELs in the near-term to protect drinking water supplies is expected to be low due to the low number of streams currently designated for drinking water (see Chapter 2).

Future nitrate standards to protect aquatic life may be another driver in the future for nitrogen based WQBELs. Adoption of these standards is anticipated in the next 2–4 years. At that time, WQBELs will be incorporated into permit renewals as needed.

While the nitrogen milestone assumes an overall reduction of 20 percent nitrogen loads from wastewater sources by 2025, there are many unknowns that could affect this projection. It is critical for the state's largest facilities to reduce their nitrogen effluent to achieve the milestone, but more information is needed regarding potential industrial sources of nitrogen and treatment processes that would not compromise phosphorus removal at treatment facilities. Consideration should be given to the goal and milestone schedule when developing nitrogen management plans for wastewater point sources.

Wastewater Strategy Step 4: Add Nitrogen Removal Capacity with Facility Upgrades. Establish a technology-based threshold to achieve nitrogen reductions based on facility type and size. Encourage early adoption of nitrogen removal for major WWTPs planning to upgrade.

As part of the Phosphorus Strategy, which began in 2000, WWTPs began implementing phosphorus removal based on a technology limit. These actions allowed for early reduction in phosphorus, prior to the Phosphorus Rule and Minnesota River Basin Permit, which required phosphorus WQBELs.

A similar strategy is proposed for nitrogen. This strategy would encourage WWTPs to incorporate capacity and technologies for nitrogen removal into planned facility upgrades to save on overall planning and construction costs that could be necessary in the future. It is not likely that construction of nitrogen treatment technologies will be fully implemented until nitrogen standards for protection of aquatic life are complete, unless incentives for early adoption are identified and provided.

Wastewater Strategy Step 5: Point Source to Nonpoint Source Trading. Pollutant trading is an example of a market-based strategy since it is driven by finding the lowest cost treatment approach. In the case where Minnesota is working in concert with other states to reduce downstream impairments, the viability of an interstate nitrogen trading network should be considered. At the same time, Minnesota should continue to explore an in-state trading framework that allows for phosphorus and nitrogen point source-to-nonpoint source trading. Addressing the primary policy principles of trading including additionality (trades involve actions that otherwise wouldn’t occur), equivalence (getting a similar outcome from the traded actions), and accountability (reasonable assurance that the actions are likely to happen) is critical to granting point sources authorization to trade. As water quality load capacity is established, trading has the potential to become more viable by generating a demand. Trading requires significant quantitative science for nonpoint source controls to demonstrate load reductions and decrease uncertainty. Development of a statewide trading framework would need to address these minimum requirements.

6.3 Strategies to Implement Recommended Agricultural BMPs

To achieve the goals and milestones, it is essential to develop strategies that will result in increased adoption of the BMPs identified in Chapter 5. Strategies to promote increased agricultural BMP adoption fall into the following categories: Increasing Agricultural BMPs in Key Categories; Accelerating and Advancing BMP Delivery Programs; Economic Strategy Options; Education and Involvement Strategies; and Research and Demonstration. Each action category is described below in more detail.

6.3.1 Stepping Up Agricultural BMP Implementation in Key Categories

Decisions that are made at the individual farm scale will be most successful when programs support and provide locally led assistance that motivates the needed changes. Annual farm planning creates the opportunity for farmers and industry and government advisers that serve them to continually improve nutrient use efficiency and reduce losses to the environment. Coordinated planning, whether through ongoing continual improvement efforts or new planning approaches, will provide the vision and pathway for achieving necessary programmatic support and local water planning activities. Conservation planning assistance from state and federal programs will create opportunities to combine efficient use of fertilizers with such practices as treating tile water and increasing living cover on the landscape.

Nitrogen and phosphorus reductions will be the result of pollution prevention and widespread BMP adoption. The following agricultural BMP implementation strategies are central to the success of the overall NRS.

Strategy: Work with Private Industry to Support Nutrient Reduction to Water. Changes that represent BMP introduction and incentive are common, but it isn't expected that government programs will be directly involved in all change that is needed. Recognizing the importance of BMP adoption that occurs outside of the direct involvement of government programs, tracking new BMP implementation stemming from private industry efforts is critical to understanding NRS progress. Private entities include individual farms, corporations, commodity groups, co-ops, certified crop advisers, and others. The NRS should build on existing partnerships among public and private entities, such as MDA's research and technical assistance program that typically includes the agricultural industry, producer groups, and individual farmers as well as consider new opportunities for private industry involvement in NRS implementation.

Strategy: Increase and Target Cover Crops and Perennial Vegetation. Large increases in living cover BMPs such as cover crops and perennial vegetation are needed to meet the milestones and goals, and are likely to become needed even more to reach the final nitrogen reduction goals. Cover crops and vegetative cover increases will need to become common if we are to meet the State's nutrient reduction goals. The NRS recommends that perennials be placed on sensitive lands such as riparian lands and on lands with marginal row crop production capability. This strategy recommends immediate promotion on two major areas, including establishing cover crops on short-season crops immediately and moving toward cover crops or double cropping of perennials within our traditional corn and corn/soybean crops. The greatest water quality benefits over the long term can be gained by establishing cover crops or perennial double cropping within our existing corn/soybean rotations; thus we need to continue research and increase the widespread practicality of such practices in Minnesota climates. The successful advancement of vegetative cover BMPs on agricultural lands hinges on a common vision and approach that is understood and supported among all key agencies, academia and private industry. Three key barriers have been identified in Minnesota to make progress in this area: (1) cover crop seed establishment in our relatively short Minnesota growing season, (2) genetics improvements on cold weather crops that can be successfully used in Minnesota, and (3) finding markets to create economic incentive for growing cover crops and perennials. MDA and USDA have prioritized cover crops as a research priority, and it is anticipated that research will address the lack of market incentives for cover crops and further the existing knowledge base on cover crop management, equipment, cost considerations, and environmental quality issues such as soil health, nutrient and sediment reduction, and water management.

Strategy: Soil Health. While the goals of the NRS are related to excessive nutrient loading to surface and groundwater, this strategy integrates those objectives with a goal of restoring and maintaining excellent soil health. Practices to improve water quality and soil health are both related to farm sustainability; and while water quality impacts generally show up downstream of the farm, soil health is more directly related to the sustained productivity of the soil on the farm itself. Integrating water quality and soil quality adds increased on-farm value to many of the practices used to mitigate nutrient loading. National initiatives are increasingly emphasizing the importance of soil health. In Minnesota, NRCS and BWSR, along with the University of Minnesota, MDA and other agencies, are working with agricultural and environmental organizations to include soil health as a conservation objective and to incorporate soil health principles with the types of BMPs in this Strategy to reduce nutrient transport to water. The four principles to improving soil health include:

- Keep the soil covered as much as possible.
- Disturb the soil as little as possible.
- Keep plants growing throughout the year to feed the soil.
- Diversify as much as possible using crop rotation and cover crops.

Improved soil health will sustain soil productivity for future generations, absorb and hold rainwater for use during drier periods, filter and buffer nutrients and sediment from leaving the fields, increase crop productivity, and minimize the impacts that severe weather conditions can have on food production and environmental quality. Thus the benefits of making widespread changes to cropland management, as outlined in this strategy, extend beyond water quality improvement, and include protecting our soil productivity for future generations.

The NRS seeks to incorporate soil health promotion as an overarching educational emphasis. As we promote the BMPs needed for nutrient reduction to waters, we should do so in concert with promoting soil health for long term food productivity and sustainability. By focusing attention on soil health and by providing education about the positive impact healthy soils can have on productivity and sustainability, Minnesota farmers will understand the multiple benefits of the BMPs to reduce nutrient losses to waters. This will increase the motivation for adopting these practices under the current policy framework.

Conservation programs such as EQIP and CRP are important to soil health. Conservation programs contribute to soil health by addressing some of the technical and financial risks associated with implementing practices that increase organic matter, water infiltration, water-holding capacity, and nutrient cycling.

Strategy: Riparian Buffers. Riparian lands, because of their close proximity to waters, contribute a higher and disproportional amount of nutrients to surface waters. Vegetative buffers are a primary watershed feature for assimilating sediment and phosphorus in overland flow. Minnesota's Shoreland Rules require that riparian lands adjacent to public waters be maintained in perennial vegetation. In addition to those streams regulated under the Shoreland Rules, buffers are encouraged along all waterways. Tracking implementation at a watershed or county scale is useful for understanding how effective the local implementation efforts are at achieving adoption and maintenance of buffers. Counties have been working for several years to implement county or watershed-scale projects to ensure that all waters regulated under the Shoreland Rules have adequate perennial buffers. An example of a local initiative is the Blue Earth County Shoreland Buffer Initiative, which was funded by a Clean Water Fund grant in 2011 with a goal of 100 percent voluntary compliance. The County and Soil and Water Conservation District (SWCD) used mapping and photo interpretation to determine areas that required a perennial buffer per county ordinance and state statue, and then worked one-on-one with landowners to implement the necessary projects. The SWCD provided technical assistance to landowners and directed landowners to available funding sources.

Strategy: Fertilizer Use Efficiencies. Increasing the efficient use of nitrogen and phosphorus fertilizers and manure is a fundamental strategy for reducing nutrient movement to waters. Fertilizer efficiency involves using BMPs for fertilizer rate, form, timing and placement. This strategy places a large emphasis on reducing industry average fertilizer applications on corn following legumes, and taking full credit for manure nitrogen sources (see also Chapter 5). Fertilizer and manure applications made in accordance with soil phosphorus testing results are also an element of the fertilizer efficiencies strategy. Expanded use of precision agriculture techniques should also be included in the fertilizer efficiency part of this strategy. The NRS recognizes that farmers rely heavily on private industry for the promotion and delivery of these potential cost-saving fertilizer efficiency improvements, with support from governmental programs relative to research, education, and demonstration. The NRS encourages crop advisors to include more emphasis on environmental protection and improvement during farm planning.

Strategy: Reduced Tillage and Soil Conservation. A key phosphorus reduction strategy is to increase crop residue on the soil surface through conservation tillage practices. The NRS calls for millions of additional acres to change tillage practices so that more than 30 percent of the ground is covered with crop residue. At the time of this NRS, crop residues may be increasingly removed from cropland for biomass energy production, potentially exacerbating soil erosion and reducing soil carbon. Private industry promotion of these practices will be key to the successful implementation of this soil conservation BMP emphasis. Re-introduction of tillage transect surveys and tracking from governmental programs will help to provide information on progress.

Strategy: Drainage Water Retention and Treatment. Reduction of nitrogen in the Mississippi River and Winnipeg major basins are dependent upon treatment or mitigation of tile drainage water that is resulting from subsurface drainage or tiling. Even with good nutrient efficiency, high nitrate levels in drainage water are observed. Wetlands, controlled drainage, bioreactors, saturated buffers and other BMPs are needed to treat tile drainage for the removal of nitrogen, and potentially dissolved phosphorus. While these BMPs are eligible for funding under existing federal and state cost-share programs, widespread increase in implementation is needed. Key strategy elements include:

- Identifying and targeting funding sources to support drainage water retention and treatment practices such as the Targeted Drainage Water Management Grants Program implemented by BWSR.
- Working with watershed groups and drainage authorities to develop tools and incentives to promote drainage water retention and treatment practices for both existing tile drainage and when new tiling is being proposed.
- Providing financial and technical assistance to implement BMPs for storing and treating tile drainage water in new and existing drainage systems.
- Mapping of drained fields and drain tile outlets on a county or watershed scale.
- Accounting for altered hydrology when drainage and watershed authorities consider new drainage systems or drainage improvements, and recommending appropriate mitigation techniques to minimize alterations to hydrology that can negatively impact water quality.

6.3.2 Support for Advancing BMP Delivery Programs

Several federal, state, and local programs currently focus on promoting and supporting implementation of many of the BMPs in Chapter 5. Where programs exist, it is necessary for program staff to work with stakeholders to identify optimization opportunities to improve targeting of BMPs in priority areas where additional nutrient reductions are most necessary. To achieve the goals and milestones, it is likely that additional resources will be needed. A federal-state partnership should be one of the primary implementation drivers. This NRS provides support for an outcome-based problem solving partnership. Consideration should be given to seeking a federal to state block grant from the USDA to provide enhanced implementation through a closely coordinated federal-state multi-year and multi-program initiative (i.e. 75 percent federal funding linked with 25 percent state funding). This block grant should support the goals and strategies described in the NRS.

Strategy: Coordinated Planning to Increase BMP Implementation. The analysis of programs described in Chapters 4 and 5 note that while progress has been made through implementation of BMPs, the current level of BMP implementation is not sufficient to achieve the NRS goals for nutrient reduction if implementation is maintained at the current pace. Stepping up the pace of BMP implementation will require coordination of state and federal program and policy support, locally led service delivery for assistance and education, and landowner readiness and motivation. The conversation that has begun with the NRS will need to become more specific to key strategies and integrate the critical links. Priority state or federal programs that deliver and support nutrient reduction BMPs should partner with key stakeholders to develop plans for coordinating these activities to meet the NRS goals and objectives. Where programs exist that currently address BMP implementation, the best approach to accelerate and advance nutrient reductions is to start with these existing program policy

Conservation Reserve Enhancement Program – An Example of Stepping Up BMP Implementation

An example of accelerated implementation planning is found in the Conservation Reserve Enhancement Program (CREP). CREP brings together the resources of Federal and State government around priority solutions such as wetland restoration and floodplain and riparian easements and accomplishes multiple benefits including nutrient retention on the landscape at an adoption scale and pace that wouldn't occur otherwise. By providing coordinated and focused planning, all stakeholders are able to more successfully achieve their objectives and accelerate overall progress. The first Minnesota CREP combined state and federal land set-aside programs and leveraged federal money (more than $163 million was available) for Minnesota. CREP 1 targeted the Minnesota River Basin, with an aim of enrolling 100,000 acres. Eligible lands include drained wetlands (for restoration), riparian lands, and flood prone lands.

The program leverages about $2.30 for each state dollar spent. BWSR and FSA jointly administer the program.

Minnesota is considering a new CREP project in the state. Nutrient retention should be one of the priority objectives in this example of an approach to integrating federal state and local actions around increased implementation.

frameworks, but also working with stakeholders to determine what additional policies, funding, support, partnerships, etc., will be necessary to accomplish the levels of BMP adoption needed to achieve the NRS milestones and goals. For some of the key BMP categories there isn't currently a coordinated program. In those cases it may be warranted to consider developing a coordinated program or project sufficient to support BMP implementation to the levels contemplated in the NRS. Chapter 5 outlines the magnitude of additional BMP implementation needs. Key categories of BMPs that need increased in BMP adoption include such areas as crop nutrient management, tile water treatment and storage, cover crops, and perennials.

Strategy: Increase Delivery of Industry-Led BMP Implementation. Strengthen public and private partnerships so that communication and promotion of BMPs is coordinated, and opportunities for improving both public and private BMP delivery can be identified and implemented. Develop mechanisms to increase delivery and account for conservation practices implemented voluntarily through industry or nongovernmental organization-led initiatives or local programs that are not reflected in existing state and federal programs. Conservation practices that agricultural industries develop and implement at the local level are keys to NRS success.

Strategy: Study Social and Economic Factors Influencing BMP Adoption. Determine the best ways to maintain an understanding of social and economic changes, constraints and considerations associated with adoption of conservation practices, participation in existing programs, perspectives on trusted sources of information, perspectives on stewardship and conservation, and role of financial and technical assistance in adoption decisions, among other factors. One area of potential study is to determine differences between rented and non-rented land regarding the acceptance and implementation of various structural and non-structural cropland BMPs, and if warranted develop effective incentive and educational programs for implementing BMPs on land that is rented.

This information would assist program managers in identifying options to optimize existing BMP delivery programs, developing more effective behavior change approaches that go beyond current education efforts, and determining what additional resources might be needed to increase local capacity to deliver agricultural BMPs. Minnesota should build on previous work aimed at better understanding social and economic factors affecting change or lack of change.

Strategy: Create a Stable Funding Source to Increase Local Capacity to Deliver Agricultural BMPs. SWCDs and watershed organizations conduct a variety of activities important to BMP implementation such as developing working relationships with landowners and delivering technical assistance and outreach and education at the local scale. Successful implementation of the NRS will require people in the field working one-on-one with landowners to explain incentives, enroll landowners in appropriate programs, design appropriate practices, and conduct appropriate follow-up and monitoring. It is recognized that additional local capacity will be required to implement the needed BMPs and strategies to achieve NRS goals and milestones. This strategy focuses on creating a stable funding source that will allow local partners to have a stronger watershed presence, resulting in more robust working relationships.

6.3.3 Economic Strategy Options

Historically, cost-share programs have been one of the most significant mechanisms for supporting voluntary agricultural BMP adoption. For areas where land is environmentally sensitive or marginal for crop production, programs to create easements that restrict crop production have been effective. However, increasing commodity prices and constrained federal resources are affecting enrollment in these programs. Since the NRS incorporates the need for maintaining perennials in sensitive and marginal lands, there is a need to develop new economic and motivational strategies to create incentives for achieving nutrient reductions, as well as disincentives for actions that could result in increased nutrient loads. Where row crops are re-established on conservation lands, BMPs are especially critical to mitigating nutrient loss.

Strategy: Nutrient BMP Crop Insurance Program. Farmers have always faced uncertainty. Weather and commodity pricing are notable, but so are the nutrient value in non-fertilizer nutrients and the fate of nutrients due to environmental factors. As farm input costs have increased, farmers have paid more attention to farm risk management. The Farm Bill's shift from direct payments to insurance subsidy reflects this, and farm surveys show that farm nutrient decision-making also includes elements of risk perception. Insurance programs can be created to reduce a farmer's risk associated with adopting a specific practice (Huang 2002). In essence, the insurance company charges a fee that is less than the farmer's perceived cost risk for adopting the practice. If the crop yield, for example, is reduced due to the adopted practice, then the insurer reimburses the farmer the difference between the profit from the actual yield and the yield that would have been obtained without the insured BMP. If the yield is not reduced, the insurer uses the premium from the farmer to cover program costs. While similar programs have been piloted in the past, they have not been successful, perhaps due in part to a lack of priority placed on incrementally reducing nitrate leaching to waters. Applying fertilizer and manure at the upper end of recommended rates is a common practice to mitigate risk of yield losses by following more conservative BMP fertilizer rates. For a farmer to enter into a nutrient insurance program, they need to be willing to take year-to-year yield loss risks to maximize long-term economic return. The insurance program can increase economic certainty and mitigate the perceived risk of changing fertilization practices.

No Till Field Photo Credit: NRCS

USDA conducted a pilot study in Minnesota in 2003 called *Nutrient BMP Endorsement* as part of the USDA's Federal Crop Insurance Corporation. *Nutrient BMP Endorsement* was created to give producers a risk management tool. Producers were required to follow the state's extension service agronomic recommendations and BMPs for nitrogen, and the program provided insurance when yield potential was less than optimal. In that case, a nutrient management plan was required to purchase the endorsement. A similar program could be further evaluated, developed, and implemented in Minnesota.

The American Farmland Trust adopted this basic approach in its *BMP Challenge for Nutrient Management* and *BMP Challenge for Reduced Tillage.* Under these programs, American Farmland Trust paid farmers cash if yield and income were reduced while participating in the BMP Challenge (*http://www.farmland.org/programs/environment/solutions/bmp-challenge.asp*). Unique performance guarantees allowed farmers to try conservation practices on their own land, observe performance over time in side-by-side comparisons, and evaluate economic impact without risk to income due to yield loss.

Strategy: Develop Markets and Technologies for Use of Perennials. Growing perennials can have as much as 95 percent removal efficiency for nitrogen as compared to row crops. As a result, research to develop the appropriate perennials and marketable uses needs to be a priority. A multi-University Midwest cornbelt project (including the University of Minnesota) funded by USDA-National Institute of Food and Agriculture is underway to develop a Sustainable Bioenergy Production and Distribution System for the Central USA. This project is being led by *CenUSA Bioenergy* at Iowa State University. Where soils are highly productive and row crops will continue to be grown, research should strive to develop a profitable cover crop or intercrop to provide ground cover and tie up nutrients prior to and following corn and soybean crops. An additional project, led by the University of Minnesota, is underway to develop a plan for Minnesota to increase long-term widespread use of perennial and cover crops. While research and development are underway and improved technologies are being established, current promotion of cover crops in Minnesota should be focused primarily on shorter-season crops and marginal lands for corn production. Development and support of new or expanded markets for perennials, such as harvested forages including alfalfa, pennycress, orchard grass, red clover, switchgrass, and smooth brome grass, could provide initial implementation opportunities, while federal research focused on energy crops will likely be critical to reaching the NRS's goal for nitrogen reduction.

Strategy: Quantify Public Environmental Benefits of Reducing Nutrient Levels in Water. Monetary and non-monetary environmental benefit information on reducing nutrient levels in waters can be used in a variety of messaging to provide additional motivation through a clearer understanding of ecosystem and other benefits to society from reduced nutrient transport into waters.

6.3.4 Education and Involvement Strategies

Adopting BMPs requires agricultural producers to make changes that are often linked to values, perceptions, and awareness of a problem. As a result, it is imperative to understand the values, perceptions, and awareness levels of Minnesota's agricultural producers and those advising agricultural producers about nutrient BMP implementation and, using this information, to develop an effective outreach and education strategy. Education and involvement strategies should be developed in coordination with the NFMP's Nitrogen Fertilizer BMP Education and Promotion Team described as an overarching strategy in Section 6.1. A wide variety of educational approaches designed to motivate BMP adoption should be considered, including messages that highlight economic benefits, peer-to-peer networks, and stewardship. The findings generated through the Study Social and Economic Factors Influencing BMP Adoption strategy described in Section 6.3.2 would significantly influence the educational messages and approaches tailored to agricultural community. Each of the following educational strategies is intended to target a specific key audience. These strategies would be supported by the Statewide Nutrient Reduction Strategy Education/Outreach Campaign described in Section 6.1

Strategy: Targeted Outreach and Education Campaign with Expanded Public-Private Partnerships. Some past studies have suggested that outreach and education activities are most effective in promoting conservation practice adoption when conducted one-on-one and coordinated by a trusted, local point-of-contact who is experienced with local farming practices and respected by the agricultural community (i.e. Jennings at al. 2012). Incorporating one-on-one education activities using trusted messengers is important to successful NRS implementation. The NRS recognizes that we will need to reach a very large number of land owners and managers. Combining multiple educational approaches will be needed for a successful strategy outcome. Nonprofits, such as the Sustainable Farming Association, and conservation organizations, such as Ducks Unlimited and Pheasants Forever, can connect with land owners and identify opportunities to promote BMPs such as wetland restoration and buffers that have multiple benefits including nutrient reduction and waterfowl habitat. Other key education and outreach partners can include watershed organizations, lake and river associations, and local government (cities, townships, counties). The goal is to build on local relationships and partnerships and ensure that outreach and education campaigns are tailored to specific sub-target audiences in locations where BMP adoption is critical. Examples of effective private-public educational partnerships should be shared across the state to allow other organizations to learn from successes and adopt similar approaches.

Strategy: Encourage Participation in the Agricultural Water Quality Certification Program. Farmers will have an opportunity to self-demonstrate a number of BMPs through participation in Minnesota's Agricultural Water Quality Certification program. This program promotes the use of BMPs, including nutrient management. While the program is farm and field specific, there is the potential for the program to promote adoption of the BMPs that are key to achieving the goals and milestones in the NRS. This program is currently in a pilot phase in four watersheds across the state, with the intent of statewide implementation in the future.

Strategy: Focus Education and Technical Assistance to Co-Op Agronomists and Certified Crop Advisers. Agricultural producers rely on a variety of individuals for technical assistance, including fertilizer dealers, co-op agronomists, and certified crop advisers, who provide information on farm nutrient plans and improved approaches for fertilizer application and other important management practices. While it is important to inform agricultural producers directly, it is also important to inform their trusted advisers about key soil and water quality approaches for reducing nutrients, such as the online courses taught through the American Society of Agronomists (*https://www.agronomy.org/education/4r-approach*). The goal of the course is to encourage agricultural service providers to understand and use the process of evaluation, learning, and refinement with their farmer clients to identify the Four Rs (right fertilizer source, right rate, right time, right place) for individual fields to optimize crop yields while reducing the environmental impact of crop production systems. Increased education and certification as part of the crop adviser certification program should be developed.

Strategy: Involve Agricultural Producers in Identifying Feasible Strategies. As the NRS shifts to the implementation phase, it is imperative to engage agricultural producers and their business associations in discussions about BMPs and strategies to address nitrogen and phosphorus. These discussions will generate a better understanding of producers' perspectives and concerns, as well as enhance their ownership of the process. Such discussions, in either survey or focus group format, are essential to identifying the most cost-effective BMPs and achieving greater implementation of proposed BMPs and strategies.

Strategy: Watershed Hero Awards. Identify agricultural producers who are watershed heroes—adopters and supporters of nutrient reduction BMPs that can serve as a champion for these practices and convey the benefits of nutrient reductions to other agricultural producers in the watershed. Several award programs exist in Minnesota, including the Minnesota Association of SWCDs award programs to recognize outstanding conservation achievements. An award program for watershed-specific leaders in the agricultural community could inspire more agricultural producers to demonstrate innovative practices and share this information with other producers in the same or nearby watersheds.

Stream in the Red River Valley Photo Credit: MPCA

Strategy: Work with SWCDs, MDA and University of Minnesota Extension to Increase Education and Involvement. Minnesota has a history of commitment working with county SWCD staff and the University of Minnesota Extension to determine opportunities for improving education/involvement with agricultural producers. The form of this relationship has shifted from County Extension Agents to regional and state experts supporting local outreach opportunities. County SWCD staff provides technical, educational, and financial assistance to promote conservation activities on private lands. Under this strategy, SWCD staff would evaluate current nutrient-related education and involvement efforts targeting agricultural producers and identify opportunities to evaluate and improve delivery of these services. Additionally, University of Minnesota, MDA and BWSR regional specialists with expertise in nutrient reduction should be available to support effective education and involvement.

Strategy: Promote Youth-Based Nutrient Reduction Education. A variety of organizations focused on educating Minnesota's youth about water-related environmental issues have the potential to bring nutrient reduction curriculum into classrooms and other educational settings. As a first step under this strategy, the Minnesota Association for Environmental Education, or another environmental education partner working in the state, should inventory existing water quality-based educational curriculum to determine which currently incorporate nutrient-related information. Where necessary, existing curriculum should be updated to include information on nutrients and nutrient-reduction activities that are age-appropriate. The Environmental Learning in Minnesota (ELM) grant program, previously funded by MPCA, is one avenue to help provide environmental education opportunities and teacher training that could bring a nutrient-reduction focus to students. The ELM grant project reached over 7,000 children in 36 schools in Minnesota when it was funded during the 2008-2010 grant cycle. Minnesota State University's programs in sustainable agriculture could help to integrate nutrient reduction education into existing agricultural programs at the college level. Other educational organizations that reach children in an agricultural setting, such as 4-H, could also use existing water-based educational resources (*http://www.4-h.org/resource-library/curriculum/4-h-theres-no-new-water/*) to focus on nutrient-reduction activities.

6.3.5 Research Strategies

In order to achieve the needed reductions to meet goals in the Mississippi River Major Basin and expected future goals for the Lake Winnipeg Major Basin, new BMPs and management approaches are necessary. Research is key to development of these practices.

Strategy: Consolidate and Prioritize Research Objectives. Develop collaborative relationships between organizations conducting research related to agricultural BMPs in Minnesota including local, state, and federal agencies, land grant universities, and industry. Leverage resources and work in partnership to achieve prioritized research objectives. Implement a method of communicating between researching organizations to share results and plan for future research needs. The Minnesota Water Research Digital Library, expected for release in 2014 by MDA, will provide a foundation for this strategy.

Strategy: Conduct Research Activities. Conduct research to enable higher levels of nutrient reductions from current and speculative BMPs and management approaches. Include the following at a minimum:

- Research on how to increase grass-fed systems for meat production and on diets for bovines to reduce nutrient losses.
- Increase knowledge base regarding fertilizer use efficiency, including ways to assess growing season crop nutrient needs and make additional applications based on those needs.
- Research on innovative approaches for reducing nutrients from tile drainage waters, including use of saturated buffers, two-stage ditches, bioreactors, constructed wetlands, and controlled drainage.
- Development of approaches that will reduce soluble phosphorus, as well as BMPs which can address multiple nutrients.
- Soil and plant tissue testing as well as remote sensing for nitrogen and phosphorus losses to the environment to help in developing nutrient efficient cropping systems.
- Further development of the NBMP tool for use in HUC8 watersheds and expansion of the tool to address phosphorus reduction BMPs.
- Increased knowledge of the potential hydrologic effects of tile drainage on downstream flows and near channel erosion.
- Expanded research on the nutrient removal efficiency of agricultural BMPs and their potential to mitigate peak flow and volume.
- Increased knowledge of cost-effectiveness of agricultural BMPs.

- Research on cover crops and intercropping techniques with corn and soybeans to increase the success rate for establishment and use as a profitable cover crop. Research should include crop genetics and crop establishment techniques. A project is underway, being led by the University of Minnesota, to consider priorities for the research needs. Results are expected Fall 2014.
- Research on soil health to demonstrate benefits.
- Research on the sources of nutrients in atmospheric deposition (local versus regional) and associated BMPs to address these sources.
- Development of effective metrics for tracking and determining how to evaluate progress toward reducing nutrient losses to waters.

6.3.6 Demonstration Strategies

Learning by doing is a powerful tool to educate and change perception about nutrient reduction practices, particularly for those agricultural producers who are not traditionally early adopters of new management approaches and technologies. Providing technical assistance through demonstration projects and hands-on opportunities will help to both increase confidence in new management approaches and minimize risk when these practices are adopted full-scale.

Strategy: Watershed Scale Nutrient Reduction Demonstration Projects. NRCS National Water Quality Initiative (NWQI), Mississippi River Basin Initiative (MRBI), and Minnesota Sentinel Watersheds are examples of watershed scale nutrient reduction demonstration projects. These projects and potential additional watershed demonstration projects will be used to create confidence in our ability to reduce nutrients in waters by better demonstration of the extent of BMP adoption that is needed. Monitoring, modeling and other information can help demonstrate that cumulative adoption of BMPs from many farms in a watershed can result in monitored water quality improvement.

Strategy: Field Scale BMP Demonstration Projects. One way to address agricultural producers' perceptions of uncertainty, risk, and other constraints associated with new BMPs is to provide opportunities for on-farm trials and demonstrations. This can be achieved by continuing and expanding MDA- and NRCS-initiated on-farm-demonstration programs, the Discovery Farms Minnesota (*http://www.discoveryfarmsmn.org/*) model, and other similar producer-led initiatives to test a variety of practices. Discovery Farms Minnesota is a farmer-led water quality research and educational program that collects field-scale water quality data under real-world conditions on a variety of farming systems and landscapes throughout Minnesota. This type of approach could be used to test specific practices in priority watersheds to demonstrate effectiveness and effect on yield. Monitoring results from demonstration projects should be compared to local and downstream water quality protection and restoration needs and goals so that edge of field benchmarks can be established.

6.4 Recommended Strategies for Miscellaneous Sources

Significant new strategies are not suggested at this time to reduce loads from Subsurface Sewage Treatment Systems [SSTS]), urban/suburban stormwater, and feedlots. Existing programs have strategies in place that allow for systematic reductions in loads from these sources. In addition, implementation of TMDLs, particularly for turbidity-impaired streams, will likely address sediment-bound phosphorus sources that are a result of bank and channel erosion.

6.4.1 Subsurface Sewage Treatment Systems Strategies

Of the approximate 500,000 septic systems across the state, slightly less than 25,000 are estimated to be imminent threats to public health and could therefore potentially be direct sources of pollution to Minnesota's water resources. The number of septic systems that are imminent public health threats has been cut by half as compared to 2002. As described in the 2013 *Draft Nonpoint Source Management Program Plan*, the SSTS program is engaged in a number of different efforts to prevent and minimize impacts to water quality degradation that include: incorporating nitrogen BMPs into SSTS rules, requiring registration of treatment products for nitrogen reduction, and identifying imminent threats to public health and safety from uncontrolled discharges. The SSTS Program is also in the middle of a 10-year plan to upgrade and maintain Minnesota's SSTS. One of the main objectives of the SSTS Program is to strengthen local county programs to reduce the percentage of failing SSTS from 39 percent to less than five percent. In 2012, about 21 percent of systems were believed to be failing. Additional information can be found at *http://www.pca.state.mn.us/index.php/water/water-types-and-programs/subsurface-sewage-treatment-system-ssts/index.html*.

In addition, the MPCA has a Large Subsurface Sewage Treatment System (LSTS) Groundwater Nitrogen Policy for systems which serve flows of 10,000 gallons per day or greater. Due to the volume of wastewater treated by LSTS systems and the associated potential for environmental and health risks, Minnesota rules require that the MPCA regulates LSTS. The discharge of LSTS facility effluent must result in a 10 mg/l or less nitrogen concentration in groundwater at the property boundary or nearest receptor (i.e., drinking water well), whichever is closer. More information can be found at *http://www.pca.state.mn.us/index.php/water/water-types-and-programs/wastewater/wastewater-technical-assistance/wastewater-engineering/technical-information.html*. Current SSTS program implementation will serve as the strategies to reduce nutrient loads from individual and LSTS.

Amity Creek, Duluth Area Photo Credit: Tetra Tech

6.4.2 Feedlot Strategies

Animal manure contains significant quantities of nutrients which, if improperly managed, can lead to contamination of surface and groundwater. The Feedlot Program reduces direct runoff from feedlots and also regulates the land application and storage of manure in accordance with Minnesota Rules §7020 for over 25,000 registered feedlots in Minnesota. The Feedlot Program requires that the land application of manure, and its storage in manure storage basins, is conducted in a manner that prevents contamination of waters of the state. Manure management plans, facility inspections, enforcement, permitting, technical assistance, and record keeping are all used to protect water quality from both the feedlot facility and the land application of manure sites.

The Feedlot Program has set the following operational measures to prevent the impairment or degradation of state waters:

1. All large concentrated animal feeding operations (CAFOs) and feedlots with greater than or equal to 1,000 animal units are in compliance with discharge standards at the time of inspection.

2. All large CAFOs and feedlots with greater than or equal to 1,000 animal units are in compliance with nitrogen and phosphorus management requirements at the time of inspection.
3. All feedlots not covered by a National Pollutant Discharge Elimination System (NPDES) or State Disposal System (SDS) permit are in compliance with discharge standards at the time of inspection.
4. All feedlots not covered by a NPDES or SDS permit are in compliance with nitrogen and phosphorus management requirements at the time of inspection, including management of land application of manure activities.

Manure use efficiency and proper accounting for manure nutrient credits should be a long range program priority. Implementation of the Feedlot Program operational measures serves as strategies to reduce nutrient loads from feedlots. Additional information on the Feedlot Program can be found on the MPCA website at *http://www.pca.state.mn.us/index.php/topics/feedlots/index.html*.

6.4.3 Stormwater Strategies

The MPCA Stormwater Program regulates the discharge of stormwater and snow melt runoff from municipal separate storm sewer systems (MS4s), construction activities, and industrial facilities, mainly through the administration of NPDES and SDS permits. These permits form the basis of the stormwater strategies. For more information, go to *www.pca.state.mn.us/stormwater*. In addition, strategies are also provided to address non-regulated stormwater sources and the need for stormwater research and demonstration projects.

Strategy: Nutrient Reduction Associated with Regulated Stormwater Sources. Regulated stormwater sources will continue to reduce nutrients associated with permitted discharges based on existing and future permit requirements.

MS4 Permit

The MS4 General Permit became effective on August 1, 2013 and requires the MS4 operator or owner to create a Stormwater Pollution Prevention Program with seven important components:

1. Public education and outreach, which includes teaching citizens about better stormwater management.
2. Public participation, which involves including citizens in solving stormwater pollution problems. This includes a required public annual meeting and an annual report.
3. A plan to detect and eliminate illicit discharges to the stormwater system (like chemical dumping and wastewater connections).

4. Construction-site runoff controls.
5. Post-construction runoff controls.
6. Pollution prevention and municipal "good housekeeping" measures, like covering salt piles and street-sweeping.
7. Requirements for discharges to impaired waters with an EPA-approved TMDL that includes an applicable wasteload allocation.

Construction General Permit

Minnesota's State Construction General Permit (CGP) was reissued and became effective on August 1, 2013. The CGP applies to new developments and redevelopments over a certain size. From a nutrient reduction perspective, the CGP addresses both construction activities including erosion control and post-construction water quality requirements. A prominent change to this updated permit is the inclusion of volume control requirements to provide for water quality treatment post-construction. The permit states that one inch of stormwater runoff from new impervious areas will be retained on-site via infiltration, harvesting or reuse, unless prohibited.

Industrial Stormwater – Multi-Sector General Permit

Minnesota's Multi-Sector General Permit was last reissued on April 5, 2010. This permit addresses stormwater being generated on industrial properties and requires a series of benchmark and effluent monitoring activities for various pollutants, depending on the type of industrial activity. Effluent limitations are required for certain categories of industrial activity (e.g., sector C1 Phosphate Subcategory of Agricultural Chemicals includes a phosphorus effluent limit for stormwater discharges). Typically, most industrial activities do not have effluent limits but are required to mitigate for pollutants that exceed the monitored benchmark values through BMP implementation.

Strategy: Stormwater Technical Assistance. Stormwater technical assistance can be found in the form of the Minimal Impact Design Standards (MIDS), as well as in the Minnesota Stormwater Manual.

The Minnesota Stormwater Manual provides detailed information on stormwater management approaches and BMPs that are recommended for use in Minnesota. The Manual is kept up-to-date via a wiki format, and work is ongoing to maintain the Manual with the most recent and relevant information.

Minnesota began development of MIDS in 2009. The Minnesota State Legislature allocated funds in 2009 to "develop performance standards, design standards, or other tools to enable and promote the implementation of low impact development and other stormwater management techniques" (Minnesota Statutes 2009, section 115.03, subdivision 5c). Adapting and using low impact development approaches offers multiple benefits including minimizing and reducing the amount of pollution reaching our lakes, rivers and streams and helps to recharge groundwater. MIDS helps communities measure progress toward water and natural resource protection and restoration goals. MIDS represents the next generation of stormwater management and contains three main elements that address current challenges:

- **A clean water performance goal** for new development and redevelopment that will provide enhanced protection for Minnesota's water resources.
- **New modeling methods and credit calculations** that will standardize the use of a range of innovative structural and nonstructural stormwater techniques.
- **A credits system and ordinance package** that will allow for increased flexibility and a streamlined approach to regulatory programs for developers and communities.

A Community Assistance Package is being developed to provide ordinances and tools that help integrate low-impact development principles, including the MIDS performance goals and calculator, into a package that can be used by local units of government. These tools can be used by communities to help them achieve MIDS performance goals for stormwater volume.

Strategy: Stormwater Research and Demonstration. Research and demonstration are needed to further enhance the design, effectiveness, and adoption of stormwater BMPs. The Minnesota Stormwater Manual Wiki maintains a list of stormwater research needs and foci, examples include:

- Performance of emerging and non-traditional BMPs
- Cold climate adaptation and simulation tools
- Low impact development/better site design construction and maintenance
- The potential impact of infiltration practices
- Incorporating new climatic and hydrologic understanding into predictive models
- Short- and long-term field data for a variety of BMPs in conditions relevant to Minnesota

There are numerous research centers in Minnesota that focus efforts on stormwater-related research needs including the University of Minnesota St. Anthony Falls Laboratory. Many other organizations conduct and fund stormwater related research, although there is no unifying group to compile and compare various research efforts.

6.4.4 Sediment Reduction Strategies

Phosphorus bound sediment sources include streambanks, bluffs, ravines and uplands. Generally, the contributions from these sources vary by watershed and geography. Sediment may run off from fields or enter through unprotected tile intakes. Higher flow conditions within stream channels can lead to an increase in near channel and bluff erosion.

Research has shown that the near channel sources, such as streambanks, bluffs and ravines, contribute the most sediment to the Minnesota River. The Minnesota River is the largest source of sediment to the Mississippi River. Several TMDLs have been completed or are underway to address turbidity and sediment in each of the basins.

Confluence of St. Croix and Mississippi Rivers Photo Credit: MPCA

A draft Sediment Reduction Strategy has been developed to address sediment loading in the Minnesota River and the South Metro Mississippi River (defined as the Mississippi River between the confluence with the Minnesota River and Lake Pepin) (MPCA 2014, draft). Priority initiatives are identified in the draft Sediment Reduction Strategy to address nonpoint upland and near channel sources, as follows:

- **Reduce peak flow magnitude and duration**. Near-channel sources of sediment are the dominant sources at the mouths of the major watersheds in the Minnesota River basin. Sediment erosion and deposition in these tributaries are not in balance given the high rates of loading. Part of the erosive process in the Minnesota River basin is caused by base level fall of the Minnesota River that occurred when it was formed some 13,000 year ago. Another factor driving erosion is that stream flows have increased, along with the rate of erosion from near channel sources such as stream banks, bluffs and ravines. Decreases in peak flows are needed to bring the system into balance. Flow reduction goals include:

  Magnitude goal: Reduce two-year annual peak flow by 25% by 2030

  Duration goal: Decrease the number of days the 2-year annual peak flow is exceeded by 25% by 2030

- **Set water storage goals by watershed**. Managing hydrology is a way to decrease stream flows and near channel sediment sources. A water storage goal is needed for each watershed that would provide a target in acre-feet of water storage in an effort to meet stream flow targets. Methods to achieve the goal could be broadly defined and include surface storage, soils with higher organic matter on working lands, perennial vegetation (increased transpiration), among others. The targets need to be set at a level to make a difference, but not too high to unnecessarily impact current land use.
- **Define effective water storage practices**. Installing practices adjacent to the near-channel sources for direct protection, for the most part, is cost prohibitive. An exception is protecting infrastructure. Water management practices need to be defined and adopted in the portions of the watersheds upstream of the near-channel sources. Some of the modeling and research of the past has pointed to the types of practices needed, but not specific BMPs. The Greater Blue Earth River Collaborative for Sediment Source Reduction is one such initiative that will provide information for the Greater Blue Earth watersheds.
- **Consider hydrology and downstream waters in local watershed planning efforts**. Downstream needs concerning flow, water quality, and stream stability should be considered in local planning efforts. Today's land use is efficient at moving water off of land. Watershed planning processes need to consider downstream waters and articulate methods to reduce the impact on them.
- **Funding assistance**. Provide funding assistance for design and implementation of water storage options in priority watersheds. Develop a sliding incentive scale to drainage authorities - the closer the mitigation site is to the impacted site, the more the incentive the state will provide.
- **Increase living cover**. Perennial vegetation increases transpiration and can protect soil during times of the year when crops are not in place or of sufficient size. Some of this vegetation could be placed in riparian areas or as vegetated floodplains to take up nutrients, slow water and trap sediment near streams.

- **Funding.** Combine state and federal funding for a CRP-RIM partnership for water storage which would be similar to CREP.

In addition to the above initiatives, civic engagement is identified as an important component of implementation. Coordination between the NRS and the sediment strategy in the Mississippi River Basin will be critical to ensuring effective use of resources and achieving multiple benefits. In the Lake Superior Basin and Red River Valley, stream turbidity impairments are widespread. Strategies similar to those presented above for the Minnesota and Mississippi River basins can be adapted for other parts of the state.

6.5 Protection Strategies

Protection strategies are needed in watersheds that are subject to changes in agricultural and land use practices, as well as vulnerable groundwater drinking water supplies in Minnesota. The Minnesota Water Management Framework, as Chapter 1 described, requires protection strategies as part of WRAPS development and watershed planning, and therefore should address the potential for increased nutrient loads at a watershed scale. Protection strategies for both new nitrogen sources and for soil phosphorus increases from land use changes are both important elements that should be addressed in WRAPS and local water planning (e.g., One Watershed One Plan).

6.5.1 Protecting the Red River from Nitrate Increases

Tile drainage is expected to increase rapidly in the Red River Basin in the coming years. As a result, an increased load of nutrients is possible. Achieving the milestone for the Red River portion of the Lake Winnipeg Basin will need a combined focus on reducing baseline loads of nitrogen through increased fertilizer efficiency combined with a strategy of wetland treatment, bioreactors, and controlled drainage to offset new sources. Protection strategies are needed to mitigate new sources of nitrogen in the Red River Basin within the next five years.

The current analysis of suitable acreage for wetlands and bioreactors in the Red River Basin does not take into account future tiling, and therefore limited pollutant load removal is identified in this NRS. An analysis of potential areas that will likely be tiled in the future would help to identify opportunities to promote mitigation. A focus on land conservation programs in the Red River Basin is also needed to protect low lying areas that could potentially be tiled in the future. Permanent conservation easements could also be used to protect these areas. An initiative is needed to 1) identify current and potential tiled lands and 2) promote mitigation in these areas.

Future protection activities in the Red River Basin should consider recent developments related to tiling. The Red River Watershed Management Board recently finalized a set of model rules/ordinances for watershed districts to adopt, as well as tile drainage permitting guidance. In addition, the Red River Retention Authority created the Basin Technical and Scientific Advisory Committee, which has been working on briefing papers related to tiling issues in the Red River Valley.

6.5.2 Lake Superior Nutrient Load

Although there are no current reductions identified for the Lake Superior Major Basin, we should continue vigilance in protecting Lake Superior from nutrient increases, while at the same time researching the effects of added nitrogen in the Great Lakes.

6.5.3 Groundwater Protection Strategies

The 2013 Draft *Nitrogen Fertilizer Management Plan* (NFMP) is Minnesota's blueprint for prevention and minimization of the impacts of nitrogen fertilizer on groundwater. The prevention goal in the NFMP is the same as the NRS goal, as defined by the Groundwater Protection Act (Chapter 103H Section 1); to maintain groundwater

> *[I]n its natural condition, free from any degradation caused by human activities. It is recognized that for some human activities this degradation prevention goal cannot be practically achieved. However, where prevention is practicable, it is intended that it be achieved. Where it is not currently practicable, the development of methods and technology that will make prevention practicable is encouraged.*

As such, the strategies outlined in the NFMP will serve as the groundwater protection strategies in the NRS:

1. Implementation of BMPs the University of Minnesota Extension and the MDA developed, which are based on the *Four Rs* (right fertilizer source, right rate, right time, right place), and consider the different geology and climate across the state.
2. Alternative management tools to reduce nitrogen fertilizer inputs—perennial crops such as alfalfa, retiring land from production for CRP, Reinvest in Minnesota, grazing, etc., alternative cropping variety that requires less nitrogen, and other new technologies.
3. Wellhead protection planning and implementation (as administered by Minnesota Department of Health's State Wellhead Program [Minnesota Rules 4720]).
4. A Nitrogen Fertilizer Education and Promotion Team will be convened to assist MDA with the coordination of prevention activities and programs and specifically promote BMPs and

alternative management tools in areas with vulnerable groundwater resources, such as wellhead protection areas, the Central Sand Plains, and southeastern Minnesota's karst area.

5. A phased mitigation strategy to reduce groundwater nitrate concentrations below the 10 mg/l drinking water standard that starts in a voluntary mode and can elevate to a regulatory mode, depending on the severity of nitrate contamination and whether BMPs are being adopted.

The NFMP emphasizes that local participation (farmers, citizens, local government units, crop consultants) is imperative in any prevention or mitigation activities, if they are to be successful. In addition to fertilizer management, the NRS also recognizes the importance of irrigation management as related to movement of nutrients in the environment. Priority areas for groundwater protection are provided in Chapter 4 based on groundwater vulnerability and existing land uses.

MDA has expressed its intention to begin a process for developing rules related to: (a) restricting certain types of fertilizer application during the fall in areas vulnerable to groundwater contamination, and (b) regulatory requirements in areas with a combination of high nitrate in groundwater caused by fertilizers and inadequate adoption of nitrogen fertilizer BMPs (in accordance with the phased approach described in the NFMP).

6.6 Summary of Strategies, Priorities, and Costs

A summary of the strategies presented in Sections 6.1 through 6.5 are presented in Table 6-1 along with the strategy's priority, expected level of costs, and lead organizations. Costs take into consideration program investments and implementation activities.

Table 6-1. Summary of strategies, priorities, schedule and costs

Strategy	Strategy Priority (H-M-L)	Anticipated Costs ($ - $$$)	Lead Organization(s)
Recommended Overarching Actions to Support NRS Implementation			
Develop a Statewide NRS Education/Outreach Campaign	H	$$	MPCA and Accountability Team
Integrate Basin Reduction Needs with Watershed Planning Goals and Efforts	H	$	
Strategies to Implement Wastewater Reductions			
Continued Implementation of the Current Phosphorus Strategy and Rule	H	$	MPCA, Met Council
Influent and Effluent Nitrogen Monitoring at WWTPs	H	$	
Nitrogen Management Plans for Wastewater Treatment Facilities	H	$$	
Nitrogen Effluent Limits as Necessary	H	$$	
Add Nitrogen Removal Capacity with Facility Upgrades	M	$$$	
Point Source to Nonpoint Source Trading	L	$$	
Strategies to Implement Recommended Agricultural BMPs			
Stepping Up Agricultural BMPs Implementation in Key Categories			
Work with Private Industry to Support Nutrient Reduction to Water	H	$$	NRCS, MDA, BWSR, DNR, LGUs, Industry
Increase and Target Cover Crops and Perennial Vegetation	H	$$$	
Soil Health	M	$	
Riparian Buffers	M	$$$	
Fertilizer Use Efficiencies	H	$$$	
Reduced Tillage and Soil Conservation	H	$$$	
Drainage Water Retention and Treatment	H	$$$	
Support for Advancing BMP Delivery Programs			
Coordinated Planning to Increase BMP Implementation	H	$$	MDA, BWSR, MPCA, UM Extension, Industry
Increase Delivery of Industry-Led BMP Implementation	H	$$	
Study Social and Economic Factors Influencing BMP Adoption	H	$	
Create a Stable Funding Source to Increase Local Capacity to Deliver Agricultural BMPs	H	$$	
Economic Strategy Options			
Nutrient BMP Crop Insurance Program	L	$$	MDA
Develop Markets and Technologies for Use of Perennials	H	$$	
Quantify Public Environmental Benefits of Reducing Nutrient Levels in Water	M	$	

Strategy	Strategy Priority	Anticipated Costs	Lead Organization(s)
Education and Involvement Strategies			
Targeted Outreach and Education Campaign with Expanded Public-Private Partnerships	H	$$	BWSR, UM Extension, MDA
Encourage Participation in the Agricultural Water Quality Certification Program	H	$	
Focus Education and Technical Assistance to Co-Op Agronomists and Certified Crop Advisors	H	$	
Involve Agricultural Producers in Identifying Feasible Strategies	H	S	
Watershed Hero Awards	M	S	
Work with SWCDs, MDA, and University of Minnesota Extension to Increase Education and Involvement	M	$	
Promote Youth-Based Nutrient Reduction Education	L	$	
Research Strategies			
Consolidate and Prioritize Research Objectives	H	$	Academia, USGS, Industry, MDA
Conduct Research Activities	H	$$$	
Demonstration Strategies			
Watershed Scale Nutrient Reduction Demonstration Projects	M	$$	MDA and Industry
Field Scale BMP Demonstration Projects	M	$$	
Recommended Strategies for Miscellaneous Sources			
Subsurface Sewage Treatment Systems Strategies	M	$	MPCA, LGUs
Feedlot Strategies	H	$	
Nutrient Reduction Associated with Regulated Stormwater Sources	M	$	
Stormwater Technical Assistance	M	$$	
Stormwater Research and Demonstration	M	$$$	
Sediment Reduction Strategies	M	$$$	
Protection Strategies			
Protecting the Red River from Nitrate Increases	H	$$$	MDA, BWSR, LGUs, NRCS
Lake Superior Nutrient Load	L	$	MPCA
Groundwater Protection Strategies	H	$	MDA, MDH

TBD – To Be Determined

a. Anticipated costs represent new efforts and do not include existing funding.
$ - Tens of thousands
$$ - Hundreds of thousands
$$$ - Millions+

Chapter 7

Adaptive Management and Tracking Progress

While the *Minnesota Nutrient Reduction Strategy* (NRS) is based on scientific analysis and considerable agency, academic and public input, there will continue to be a need to improve and refine the NRS based on new information and input from scientists, key stakeholders and partners. The NRS will be frequently evaluated and periodically updated using an iterative process of planning, implementing, assessing and adapting, often referred to as *adaptive management* (Figure 7-1). In essence, adaptive management is learning by doing and using improved data and information over time to improve decision making with the intent of achieving a goal within a specified timeframe. Adaptive management incorporates data gathering and learning from experience and improved science. The adaptive management plan described in this chapter documents the procedures for assessing progress over time and the triggers for updating the NRS to achieve the nutrient reduction goals and milestones.

The NRS sets out goals and milestones for nutrient load reductions, as well as recommended approaches for achieving the milestones. To ensure that on-the-ground implementation is on pace with the NRS milestones and goals, it is imperative to have an adaptive management plan that will guide an evaluation of the NRS's progress over time. The basic components of the NRS's adaptive management plan are as follows:

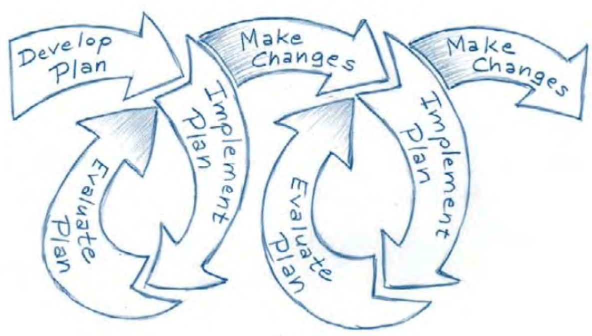


Figure 7-1. Adaptive management iterative process (USEPA 2008).

- Identify data and information needed to track progress toward NRS goals and milestones.
- Create a system or approach for collecting data and information needed to track progress toward NRS goals and milestones.
- Evaluate trends as well as relationships between actions and outcomes.
- Adjust the NRS as necessary.

Each of these components as it relates to the NRS is discussed in more detail below.

7.1 Information Needed to Track Progress

To understand the level of nutrient reduction progress being achieved, it is important to evaluate both changes in the adoption of best management practices (BMPs) (human actions) and water quality monitoring information (environmental outcomes). Water quality monitoring data alone will not provide sufficient information to evaluate progress and make needed adjustments to the NRS. Water monitoring does not provide reliable information on incremental nutrient reduction progress when the level of BMP adoption is not extensive enough to overshadow natural water quality variations, or when lag times are large due to phosphorus cycling in stagnant waters or when nitrate movement through the groundwater hydrologic pathway is slow compared to other pathways.

Both action and environmental outcome data will be necessary to track progress toward NRS goals and milestones. Implementation data provides early indicator information about nitrogen and phosphorus reductions that, over time, should translate to in-stream nutrient reductions. Expected water quality changes can be analyzed and modeled when the following types of information are available:

- BMP implementation through programs
- Overarching management changes through BMP adoption by all government and private action
- Land use and management changes apart from BMP adoption (i.e., cropping rotation changes, deforestation, urbanization, tiling, etc.)
- Precipitation and hydrologic information

Environmental outcomes as represented by water quality monitoring trends are an important part of tracking NRS success, since they are a direct measure of NRS goals. This is especially the case when the monitoring results are analyzed in concert with the above list of information, allowing evaluation of not only progress toward goals, but the effectiveness of actions taken to influence those outcomes. Water quality monitoring results should be evaluated at different points and scales, including:

- Watershed outlets (i.e., major 8-digit hydrologic unit code [HUC8] watershed, basin and major basin)
- Major river monitoring sites with historical monitoring
- Water supply wells (for nitrate)
- Sentinel and demonstration watersheds for studying water quality cause and effects

When all of the information above is considered together, progress toward achieving milestones and goals can be evaluated. Each information need and corresponding evaluation approach is described below.

7.1.1 BMP Implementation Evaluation

The implementation evaluation piece of the NRS's adaptive management process focuses on implementation of the most influential categories of BMPs and management actions described in Chapters 5 and 6. The objective of evaluating programs and BMP implementation is to determine progress toward the milestones and goals outlined in Chapter 2. The emphasis of this initial version of the NRS is on reaching goals and the Phase 1 nitrogen milestone and has an 11-year planning horizon from 2014 to 2025. Under an adaptive management approach, the implementation evaluation would allow opportunities to gauge implementation progress at several key intervals to ensure implementation is on track to achieve the goals and Phase 1 nitrogen milestone. Tracking environmental outcomes helps to inform needs to achieve environmental goals. Quantifying changes in both program implementation and water quality outcomes are complementary parts of the NRS. The approach for quantifying these changes must be meaningful, sustainable, and replicable.

The selected key programs identified in Chapter 4 implement a variety of structural and nonstructural BMPs. While programs are expected to provide accounting of the actions that they directly control, whether through permit or assistance contracts, attempting to quantify nutrient reductions for every BMP influenced by each program is not always possible with limited resources. Federal programs play an important role in promoting adoption of agricultural conservation practices using key BMPs. There is a need to develop mechanisms that allow for improved federal agency data sharing and changes to existing federal databases to support NRS tracking over time. It is expected that the public will continue to call for improved accountability in government programs.

A suite of program measures have been developed in an effort to narrow down the potential BMPs under each identified program to focus on those that are the most meaningful indicators of readily available data on statewide nutrient reduction progress. This can streamline the tracking process, but where only indicator BMPs are being tracked, a relationship to overall BMP implementation should be developed. Tracking the implementation information associated with the selected program measures provides the pulse of key implementation programs. Nutrient reduction trends for the selected program measures will show progress related to certain BMPs; yet it is important to keep in mind that there is a wide range of BMPs that are beneficial to achieving the nutrient reduction goals (as listed in Appendix B). Table 7-1 summarizes the priority programs with the associated measure and indicator BMPs. It is important to note that some measures capture more than one program. Not all programs have measures at this time due to data limitations, specific program development issues, or project resource constraints.

Each program measure has a corresponding metadata worksheet (see Appendix F). The metadata worksheets capture all the relevant information about the measure to ensure that the methodology is documented and replicable in the future. The metadata worksheets also capture data limitations and caveats associated with each measure to help the reader understand how best to interpret the measure and the type of future improvements that are necessary to make the measure more robust over time. The format used for the metadata worksheets follows the template used in the Clean Water Legacy Fund Performance Report. This will allow for agency familiarity with the format, as well as integration of measures from that effort that capture programmatic progress related to nutrient reductions.

Table 7-1. Program measures summary

Program	Measure for quantification	Indicator BMPs
Erosion Control and Water Management Program/State Cost-Share Program (BWSR)	Implementation of nonpoint source BMPs tracked via eLink and estimated BMP nutrient load reductions	All BMPs captured in eLink
Reinvest in Minnesota (RIM) Reserve Program (BWSR)	Implementation of permanent easements and associated nutrient load reductions	Acreage and percent of permanent conservation easements on environmentally sensitive and marginal agricultural land (as defined in RIM eligibility handbook)
Nonpoint Source Management Program (Section 319) (MPCA)	Implementation of nonpoint source BMPs tracked via eLink and estimated nutrient load reductions	All BMPs captured in eLink
Nitrogen Fertilizer Management Plan (NFMP) (MDA)	Implementation of nitrogen fertilizer management BMPs	1. Nitrogen fertilizer application rates 2. Nitrogen fertilizer application timing 3. Nitrification inhibitor use 4. Use of additive and specialty formulations
Clean Water Land and Legacy Program (BWSR)	Implementation of nonpoint source BMPs tracked via eLink and estimated nutrient load reductions	All BMPs captured in eLink
Conservation Reserve Program (CRP) and Conservation Reserve Enhancement Program (CREP) (FSA)	Implementation of priority CRP conservation practices and estimated nutrient load reductions	1. Filter strips (CP 21) 2. Riparian forested buffers (CP 22)
Conservation Security Program (CSP)/ Conservation Stewardship Program (CStP) (NRCS)	No measure at this time	

Program	Measure for quantification	Indicator BMPs
Environmental Quality Incentives Program (EQIP) (NRCS)	Implementation of priority EQIP management practices and estimated nutrient load reductions	1. Residue management 2. Nutrient management 3. Forage and biomass planting
Wetland Reserve Program (WRP) (NRCS)	No measure at this time	
Agricultural Best Management Practices (AgBMP) Loan Program (MDA)	Implementation of conservation tillage funded through AgBMP Loans	1. Conservation tillage projects
Commercial Animal Waste Technicians (CAWT) Program (MDA)	No measure at this time	
Minnesota Agricultural Water Quality Certification Program	No measure at this time	
Industrial/Municipal Wastewater National Pollutant Discharge Elimination System (NPDES) Permitting (MPCA)	Municipal wastewater phosphorus trends (excerpted from the Clean Water Fund performance measures)	Phosphorus effluent statewide trends

The selected program measures reflect government programs and do not capture all voluntary or industry-led conservation activities. Voluntary conservation activities that are not related to a specific government program can contribute a significant percentage of overall BMP adoption, especially for practices including precision farming, conservation tillage, nitrogen fertilizer BMPs, phosphorus use, and cover crops. While government funded education, demonstration and research can increase private action, BMPs adopted apart from government programs are more difficult to track and evaluate. However, certain indicators of progress can be useful for evaluating the overarching BMP adoption changes that occur through the collective private actions. Changes to the National Resource Inventory or Agricultural Census could provide statistical representation of land management and should be explored.

It is anticipated that through NRS assessments, additional measures will be developed in the future to track implementation success related to other programs and implementation-related activities. For example, measures should be evaluated to determine the applicability of existing techniques to track vegetative cover changes. With advancements in satellite imagery and other remote sensing techniques, it is now possible to discern changes in vegetative cover. This NRS recommends using such technology, along with on-the-ground inventory information, to evaluate changes in vegetative cover practices such as establishment of cover crops, perennials, hay, riparian buffers and potentially crop residue cover. Crop residue cover and other ground-cover BMPs should also be determined with transect surveys, similar to transect surveys conducted during previous years so that changes can be evaluated from historical levels of crop residue cover.

Because nutrient efficiency is such a critical NRS element, metrics need to track improvements in overall nutrient efficiencies. These efficiencies should be also be used to estimate nutrient changes in the receiving waters. Nitrogen fertilizer sales and crop yield information are tracked and have been used to show that, during the past couple of decades, agricultural producers have made progress in growing more corn for each pound of nitrogen fertilizer. Fertilizer sales and crop yield information, when combined with trends in planting densities, manure nutrient availability, grain protein content, and other information, could provide an indication of trends related to nutrient efficiencies and changes in the amount of soil nutrients that are potentially available for losses to the environment.

BMP implementation that takes place on a watershed scale, but is occurring outside of government assistance, is likely the largest gap relative to measuring success of the NRS. Comprehensively determining outcomes will require measuring of conservation practices and farming activities that are not funded and tracked through government programs. Potential BMP implementation not accounted for due to private implementation efforts could include conservation tillage, nitrogen fertilizer BMPs, phosphorus use, cover crops and non-commodity crops.

Other metrics of nutrient efficiency, based on data from combined public and private efforts, should also be considered and developed. Sources of data for additional metrics of nutrient efficiency could include farmer and crop advisor surveys (i.e. NASS and FANMAP surveys), soil phosphorus test results, sales and use of farm implements and equipment needed for BMPs and higher precision nutrient management, and a geographically based statistical survey similar to a natural resources inventory.

Other future measures could address the following:

- Improvements in working with national and regional statistical surveys as well as with local partners to track voluntary, non-government funded BMP implementation
- CSP/CStP program measure
- Municipal wastewater nitrogen effluent trends
- Tile drainage water management practices
- Other program BMPs (e.g., constructed wetlands, cover crops)

7.1.2 Estimating Effects of BMPs on Nutrient Reduction

Estimates of expected nutrient reductions in waters from BMP adoption can be developed based on the level of BMP adoption change using various models and tools. However, evaluation of NRS progress should also consider the effects of non-BMP land use and management changes, as well as climate influences, so that both the estimated effects of the BMPs and other factors influencing water nutrient levels can be understood.

One of the models that can be used to evaluate the effects of changing precipitation and land use is the Hydrologic Simulation Program FORTRAN (HSPF) model. In an effort to aid the completion of watershed restoration and protection strategies (WRAPS), the Minnesota Pollution Control Agency (MPCA) is in the process of constructing HSPF watershed models for many of the HUC8 major watersheds. The HSPF model is a comprehensive model for simulating watershed hydrology and water quality for both conventional pollutants such as nutrients and sediment and toxic organic pollutants. HSPF allows the integrated simulation of land and soil runoff processes with in-stream hydraulic and sediment-chemical interactions. In the Minnesota River Basin, HSPF models for ten major watersheds have been aggregated to represent the larger basin. The results of HUC8 watershed modeling will further inform NRS implementation in the future.

Figure 7-2 provides a summary of the current status of HSPF modeling in the state (current through August 2014). HSPF and other models such as Soil Water Assessment Tool and SPARROW combined with other modeling approaches, such as the University of Minnesota’s NBMP spreadsheet, should be used to estimate the NRS’s progress made by BMPs, along with confounding effects of changing crop rotations, hydrologic modifications, and precipitation.

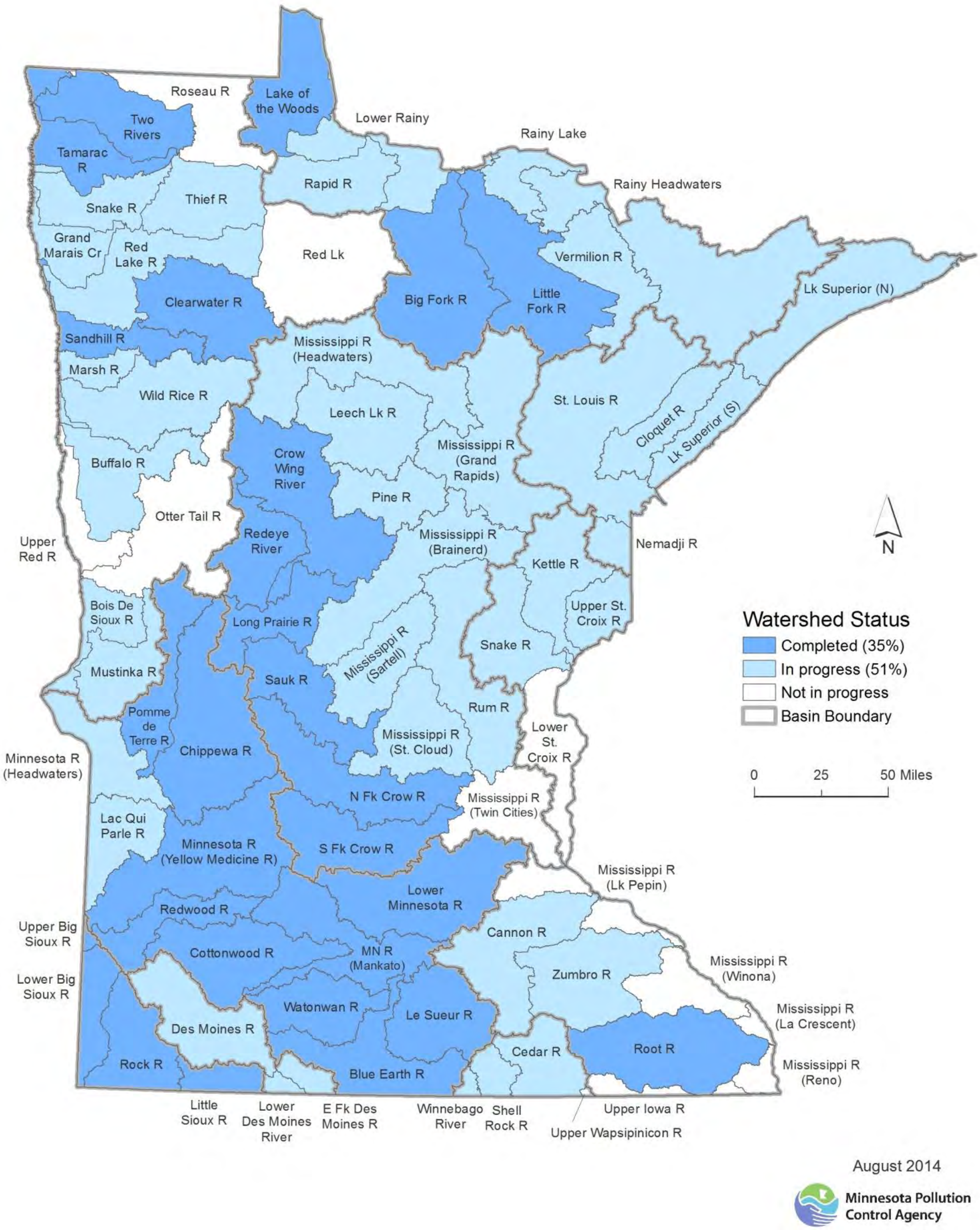


Figure 7-2. Status of HSPF modeling (August 2014).

7.1.3 Water Quality Monitoring Evaluation

Water quality evaluations will largely rely on the Watershed Pollutant Load Monitoring Network (WPLMN). This network will be supplemented with special watershed monitoring projects for environmental changes below the HUC8, monitoring of sentinel watersheds, ground water nitrate monitoring, National Water Quality Initiative projects, Targeted Watershed Demonstration Program Projects, BMP effectiveness as provided in research and Discovery Farm monitoring, along with other special projects and water quality modeling. There are many other local, regional, statewide, and national monitoring programs that will inform water quality evaluations including those being conducted by the new Mississippi River Monitoring Collaborative, which is made up of federal and state agencies along the Mississippi River between the Gulf of Mexico and Minnesota. Efforts will be made to coordinate Minnesota monitoring with national monitoring initiatives.

Due to lag effects in transport of nutrients through groundwater, lakes and reservoirs, the full effects of BMPs often do not show up at river monitoring stations for years or even as long as decades. Therefore, the monitoring results will be evaluated along with estimated lag times. Some monitored watersheds will show quicker response times to BMP implementation, such as heavily tiled watersheds and watersheds where phosphorus is less likely to by cycled and held in reservoirs or stagnant waters.

Water quality and flow analysis will include trends in total load and flow weighted mean concentrations (FWMC) (see Chapter 3). Both measures are important to understand changes in load over time and tracking progress toward milestones and goals. Progress toward achieving eutrophication standards in lakes and flowing waters also provides a measure for how well the

How soon will the effects of BMPs show up in the water?

It is difficult to predict when in-stream conditions will respond to implementation activities. As a general rule, larger watersheds are slower to respond because of the pollutant transport mechanisms involved. Watersheds exceeding 5,000 acres generally require monitoring programs of 10 years or more to measure the effects of management measures, although the exact timeframe depends on a range of factors, including the type of problem being addressed, the monitoring design employed, the weather during the monitoring period, and the type and extent of treatment implemented. HUC 8 major watersheds are much larger than 5,000 acres.

In rivers fed largely by groundwater, as opposed to surface runoff or tile drainage, there can be a lag time of decades or more before the effects of nitrate reduction BMPs can be observed in the river. Groundwater often moves very slowly toward streams, whereas tile drainage and surface runoff pathways to rivers are much faster.

For phosphorus, a key factor is the amount of reservoirs and pools of more stagnant water that exist. In these pools, phosphorus can settle and then be released over time back into the water.

NRS addresses in-state load reduction goals. Important measures of NRS progress include:

- Trend in actual load
- Trend in FWMC
- Extent of stream and lake eutrophication impairments
- Statistical comparisons of baseline loads and concentrations at low, medium and high flow periods with comparable flow periods during recent years
- Extent of groundwater nitrate above drinking water standards in high-nitrate areas, including those watersheds where nitrate coming from groundwater currently impairs surface waters

When multiple water quality monitoring measures are considered, along with the BMP adoption and modeling evaluations previously described, then progress toward NRS goals and milestones can be more accurately assessed.

Watershed Pollutant Load Monitoring Network

The WPLMN is a multi-agency effort that the MPCA leads to measure and compare regional differences and long-term trends in water quality among Minnesota's major rivers including the Red, Rainy, St. Croix, Minnesota, and Mississippi, the outlets of major HUC8 watershed tributaries draining to these rivers, and select subwatersheds. The network was established in 2007. Site-specific streamflow data from U.S. Geological Survey (USGS) and Minnesota Department of Natural Resources (DNR) flow gauging stations is combined with water quality data collected by Metropolitan Council Environmental Services, local monitoring organizations, and MPCA staff. Annual pollutant loads are computed from these data at river monitoring sites across Minnesota. The WPLMN is summarized at *http://www.pca.state.mn.us/pyrieeb*.

The WPLMN has been collecting water quality at an increasing number of locations since 2007, reaching 79 major watershed and mainstem river monitoring sites by 2010 (Figure 7-3). The design scale is focused toward, but not limited to, monitoring HUC8 watershed outlets within the state. By the end of 2014, about 150 additional subwatershed monitoring sites will be installed to further apportion pollutant loads. Strategic major river mainstem sites are included to determine basin loads and assist with statewide mass balance calculations.

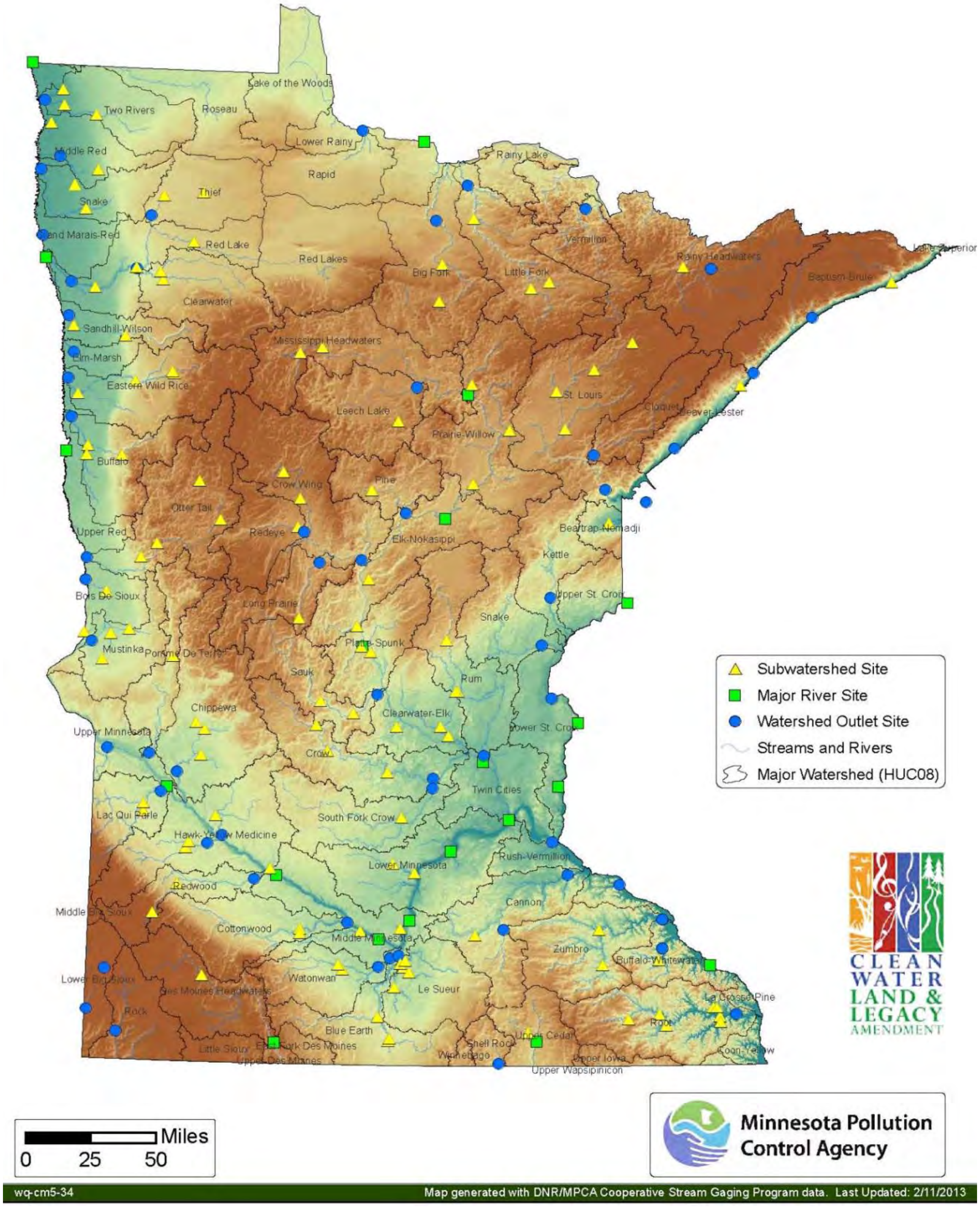


Figure 7-3. WPLMN monitoring sites.

Pollutant loads are calculated from water quality analysis and daily average discharge data collected at each site, using the Flux32 software. The software was designed to provide seasonal or annual pollutant loads and flow-weighted mean concentrations, but enhancements to the program allow the estimation of daily loads and concentrations. Loads and flow weighted mean concentrations are calculated annually for total suspended solids, phosphorus, dissolved orthophosphate, nitrate plus nitrite nitrogen and total Kjeldahl nitrogen. The nitrate plus nitrite nitrogen parameter is added to total Kjeldahl nitrogen to represent total nitrogen.

This network can be used to track changes in nutrient pollutant load, yields, and mean concentrations at a major river/basin, watershed, and subwatershed scales.

Sentinel Watersheds

The *Selection of Sentinel Watersheds* in Minnesota was developed by the University of Minnesota and a working group consisting of agency and stakeholder representatives in 2013 as part of a project funded by the MDA. Watersheds at the HUC10 and HUC8 scales were prioritized for long-term, intensive monitoring. Criteria in the selection process included:

- Available historical data
- Diversity of landscapes and watershed characteristics
- Entities with demonstrated local capacity present
- Existing programs could be used to coordinate new activities
- Representation of water quantity and quality issues at different scales

Nineteen HUC8 watersheds and eleven HUC10 watersheds were selected as sentinel watersheds. These watersheds may be used to be used to monitor changes in water quality as a result of conservation practices on the ground.

Ground Water Monitoring

Long-term ground water monitoring for nitrate conducted by state and local agencies should continue for public wells, private wells and monitoring wells, so that trends and progress to reduce nitrate levels can be evaluated. This monitoring should be coordinated with the NFMP and Source Water Protection Program efforts.

7.2 Tracking and Communicating Progress

Teamwork through the NRS Interagency Coordination Team (ICT) was integral to NRS development and teamwork will continue to be integral to overall NRS implementation. Accountability has been given a high priority through the legislatively mandated Clean Water Accountability Act of 2013. Accountability to the NRS should be integrated and coordinated with those existing coordinating mechanisms where possible with a subcommittee or adjunct team maintaining the perspective of the NRS. An Accountability Team could be formed, composed of a person or small group of implementation coordinators who would oversee the implementation of the NRS with input from critical program managers, represent NRS interests at a statewide level, lead tracking and reporting efforts, and oversee adaptive management adjustments to the NRS over time.

The Clean Water Accountability Act of 2013 will guide tracking efforts which may include annual or biennial reporting on the program measures developed as indicators of implementation progress, as well as planning and assessment activities triggered at 2 years, 5 years, and 10 years for reassessment, starting with the NRS implementation kickoff date and working toward the year 2025. Reporting and NRS updates will be led by an Accountability Team, who may report findings to the Clean Water Council or Minnesota Legislature. An outline of the tracking steps is outlined below.

First year of NRS (2015)

- Determine and initiate appropriate accountability process
- Identify Tracking Tool Team (see Section 7.2).
- Tracking Tool Team begins implementation of activities included in Section 7.2.

Two-year tracking and reporting (2016)

- Agencies and stakeholders develop approaches and plans to achieve BMP adoption goals
- Update NRS to incorporate additional implementation activities such as stepped up actions and tracking tool development.
- Evaluate program output and water quality outcomes.
- Evaluate implementation progress reported through the 2013 Clean Water Accountability Act to determine relevance to NRS progress reporting and tracking.
- Review progress toward goals and milestones.
- Update research for expanding feasible implementation activities (e.g., cover crops and biomass crops).
- Review effectiveness of comprehensive NRS outreach campaign and adjust as necessary.

Five-year tracking and reporting (2019)

- Assess implementation progress through other reporting (e.g., 2013 Clean Water Accountability Act).
- Report on success of implementation activities and strategies and identify needed adjustments to achieve goals and milestones.
- Survey key target audiences to gauge changes in management associated with comprehensive NRS outreach campaign.
- Evaluate program output and water quality outcomes.
- Continue to assess voluntary and industry-led implementation activities and associated nutrient reductions.

Ten-year NRS reassessment tracking and reporting (2024)

- Evaluate goals and milestones for future phases of implementation.
- Assess changes in natural conditions (e.g., climate and landscape) and potential impact on reductions.
- Establish new higher milestones that will make use of the researched BMPs.
- Continue making nutrient reduction progress as new research begins.
- Publish updated NRS document.

7.2.1 Approach for Tracking Progress

As described in the previous section, a wide range of data and information is needed to track progress in meeting the NRS goals and milestones. Synthesizing this array of data and information will require a coordinated system for tracking nutrient reductions associated with implementation activities. The previously described program and water quality measures highlight the challenges associated with compiling the data necessary to quantify implementation activities and nutrient loads. The data compiled for the suite of programmatic and water quality measures vary in collection methodology and frequency, documented in the metadata worksheets provided in Appendix F. Data from several nutrient reduction programs are tracked through grant or program-specific systems such as the BWSR's eLink database. Over time, an interagency, integrated tracking tool would provide a more systematic approach for compiling the data from the various programs to support regular assessments of the NRS's progress and reporting to key stakeholders within and outside of Minnesota.

A systematic approach for collecting and analyzing the output and outcome data and information would be helpful to track and communicate progress over time. The metadata worksheets in Appendix F provide an initial mechanism for capturing key output information about the suite of NRS measures.

Updating the metadata worksheets on a regular basis (e.g., annually) will help generate trend information on the particular BMPs associated with each measure to compare against the BMP adoption needs identified in Chapter 5. This will require a comparison of the BMPs identified on the NRS Reduction Summaries for each major basin presented in Chapter 5 with the BMPs associated with the quantified program measures at the HUC8, basin, and major basin scales. The comparison of these two components of the NRS will illustrate where BMPs have been implemented at the needed levels through existing government-based programs. The approach for tracking progress needs to also account for nongovernment-affiliated BMP implementation and the water quality monitoring findings.

7.2.2 Tools for Tracking Progress

There are a variety of ongoing information technology-related activities taking place within the MPCA and other key agencies. Under the Clean Water Accountability Act of 2013, MPCA must report progress toward implementation milestones and water quality goals for TMDLs and, where available, WRAPS beginning July 1, 2016, with updates on progress made every other year. The MPCA's Watershed Data Integration Project (WDIP) is an initiative to improve data sharing among MPCA programs at a watershed level to support the Minnesota Water Management Framework. WDIP is also working to develop a template for the TMDL and WRAPS Web-based implementation tables. MPCA also has a transformation project underway that is converting MPCA's existing databases to an enterprise system. These are examples within one agency that will provide information for the NRS. It is likely that similar data management projects and initiatives key to tracking the NRS's progress are also underway within other federal and state agencies. Ongoing and planned information technology-related efforts provide an opportunity to integrate the NRS's tracking needs into the design and development of new and upgraded systems. Similar considerations may be necessary for other Minnesota agencies with key nutrient reduction programs.

There is currently no integrated tool that will allow for automated tracking of NRS output and outcome information to assess progress over time. The approach for tracking progress requires developing a tool to ensure efficient and reliable progress tracking. Developing a tool of this nature will be a multi-agency undertaking that must take into consideration the existing data management approaches and numerous programs being uses within several agencies.

An evaluation of the website and tools used to track water quality implementation in the Chesapeake Bay (*ChesapeakeStat*) was conducted to determine if this existing tracking tool could provide a framework to incorporate an effective method for tracking nutrient reduction progress in Minnesota (Appendix G). ChesapeakeStat was viewed as a potential model for a new tool to communicate with stakeholders and watershed managers in Minnesota as well as other states and interested parties. Analysis performed during the evaluation revealed significant gaps between data required to support a Chesapeake-style website and the current abilities of state and federal agencies to provide that data. Future planned work will increase data availability, but significant work remains to be done for watershed modeling as well as program requirements.

A NRS tracking tool would improve process and information management efficiency among the many state and federal agencies, as well as local partners, that promote BMP adoption necessary for NRS success. The recommended approach for a NRS tracking tool is one that would serve as a hub of information, extracting data from a variety of existing monitoring and program implementation databases. Using a Web-based interface, the NRS tracking tool would not only present integrated information from existing databases, but also allow for the input of voluntary BMP information by private landowners and key local or nongovernmental organizations working with private landowners (e.g., county soil and water conservation districts, university extension staff, crop advisors).

A brief overview of the recommended tasks for developing this type of NRS tracking tool is provided below. Appendix H provides more detailed information on the preliminary requirements of developing this type of tracking system and each task.

Task 1: Identify Tracking Tool Team. A subgroup of existing Interagency Coordination Team (ICT) members, as well as program data analysts, will provide input on the preliminary system requirements and aid in refining those requirements.

Task 2: Review Existing Program Measures, Refine Metrics, Select Measures for Tracking Pilot. The NRS tracking tool team will identify program measures that require updating or refinement for tracking purposes and select 3—5 measures to use during the pilot phase of the tracking tool. The metadata worksheets presented in Appendix F should be evaluated to determine what is adequately measured and areas that are not adequately measured. This analysis could be used to develop a matrix that identifies which existing tracking efforts are adequate, what voids exist, and whether a new tracking tool needs to be developed, or if existing tracking tools can be modified.

Task 3: Analyze Existing Data Management Systems to Support Data Extraction and Integration. The NRS tracking tool team will collect detailed information on the functionality of each data management system that will contribute nutrient data to the System, including the type of system, planned or existing changes, users, maintenance procedures, and other factors that could influence export of data from the system into the NRS tracking tool.

Task 4: Identify Data Sources or Approaches for Obtaining Voluntary or Industry-Led BMP Information. The NRS tracking tool team would work with local partners (e.g., county SWCD staff, watershed districts, crop advisors, extension staff, and other entities) working with agricultural producers to improve adoption of conservation practices and BMPs, inventory voluntary BMPs not associated with governmental programs, and understand existing systems used to track this information.

Task 5: Conduct Comprehensive System Requirements Analysis. The NRS tracking tool team would verify the preliminary tracking tool requirements and, as necessary, add other requirements to inform tool development.

Task 6: Develop NRS Tracking and Accounting System Web Page. The final comprehensive system requirements analysis would then allow the NRS tracking tool team to proceed with initial development and piloting of the tool using the 3–5 selected program measures.

Task 7: Long-Term Operations and Maintenance System Plan. In support of the production deployment of the tool, the NRS tracking tool team should develop an Operation and Maintenance Plan, which will address staffing, tasks, processes, and tools necessary to ensure consistent, reliable, and comprehensive production support of the NRS tracking tool.

The timing of the NRS and the associated data tracking needs coincides with several other tracking and reporting efforts taking place within the state. This allows for the incorporation of the NRS's tracking needs into other ongoing system development and refinement projects. Examples of ongoing system development opportunities that could integrate NRS tracking needs include the following:

MPCA's Transformation Project. MPCA is currently changing their information systems to a tempo-based enterprise system. As a result, all program data will be managed in a similar manner, allowing program data within the agency to be better integrated.

MPCA's Watershed Data Integration Project (WDIPs). A multiyear data integration project intended to improve MPCA's staff handling and sharing of data and information generated through the watershed management process. (*http://www.pca.state.mn.us/index.php/view-document.html?gid=15386*) Through the WDIP, MPCA staff are working with total maximum daily load and WRAPS program staff to develop a data capture tool to meet a 2016 deadline of making implementation tables available on MPCA's website.

Portal. Minnesota agencies are also engaging in a Portal project that would allow better interagency data sharing. This project is currently in the discovery stage. It would offer the opportunity to integrate MPCA's data systems with those at other key agencies, including the BWSR, MDA, Minnesota Department of Health, DNR, and the Metropolitan Council.

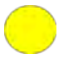
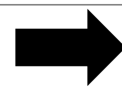
There is also a need for improved data collection and sharing among Minnesota agencies and key federal agencies working within the state, specifically Farm Service Agency and Natural Resource Conservation Service (NRCS). There is also a need for a tracking tool that would allow private landowners or other local government entities such as counties and SWCDs to provide information on voluntary conservation practices that are not related to state or federal programs and funding.

7.2.3 Communicating Progress

Communicating the ongoing level of progress can be challenging, especially given that progress is not evaluated by a single indicator, but rather by a suite of indicators including BMP adoption, modeling and monitoring. The tracking tool described in the previous section, once developed, could serve as a way of communicating ongoing progress to interested parties. Until a tracking and communication tool is developed, Program Output Scorecards could be used which are similar in concept to the report cards used in the Clean Water Fund Performance Report *http://www.legacy.leg.mn/sites/default/files/resources/2012%20Clean%20Water%20Fund%20Report%20Card_web%20version.pdf*.

The report card can provide both a qualitative and quantitative approach to reporting on progress toward nutrient reduction goals (Table 7-2). A program measure that is showing negative implementation trends (e.g., diminished voluntary participation or significant exceedances of a mass limit) can be represented by a red symbol on the NRS report card. A yellow symbol can represent programs that have no change in implementation over time. A green symbol can represent programs that demonstrate progress toward programmatic nutrient reduction goals over time. As NRS implementation actions are further derived, specific targets can be added to the measures, and the report card can be updated to reflect quantitative targets.

Table 7-2. Report card symbols

Status Scores		Trend	
	We are making good progress. If there is a target, we are meeting the target.		Improving trend
	We anticipate difficulty; it is too early to assess; or there is too much variability to assess.		No change
	Progress is slow. If there is a target, we are not meeting the target. It is likely that the activity or target is not commensurate with the scope of the problems.		Declining trend

The Program Output report card (Table 7-3) is based on seven program output measures developed for high-priority programs and provides a qualitative assessment of the nutrient reduction trends over time (see Appendix F). The scores for program output measures are based on data provided by state and federal agencies and best professional judgment of agency experts. At this time, the Program Output Report card focuses on trend data, but can eventually assess progress against a specific nutrient reduction target set for a specific measure in the context of overall NRS goals and milestones. This format is similar to the Clean Water Fund Performance Report measure report card, allowing for consistency in reporting to promote cross-effort reporting when feasible. Using the program measures, it will be possible to see trends and track progress during NRS implementation. At this time, specific targets are not provided for programmatic measures. In the future targets should be added to the measures to provide a yardstick for whether the measure is making adequate progress that will have the necessary effect on nutrient load reductions.

Table 7-3. NRS report card, program output measures

Measures	Status	BMP Adoption Trend	Description
Program Output Measures			
Implementation of priority EQIP management practices and estimated nutrient load reductions	Residue management		Acreage enrolled under EQIP for these three priority practices has steadily declined since 2007–2010.
	Nutrient management		
	Forage and biomass planting		
Implementation of permanent conservation easements under RIM and estimated nutrient load reductions			Acreage under permanent conservation easements has increased since 2000, with an upward trend since 2008.
Implementation of nonpoint source BMPs tracked via eLink and estimated nutrient load reductions			Although funding has increased and there is a continued increase in practices being implemented, the total requests for projects were approximately three times greater than available funds.
Implementation of priority CRP conservation practices	Filter strips		The general trend since 2002 has been decline, but there are signs of increasing acreage under these practices. Although there isn't a target, it appears that progress is slow.
	Riparian buffers		
Implementation of conservation tillage funded through AgBMP Loans			The annual acreage associated with conservation tillage projects reported by borrowers under MDA's AgBMP Loan Program declining from 2006–2012. Less annual marginal gains under the program.

Measures	Status	BMP Adoption Trend	Description
Program Output Measures			
Implementation of nitrogen fertilizer BMPs	Application rate on corn following corn (surveyed fields)		Data from the 2010 Survey of Nitrogen Fertilizer Use on Corn in Minnesota only includes data point for three of four BMPs, so no trend data are available. Survey results, however, show that application rate on corn following corn are within the acceptable rates, although rates on the more common rotation of corn following legumes can in many cases be reduced. Nitrogen fertilizer timing is occurring in spring or as a sidedress, and inhibitor use increasing over time. The use of additives and specialty fertilizers is less than 9% on surveyed fields.
	Application rate on corn following legumes		
	Application timing of nitrogen (surveyed fields)		
	Nitrogen inhibitor use		
	Use of additives and specialty fertilizers (surveyed fields)		
Changes over time in municipal wastewater phosphorus discharges			Long-term ramp-up in requirements coupled with new Clean Water Fund investments are helping wastewater sources continue to reduce phosphorus discharges.

The Program Output Report card indicates some progress in program implementation. A majority of the measures indicate an improving trend. However, several of the measures indicate that sufficient progress is not being made or achievement of targets or goals is uncertain. The only measure that does not require additional attention is related to programs for reducing phosphorus in municipal wastewater on an overall, statewide basis, although there is still progress that can be made. The current report card demonstrates that all measures require attention during implementation. Overall, the current report card provides a starting point for implementation and can be used to track progress across multiple program measures over time.

The program progress included in the above tables does not provide the complete picture of progress, and additional tables, documents, and communication tools will need to be provided. It is also important to show progress status with non-governmental program BMP implementation and with water quality monitoring results.

7.3 Adjust Nutrient Reduction Strategy

The ultimate step of the adaptive management process is adjusting the NRS implementation activities based on the data collection and trend evaluation process to ensure progress toward the NRS goals and milestones. Adjustments to the NRS could include recommendations for adjusting implementation guided by the trends seen in the suite of programmatic measures. A formal update of the NRS will be completed in 2016. A second update would be expected prior to 2025 to incorporate updated milestones and recent progress.

In addition, adjustments to the NRS could include recommendations guided by research, additional planning details, BMP adoption progress, programmatic measures, in addition to new water quality modeling/monitoring information. It will be necessary to document the rationale for any adjustments to the NRS on the basis of progress evaluation, coordination with program management and water quality data compiled to support the NRS. Where adjustments are necessary, updated versions of the NRS will document the changes.

Chapter 8

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Appendix A: Statewide Buffer Analysis

Existing data on the presence of perennial vegetation in riparian areas are available from the Minnesota Center for Environmental Advocacy (MNCenter) and the Cannon River Watershed Partnership (CRWP) (Figure A-1). These data were used to calibrate an analysis of riparian vegetation using the 2012 Cropland Data Layer (CDL). The MnCenter and CRWP data were not able to be used directly because not all streams were evaluated and the buffer evaluated ranged from 50 – 300 feet.

Five geospatial (GIS) data sets served as the foundation of the statewide riparian buffer analysis:

1. The 8-digit Hydrologic Unit Code (HUC8) watershed boundaries provided as part of Minnesota Department of Natural Resources (MNDNR) "Level 08 (All Catchments)"
2. MNDNR 24K resolution stream GIS polylines
3. MNDNR Public Waters Inventory (PWI) Watercourse Delineations
4. Land Cover - Minnesota Land Cover Classification System (MLCCS)
5. The 2012 CDL 30-meter gridded coverage as provided by the USDA's National Agricultural Statistics Service (NASS)

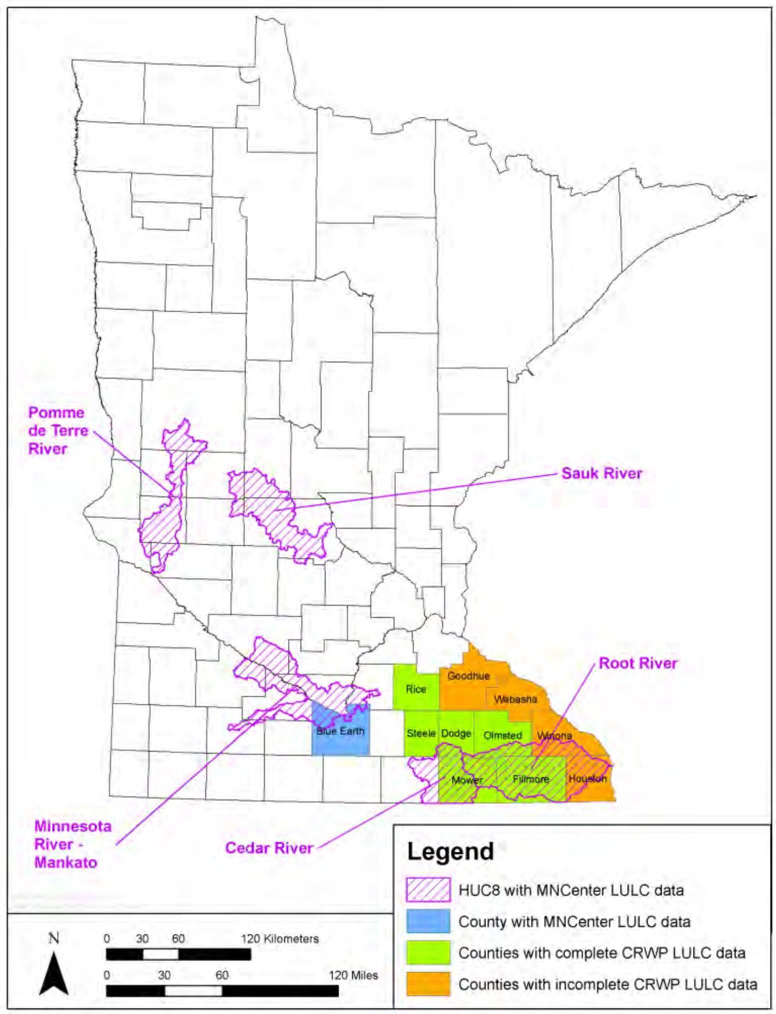

Figure A-1. Available high resolution data on riparian buffer vegetation

An initial analysis was conducted to compare riparian buffer land use and land cover (LULC) mapping outputs using high-resolution aerial imagery (MnCenter and CRWP data) to a GIS-based approach employing a lower-resolution, state-wide LULC dataset (2012 CDL).

The MnCenter data applied to a 50-foot riparian buffer of MNDNR's PWI stream polyline dataset with the exception of the Root River HUC8 which included data a 300-foot riparian buffer of the PWI dataset. The CRWP mapping outputs were all done for a 300-foot riparian buffer of the PWI dataset. Note that neither of the datasets applied to the DNR 24K streams, which is the basis of the Strategy buffer recommendations.

The area of perennial vegetation within the MnCenter and CRWP 50- and 300-foot buffers was extracted from the 2012 CDL. The following vegetation types were assumed to be perennial:

- Other Hay/Non Alfalfa
- Clovers/Wildflowers
- Sod/Grass Seed
- Switchgrass
- Fallow/Idle Cropland
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrubland
- Grassland/Herbaceous
- Woody Wetlands
- Herbaceous Wetlands

A comparison of the MnCenter and CRWP data versus the CDL derived data are presented in Table A-1. An adjustment factor is provided based on this comparison for CDL data. A 30-meter riparian buffer from the MNDNR 24k resolution stream polyline dataset was then created, as described in Chapter 5 and the area of perennial vegetation in the buffer was tabulated by HUC8.

The first of the Average Adjustment Factors from Table A-1 (1.326) was used to modify (i.e., increase) the percent of the buffer in perennial vegetation which was derived from the 2012 CDL for the 30-meter buffer. This adjustment applied to all HUC8s with the exception of those HUC8s identified in Figure A-2 for which the second average adjustment factor (0.932) was applied. The Existing Adoption Rate, presented in Figure A-3, is based on the adjusted percent of the buffer that is in existing perennial vegetation. The assumptions applied in this analysis are rudimentary; however the analysis represents the best available data at the time of this analysis.

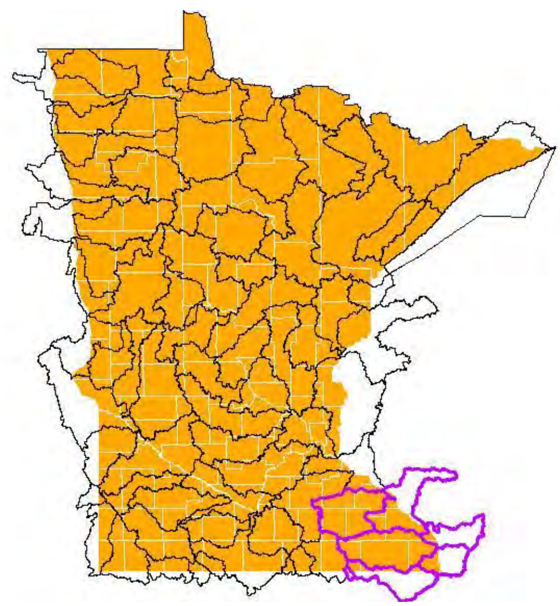

Figure A-2. An adjustment factor of 0.932 was applied to the HUC8s in purple

Table A-1. Buffer comparison results. Percentages represent percent of all land in the buffered area (agricultural and other lands).

Mapped Area (HUC8 or County)	High Resolution Data Source	Date of Imagery Used	Percent of Riparian Buffer Considered Perennially Vegetated		CDL 2012	Adjustment Factor	Average Adj. Factor
			Buffer Analysis Width (ft)	MNCenter/ CRWP Results			
Sauk River	MNCenter	2010	50	84.07	62.73	1.34	1.326
Pomme de Terre River	MNCenter	2010	50	87.97	65.74	1.34	
Minnesota River - Mankato	MNCenter	2010	50	83.00	47.54	1.75	
Root River	MNCenter	2009	300	76.14	75.00	1.02	
Cedar River	MNCenter	2009	50	77.30	72.59	1.06	
Blue Earth County	MNCenter	2009	50	88.30	60.74	1.45	
Mower County	CRWP	2009	50	82.20	79.19	1.04	0.932
Rice County	CRWP	2009	50	59.60	65.32	0.91	
Steele County	CRWP	2009	50	74.76	78.43	0.95	
Dodge County	CRWP	2009	50	80.81	78.34	1.03	
Olmsted County	CRWP	2009	50	77.51	82.84	0.94	
Fillmore County	CRWP	2009	50	59.28	82.41	0.72	
*Goodhue County***	*CRWP*	*2009*	*50*	*88.12*	*72.78*	*1.21*	*Not Used*
*Wabasha County***	*CRWP*	*2009*	*50*	*66.70*	*65.61*	*1.02*	
*Houston County***	*CRWP*	*2009*	*50*	*61.58*	*75.81*	*0.81*	
*Winona County***	*CRWP*	*2009*	*50*	*81.84*	*79.83*	*1.03*	

*** = missing buffered areas along River/State Boundary*

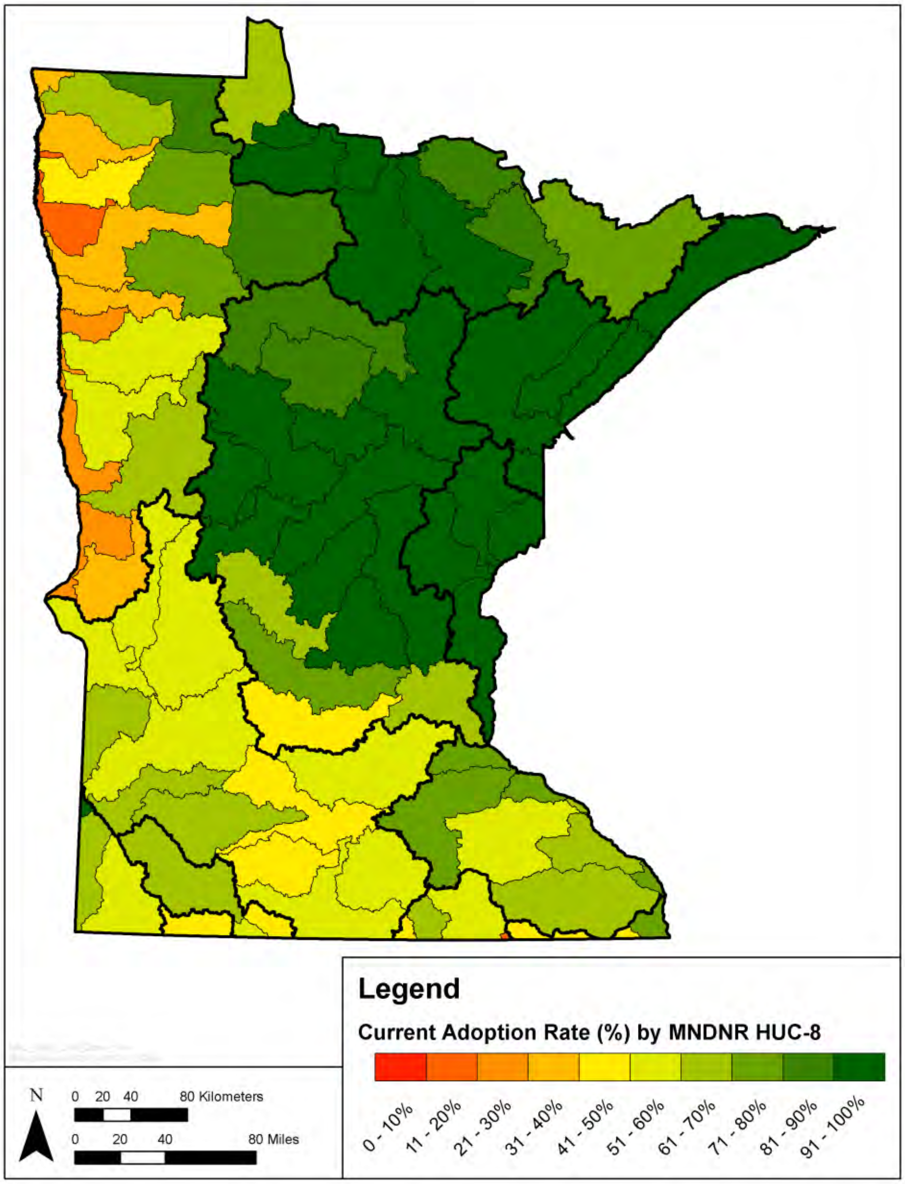

Figure A-3. Existing buffer adoption rate.

Appendix B: Progress Assessed through Program Quantification

Program quantification is intended to provide an assessment of the recent progress that has been achieved, in terms of nitrogen and phosphorus load reduction, through documented implementation of best management practices (BMPs) and wastewater treatment adopted in direct response to government programs. Many of the nutrient reducing programs (see Chapter 4) contain numerous structural and non-structural BMPs implemented as part of these programs. Not all programs had data that were able to be translated into spatially quantified nutrient load reductions. Program quantification therefore only addresses those programs with applicable data on a HUC8 scale.

Program quantification included the following indicator BMP categories:

- Nutrient management (NRCS EQIP)
- Forage and biomass planting (NRCS EQIP)
- Residue management (NRCS EQIP)
- Conservation easements (BWSR Reinvest in Minnesota [RIM])
- Nonpoint source BMPs (as reported in BWSR's eLINK, not including feedlot BMPs)
- Septic system improvements (MPCA Subsurface Sewage Treatment System Program)
- Feedlot projects (MPCA Feedlot Program)
- Phosphorus lawn fertilizer ban

Data for nutrient management, forage and biomass planting, and residue management were obtained from the EQIP program, while data for conservation easements were obtained from the BWSR RIM program. Data for nonpoint source BMPs were provided through the eLINK system, maintained by BWSR. The eLINK system only tracks and reports phosphorus load reductions associated with BMPs. Total acres (by HUC8) were tabulated for each BMP category with the exception of the nonpoint source BMPs from eLINK, for which total load reduction data (lbs/year) were provided for each HUC8, for phosphorus only. Feedlot phosphorus load reductions are tracked separately in eLINK, and are reported separate from other nonpoint source BMPs in this section based on data from Open Lot Agreements tracked by the MPCA's Feedlot Program. Phosphorus reductions from septic system improvements were based on the estimated number of septic systems that had been identified as an imminent threat to public health or safety (ITPHS) and had been brought into compliance. Reductions in phosphorus loading as a result of the statewide phosphorus fertilizer ban were compiled from various sources (Vlach et al. 2010, Lehman et al. 2009, and Schueler and Lane 2013); a 10 percent in phosphorus loading from urban areas was assumed.

Recent trends in point source loads (wastewater) were quantified based on SPARROW results. A more recent version of the SPARROW model is available which provides updated (2005–2006 for nitrogen and 2005–2009 for phosphorus) point source data. These updated results were compared to the original SPARROW results to calculate the relative percent change in phosphorus and nitrogen loading from point sources that has recently occurred.

Assumptions

A key assumption used in program quantification is that the SPARROW results approximate conditions prior to recent program efforts to increase BMP adoption. This assumption enables us to determine the loads reduced by existing BMPs by using SPARROW generated watershed loads combined with BMP load reduction efficiencies.

Cropland BMPs were applied to only the agricultural loads in SPARROW. SPARROW agricultural loads are the summed loads for manure, other agricultural sources, and atmospheric deposition (scaled by the proportion of the HUC8 that is agricultural).For phosphorus, it is important to note that approximately 15 percent of the load in the Mississippi River Basin is derived from streambank erosion (Barr Engineering 2004). SPARROW, however, does not separately account for streambank erosion as a source and the agricultural load portion of SPARROW accounts for both upland sources and sources associated with streambank erosion in agricultural areas. Accordingly, the phosphorus source allocation fraction estimated in the *Detailed Assessment of Phosphorus Sources to Minnesota Watersheds* (Barr Engineering 2004) was applied to the HUC8 phosphorus loads from SPARROW to identify the load derived from upland agricultural sources.

Source load reductions may not yet be fully realized at the instream stations near the Minnesota state line, particularly for phosphorus, due to lags in transport through the stream network, but are expected to be achieved over time.

BMP removal efficiencies were assigned to each indicator cropland BMP based on recent literature review efforts by the MPCA, MDA, and Iowa State University (Table B-1). Removal efficiencies were selected from these efforts with a focus on studies in the Midwest, with Minnesota-based studies receiving the highest priority. Chapter 5 includes additional discussion on available literature sources.

Table B-1. BMP removal efficiencies (see Chapter 5 for further discussion)

Indicator BMP Category	Nitrogen Removal (%)	Phosphorus Removal (%)	Sources
Residue Management	0	63	Miller et al. 2012; Iowa State University 2013; Simpson and Weammert 2009
Nutrient Management	16	24	MPCA 2013a ; Iowa State University 2013
Forage and Biomass Planting	95	59	Iowa State University 2013; MPCA 2013a
Conservation Easements	83	56	Iowa State University 2013; MPCA 2004; MPCA 2013a

Reductions for miscellaneous sources apply to phosphorus only and include septic system improvements, feedlots, and the phosphorus lawn fertilizer ban. Reductions in phosphorus from septic systems was estimated using MPCA program data based on the number of ITPHSs that had been brought into compliance. The average total phosphorus production per capita (2.3 lbs phosphorus produced per capita per year) was estimated from a septic system's average flow (60 gallons per capita per day; Lowe 2009), the average phosphorus concentration of septic tank effluent (12.5 mg/l phosphorus; EPA 2002; Crites and Tchobanoglous 1998), and the average number of people per dwelling (2.46 people per dwelling; 2010 U.S. Census). The percentage of phosphorus that reaches surface waters from ITPHS and conforming systems (Table B-2; Barr Engineering 2004) was then used to estimate the reduction of phosphorus loading to surface waters as a result of the upgrades. Permanent and seasonal residences were both taken into account, and it was assumed that 16 percent of all dwellings in the state are seasonal. Between 2002 and 2013, an estimated 27,710 ITPHSs were brought into compliance. The SPARROW attenuation factors were applied to the load reduction estimates.

Table B-2. Percent of phosphorus from septic systems that reaches surface waters (from Barr Engineering 2004)

Description	Percent of phosphorus that reaches surface waters from septic systems (%)
Permanent residence, conforming system	10
Permanent residence, failing system	30
Permanent residence, imminent threat to public health system	43
Seasonal residence, conforming system	20
Seasonal residence, failing system	43
Seasonal residence, imminent threat to public health system	43

The Open Lot Agreement is a provision in the Feedlot Rule (7020) in which eligible livestock producers can receive an extended time for making improvements to open feedlots for water quality issues. Between 2000 and 2010, there was an average of 141 additional feedlot fixes per year from open lot agreements and other efforts to reduce feedlot runoff. Another 108 feedlot closings per year occurred, on average. A typical MinnFARM model annual load reduction of 25 pounds of phosphorus reduced per project was used to determine total phosphorous load reductions by major basin. Basin or smaller scale data were not available. This estimate does not include manure application to cropland related reductions stemming from rule revisions made in 2000 or voluntary changes for livestock feed which reduced phosphorus in manure.

A 10 percent reduction in phosphorus loading from urban areas was assumed to have occurred as a result of the statewide phosphorus fertilizer ban. The Chesapeake Stormwater Network estimated that statewide phosphorus fertilizer bans in the Chesapeake Bay watershed have led to a load reduction from the overall urban stormwater sector of approximately 10 percent (Schueler and Lane 2013). The authors found that their results were consistent with research in Minnesota (Vlach et al. 2010) and Michigan (Lehman et al. 2009 [1]). A 10 percent phosphorus load reduction was applied to the average loads from urban runoff in the *Detailed Assessment of Phosphorus Sources to Minnesota Watersheds* (Barr Engineering 2004) to estimate the total load reductions that resulted from the phosphorus fertilizer ban.

The following key assumptions were also considered in the program quantification analysis:

- Existing BMPs are applied to mutually exclusive land areas. For example, nutrient management and residue management are not implemented on the same farms. In reality it is likely that these practices are implemented concurrently on the same fields.
- BMP efficiency is presumed to be the same for tiled versus non-tiled lands.

Cropland and Miscellaneous Source Results

Table B-3 and Table B-4 present a summary of non-wastewater program quantification results for nitrogen and phosphorus, respectively. The loads presented in these tables represent the loads generated within Minnesota by major basin or basin, delivered to the state line. The current conditions load presented in the tables (second column in each table) reflect the recent point source update to SPARROW.

[1] This study found higher percent reductions in a subset of the data. Their reported percent reductions (28%) represent an upper estimate of May through September monthly phosphorus concentration reductions in their study area.

The results of the program quantification analysis suggest that recent implementation of cropland BMPs has not achieved a significant nitrogen load reduction relative to conditions in 2000, as represented by SPARROW. For nitrogen, about a 1 percent reduction of nitrogen load statewide was estimated. For phosphorus, it appears that modest load reductions have recently been achieved (almost 8 percent reduction of the statewide phosphorus load).

Table B-3. Summary of recent progress for cropland nitrogen loads (total to state line)

Basin	Current Conditions N with Point Source Update (metric tons/ yr) [a]	N Reduced by Nutrient Mgmt. (metric tons/yr)	N Reduced by Forage and Biomass Planting (metric tons/yr)	N Reduced by Residue Mgmt. (metric tons/yr)	N Reduced by Conservation Easements (metric tons/yr)	Net N Reduction (metric tons/yr)	% of N Reduced by BMPs
Cedar River	6,918	16	1	0	53	70	1.0%
Des Moines River	4,507	36	1	0	36	73	1.6%
Lake Superior	3,656	0	0	0	0	0	0.0%
Mississippi River [b]	99,441	476	47	0	837	1,361	1.4%
Missouri River	5,208	34	3	0	16	52	1.0%
Rainy River	2,606	1	3	0	0	4	0.1%
Red River	16,822	90	30	0	40	159	0.9%
Total	**139,159**	**654**	**85**	**0**	**981**	**1,719**	**1.2%**

a. Loads calculated from SPARROW.

b. Loads for the Mississippi River basin are tabulated at De Soto, WI downstream of the MN/IA state line, using SPARROW.

Table B-4. Summary of recent progress for cropland and miscellaneous source phosphorus loads (total to state line)

Basin	Current Conditions P with Point Source Update (metric tons/yr) [a]	P Reduced by Nutrient Mgmt. (metric tons/yr)	P Reduced by Forage and Biomass Planting (metric tons/yr)	P Reduced by Residue Mgmt. (metric tons/yr)	P Reduced by Conservation Easements (metric tons/yr)	P Reduced by BMPs tracked in eLINK [c] (metric tons/yr)	P Reduced by Septic System BMPs (metric tons/yr)	P Reduced by Feedlot Projects (metric tons/yr)	P Reduced by Urban Fertilizer Ban (metric tons/yr)	Net P Reduction (metric tons/yr)	% of P Reduced by BMPs
Lake Superior	255	0	0	0	0	2	0.7	0.1	2.3	5	2%
Cedar River	242	0	0	1	1	3	0.6		0.4		
Des Moines River	251	1	0	1	1	7	0.6		0.2		
Mississippi River [b]	5,553	18	1	28	13	395	13		23.4		
Missouri River	290	1	0	1	0	11	0.7	30.5	0.2	556	9%
Rainy River	204	0	1	1	0	4	0.2		0.2		
Red River	949	4	0	6	1	28	1.3	0.7	1.1	49	4%
Total	**7,742**	**24**	**2**	**39**	**15**	**450**	**17**	**31**	**28**	**610**	**8%**

a. Loads calculated from SPARROW.

b. Loads for the Mississippi River basin are tabulated at De Soto, WI downstream of the MN/IA state line, using SPARROW.

c. eLINK loads do not include feedlot projects.

Wastewater Source Results

Table B-5 presents recent trends in wastewater point source loads. Point source data (as loads generated within Minnesota and transported to the state line) were summarized in two different SPARROW models representing progress between the early and late 2000s. These data do not reflect the most up-to-date monitoring information, but are adequate to quantify progress. The data contained in the SPARROW models were derived from point source discharge monitoring records. The difference in wastewater loads from 2002 and 2005–2006 for nitrogen and 2005–2009 for phosphorus were used to calculate the change in phosphorus and nitrogen loading from point sources that has recently occurred. In general, there have been treatment improvements (especially for phosphorus in the Minnesota River, part of the Mississippi Major Basin), but also offsetting increases in discharge volumes. Wastewater phosphorus reductions in the Mississippi River Major Basin account for a 24 percent reduction in monitored baseline loads.

Table B-5. Summary of recent trends in point sources

Major basin	Nitrogen		Phosphorus	
	Recent Change in Point Source (metric tons/yr)	Percent Change in Baseline Loads	Recent Change in Point Source (metric tons/yr)	Percent Change in Baseline Loads
Lake Superior	+411	+13%	+7	undetermined
Mississippi River	+1,492	+2%	-1,113	-24%
Lake Winnipeg	-55	0%	-4	-0.3%

Appendix C: Agricultural BMPs

In addition to the BMPs presented in Chapter 5, additional BMPs can be used to achieve nutrient reductions including the following (NRCS Technical Practice number precedes the BMP name):

Core Practices

AVOIDING

328 - Conservation Crop Rotation
340 - Cover Crop
528 - Prescribed Grazing
590 - Nutrient Management
633 - Waste Utilization

CONTROLLING

329 - Residue and Tillage Management - No Till/Strip Till
330 - Contour Farming
345 - Residue and Tillage Management - Mulch Till
346 - Residue and Tillage Management - Ridge Till
412 - Grassed Waterway
512 - Pasture and Hayland Planting
554 - Drainage Water Management
585 - Stripcropping
600 - Terrace

TRAPPING

332 - Contour Buffer Strips
390 - Riparian Herbaceous Cover
391 - Riparian Forest Buffer
393 - Filter Strip
601 - Vegetative Barriers
635 - Vegetated Treatment Area
656 - Constructed Wetland
657 - Wetland Restoration

658 - Wetland Creation
659 - Wetland Enhancement
747 - Denitrifying Bioreactor

Supporting Practices

AVOIDING

313 - Waste Storage Facility
317 - Composting Facility
327 - Conservation Cover
381 - Silvopasture Establishment
382 - Fence
472 - Access Control
511 - Forage Harvest Management
558 - Roof Runoff Structure
561 - Heavy Use Area Protection
612 - Tree and Shrub Planting
632 - Solid/Liquid Waste Separation Facility
634 - Waste Transfer

CONTROLLING

324 - Deep Tillage
342 - Critical Area Planting
362 - Diversion
386 - Field Border
410 - Grade Stabilization Structure
430 - Irrigation Water Conveyance
447 - Tailwater Recovery
449 - Irrigation Water Management
468 – Lined Waterway or Outlet
484 - Mulching
533 - Pumping Plant
587 - Structure for Water Control
606 - Subsurface Drainage
607 - Surface Drainage

620 - Underground Outlet

638 - Water & Sediment Control Basin

TRAPPING

342 - Critical Area Planting

350 - Sediment Basin

356 - Dike

436 - Irrigation Storage Reservoir

490 - Forest Site Preparation

533 - Pumping Plant

587 - Structure for Water Control

629 - Waste Treatment

638 - Water and Sediment Control Basin

646 - Shallow Water Development and Management

Appendix D: Conservation Effects Assessment Project Summary

The USDA NRCS Conservation Effects Assessment Project (CEAP) estimated the benefits of the 2002 Farm Bill's increase in conservation funding at a national, regional, and watershed scale. The Upper Mississippi River Basin (UMB) was one of 13 basins studied by CEAP. Two nutrient loading scenarios in the CEAP study dealt with increasing treatment for undertreated areas and, more specifically, simulated the effects of structural conservation practices, residue and tillage management, and nutrient management. Similar to the NRS load reduction estimates, the practices used for simulation were selected as example practices that represent the broader range of practices available to operators. Using different analysis methods from this NRS, the CEAP study showed considerable room for improvement in reducing cropland nutrient transport to waters in Minnesota and neighboring states. By treating critical undertreated areas, the CEAP study estimated a 6 percent reduction of overall phosphorus loss to waters from all sources (12 percent reduction of the cropland only losses).By treating all undertreated areas the CEAP study estimated that phosphorus losses to water could be reduced by 17 percent or more (30 percent reduction in the cropland only losses).

The NRS goal of reducing Mississippi River phosphorus by 7.5 percent through cropland BMPs is within the 6 to 17 percent reduction range that the CEAP study determined possible through BMP adoption on some or all of the undertreated areas. The CEAP Study supports the achievability of this NRS's recommendations for additional phosphorus loss reductions in the Mississippi River using traditional cropland conservation BMPs.

The simulated practices included terraces, contouring or strip cropping, riparian buffers, filter strips, nutrient management, and efficiency of irrigation water conveyances and water application. In reality, tillage or residue management and cover crops may be used instead of the simulated structural practices, and drainage water management or cover crops may be used instead of strict nutrient management practices (USDA 2012a).

USDA NRCS conducted an extensive survey of current farming practices to estimate the load reduction being achieved through conserving practices. The farm–scale Agricultural Policy/ Environmental Extender simulation model was used to estimate weighted average yields of surface water delivery, sediment, nutrients, and pesticides. These results were multiplied by the area of cultivated cropland obtained from the Hydrologic Unit Model for the United States database and entered into the Soil and

Water Assessment Tool (SWAT) watershed model for each 8-digit HUC. The SWAT model was used to simulate nonpoint source loadings from land uses other than cropland and aggregate HUC8 loading results for all land uses to the HUC4 scale (Gervino 2013).

While the majority of the modeling steps were specific to the HUC8 scale, the results were reported at the HUC4 level. Seven HUC4 UMB watersheds intersect with Minnesota (Gervino 2013):

- Mississippi Headwaters HUC4 0701: 100 percent within Minnesota
- Minnesota River HUC4 0702: 81 percent in Minnesota
- St. Croix HUC4 0703 and Black–Root HUC4 0704: intersected by the Minnesota-Wisconsin border, relatively large portions within Minnesota
- HUC4s 0706, 0708, and 0710: small portions are located in Minnesota, intersecting at the Minnesota-Iowa border

Since CEAP results at the HUC8 scale are not available, the Mississippi Headwaters 0701 and the Minnesota River 0702 provide the best means of comparison between the NRS and CEAP load reduction results. These watersheds combined represent 74 percent of the UMB within Minnesota (Gervino 2013).

Table D-1 compares the land area assumptions and load reduction results, in terms of percent, between the NRS (Minnesota only, all Mississippi River drainage) and the CEAP study (Mississippi Headwaters and Minnesota River HUC4s). The geographic areas are not the same but they overlap considerably. The relative percentages provide a means of comparison between the NRS and CEAP approaches. Both approaches consider a similar percentage of cultivated land compared to the total land within the study areas. While the simulated BMPs differed, as well as the assumptions, the percent of new treated area is similar between the NRS and the CEAP scenarios. Comparing the CEAP undertreated areas scenario to the NRS, the CEAP results estimate is twice the phosphorus load reduction compared to the NRS (17 percent versus 7.5 percent). The other CEAP scenario shown in Table D-1, treating critical undertreated areas only, simulates a much smaller treated area compared to all undertreated areas but is estimated to achieve a reasonably large percentage of load reduction compared to its treated area.

Underlying both the NRS and CEAP study results are many detailed assumptions and decision rules regarding the extent and type of increased treatment. While the percent of total cultivated land estimates are similar, the source of data on current practices also differs between CEAP and the NRS. Finally, both methods used an uncalibrated approach for estimating pollutant load reductions from practices. When two efforts conduct large scale, uncalibrated loading estimations, a difference in results is expected. While the methods differed considerably, CEAP provides an additional line of evidence for major nutrient load reductions that can be achieved through additional conserving practices on cultivated land.

Table D-1. Comparison between NRS and CEAP land areas and load reduction results

	Percent of land that is cultivated [a]	Percent of cultivated land simulated with additional treatment	Percent load reduction estimated as a percent of all sources
MN NRS [b]	46%	62%	7.5%
CEAP, Treatment of Critical Undertreated Areas [c]	48%	13%	6%
CEAP, Treatment of All Undertreated Areas [c]	48%	57%	17%

a. CEAP cropland estimates include Conservation Reserve Program land.

b. Represents Minnesota portion of Mississippi Basin, 2012 CDL.

c. Represents mostly Minnesota area with some area in adjacent states; limited to HUC4 0701 (Mississippi Headwaters) and 0702 (Minnesota River).

Appendix E: HUC8 Watershed Loads and Reductions

Chapter 6 includes a strategy for nutrient reduction which calls for achieving nutrient reductions within the 8-digit hydrologic unit code (HUC8) major watersheds which will cumulatively achieve the downstream goals and Mississippi River nitrogen milestone. The watershed restoration and protection strategy (WRAPS) for each major watershed includes such elements as timelines, interim milestones, and responsible governmental units for achieving the needed pollutant reductions. The WRAPS and associated local water management plan (e.g., One Watershed One Plan) should be developed to not only have the goal of protecting and restoring water resources within the watershed, but to also contribute to nutrient reductions needed for downstream waters (in-state and out-of-state).

A set of HUC8 nutrient reduction targets is provided in this appendix as a guide to provide an estimate of the magnitude of individual HUC8 reductions which will collectively reach NRS goals and milestones (Table E-1). One approach in this appendix is based on reducing a common percentage of SPARROW-modeled loads for each HUC8 watershed outlet in the major basin (i.e. 20 percent for the Mississippi nitrogen milestone reduction for each HUC8 in the Mississippi Basin). This approach, as shown in Table E-2, includes loads from all sources and takes into consideration recent progress as documented in Chapter 4. If other watershed monitoring and modeling is available (e.g., calibrated HSPF watershed model), the major basin reduction needs in Table E-1 could instead be applied to the modeled existing condition load to estimate the needed HUC8 load reduction.

Table E-1. Summary of new reductions needed

Major Basin	Phosphorus			Nitrogen		
	Goal Reduction	Recent Progress Reduction	Remaining Reduction Needed	Goal/ Milestone Reduction	Recent Progress Reduction	Remaining Reduction Needed
Mississippi River	45%	33%	**12%**	20%	0%	**20%**
Lake Winnipeg	10%	4.3%	**5.7%**	13%	0%	**13%**

A different approach provided in this appendix is based on estimated HUC8 watershed nutrient reduction needs from cropland sources only. Table E-3 shows estimates for HUC8 load reductions that would collectively achieve the cropland nutrient reduction goals and milestones. The BMP adoption targets are predicted to be sufficient to meet environmental milestones and goals for nitrogen and phosphorus loading, if adopted on the suitable acres as described in Chapter 5. The cropland load reduction approximations are summarized from the NBMP tool and the phosphorus analysis, which considers the amount of land that is suitable and available for the various agricultural BMPs in each watershed. Individual HUC8 watershed modeling and planning should be used along with information in the NRS to determine the best scenario for HUC8 nutrient reductions and the associated BMP adoption to achieve both local and downstream milestones and goals.

In addition to these watershed nutrient reduction guidelines and scenarios, TMDLs will inform watershed and point source reductions needed to address specific water body impairments. In cases where downstream TMDLs require large reductions, interim implementation targets consistent with these reduction targets may be considered, but in all cases TMDLs are applicable and this NRS is not intended to supersede any regulatory requirements. Of particular importance are the reductions needed for those HUC8s that drain to lakes with approved TMDLs such as Lake St. Croix and in the future Lake Pepin. Chapter 2 of the NRS summarizes key eutrophication-impaired lakes with large watersheds in Minnesota that are in need of phosphorus load reductions to meet water quality standards.

Table E-2. SPARROW modeled loads at HUC8 outlets from all sources to collectively achieve goals and nitrogen milestone when each watershed in the major basin is reduced by the same percentage according to Table E-1.

Note: The reduction targets in this table indicate the general magnitude of reductions needed. Additional monitoring and modeling information should be used determine watershed reduction goal planning.

HUC8 Number	HUC8 Name	Basin	Major Basin	Phosphorus		Nitrogen	
				Load [a] (MT/year)	Reduction (MT/year) [b]	Load [a] (MT/year)	Reduction (MT/year) [b]
07080102	Upper Wapsipinicon River	Cedar	Mississippi	2.8	0.3	80.4	16.1
07080201	Cedar River	Cedar	Mississippi	169.3	20.3	4,660.9	932.2
07080202	Shell Rock River	Cedar	Mississippi	57.6	6.9	1,359.4	271.9
07080203	Winnebago River	Cedar	Mississippi	12.2	1.5	817.5	163.5
07100001	Des Moines River - Headwaters	Des Moines	Mississippi	199.3	23.9	3,709.3	741.9
07100002	Lower Des Moines River	Des Moines	Mississippi	19.2	2.3	246.0	49.2
07100003	East Fork Des Moines River	Des Moines	Mississippi	32.1	3.9	552.1	110.4
10170202	Upper Big Sioux River	Missouri	Mississippi	6.9	0.8	124.4	24.9
10170203	Lower Big Sioux River	Missouri	Mississippi	83.6	10.0	1,504.5	300.9
10170204	Rock River	Missouri	Mississippi	147.6	17.7	2,655.4	531.1
10230003	Little Sioux River	Missouri	Mississippi	51.4	6.2	924.2	184.8
07010101	Mississippi River - Headwaters	Upper Mississippi	Mississippi	15.7	1.9	181.3	36.3
07010102	Leech Lake River	Upper Mississippi	Mississippi	7.2	0.9	79.4	15.9
07010103	Mississippi River - Grand Rapids	Upper Mississippi	Mississippi	123.2	14.8	982.1	196.4

HUC8 Number	HUC8 Name	Basin	Major Basin	Phosphorus		Nitrogen	
				Load [a] (MT/year)	Reduction (MT/year) [b]	Load [a] (MT/year)	Reduction (MT/year) [b]
07010104	Mississippi River - Brainerd	Upper Mississippi	Mississippi	111.7	13.4	1,611.4	322.3
07010105	Pine River	Upper Mississippi	Mississippi	6.0	0.7	89.3	17.9
07010106	Crow Wing River	Upper Mississippi	Mississippi	53.9	6.5	905.2	181.0
07010107	Redeye River	Upper Mississippi	Mississippi	39.9	4.8	806.7	161.3
07010108	Long Prairie River	Upper Mississippi	Mississippi	52.6	6.3	733.6	146.7
07010201	Mississippi River - Sartell	Upper Mississippi	Mississippi	115.1	13.8	1,847.7	369.5
07010202	Sauk River	Upper Mississippi	Mississippi	149.8	18.0	2,076.6	415.3
07010203	Mississippi River - St. Cloud	Upper Mississippi	Mississippi	106.0	12.7	1,783.7	356.7
07010204	North Fork Crow River	Upper Mississippi	Mississippi	173.3	20.8	3,287.1	657.4
07010205	South Fork Crow River	Upper Mississippi	Mississippi	296.0	35.5	5,811.2	1162.2
07010206	Mississippi River - Twin Cities	Upper Mississippi	Mississippi	291.5	35.0	5,108.6	1021.7
07010207	Rum River	Upper Mississippi	Mississippi	103.4	12.4	1,647.2	329.4
07020001	Minnesota River - Headwaters	Minnesota	Mississippi	42.0	5.0	512.9	102.6
07020002	Pomme de Terre River	Minnesota	Mississippi	135.2	16.2	1,643.4	328.7
07020003	Lac Qui Parle River	Minnesota	Mississippi	117.3	14.1	1,705.0	341.0
07020004	Minnesota River - Yellow Medicine River	Minnesota	Mississippi	435.7	52.3	6,910.6	1382.1
07020005	Chippewa River	Minnesota	Mississippi	234.4	28.1	3,882.9	776.6
07020006	Redwood River	Minnesota	Mississippi	199.3	23.9	1,998.5	399.7
07020007	Minnesota River - Mankato	Minnesota	Mississippi	299.4	35.9	8,245.0	1649.0
07020008	Cottonwood River	Minnesota	Mississippi	261.0	31.3	5,305.0	1061.0
07020009	Blue Earth River	Minnesota	Mississippi	376.5	45.2	8,022.1	1604.4
07020010	Watonwan River	Minnesota	Mississippi	192.0	23.0	4,176.2	835.2
07020011	Le Sueur River	Minnesota	Mississippi	351.8	42.2	7,067.9	1413.6
07020012	Lower Minnesota River	Minnesota	Mississippi	338.4	40.6	9,249.1	1849.8
07030001	Upper St. Croix River	St. Croix	Mississippi	19.5	2.3	377.6	75.5
07030003	Kettle River	St. Croix	Mississippi	53.2	6.4	777.3	155.5
07030004	Snake River	St. Croix	Mississippi	63.5	7.6	911.2	182.2
07030005	Lower St. Croix River	St. Croix	Mississippi	66.9	8.0	1,428.8	285.8
07040001	Mississippi River - Lake Pepin	Lower Mississippi	Mississippi	97.1	11.7	1,735.4	347.1
07040002	Cannon River	Lower Mississippi	Mississippi	248.0	29.8	6,265.3	1253.1

HUC8 Number	HUC8 Name	Basin	Major Basin	Phosphorus		Nitrogen	
				Load [a] (MT/year)	Reduction (MT/year) [b]	Load [a] (MT/year)	Reduction (MT/year) [b]
07040003	Mississippi River - Winona	Lower Mississippi	Mississippi	161.0	19.3	1,744.0	348.8
07040004	Zumbro River	Lower Mississippi	Mississippi	314.6	37.8	5,575.3	1115.1
07040006	Mississippi River - La Crescent	Lower Mississippi	Mississippi	30.0	3.6	412.4	82.5
07040008	Root River	Lower Mississippi	Mississippi	322.5	38.7	5,821.4	1164.3
07060001	Mississippi River - Reno	Lower Mississippi	Mississippi	30.5	3.7	404.7	80.9
07060002	Upper Iowa River	Lower Mississippi	Mississippi	25.1	3.0	677.7	135.5
09020101	Bois de Sioux River	Red	Winnipeg	35.2	2.1	471.8	47.2
09020102	Mustinka River	Red	Winnipeg	155.7	9.3	1,653.3	165.3
09020103	Otter Tail River	Red	Winnipeg	116.7	7.0	1,569.1	156.9
09020104	Upper Red River of the North	Red	Winnipeg	69.6	4.2	684.8	68.5
09020106	Buffalo River	Red	Winnipeg	98.8	5.9	1,687.3	168.7
09020107	Red River of the North - Marsh River	Red	Winnipeg	27.9	1.7	552.9	55.3
09020108	Wild Rice River	Red	Winnipeg	104.9	6.3	2,214.1	221.4
09020301	Red River of the North - Sandhill River	Red	Winnipeg	39.0	2.3	963.0	96.3
09020302	Upper/Lower Red Lake	Red	Winnipeg	2.4	0.1	21.6	2.2
09020303	Red Lake River	Red	Winnipeg	86.2	5.2	1,689.6	169.0
09020304	Thief River	Red	Winnipeg	14.3	0.9	255.4	25.5
09020305	Clearwater River	Red	Winnipeg	53.0	3.2	964.3	96.4
09020306	Red River of the North - Grand Marais Creek	Red	Winnipeg	47.9	2.9	809.4	80.9
09020309	Snake River	Red	Winnipeg	43.2	2.6	1,079.4	107.9
09020311	Red River of the North - Tamarac River	Red	Winnipeg	44.3	2.7	1,160.2	116.0
09020312	Two Rivers	Red	Winnipeg	79.0	4.7	1,532.1	153.2
09020314	Roseau River	Red	Winnipeg	54.7	3.3	1,033.6	103.4

a. Load delivered to HUC8 outlet derived from SPARROW, results reflect point source update. Note that these loads are higher than the loads delivered to De Soto (state line) due to attenuation.
b. Load reduction is proportional based on Major Basin reduction milestones, at the HUC8 outlet (Table E-1).

Table E-3. HUC8 loading results and reductions from new agricultural BMPs.

BMP adoption scenarios are based on the levels of adoption described Chapter 5. Total loads are at HUC8 outlets. The cropland load reduction indicates the general magnitude of reductions needed from cropland to collectively achieve goals and nitrogen milestone. Additional monitoring and modeling information where available and appropriate should be used to complete a watershed-specific nutrient reduction planning process.

HUC8 Number	HUC8 Name	Basin	Major Basin	Phosphorus		Nitrogen	
				Load [a] (MT/year)	Cropland Load Reduction (MT/year) [b]	Load [a] (MT/year)	Cropland Load Reduction (MT/year)[b]
07080102	Upper Wapsipinicon River	Cedar	Mississippi	2.8	0.2	80.4	7.4
07080201	Cedar River	Cedar	Mississippi	169.3	12.7	4,660.9	435.2
07080202	Shell Rock River	Cedar	Mississippi	57.6	3.1	1,359.4	123.4
07080203	Winnebago River	Cedar	Mississippi	12.2	1.6	817.5	31.7
07100001	Des Moines River - Headwaters	Des Moines	Mississippi	199.3	20.7	3,709.3	581.4
07100002	Lower Des Moines River	Des Moines	Mississippi	19.2	2.4	246.0	52.7
07100003	East Fork Des Moines River	Des Moines	Mississippi	32.1	4.2	552.1	123.0
10170202	Upper Big Sioux River	Missouri	Mississippi	6.9	1.5	124.4	13.8
10170203	Lower Big Sioux River	Missouri	Mississippi	83.6	8.7	1,504.5	171.0
10170204	Rock River	Missouri	Mississippi	147.6	13.7	2,655.4	304.9
10230003	Little Sioux River	Missouri	Mississippi	51.4	5.5	924.2	139.4
07010101	Mississippi River - Headwaters	Upper Mississippi	Mississippi	15.7	1.0	181.3	--
07010102	Leech Lake River	Upper Mississippi	Mississippi	7.2	0.3	79.4	--
07010103	Mississippi River - Grand Rapids	Upper Mississippi	Mississippi	123.2	1.3	982.1	33.6
07010104	Mississippi River - Brainerd	Upper Mississippi	Mississippi	111.7	4.6	1,611.4	139.6
07010105	Pine River	Upper Mississippi	Mississippi	6.0	0.1	89.3	--
07010106	Crow Wing River	Upper Mississippi	Mississippi	53.9	2.3	905.2	--
07010107	Redeye River	Upper Mississippi	Mississippi	39.9	3.1	806.7	125.0
07010108	Long Prairie River	Upper Mississippi	Mississippi	52.6	3.8	733.6	129.7
07010201	Mississippi River - Sartell	Upper Mississippi	Mississippi	115.1	9.1	1,847.7	121.7
07010202	Sauk River	Upper Mississippi	Mississippi	149.8	17.4	2,076.6	144.9
07010203	Mississippi River - St. Cloud	Upper Mississippi	Mississippi	106.0	6.9	1,783.7	219.7
07010204	North Fork Crow River	Upper Mississippi	Mississippi	173.3	17.7	3,287.1	480.7
07010205	South Fork Crow River	Upper Mississippi	Mississippi	296.0	33.9	5,811.2	682.8
07010206	Mississippi River - Twin Cities	Upper Mississippi	Mississippi	291.5	13.5	5,108.6	288.6
07010207	Rum River	Upper	Mississippi	103.4	6.3	1,647.2	122.2

HUC8 Number	HUC8 Name	Basin	Major Basin	Phosphorus		Nitrogen	
				Load [a] (MT/year)	Cropland Load Reduction (MT/year) [b]	Load [a] (MT/year)	Cropland Load Reduction (MT/year)[b]
		Mississippi					
07020001	Minnesota River - Headwaters	Minnesota	Mississippi	42.0	3.1	512.9	109.3
07020002	Pomme de Terre River	Minnesota	Mississippi	135.2	15.7	1,643.4	280.7
07020003	Lac Qui Parle River	Minnesota	Mississippi	117.3	12.5	1,705.0	408.1
07020004	Minnesota River - Yellow Medicine River	Minnesota	Mississippi	435.7	47.0	6,910.6	1,038.4
07020005	Chippewa River	Minnesota	Mississippi	234.4	22.5	3,882.9	572.1
07020006	Redwood River	Minnesota	Mississippi	199.3	12.5	1,998.5	334.2
07020007	Minnesota River - Mankato	Minnesota	Mississippi	299.4	32.5	8,245.0	790.7
07020008	Cottonwood River	Minnesota	Mississippi	261.0	24.6	5,305.0	691.0
07020009	Blue Earth River	Minnesota	Mississippi	376.5	52.8	8,022.1	976.8
07020010	Watonwan River	Minnesota	Mississippi	192.0	22.7	4,176.2	649.4
07020011	Le Sueur River	Minnesota	Mississippi	351.8	50.9	7,067.9	897.2
07020012	Lower Minnesota River	Minnesota	Mississippi	338.4	25.5	9,249.1	1,023.4
07030001	Upper St. Croix River	St. Croix	Mississippi	19.5	0.8	377.6	77.9
07030003	Kettle River	St. Croix	Mississippi	53.2	1.1	777.3	96.2
07030004	Snake River	St. Croix	Mississippi	63.5	3.2	911.2	27.7
07030005	Lower St. Croix River	St. Croix	Mississippi	66.9	2.9	1,428.8	134.6
07040001	Mississippi River - Lake Pepin	Lower Mississippi	Mississippi	97.1	4.9	1,735.4	209.5
07040002	Cannon River	Lower Mississippi	Mississippi	248.0	20.3	6,265.3	743.1
07040003	Mississippi River - Winona	Lower Mississippi	Mississippi	161.0	9.8	1,744.0	340.6
07040004	Zumbro River	Lower Mississippi	Mississippi	314.6	37.7	5,575.3	982.0
07040006	Mississippi River - La Crescent	Lower Mississippi	Mississippi	30.0	0.5	412.4	26.8
07040008	Root River	Lower Mississippi	Mississippi	322.5	33.1	5,821.4	913.6
07060001	Mississippi River - Reno	Lower Mississippi	Mississippi	30.5	0.9	404.7	67.4
07060002	Upper Iowa River	Lower Mississippi	Mississippi	25.1	3.3	677.7	143.1
09020101	Bois de Sioux River	Red	Winnipeg	35.2	1.2	471.8	32.1
09020102	Mustinka River	Red	Winnipeg	155.7	3.6	1,653.3	54.6
09020103	Otter Tail River	Red	Winnipeg	116.7	2.6	1,569.1	158.2
09020104	Upper Red River of the North	Red	Winnipeg	69.6	2.9	684.8	21.7
09020106	Buffalo River	Red	Winnipeg	98.8	3.2	1,687.3	82.0
09020107	Red River of the North - Marsh River	Red	Winnipeg	27.9	1.1	552.9	13.2
09020108	Wild Rice River	Red	Winnipeg	104.9	3.7	2,214.1	70.7

HUC8 Number	HUC8 Name	Basin	Major Basin	Phosphorus		Nitrogen	
				Load [a] (MT/year)	Cropland Load Reduction (MT/year) [b]	Load [a] (MT/year)	Cropland Load Reduction (MT/year)[b]
09020301	Red River of the North - Sandhill River	Red	Winnipeg	39.0	1.5	963.0	34.2
09020302	Upper/Lower Red Lake	Red	Winnipeg	2.4	0.1	21.6	
09020303	Red Lake River	Red	Winnipeg	86.2	2.9	1,689.6	40.6
09020304	Thief River	Red	Winnipeg	14.3	0.4	255.4	19.9
09020305	Clearwater River	Red	Winnipeg	53.0	1.4	964.3	65.7
09020306	Red River of the North - Grand Marais Creek	Red	Winnipeg	47.9	2.1	809.4	19.4
09020309	Snake River	Red	Winnipeg	43.2	1.6	1,079.4	90.1
09020311	Red River of the North - Tamarac River	Red	Winnipeg	44.3	1.9	1,160.2	29.5
09020312	Two Rivers	Red	Winnipeg	79.0	2.4	1,532.1	23.4
09020314	Roseau River	Red	Winnipeg	54.7	1.3	1,033.6	--

a. Load delivered to HUC8 outlet derived from SPARROW, results reflect point source update. Note that these loads are higher than the loads delivered to De Soto (state line) due to attenuation.
b. Load reduction is from new agricultural BMPs, as summarized in Chapter 5, at the HUC8 outlet.

Appendix F: Program Metadata Worksheets

Implementation of Nonpoint Source (NPS) Best Management Practices (BMPs) Tracked via eLink and Estimated Nutrient Load Reductions

Measure Background

Visual Depiction

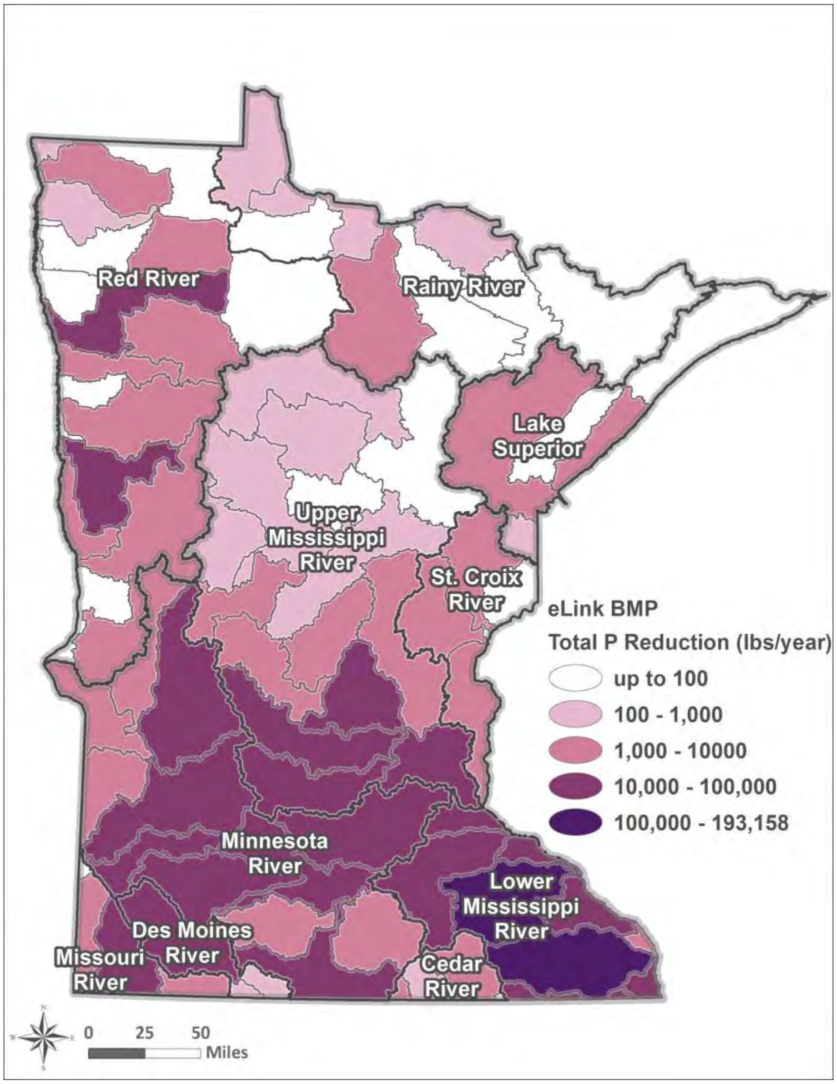

Figure 1. TP load reductions as reported in eLINK, data retrieved March 2013.

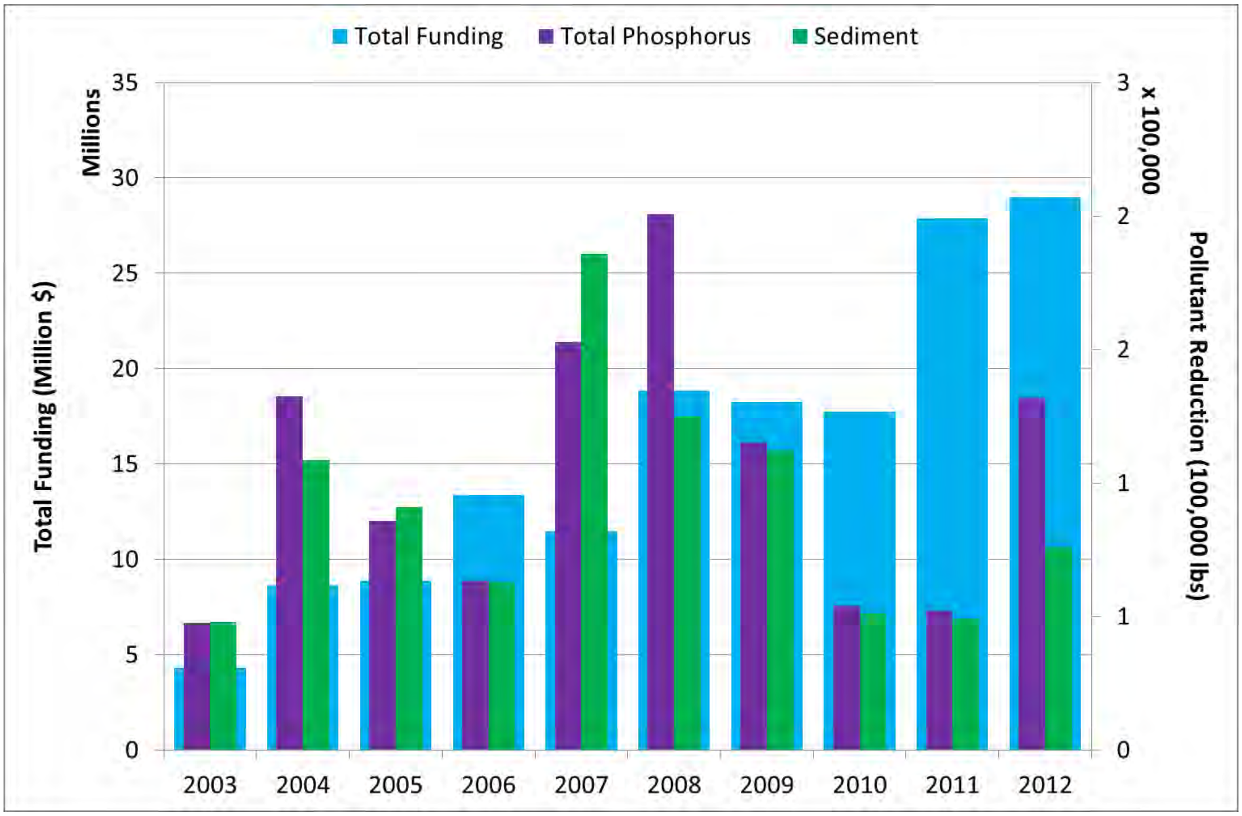

Figure 2. Annual total funding for NPS projects, as reported in eLINK, 2003- 2012.
Note – Annual total funding is a combination of multiple fund sources including Federal and local dollars, dates are based on the project year included in the database. Any other reported years were ignored in Figure 2, although they are included in Figure 1.

Measure Description

This measure communicates the phosphorus reduction and number of nonpoint source (NPS) best management practices (BMPs) implemented through a variety of key programs administered by several agencies and tracked through eLINK. Figure 1 describes the phosphorus load reductions by 8-digit HUC for projects included in the eLINK database (data retrieved March 2013). Figure 2 illustrates the total funding associated with these BMPs from 2003-2012, as well as associated reductions in total phosphorus, sediment, and soil. According to Figure 2, funding for NPS projects as tracked in eLINK has increase significantly over time. In 2007, Clean Water Legacy Act funding became available. In 2009, funding associated with the passage of the Clean Water Land and Legacy Amendment began to be tracked.

The eLINK database, which is presented in summary above, is the result of self-reported load reductions, calculated in a variety of ways. A review of the eLINK database identified anomalies and potential missing data as related to pollutant load reductions; however no efforts were made to further investigate. One outlier was removed in 2010.

Funding for NPS projects tracked in this database has clearly increased. The dollars spent per load of pollutant removed has increased as well in recent years. The cause of this is unknown.

This measure is an indirect or surrogate measure of environmental response. It does not provide information on watershed health, but does provide information on efforts to reduce pollutant loads over time.

Associated Terms and Phrases

To better understand this measure, it is necessary to understand a few program specific terms and phrases.

BMPs: Conservation practices that improve or protect water quality in agricultural, forested, and urban areas.

Phosphorus: In this measure, we report the estimated reduction in the amount of total phosphorus reaching surface waters as a result of runoff or soil erosion (sheet, rill, gully erosion, or steam channel).

Sediment Loss: The estimated amount of sediment reaching the nearest surface water body as a result of soil erosion from water (sheet, rill, gully erosion, or stream channel).

Target

There is no specific numeric target for this measure to date.

Baseline

2003-2012

Geographical Coverage

Spatial data points associated with each eLINK project.

Data and Methodology

Methodology for Measure Calculation

This measure represents NPS BMPs implemented through a number of state grant and loan programs. To calculate this measure, state agencies collect data on the NPS BMPs implemented by multiple programs including BWSR State Cost-Share and BWSR Clean Water Fund, amongst others.

Pollutant estimates are entered into the Minnesota Board of Water and Soil Resources' (BWSR's) web-based grant reporting and tracking tool, eLINK, by grant recipients when entering BMP data. The State of Minnesota does not require a specific methodology for developing pollutant load estimates. Pollutant load reductions using existing models developed for estimating pollutant load are acceptable. BWSR provides several pollution reduction calculators that can be used at http://www.bwsr.state.mn.us/outreach/eLINK/index.html. In the past, BQSR has provided pollutant estimators for eLINK based on soil erosion (sheet, rill, gully and stream channel). Sediment reduction estimates in eLINK were based on the distance to the nearest surface waters and soil loss calculations using USDA's Revised Universal Soil Loss Equation (RUSLE2). Phosphorus reduction estimates were derived from sediment reduction estimates.

For programs administered by BWSR, local grant recipients are required to enter BMP data in eLINK. More information on eLINK is available at http://www.bwsr.state.mn.us/outreach/eLINK/index.html.

Data Source

Minnesota Board of Water and Soil Resources

Data Collection Period

For Figure 1, as explained below in Caveats and Limitations, there is a lag time between grants being awarded and BMPs being fully implemented and recorded. The dataset will be complete once all of the BMPs funded are fully implemented and recorded. Until then, the dataset for this measure only provides a snapshot in time.

For Figure 2, the data collection period was 2003 through 2012.

Data Collection Methodology and Frequency

BWSR staff extracts the data by summarizing all BMPs in the database. Local grant recipients enter BMP information into eLINK every six months, recording only those BMPs that are fully implemented at that time. BMP data are analyzed by the fiscal year the grant was awarded rather than the calendar year the BMP was installed.

Supporting Data Set

Table 1. eLINK database summary, March 2013 data pull

HUC8	eLINK P Reduction	eLINK Count of BMPs	HUC8	eLINK P Reduction	eLINK Count of BMPs
04010101	96	50	07040006	3,752	54
04010102	1,799	49	07040008	118,219	1,199
04010201	1,778	50	07060001	10,444	239
04010202	1	6	07060002	80,598	140
04010301	368	43	07080102	0	0
04020300	143	2	07080201	5,758	132
07010101	209	78	07080202	280	61
07010102	116	18	07080203	1,073	6
07010103	49	89	07100001	14,977	1,346
07010104	752	214	07100002	257	35
07010105	34	51	07100003	197	97
07010106	337	361	09020101	14	111
07010107	666	569	09020102	1,190	201
07010108	1,495	418	09020103	5,027	634
07010201	4,329	431	09020104	7,949	264
07010202	8,124	469	09020106	19,582	814
07010203	16,324	550	09020107	0	84
07010204	81,786	529	09020108	6,722	402
07010205	13,801	552	09020301	1,890	99
07010206	13,094	293	09020302	43	22
07010207	2,277	169	09020303	10,822	353
07020001	1,769	278	09020304	2,520	146

HUC8	eLINK P Reduction	eLINK Count of BMPs	HUC8	eLINK P Reduction	eLINK Count of BMPs
07020002	3,308	269	09020305	1,471	195
07020003	6,309	588	09020306	0	111
07020004	27,247	2,428	09020309	39	119
07020005	24,362	1,123	09020311	147	77
07020006	41,260	926	09020312	4,093	187
07020007	10,839	462	09020314	81	136
07020008	12,073	1,384	09030001	0	2
07020009	69,187	655	09030002	0	1
07020010	5,871	789	09030003	237	15
07020011	8,330	576	09030004	188	5
07020012	26,716	1,970	09030005	19	12
07030001	2	9	09030006	8,806	47
07030003	1,092	38	09030007	0	2
07030004	2,974	90	09030008	716	75
07030005	1,419	232	09030009	158	101
07040001	22,107	175	10170202	64	37
07040002	23,976	925	10170203	5,553	334
07040003	82,823	458	10170204	14,641	528
07040004	705,504	684	10230003	4,314	152

Caveats and Limitations

There is lag time between when grant funds are awarded and when BMPs are fully implemented and recorded in eLINK. This measure reports only BMPs that are fully implemented; it does not report on those that are planned or in progress.

Pollution reductions entered into eLINK are calculated at the field scale, not the watershed scale.

Not all projects have associated pollutant load reductions for phosphorus in the database. No effort was made to assign a phosphorus load reduction for these projects.

Potential Double-Counting of BMPs: An individual BMP may be co-funded by several implementation programs tracked through eLink. For example, a gully/grade stabilization structure might be funded 75% through a BWSR grant and 25 percent by an AgBMP loan—with both programs counting the same structure in their respective databases. In another example, a BWSR grant might provide financial incentives for a farmer to switch to no-till, while an AgBMP loan finances the farmers' purchase of a no-till drill —again, both programs might record the same structure. Until a method is developed to identify such projects and coordinate the way they are recorded, it is necessary to report eLINK-entered data in total, noting potential data overlaps.

eLINK does not request nitrogen removal associated with BMPs being recorded.

Future Improvements

Improvements to this measure will be made over time. The type of pollutant reductions estimated in eLINK will expand in the short-term; therefore, this measure will track additional estimated pollutant load reductions associated with NPS BMPs.

Ideally this measure will be able to compare estimated pollutant load reductions in a particular watershed with pollutant load reduction targets established through TMDLs and other plans. However, accurate comparisons would require tracking all BMPs in a watershed, not just those reported in eLINK, as well as point source pollutant load reductions.

The inclusion of nitrogen reductions as part of required eLINK reporting would allow tracking of this pollutant. In addition, ensuring pollutant load reductions are associated with each project is critical to tracking progress over time.

Financial Considerations

Contributing Agencies and Funding Sources

eLINK tracks a large universe of grant funded BMPs funded through a wide array of funding sources.

Measure Points of Contact

Agency Information

Marcey Westrick
Board of Water and Soil Resources
520 Lafayette Road North
St. Paul, MN 55155
(651) 296-3767
Marcey.Westrick@state.mn.us

Implementation of Permanent Easements and Associated Nutrient Load Reductions

Measure Background

Visual Depiction

The map in Figure 1 shows the percentage of agricultural area in permanent conservation easements made through the Reinvest in Minnesota (RIM) easement program, administered by the Minnesota Board of Water and Soil Resources (BWSR), in each 8 digit-HUC. Figure 2 shows the aggregated annual acreage of permanent conservation easements and annual RIM costs associated with permanent easements from 2000-2012.

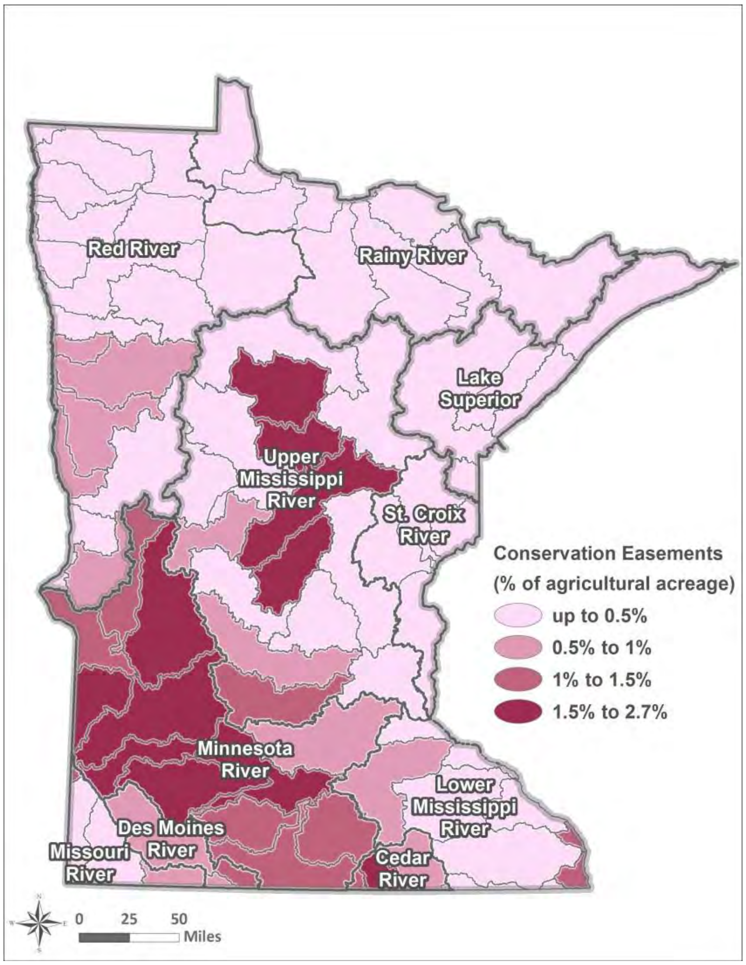

Figure 1. Percentage of permanent conservation easements of total agricultural acreage by 8-digit HUC.

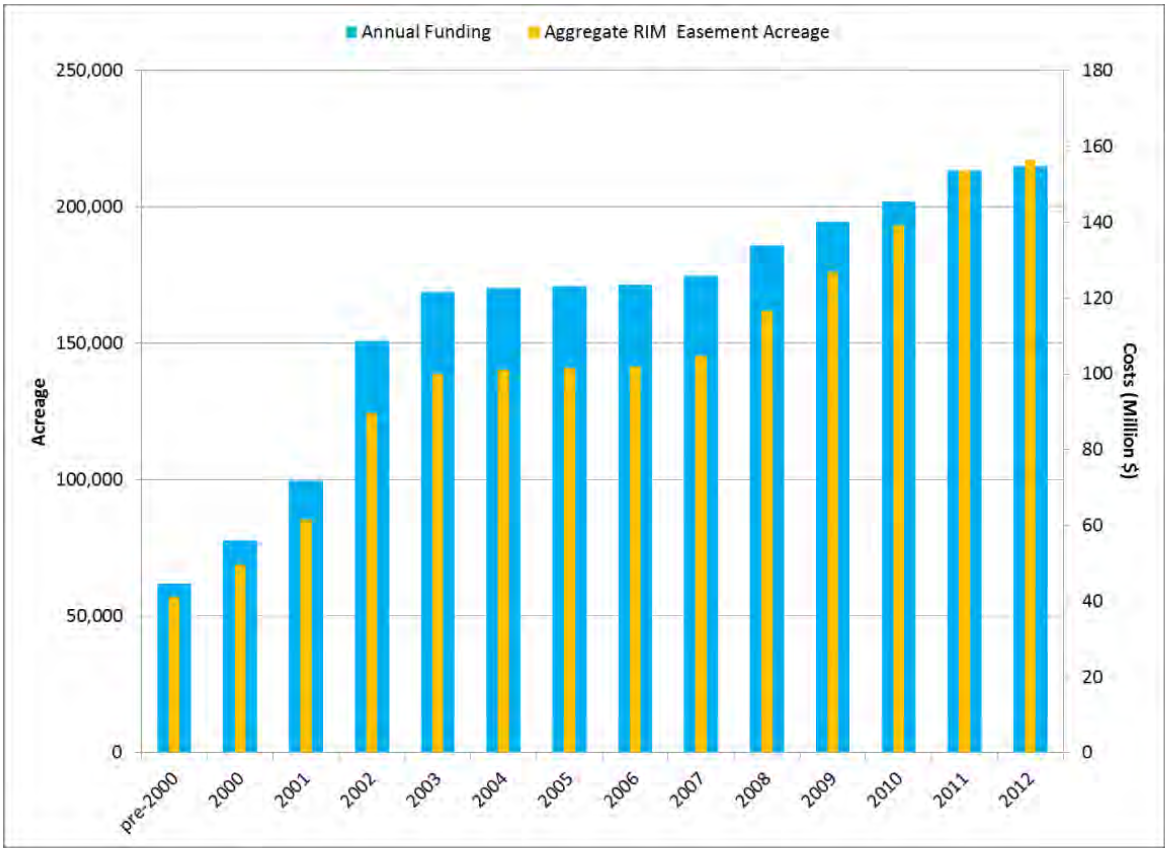

Figure 2. Aggregated annual RIM permanent conservation easement acreage and annual RIM funding.

Measure Description

This measure focuses on implementation trends for permanent easements on eligible agricultural land acquired through RIM. Agricultural land eligible for RIM easements are defined in the RIM Eligibility Handbook (http://www.bwsr.state.mn.us/easements/handbook/rimeligibility.pdf)

Figure 1 shows the percent of agricultural acreage within each 8-digit HUC that has permanent easements through the RIM program. The 8-digit HUCs with the highest percentages of agricultural land acquired for permanent easements through RIM are located in the Upper Mississippi River basin (primarily due to the small amount of agricultural land) and the Minnesota River basin. According to Figure 2, the aggregate acreage of permanent conservation easements through RIM increased from 2000-2003, but remained relatively steady until 2007, when an increase in acreage occurred until present. This increase has been primarily due to funding secured through the Legacy Amendment and increases in Capitol Investment (bonding). The trends in funding mirror the trends in acreage.

Table 1 below shows the estimated percent nitrogen and phosphorus removal associated with permanent conservation easements.

Table 1. Estimated nutrient removal efficiencies for conservation easements

Best Management Practice	Phosphorus Removal (%)	Nitrogen Removal (%)
Conservation easements[a]	56	83

a. Iowa State, 2013; MPCA, 2013; MPCA, 2004

Associated Terms and Phrases

To better understand this measure, it is necessary to understand a few program specific terms and phrases.

The Reinvest in Minnesota (RIM) Resources Law of 1986, Minnesota Statutes, sections 103F.501 to 103F.531, as amended, states: " It is the purpose of [the program] to keep certain marginal agricultural land out of crop production to protect soil and water quality and support fish and wildlife habitat. It is state policy to encourage the retirement of marginal, highly erodible land, particularly land adjacent to public waters, drainage systems, wetlands, and locally designated priority waters, from crop production and to reestablish a cover of perennial vegetation."

Definitions used in this measure are as follows:

Agricultural Land: According to the RIM Eligibility Handbook, agricultural land means land devoted for use as pasture or hayland or to the production of horticultural, row, close grown, introduced pasture, or introduced hayland crops, or to growing nursery stocks, or for pasturing domestic livestock or dairy animals, or for use as animal feedlots, and may include contiguous land associated with the production of the above.

Conservation Easements: the acquisition of limited rights in land for conservation purposes. Landowners who offer the state a conservation easement receive a payment to stop cropping and/or grazing the land, and in turn the landowners establish conservation practices such as native grass and forbs, trees or wetland restorations. The easement is recorded on the land title with the county recorder and transfers with the land when the parcel is sold. Most easements purchased by the state are perpetual (forever). Some eligible lands may be enrolled under limited duration easements (not less than 20 years), depending on programs available. The focus of this measure is on permanent/perpetual conservation easements.

Marginal Agricultural Cropland Area: Land with crop history that is composed of class IIIe, Ive, V, VI, VII, or VIII land as identified in the land capability classification system of the United States Department of Agriculture.

Target

There is no specific numeric target for this measure to date.

Baseline

Covers pre-2000-2013 data

Geographical Coverage

Statewide, major basin, 8-digit HUC

Data and Methodology

Methodology for Measure Calculation

BWSR manages a RIM program database to track specific information related to RIM land acquisitions over time. A variety of RIM reports are made available on the BWSR RIM website http://maps.bwsr.state.mn.us/rimonline/.

To develop the map for this measure (Figure 1), data from BWSR's RIM Spatial Dataset derived from the RIM database were downloaded from the RIM website. Using this data, information on permanent conservation easements were isolated from other easement types, including the associated acreage, location, cost, and start date. This information was then compiled by 8-digit HUC and compared to the total agricultural acreage in each HUC, derived using NLCD land use/land cover data, focusing on coverages for pasture/hay and cultivated crops. This information was then mapped using GIS to show total conservation easement acreage in each 8-digit HUC as a percentage of the total agricultural acreage by 8-digit HUC within each major basin.

To develop the bar graph (Figure 2), data on acreage and funding associated with permanent conservation easements from BWSR's RIM database were downloaded from the RIM website. This information was placed into an Excel spreadsheet and graphed.

Data Source

Minnesota Board of Water and Soil Resources

Data Collection Period

2000 through 2012. (data in the Spatial Dataset spans 1986-2012)

Data Collection Methodology and Frequency

Using the RIM database, BWSR staff track the following information: type of easement, acreage, county, start date (i.e., date the easement is recorded at the courthouse), and funding source (i.e., paid or donated). Data from the RIM database is uploaded to the RIM website twice yearly in May and September.

Supporting Data Set

Table 2 contains the acreage under permanent conservation easements through RIM by 8-digit HUC, as well as the total agricultural acreage by 8-digit HUC derived through the NLCD dataset.

Table 2. Acreage under permanent conservation easement through RIM and total agricultural acreage from NLCD by 8-digit HUC to derive percent agricultural acreage under conservation easements within each 8-digit HUC

HUC8	NLCD 2006 Pasture/Hay (acres)	NLCD 2006 Cultivated Crops (acres)	Total NLCD Agriculture	BWSR Conservation Easements (acres)	Percent Conservation Easements
04010101	251	346	597	0	0.00%
04010102	8,088	656	8,744	0	0.00%
04010201	64,220	5,999	70,219	1	0.00%
04010202	4,546	493	5,038	0	0.00%
04010301	17,309	1,799	19,109	0	0.00%
04020300	6	2	9	0	0.00%
07010101	71,996	13,773	85,769	184	0.21%
07010102	29,768	4,334	34,102	538	1.58%
07010103	54,101	11,026	65,127	83	0.13%
07010104	161,571	108,288	269,859	5,202	1.93%
07010105	20,738	7,696	28,434	773	2.72%
07010106	143,492	126,483	269,975	1,175	0.44%
07010107	116,519	145,759	262,278	605	0.23%
07010108	118,441	150,375	268,816	2,588	0.96%
07010201	207,373	190,071	397,444	6,681	1.68%
07010202	161,108	333,713	494,821	1,660	0.34%
07010203	126,728	280,122	406,850	839	0.21%
07010204	134,538	525,184	659,722	5,164	0.78%
07010205	78,360	592,556	670,917	8,810	1.31%
07010206	65,082	52,434	117,517	286	0.24%
07010207	164,848	183,675	348,524	1,516	0.43%
07020001	30,780	328,027	358,807	4,701	1.31%
07020002	36,536	352,347	388,883	4,430	1.14%
07020003	34,307	365,658	399,965	7,625	1.91%
07020004	47,850	1,066,063	1,113,913	23,548	2.11%
07020005	104,517	913,106	1,017,623	22,614	2.22%
07020006	13,924	351,114	365,038	6,700	1.84%
07020007	22,222	656,913	679,134	13,698	2.02%
07020008	14,443	713,427	727,870	14,513	1.99%
07020009	5,966	643,771	649,737	8,456	1.30%
07020010	2,965	484,237	487,203	7,211	1.48%
07020011	9,881	586,803	596,684	8,341	1.40%
07020012	122,496	671,582	794,078	7,272	0.92%
07030001	23,976	7,517	31,494	1	0.00%

HUC8	NLCD 2006 Pasture/Hay (acres)	NLCD 2006 Cultivated Crops (acres)	Total NLCD Agriculture	BWSR Conservation Easements (acres)	Percent Conservation Easements
07030003	86,858	14,955	101,813	28	0.03%
07030004	124,826	54,365	179,192	441	0.25%
07030005	130,037	137,247	267,284	48	0.02%
07040001	43,927	156,210	200,137	382	0.19%
07040002	90,883	568,985	659,868	5,459	0.83%
07040003	70,721	123,252	193,973	738	0.38%
07040004	104,136	507,351	611,488	1,358	0.22%
07040006	14,186	2,201	16,387	194	1.18%
07040008	216,226	436,022	652,248	2,553	0.39%
07060001	27,875	20,885	48,760	714	1.46%
07060002	17,517	88,797	106,315	455	0.43%
07080102	75	7,009	7,083	38	0.54%
07080201	6,950	367,602	374,552	2,956	0.79%
07080202	2,964	107,888	110,852	1,701	1.53%
07080203	957	35,630	36,587	476	1.30%
07100001	11,857	647,304	659,161	6,463	0.98%
07100002	144	46,181	46,324	393	0.85%
07100003	306	109,092	109,399	1,376	1.26%
09020101	5,220	304,792	310,013	1,293	0.42%
09020102	7,817	465,522	473,339	2,502	0.53%
09020103	173,649	330,788	504,437	1,855	0.37%
09020104	5,641	268,935	274,576	1,513	0.55%
09020106	49,221	476,923	526,144	3,093	0.59%
09020107	3,133	199,060	202,193	1,531	0.76%
09020108	68,341	555,010	623,351	4,665	0.75%
09020301	16,610	293,147	309,756	659	0.21%
09020302	70,785	10,170	80,956	56	0.07%
09020303	46,450	507,434	553,884	855	0.15%
09020304	47,405	241,516	288,921	353	0.12%
09020305	158,421	288,569	446,990	574	0.13%
09020306	1,055	345,832	346,887	244	0.07%
09020309	14,917	392,096	407,013	321	0.08%
09020311	11,220	445,939	457,159	327	0.07%
09020312	34,669	448,266	482,936	226	0.05%
09020314	58,441	213,920	272,361	37	0.01%
09030001	358	129	487	0	0.00%

HUC8	NLCD 2006 Pasture/Hay (acres)	NLCD 2006 Cultivated Crops (acres)	Total NLCD Agriculture	BWSR Conservation Easements (acres)	Percent Conservation Easements
09030002	2,522	577	3,099	0	0.00%
09030003	2,302	1,709	4,011	0	0.00%
09030004	8,148	4,619	12,767	0	0.00%
09030005	18,390	6,281	24,672	0	0.00%
09030006	22,767	3,072	25,839	0	0.00%
09030007	6,124	5,839	11,963	7	0.06%
09030008	12,308	13,892	26,200	0	0.00%
09030009	30,224	48,459	78,683	5	0.01%
10170202	1,990	16,237	18,228	271	1.49%
10170203	22,960	252,756	275,716	960	0.35%
10170204	22,021	465,294	487,315	1,445	0.30%
10230003	798	166,435	167,233	887	0.53%

Caveats and Limitations

- Acquisition of agricultural land for conservation easements through RIM is dependent on available funding.
- BWSR does not track nutrient load reductions associated with easements under RIM, although BWSR is interested in doing so in the future.
- Not all agricultural lands are eligible for conservation easements under RIM. Specific eligibility criteria are contained in the RIM Eligibility Handbook. This measure assumes that all agricultural lands within an 8-digit HUC are eligible for purposes of the analysis, due to the challenge in spatially defining marginal agricultural land because this definition is based on land productivity. Therefore, the percent of agricultural land under conservation easements within each 8-digit HUC are likely lower than if the measure were to assess the percent of eligible agricultural land under conservation easements within each 8-digit HUC.
- There is the possibility for a small overlap between agricultural land reflected in the CRP program indicators and this measure for RIM. However, BWSR has stated that this overlap is not significant.

Future Improvements

Improvements to this measure will be made over time.

Ideally this measure will be able to focus on RIM eligible agricultural lands within each 8-digit HUC rather than all agricultural acreage to assess implementation trends. In addition, it would be helpful for BWSR to incorporate a mechanism for estimated nutrient load reductions associated with RIM conservation easements as part of the RIM database. BWSR is considering doing this in a future version of the RIM database.

Financial Considerations

Contributing Agencies and Funding Sources

This measure tracks the annual funding associated with permanent conservation easements acquired under RIM. BWSR establishes payment rates on an annual basis. Payment rates vary for land with a crop history versus land without a crop history. The basis for BWSR's payment rates are described in the RIM Eligibility Handbook (http://www.bwsr.state.mn.us/easements/handbook/rimeligibility.pdf)

References

Iowa State University. 2013. *Iowa Science Assessment of Nonpoint Source Practices to Reduce Nitrogen and Phosphorus Transport in the Mississippi River Basin*. May 2013. Section 2 of the Iowa Nutrient Reduction Strategy developed by Iowa Department of Agriculture and Land Stewardship, Iowa Department of Natural Resources, and Iowa State University College of Agriculture and Life Sciences.

MPCA. 2004. Detailed Assessment of Phosphorus Sources to Minnesota Watersheds. Minnesota Pollution Control Agency, St. Paul, MN. 280 pp + appendices.

MPCA. 2013. D1 Nitrogen Sources to Land and Waters - Results Overview. DRAFT 2013 (Dave Wall, David J. Mulla, and Steve Weiss, MPCA).

Measure Points of Contact

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Implementation of Nitrogen Fertilizer Management BMPs

Measure Background

Visual Depiction

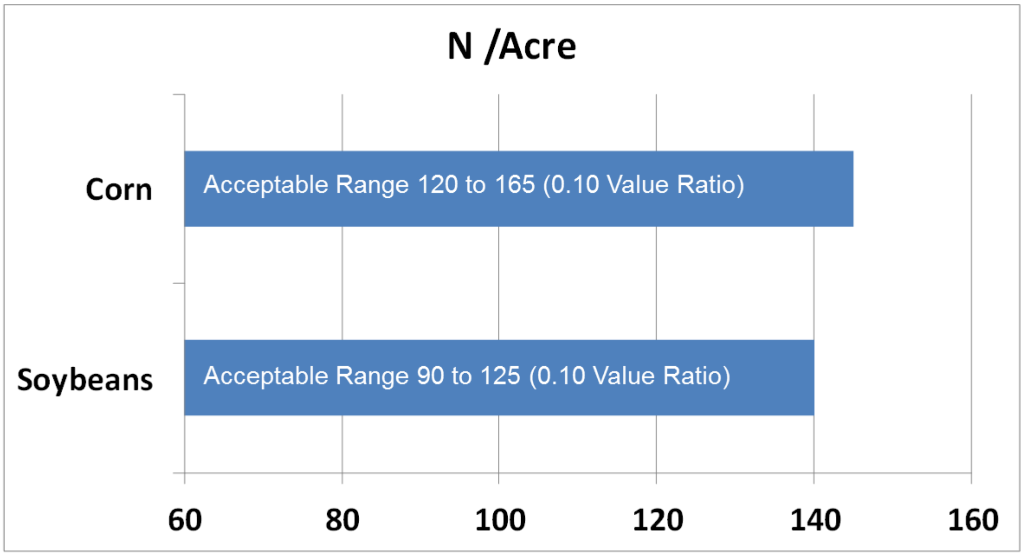

Figure 1. Nitrogen fertilizer application rates on non-manured corn following different crops in 2009 by surveyed farmers reporting on an average field

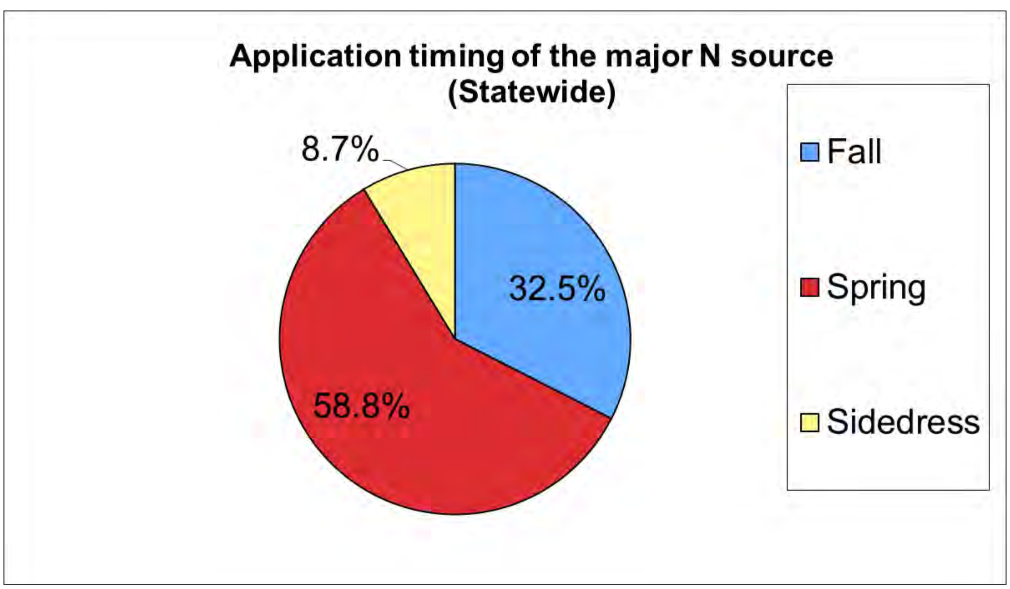

Figure 2. Statewide 2009 nitrogen fertilizer application timing on corn

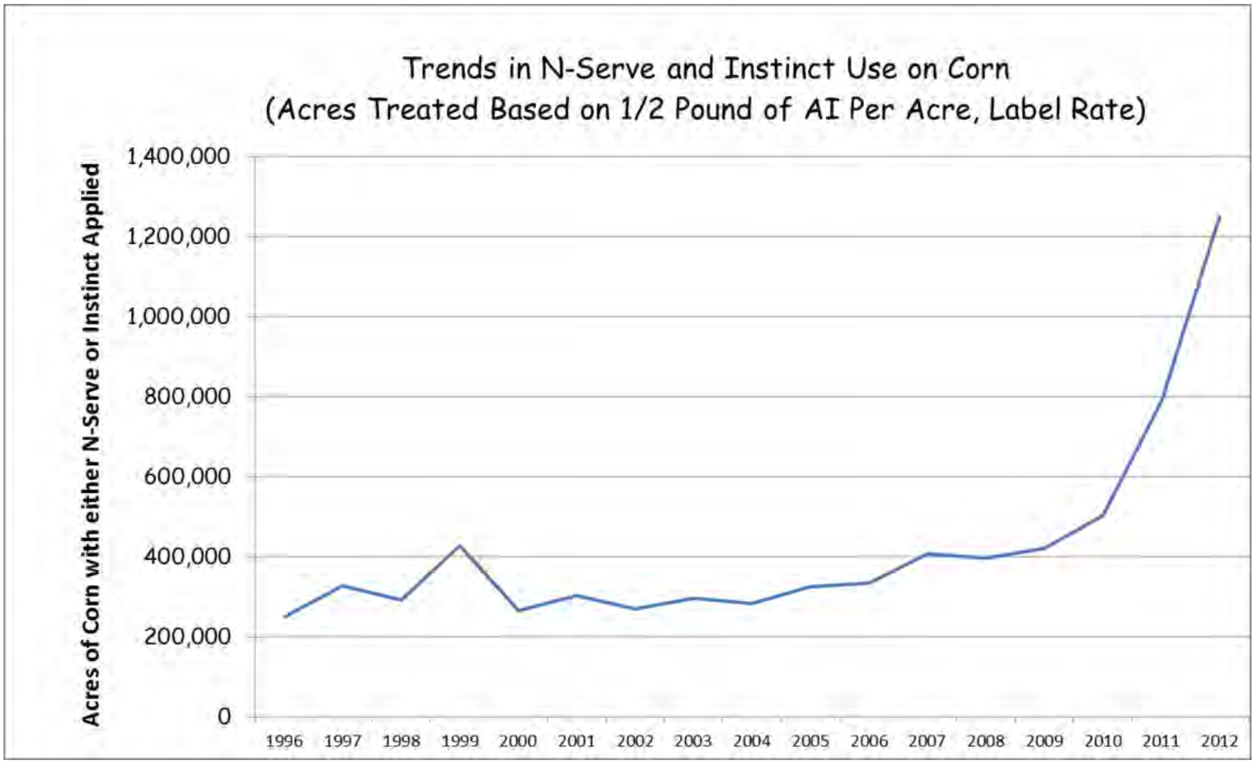

Figure 3. Statewide trends in nitrogen inhibitor use on corn

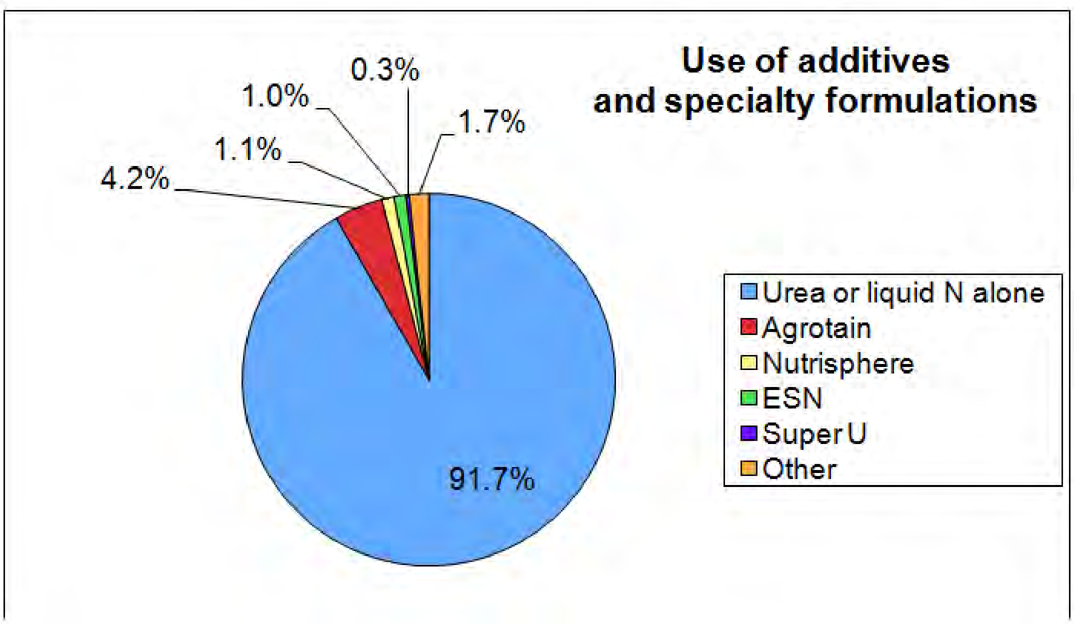

Figure 4. Use of additive and specialty formulations of urea and liquid nitrogen fertilizers applied to corn in 2009 by surveyed farmers reporting on average farm fields.

Measure Description

This measure is intended to communicate voluntary nitrogen fertilizer best management practices (BMPs) promoted through the Minnesota Department of Agriculture's (MDA) Nitrogen Fertilizer Management Plan (NFMP). The key voluntary nitrogen fertilizer BMPs are nitrogen fertilizer application rates on corn, nitrogen fertilizer application timing on corn, nitrogen inhibitor use on corn, and use of additive and specialty formulations of urea and liquid nitrogen fertilizers applied to corn.

Nitrogen Fertilizer Application Rates. Figure 1 shows the nitrogen fertilizer application rates on non-manured corn following different crops in 2009 by surveyed farmers reporting on average farm fields. According to Figure 1, nitrogen fertilizer application rates on corn following corn in 2009 fall within the acceptable nitrogen application rate range of 120-165 pounds (lbs)/acre of nitrogen. For corn following soybean, the nitrogen application rates exceed the acceptable range of 95-120 lbs/acre of nitrogen.

Nitrogen Fertilizer Application Timing. Figure 2 shows the nitrogen fertilizer application timing on corn in 2009 by surveyed farmers reporting on average farm fields, with 58.8 percent of surveyed farmers applying nitrogen fertilizer during the spring and 8.7 percent of surveyed farmers applying as a sidedress; both of these practices are better than fall applications.

Nitrogen Inhibitor Use. Figure 3 shows the statewide trends in nitrogen inhibitor use on corn from 1996-2012, with a steady increase in use over time.

Use of Additive and Specialty Formulations. Figure 4 shows the use of additive and specialty formulations of urea and liquid nitrogen fertilizers applied to corn in 2009 by surveyed farmers reporting on average farm fields, indicating that 91.7 percent of surveyed farmers use urea or liquid nitrogen fertilizer alone.

Table 1 below shows the estimated percent nitrogen and phosphorus removal associated with the nitrogen fertilizer BMPs presented in this measure. These efficiencies were derived from a comprehensive literature review.

Table 1. Estimated nutrient removal efficiencies for key nitrogen fertilizer BMPs

Best Management Practice	Nitrogen Removal (%)	Phosphorus Removal (%)
	Average[a]	Average[b]
Fertilizer Application Rates [From existing rates down to rates providing the maximum return to nitrogen value (133 lb/acre corn-soybean and 190 lb/acre on corn-corn)]	10	17
Fertilizer Application Timing		
From fall to spring pre-plant	6	NA
From fall to spring pre-plant/sidedress 40-60 split	5	NA
From pre-plant application to sidedress	7	NA
From pre-plant to sidedress – soil test based	4	NA
Nitrogen Inhibitor Use (From fall applied without inhibitor to fall applied with Nitrapyrin)	9	NA
Use of Additive and Specialty Formulations	Unknown	NA

a. MPCA, 2013
b. Iowa State University, 2013

Associated Terms and Phrases

To better understand this measure, it is necessary to understand a few program specific terms and phrases.

Nitrogen Fertilizer Application Timing: By moving application timing closer to the actual use of the crop reduces the potential for nitrogen fertilizer loss. Spring application is better than fall, and side-dress is better than spring.

Nitrogen Fertilizer Rate: University of Minnesota recommended fertilizer rates strive to maximize nitrogen use efficiency. They are also based to utilize carry-over nitrogen from previous crops (soybeans, alfalfa) and manure.

Nitrogen Fertilizer Variable Rate: Precision agriculture, through the use of GPS technology, can adjust nitrogen fertilizer application rates according to soil type within a field or crop condition in order to increase nitrogen use efficiency.

Inhibitors: Nitrification inhibitor delay the conversion of ammonia, an immobile form of nitrogen, to nitrate, which can move freely with soil water, or be lost to the atmosphere.

Nitrogen Fertilizer Formulations: Some urea nitrogen fertilizers are formulated to release nitrogen slowly so it is available closer to when the crop needs it.

Sidedress: Fertilizer application technique where fertilizer is applied beside the row after plant emergence; a better nitrogen fertilizer application practice than spring or fall application

Target

There is no specific numeric target for this measure to date.

Baseline

1996-2012 (nitrogen inhibitor only); statewide data reported during 2010 survey to reflect 2009 growing season

Geographical Coverage

Statewide

Data and Methodology

Methodology for Measure Calculation

These measures are based on information from the *2010 Survey of Nitrogen Fertilizer Use on Corn in Minnesota*.

Data Source

Minnesota Department of Agriculture

Data Collection Period

2010 for 2009 growing season (Figures 1, 2, 4)

1996-2012 (Figure 3)

Data Collection Methodology and Frequency

The MDA has partnered with the USDA National Agricultural Statistic Service (NASS) and University of Minnesota researchers to collect information about fertilizer use and farm management at the statewide level. Partners have pioneered a survey tool for characterizing fertilizer use and associated management on a regional and statewide scale. Surveys are conducted over the phone. The statewide fertilizer use survey will alternate every other year. Much of the focus will be on corn production, where 70 percent of the commercial inputs are used. The first attempt using this technique was in 2010. NASS enumerators surveyed approximately 1,500 corn farmers from across the state to gather information about commercial fertilizer use.

Project personnel collaborated with the Minnesota Department of Agriculture (MDA) to develop survey questions and MDA worked with the USDA National Agricultural Statistics Service (NASS), Minnesota Field Office to conduct the survey.

Farmers in the survey were from a database of the Minnesota Field Office of NASS. An initial pool of 7,000 farmers was randomly selected by NASS from their database of about 31,000 Minnesota farmers who have recently grown corn. The survey was carried out through phone interviews conducted at the North Dakota Field Office of NASS in Fargo. Interview staff were the same experienced interviewers that are routinely used to perform the regular surveys conducted by NASS. The survey consisted of 42 questions and it took about one-half hour to complete the interview with farmers who were able to finish the entire survey. Interviews and follow-up calls necessary to clarify some of the responses were conducted between February and June of 2010.

Interviewers were able to contact 4,461 of the initial pool of 7,000 farmers. Those not contacted were called more than once, but failed to answer the phone. Of the farmers contacted, 3,358 grew corn in 2009. The 2,769 farmers who continued the interview grew corn on 656,312 acres in 2009. Manure had been applied to 32% of these acres in the previous five years. The focus of the survey was use of manufactured N fertilizers, so to avoid the complicating effects of previous manure application on N fertilizer rates the farmers were asked to report on an average field with no manure applied in the last five years. The 866 farmers who did not have a field where no manure had been applied in the last five years were eliminated. Also eliminated were 407 of the remaining farmers who did not have a field where they knew the total amount of N applied per acre. This left 1,496 farmers, who grew corn on 482,812 acres in 2009. The survey results reported below are from this subsample of Minnesota corn farmers.

Supporting Data Set

Table 1. Nitrogen fertilizer rates on corn following different crops in 2009 by surveyed farmers reporting on an average field (Bierman et al. 2011).

Crop	N rate (lbs/acre)
Corn	145
Soybean	140

Caveats and Limitations

- The survey was restricted to nitrogen management on corn because corn is the most widely grown crop in Minnesota that requires nitrogen application and the majority of the nitrogen fertilizer applied in the state is used in corn production.
- Responses of individual farmers in this survey represent their “average” or “typical” nitrogen management practices. In some cases farmers may have strayed from the “average field”

restriction, especially as the interview progressed, and some of their answers may have reflected the entire range of the nitrogen management options they employed.

- The average size of the corn fields reported on by farmers in this survey was 81 acres.
- Information reported in the survey report broke Minnesota into BMP regions by groups of counties. Although the final survey report did report number of fields by county, it did not provide acreage associated with the number of fields captured in the survey. Therefore, it is difficult to analyze survey results at the 8-digit HUC scale.
- MDA does not track nitrogen load reductions associated with implementation of nitrogen BMPs.

Future Improvements

According to MDA, the next statewide nutrient fertilizer survey will include not only number of fields by county, but also the associated acreage. This will allow nitrogen fertilizer survey results to be further analyzed at the 8-digit HUC scale and included in an updated Strategy analysis.

Financial Considerations

Contributing Agencies and Funding Sources

This survey was supported by the MDA using dollars provided by the Clean Water Fund (from the Clean Water, Land and Legacy Amendment).

References

Iowa State University. 2013. *Iowa Science Assessment of Nonpoint Source Practices to Reduce Nitrogen and Phosphorus Transport in the Mississippi River Basin*. May 2013. Section 2 of the Iowa Nutrient Reduction Strategy developed by Iowa Department of Agriculture and Land Stewardship, Iowa Department of Natural Resources, and Iowa State University College of Agriculture and Life Sciences.

MPCA. 2013. D1 Nitrogen Sources to Land and Waters - Results Overview. DRAFT 2013 (Dave Wall, David J. Mulla, and Steve Weiss, MPCA).

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Implementation of Priority CRP Conservation Practices and Estimated Nutrient Load Reductions

Measure Background

Visual Depiction

The bar graphs below show the acreage and number of occurrences for two conservation practices funded through the Conservation Reserve Program (CRP) in Minnesota administered by the U.S. Department of Agriculture (USDA) Farm Service Agency (FSA). The two highlighted management practices (filter strips and riparian buffers) are considered priority water quality practices.

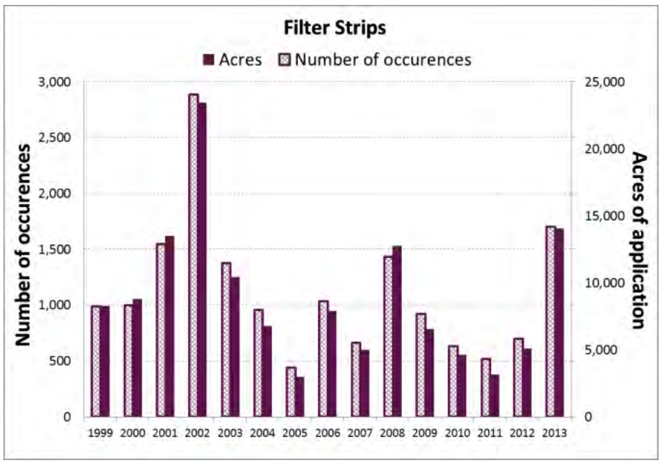

Figure 2. Number of occurrences and acres of application for filter strips funded by CRP from 1999-2013

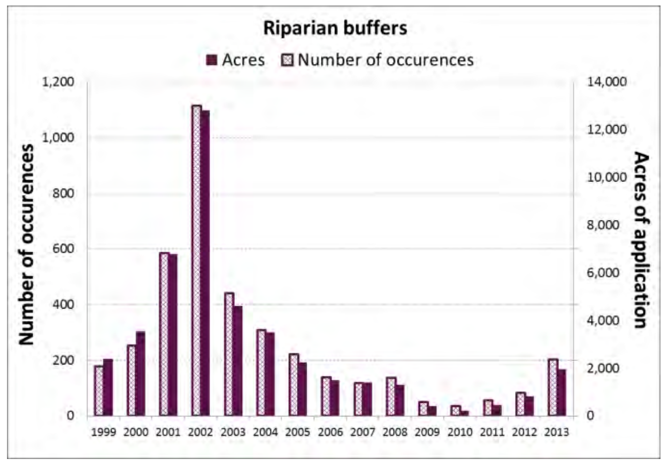

Figure 1. Number of occurrences and acres of application for riparian forested buffers funding by CRP from 1999-2013

Measure Description

This measure focuses on implementation trends for two key conservation practices funded by through CRP administered by FSA, as well as the estimated associated reduction in nutrients through implementation. It is an indirect or surrogate measure for the overall CRP program in Minnesota, focusing on conservation practices identified by FSA as key to reducing nutrient contributions from agricultural land eligible to receive funding through CRP.

Figure 1 shows the number and acreage of filter strips implemented through CRP in Minnesota from 1999-20013. As shown in Figure 1, the number and acreage associated with filter strips from 1999-2013 peaked in 2002, with a decline until 2006. In 2007, the number and acreage declined again, but rose in 2008. The number and acreage of filter strips declined during 2009-2011, with small gains made in 2012. During 2013, the number and acreage of filter strips exceeded 2008 levels, but have not achieved the 2002 peak year quantities.

Figure 2 shows the number and acreage of riparian forested buffers implemented through CRP in Minnesota. According to Figure 2, the number and acreage of riparian forested buffers peaked in 2002 and steadily declined until a slight uptick in 2008, with further decline in 2009 and 2010. The number and acreage of riparian forested buffers funded through CRP increased slightly in 2011 and 2012, with a return to 2005 levels in 2013.

Table 1 below shows the estimated percent nitrogen and phosphorus removal associated with these practices.

Table 1. Estimated nutrient removal efficiencies for two key CRP practices

Best Management Practice	Phosphorus Removal (%)	Nitrogen Removal (%)
Filter Strips[1]	65	27
Riparian Buffers[2]	95	58

[1] Miller et al., 2012
[2] MPCA 2013; Iowa State, 2013

Associated Terms and Phrases

To better understand this measure, it is necessary to understand a few specific terms and phrases. Definitions used in this measure are as follows:

Conservation Reserve Program (CRP): a land conservation program administered by the Farm Service Agency (FSA). In exchange for a yearly rental payment, farmers enrolled in the program agree to remove environmentally sensitive land from agricultural production and plant species that will improve environmental health and quality. Contracts for land enrolled in CRP are 10-15 years in length. The long-term goal of the program is to re-establish valuable land cover to help improve water quality, prevent soil erosion, and reduce loss of wildlife habitat.

Filter strips: an area of permanent herbaceous vegetation used to reduce sediment, organics, nutrients, pesticides, and other contaminant loadings in runoff. Filter strips provide a buffer between fields and water bodies and allow for settling out of suspended soil particles, infiltration of runoff and soluble pollutants, adsorption of pollutants on soil and plant surfaces, and uptake of soluble pollutants by plants. Conservation Practice 21/Minn. NRCS Conservation Practice Standard (393). More information on the design standards is available at http://efotg.sc.egov.usda.gov/references/public/MN/393mn.pdf

Riparian buffers: an area of trees and shrubs located adjacent to streams, lakes, ponds, or wetlands. Riparian forest buffers of sufficient width intercept sediment, nutrients, pesticides, and other materials in surface runoff and reduce nutrients and other pollutants in shallow subsurface water flow. Buffers are located along or around permanent or intermittent streams, lakes, ponds, wetlands, or seeps. Conservation Practice 22/Minn. NRCS Conservation Practice Standard (391). More information on the design standards is available at http://efotg.sc.egov.usda.gov/references/public/MN/391mn.pdf

Target

There is no specific numeric target for this measure to date.

Baseline

Covers 1999-2013 (through May)

Geographical Coverage

Statewide

Data and Methodology

Methodology for Measure Calculation

FSA tracks specific information related to CRP implementation and sign-ups over time. A variety of CRP reports are made available on the FSA CRP website https://arcticocean.sc.egov.usda.gov/CRPReport/monthly_report.do?method=selectMonthlyReport&report=May-2013

To calculate this measure, information on annual practice acres and practice occurrences for CP-21 and CP-22 were extracted from FSA's CRP report entitled SUMMARY OF ACTIVE CONTRACTS BY PROGRAM YEAR BY STATE CRP - MONTHLY CONTRACTS REPORT for Minnesota . This information was placed into an Excel spreadsheet to generate the bar graphs shown in Figures 1 and 2.

Data Source

USDA-FSA Minnesota State Office

Data Collection Period

1999 through 2013

Data Collection Methodology and Frequency

FSA is in the process of transferring to a new data management system for CRP information. Information from October 2012 to present is contained in the new data management system. Information prior to October 2012 remains in the old system. Eventually, all data will be housed in the new data management system.

Supporting Data Set

Table 2 provided below contains practice acreage and number of occurrences for filter strips (CP-21) and riparian buffers (CP-22) from 1999-2013 as available in FSA's CRP report entitled SUMMARY OF ACTIVE CONTRACTS BY PROGRAM YEAR BY STATE CRP - MONTHLY CONTRACTS REPORT for Minnesota.

Table 2. Practice acreage and number of occurrences for filter strips (CP-21) and riparian buffers (CP-22) funded by FSA through the CRP program by year

Year	Practice	Acres	Number of Occurrences
1999	Filter strips	8,275.10	991
2000	Filter strips	8,775.50	998
2001	Filter strips	13,500.20	1547
2002	Filter strips	23,433.90	2884
2003	Filter strips	10,442.40	1374
2004	Filter strips	6,756.10	958
2005	Filter strips	2,996.50	442
2006	Filter strips	7,869.60	1034
2007	Filter strips	4,990.30	665
2008	Filter strips	12,740.10	1435
2009	Filter strips	6,535.70	920
2010	Filter strips	4,609.20	634
2011	Filter strips	3,166.00	518
2012	Filter strips	5,105.60	698
2013	Filter strips	14,071.10	1700
1999	Riparian buffers	2,394.60	178
2000	Riparian buffers	3,545.50	253
2001	Riparian buffers	6,789.10	586
2002	Riparian buffers	12,811.50	1116
2003	Riparian buffers	4,600.70	442
2004	Riparian buffers	3,510.20	308
2005	Riparian buffers	2,246.10	221
2006	Riparian buffers	1,492.00	140
2007	Riparian buffers	1,391.70	118
2008	Riparian buffers	1,295.80	137
2009	Riparian buffers	418.7	51
2010	Riparian buffers	207.6	35
2011	Riparian buffers	470.4	57
2012	Riparian buffers	814.9	84
2013	Riparian buffers	1,968.20	204

Caveats and Limitations

- This measure only tracks two priority management practices funded by FSA through CRP conservation payments.
- Implementation of these management practices are largely determined by the amount of funding available annually through Minnesota's CRP program.
- FSA does not track nutrient load reductions associated with management activities implemented under CRP.
- Land enrolled in other conservation programs is eligible under CRP provided CRP does not pay for the same practice on the same land as any other USDA program. As a result, acreage captured under this measure might also be captured under other program indicators.
- The use of two data management systems creates challenges for easily reporting practice information by county. Current county-specific CRP reports provided by FSA do not specify individual practice acreages and occurrences. Lack of county-specific information for each practice over time does not allow the acreage information to be incorporated into the Strategy's 8-digit HUC analysis of implementation.

Future Improvements

Improvements to this measure will be made over time. Ideally this measure will be able to report on implementation of the two key practices by 8-digit HUC, as well as compare estimated nutrient load reductions. It would be helpful for FSA to incorporate a mechanism for estimated nutrient load reductions associated with CRP practices as part of programmatic tracking, possibly through CRP reporting requirements. However, this would require a national change in approach because CRP is a federal program.

Financial Considerations

Contributing Agencies and Funding Sources

This measure only tracks the two priority management practices identified by FSA funded using CRP to make conservation payments. Payment rates for each management practice vary annually.

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Measure Points of Contact

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Implementation of Priority EQIP Management Practices and Estimated Nutrient Load Reductions

Measure Background

Visual Depiction

The maps and charts below provide a representative summary of the extent of implementation of key management practices through the Environmental Quality Incentives Program (EQIP) administered by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). The three management practices (nutrient management, residue management, and forage and biomass (pasture/hayland) planting) are considered priority practices for nutrient reductions in Minnesota by NRCS. The maps show the percentage of eligible agricultural acreage in each county (by major basin) enrolled in the three management practices. The bar graphs show the annual number of EQIP contracts for each practice and the associated acreage.

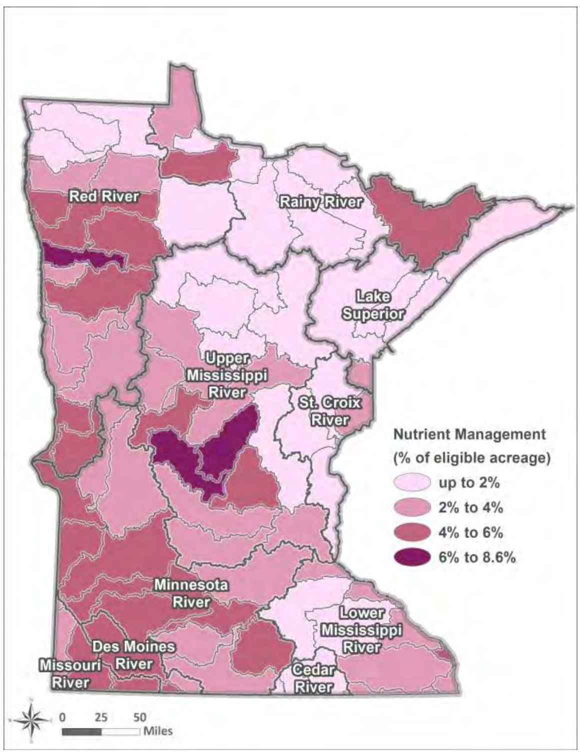

Figure 1. Percent of eligible acreage implementing nutrient management through EQIP by 8-digit HUC

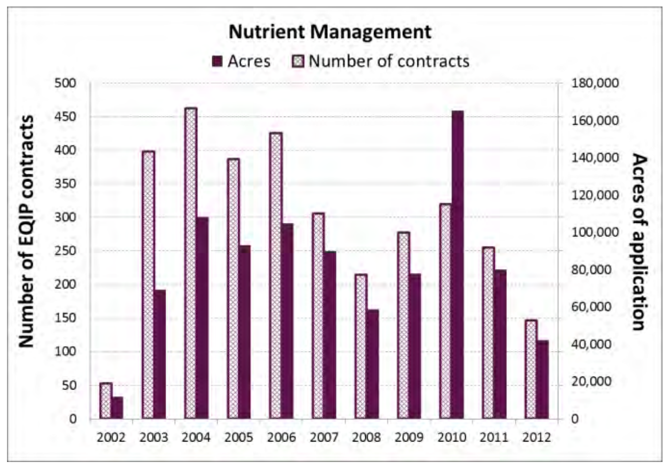

Figure 2. Annual trends in nutrient management implementation through EQIP by acres of application and number of EQIP contracts

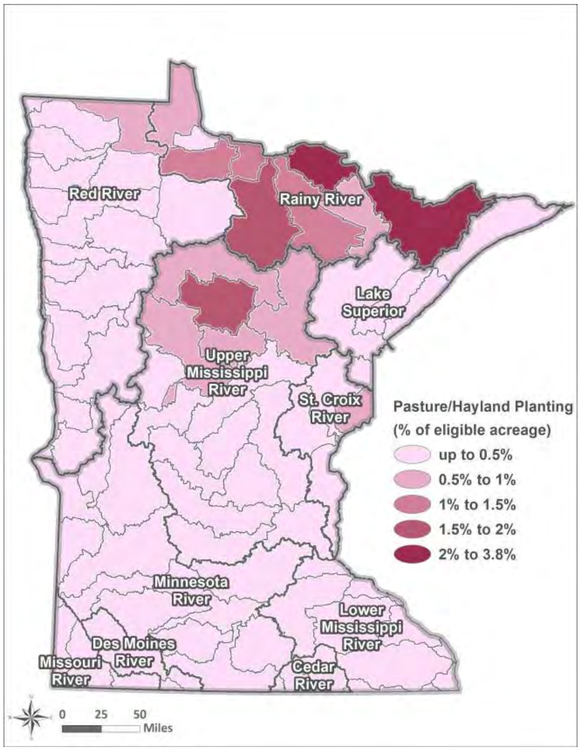

Figure 4. Percent of eligible acreage implementing forage and biomass (pasture/hayland) planting through EQIP by 8-digit HUC

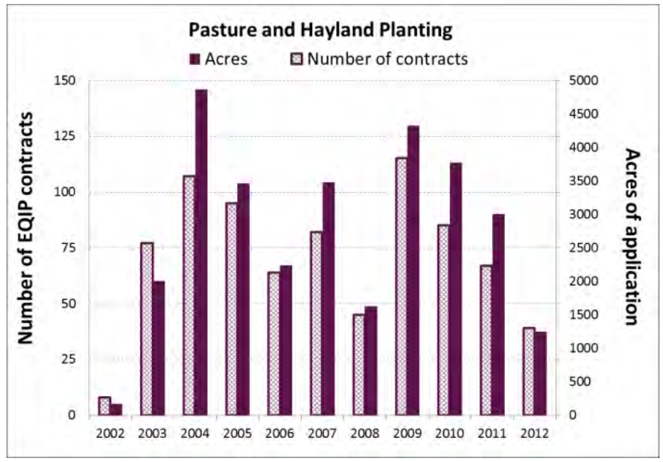

Figure 5. Annual trends in forage and biomass (pasture/hayland) planting implementation through EQIP by acres of application and number of EQIP contracts

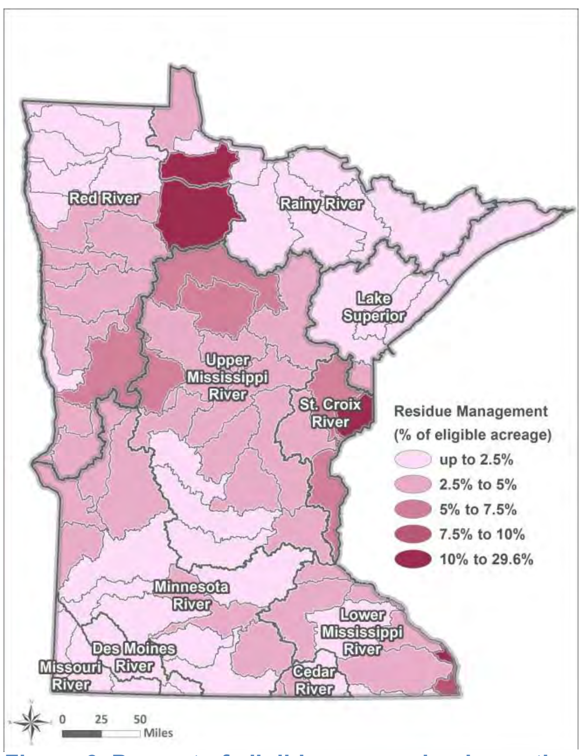

Figure 6. Percent of eligible acreage implementing residue management through EQIP by 8-digit HUC

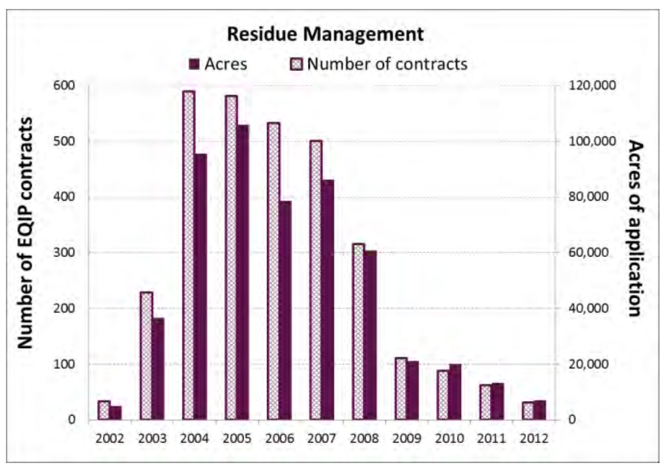

Figure 3. Annual trends in residue management implementation through EQIP by acres of application and number of EQIP contracts

Measure Description

This measure focuses on the extent of implementation of three priority management practices within Minnesota's 8 digit HUCs funded by NRCS under EQIP, the annual enrollment trends for these management practices, and the estimated associated reduction in nutrients through implementation. It is an indirect or surrogate measure for the overall EQIP program in Minnesota, focusing on management practices identified by NRCS as key to reducing nutrient contributions from agricultural land eligible to receive funding through EQIP. The analysis of the measures for each priority management practice is provided below.

Nutrient Management. Figure 1 shows the percentage of eligible agricultural acreage on which nutrient management funded through EQIP is being implemented by 8-digit HUC. According to this figure, only three 8-digit HUCs have between 6-8 percent of eligible agricultural acreage with nutrient management implementation through EQIP. The 8-digit HUCs in the southwest portion of the state have between 2-6 percent of eligible agricultural acreage under nutrient management via EQIP. Figure 2 shows the annual acreage enrolled in EQIP for nutrient management has vacillated since 2000, with a spike in enrolled acreage in 2010. Since that spike, acreage has declined.

Forage and Biomass (Pasture/Hayland) Planting. Figure 4 shows the percentage of eligible agricultural acreage on which forage and biomass planting funded through EQIP is being implemented by 8-digit HUC. According to this figure, forage and biomass planting is occurring in northern 8-digit HUCs, with up to 0.5 percent occurring in a majority of the state. Figure 5 shows a spike in enrolled acreage for this practice in 2004, with a decline until 2007, a significant drop off in acreage in 2008, and despite an increase in 2009, a steady decline through 2012.

Residue Management. Figure 6 shows the percentage of eligible agricultural acreage on which residue management funded through EQIP is being implemented by 8-digit HUC. According to this figure, three 8-digit HUCs have 10-29.6 percent of eligible acreage enrolled in contracts for residue management under EQIP. A majority of 8-digit HUCs in the state have between 5-7.9 percent of eligible agricultural land enrolled in contracts under EQIP for residue management. According to Figure 3, the amount of acreage enrolled in residue management spiked in 2005, declined in 2006, and spiked again in 2007. From 2007, the total acreage enrolled in this management practice under EQIP contracts steadily declined.

Table 1 shows the estimated percent nitrogen and phosphorus removal associated with these practices. These efficiencies were derived from a comprehensive literature review.

Table 1. Estimated nutrient removal efficiencies for three key EQIP practices

Best Management Practice	Subcategory (if applicable)	Nitrogen Removal (%)	Phosphorus Removal (%)
Residue Management[a]	Cover Crops	51	29
	Conservation Tillage	0	63
Nutrient Management[b]		16	24
Forage and Biomass Planting[b]		95	59

a. Miller et al 2012; MPCA Nitrogen Study, 2013; Iowa Nutrient Reduction Strategy, 2013; Simpson and Weammert, 2009
b. MPCA Nitrogen Study, 2013; Iowa Nutrient Reduction Strategy, 2013

Associated Terms and Phrases

To better understand this measure, it is necessary to understand a few specific terms and phrases. Definitions used in this measure are as follows:

Eligible agricultural land: Pasture/hay and cultivated crops on one of the three practices that could be implemented under EQIP contracts

Residue management: According to the NRCS Conservation Practice Standard, this management activity (Codes 329, 329A, 329B, 329C, 345, 346) is defined as managing the amount, orientation, and distribution of crop and other plant residue on the soil surface year-round, while limiting the soil disturbing activities used to grow crops in systems where the entire field surface is tilled prior to planting. This practice is intended to reduce sheet and rill erosion; wind erosion; soil particulate emissions; and maintain or improve soil condition. It applies to all cropland. More information on the practices that fall under this category from the Minnesota NRCS Field Office Technical Guide (FOTG) is available at http://efotg.sc.egov.usda.gov/treemenuFS.aspx

Nutrient management: According to the NRCS Conservation Practice Standard, this management activity (Code 590) is defined as managing the amount, source, placement, form, and timing of the application of nutrients and soil amendments. The criteria for this practice are intended to minimize nutrient entry into surface water, groundwater, and atmospheric resources while maintaining and improving the physical, chemical, and biological condition of the soil. The standard for this conservation practice applies to all fields where plant nutrient sources and soil amendments are applied during the course of a rotation. More information on this conservation practice from the Minnesota NRCS FOTG is available at http://efotg.sc.egov.usda.gov/references/public/MN/590mn.pdf

Forage and biomass (pasture/hayland) planting: According to the NRCS Conservation Practice Standard, this management activity (Codes 512) is defined as establishing adapted and/or compatible species, varieties, or cultivars of herbaceous species suitable for pasture, hay, or biomass production. This practice is intended to reduce soil erosion and improve soil and water quality. This practice applies to all lands suitable to the establishment of annual, biennial or perennial species for forage or biomass production. This practice does not apply to the establishment of annually planted and harvested food, fiber, or oilseed crops. More information on this conservation practice from the Minnesota NRCS FOTG is available at http://efotg.sc.egov.usda.gov/references/public/MN/512mn.pdf

Target

There is no specific numeric target for this measure to date.

Baseline

Covers 2000-2012 EQIP data

Geographical Coverage

Statewide, by major basin, by 8-digit HUC

Data and Methodology

Methodology for Measure Calculation

NRCS tracks specific information related to EQIP implementation and participation over time. Information tracked includes type of management practice, county, acreage treated, enrollment date, and contract length, in addition to associated financial information such as payment rate and payment schedules.

To calculate this measure, NRCS compiled information on the acreage treated under residue management, nutrient management, and forage and biomass (pasture/hayland) planting practices by county. The county information was then mapped according to 8-digit HUC. This information was then compared to the total acreage in each 8-digit HUC that is potentially eligible for these management practices under EQIP. Potentially eligible acreage for each 8-digit HUC was derived using NLCD land use/land cover data, focusing on coverages for pasture/hay and cultivated crops. This information was then mapped using GIS to show implementation of each management practice as a percentage of the total eligible acreage within each 8-digit HUC by major basin. Table 1 under Supporting Data Set presents the breakdown of treated acreage for each management practice by 8-digit HUC, as well as total eligible acreage, used to derive the maps for this measure. Table 2 presents the annual number of contracts and acreage for each management practice.

Data Source

- Minnesota USDA-NRCS State Agronomist
- NLCD for agricultural land use/land cover

Data Collection Period

2000 through 2012.

Data Collection Methodology and Frequency

The data presented in the measure is reported by NRCS field offices once the BMP implementation has been certified. Data are obtained directly from NRCS as provided in http://prohome.nrcs.usda.gov.

Each county field office is responsible to verify and certify that each practice has been completed to NRCS standards and specifications. Once certified the practice is entered into our payment software and producer is paid for the practice. Practice is considered planned and certified and becomes available for querying of data.

Supporting Data Set

Table 2 contains treated acreage by county tracked by NRCS for the three priority management practices, as well as the potential eligible agricultural acreage derived through the NLCD dataset. Table 3 presents the data on an annual basis.

Table 2. Acreage treated by three priority management practices funded through EQIP (2000-2012) and total eligible agricultural lands by 8-digit HUC used to derive percent implementation

HUC8	NLCD 2006 Pasture/ Hay (acres)	NLCD 2006 Cultivated Crops (acres)	Total NLCD Agriculture	EQIP Nutrient Management (acres)	EQIP Forage and Biomass Plantings (acres)	EQIP Residue Management (acres)	Percent Nutrient Management	Percent Pasture/Hay	Percent Residue Management
04010101	251	346	597	0	0	0	0.00%	0.00%	0.00%
04010102	8,088	656	8,744	7	5	0	0.08%	0.05%	0.00%
04010201	64,220	5,999	70,219	401	124	36	0.57%	0.18%	0.60%
04010202	4,546	493	5,038	21	14	0	0.42%	0.27%	0.00%
04010301	17,309	1,799	19,109	466	69	77	2.44%	0.36%	4.28%
04020300	6	2	9	0	0	0	0.02%	0.01%	0.00%
07010101	71,996	13,773	85,769	570	610	882	0.66%	0.71%	6.40%
07010102	29,768	4,334	34,102	571	608	319	1.67%	1.78%	7.36%
07010103	54,101	11,026	65,127	240	467	403	0.37%	0.72%	3.66%
07010104	161,571	108,288	269,859	9,077	531	5,042	3.36%	0.20%	4.66%
07010105	20,738	7,696	28,434	97	231	205	0.34%	0.81%	2.66%
07010106	143,492	126,483	269,975	6,003	1,355	3,453	2.22%	0.50%	2.73%
07010107	116,519	145,759	262,278	8,523	631	7,977	3.25%	0.24%	5.47%
07010108	118,441	150,375	268,816	12,571	485	5,553	4.68%	0.18%	3.69%
07010201	207,373	190,071	397,444	29,638	278	9,346	7.46%	0.07%	4.92%
07010202	161,108	333,713	494,821	42,492	303	7,301	8.59%	0.06%	2.19%
07010203	126,728	280,122	406,850	18,585	215	7,486	4.57%	0.05%	2.67%
07010204	134,538	525,184	659,722	25,173	336	11,687	3.82%	0.05%	2.23%
07010205	78,360	592,556	670,917	26,264	293	9,934	3.91%	0.04%	1.68%
07010206	65,082	52,434	117,517	2,590	45	2,567	2.20%	0.04%	4.90%
07010207	164,848	183,675	348,524	6,680	515	7,766	1.92%	0.15%	4.23%
07020001	30,780	328,027	358,807	19,036	82	10,610	5.31%	0.02%	3.23%
07020002	36,536	352,347	388,883	8,170	217	11,204	2.10%	0.06%	3.18%

HUC8	NLCD 2006 Pasture/ Hay (acres)	NLCD 2006 Cultivated Crops (acres)	Total NLCD Agriculture	EQIP Nutrient Management (acres)	EQIP Forage and Biomass Plantings (acres)	EQIP Residue Management (acres)	Percent Nutrient Management	Percent Pasture/Hay	Percent Residue Management
07020003	34,307	365,658	399,965	18,606	81	9,591	4.65%	0.02%	2.62%
07020004	47,850	1,066,063	1,113,913	56,735	326	23,661	5.09%	0.03%	2.22%
07020005	104,517	913,106	1,017,623	24,885	577	25,820	2.45%	0.06%	2.83%
07020006	13,924	351,114	365,038	19,655	205	5,125	5.38%	0.06%	1.46%
07020007	22,222	656,913	679,134	27,273	206	18,347	4.02%	0.03%	2.79%
07020008	14,443	713,427	727,870	31,898	268	15,957	4.38%	0.04%	2.24%
07020009	5,966	643,771	649,737	13,622	233	8,026	2.10%	0.04%	1.25%
07020010	2,965	484,237	487,203	18,052	50	10,966	3.71%	0.01%	2.26%
07020011	9,881	586,803	596,684	24,218	172	18,308	4.06%	0.03%	3.12%
07020012	122,496	671,582	794,078	31,205	237	14,781	3.93%	0.03%	2.20%
07030001	23,976	7,517	31,494	1,103	274	804	3.50%	0.87%	10.69%
07030003	86,858	14,955	101,813	1,745	394	896	1.71%	0.39%	5.99%
07030004	124,826	54,365	179,192	1,704	326	1,402	0.95%	0.18%	2.58%
07030005	130,037	137,247	267,284	939	485	10,031	0.35%	0.18%	7.31%
07040001	43,927	156,210	200,137	5,492	244	5,360	2.74%	0.12%	3.43%
07040002	90,883	568,985	659,868	13,193	423	22,405	2.00%	0.06%	3.94%
07040003	70,721	123,252	193,973	6,209	298	4,503	3.20%	0.15%	3.65%
07040004	104,136	507,351	611,488	10,985	476	11,866	1.80%	0.08%	2.34%
07040006	14,186	2,201	16,387	965	41	652	5.89%	0.25%	29.62%
07040008	216,226	436,022	652,248	22,685	443	13,284	3.48%	0.07%	3.05%
07060001	27,875	20,885	48,760	1,312	91	1,835	2.69%	0.19%	8.79%
07060002	17,517	88,797	106,315	3,106	41	1,765	2.92%	0.04%	1.99%
07080102	75	7,009	7,083	176	0	110	2.49%	0.00%	1.57%
07080201	6,950	367,602	374,552	7,382	50	7,787	1.97%	0.01%	2.12%
07080202	2,964	107,888	110,852	509	40	3,491	0.46%	0.04%	3.24%

HUC8	NLCD 2006 Pasture/ Hay (acres)	NLCD 2006 Cultivated Crops (acres)	Total NLCD Agriculture	EQIP Nutrient Management (acres)	EQIP Forage and Biomass Plantings (acres)	EQIP Residue Management (acres)	Percent Nutrient Management	Percent Pasture/Hay	Percent Residue Management
07080203	957	35,630	36,587	146	11	973	0.40%	0.03%	2.73%
07100001	11,857	647,304	659,161	37,601	157	9,841	5.70%	0.02%	1.52%
07100002	144	46,181	46,324	1,978	22	561	4.27%	0.05%	1.21%
07100003	306	109,092	109,399	3,024	49	901	2.76%	0.04%	0.83%
09020101	5,220	304,792	310,013	13,146	36	7,943	4.24%	0.01%	2.61%
09020102	7,817	465,522	473,339	19,543	118	13,069	4.13%	0.02%	2.81%
09020103	173,649	330,788	504,437	19,772	919	20,858	3.92%	0.18%	6.31%
09020104	5,641	268,935	274,576	8,291	20	5,652	3.02%	0.01%	2.10%
09020106	49,221	476,923	526,144	12,361	301	12,137	2.35%	0.06%	2.54%
09020107	3,133	199,060	202,193	7,337	48	6,084	3.63%	0.02%	3.06%
09020108	68,341	555,010	623,351	35,055	854	15,791	5.62%	0.14%	2.85%
09020301	16,610	293,147	309,756	19,266	321	9,311	6.22%	0.10%	3.18%
09020302	70,785	10,170	80,956	75	221	1,239	0.09%	0.27%	12.18%
09020303	46,450	507,434	553,884	29,146	1,572	14,536	5.26%	0.28%	2.86%
09020304	47,405	241,516	288,921	8,839	708	4,153	3.06%	0.24%	1.72%
09020305	158,421	288,569	446,990	26,186	2,146	12,209	5.86%	0.48%	4.23%
09020306	1,055	345,832	346,887	17,409	391	8,186	5.02%	0.11%	2.37%
09020309	14,917	392,096	407,013	10,337	730	4,391	2.54%	0.18%	1.12%
09020311	11,220	445,939	457,159	6,850	1,090	6,593	1.50%	0.24%	1.48%
09020312	34,669	448,266	482,936	5,021	1,713	8,036	1.04%	0.35%	1.79%
09020314	58,441	213,920	272,361	4,628	1,656	4,745	1.70%	0.61%	2.22%
09030001	358	129	487	28	18	0	5.84%	3.78%	0.00%
09030002	2,522	577	3,099	35	23	0	1.13%	0.73%	0.00%
09030003	2,302	1,709	4,011	65	124	10	1.61%	3.08%	0.60%
09030004	8,148	4,619	12,767	70	172	16	0.55%	1.35%	0.35%

HUC8	NLCD 2006 Pasture/ Hay (acres)	NLCD 2006 Cultivated Crops (acres)	Total NLCD Agriculture	EQIP Nutrient Management (acres)	EQIP Forage and Biomass Plantings (acres)	EQIP Residue Management (acres)	Percent Nutrient Management	Percent Pasture/Hay	Percent Residue Management
09030005	18,390	6,281	24,672	139	289	31	0.56%	1.17%	0.49%
09030006	22,767	3,072	25,839	177	446	68	0.69%	1.73%	2.20%
09030007	6,124	5,839	11,963	512	154	647	4.28%	1.29%	11.08%
09030008	12,308	13,892	26,200	292	43	286	1.11%	0.17%	2.06%
09030009	30,224	48,459	78,683	1,904	514	1,897	2.42%	0.65%	3.91%
10170202	1,990	16,237	18,228	667	9	402	3.66%	0.05%	2.47%
10170203	22,960	252,756	275,716	10,364	215	5,224	3.76%	0.08%	2.07%
10170204	22,021	465,294	487,315	22,400	233	11,005	4.60%	0.05%	2.37%
10230003	798	166,435	167,233	7,436	61	3,026	4.45%	0.04%	1.82%

Table 3. Annual number of EQIP contracts for key management practices and associated acreage (2002-2012)

Year	Key EQIP Management Practices					
	Nutrient Management		Residue Management		Forage and Biomass Plantings	
	Contracts	Acreage	Contracts	Acreage	Contracts	Acreage
2002	53	11,924	33	5,077	8	171
2003	398	69,065	229	36,645	77	2,005
2004	463	108,405	590	95,498	107	4,866
2005	387	93,183	581	105,893	95	3,468
2006	426	105,022	533	78,553	64	2,241
2007	306	90,129	501	86,265	82	3,481
2008	215	58,814	316	60,742	45	1,629
2009	278	77,981	111	21,133	115	4,326
2010	320	165,510	88	20,059	85	3,779
2011	255	79,988	62	13,168	67	3,007
2012	147	42,264	31	7,004	39	1,246

Caveats and Limitations

- This measure only tracks three priority management practices funded by NRCS through EQIP conservation payments.
- Implementation of these management practices are largely determined by the amount of funding available annually through Minnesota's EQIP program.
- NRCS tracks information by county, not by 8-digit HUC. Providing data by 8-digit HUC requires additional analysis.
- NRCS does not track nutrient load reductions associated with management activities implemented under EQIP.
- Treated acreage is reported by EQIP applicants.
- Land enrolled in other conservation programs is eligible under EQIP provided EQIP does not pay for the same practice on the same land as any other USDA program. As a result, acreage captured under this measure might also be captured under other program indicators.
- Contact length versus implementation timeframe

Future Improvements

Improvements to this measure will be made over time.

Ideally this measure will be able to compare estimated nutrient load reductions for more EQIP conservation practices that affect nutrient loads. In addition, it would be helpful for NRCS to incorporate a mechanism for estimated nutrient load reductions associated with EQIP conservation practices as part of programmatic tracking, possibly through EQIP reporting requirements. However, this would require a national change in approach because EQIP is a federal program.

Financial Considerations

Contributing Agencies and Funding Sources

This measure only tracks the three priority management practices identified by NRCS funded using EQIP to make conservation payments. Payment rates for each management practice vary annually.

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Measure Points of Contact

Agency Information

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Implementation of Conservation Tillage Funded through AgBMP Loans

Measure Background

Visual Depiction

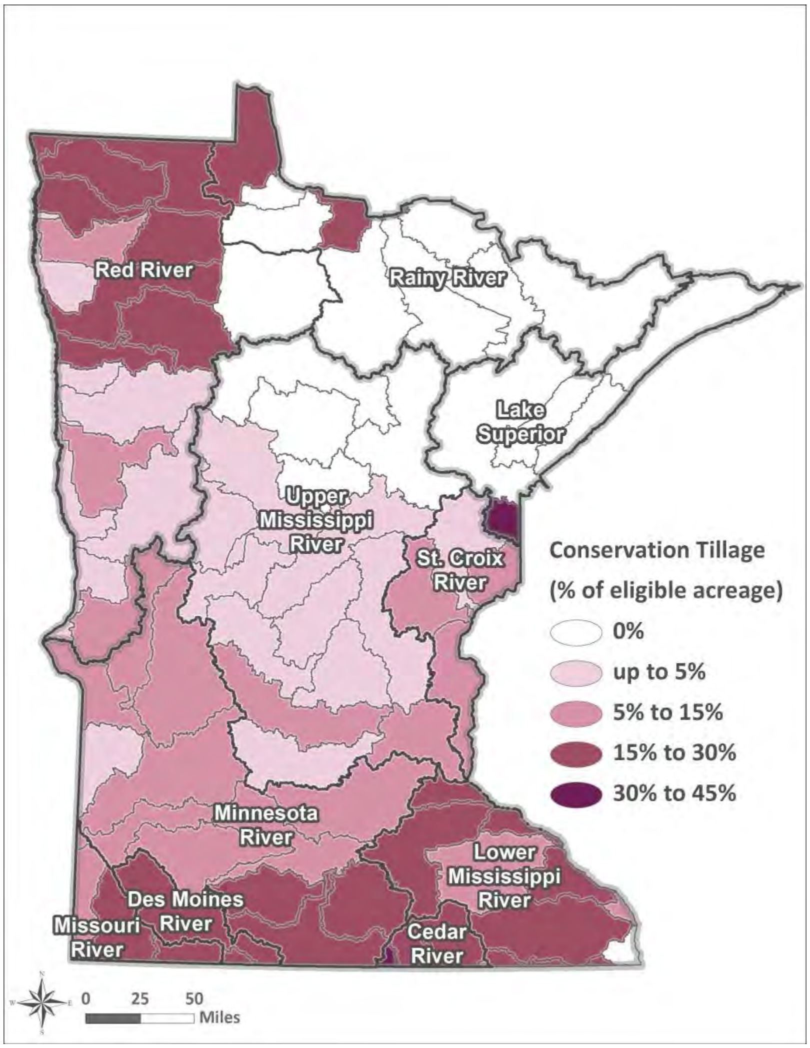

Figure 1. Percentage of agricultural acreage under conservation tillage funded through the AgBMP Loan Program by 8-digit HUC

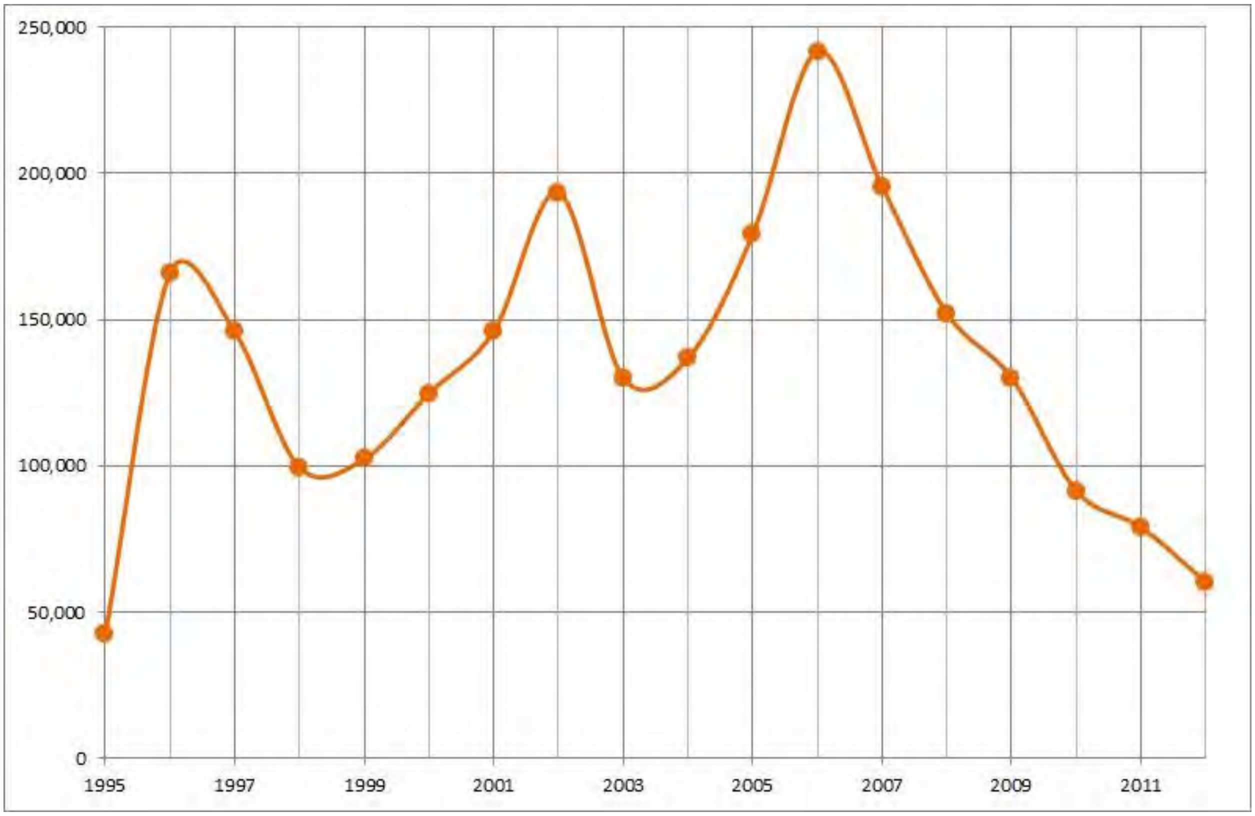

Figure 2. Acreage of agricultural land in Minnesota under conservation tillage through AgBMP Loan Program by year

Measure Description

This measure communicates the acreage of agricultural land under conservation tillage as reported by borrowers receiving loans through the Minnesota Department of Agriculture's (MDA's) AgBMP Loan Program. Acreage under conservation tillage in Figure 1 is shown by 8-digit HUC. According to Figure 1, higher percentages of agricultural acreage is under conservation tillage through the AgBMP Loan Program in northwest and southern Minnesota.

Figure 2 shows the new acreage reported to be under conservation tillage annually through the MDA's AgBMP Loan Program from 1995 through 2012. According to Figure 2, acreage under conservation tillage as reported by borrowers declined annually from 1996 to 1998, with an increasing trend from 2000 to 2002. In 2006, the acreage reported under conservation tillage spike, declined, with acreage reported during 2012 nearly equivalent to the acreage reported in 1995.

It is an indirect or surrogate measure of environmental response. It does not provide information on nutrient reduction, but does provide information on efforts to reduce pollutant loads over time that are likely to reduce nutrients.

Table 1 below shows the estimated percent nitrogen and phosphorus removal associated with conservation tillage. These efficiencies were derived from a comprehensive literature review.

Table 1. Estimated nutrient removal efficiencies for conservation tillage

Best Management Practice	Nitrogen Removal (%)	Phosphorus Removal (%)
Conservation Tillage[a]	0	63

a. Miller et al. 2012; Iowa State University 2013; Simpson and Weammert 2009

Associated Terms and Phrases

To better understand this measure, it is necessary to understand a few program specific terms and phrases.

Conservation Tillage: The category of *conservation tillage* for the AgBMP Loan program means any loan for a piece of equipment that can be used for conservation tillage. Each loan is placed in one of the following categories with conservation tillage:

CON-TILL - CHISEL PLOW
CON-TILL - CULTIVATOR
CON-TILL - DISK
CON-TILL - EQUIPMENT
CON-TILL - MULCHER
CON-TILL - PLANTER
CON-TILL - RIPPER
CON-TILL - SOIL FINISHER
CON-TILL - STRIP/RIDGE TILL
CON-TILL - CONSERVATION CHOPPER HEAD
CON-TILL - VERTICAL TILL

Target

There is no specific numeric target for this measure to date.

Baseline

2000-2012

Geographical Coverage

Statewide, major basin, 8-digit HUC

Data and Methodology

Methodology for Measure Calculation

This measure represents the agricultural acreage under conservation tillage as reported by agricultural operators receiving AgBMP Loan funding for equipment. To calculate this measure, MDA extracted data from the AgBMP Loan database "conservation tillage acres after project" and "total acres farmed" for all funded projects within each 8-digit HUC across the state from 1995-20013.

Data Source

Minnesota Department of Agriculture

Data Collection Period

1995-2013

Data Collection Methodology and Frequency

All data in the AgBMP Loan Program database reflects information as reported by the local government agency responsible for the oversight of the projects. All loan information is entered by MDA staff prior to disbursal. Projects are entered into the AgBMP Loan Program database as they are submitted for disbursal. Participants provide basic information about the project, which includes basic borrower information and loan terms. In addition, the program currently collects additional data that serves as an indicator of program trends and environmental benefits. This additional data currently includes information regarding what is being constructed or purchased, project location, farm size (animal units or acres), and type of crop or animals managed. AgBMP project data is reported by the calendar year the loan is issued.

Supporting Data Set

Table 2 contains the acreage of agricultural land under conservation tillage as reported annually by borrowers to MDA by 8-digit HUC for 1995-2012.

Table 2. AgBMP program data, acres enrolled under conservation tillage

HUC_8	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Grand Total
4010101																			
4010102																			
4010201																			
4010202																			
4010301													800						800
7010101																			
7010102																			
7010103																			
7010104				800			1,500		250						225				2,775
7010105																			
7010106									150				800						950
7010107									525	250									775
7010108			450	800						200			800		1,250				3,500
7010201		150	800			800		230	426	800	200	2,200	370		300				6,276
7010202		800	100					600	423	750	850	800	2,175	350	1,025	250			8,123
7010203		350	1,500	360	550	800	650		920		2,025	800	645	800					9,400
7010204		4,600	6,600	150	1,280	2,215		1,040	3,882	2,616	4,540	4,743	800	1,400	544	1,400	300	100	36,210
7010205	157	5,797	1,400	200	800	2,488	240	400	1,550	1,200	4,815	850	1,200	600					21,697
7010206		3,150	800	300	667		275	713			570	375							6,849
7010207				800					998	800			2,100	41			1,400		6,139
7020001			3,530	350	1,000	1,500	3,000	4,372	690			2,150	2,000		480	1,000	450		20,522
7020002			1,700	2,300	800			1,367	405				5,140	1,450	3,840	1,175	1,885		20,062
7020003	800	1,420	3,192	479				550	2,100	2,500		600	1,600	1,466					14,707
7020004	3,551	6,586	6,661	1,802	3,976	1,680	3,150	11,698	6,195	2,000	5,000	5,684	2,852	7,947	3,825			2,675	75,281
7020005		1,100	8,650	4,850		1,263	3,780	8,600	6,502	4,250	2,930	2,020	11,490	8,250	2,733	1,050	1,391	1,700	70,559
7020006	800	4,866	950	1,000	2,200	1,201	3,850	500	3,505		2,550	5,775	3,566	2,683	448		320	1,175	35,389
7020007	2,903	9,083	6,427	1,666	1,510	1,577	8,896	1,800	1,395	3,721	4,900	9,987	11,941	4,130	1,627	4,385	985	2,180	79,112

HUC_8	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Grand Total
7020008	923	8,741	5,218	2,885	900	10,951	12,742	2,793	5,484	6,780	8,367	5,168	6,319	3,417	4,030	3,525	3,090	1,000	92,332
7020009	7,999	9,663	3,330	3,283	8,800	8,792	772	11,927	3,300	9,238	8,886	10,535	2,012	9,864	5,948				104,348
7020010	8,042	14,209	7,174		8,801	2,643	6,331	9,870	1,641	7,659	8,769	20,399	13,365	3,775	9,546	5,082	3,775	5,500	136,579
7020011	4,633	14,647	7,385	783	2,200	3,433	4,838	12,068	6,290	5,899	6,511	15,445	12,299	18,974	15,427	6,195	6,645	1,200	144,872
7020012	240	6,557	5,551	3,618	2,282	3,572	1,550	2,209	1,485	6,468	14,608	6,702	5,195	1,600	1,470	3,667	4,165		70,939
7030001										675									675
7030003				375															375
7030004		146	1,950	900	200	650	102					450	600	210					5,208
7030005		1,700	1,250	2,400			800				600		330	1,000					8,080
7040001		128	648	1,880	385	1,320	1,059	2,500	459		5,452	8,600	273	3,700	1,425	2,000	3,950		33,779
7040002	6,930	6,180	7,113	2,517	1,967	3,500	3,180	4,271	4,809	8,478	8,393	7,512	5,497	11,911	2,571	1,368	2,990		89,185
7040003	535	1,865	2,568	243	2,693	850		3,500	1,795	356	1,106		1,950	2,330	200				19,991
7040004	814	5,144	8,320	925	2,895	2,271	3,330	11,093	4,875	2,840	3,765	3,410	6,575	2,150	405	2,268	2,775		63,853
7040006															135				135
7040008	1,598	925	2,200	4,438	4,150	6,678	5,974	14,375	5,825	1,050	4,555	7,485	2,300	3,800	450	1,878			67,681
7060001																			
7060002		3,433					400	2,500	1,440	500	3,017		1,900	400					13,590
7080102															583				583
7080201		1,600	3,200	800	1,937	3,453	3,341	4,660	8,065	1,815	8,905	10,948	3,500	1,180	6,268	500	1,675	7,145	68,992
7080202		1,800	550	1,640	430	2,500	7,530			4,100	1,500	1,326	2,235						23,611
7080203		2,150	1,550				1,400	2,000		1,500	800				1,200	1,060			11,660
7100001		14,531	12,415	8,999	17,649	11,567	16,721	9,375	8,260	19,535	20,133	14,906	11,630	7,933	4,442	5,048	4,283	4,188	191,614
7100002		1,088			750	1,760	1,083			2,700		250	1,000	1,267				2,033	11,931
7100003		2,447							7,665	230	1,730	2,325	1,800	1,000		5,817	2,400		25,413
9020101				565											2,000		5,350		7,915
9020102			1,300	4,100	5,350	2,788	3,050			700		3,000	2,712	3,910	2,571	2,100		2,222	33,803
9020103			2,400	3,100					700		1,100			700				70	8,070
9020104				800			1,650	1,100											3,550

HUC_8	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Grand Total
9020106				800	1,267	1,600	5,700	500	2,050	2,500	5,500	6,440	4,420	2,600		1,200		250	34,827
9020107												4,500							4,500
9020108					800				827		4,000	46	2,500	6,950	1,500				16,623
9020301			1,800	3,727	1,825		6,000	6,600	4,744	1,500	700	18,619	10,000		1,275	3,000		700	60,490
9020302																			
9020303		2,100	800	1,800		8,155	2,800	6,400		1,875	11,900	14,789	4,800	1,250	13,200	1,250	7,500	11,100	89,719
9020304				2,530	1,683			7,800	1,800	2,750	400	2,262	8,242	7,000	700	7,800	2,400		45,366
9020305		800		2,400	800		1,100	5,133	2,800	1,950	1,736		4,600	9,120	3,000	8,500	4,500		46,439
9020306							1,100	7,000	1,550			2,863	1,500		2,500				16,513
9020309		3,200	800	800	3,070	8,225	5,557	3,100		1,000	800	3,600	3,000		6,647	3,801		3,543	47,143
9020311		2,038	2,300		3,500	800	800	10,923	600	7,208	300	12,405	5,422	3,577	10,067	4,650	4,625	3,775	72,989
9020312		14,440	12,611	7,962		11,600	6,200	12,170	9,100	5,480	2,600	9,950	10,090	4,440	7,000	6,460	1,700	5,333	127,137
9020314				8,350	3,150	2,600	1,600	1,700	4,010			5,100	1,560	3,625		1,200	3,590		36,485
9030001																			
9030002																			
9030003																			
9030004																1,000			1,000
9030005																			
9030006																			
9030007																			
9030008																			
9030009			800							4,300		650	2,300	800		1,500	1,650		12,000
10170202	700		766									750							2,216
10170203	1,200	1,156	1,099		3,844		2,025	2,300	1,550	850		1,250	300		2,000		1,000	800	19,374
10170204	800	1,680	4,735	6,750	8,267	4,578	10,210	2,050	5,464	5,003	7,975	2,595	5,783	1,860	3,240	1,244	2,709	3,511	78,454
10230003		5,765	3,243	4,200		6,967	1,800	1,600	3,549	2,835	6,663	1,450	1,212	2,630	4,000		1,500		47,413

Caveats and Limitations

Loan vs. Producer: A loan is different than an individual producer in that any individual can have multiple loans with the program. This is important to note when MDA reports conservation tillage acres because a single farmer may receive a loan for a cultivator one day and a planter the next. Therefore, MDA reports only the first loan for a borrower and uses the borrower's average acreage for all of their subsequent loans.

BMPs vs. Projects: The Minnesota Department of Agriculture's AgBMP Loan Program database does not record BMPs implemented per se, but rather loan projects completed. MDA collects information on "conservation tillage acres after project" and "total acres farmed" for all projects.

Voluntary information: The information provided by borrowers on conservation tillage acres after project is voluntary, but the numbers are generally provided for conservation tillage projects. If acreage isn't provided, MDA used 800 acres, which is the mode for all conservation tillage equipment loans with the AgBMP Loan Program.

Potential Double-Counting of BMPs: There could be any other number of state, local, federal, non-profit, or private dollars going towards a project. There are several barriers that make it difficult to avoid double-counting:

- Privacy/fairness issues associated with recipients of federal funds, MDA is not supposed to ask loan participants about their other sources of funds. MDA does report the total project cost when available. Loan funds are often used as the borrower cost share portion of grant funds, it sometimes makes sense to report dollars as opposed to number of projects because rather than reporting the same project twice, the cumulative cost is reported.
- There is not an easy unique identifier for MDA to use to identify projects between programs. Location can be used to some effect. MDA collects project location, but the accuracy varies (i.e., did the borrower report the exact project site, nearest 40, center of their farm, their home?). AgBMP loans are in the name of the borrower, but the project might include many people or organizations. As a result, other funding contributors (e.g., NRCS) might have a different contact person for the project.

Quantifying Environmental Benefits: MDA does not require extensive monitoring and reporting for projects because the AgBMP Loan Program is based on implementing recognized and demonstrated BMPs recommended in environmental plans such as the Local Comprehensive Water Management Plans, Total Maximum Daily Load (TMDL) Implementation Plans, and the State 319 Nonpoint Source Management Plan. These practices have been shown to be effective by researchers, University Extension, state & federal agencies, and industry research and development. Since it is a loan program, and the borrower has to repay the funds, MDA is satisfied with the approval from the local government that the project will have a water quality benefit. Because of this approach, MDA has been able to keep the program as simple and cost effective as possible – ensuring that more practices are completed. It is important to note that any environmental benefits are theoretical.

Future Improvements

Future improvements to this indicator would include a method for avoiding double-counting among other funding programs and a mechanism to verify the actual acreage under conservation tillage as a result of the loan.

Future iterations of the measure for the AgBMP Loan Program would also include AgWaste projects that relate to nutrient management on feedlots. To date, inclusion of AgWaste projects is challenging because MDA tracks a wide variety of equipment and approaches under the AgWaste category, including manure pumping and application equipment, manure basins, or feedlot upgrades such as a monoslope roof over a previously open feedlot. Below is a list of the practice categories that MDA uses under the AgWaste category:

FDLT - COMPOSTING
FDLT - ENGINEERING ASSISTANCE
FDLT - FEEDLOT IMPROVEMENTS
FDLT - FILTER and BUFFER STRIPS
FDLT - LANDSCAPING and DIVERSIONS
FDLT - LIVESTOCK EXCLUSION
FDLT - MORTALITY MANAGEMENT
FDLT - ROOF RUNOFF CONTROL
FDLT PRACTICE - GENERAL PRACTICE - Not Specified
MANURE AGITATION,PUMPING, LOADING - Liquid
MANURE APPLICATION EQUIPMENT- Not Specified
MANURE CUSTOM APPLICATION SERVICE
MANURE HANDLING and LOADING EQUIPMENT - Dry
MANURE HAULING and SPREADING EQUIPMENT
MANURE IRRIGATION EQUIPMENT
MANURE TREATMENT and PROCESSING
MILKHOUSE WASTE MANAGEMENT
NUTRIENT MANAGEMENT PLANS
ROTATIONAL GRAZING PRACTICES
STORAGE - BEDDING MANAGEMENT
STORAGE - HOOP BARNS
STORAGE - SLURRYSTORE
STORAGE - STACKING PAD
STORAGE BASIN - CONCRETE
STORAGE BASIN - EARTHEN
STORAGE BASIN - GEOTEXTILE LINER
STORAGE BASIN - TYPE UNKNOWN
STORAGE BASIN ABANDONMENT

For these projects, MDA collects the number of animal units that the borrower reports and the type of animals, which is essentially nutrients managed as opposed to nutrients reduced.

Financial Considerations

Contributing Agencies and Funding Sources

NA

References

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Measure Points of Contact

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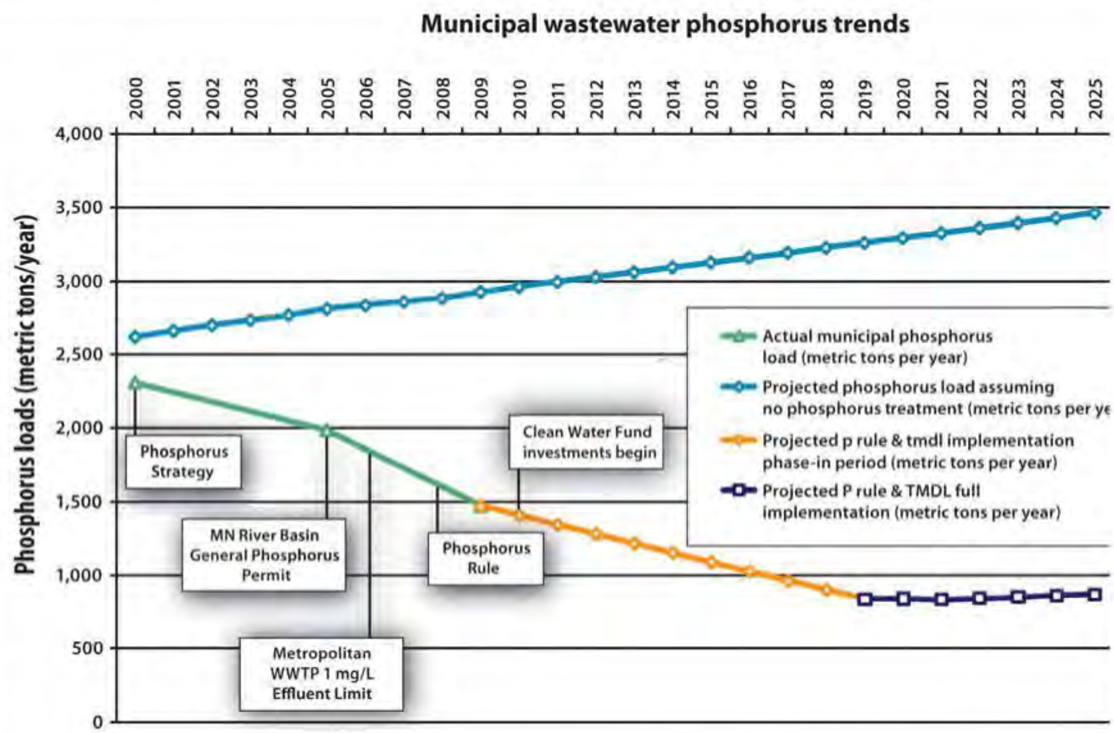
Municipal Wastewater Phosphorus Trends (excerpt from the Clean Water Fund Report)

Measure Background

Visual Depiction

This graph represents estimated statewide municipal wastewater treatment facility phosphorus reductions since the year 2000, projects future reductions based on the implementation of current permitting policies and contrasts them to anticipated increases in phosphorus loading that would have resulted from the perpetuation of previous permitting policies.



Estimated statewide reductions in phosphorus from municipal wastewater treatment facilities since the year 2000 and projections of future reductions based on current permitting policies, implementation of Total Maximum Daily Load (TMDL) requirements, and Clean Water Fund investments.

Measure Description

Statewide municipal wastewater treatment facility phosphorus trends and projections assume a 1 percent per year population growth rate:

- The **red line** assumes pre-2000 business as usual with effluent phosphorus concentrations of 4 mg/L.
- The **yellow line** represents DMR data reported for 2000, 2005 and 2009.
- The **blue line** (Projected Phosphorus Rule and TMDL Implementation Phase-In Period) simply joins the actual to the projected loads assuming a 10-year period.

- The **green line** represents full implementation of the phosphorus rule and continued phosphorus concentration declines from small municipal WWTPs.

Actual wastewater loads based on discharge monitoring report data. Projected phosphorus rule and TMDL implementation phase-in period assumes a 10-year period to achieve full implementation. TMDL requirements and operational margins of safety will likely reduce future phosphorus loads beyond projected values.

Associated Terms and Phrases

- The Phosphorus Strategy was a permitting approach adopted by the MPCA in 2000. It established policies to assign 1 mg/L effluent phosphorus permit limits for municipal wastewater treatment facilities that had the potential to discharge annual phosphorus loads in excess of 1,800 lbs/year to specific watersheds and waterbodies. Municipal wastewater treatment facilities that were not assigned effluent phosphorus limits were required to monitor influent and effluent phosphorus and develop phosphorus management plans.
- The Minnesota River Basin General Phosphorus permit was issued in 2005 to implement the wasteload allocations established by the Lower Minnesota River Dissolved Oxygen TMDL. It established baseline load and pollutant load reduction requirements for the 39 largest continuously discharging municipal and industrial wastewater dischargers in the 8 major watersheds of the Minnesota River basin.
- The Metropolitan WWTP is the largest wastewater treatment facility in Minnesota with an average annual design flow of 251 MGD.
- The “phosphorus rule” refers to Minnesota Rules Chapter 7053.0255. It codifies the phosphorus strategy but extends its requirements to all Minnesota watersheds.

Target

There is no specific numeric target for this measure to date.

Baseline

Baseline year: 2000

Baseline load: 2,305 MT per year

Geographical Coverage

Statewide

Data and Methodology

Methodology for Measure Calculation

- The projections are based on a 1 % per year population growth estimate.
- All municipal (“city”) populations are used to calculate municipal flow. All rural (“township”) populations are assumed to be outside municipal service boundaries.

- 92 percent of the flow and load are assumed to be from cities with populations ≥ 2000.
- Loads from municipalities with populations ≥ 2000 are estimated based on flow projections and a 1 mg/L concentration. Loads from municipalities with populations < 2000 are estimated based on flow projections and effluent concentrations that decline gradually based on the reductions shown in the 2000 to 2009 effluent data. They bottom out at 1 mg/L around 2020.
- TMDLs and operational margins of safety push actual future loads below the projections.

<u>About the graph:</u>

The red line assumes pre-2000 business as usual with effluent phosphorus concentrations of 4 mg/L.

The yellow line represents DMR data reported for 2000, 2005 and 2009.

The blue line (Projected Rule and TMDL Implementation Phase-In Period) simply joins the actual to the projected loads assuming a 10-year period.

The green line represents full implementation of the P rule and continued phosphorus concentration declines from small municipal WWTPs.

Actual wastewater loads based on discharge monitoring report data.

Projected P Rule and TMDL Implementation Phase-In Period assumes a 10-year period to achieve full implementation.

The year 2000 discrepancy between "Actual Municipal Phosphorus Load" and "Projected Phosphorus Load Assuming Non Phosphorus Treatment" reflects pre-2000 implementation of phosphorus effluent limits.

Data Source

WQ Delta database discharge monitoring report data and State demographic center population estimates

Data Collection Period

2000, 2005, 2009

Data Collection Methodology and Frequency

Supporting Data Set

	Domestic						
	Flow (MG/y)	Conc. (mg/L)	TP Load (MT/y)	Project TP Load @ 2000	No of Permits		No. of Permits with P
2000	178,106	3.42	2,305	2,305	511		80
2005	210,756	2.49	1,985	2,727	552		100
2009	160,932	2.41	1,471	2,082	573		119

Year	City Population	City > 2000 Population	City > 2000 Pop as % of Tot. City Pop	City < 2000 Pop as % of Tot. City Pop	Actual Municipal Wastewater Flow (MG/y)	Actual Municipal Phosphorus Load (MT/y)	Projected Average Municipal Wastewater Flow (MG/y)	Projected Phosphorus Load Assuming No Phosphorus Treatement (MT/year)	City > 2000 Projected P Rule Implementation Load (MT/year)	City < 2000 Projected P Load (MT/year)	Projected P Rule & TMDL Implementation Phase-In Period MT/year)	Projected P Rule & TMDL Full Implementation (MT/year)
2000	4,257,328	3,900,753	92%	8%	178,106	2,305	172,848	2,617	599	187		
2001	4,324,100	3,964,161	92%	8%			175,558	2,658	609	183		
2002	4,387,230	4,022,758	92%	8%			178,122	2,697	618	175		
2003	4,444,786	4,077,722	92%	8%			180,458	2,732	627	174		
2004	4,500,777	4,129,621	92%	8%			182,732	2,767	635	169		
2005	4,567,652	4,191,489	92%	8%	210,756	1,985	185,447	2,808	644	165		
2006	4,607,356	4,220,005	92%	8%			187,059	2,832	648	164		
2007	4,648,222	4,259,669	92%	8%			188,718	2,857	655	157		
2008	4,686,816	4,294,835	92%	8%			190,285	2,881	660	152		
2009	4,762,705	4,365,483	92%	8%	160,932	1,471	193,366	2,928	671	147	1,471	
2010	4,816,929	4,415,002	92%	8%			195,567	2,961	678	142	1,407	
2011	4,871,153	4,464,520	92%	8%			197,769	2,994	686	137	1,344	
2012	4,925,377	4,514,039	92%	8%			199,970	3,028	694	131	1,280	
2013	4,979,601	4,563,557	92%	8%			202,172	3,061	701	125	1,216	
2014	5,033,825	4,613,076	92%	8%			204,373	3,094	709	120	1,153	
2015	5,088,048	4,662,594	92%	8%			206,575	3,128	717	114	1,089	
2016	5,142,272	4,712,113	92%	8%			208,776	3,161	724	107	1,026	
2017	5,196,496	4,761,631	92%	8%			210,978	3,194	732	101	962	
2018	5,250,720	4,811,150	92%	8%			213,179	3,228	739	95	898	
2019	5,304,944	4,860,669	92%	8%			215,381	3,261	747	88	835	835
2020	5,359,168	4,910,187	92%	8%			217,582	3,294	755	81		836
2021	5,413,392	4,959,706	92%	8%			219,784	3,328	762	70		832
2022	5,467,616	5,009,224	92%	8%			221,985	3,361	770	70		840
2023	5,521,840	5,058,743	92%	8%			224,187	3,394	777	71		849
2024	5,576,064	5,108,261	92%	8%			226,388	3,428	785	72		857
2025	5,630,288	5,157,780	92%	8%			228,590	3,461	793	73		865

Caveats and Limitations

The projections are based on a **1 percent per year population** growth estimate.

All municipal ("city") populations are used to calculate municipal flow. All rural ("township") populations are assumed to be outside municipal service boundaries.

92 percent of the flow and load are assumed to be from cities with populations ≥ 2000.

Loads from municipalities with populations ≥ 2000 are estimated based on flow projections and a 1 mg/L concentration. Loads from municipalities with populations < 2000 are estimated based on flow projections and effluent concentrations that decline gradually based on the reductions shown in the 2000 to 2009 effluent data. They bottom out at 1 mg/L around 2020.

TMDLs and operational margins of safety push actual future loads below the projections.

Projected P Rule & TMDL Implementation Phase-In Period assumes a 10-year period to achieve full implementation.

The year 2000 discrepancy between "Actual Municipal Phosphorus Load" and "Projected Phosphorus Load Assuming Non Phosphorus Treatment" reflects pre-2000 implementation of phosphorus effluent limits.

Future Improvements

Increased frequency of phosphorus monitoring in industrial permits should allow for future estimates and projections to include industrial wastewater loads.

Financial Considerations

Contributing Agencies and Funding Sources

NA

Communication Strategy

Target Audience

The primary audience would be regulated municipalities and permitting authorities. However, this measure is of interest to anyone interested in the effectiveness of wastewater programs.

Associated Messages

This measure is important to communicate to a variety of audiences to help understand the long term trends in wastewater control measure effectiveness.

Other Measure Connections

This measure links to other outcome-related measures on environmental trends, as well as financial measures showing inputs and activities related to wastewater funding.

Measure Points of Contact

Agency Information

Marco Graziani, Minnesota Pollution Control Agency Marco.Graziani@state.mn.us

Appendix G: Evaluation of ChesapeakeSTAT

Minnesota Pollution Control Agency

Analysis Report

ChesapeakeStat and Minnesota State Level Nutrient Reduction Project

Watershed Data Integration Program

Analysis on the Use of ChesapeakeStat for the Minnesota State Level Nutrient Reduction Project

Executive Summary

There is a business need to present the strategies and trends emerging from monitoring and data collection related to nutrient reduction implementation activities in order to showcase resulting milestones from 2012 through 2025. This project is funded by the EPA Gulf of Mexico Regional Partnerships "intended to increase regional and national coordination to reduce Hypoxia in Gulf of Mexico coastal waters and estuaries and will be part of a state level strategy to reduce nutrient loading to waters of the state". The MPCA Watershed Division requested that a tool be built for the tracking and communicating progress toward state-level nutrient loading reduction. If implemented, this tool may contribute to meeting EPA grant requirements for delivering enhanced water quality as part of the Minnesota State level Nutrient Reduction Strategies. This report summarizes the background, context, and discoveries made while assessing the feasibility of adapting the ChesapeakeStat website framework.

When this project was chartered, it had been thought that the ChesapeakeStat website could provide a framework to incorporate an effective method for tracking nutrient reduction progress along the Mississippi River Basin. The site was viewed as a potential model for a new tool to communicate with stakeholders and watershed managers in Minnesota as well as with member states along the Mississippi River Basin and the Gulf of Mexico Task Force. Analysis performed during the project revealed significant gaps between data required to support a Chesapeake-style website and the current abilities of MPCA to provide that data. Future planned work at MPCA will increase data availability, but significant work remains to be done for watershed modeling as well as program requirements.

Table of Contents

Minnesota State Level Nutrient Reduction Program (MSLNRP)

The Minnesota State Level Nutrient Reduction Strategy Project is funded by a Gulf of Mexico Regional Partnerships Grant from the Environmental Protection Agency Gulf of Mexico Program. The goal of the project is to develop nutrient reduction strategies designed to be protective and restorative for Minnesota waters as well as contribute progress toward the downstream collective responsibilities to meet the Goals of the Gulf of Mexico Action Plan. The national effort that Minnesota has committed to be a part of to protect the Mississippi is being coordinated by the "Mississippi River/Gulf of Mexico Watershed Nutrient Task Force". One task of the project is to develop a progress tracking and communication tool for use with the nutrient reduction strategies. Initial communications with EPA staff indicated that the Chesapeake Bay tracking database, Chesapeake Stat, could be modified and developed for use in reporting progress on Minnesota State Level Nutrient Reduction Strategies developed through the overall project. It was envisioned that water quality and BMP implementation data from the MPCA and other state agencies be gathered to generate and publish clean water outcomes in the Mississippi watershed related to the restoration and protection of the Upper Mississippi River basin's water quality. It was also envisioned that the development of such a tool could be incorporated into a multi-state effort to track state level strategy efforts in reducing the hypoxic zone in the Gulf of Mexico.

ChesapeakeStat

A goal of the Minnesota State Level Nutrient Reduction Project is to provide a progress tracking and communication tool for the state level nutrient reduction strategies being developed by the project. The concept was to publish relevant water quality and BMP implementation data on a website. To that end the MPCA team had preliminary conversations with the EPA/Chesapeake Bay administrators and initially believed the site could be adaptable for use in Minnesota and eventually with other Mississippi River Basin states.

A small amount of project funds were allocated to the task of developing such a tool. These funds were set up for use as a sub-project (7a) in the MPCA Water Data Integration Project (WDIP) to evaluate whether and how the Chesapeake Stat program could be adapted and utilized by the MPCA for tracking the state's nutrient reduction strategies when the project was completed. WDIP Project 7a was undertaken to gather business requirements at MPCA, evaluate the capabilities of the website, and define requirements for website implementation.

MSLNRP Business Requirements

- A web-based database that tracks and communicates progress on statewide nutrient level reductions.
- Statewide phosphorus and nitrogen pollution reduction strategies publically available via web sites and other formats
- An effective tool for making adaptive management decisions that will ensure that nutrient reduction activities will coincide with monitored water quality information
- Timely communication with the public about nutrient sources when goals and reductions are, or are not, achieved
- An effective method for tracking nutrient reduction progress and communicating with member states along the Mississippi River Basin and the Gulf of Mexico Task Force about Minnesota's contribution of nutrients
- Nutrient reduction activities in the watersheds are tracked over time to gain a better understanding of how nutrient reduction actions are linked to reduced nutrient conditions in streams

As part of the project to evaluate whether the ChesapeakeStat website would meet the needs of the Minnesota State Level Nutrient Reduction Program, business requirements were gathered from MPCA employees. These requirements are contained in the following spreadsheet as compiled by Greg Johnson.

Topic/Hyperlink	Information Needed	Use (P–Presentation, F–Functionality, PF–Both)	Data Source/ Availability	Priority (H, M, L)
About ChesapeakeStat http://stat.chesapeakebay.net/?q=node/5	Background text	P	To be written (TBW) – mainly static	H
Partner Coordination and Support - Overview http://stat.chesapeakebay.net/?q=node/127	Text – including Watershed Framework diagram	P	Written or TBW – mainly static	H
Partner Coordination & Support – Making Connections http://stat.chesapeakebay.net/?q=node/127&quicktabs_25=1	Text and diagram – describing processes and focus areas	P	TBW	L
Partner Coordination & Support – Funding http://stat.chesapeakebay.net/?q=node/127&quicktabs_25=2	Source of funds – federal, state, local Year of funds Goal(s) funds used for – initially just Water Quality Topic for funds – wastewater, agriculture and animals, stream restoration, stormwater	PF	CWF Annual program budgets TBW TBW	H H M L
Partner Coordination & Support – Monitoring http://stat.chesapeakebay.net/?q=node/127&quicktabs_25=3	Integrated report – impaired, non-impaired – state, major watershed Report cards – link to major watershed page information Water monitoring details – sites, data results (chemistry, biology), trends, yields; nitrogen, phosphorus, TSS	P	EDA, MPCA watershed web pages, TBW	M
Water Quality – Overview http://stat.chesapeakebay.net/?q=node/130	Total loads – nitrogen, phosphorus, sediment; years – observed and target; scale – statewide, 8-digit HUC watershed Total funds spent Current health of lakes and streams – individual lakes and streams, benthic IBI Detailed WQ Funding – same as Partner Coordination & Support – Funding above	PF	Watershed load monitoring and/or Modeling CWF TBW See above	H H L See above
Water Quality – Agriculture http://stat.chesapeakebay.net/?q=node/130&quicktabs_10=1 (There is overlap between this and the TMDL tracking.)	Goals – load per year, N. P, and sediment – the TMDL (ultimate goal), interim goals TMDL – allocations by sector – WLA and LA Baseline loads Factors Influencing Goals – Land cover, soils; estimated loads by source, location, etc. Current Efforts and Gaps – BMPs implemented and needed Strategies and Resources – BMP targets (#), resources available Monitoring – measured pollutant loads, trend analyses Performance Assessment – tracking progress to meet TMDL allocations and evaluation of BMPs for use in implementation; Case Studies Make Your Own Map (available on several pages)	PF	State level goals TMDLs Wtshd. loads &/or modeling GIS, modeling eLink TBW TBW, EQuIS, Hydstra, Delta TBW	H M H M L M M M L

Topic/Hyperlink	Information Needed	Use (P–Presentation, F–Functionality, PF–Both)	Data Source/ Availability	Priority (H, M, L)
	Agriculture Workgroup members – some list of an organizational team			L
Water Quality – TMDL Tracking http://stat.chesapeakebay.net/?q=node/130&quicktabs_15=8&quicktabs_10=2	Chesapeake Bay TMDL Tracking and Accounting System – allocations and progress towards meeting planning targets by State Basin Segment (8-digit HUC watershed and/or other scales) Permitted Facilities By Year, Scale (above), Source (below), Goal, Program (below), Practices Point sources TMDL Implementation Goals – WLA's Permit requirements – wastewater, stormwater, industrial Effluent reporting, SWPPP reporting Nonpoint sources Targets – LA's Program data – 319, CWP,CWF, BWSR cost-share, other BWSR $, MDA loan $; grant dollars, # and type of projects, individual project list, SWIFT Implementation data – e-Link Legacy funds Local planning USDA funds Other funds Sources: Ag., forestry, urban, etc. Practices – NRCS Standards, BWSR, other	PF	TBW	MN only – H M L M
Water Quality – 2009-2011 Milestones http://stat.chesapeakebay.net/?q=node/130&quicktabs_15=8&quicktabs_10=4	Commitments/Targets for BMP types/groups by sector – Ag., wastewater, stormwater, forestry; by scale – statewide, basin, major watershed	PF	TBW from Nutrient Reduction Strategies, WRAPS, and implementation plans	H (State reduction strategy)
Water Quality – 2012-2013 Milestones http://stat.chesapeakebay.net/?q=node/130&quicktabs_15=8&quicktabs_10=5	Progress in meeting milestone commitments by location and year	P	TBW	L
Watersheds - Overview http://stat.chesapeakebay.net/?q=node/131	Overall progress in protecting lands Overall amount of money being spent on watersheds Current health of smaller watersheds – benthic IBI scores for Chesapeake	P	TBW with eLink, CWF reporting, some sort of assessment of our WQ data	M H L
Fisheries – Overview http://stat.chesapeakebay.net/?q=node/128	Not applicable, in near term		Some future effort	Very L

Topic/Hyperlink	Information Needed	Use (P–Presentation, F–Functionality, PF–Both)	Data Source/ Availability	Priority (H, M, L)
Habitats – Overview http://stat.chesapeakebay.net/?q=node/128	Progress and funding in restoring habitats		Some possible future effort	Very L
Habitats – Submerged Aquatic Vegetation http://stat.chesapeakebay.net/?q=node/129&quicktabs_13=1	Not applicable, in near term		Some possible future effort	Very L

Description of the ChesapeakeStat

The ChesapeakeStat website [http://stat.chesapeakebay.net/] presents water quality implementation results for the Chesapeake Bay Estuary and the nine large contributing tributaries to the Chesapeake Bay (CB) watershed. The statistical model used by the ChesapeakeStat web site WRTDS[1] is referenced in the footnote. The CB statistical model is a weighted regression equation with time, discharge, and season as independent variables. It does not encompass Best Management Practices (BMPs) and has provided time and season variables with a goal of gleaning information from long term data sets comprised of varied sampling approaches. Data sampling at multiple sites in the Chesapeake Bay watershed has occurred over a period of the past 30 years. The website reports on multiple aspects of Chesapeake Bay water quality, watershed health, fisheries, habitat, and partner coordination and support; this Analysis Report focuses on the Water Quality aspects of the site (See *Overall Web Flow ChesapeakeStat site* in APPENDIX C*)*.

1. The ChesapeakeStat (CB-Stat) website presents the analysis of long-term surface water-quality strategy goals implemented to decrease pollutants existing in the Chesapeake Bay Estuary and the nine large tributaries of Chesapeake Bay from 1978 to 2008 across multiple states.
2. The milestones are showcased in the CB-Stat website and show a wide range of patterns of change in Total Phosphorus and in Dissolved Nitrate plus Nitrite. These results are presented with a variety of charts and interactive map features which lend themselves to the overall understanding of the actions taken and the funding provided by federal, state and local entities contributing to the predefined targets of restoration and protection using Best Management Practices and cooperation among multiple partners, states and federal agencies.
3. In 1996 the Chesapeake Bay *Strategy for Increasing Basin-wide Public Access to Chesapeake Bay Information* called for development of a shared resource of information, available through the internet, and based on standards and protocols that facilitate access to information and data across agency and jurisdictional boundaries.
4. As a result, the Chesapeake Information Management System (CIMS) was created as the framework to carry out the *Strategy*.
    a. Within CIMS, it is necessary to have consistent standards and uniformity for recording and reporting data and information to allow users in different locations to access the data and information they need.
    b. The foundation to this level of consistency and uniformity is metadata. Metadata provide basic documentation about the source, content, and quality of data and other information.
    c. The metadata has been evolving over the past 20 years and continues to evolve. See APPENDIX B for the metadata data schema used by the CB-Stat Program to collect data from multiple contributing state sources.
5. A representative sampling of CB-Stat website pages is included in APPENDIX D.
    a. These web page screen shots have been provided by Denise Leezer to show how a chart or map might be utilized to display water quality data gathered for a Mississippi Nutrient Reduction Project.

[1] Hirsch, Robert M., Douglas L. Moyer, and Stacey A. Archfield, 2010. Weighted Regressions on Time, Discharge, and Season (WRTDS), With an Application to Chesapeake Bay River Inputs. *Journal of the American Water Resources Association* (JAWRA) 46(5):857-880. DOI: 10.1111/j.1752-1688.2010.00482.x

6. The architecture of the CB-Stat website includes a complicated Watershed Basin statistical model in combination with use of HSPF modeling and the outcome drives the reporting accuracy and pertinence of the information presented on this site.
   a. A statistical model could be implemented to help the context of additional data monitoring and water quality collections based on the work undertaken for the Minnesota state level nutrient reduction project as it relates to the Mississippi Basin within the state of Minnesota.

7. The data on *point-source* and *non-point-source* depositions within the dense urban setting of the Chesapeake Bay relate to the water quality of the Chesapeake Bay estuary. TMDL data supporting the CB Milestone targets and resulting outcomes are presented on the site using the environmental models used throughout the CB-Stat website.

8. The Chesapeake Bay statistical models (see footnote 1 for reference) focuses on monitoring sites for point-sources and non-point sources. The Point-source & Non-Point Source Best Management Practices (monitoring sites and collection of sample data from each of these sites) of the Chesapeake Bay area of study is sent quarterly to the Chesapeake Bay Office repository for storage and aggregation of this data. Each of the six states participating in this program sends data based on a request from the Chesapeake Bay Program Office node (receiving hardware site for standard data formatted for water quality).

9. Data is exchanged automatically to the CBO (Chesapeake Bay Office) node and is refreshed with each new quarterly request; all historical data is kept in the Chesapeake Bay Data Warehouse repository.
   a. See Figure 2 below for flow of data example from MPCA node to EPA. See APPENDIX A-1 for flow of data via any state 'node' (CBO and MPCA, etc.) to the EPA NEIEN (National Environmental Information Exchange Network) data mart.
   b. See APPENDIX A-2 for additional technical details on the architecture employed for the CB site data flowing to the EPA and infrastructure involved for the Chesapeake Bay program office node.

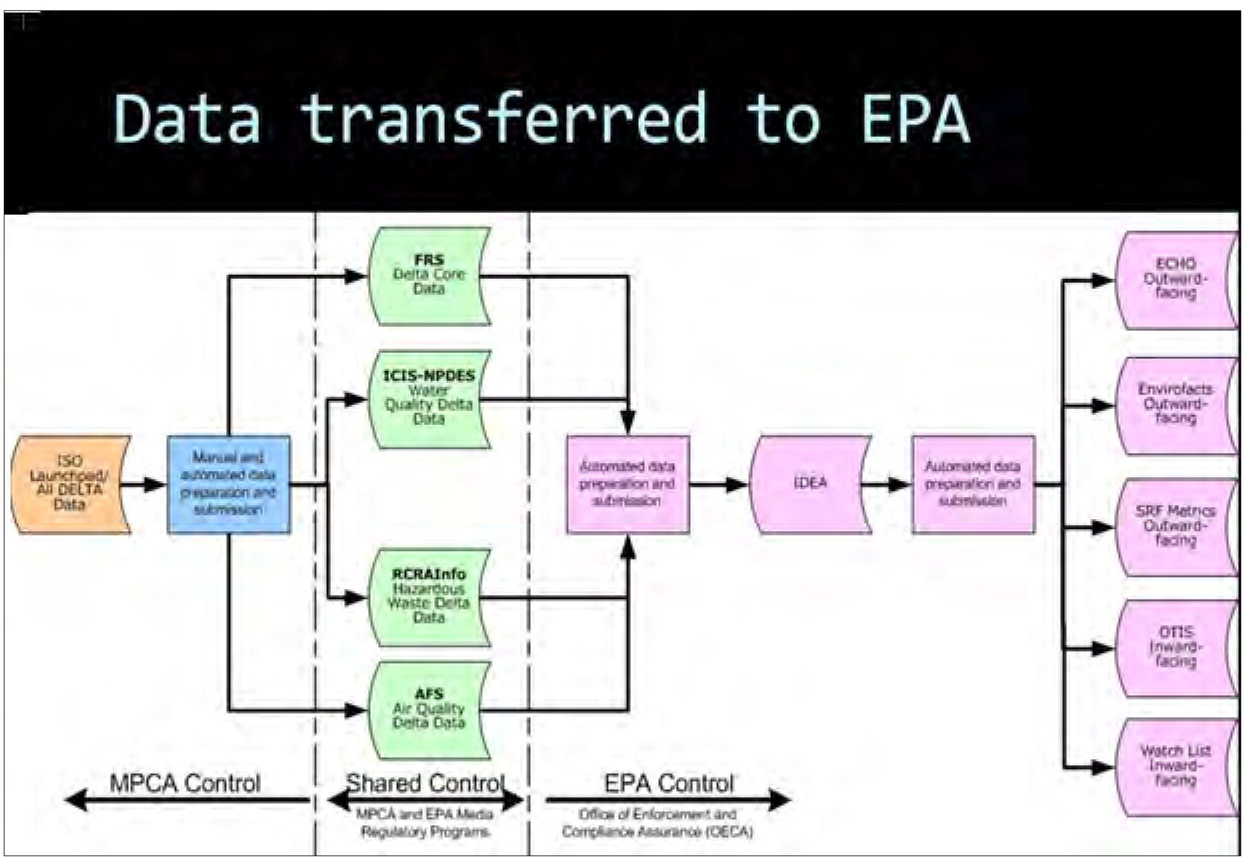


Figure 2: How Data flows to and from the EPA for point source & non-point source data.

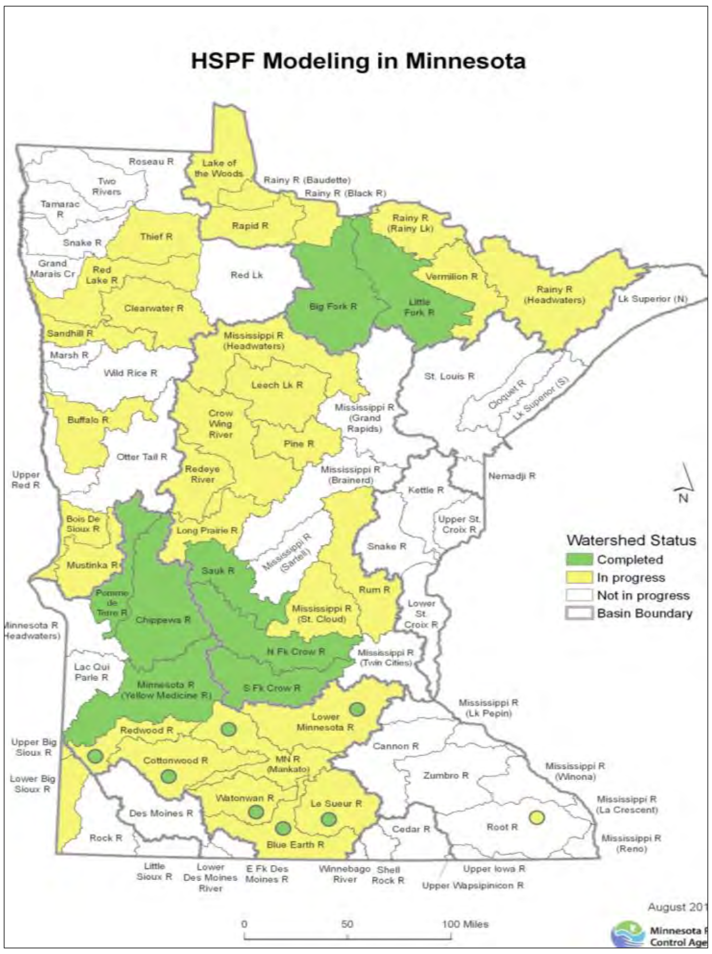
10. Hardware Nodes are required for states to automatically send data to the EPA data exchange network. All data must conform to the strict guidelines and correct data formatting for the type of data being submitted via a Node.
    a. A sample of the Chesapeake Bay Information Management System data schema used for EPA data submissions and also used to submit data to the Chesapeake Bay node is included in APPENDIX B. The full instructions needed to implement the data fields of this schema as well as the required heading and trailer information for each data file is contained in detail in the primary document, which is accessible via the link in the appendix.

Prerequisites for a ChesapeakeStat-Style Website

1. Uniform water quality data – chemistry and flow, with loads calculated from the data – plus statistical model/analyses to show changes
2. Uniform watershed modeling – Chesapeake Bay Program uses HSPF; need a means of tying the model outputs together
3. Nonpoint source BMPs and related information – number, cost, location, reduction estimates – need from all agencies in state; need database to house the data or portal to access other agencies data
4. Point source data – WQ Delta upgrades or a successor
5. Data reporting, storage and aggregation processes for the two items above
6. Mechanism for data exchange and update, and data access for the web software/portal
7. Hardware Nodes are required for all parties to automate data exchange to the EPA and are used in the CB-Stat currently. (See APPENDIX A-2 for further technical information.)

MPCA Watershed Modeling

The MPCA has selected the HSPF watershed model for use in its Watershed Restoration and Protection Strategy (WRAPS) approach. The HSPF model is being developed for all 8-digit HUC watersheds in the state. The map below shows the current status of the modeling. At this time, the modeling has not yet been completed on all watersheds that are part of the Mississippi River basin. The HSPF models, when complete, could be used in a CB-Stat-like web portal with supporting data system. Work would have to be undertaken to provide the linkage of models to data to provide a comparison between watersheds from the outlet of the Mississippi River in Minnesota.



MPCA staff indicated that an alternative to the use of the HSPF model for the development of a tracking system for the state level nutrient reduction strategy may be the use of the SPAtially Referenced Regressions On Watershed attributes (SPARROW) watershed model. SPARROW integrates water monitoring data with landscape information to predict long-term average nutrient loads that are delivered to downstream receiving waters.   Results of the modeling completed for the upper Midwest could be used in presenting a static picture of nutrient loads for the state level strategies in lieu of an active CB-Stat-like web portal.

MPCA Watershed Monitoring

The MPCA has begun a long-term watershed load monitoring program where flow and water quality data are collected for use in calculating pollutant loads. The outlet of each 8-digit HUC watershed is monitored in this program. The monitoring results will be available for presentation, but the reporting system is yet to be built. This may become a part of the WDIP development process.

A report, *Upper Mississippi River Nutrient Monitoring, Occurrence, and Local Impacts: A Clean Water Act Perspective,* published in September 2011 by the *UMRCC* (Upper Mississippi River Conservation Committee), provided recommendations for improving the consistency and comprehensiveness of water quality monitoring in the Upper Mississippi River basin. The needs and recommendations should be considered when/if a tracking system is explored with the Mississippi River states.

In order to create a web portal for featuring the strategies and reporting of trends and outcomes from the MSLNRP, the data collected at multiple sites within the basin and sub-watershed areas would need to be tracked and stored in a database that would be able to aggregate the data into various views of results based on funding, environmental restoration and protection actions implemented to create cleaner watershed quality standards for Minnesota and also for the partners and agencies involved in these efforts.

There is a long-term interest in including a hoped-for vision of data from the 9 downstream partner states to contribute to the restoration and protection of the Mississippi Basin. The Minnesota State Level Nutrient Reduction goals will contribute collection and monitoring data results to extend the water quality information within the Minnesota state boundaries and hope to coordinate these downstream partner states to apply their data to a watershed model developed for the restoration and protection goals for reducing nutrient loads from point source and non-point source outflows along the Mississippi Basin and Atchafalaya Basin to the northern Gulf of Mexico. The geographic scope of such an undertaking is considerable.

MPCA Existing Integrated Infrastructure

1. The MPCA uses the EPA node exchange network to send point source and non-point source data monitoring to the EPA.
   a. The point-source water quality data the MPCA sends to EPA through the node to the Central Data Exchange (CDX) is referred to by the business as DMR (daily monitoring results). (See APPENDIX A-1 for flow).
   b. MPCA is required to do monitoring and send the results to EPA based on the National Pollution Discharge Elimination System (NPDES) permit. MPCA data is stored in WQ Delta.
2. The Environmental Data Access (EDA) water quality section on the MPCA website features data from surface water monitoring sites located around Minnesota. Where available, you can also view the conditions of lakes, rivers or streams that have been assessed.
   a. EDA (on the MPCA website) accesses data from the EQuIS and WQ Delta databases.
   b. WQ monitoring data going to EPA's WDX [water data exchange] comes from both the WQ Delta database which holds compliance monitoring data; and from the EQuIS database which is the repository of ambient WQ monitoring data. There may be a few exceptions, but generally this is the concept of how the data is organized at MPCA. (Source: Joan de Meurisse, 9/2012).
3. The MPCA node is of the same type as that used by the Chesapeake Bay Program, node.
   a. This node is of the hardware 2C# (i.e., written in 2C sharp programming language).
   b. See APPENDIX A-1 and A-2 respectively, for the EPA NEIEN flow of data and technical information and see APPENDIX B for the spreadsheet of partial data fields which are mandated by the EPA for sending data to the Water Quality Data Exchange network of the Central Data Exchange.

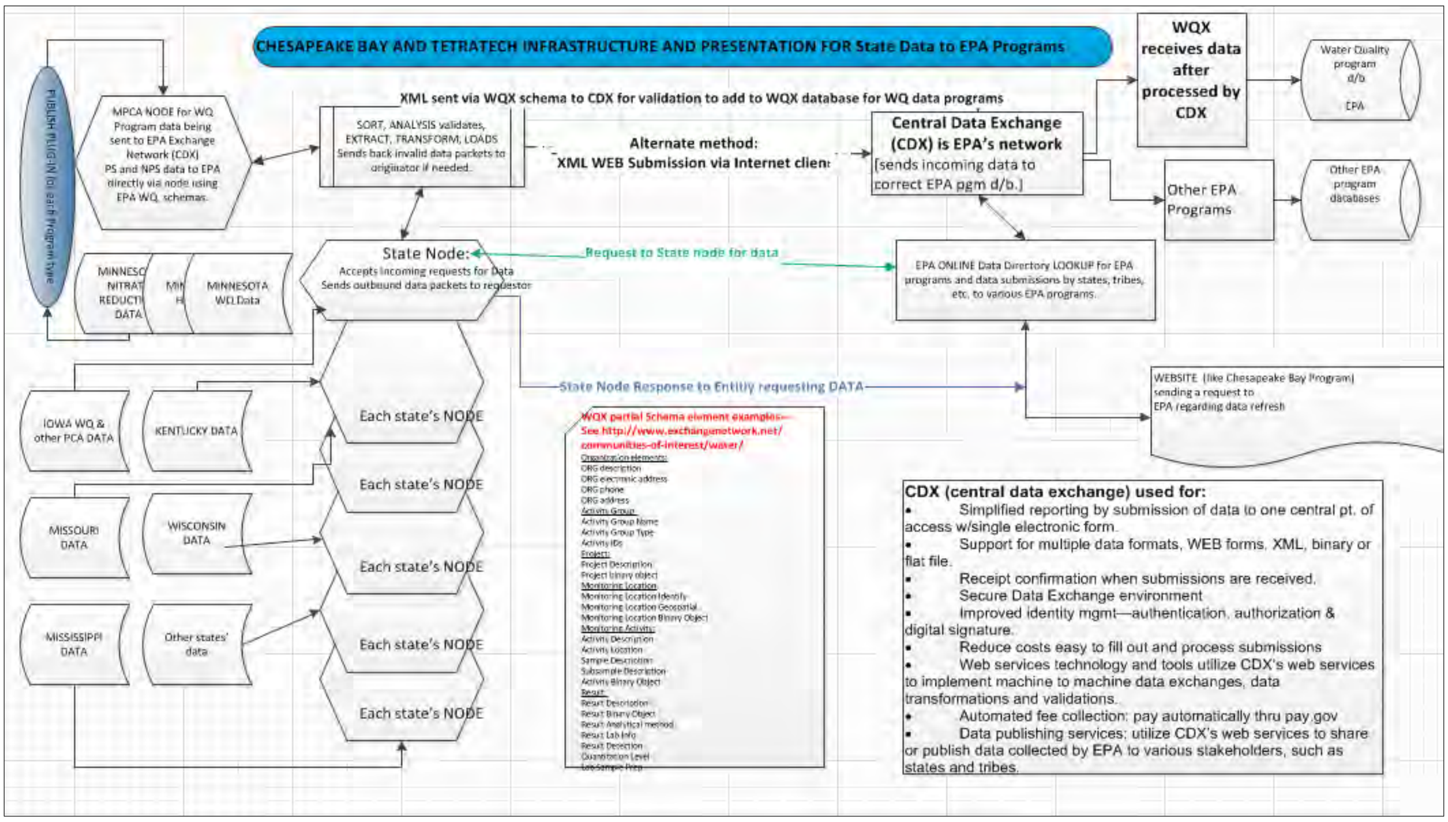
Elements Needed for Future Completion of a Mississippi River CB-Stat type of system

- A Watershed Statistical Model to provide context for Minnesota data.
- Data to support this model from the State of Minnesota, related to Mississippi river headwaters and all outflows beyond state borders.
- Minnesota inter-agency data collection project
- Interstate agreements and development of databases and system for the Mississippi River Nutrient Reduction efforts

Recommended Steps for Development of a Tracking Tool for MSLNRP

1. Coordinate data definition with other agencies in Minnesota to enable aggregation, standardization, and reporting of calibrated data. This would involve considerable effort to achieve.
2. Coordinate the vision of the MSLNRP with the MPCA Watershed Data Integration Program. Combine resources when appropriate funding becomes available. Track and store data at levels of detail and in formats: that enable aggregation; that make the data compatible with reporting guidelines, and; that meet requirements to support development of an inter-agency web portal.
3. Apply synergies between the MSLNRP visions with strategies of the WDIP program wherever feasible. Incorporate water quality WRAP information in communications to a wider audience by using viable outcomes from the WDIP program. Store data and share via the web when possible using options as they become available.
4. Promote creation of web services for data sharing at each partner organization.
5. Support creation of an interagency network of databases and portals needed to enable the tracking and presentation of BMP implementation progress to address the reduction strategies to be developed in the MSLNRP.
6. Coordinate with other state agencies both within Minnesota and outside of Minnesota to coordinate in the monitoring and collection of data at sites along the Mississippi Basin. Data exchange nodes are available at many of the downstream states on the Mississippi Basin and these partners, as well as in-state agency partners would enhance nutrient reduction efforts.
7. Define a Watershed Statistical Model which could be similar to the undertaking of the Chesapeake Bay.
8. Collect, store, and transmit data according to EPA requirements (i.e., NEIEN WQX schema). See flow in APPENDIX A-1.

APPENDIX A-1 Data Flow Diagram to US EPA via NEIEN Nodes from CB & Other States



APPENDIX A-2: CB Technical Information on EPA Node Setup & Management of Data

The National Environmental Information Exchange Network (NEIEN) is an innovative approach for the exchange of data between the EPA, states, and partner organizations. The Network provides the framework for the exchange of quality environmental information. The framework is built on Internet-based standards, technologies, and protocols. This is critically important for the long-term success of the Network.

To participate in the Network, each exchange partner requires a Network node (Node). The Node hosts a suite of standard web services that facilitate the authentication and exchange of data between partners. The messaging between partners is handled through standard extensible markup language (XML).

In federal fiscal year 2004, the Pennsylvania Department of Environmental Protection (PADEP) was awarded a Network Challenge Grant to facilitate the exchange of non-point source best management practice (BMP) data between the Chesapeake region states of Pennsylvania, Maryland and Virginia; and the Chesapeake Bay Program Office (CBPO).

The grant called for the establishment of a new Node at the Chesapeake Bay Program Office in Annapolis, Maryland (Chesapeake node). The Chesapeake node is required to support exchanges between the state nodes and Chesapeake node, and the EPA node (CDX) and the Chesapeake node.

The technology of choice for the Chesapeake node is the Microsoft .NET framework with Microsoft's SQL Server as the backend data store. Existing node configuration and requirements serve as the blueprint for the Chesapeake node. In particular, the development team follows the guidelines established in the *Network Node Functional Specification* (v.1.1, September 2003); the *Exchange Network Node Implementation Guide* (v.1.0, April 2003); and the *Developing and Implementing an Exchange Network Node, 30 Minute Guide* (v.1.1, March 2005).

Further, the CB development team plans on leveraging existing demonstrated node configuration documents. The *Washington State Department of Ecology, Demonstrated Node Configuration* (v.1.0, November 2003), the *Mississippi Demonstrated Node Configuration* (v.1.1, December 2003), and the demonstrated node configuration server side code for Microsoft C#.NET and Microsoft VB.NET were all considered prior to the development of the Chesapeake node.

Node Authentication Model

The Chesapeake node uses the Network's Network Authentication and Authorization Service (NAAS) to handle all authentication functions. The Chesapeake Bay Program manages privilege to the Chesapeake node within the NAAS using a web-based user interface provided by the Network.

As detailed in Figure 1, the Chesapeake node obtained a security token from the NAAS using the authentication service. The security token is passed to send or retrieve data from a partner node. The partner node validates the security token prior to responding to the request.

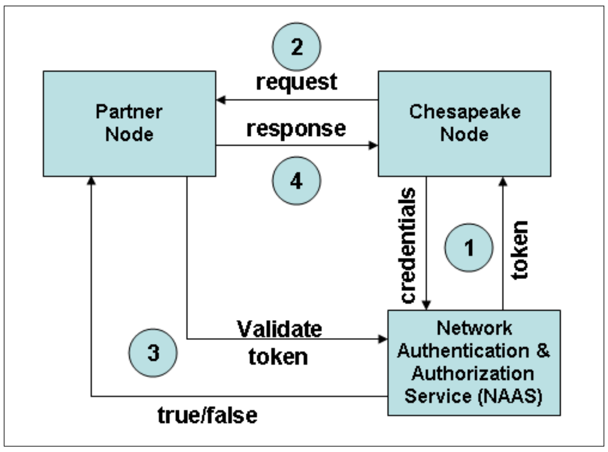


Figure 1: Authentication Model

Auditing

Pertinent node activity is logged to a Microsoft SQL Server database. This includes the date and time of outbound requests submitted to partner nodes, the date and time of inbound requests from partner nodes, and the status of those requests. Additional information about the requests may be captured in the future, which may include the request parameters and request response times.

Technical Specification

The following specifications will be used for the initial installation of the Chesapeake node:

- Microsoft Server 2003, Enterprise Edition
- Microsoft Internet Information Server (IIS) 6.0
- Microsoft SQL Server 2003
- Microsoft .NET Framework 1.1
- Web Services Enhancements 1.0 (WSE)

References

For further specifications about the Chesapeake Bay Node and Data consult the following links at MPCA node documentation and referenced documents below the links.

1. X:\Agency_Files\Administrative_Services\Information_Systems\Section_Stuff\Projects\WDIP Phase 3\Projects\7a ChesStat BayTAS\NEIEN\CIMS Metadata Report Guidelines.pdf

2. X:\Agency_Files\Administrative_Services\Information_Systems\Section_Stuff\Projects\WDIP Phase 3\Projects\7a ChesStat BayTAS\NEIEN\NodeFunctionalSpecification_v2.1.pdf

3. X:\Agency_Files\Administrative_Services\Information_Systems\Section_Stuff\Projects\WDIP Phase 3\Projects\7a ChesStat BayTAS\NEIEN\WQ Data Exchange Node tutorial.pdf

4. X:\Agency_Files\Administrative_Services\Information_Systems\Section_Stuff\Projects\WDIP Phase 3\Projects\7a ChesStat BayTAS\NEIEN\WQX_FCD_v2.1.pdf

5. X:\Agency_Files\Administrative_Services\Information_Systems\Section_Stuff\Projects\WDIP Phase 3\Projects\7a ChesStat BayTAS\NEIEN\NPS_Schema_Users_Guide.doc and in same folder: ..\NEIEN\NPS_NEIENetwork ExchangeTradingPartnerAgreement.doc

6. *Network Node Functional Specification*, v.1.1, September, 2003

7. *Network Exchange Protocol*, v.1.1, September, 2003

8. *Exchange Network Node Implementation Guide*, v1.0, April, 2003

9. *Washington State Department of Ecology, Demonstrated Network Node Configuration*, v1.0, November 2003

10. *Developing and Implementing an Exchange Network Node*, v1.1, March, 2005

11. *Mississippi Demonstrated Node Configuration*, v1.1, December 2003

APPENDIX B: Data Schema Used to Transmit Data to EPA

The EPA uses a data schema (partial schema fields below) for transmission of data that is defined by Categories, sub-categories, sorts within the sub-categories, and Data Element XML tags. The full spreadsheet of EPA schema is located at the following link within the MPCA server environment:

X:\Agency_Files\Administrative_Services\Information_Systems\Section_Stuff\Projects\WDIP Phase 3\Projects\7a ChesStat BayTAS\CHESAPEAKE BAY SITE DATA & CHARTS\Data Elements for EPA schema__WQX_DET_v2.1b.xls

Sample of schema:

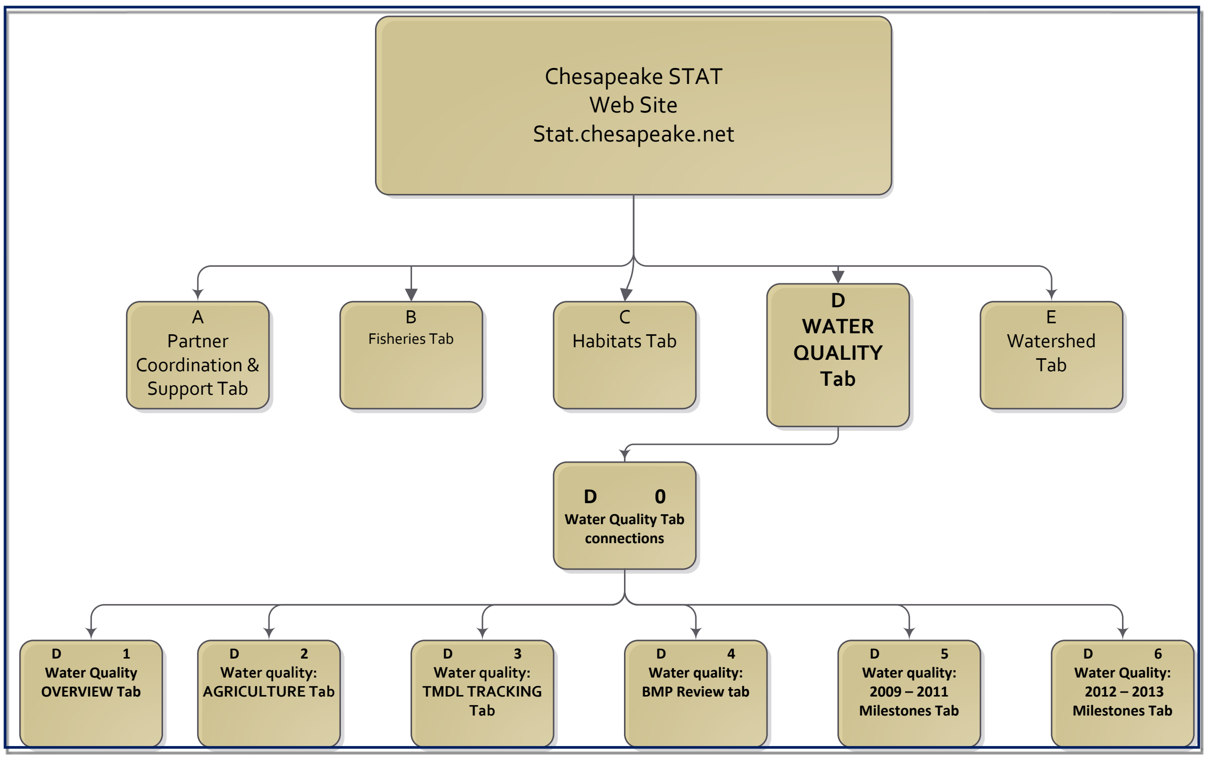
WQX Exchange schema v. 2.1 (abbreviated form)			
Category	**Subcategory**	**Data Element XML Tag**	**WQX Definition**
ORGANIZATION	ORG Description	OrganizationDescription	Header The particular word(s) regularly connected with a unique framework of authority within which a person or persons act, or are designated to act, towards some purpose.
	ORG Electronic Address	ElectronicAddress	Header This section allows for the description of many electronic addresses per owning Organization.
	ORG Telephonic	Telephonic	Header This section allows for the description of many telephone numbers per owning Organization.
	ORG Organization Address	OrganizationAddress	Header This section allows for the description of up to three physical addresses for the owning Organization.
PROJECT	PROJ Description	Project	Header; This section allows for the description of Organization Projects.
	PROJ Binary Object	ProjectAttachedBinaryObject	Header; This section allows for the association of References and electronic attachments to the project, including formal Project Plan and any other documents, images, maps, photos, laboratory materials, geospatial coverages, and other objects associated with the Project..
PROJECT MONITORING LOCATION WEIGHTING	Project Monitoring Location Weighting	ProjectMonitoringLocationWeighting	Header This section describes the probability weighting information for a given Project / Monitoring Location Assignment.
	Project Monitoring Location Weighting	LocationWeightingFactorMeasure	Header; A measurement of the monitoring location selection weighting factor.
	Project Monitoring Location Weighting	ReferenceLocationCitation	Header; Identifies the source that created or defined the Reference Location.
MONITORING LOCATION	Monitoring Location Identity	MonitoringLocationIdentity	Header This section allows the owning Organization to describe monitoring locations.
	Monitoring Location Geospatial	MonitoringLocationGeospatial	Header; This section allows for the geospatial description of a monitoring station. This section records the location in 3 dimensions.
	Monitoring Location Geospatial	HorizontalAccuracyMeasure	Header; The horizontal measure of the relative accuracy of the latitude and longitude coordinates
	Monitoring Location Geospatial	VerticalMeasure	Header; The measure of elevation (i.e., the altitude), above or below a reference datum.
	Monitoring Location Well Information	WellInformation	Header; Description of the attributes of a well
	Monitoring Location Binary Object	AttachedBinaryObject	Header; This section allows for the association of References and electronic attachments to the Monitoring Location description including any other documents, images, maps, photos, laboratory materials, geospatial coverages, and other objects associated with the Project.

WQX Exchange schema v. 2.1 (abbreviated form)			
Category	**Subcategory**	**Data Element XML Tag**	**WQX Definition**
	Biological Habitat Index	BiologicalHabitatIndex	Header; This section allows for the reporting of habitat and biotic integrity indices as a representation of water quality conditions.
	Biological Habitat Index	IndexType	Header; This section identifies the index type reported as part of a biological or habitat index.
	Biological Habitat Index	IndexTypeCitation	Header; Provides additional description of the source that created or defined the index.
MONITORING ACTIVITY	ACTIVITY Description	Activity	Header; This section allows for the reporting of monitoring activities conducted at a Monitoring Location
	ACTIVITY Description	ActivityStartTime	The measure of clock time when the field activity began.
	ACTIVITY Description	ActivityEndTime	The measure of clock time when the field activity ended.
	ACTIVITY Description	ActivityDepthHeightMeasure	Header; A measurement of the vertical location (measured from a reference point) at which an activity occurred.
	ACTIVITY Description	ActivityTopDepthHeightMeasure	Header; A measurement of the upper vertical location of a vertical location range (measured from a reference point) at which an activity occurred.
	ACTIVITY Description	ActivityBottomDepthHeightMeasure	Header; A measurement of the lower vertical location of a vertical location range (measured from a reference point) at which an activity occurred.
	BIOLOGICAL ACTIVITY Description	BiologicalActivityDescription	Header; This section allows for the reporting of biological monitoring activities conducted at a Monitoring Location
	BIOLOGICAL Habitat Collection Information	BiologicalHabitatCollectionInformation	Header; Allows for the reporting of biological habitat sample collection information
	BIOLOGICAL Habitat Collection Information	ReachLengthMeasure	Header; A measure of the water body length distance in which the procedure or protocol was performed.
	BIOLOGICAL Habitat Collection Information	ReachWidthMeasure	Header; A measurement of the reach width during collection procedures.
	BIOLOGICAL ACTIVITY Net Information	NetInformation	Header; Allows for the reporting of net sample collection information
	BIOLOGICAL ACTIVITY Net Information	NetSurfaceAreaMeasure	Header; A measurement of the effective surface area of the net used during biological monitoring sample collection.
	BIOLOGICAL ACTIVITY Net Information	NetMeshSizeMeasure	Header; A measurement of the mesh size of the net used during biological monitoring sample collection.
	BIOLOGICAL ACTIVITY Net Information	BoatSpeedMeasure	Header; A measurement of the boat speed during biological monitoring sample collection.
	BIOLOGICAL ACTIVITY Net Information	CurrentSpeedMeasure	Header; A measurement of the current during biological monitoring sample collection.
	SAMPLE Description	SAMPLE Description	Header; header in schema for Sample only
	SAMPLE Description	SampleCollectionMethod	Header: Identifies sample collection or measurement method procedures. Where a documented sample collection method has been employed, this enables the data provider to indicate the documented method that was employed during the field sample collection. Otherwise, the sample collection procedure will best be described in a freeform text.

WQX Exchange schema v. 2.1 (abbreviated form)			
Category	**Subcategory**	**Data Element XML Tag**	**WQX Definition**
	SAMPLE Prep	SamplePreparation	Header This section describes a sample preparation procedure which may be conducted on an initial Sample or on subsequent subsamples.
	SAMPLE Prep	SamplePreparationMethod	Header Identifying information about the method(s) followed to prepare a sample for analysis.
	ACTIVITY Metric	ActivityMetric	Header; This section allows for the reporting of metrics to support habitat or biotic integrity indices.
	ACTIVITY Metric	ActivityMetricType	Header; This section identifies the metric type reported as part of an activity metric.
	ACTIVITY Metric	MetricValueMeasure	Header; A non-scaled value calculated from raw results that may be scaled into a metric score.
	Activity Binary Object	ActivityAttachedBinaryObject	Header; This section allows for the association of References and electronic attachments to the Activity description including any other documents, images, maps, photos, laboratory materials, geospatial coverages, and other objects associated with the Project..
RESULT	Result Description	Result	Header; This section describes the results of a field measurement, observation, or laboratory analysis.
	Result Description	ResultMeasure	Header; The reportable measure of the result for chemical, microbiological, or other characteristics being analyzed.
	Result Description	DataQuality	Header; The quantitative statistics and qualitative descriptors that are used to interpret the degree of acceptability or utility of data to the user.
	Result Description	ResultDepthHeightMeasure	Header; A measurement of the vertical location (measured from a reference point) at which a result is obtained.
	BIOLOGICAL Result Description	BiologicalResultDescription	Header; This section allows for the reporting of biological result information.
	BIOLOGICAL Result Description	GroupSummaryCountWeight	Header: Captures the total count or total sample weight for a Group Summary
	Result Taxonomic Details	TaxonomicDetails	Header; This section allows for the further definition of user-defined details for taxa.
	Result Taxonomic Details	TaxonomicDetailsCitation	Header; Identifies the source that created or defined the Taxonomic Details.
	Result Frequency Class Information	FrequencyClassInformation	Header; This section allows for the definition of a subgroup of biological communities by life stage, physical attribute, or abnormality to support frequency class studies.
	Result LAB Info	ResultLabInformation	Header; Information that describes information obtained by a laboratory related to a specific laboratory analysis.
	Result LAB Info	AnalysisStartTime	The local time and relative time zone when the analysis began.
	Result LAB Info	AnalysisEndTime	The local time and relative time zone when the analysis was finished.
	Result Detection Quantitation Limit	ResultDetectionQuantitationLimit	Header; Information that describes one of a variety of detection or quantitation limits determined in a laboratory.

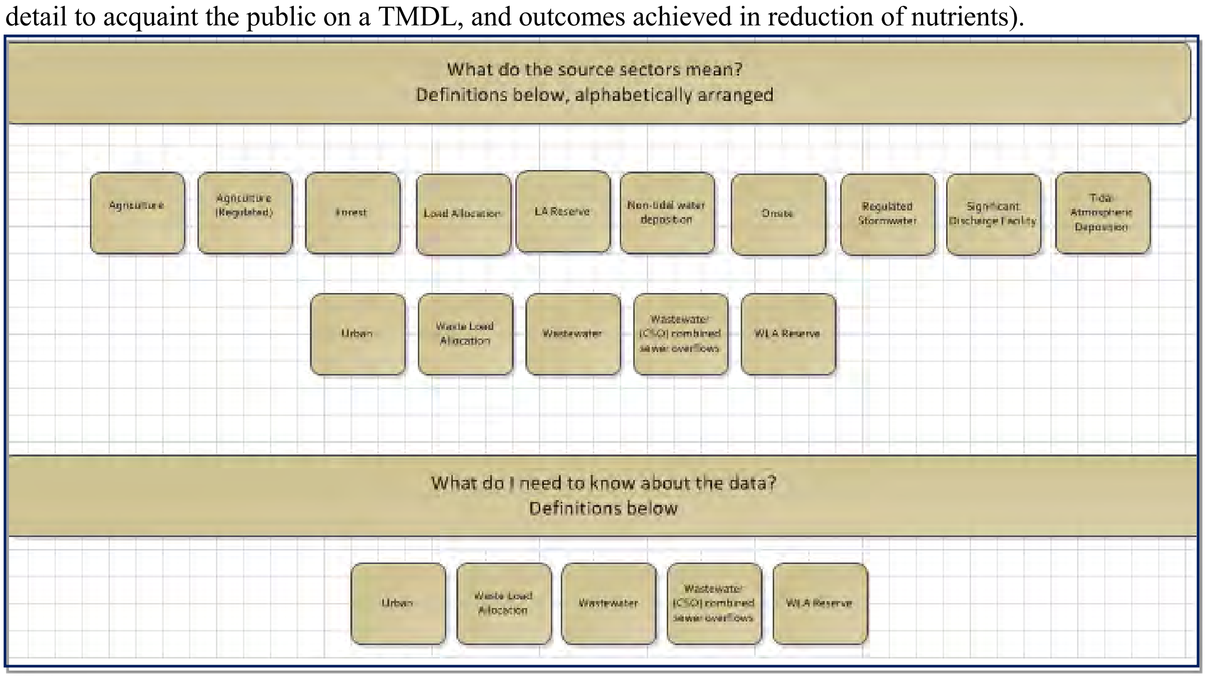
WQX Exchange schema v. 2.1 (abbreviated form)			
Category	**Subcategory**	**Data Element XML Tag**	**WQX Definition**
	Result Detection Quantitation Limit	DetectionQuantitationLimitMeasure	Constituent concentration that, when processed through the complete method, produces a signal that is statistically different from a blank.
	LAB Sample Prep	LabSamplePreparation	Header; Describes Lab Sample Preparation procedures which may alter the original state of the Sample and produce Lab subsamples. These Lab Subsamples are analyzed and reported by the Lab as Sample results.
	LAB Sample Prep	LabSamplePreparationMethod	Header; Identifying information about the method followed to prepare a sample for analysis
	LAB Sample Prep	PreparationStartTime	The local time when the preparation/extraction of the sample for analysis began.
	LAB Sample Prep	PreparationEndTime	The local time when the preparation/extraction of the sample for analysis was finished.
	ACTIVITY Group	ACTIVITY Group	Header; Allows for the grouping of activities

APPENDIX C: Overall Web Flow of ChesapeakeStat Site



Above are the primary tabs for navigation of the Water Quality section of the CB website. The Water Quality Tab is expanded into tabs D1 through D6 (above). These are the main tabs evaluated for the analysis project. Sample pages from the website which are representative of the types of presentation and formatting recommended for the Minnesota project are contained below in APPENDIX D.

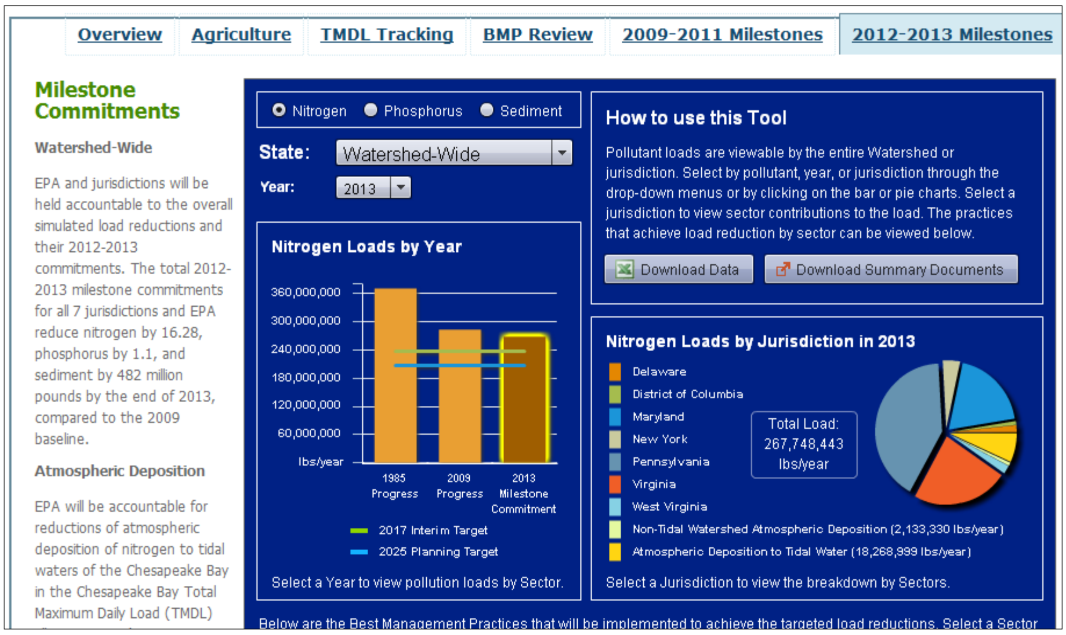
The following shows the D3 Tab TMDL detailed steps presenting the TMDL elements (specific definition, detail to acquaint the public on a TMDL, and outcomes achieved in reduction of nutrients).



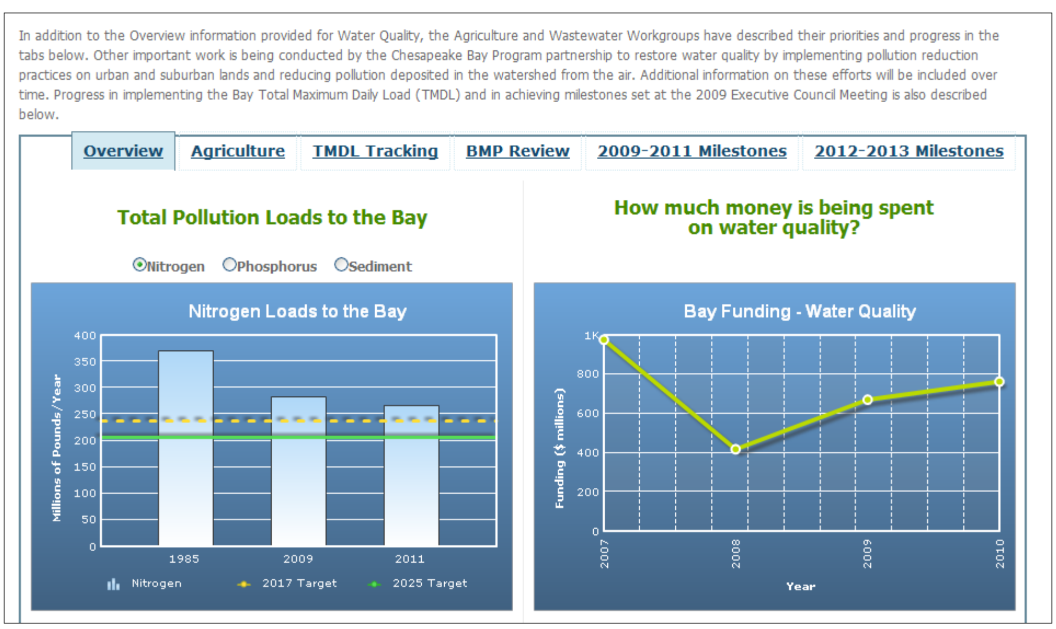
APPENDIX D: Examples of ChesapeakeStat Website Pages for Visual Reference

Partial Sampling of Interactive Charts and Maps from the ChesapeakeStat website which provide a visual presentation of water quality data and how it might be presented to convey nutrient reduction targets set and achieved over 25 years for the Bay estuary.

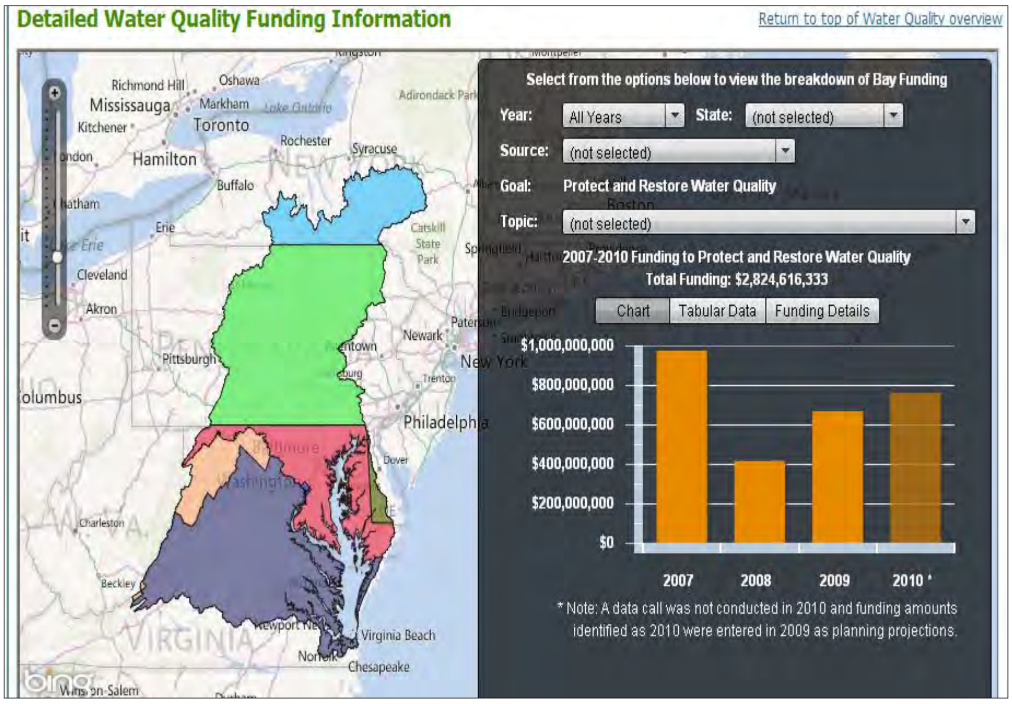
Milestones 2012-2013



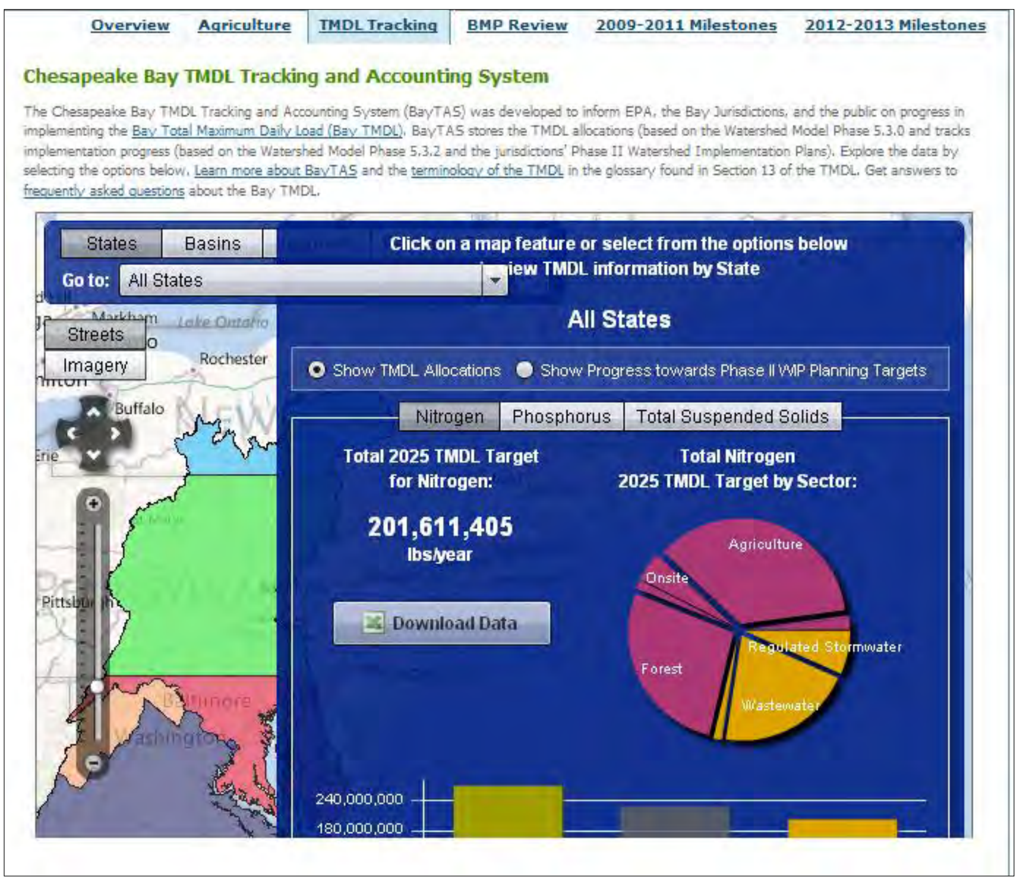
Overview: Pollution Loads and Funds Spent



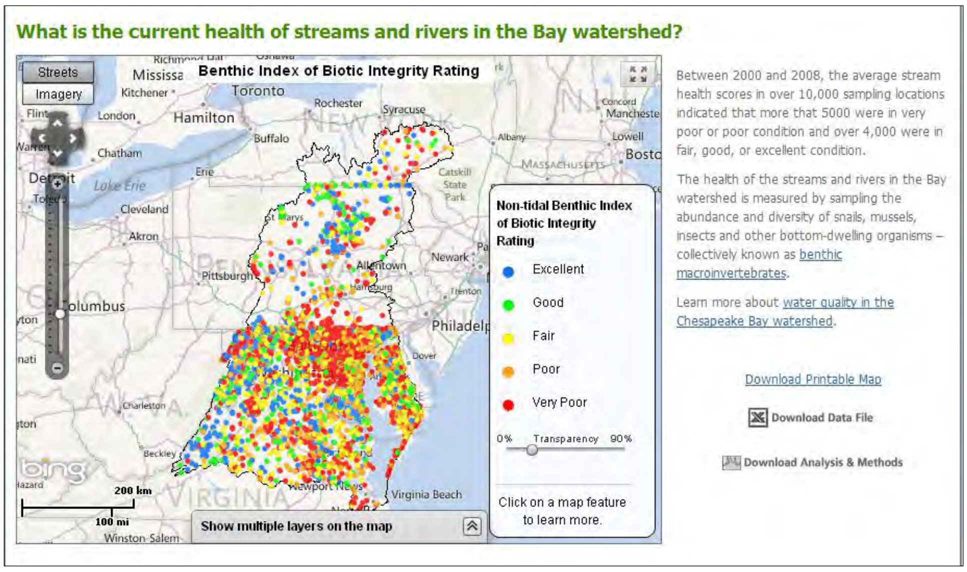
Detailed Water Quality Funding by State, Year, Source, Goal & Topic



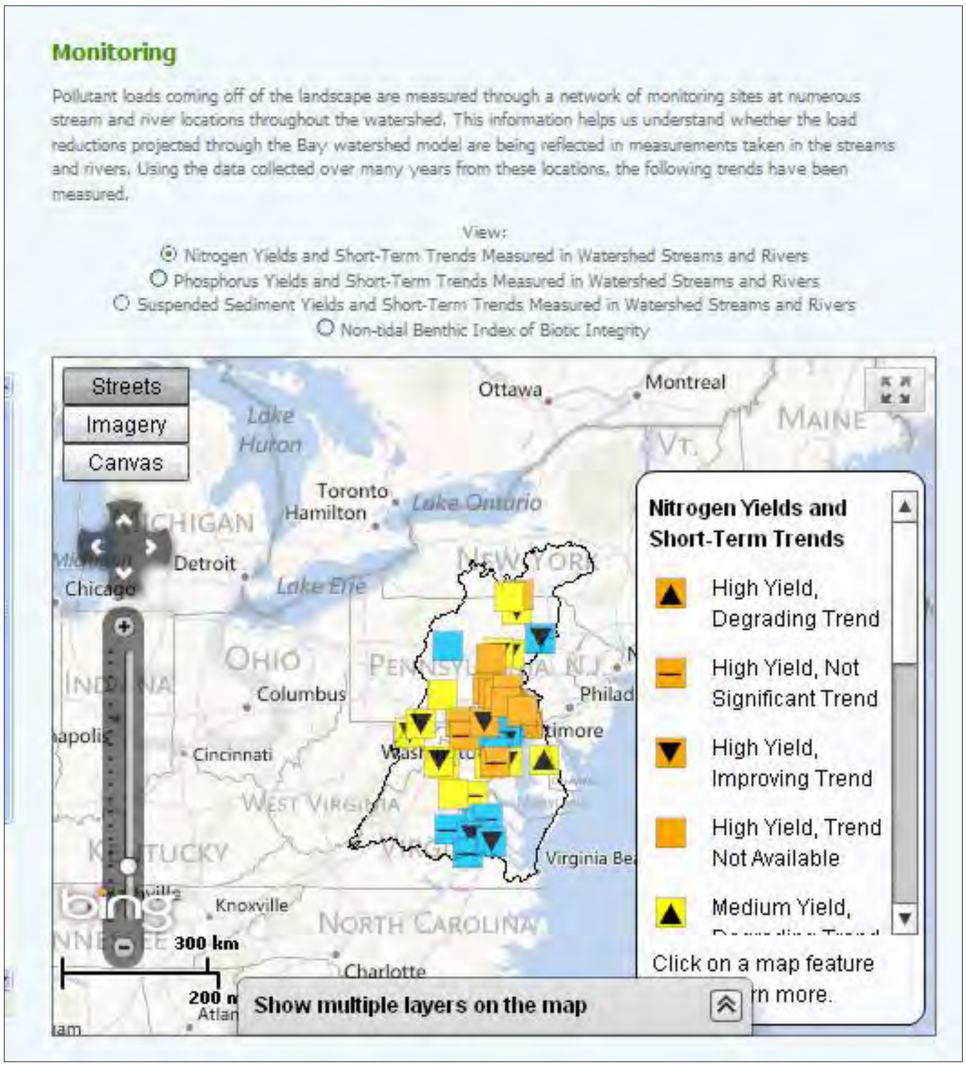
Interactive Map/Chart for TMDL tracking by State, Basin and Pollutant



Interactive Map tool showing Major Basin Health



Interactive Map/Chart for Monitoring Strategy by Pollutant



End of Report

Appendix H: Tracking Tool Recommendations

Purpose of this Document

Tracking progress toward the Minnesota Nutrient Reduction Strategy (NRS) goals and milestones requires a wide array of program output and water quality outcome data and information from federal, state, and local partners and stakeholders. While a variety of tracking tools exist within many federal, state, and local agencies, a coordinated system for tracking nutrient reductions associated with implementation activities to support the NRS is not available.

The development of the program and water quality measures highlighted the challenges associated with compiling the data necessary to quantify implementation activities and nutrient loads by major basin. The data compiled for the suite of programmatic and water quality measures vary in collection methodology and frequency, documented in the measure metadata worksheets provided in Appendix F of the NRS. Data from several nutrient reduction programs are tracked through grant or program-specific systems such as BWSR's eLink. Over time, an inter-agency, integrated tracking tool will provide a more systematic approach for compiling the data from the various programs to support regular assessments of the NRS's progress and reporting to key stakeholders within and outside of Minnesota.

This document provides an overview of the preliminary requirements for a NRS tracking tool, as well as information on existing data management systems related to program measures, and an overview of IT efforts taking place in Minnesota that could affect the development of a NRS tracking tool. It concludes with recommendations on the type of tracking tool Minnesota should be considered to support progress tracking and reporting for the NRS goals and milestones, with both short- and long-term proposed tasks and estimated costs for tool development.

Preliminary NRS Tracking Tool Requirements

In information management system development, the term *requirement* is used to describe a feature, behavior, or performance goal expected from an information management system. In this context, requirements are the features and performance goals needed from a tracking tool to support the NRS. There are three types of requirements involved in the system development process: 1) business requirements, 2) user requirements, and 3) non-functional requirements. A description of each type of requirement is provided below. The sections below discuss preliminary system requirements. These requirements are by no means comprehensive; they represent requirements gleaned from the information provided by MPCA staff through the NRS development process. A more rigorous requirements analysis would be required prior to system development, but the information here could serve as a starting point.

Business Requirements

Business requirements provide the high-level vision for the NRS tracking tool. They explain the compelling reasons for the NRS tracking tool, including the expected benefits. At the highest level, these requirements define what would be expected for the tracking tool to be successful. The business requirements will enable MPCA and other agencies involved in NRS implementation to measure the success of the tracking tool by tracing the requirements through the tracking tool design into tool use so that every element of the tool can be evaluated against these overarching requirements. Table 1 presents the high-level business requirements identified through discussions with MPCA staff and a working knowledge of the NRS's tracking needs.

Table 1. Preliminary High-level Business Requirements and Priority for the NRS Tracking Tool

BR ID	High-level business requirements	Priority
BR1	Track BMP implementation related to the NRS, including the key BMPs identified under selected program measures implemented by state agencies and federal agencies	High
BR2	Improve process and information management efficiency among many state and federal agencies, as well as local-level partners	High
BR3	Extract BMP information (type, location, date of implementation, treatment area, size of BMP) from existing data management tools and systems associated with key programs reflected in program measures	High
BR4	Calculate or estimate the phosphorus and nitrogen load reductions associated with BMPs	High
BR5	Track nutrient reductions associated with BMP implementation over time against Phase I Milestone s	High
BR6	Track implementation of BMPs by major basin and HUC8	High
BR7	Track BMP implementation implementation-related activities related to other state agency programs including Farm Bill programs	High
BR8	Track BMPs implemented voluntarily by landowners that are not affiliated with specific governmental programs	High
BR9	An effective tool for making adaptive management decisions that will ensure that nutrient reduction activities will coincide with monitored water quality information	High
BR10	Provide data to support communicating with member states along the Mississippi River Basin and the Gulf of Mexico Task Force about Minnesota's contribution of nutrients	High
BR11	Support timely communication with the public and nutrient sources when goals and reductions are or aren't achieved	High
BR12	Provide web-accessible implementation progress information for all stakeholders	High
BR13	Integrate with ongoing MPCA IT initiatives and other statewide IT data considerations	High
BR14	Track BMP costs where cost information is available	High

User Requirements

The user requirements describe the processes and tasks that system users need to perform their job. For the NRS tracking tool, user requirements include tracking specific BMPs in the program measures, using pre-determined effectiveness values for nitrogen and phosphorus for each type of BMP, extracting data from existing agency systems, and providing information in useable formats such as Excel spreadsheets, GIS mapping, and charts. Table 2 provides a preliminary list of the user requirements that a NRS tracking tool for Minnesota should address and links these user requirements to the high-level business requirements described in the previous section.

Table 2. Preliminary User Requirements and Related Business Requirements for the NRS Tracking Tool

UR ID	User Requirements	Related BR ID
UR1	The system should track the specific BMPs in the program measure metadata worksheets used to quantify implementation in the NRS	BR1, BR3
UR2	The system should use pre-determined effectiveness values for phosphorus and nitrogen removal assigned to each BMP	BR4, BR5
UR3	The system should extract data from eLink, the RIM database, NRCS database for EQIP, FSA database for CRP, AgBMP database, WQ Delta database.	BR2, BR3
UR4	The system should develop reports in tabular format using Excel spreadsheets.	BR2, BR9, BR10
UR5	The system should allow for GIS mapping of BMP locations at the HUC8 scale.	BR2, BR6, BR9, BR10
UR6	The system should generate online graphs and charts to illustrate trends over time.	BR2, BR9, BR10
UR7	The system should track nitrogen and phosphorus reductions from sector-specific BMPs against Phase I Milestone for each major basin as documented in the NRS.	BR1-11
UR8	The system should capture instream monitoring and modeling information generated by MPCA's watershed approach to show trends in instream nutrient loads at key locations.	BR5, BR9-11
UR9	The system should allow other implementation partners to manually enter voluntary BMP implementation data related to non-governmental activities through a web-based interface.	BR7, BR8, BR12
UR10	The system should track BMP and in-stream trend information at the HUC8 level	BR6
UR11	The system should allow for additional integration with future state program databases.	BR13
UR12	The system should allow for manual input of additional program information that is not stored via database.	BR8
UR13	The system should export BMP costs where cost information is available in existing systems and allow for manual input of cost information where it is not tracked in existing systems.	BR14

There are other user requirements for the NRS tracking tool that will need to be defined by potential tool users. These requirements can be defined through a requirements scoping session by answering a series of questions, including:

- How many different report structures will there be?
- What functions will be offered to the public versus backend users?
- How many users will there be?
- How many user roles and will there be and what will they be able to do?
- What are the technology and hosting requirements of the system (e.g., which agency will host the NRS tracking tool)?
- How many records will it need to manage?
- What advanced features, such as complex logic, computations and integrations with 3rd-party tools, are required to make the system successful?
- What is the final number of other systems that it must interact with, what is the complexity of each interaction, what is the maturity and stability of each peer system?
- What is the degree of GIS functionality required and what is the level of GIS data integration?

- How flexible must the system be accommodate changes in business processes? Will those changes be configured and entered by administrative users, or will they implemented by changes to programming code?

Nonfunctional Requirements

Limitations that affect one or more user or functional requirements are referred to as nonfunctional requirements. For example, "Maintain a schedule" is a functional requirement. The corresponding nonfunctional requirement might state "Do not let the schedule consume more than 10MB of disk space." Table 3 presents common types of nonfunctional requirements. Table 4 contains a preliminary list of nonfunctional requirements related to the NRS tracking tool.

Table 3. Type of Nonfunctional Requirements

Type	Description
Availability	The amount or percentage of time that the system is available for use by the users. Availability may be negatively affected by a variety of events including user error, hardware failure, external system events, unavailability of support personnel, and such.
Compatibility	The ability of the system under discussion to appropriately interact with others systems in its context
Completeness	For the domain of the system, the allowable maximum number or percentage of errors of omission
Correctness	The allowable maximum number or percentage of errors of commission
Cost of Ownership/ROI	The total costs (direct and indirect) of owning the system
Environmental	The environmental conditions in which the system must function
Extensibility	The use of the system in the same context with additional functionality
Installation Complexity	The combination of direct or indirect costs of installing the system
Parallel Processing	The ability of the system to fulfill requirements simultaneously using duplicated rather than shared resources
Performance	A measure of user expectations of system response times
Portability	The ability of the system to fulfill its requirements in more than one operating environment
Regulatory	The specific regulation(s) with which the system must be compliant
Reusability	The use of the system in a different context with the same functionality
Scalability	The ability of the system to fulfill its requirements for increasing numbers of users, transactions, and such.
Security	The requirements of the system with respect to access control and/or other context-specific security rules and/or regulations
Time to Market	The statement of the time at which the system must become available to and operable by its intended users
Training Complexity	The combination of direct or indirect costs for training the system's users
Usability	The measurement of how often, how efficiently, and/or correctly people use the system
Portability	The ability of the system to fulfill its requirements in more than one operating environment

Table 4. Preliminary List of Nonfunctional Requirements for the NRS Tracking Tool and Associated Category

NFR ID	Nonfunctional Requirement	Category
NFR1	The system should be consistent with the NRS goals, milestones and Minnesota's water quality standards	Compatibility
NFR2	The system should link to existing state agency and federal partners' tracking tools (i.e., databases, spreadsheets)	Compatibility
NFR3	The system should have the capacity to include additional information beyond the program measures over time	Extensibility
NFR4	Make it available to the public over time	Scalability
NFR5	Allow third-party volunteer information with screening	Security

Constraints

Constraints limit the system development process. They affect user and functional requirements at the management level. Table 5 contains a preliminary list of constraints based on knowledge of the NRS. More constraints would be identified in a comprehensive system requirements analysis.

Table 5. Preliminary List of Constraints for the NRS Tracking Tool

CON ID	Constraint	Priority
CON1	The system should be compatible with the new MPCA enterprise data model.	High
CON2	The system should be maintained and operated by MPCA, with accessibility by other state agencies.	High
CON4	Involve point person from each program captured through the existing program measures.	High

Ongoing Data Management Initiatives Affecting the NRS Tracking Tool Conceptualization

The timing of the NRS and the associated data tracking needs coincides with several other tracking and reporting efforts taking place within the state. This allows for the NRS's tracking needs to be incorporated into other ongoing system development and refinement projects. Examples of ongoing system development opportunities that could integrate NRS tracking needs include the following:

MPCA's Transformation Project. MPCA is currently changing their information systems to a tempo-based enterprise system. As a result of this change, all program data will be managed in a similar manner, allowing program data within the agency to be better integrated.

MPCA's Watershed Data Integration Project (WDIPs). A multi-year data integration project intended to improve MPCA's staff handling and sharing of data and information generated through the watershed management process. (http://www.pca.state.mn.us/index.php/view-document.html?gid=15386) Through the WDIP, MPCA staff are working with TMDL and WRAP program staff to develop a data capture tool to present implementation tables on MPCA's website by 2016, as required under the 2013 Clean Water Legacy Accountability Act.

Portal. Minnesota agencies are also engaging in a Portal project that would allow better inter-agency data sharing. This project is currently in the discovery stage. It would offer the opportunity to integrate MPCA's data systems with those at other key agencies, including BWSR, MDA, and MDNR.

FSA CRP System. FSA mentioned that their existing data management system is currently changing. Further information about the old system and the new system would be needed for integration into a NRS tracking tool.

There is also a need for improved data sharing among Minnesota agencies and key federal agencies working within the state, specifically FSA and NRCS. In addition there is a need for a tracking tool that would allow private-landowners or other government entities such as counties and SWCDs to provide information on voluntary conservation practices that are not related to state or federal programs and funding.

In addition to the programs and BMPs currently identified in the NRS, the NRS tracking tool will also need to capture non-governmental program information about voluntary BMP implementation from other entities, possibly soil and water conservation districts and extension programs. At this point in time, it is unclear how this voluntary BMP information is tracked at the local level and the type of systems that might be in place to manage this type of information. Tracking tool development will need to include a task to investigate data sources for voluntary BMP implementation and determine feasible mechanisms to either capture information from existing data systems with this information or allow for manual data entry from these entities via a Web-based interface.

NRS Tracking Tool Development Recommendations

Based on the review and understanding of the preliminary requirements of the NRS tracking tool and the current understanding of the technical environment, it is recommended that Minnesota consider developing a tracking tool that is conceptually similar to the Chesapeake Bay Tracking and Accounting system (BayTAS) as a starting point for development of the Minnesota NRS Tracking and Accounting System (System) using .NET, ESRI Flex or JS API and SQL Server. The concept of BayTAS is a hub and spoke tool, meaning that the tracking system pulls data from a variety of existing data sources and integrates the information according to a set of specified metrics to fulfill program tracking and reporting needs. Therefore, development of the tool requires an in-depth understanding of the existing data management systems used by information that will travel from the spokes to the hub or, in this context, the NRS tracking tool.

The functionality of the NRS tracking tool will ultimately depend on the high-level business and user requirements for the tool, coupled with information about the existing data management systems. Developing this type of tool will require additional scoping to refine the business and user requirements to further define functionality. Once a final comprehensive system analysis is complete, Minnesota can begin to develop the NRS tracking tool's Web page interface and defined functionality, using 3-5 program measures as a tracking pilot for the tool. The recommended tasks for comprehensive scoping, initial development, and long-term maintenance of the NRS tracking tool are described below.

TASK 1: IDENTIFY TRACKING TOOL TEAM

The initial task for development of the NRS tracking tool is to assemble a Tracking Tool Team that can draw from the existing ICT members, as well as include program data analysts who understand the functionality of the existing data systems that will feed the NRS tracking tool. The Team will provide input on the preliminary system requirements and aid in refining those requirements.

TASK 2: REVIEW EXISTING PROGRAM MEASURES, REFINE METRICS, SELECT MEASURES FOR TRACKING PILOT

Under this task, the NRS tracking tool team will review the existing program measures in Appendix F of the NRS and identify those that require updating or refinement.

To focus efforts and demonstrate utility from development to web reporting, the number of program measures used in the initial NRS tracking tool should be limited to 3-5. This will allow for piloting the NRS tracking tool to assess the functionality before incorporating the other measures. Once the Team identifies the 3-5 pilot program measures, work can begin to refine these program measures, using the existing measure metadata worksheets.

TASK 3: ANALYZE EXISTING DATA MANAGEMENT SYSTEMS TO SUPPORT DATA EXTRACTION AND INTEGRATION

There are several data sources that are not clearly understood at this point in time or are in transition. This task focuses on collecting detailed information on the functionality of each data management system that will contribute nutrient data to the NRS tracking tool, including the type of system, planned or existing changes, users, maintenance procedures, and other factors that could influence export of data from the contributing systems into the NRS tracking tool. This task will likely require the Team to work with data management analysts and specialists from the agencies that support the program measures.

TASK 4: IDENTIFY DATA SOURCES OR APPROACHES FOR OBTAINING VOLUNTARY OR INDUSTRY-LED BMP INFORMATION

Understanding data systems used to track voluntary and industry-led BMPs that aren't affiliated with a specific governmental program is a less straightforward task, but is necessary to ensure the NRS tracking tool provides as thorough a picture of statewide BMP adoption as possible. At this point in time, voluntary BMP implementation is a significant data gap that the NRS tracking tool should attempt to fill. Under this task, the Team would work with county soil and water conservation district staff, watershed districts, crop advisors, extension staff, and other entities working with agricultural producers to improve adoption of conservation practices and BMPs on agricultural lands. This could occur through focus group sessions or a survey to better understand 1) if these voluntary BMPs are tracked, 2) the type of systems used, and 3) potential challenges to having these entities use the NRS tracking tool to voluntarily provide this information via the Web-based interface. This information will help the Team understand the requirements necessary for reaching non-governmental BMP adoption information and how to develop NRS tracking tool in a way to capture this information.

TASK 5: CONDUCT COMPREHENSIVE SYSTEM REQUIREMENTS ANALYSIS

Using the information collected under Tasks 2-4 coupled with the preliminary system requirements documented in Tables 1, 2, 4, and 5, the Team should conduct a comprehensive system requirements analysis. Under this task, the Team would verify the preliminary requirements are accurate and identify additional user requirements based on the list of questions identified under Table 2. This analysis might benefit from facilitation by a neutral third-party with IT experience to ensure the Team answers all necessary system questions and that the analysis is comprehensive.

TASK 6: DEVELOP NUTRIENT STRATEGY TRACKING AND ACCOUNTING SYSTEM WEBPAGE

The final comprehensive system requirements analysis developed under Task 5 will then allow the Team to proceed with initial development of the NRS tracking tool using the 3-5 pilot program measures identified under Task 2.

The features described below serve as a preliminary starting point, based on Minnesota's interest in the approach used for the Chesapeake Bay tracking and accounting system (BayTAS). These features are subject to evolve based on the findings under Task 5.

1. **System Database.** Like the BayTAS, the NRS tracking tool would include an enterprise database. The NRS tracking tool database should be modeled to support short and long-term goals and allow Minnesota to add future program measures and tracking against those measures. These will also include quantitative Phase I Milestone tracking for both program outputs and environmental outcomes.
2. **Public Module:** The NRS tracking tool Public Module would display NRS metrics (e.g., program outputs and environmental outcomes) in a way that is easily understandable and meaningful to the public using a GIS interface integrated with an existing Minnesota agency website, such as MPCA or BWSR, using either ESRI Flex or Javascript viewer (not Flex viewer which was used for BayTAS). The Public Module will provide a public facing web page that will inform the state, local, and federal stakeholders of the progress being made toward the NRS goals and milestones. The agency hosting the NRS tracking tool would have full control over the data that is shared through the Public Module so that the data available is relevant, timely, and accurate. In addition to distribution of data, the Public Module will also serve as a communication and outreach tool to communicate success, improve awareness and encourage action by specific sectors key to NRS success. For example, the Planning and Management module in BayTAS provides services to the public facing portion of the application maintained by the Bay program. The same initial design could be developed for the NRS tracking tool, which will provide key features and benefits in meeting the requirements identified for NRS tracking tool and will be a starting point for further refinement using an iterative tool development process.

- ✓ Provides a flexible GIS framework and driven webpage, dedicated to NRS tracking and accounting that contains HUC8 and major basin information on progress towards implementing goals and milestones.
- ✓ As data is populated and managed in the Planning and Management Module it could be automatically visible in the Public Module using web services.
- ✓ Includes general information related to the NRS and opportunities to be engaged and provides information relevant to those responsible for implementing various aspects of the NRS and what resource may be available to assist them (e.g., funding, technical assistance).
- ✓ Displays implementation actions spatially to allow the public to see the activities going on
- ✓ Allows user to view progress across the NRS's key metrics (e.g., program output measures and environmental outcomes by basin and HUC8) to spatially communicate progress toward meeting goals and milestones
- ✓ Can be fully integrated into an existing web presence, such as BWSR's eLink, to leverage existing stakeholder awareness and to ensure consistency and recognition for the user community

3. **Planning and Management Module:** The NRS tracking tool Planning and Management Module would be designed for users who are responsible for the planning, management, and oversight of the NRS implementation activities. This would include Minnesota agency staff, partner agency staff, and other people that are recording information related to specific NRS metrics (e.g., program measure outputs and environmental outcomes). The Module would provide users with tools that allow them to enter, manage, track, account, and report all of the data related to the NRS, or future NRS metrics added to the System. This include screens for data entry and editing of basic data elements, data upload tools for streamlining loading of larger more complex data sets, a map interface for spatial tagging and viewing NRS progress and actions across the key parameters/metrics, and a reporting dashboard to provide real time metric tracking and enable enhanced decision making. The Planning and Management Module would provide a single login secure access point for all of the data being collected, analyzed, and tracked as part of the NRS.

4. **Home Page and Data Viewer**
   - ✓ Password protected to allow only certain users to add/edit information.
   - ✓ Home Page provides a snap shot of progress at the State, Basin, and HUC8 levels for nitrogen and phosphorus.
   - ✓ Toggling capability provides the ability to view data across a variety of filters such as Delivered and Edge of Stream loadings as well as multiple data source dates or versions
   - ✓ A series of action icons serve as communication and outreach tools, allowing users to generate standardized reports in various formats, providing ease access to supplemental resources, and highlighting current system functions and future enhancements.
   - ✓ The site would provide access to online information identified or developed as part of this NRS tracking tool so that implementing parties can prioritize their activities and report on progress toward meeting goals and milestones, as well as program optimization goals, if desired.
   - ✓ Data viewer would provide a GIS map interface with supporting tabular data dynamically updated based on map selection and filtering
   - ✓ Provides spatial view of progress and implementation activities

5. **Data Admin, Milestones and Facilities**
   - ✓ Data Admin screens provide straight forward data entry screens for the adding, editing, and review of relevant NRS data. Allows specified users to manage and work with their own data including adding new metrics at a later date.
   - ✓ The Facility data entry module provides screens for capturing Facility location, permitting, DMR, and allocation data to allow for integrated tracking of Facilities within HUC8 watersheds.
   - ✓ The Facility data entry screens are integrated with the GIS capabilities so as Facilities are added or progress data is updated they become accessible from the map interface
   - ✓ Data Admin screens provide straight forward data entry screens for the adding, editing, and review of implementation Milestones for the tracking and accounting of planned activities and future progress.
   - ✓ The System accommodates both quantitative and qualitative goals and milestones providing users full flexibility in capturing the planned implementation actions.
   - ✓ Each goal or milestone can be linked spatially to HUC8 watersheds and basins, displayed through the map interface

- ✓ Goal and milestone tracking can be integrated with existing program databases to show a consolidated view of actual versus planned actions

6. Management Reporting

- ✓ The fully integrated and automated Management Report can be generated at any time and will reflect the most current data.
- ✓ The Management Report presents a status of the progress towards meeting the NRS goals and milestones, including WWTP nitrogen and phosphorus loads, agricultural nitrogen and phosphorus loads, aggregated loads by parameter, facility permitting action status, and overall load vs milestone target comparison.
- ✓ The Management Report can be generated in a variety of formats (PDF, Word, Excel) and can be used as both a formal communication tool as well as an internal working reporting for data analysis and decision support.

TASK 7: LONG-TERM O&M NRS TRACKING TOOL PLAN

In support of the production deployment of the NRS tracking tool, the Team should develop an Operation and Maintenance (O&M) Plan, which will address staffing, tasks, processes, and tools necessary to ensure consistent, reliable, and comprehensive production support of the NRS tracking tool. The plan should recommend O&M and hosting service level agreements to be documented in the plan to establish clear and standardized performance benchmarks to be maintained throughout the O&M period by the hosting provider.

The O&M Plan shall lay out a strategy along with the roles and responsibilities for the continued use and enhancement of the NRS tracking tool. The O&M Plan should recommend a Change Control Board that would serve as the primary decision makers regarding system priorities and enhancements and should also document the processes that will be followed for the submission of enhancement request for the Board to consider. The O&M Plan should also include technical considerations such as implementation of web services, technology enhancements, and integration with other County, State or Federal tools over time.

COST ESTIMATE

Developing the proposed NRS tracking tool is estimated between $200-$900K, depending on the full suite of comprehensive system requirements developed under Task 5. A variety of variables affect the potential cost of developing the recommended NRS tracking tool. Factors that impact costs include the following:

- Level of involvement and availability of client staff to assist with system design, data integration, and other tasks relating to designing and building the system
- Amount and types data analysis and migration that would be required to start using the system, as well who is responsible for the migration (contractor or client IT staff)
- Level of data cleanliness and corrections and/or transformations that must be applied before loading them, as well who is responsible for the data changes (contractor or client IT staff)
- How many stakeholders will provide input on the design and implementation of system, how involved will they be
- Amount and type of training and system documentation is required. How many people will be trained over how many sessions.
- Who will be responsible for system deployment and final system integration
- Who will be responsible for which types of testing