The Minnesota Nutrient Reduction Strategy

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

Table of Contents

Acronyms

BMP	best management practice
BNR	Biological Nutrient Removal
BOD_5	5-day biochemical oxygen demand
BWSR	Board of Water and Soil Resources
CAFO	concentrated animal feeding operation
CAWT	Commercial Animal Waste Technicians
CDL	Cropland Data Layer
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
DOP	dissolved orthophosphate
ENR	Enhanced Nutrient Removal
EPA	U.S. Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
FANMAP	Farm Nutrient Management Assessment Program
Framework	Minnesota Water Sustainability Framework
FSA	Farm Service Agency
FWMC	flow weighted mean concentrations
HUC8	8-digit hydrologic unit code
I&E Plan	Involvement and Education Plan
ICT	interagency coordination team
LES	lake eutrophication standards

LGU	Local Governmental Unit
LOT	Limit of Technology
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
MRB3	Major River Basin 3
MS4	municipal separate storm sewer system
N	nitrogen
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
NO_x-N	nitrate-nitrite
NPDES	National Pollutant Discharge Elimination System
NPV	net present value
NRCS	Natural Resource Conservation Service
P	phosphorus
RES	river eutrophication standards
RIM	Reinvest in Minnesota
SCWD	soil and water conservation district
SDS	State Disposal System
SPARROW	Spatially Referenced Regressions on Watershed
SSTS	subsurface sewage treatment system
Strategy	Minnesota Nutrient Reduction Strategy
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 draft *Minnesota Nutrient Reduction Strategy* (Strategy) will be available for public review and comment from October 7, 2013, to December 18, 2013. The conversation which begins during this comment period will be integrated to strengthen the recommendations contained in the Strategy. Once finalized, this initial iteration of the Strategy will serve as a guide for the reduction of nutrients in waters throughout Minnesota, providing additional data and information for future improvements.

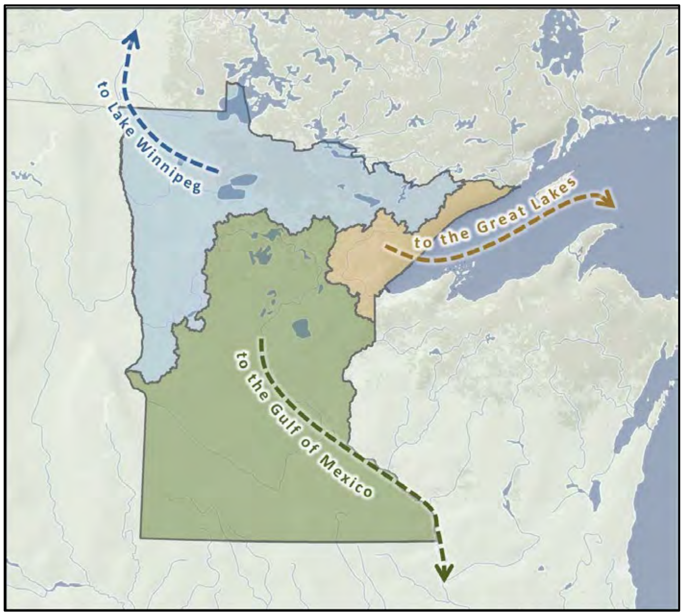


Figure 1. Major drainage basins in Minnesota.

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. A number of federal, regional, and state initiatives drive the need for a statewide nutrient reduction strategy in Minnesota.

At the federal level, the U.S. Environmental Protection Agency (EPA) focus on statewide nutrient reduction planning served as a key driving force for Minnesota's Strategy development. Regionally, Minnesota's involvement in the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force also served as a driving force. In recent decades, nutrient issues downstream of Minnesota have reached critical levels, including the effect of nutrients in the Gulf of Mexico which resulted in a dead zone, eutrophication issues in Lake Winnipeg, and algal blooms in the Great Lakes. Several state-level initiatives and actions highlighted the need for a statewide strategy that ties separate but related activities together to further our progress in making nutrient reductions.

The Strategy guides state-level programs to achieve nitrogen and phosphorus reductions within Minnesota water bodies to enhance the health of aquatic life, improve public health and safety, and increase the recreational potential of Minnesota's numerous lakes, rivers, and streams, as well as the health of the groundwater supply. 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. The theme of the overall Strategy is *A Path to Progress in Achieving Healthy Waters*, which includes the following:

- Defining progress with clear goals
- Building on current strategies and success
- Prioritizing problems and solutions
- Leading to local implementation

Successful implementation of the Strategy will require broad agency support, coordination, and collaboration. An interagency coordination team (ICT), representing ten state agencies, helped develop the Strategy.

Goals and Milestones

The Strategy includes goals and milestones for nutrient reduction at multiple scales including basin (e.g., Mississippi River Basin at the state line) and watershed (e.g., 8-digit hydrologic unit code [HUC 8] watersheds) (Table 1). Progress towards goals and milestones can be tracked over time to determine if strategies are successful and where additional work is needed. Several existing efforts establish nutrient reduction targets for large drainages within Minnesota and provide a suitable framework for load reduction goals. In addition, the Strategy includes a groundwater/source water protection goal to address groundwater as a drinking water source.

Table 1. Basin-wide nutrient reduction goals

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 percent reduction from 2003 conditions	13 percent reduction from 2003 conditions
Mississippi River [c]	45 percent reduction from average 1980–1996 conditions	45 percent reduction from average 1980–1996 conditions
Statewide Groundwater/ Source Water [d]	No goal identified	Qualitative – achieve and maintain drinking water standards

a. Great Lakes Water Quality Agreement of 1978, amended by a protocol signed November 18, 1987.
b. 2003 Lake Winnipeg Action Plan (Manitoba Water Stewardship Division, 2003); Provisional goal, to be revised once the Red River/Lake Winnipeg strategy is complete. 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; Includes drainage associated with Missouri, Des Moines, and Cedar rivers.
d. Based on 1989 Minnesota Groundwater Protection Act.

In addition to goals, milestones serve as interim measures of progress. Milestones provide a step-wise approach to meeting basin goals for nutrient reduction and can take into account the changing landscape, regulatory environment, and available best management practices (BMPs). Milestones are an important component of the Strategy due to a variety of factors:

- 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 can be expected.
- Effective nitrogen reductions at wastewater treatment facilities require several years of planning.

The milestones are phased over time, depending on parameter and basin. Table 2 presents the milestones, which are based on reducing basin outlet loads to eventually achieve the goals. Strategies and target dates will be adjusted through an adaptive management process.

Table 2. Milestones

Basin	Pollutant	Phase 1 Milestone	Phase 2 Milestone	Phase 3 Milestone
Mississippi River (Includes the Cedar, Des Moines, and Missouri Rivers)	Phosphorus	Achieve 35% reduction from baseline by 2025 [a]	Achieve 45% reduction goal	Meeting goals, no net increase
	Nitrogen	Achieve 20% reduction from baseline by 2025 [b]	Achieve 30% reduction from baseline	Achieve 45% reduction goal
Lake Winnipeg [c] (Red River Only)	Phosphorus	Achieve 10% reduction goal by 2025	Adapt goals, if necessary, based on international joint efforts with Canada	
	Nitrogen	Achieve 13% reduction goal by 2025	Adapt goals, if necessary, based on international joint efforts with Canada	
Lake Superior	Phosphorus	Achieve 3% reduction goal by 2025	Meeting goals, no net increase	
	Nitrogen	Maintain protection		
Statewide Groundwater/ Source Water	Nitrogen	Meet goals of 1989 Groundwater Protection Act		

a. It is important to note that active phosphorus reduction began with the completion of the *Detailed Assessment of Phosphorus Sources to Minnesota Watersheds* (Barr Engineering 2004) and Phosphorus Strategy adopted by MPCA's Citizens' Board in 2000.

b. While the baseline for nitrogen reduction is established as prior to 2000, no active strategy has been established since that time to coordinate actions.

c. Milestones to be revised upon completion of the Red River/Lake Winnipeg strategy.

This Strategy emphasizes the need to base HUC8 watershed nutrient goals on the downstream needs outside of the HUC8 watersheds, in addition to needs within the HUC8 watershed. HUC8 watershed milestones are derived from the basin milestone, and apply to all HUC8 watersheds within the respective basin (e.g., all HUC8 watersheds in the Mississippi River Basin should reduce nitrogen by 20 percent from baseline conditions). In the future, additional data and analysis might support local milestone goals that are specific for each watershed.

Headwaters to the Mississippi River
Photo Credit: MPCA

Water Quality Standards

Nitrate and eutrophication water quality standards for protection of Minnesota's water resources are important components of the Strategy. Both the existing lake and proposed river eutrophication standards (RES) in Minnesota include phosphorus, but they do not include nitrogen. Eutrophication standards were promulgated for lakes in 2008, and finalization of the RES should occur in 2014. Nitrate toxicity standards to protect aquatic life in surface waters of the state are expected by about 2015.

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 turbidity total maximum daily loads (TMDLs) have a TSS surrogate to facilitate the calculation of load allocations.

An evaluation of the data indicates that meeting in-state lake and proposed RESs will likely result in meeting the basin-wide goals for phosphorus reduction. For example, Lake Pepin, a 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. Lake Pepin's watershed includes over half of Minnesota.

Downstream reduction needs will drive nitrogen reductions (e.g., Gulf of Mexico and Lake Winnipeg). At this time, existing local surface and groundwater nitrogen standards will not drive enough change to protect out-of-state waters due to limited nitrogen impairments in the state.

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 Strategy is being developed in consideration of the state-level programs, efforts, and goals which can aid local governmental units in addressing nutrients within their HUC8 watersheds and thereby achieve these multipurpose goals.

Evaluating Recent Progress

Understanding the progress made since the baseline conditions is a key component of the Strategy. *Recent Progress* is quantified through available program data and helped to define meaningful Phase 1 Milestones.

Sixteen regional, state, or federal programs were identified as key nutrient-reducing programs in Minnesota. Each of these programs provided input on quantifying outputs or outcomes associated with program implementation. Data from the Natural Resource Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP), the Reinvest in Minnesota Program (conservation easements), and Minnesota's eLINK database, which tracks state-funded nonpoint source BMPs, were compiled from 2000 to present. Reductions in wastewater nutrients were also quantified. These programs and the BMPs chosen for quantification are indicators of program implementation and are thus applied as Recent Progress against the reductions needed to meet basin goals and milestones (Figure 2 and Figure 3).

This Strategy addresses the gap between Recent Progress and Phase 1 Milestones.

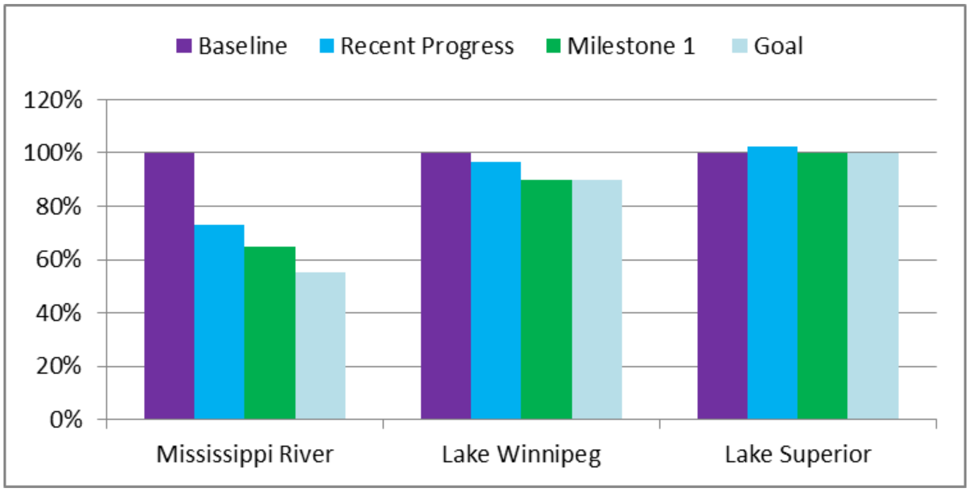


Figure 2. Summary of recent trends in phosphorus source loads by major basin.

Notes:
Recent Progress is the percent of baseline load remaining after accounting for estimated reductions since 2000.
The Lake Winnipeg Milestone 1 and Goal are expected to change in the near future, resulting in additional load reduction needs.

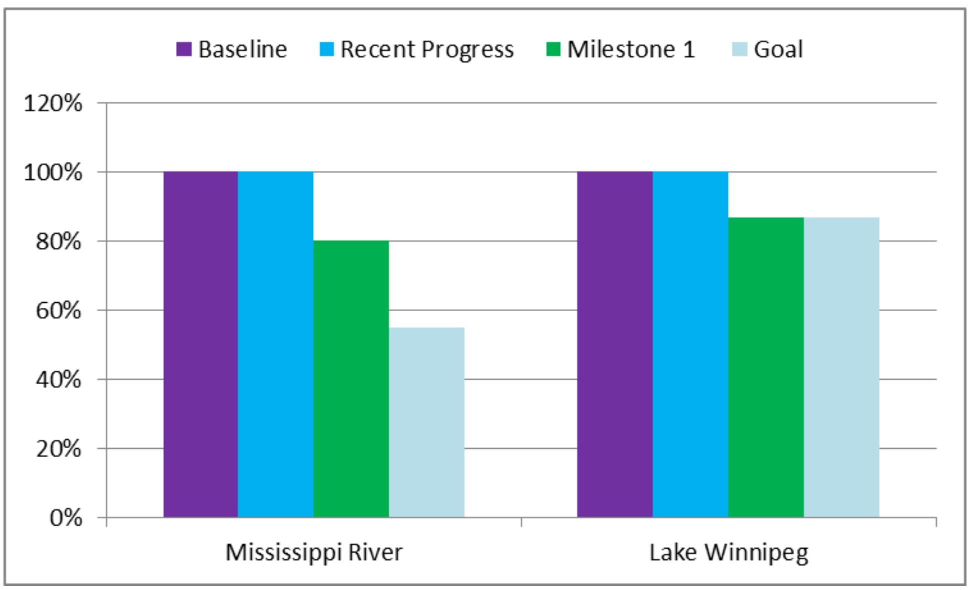


Figure 3. Summary of recent trends in nitrogen source loads by major basin.

Notes:
There is not a reduction goal for nitrogen assigned in the Lake Superior Basin.
Recent Progress is the percent of baseline load remaining after accounting for estimated reductions since 2000.
The Lake Winnipeg Milestone 1 and Goal are expected to change in the near future, resulting in additional load reduction needs.

Priority Management Areas

Priority management areas are based on priority sources and watersheds. Targeting implementation activities to priority sources in high-priority watersheds is a potential cost-effective approach to achieve initial nutrient reductions. It is important to recognize that while prioritization is an effective management tool for directing limited resources, significant reduction targets to meet the Strategy goals cannot be achieved through implementation in a limited number of high-priority watersheds.

Priority sources are based on studies that identified the sources of nutrients in Minnesota water (Barr Engineering 2004; MPCA 2013). Priority sources 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. There are also sources that cannot be reliably reduced by local or regional scale implementation activities, including atmospheric deposition and loads from forested areas. Therefore, this initial iteration of the Strategy does not consider these sources as priority sources.

Table 3. Priority sources

Basin	Priority phosphorus sources	Priority nitrogen sources
Mississippi River	Cropland runoff, permitted point sources, and streambank erosion	Agricultural tile drainage and cropland groundwater [b]
Lake Superior	Nonagricultural rural runoff [a], permitted point sources, and streambank erosion	Permitted point sources
Lake Winnipeg	Cropland runoff and nonagricultural rural runoff	Cropland groundwater

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

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

Priority watersheds represent those watersheds with the highest nutrient yields (loads normalized to area) or contain a large proportion of potentially impaired segments based on the proposed RES. Figure 4 identifies these watersheds.

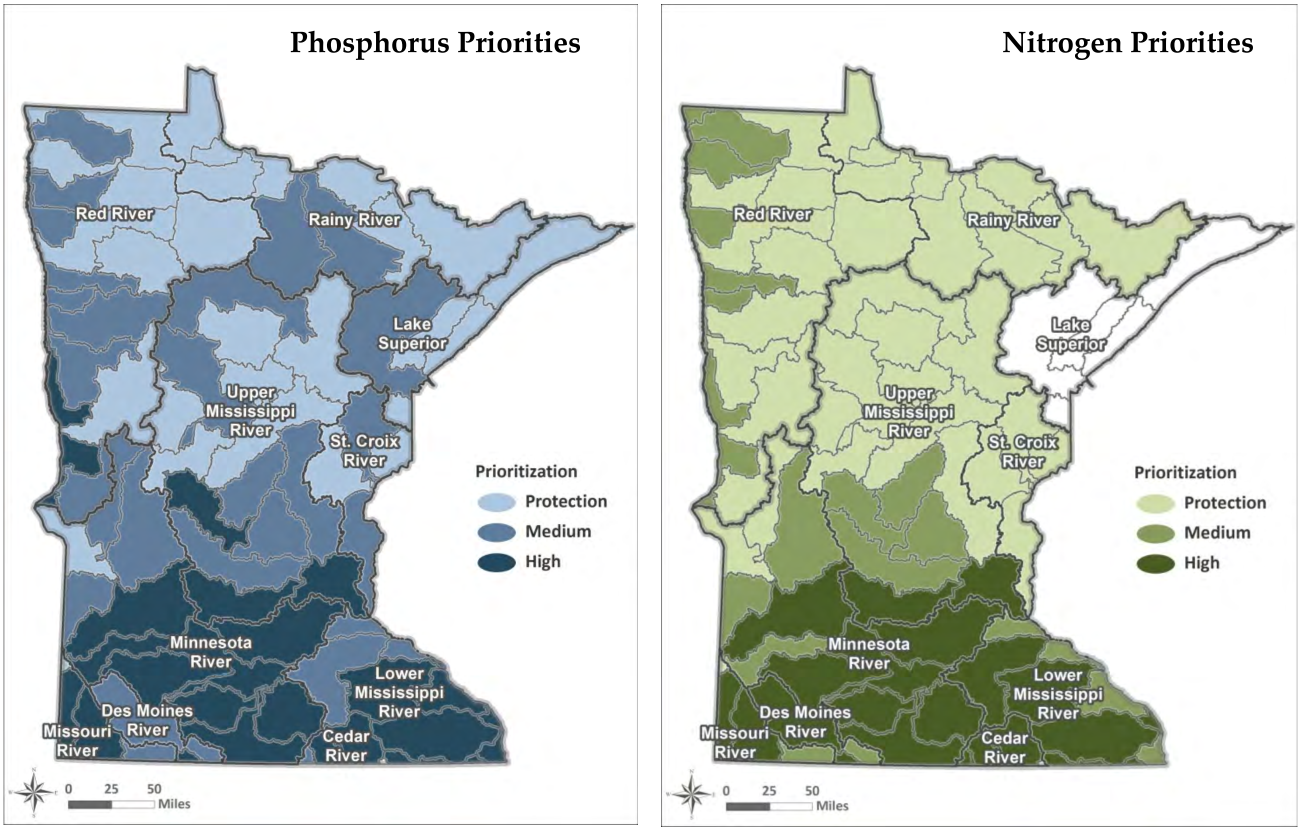


Figure 4. HUC8 watershed priorities (Lake Superior Basin not evaluated for nitrogen).

Nutrient Reduction Strategies

Development of the Strategy builds on previous implementation efforts in the state. Working toward the milestones over time requires a significant amount of coordination and communication at a statewide level. Infrastructure will be necessary to support coordination and communication among the various 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. These recommendations include the following:

- Create accountability team and coordinating mechanism to integrate Strategy with other efforts.
- Develop a statewide Strategy education/outreach campaign.
- Integrate basin reduction goals with watershed planning efforts.
- Integrate Strategy tracking considerations into key program databases and tracking tools.
- Create new statewide nutrient reduction incentives for voluntary or industry-led BMP adoption.
- Develop mechanisms to improve state agency and federal agency data sharing and coordination.
- Commit to an adaptive management plan for the Strategy.

Specific strategies are necessary to increase agricultural BMP adoption, achieve wastewater reductions, address miscellaneous sources, and provide protection to areas under pressure.

Wastewater Strategies

The current Phosphorus Rule has and will continue to address phosphorus reductions in wastewater. The adoption of RES 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 a relevant example of a successful program to reduce a pollutant of concern. Several successful techniques utilized in the Phosphorus Strategy (MPCA 2000) are 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

A 20 percent reduction in wastewater nitrogen loads is anticipated to reach the Phase 1 Milestones for the Mississippi River.

Agricultural BMP Adoption Strategies

To reach the Phase 1 Milestones in 2025, and eventually reach basin-wide goals, additional BMPs, wastewater treatment, and other nutrient-reducing activities will be necessary. The Strategy includes select BMPs and treatment options to guide implementation; however, any combination of BMPs and treatment options which achieve the load reduction goals can be used. As new research is conducted, additional BMPs and treatment options are expected to become part of the Strategy.

Potential agricultural BMPs for this Strategy were identified from the Nitrogen Study (MPCA 2013), the Iowa Strategy (Iowa State University 2013), the AgBMP Handbook (Miller et al. 2012), literature on the Minnesota Phosphorus Index (Moncrief et al. 2006), and the Lake Pepin implementation planning work (Tetra Tech 2009). The Watershed Nitrogen Reduction Planning Tool (Lazarus et al. 2013) was also used to derive various BMP inputs. BMPs were evaluated to determine which would be most likely to help achieve the Strategy nutrient reduction goals. BMPs are grouped into the following four categories:

1. Increase 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)

Suitable acres for each BMP type are determined on a HUC8 watershed scale, and existing BMP implementation is taken into account as part of this analysis. A spreadsheet analysis was conducted to evaluate various BMP scenarios.

Example BMP scenarios to achieve the phosphorus Phase 1 Milestones were developed, paying attention to both effectiveness and cost of BMPs. 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 30 percent residue where not already applied (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, grass waterways, and cover crops that currently have a net cost to producers.

Residue Management Using Strip Till
Photo Credit: NRCS

Table 4. Example BMP scenario for achieving the phosphorus Phase 1 Milestones 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	90%	1.9	0%	0
Increase and Target Living Cover	Riparian buffers	25%	0.3	60%	0.3
	Cover crops	10%	0.3	20%	0.2
	Conservation reserve	3%	0.2	0.6%	0
Field Erosion Control	Conservation tillage	85% of available area; 90.7% net	7.2	53% of available area, 63.5% net	1.4

Notes:

Adoption rates are expressed as a percentage of the total area on which a practice is applicable, with the exception of conservation tillage, which is expressed as a fraction of the area not currently in conservation tillage. A cumulative adoption rate for conservation tillage is also shown.

Acreage from program quantification for 2000–2013 is excluded from total future acres where applicable. Adoption rate percentages are relative to suitable areas and represent the percentage of land in total that would require the BMP. The SPARROW model is assumed to reflect 2000 agricultural conditions.

For the Lake Superior Basin, the goal is a 3 percent decrease in phosphorus loads. Agriculture is estimated to contribute only 6 percent of the total phosphorus load in this basin, and many agricultural BMPs for phosphorus are not particularly useful because of low soil phosphorus concentrations. The needed reduction in the Lake Superior Basin is expected to come from a combination of point source reductions and miscellaneous nonpoint runoff reductions.

Example BMP scenarios to achieve the nitrogen Phase 1 Milestones were also developed. In general, the conceptual strategy for nitrogen includes increasing fertilizer use efficiency through nutrient management, treating tile drainage, and implementing living cover BMPs, which are consistent with the phosphorus evaluation. Table 5 summarizes the results of this analysis.

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

BMP category	Example BMP	Mississippi River		Lake Winnipeg (Red River Only)	
		Future adoption rate	New total acres (million acres)	Future adoption rate	New total acres (million acres)
Increasing Fertilizer Use Efficiencies	Use recommended fertilizer application rates	80%	13.2	95%	6.0
Increase and Target Living Cover	Cover crops	10%	0.3	20%	0.2
	Riparian buffers	25%	0.3	60%	0.3
	Conservation reserve	3%	0.2	0.10%	0
Drainage Water Retention and Treatment	Wetlands and controlled drainage	18%	1.1	25%	0.001

Notes:
Adoption rates are expressed as a percentage of the total area on which a practice is applicable.
Acreage from program quantification for 2000–2013 is excluded from future acres where applicable. Adoption rate percentages are relative to the area for which a given practice is suitable and represent the percentage of land in total that would require the BMP. The SPARROW model is assumed to reflect 2000 agricultural conditions.

Increased adoption of agricultural BMPs is critical to implementing the Strategy and achieving goals and milestones. Recommended strategies to achieve the Phase 1 Milestones include the following:

- Optimization Strategies
  - Develop state and federal program Step Up Plans for select programs.
  - Increase delivery and track implementation of industry-led BMPs.
- Economic Strategies
  - Evaluate potential nutrient-based crop yield insurance program.
  - Develop markets and technologies for use of perennials.
  - Quantify cost-effectiveness of reducing nutrient levels in water.
  - Enhance partnerships with federal partners.
- Education and Involvement Strategies
  - Implement targeted outreach and education campaign.
  - Encourage participation in the Agricultural Water Quality Certification Program.
  - Focus education and technical assistance to co-op agronomists and certified crop advisors
  - Involve agricultural producers in identifying feasible strategies.

- Share nutrient reduction success stories and make awards to watershed heroes.
- Work with soil and water conservation districts, University of Minnesota Extension, and community engagement initiatives to improve education and involvement.
- On-farm trials and demonstration projects.
- Focus demonstration initiatives on soil health, including cover crops.

- Research
  - Improve success rate for cover crop establishment and continue to develop the best and most profitable cover crops.
  - Research on forages for livestock.
  - Increase knowledge base regarding fertilizer use efficiency.
  - Continue to research innovative approaches for removing nutrients from tile drainage waters, including use of saturated buffers, two-stage ditches, etc.
  - Develop approaches that will reduce soluble phosphorus, as well as BMPs which can address both phosphorus and nitrogen.
  - Research use of remote sensing for nitrogen and phosphorus losses to the environment to help develop nutrient-efficient cropping systems.
  - Further development of the Watershed Nitrogen Reduction Planning Tool, including adding a phosphorus component.

Lake Superior
Photo Credit: MPCA

Miscellaneous Source Strategies

New strategies are not suggested at this time to reduce loads from miscellaneous sources; however, existing programs have strategies in place that allow for systematic reductions in loads from sewage treatment systems, stormwater, and feedlots. A statewide strategy is also under development to address sediment reduction. The statewide strategy will help address sediment-related nutrient load reductions. 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.

Protection Strategies

Protection strategies are needed in watersheds facing development pressures and changes in agricultural and land use practices, as well as vulnerable groundwater drinking water supplies. The Watershed Approach, as described in Chapter 1, requires protection strategies as part of watershed restoration and protection strategy (WRAPS) development, and therefore should address the potential for increased nutrient loads at a watershed scale. Ensuring that nitrogen and phosphorus reductions are addressed as part of WRAPS development is important. In addition, protection strategies are necessary to address increases in Red River watershed tile drainage and nitrogen loads to Lake Superior.

Strategy Summary

The following figures for the Mississippi River summarize the overall strategies to achieve nutrient reduction milestones. Chapter 5 includes strategy summary figures for all basins. Each of the figures includes suggested reductions by source for each of the BMP categories, as described previously.

20% Reduction Milestone — Mississippi River Nitrogen

Baseline Load (1980–1996) Units = 1,000 metric tons (MT) per year	Agricultural	Wastewater	Miscellaneous	Total
Baseline Load	98.7	7.9	7.0	113.6
Progress Since Baseline	1.5	-1.5	0	0
Recommended Strategy Reductions				
Increasing Fertilizer Use Efficiencies on 13.2 Million Acres: Recommended fertilizer rates; Placement and timing of application; Nitrification inhibitors	15 (13.2%)			
Increase and Target Living Cover on 800,000 Acres: Cover crops; Perennial buffers; Forage and biomass planting; Perennial energy crops; Conservation easements and land retirement	3.1 (2.7%)			
Drainage Water Retention and Treatment for 1.1 Million Acres: Constructed wetlands; Controlled drainage; Bioreactors; Two stage ditches	3.7 (2.4%)			
Wastewater Treatment		1.9		
Total Reductions	20.8 +	1.9 +	0 +	0 = Total 22.7

Milestone Target **20%** from Baseline Load = 22.7 Metric Tons Reduced

Progress Since Baseline 0 + **Additional Reductions 22.7** = **Milestone 22.7 MT Reduced = 20% by 2025**

1,000 kg = 1 MT

35% Reduction Milestone — Mississippi River Phosphorus

Baseline Load (1980–1996) Units = 100 metric tons (MT) per year	Agricultural	Wastewater	Miscellaneous	Total
Baseline Load	24	22	12	58
Progress Since Baseline	5	11	0	16
Recommended Strategy Reductions				
Increasing Fertilizer Use Efficiencies on 1.9 Million Acres: Recommended fertilizer rates; Placement and timing of application; Reducing soil P levels; Livestock feed management	1.8 (3.1%)			
Increase and Target Living Cover on 800,000 Acres: Cover crops; Perennial buffers; Forage and biomass planting; Perennial energy crops; Conservation easements and land retirement	1.0 (1.7%)			
Field Erosion Control on 7.2 Million Acres: Conservation tillage and residue management; Terraces/grassed waterways; Sediment control basins	0.5 (0.9%)			
Urban Stormwater + Other Sources			0.6 (1.0%)	
Wastewater Treatment		0.3 (0.5%)		
Total Reductions	3.3 +	0.3 +	0.6 +	16 = Total 20.2

Milestone Target **35%** from Baseline Load = 20.2 Metric Tons Reduced

Progress Since Baseline 16 + **Additional Reductions 4.2** = **Milestone 20.2 MT Reduced = 35% by 2025**

1,000 kg = 1 MT

Adaptive Management and Tracking Progress

Establishing a coordinated strategy that provides an efficient and effective pathway to achieving statewide goals is the first step in an iterative process of planning, implementing, assessing, and adjusting. This iterative process is often referred to as *adaptive management*. The Strategy sets out goals and milestones for nutrient load reductions, as well as recommended approaches for achieving the milestones (Figure 5). To ensure that on-the-ground implementation is on pace with the Strategy milestones and goals, it is imperative to have an adaptive management plan that will guide an evaluation of the Strategy's progress over time. The basic components of the Strategy's adaptive management plan are as follows:

- Identify data needed to track progress toward Strategy goals and milestones.
- Create a system or approach for collecting data and information needed to track progress toward Strategy goals and milestones.
- Evaluate trends.
- Adjust the Strategy as necessary.

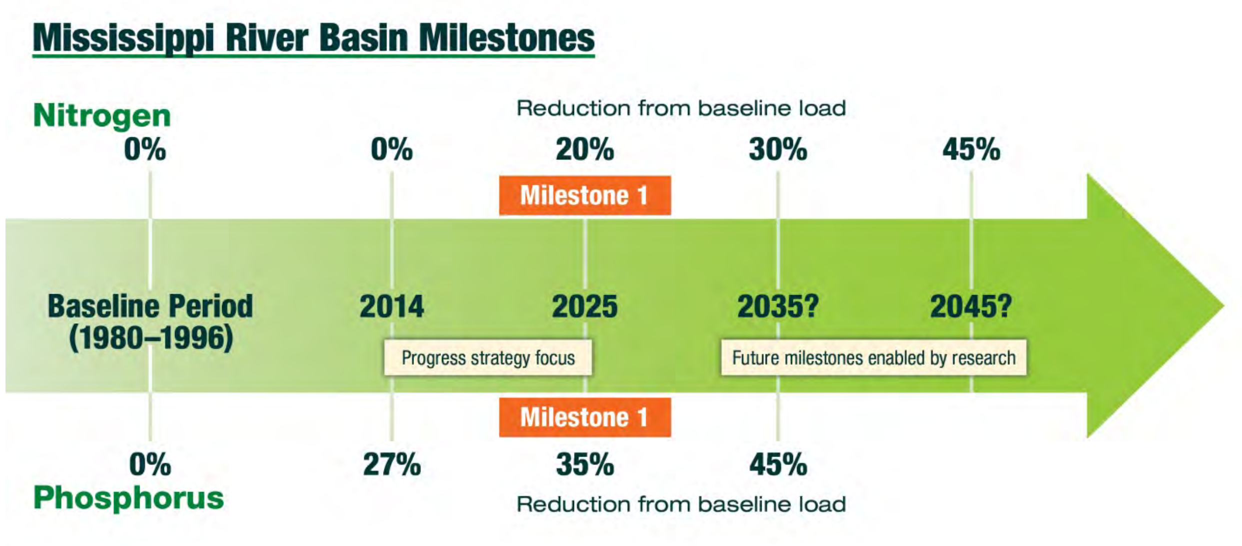


Figure 5. Example adaptive management schedule for the Mississippi River basin.

Implementation tracking will be done through both program implementation and in-stream data. Program implementation data provides early indicator information about nitrogen and phosphorus reductions that, over time, should translate to in-stream nutrient reductions.

Several key programs in Minnesota implement a variety of structural and nonstructural BMPs. Quantifying nutrient reductions for BMPs associated with each program would not be a sustainable and replicable approach to show progress toward Strategy goals over time. A streamlined approach quantifies implementation progress over time, which involves the development and tracking of program measures. The Strategy contains a suite of program measures:

- Implementation of nonpoint source BMPs tracked via eLINK and estimated nutrient load reductions
- Implementation of permanent easements and associated nutrient load reductions
- Implementation of nitrogen fertilizer management BMPs
- Implementation of priority Conservation Reserve Program (CRP) conservation practices and estimated nutrient load reductions
- Implementation of priority EQIP management practices and estimated nutrient load reductions
- Implementation of conservation tillage funded through Agricultural BMP (AgBMP) Loans
- Municipal wastewater phosphorus trends (excerpted from the Clean Water Fund performance measures)

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.

Future water quality evaluations will rely upon the Watershed Pollutant Load Monitoring Network (WPLMN) and efforts to complete statewide water quality modeling. There are many other local, regional, statewide, and national level monitoring programs that will inform water quality evaluations, including those that the new Mississippi River Monitoring Collaborative is conducting. The Mississippi River Monitoring Collaborative is made up of federal and state agencies along the Mississippi River between the Gulf of Mexico and Minnesota.

Although the annual program measures will provide an indication of implementation progress, the water quality outcome measures will provide a more significant yardstick for measuring progress toward Strategy interim milestones over time. Water quality outcome measures include the following:

- Trend in actual load
- Trend in flow weighted mean concentration
- Progress toward meeting eutrophication standards
- Statistical comparisons of baseline loads/concentrations at low, medium, and high flow periods with comparable flow periods during recent years

- Progress toward reducing groundwater nitrate in high-nitrate areas, including those watersheds where nitrate coming from groundwater currently impairs surface waters

The Strategy 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 through adaptive management (Figure 5). Milestone tracking and reporting will occur at 2-year, 5-year, and 10-year intervals. There is currently no integrated tool that will allow for automated tracking of Strategy output and outcome information to assess progress over time. The approach for tracking progress requires the development of a tool to ensure the efficiency and reliability of progress tracking. Developing a tool 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.

Chapter 1

Development of the Minnesota Nutrient Reduction Strategy

The Minnesota Pollution Control Agency (MPCA) and Minnesota partner agencies are collaborating to provide a public review draft of a statewide strategy to reduce levels of phosphorus and nitrogen, collectively referred to as *nutrients*. Following input by the public, 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* (Strategy) will guide state-level programs to achieve nitrogen and phosphorus reductions within Minnesota water bodies to enhance the health of aquatic life, improve public health and safety, and increase the recreational potential of Minnesota's numerous lakes, rivers, and streams, as well as the health of the groundwater supply. 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 Strategy

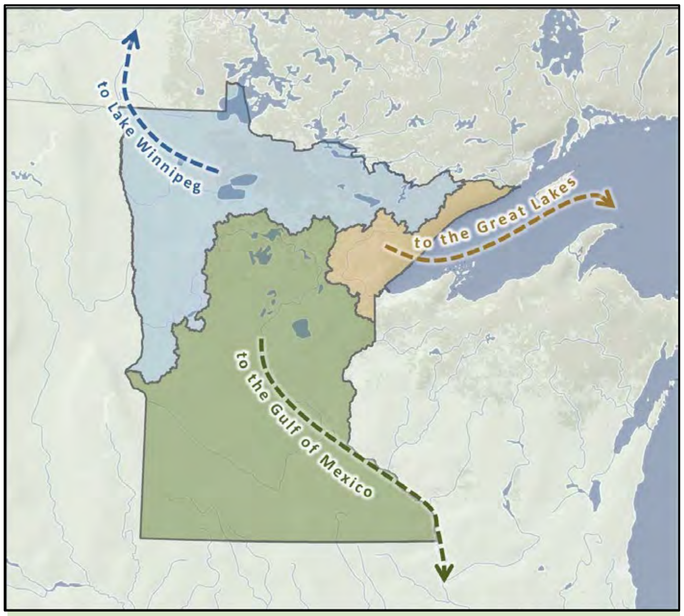


Figure 1-1. Major drainage basins in Minnesota.

The Minnesota Water Sustainability Framework (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.

is *A Path to Progress in Achieving Healthy Waters* (Figure 1-2).

Figure 1-2. Pathways to progress.

The mission of the Strategy is 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 Strategy 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 Strategy is to add further focus to those efforts, specifically on nutrients, thereby supplementing and coordinating among these other plans.
2. **Work Toward Progress Goals for Downstream Waters** – Meaningful and achievable nutrient loading reduction milestone targets are developed that allow for incremental and adaptive

progress toward final goals. The milestone targets have a baseline date within the scope of timeframes for downstream goals. Milestones target phosphorus and nitrogen 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** – Establishing state standards for nutrients to protect beneficial uses is key to ongoing state-level programs. This Strategy does not influence the nutrient criteria development process, but will be affected by the result of that process as programs work to achieve nutrient criteria. The Strategy 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 unimpaired, by nutrients or eutrophication.

4. **Prioritize and Target** – Watersheds 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, while other factors might be contributing to a trend toward increased loads. The Strategy describes reasonable outcomes from maintaining the current approach to nutrient reduction expected with existing programs and efforts, and then identifies ways to close the gap between anticipated outcomes with existing efforts and achievement of local and downstream water quality goals. The Strategy 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 Strategy will support and work with Minnesota's Watershed Approach, 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 Local Implementation** – While the primary developers and users of this state-level Strategy are federal, state, and regional public and private entities, the Strategy is also relevant at the local level. The Strategy 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. These customers will take the large-scale data, priorities, and recommendations and consider that information when developing localized implementation plans (i.e., for 8-digit hydrologic unit code [HUC8] watershed scale and smaller). Efficiencies will be gained by making large-scale information available to local watersheds. This work will 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 Strategy 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 a dead zone, eutrophication issues 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 federal, regional, and state driving forces.

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 the *Minnesota Nutrient Reduction Strategy*. The Strategy 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 watershed 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 water 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 Strategy 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 plans to promulgate *river and stream eutrophication standards* (RES) 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 draft 2012 Impaired Waters List, almost 20 percent of Minnesota lakes and river segments has been assessed as impaired due to excess nutrients or nutrient-related parameters. 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 RES; therefore, many more streams and rivers are anticipated to be added to future Impaired Waters Lists.

The 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, as the Watershed Approach below describes.

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* 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 increases 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 will be 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 released their *first collaborative report* in February 2012. Overall, the report shows the state is on track with its investments, though challenges remain. The 18 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 three measures 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. Of the 18 measures, status and trends vary; 6 measures showed improving trends, 11 showed no trend or were too early to assess, and one showed a slightly declining trend.

Minnesota's Watershed Approach – A Framework for Protecting and Restoring Water Quality in Minnesota's Watersheds

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 major Watershed Approach that will lead to comprehensive restoration and protection strategies for each watershed. TMDLs are incorporated into these studies, as are targets, goals, and strategies to protect unimpaired waters.

TMDLs provide strategies, goals, and objectives to protect and restore surface water quality to a level that supports designated uses. Implementation plans developed at the local level outline specific actions necessary to achieve pollutant reduction goals established through the TMDL, as well as protection needs identified through monitoring and assessment efforts. Completed studies and implementation plans provide important guidance for regulatory and nonregulatory planning, and create opportunities for access to implementation funds. Watershed implementation plans largely utilize existing federal, state, and local programs and policies to accomplish water quality protection and restoration. A state-level nutrient reduction strategy that improves state-level programs will increase the ability of local watershed efforts to achieve successful implementation of BMPs on critical parts of the landscape.

A primary feature of the Watershed Approach is that it focuses on the watershed's condition as the starting point for water quality assessment, planning, implementation, and measurement of results. Minnesota works on a 10-year cycle of monitoring, assessment, planning, and implementation for 81 major watersheds. This reoccurring sequence allows for the completion of comprehensive studies addressing multiple impairments and covering multiple parameters in a condensed 4-year timeframe. By the end of 10 years, all major watersheds will be completed, in effect, completing TMDL/protection studies across the entire state.

The overlapping steps of the Watershed Approach are as follows, with the goal of completing Steps 1 through 3 within 4 years of initiation in each watershed, and with Step 4 starting in the fifth year:

Step 1 — Monitor water bodies and collect data

Step 2 — Assess collected information

Step 3 — Develop strategies to restore and protect the watershed's water bodies

Step 4 — Conduct restoration and protection projects in the watershed

Prior to Step 1, it is assumed that historical work has taken place in the watershed to implement water resource protection and restoration activities, along with some level of monitoring and assessment. Building on those previous efforts, the four-step cycle is initiated, as described in more detail below.

Step 1 — Monitor water bodies and collect data

The cycle begins with a 2-year intensive watershed monitoring effort to collect data on the following:

- Water conditions throughout the watershed, including biological and physical monitoring, flow and load monitoring, and chemical monitoring.
- Monitoring results from other state, federal, and local organizations
- Watershed physical characteristics, including land use, topography, soils, and pollution sources.

Step 2 — Assess collected information

Next, MPCA and local partners evaluate the collected data to do the following:

- Identify waters that do not meet water quality standards, goals, and designated uses.
- Identify current water quality conditions and waters that are not impaired but should be protected.
- Identify stressors to aquatic life (fish and invertebrates) causing impairments or threats to water quality, including such possible stressors as dissolved oxygen, nitrate, phosphorus, turbidity, fish passage (dams), and altered hydrology and habitat.
- Evaluate trends and effectiveness of ongoing efforts to protect and restore waters.
- Assess the human capacity to increase protection and restoration efforts, while at the same time enhancing the stakeholder network.
- Determine pollution load allocations and priority areas within the watershed to target for improved water quality, using water quality models (i.e. HSPF) and other necessary models.
- Identify point and nonpoint sources of pollution that require an NPDES permit.
- Determine data gaps and the best ways to monitor changing conditions and implementation effectiveness.

Step 3 — Develop strategies to restore and protect the watershed's water bodies

Based on the watershed assessment, the MPCA completes a watershed restoration and protection strategy (WRAPS) in collaboration with local partners. The WRAPS report includes the assessment findings from Step 2, a table which contains water quality goals and targets by parameter of concern, and strategies and actions designed to cumulatively achieve needed pollutant load reductions for point and nonpoint sources. The WRAP incorporates load reductions needed for each source or source category to meet water quality standards and goals, including allocations for TMDLs. It also includes timelines, interim milestone targets, and responsible governmental units for implementing the strategy.

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.

Then, with the Local Governmental Unit (LGU) in the lead, a comprehensive watershed management plan is developed. This plan is based on the assessment work and WRAPS reports, and also considers state-level goals and strategies for downstream waters affected by the watershed. The comprehensive watershed management plan that the LGU develops builds on these other efforts, and also incorporates the following:

- Stakeholder input
- Refined targeting based on community priorities and local knowledge
- Priority practices to provide the most overall protection and improvement of waters (based on costs and benefits)

The strategy for the major watershed summarizes issues, locations of strategies, timelines, measure, roles and financing for all priorities. Commitments for action are reviewed on a biennial schedule.

Step 4 — Conduct restoration and protection projects in the watershed

In this step, restoration and protection projects are implemented in the major watershed. This includes all traditional permitting activities, in addition to programs and actions directed at nonpoint sources. Partnerships with state/federal agencies and various LGUs, including watershed districts, municipalities, and soil and water conservation districts and the U.S. Department of Agriculture (USDA), will be necessary to implement these water quality activities.

The Strategy is established to create greater efficiencies and opportunities for nitrogen and phosphorus reduction through state-level programs and efforts, increasing the capacity of LGUs to effectively reduce nutrients entering waters.

The MPCA's improved system for integrating and managing water quality programs will yield considerable benefits in the form of efficiencies and environmental benefits, including the following:

- An ongoing, predictable cycle for water quality management and evaluation
- Integrating watershed protection and restoration needs into a single management plan
- A more efficient approach to addressing impairments
- A common framework for monitoring, TMDL studies, and implementation strategies
- Increased stakeholder interest and local support
- Improved collaboration and innovation
- A reduction in the cost of improving water quality

Groundwater Protection and the Nitrogen Fertilizer Management Plan

The Comprehensive Groundwater Protection Act of 1989 (Minnesota Statute § 103H) significantly altered the direction of water resource protection 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, 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.*

The NFMP is organized into nine chapters. Chapter 1 provides a general introduction to the plan. Chapters 2 through 6 include background and technical information about nitrogen and groundwater. Chapters 7 through 9 outline the revised NFMP process, with detailed information about prevention, monitoring, preliminary assessment, and mitigation.

Minnesota Water Sustainability Framework

The University of Minnesota Water Resources Center developed the *Minnesota Water Sustainability Framework* (Framework), as directed by the Legislature, in 2010—2011. The Framework addresses drinking water, stormwater, agricultural and industrial use, surface and groundwater interactions, and infrastructure needs. The Framework includes the 10 most significant issues related to sustainable water use and strategies and recommendations to address these issues.

Excess Nutrients and Other Conventional Pollutants are identified as significant issues in the state. The desired future or goal is described as "*The 'Land of Unimpaired Waters', where we have met all our water standards for nutrients and solids, we are not contributing to eutrophication problems beyond our borders, we can safely eat local fish.*" Strategies and recommendations to address this issue include the following:

- Reduce excess nutrient and conventional pollutant loads by strengthening policies to meet clean water standards, and require implementation of pollutant load reductions by all sources.
- Establish a farmer-led, performance-based approach to meeting clean water standards.

Mississippi River at St. Cloud Photo Credit: MPCA

1.2 Project Collaborators

Successful implementation of the Strategy will require broad agency support, coordination, and collaboration. An interagency coordination team (ICT) is supporting development of the Strategy and 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 comprised of senior agency managers and a work group comprised of agency program managers. Two sector-specific focus groups were also formed to provide input and direction on Strategy development. The Agricultural Sector group includes representation from MDA, Natural Resource Conservation Service (NRCS), Board of Water and Soil Resources (BWSR), 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

1.3 Strategy Building Blocks

This Strategy 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
- 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 major watersheds (basins). The 2004 report can be found at: *http://www.pca.state.mn.us/index.php/water/water-monitoring-and-reporting/water-quality-and-pollutants/phosphorus/detailed-assessments-of-phosphorus-sources-to-minnesota-watersheds.html*.

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

Nitrogen in Minnesota Surface Waters Report

In 2013 the MPCA released a comprehensive study of nitrogen in surface waters 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, developed by the MPCA, University of Minnesota, and USGS, can be found at *http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/nutrient-reduction/nitrogen-study-looks-at-sources-pathways.html*.

Several parts of the report were used in the Strategy, 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 Spatially Referenced Regressions on Watershed attributes (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 throughout the Strategy to provide comparable watershed nutrient yield and loading data, inform sources of nutrients, and estimate loading in the Lake Superior and Rainy River watersheds.

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 is summarized at *www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/streams-and-rivers/watershed-pollutant-load-monitoring-network.html*.

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 (DOP), 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 Strategy development. These data will be critical to future iterations of the Strategy as data become available for the majority of HUC8 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 Strategy.

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 Flux 32.
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.

Red River at Fargo/Moorhead Photo Credit: MPCA

Best Management Practices for Nitrogen 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 (AgBMP) included: (1) Minnesota AgBMP Handbook; (2) University of Minnesota Nitrogen Best Management Practice watershed planning tool (NBMP); and (3) Iowa State University literature review.

Miller et al. (2012) completed the Minnesota AgBMP Handbook, which 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. The handbook can be found at: *www.eorinc.com/documents/AG-BMPHandbookforMN_09_2012.pdf*.

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). Their report, which was developed by a team of scientists from Iowa Universities led by Iowa State, can be found at *www.nutrientstrategy.iastate.edu*.

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. The NBMP tool can be downloaded at *z.umn.edu/nbmp*, and more information about the development and use of the spreadsheet is found at: *faculty.apec.umn.edu/wlazarus/documents/nbmp_overview.pdf*.

Chapter 2

Setting Goals and Milestones

The *Minnesota Nutrient Reduction Strategy* (Strategy) includes goals and milestones for nutrient reduction at multiple scales including basin (e.g., Mississippi River Basin at the state line) and watershed (e.g., 8-digit hydrologic unit code [HUC8] watersheds). 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 Strategy 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 basins.
- **Milestone** – An interim goal to be achieved; expressed in terms of load reduction. Milestones are used in this Strategy to define loading reductions that represent environmental progress.
- **Baseline** – Represents initial time period that goals are compared against and which trends in water quality and programmatic implementation are evaluated.

This state-level strategy emphasizes the need for watershed nutrient goals to be based, in part, on the downstream needs outside of the HUC8 level watersheds. Downstream needs include total maximum daily loads (TMDLs) for phosphorus impacted in-state rivers and reservoirs and nitrogen reduction needs for the Gulf of Mexico, Lake Winnipeg, and other out-of-state waters.

2.1 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 Strategy are included for the following three major river basins (Figure 2-1):

- Mississippi River Basin (including the Missouri, River, and Des Moines river’s subbasins)
- Lake Superior Basin
- Lake Winnipeg Basin (including the Red and Rainy river’s subbasins)

In addition, a groundwater/source water protection goal is included to address groundwater as a drinking water source.

Figure 2-1. Minnesota drainage basins.

The Strategy is based on load reduction goals that have previously been stated in existing 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:

- **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. Goals associated with this reference are included as provisional goals and are expected to be raised 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, along with other nearby states, will strive to reduce nutrient loads using an equitable approach. Goals associated with this reference are included as provisional goals.
- **Statewide Groundwater/Source Water** – Minnesota Groundwater Protection Act.

Table 2-1. Basin-wide nutrient reduction goals

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 [d]	No goal identified	Qualitative – achieve and maintain drinking water standards

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.
c. 2008 Gulf Hypoxia Action Plan; Provisional goal; Includes drainage associated with Missouri, Des Moines, and Cedar rivers.
d. Based on 1989 Minnesota Groundwater Protection Act.

In addition to goals, milestones serve as interim measures of progress. Milestones provide a step-wise approach to meeting basin goals for nutrient reduction and can take into account the changing landscape, regulatory environment, and available best management practices (BMPs).

Milestones are an important component of the Strategy 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 requires several years of planning.

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

The milestones are phased over time, depending on parameter and basin. Table 2-2 presents the milestones, which are based on reducing basin outlet loads to eventually achieve the goals. Strategies and target dates will be adjusted through an adaptive management process.

Mississippi – Much progress has been made to address phosphorus loads in the Mississippi River Basin; however, there is still significant load reduction needed to meet goals. While progress can be made with existing BMPs for nitrogen reduction, achieving nitrogen goals will also require research and development of new BMPs. 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. The Minnesota Pollution Control Agency (MPCA) established a Phosphorus Strategy in 2000 and completed a statewide assessment of phosphorus sources in 2004 (Barr Engineering 2004). The Phase 1 phosphorus milestone is a cumulative target reduction of 35 percent with a target date of 2025. For nitrogen, a milestone reduction of 20 percent is established with a target date of 2025.

Future milestones for nitrogen and phosphorus reduction will be established based on progress as represented by the results of this milestone strategy, along with adaptations which integrate new knowledge and needs for continued improvement. A general expectation might be represented by a Phase 2 Milestone for nitrogen of 30 percent, with a projected target date of 2035 and a Phase 3 Milestone meeting the Strategy provisional goal of 45 percent reduction from baseline by 2045. For phosphorus, the Phase 2 Milestone is meeting the Strategy provisional goal of 45 percent reduction, with a potential target date of 2035.

Winnipeg – Since the load reduction goals are fairly small, the Phase 1 Milestone suggests meeting the provisional goals for both phosphorus and nitrogen. The target date for this milestone is 2025. New milestones will likely be necessary after the International Red River Board completes its development of an updated strategy to protect Lake Winnipeg.

Superior –Since the load reduction is very small, the Phase 1 Milestone suggests meeting the goals for phosphorus reduction (no goal for nitrogen). The target date for this milestone is 2025.

Table 2-2. Milestones

Basin	Pollutant	Phase 1 Milestone	Phase 2 Milestone	Phase 3 Milestone
Mississippi River (Includes the Cedar, Des Moines, and Missouri Rivers)	Phosphorus	Achieve 35% reduction from baseline by 2025 [a]	Achieve 45% reduction goal	Meeting goals, no net increase
	Nitrogen	Achieve 20% reduction from baseline by 2025 [b]	Achieve 30% reduction from baseline	Achieve 45% reduction goal
Lake Winnipeg [c] (Red River Only)	Phosphorus	Achieve 10% reduction goal by 2025	Adapt goals, if necessary, based on international joint efforts with Canada	
	Nitrogen	Achieve 13% reduction goal by 2025	Adapt goals, if necessary, based on international joint efforts with Canada	
Lake Superior	Phosphorus	Achieve 3% reduction goal by 2025	Meeting goals, no net increase	
	Nitrogen	Maintain protection		
Statewide Groundwater/ Source Water	Nitrogen	Meet the goals of the 1989 Groundwater Protection Act		

a. It is important to note that active phosphorus reduction began with the completion of the *Detailed Assessment of Phosphorus Sources to Minnesota Watersheds* (Barr Engineering 2004) and Phosphorus Strategy adopted by MPCA's Citizens' Board in 2000.

b. While the baseline for nitrogen reduction is established as prior to 2000, no active strategy has been established since that time to coordinate actions.

c. Milestones to be revised upon completion of the Red River/Lake Winnipeg strategy.

To track progress toward each of the 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 Minnesota Accountability Act of 2013 will guide tracking efforts, and might include programmatic annual or biennial reporting. Chapter 7 describes the Strategy's adaptive management process in greater detail and highlights the interim implementation goals that will occur annually and at the key 2-year, 5-year, and 10-year marks leading up to the phased milestones.

2.2 Watershed Load Reductions

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 HUC8 watershed and subbasin scale will be determined by existing or future TMDLs and as part of watershed planning activities (e.g., watershed restoration and protection strategy [WRAPS]) that will help to focus nutrient reduction activities at the watershed level. Additionally, HUC8 watershed milestones are derived from the basin milestone, which are applied equally to all HUC8 watersheds within the respective basin (e.g., all HUC8 watersheds in the Mississippi River Basin should reduce nutrients by 20 percent from baseline conditions). Section 6.1 includes further description of the watershed load reduction goals.

For many of Minnesota's watersheds, downstream impacts mean meeting goals for Lake Pepin. In the case of Lake Pepin, upstream watersheds will need to integrate internal reduction needs of lakes and streams undergoing eutrophication and also consider meeting their part of the reduction needs of Lake Pepin at their outlets.

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 otherwise. 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 Strategy 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 In-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. 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 Strategy 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 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. 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 Strategy. Both the existing lake and proposed river eutrophication standards (RES) in Minnesota include phosphorus, but they do not include nitrogen. Eutrophication standards were promulgated for lakes in 2008 and RES 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 Strategy takes into consideration the state-level programs, efforts, and goals which can aid local governmental units in addressing nutrients within their HUC8 watersheds and thereby achieve these multipurpose goals.

Addressing the mutually beneficial goals of meeting in-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 local and downstream waters.

Since some high nutrient-loading waters are not within or upstream of watersheds with eutrophication impairments, the Strategy addresses nutrient reduction in geographic areas extending beyond watersheds with eutrophication-impaired waters. Many agricultural nonpoint sources are voluntarily controlled within and outside of watersheds with impaired waters, and thus the programs to achieve reductions and protection in all watersheds are largely the same and can be maximized by viewing both local and downstream needs together. Reducing loads in all watersheds will also protect waters that currently meet eutrophication standards from degrading.

The following sections describe the potential 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

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 states’ Impaired Waters List for exceeding the 10 mg/L NO_3-N threshold (Figure 2-2). In 2011 the Impaired Waters List noted 15 cold-water streams in Minnesota as not meeting the 10 mg/l NO_3-N water quality standards 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 needed. The other 77 percent of Minnesota's population gets its drinking water from groundwater. Groundwater is an important source of drinking water in southern Minnesota where river and stream nitrate-nitrogen (NO_3-N) concentrations can exceed 10 mg/L. Nitrate in groundwater used as a drinking water source is a concern in several areas in Minnesota (Figure 2-3).

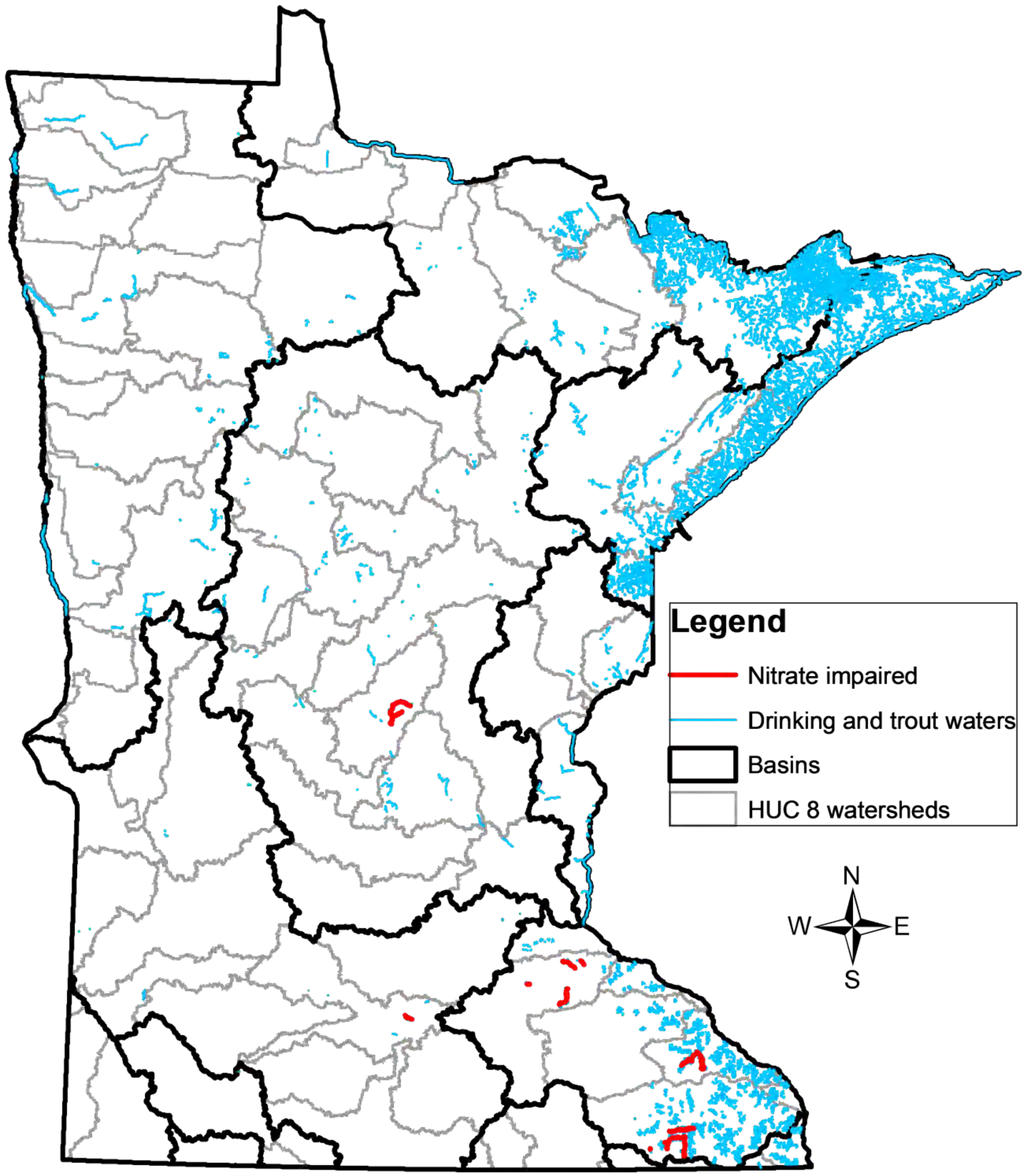


Figure 2-2. River and stream reaches protected as drinking water sources, including cold-water streams. The blue waters have a 10 mg/L NO_3-N drinking water standard and the red waters have a nitrate impairment based on exceedances of the drinking water standard.

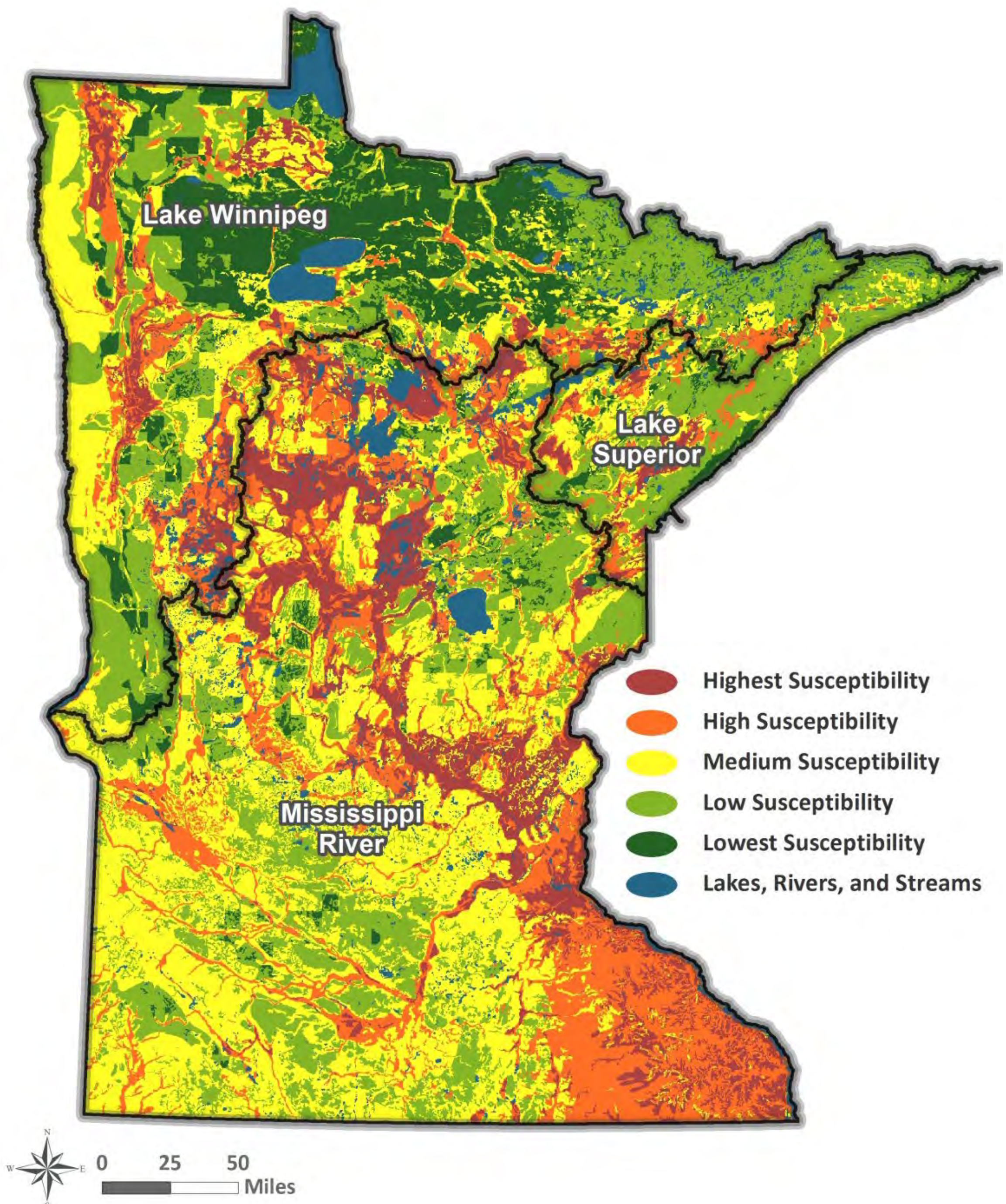


Figure 2-3. Groundwater susceptibility to contamination (MPCA 1989).

2.2.2 Future Aquatic Life Nitrate Toxicity Standards

The downstream benefits of achieving future nitrate standards (based on aquatic life toxicity) are difficult to assess at this time; toxicity tests are ongoing to inform the nitrate aquatic life standard rule-making process. This Strategy does not influence the nitrate toxicity standard. It will be independently 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 in-state standard for nitrate is exceeded during this high loading period, then reduction strategies to meet in-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 NO_3-N 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.

2.2.3 Lake Eutrophication Standards

With lake eutrophication standards (LES) in place and RES proposed, Minnesota is better positioned to evaluate the relationship between in-state phosphorus reduction needs and corresponding downstream phosphorus reduction potential. Both proposed and existing 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. Most of the watershed drainage areas for these lakes are quite small. Yet the watersheds (also referred to as lakesheds) for these lakes, including Lake Pepin and other lakes with large watersheds, drain 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 within a lake's 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 for the lakes with sufficient data to make percent reduction calculations (Figure 2-4). Lake Pepin, a 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.

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

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 Backwaters Photo Credit: MPCA

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 Mississippi River
  - 50% in Cannon River
  - Reduced point source loads
- Hundreds of impaired lakes within Lake Pepin watershed
  - **Lake St. Croix** (7,674 square miles)
  - **Lake Byllesby** (1,116 square miles)

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

- Approx. 10% reduction needed

Lake Zumbro (845-square-mile watershed)

- Approx. 40% reduction needed

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

- Approx. 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
Cedar	48%	62%	73%	6
Des Moines	23%	47%	81%	13
Lower Mississippi	29%	67%	95%	36
Superior	11%	36%	90%	7
Minnesota	0%	47%	95%	93
Missouri	20%	49%	73%	5
Red River	4%	32%	71%	23
Rainy River	4%	27%	55%	5
St. Croix	0%	45%	88%	50
Upper Mississippi	0%	42%	95%	195
Grand average/total	**0%**	**45%**	**95%**	**433**

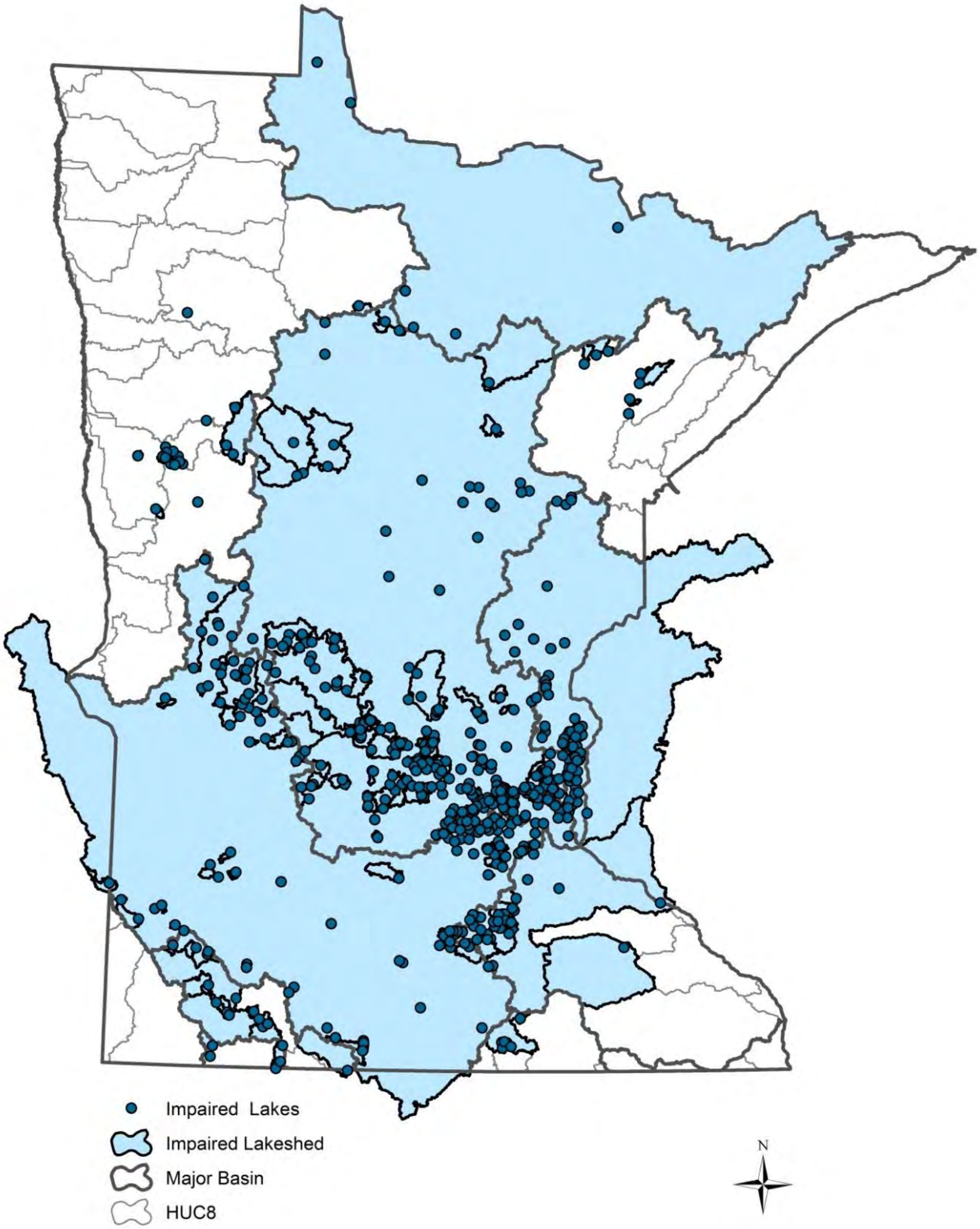


Figure 2-4. Contributing watersheds/lakesheds of lakes and reservoirs impaired due to eutrophication.

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

2.2.4 River Eutrophication Standards (RES)

Table 2-6 and Table 2-7 show proposed RES. The phosphorus reductions needed to meet RES are highly variable throughout Minnesota based on data from the past 10 years. Available data for dissolved oxygen (DO) flux and 5-day biochemical oxygen demand (BOD_5) in streams and rivers is limited so only phosphorus and chlorophyll-a (chl-a) were assessed for the purposes of this exercise. Approximately 38 percent of streams and rivers in the state with 12 or more observations of both phosphorus and chl-a are meeting the proposed RES (Figure 2-5). Eighteen percent of rivers with sufficient data exceed both the cause (phosphorus) and response (chl-a) variable of proposed RES. 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 RES or LES. For example, the Minnesota River Basin has 21 reaches that are not locally impaired for RES, but would need reductions to meet standards at the Lower Minnesota River at Jordan, Minnesota (projected to be impaired for RES), and Lake Pepin (impaired for LES). Other river reaches, such as several of those in the Red River of the North subbasin, 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 needed to meet proposed RES average 41 percent for the potentially impaired rivers (Table 2-8). These reductions are comparable 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).

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

	Nutrient	Response variables		
Region	Phosphorus µg/L	Chl-a µg/L	DO flux mg/L	BOD_5 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. Source of data for assessment noted. Assumes aquatic recreational and aquatic life uses are maintained if phosphorus and chl-a are at or below criteria levels.

River / Pool	Site	Data source	Phosphorus µg / L	Chl-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

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 lakewide mean from four monitoring sites.
6. Minimize frequency of severe blooms; upstream phosphorus requirements benefit lower pools. WI 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 proposed RES. Monitoring data are from 2003–2012. Percent reduction is the average reduction to meet phosphorus variable of river eutrophication standards.

	Elevated phosphorus and chl-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.

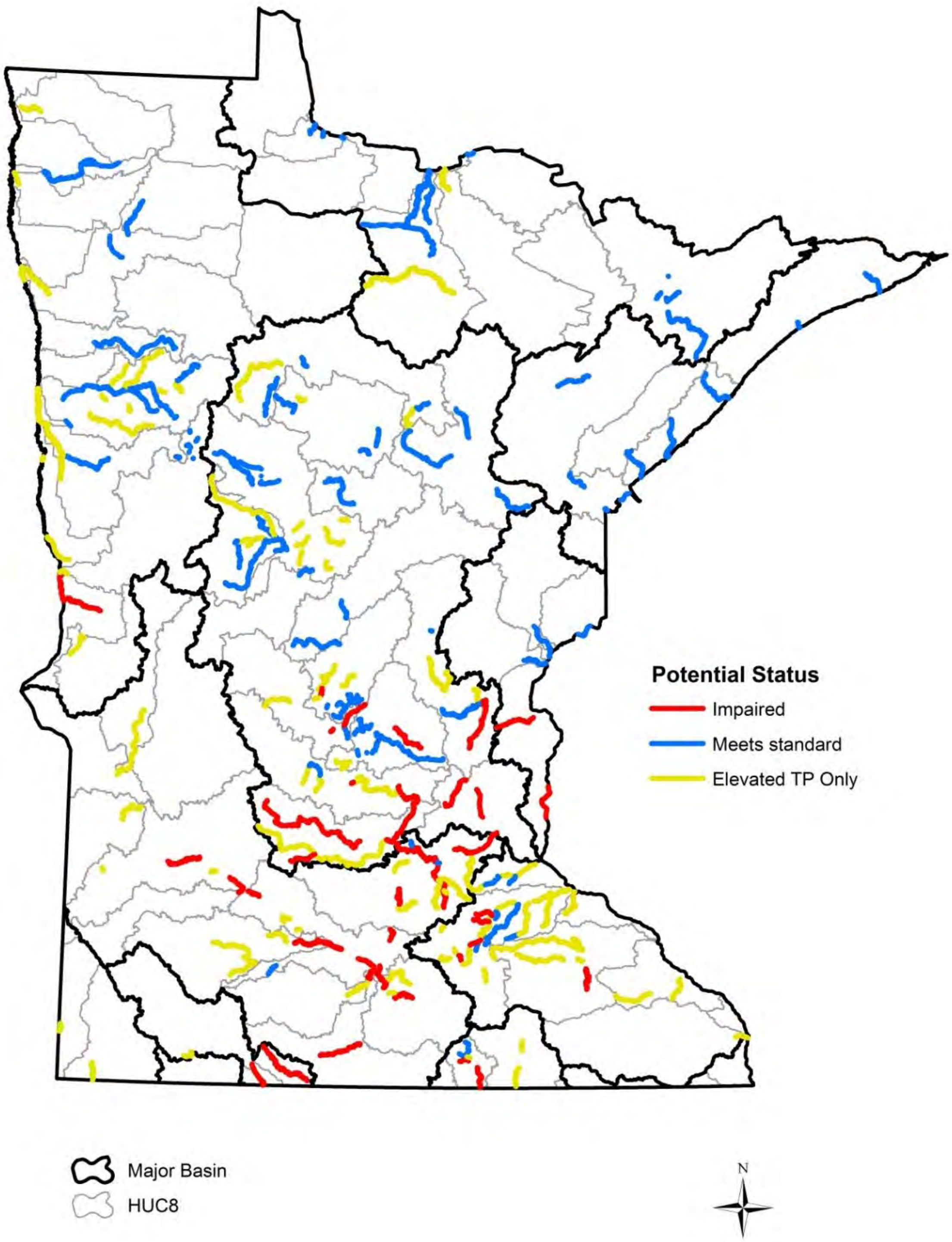


Figure 2-5. Projected status of assessed rivers potentially impaired by the proposed river eutrophication standards (red) and rivers which exceed the phosphorus part of the proposed standard, but do not also exceed the chl-a response variable (yellow).

2.2.5 Turbidity/TSS Standards

Phosphorus is typically attached to suspended particles in river systems. The state of 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 phosphorus as a driver of eutrophication. At the same time, reducing turbidity/TSS will result in lower phosphorus levels in streams, especially during high flows. This will be an important driver for phosphorus reductions in areas where response variables for LES and RES are not exceeded. For instance, there is limited algal growth in the mainstem of the Red River of the North. Thus, nutrient reductions might not be needed for meeting LES or RES. In this river, reductions for turbidity and TSS will be the main driver for phosphorus reductions, along with eutrophication considerations for Lake Winnipeg in Cananda.

The turbidity standard will also be important in rivers exceeding the proposed RES, since RES 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 October. 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. This is important since some streams with high phosphorus and TSS levels might not exceed RES, and thus no local reductions for phosphorus may be required. TSS and associated phosphorus reductions will be most important for downstream resources such as Lake Pepin and the Gulf of Mexico. LES and RES will be important for limiting phosphorus at average to low flows during the summer, when algal production in rivers and reservoirs is most problematic.

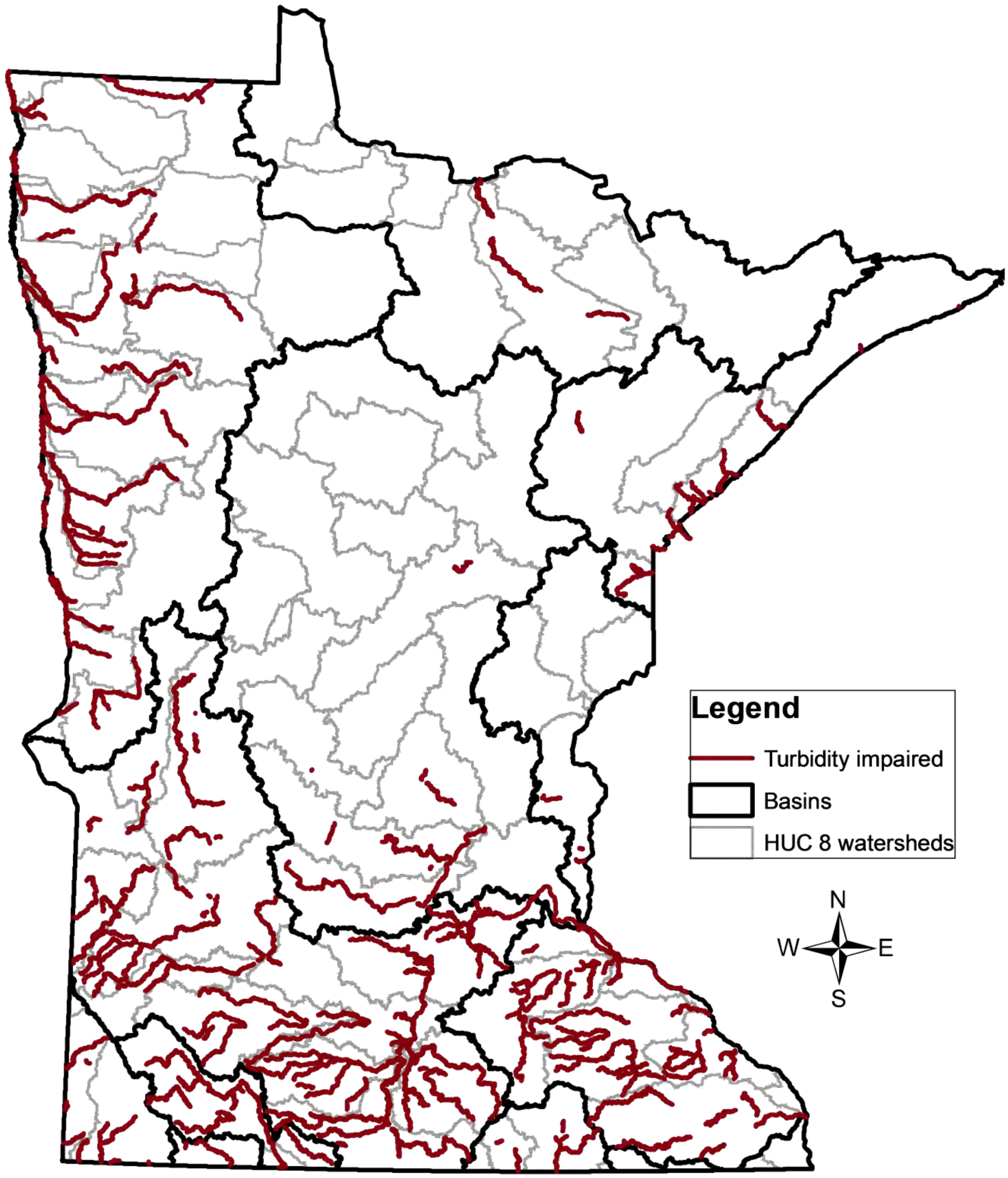


Figure 2-6. Turbidity-impaired streams included on draft 2012 Impaired Waters List.

The Lower Minnesota River Dissolved Oxygen TMDL

In addition to impaired lakes, streams and rivers can also be impaired due to nutrients, even without RES. 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 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 in-state phosphorus-related standards and protection will likely result in long-term, out-of-state downstream needs being met. Subbasin and HUC8 watershed planning activities (e.g., WRAPS) will help focus phosphorus reduction activities at the watershed level. For nitrogen, the Strategy should focus on downstream waters, since at this time existing local surface and groundwater standards will not sufficiently reduce 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.

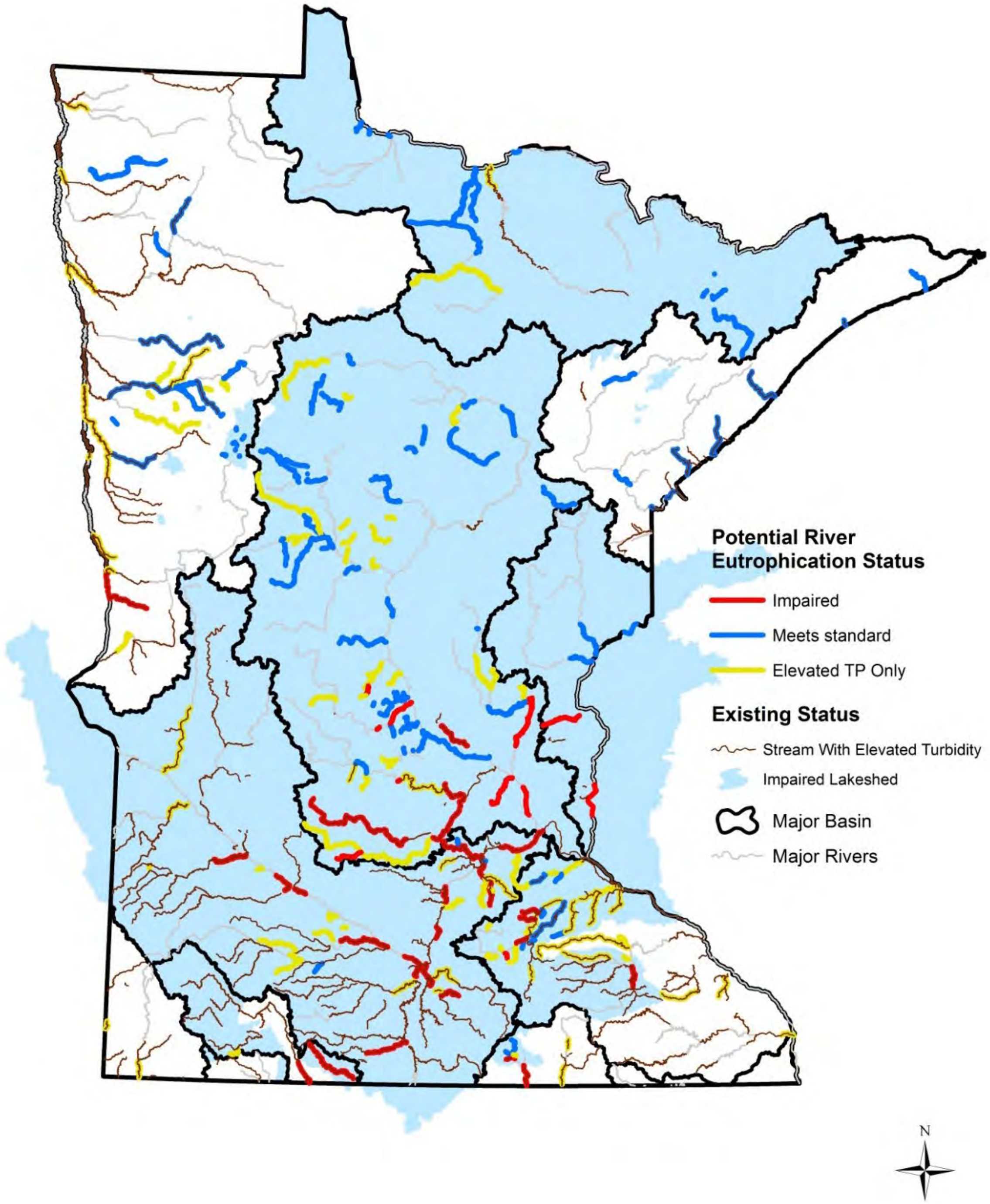


Figure 2-7. Summary of turbidity-impaired streams, streams with potential eutrophication impairments, and lakesheds of eutrophication-impaired lakes in Minnesota. Note: Not all water resources in Minnesota have sufficient data to assess for eutrophication and turbidity.

2.3.1 Mississippi River/Gulf of Mexico Basin

Upper Mississippi River

The Upper Mississippi River subbasin transitions from watersheds with limited eutrophication issues in the northern portion of the subbasin to watersheds with more eutrophication issues in the southern portion of the subbasin. Unlike the lower Minnesota River, which clearly exceeds the proposed RES, the Mississippi River at Anoka is essentially at the proposed RES. Therefore, the downstream driver for phosphorus reductions is Lake Pepin, which is outside the subbasin. Pool 2 of the Mississippi River is close to exceeding the proposed chl-a threshold. Key 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 HUC8 watershed outlets could be an approach to meeting the target for the downstream resource.

Portions of this subbasin have high densities of lakes. This subbasin has the most eutrophication-impaired lakes in the state, including key lakes such as the Horseshoe Chain (near 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 subbasin is 42 percent.

Minnesota River

Forty-four reaches in the Minnesota River subbasin had sufficient data to determine if a given stream reach would exceed the proposed RES. These reaches included the majority of the HUC8 watershed outlets in the Minnesota River subbasin. The downstream reach of Minnesota River at Jordan and Lake Pepin has chl-a levels above the proposed RES and existing lake standards, respectively, and therefore there are downstream needs to reduce phosphorus from the entire Minnesota River subbasin. Of the 44 reaches in the Minnesota River subbasin, 20 have chl-a levels above the proposed RES. The average reduction to meet the local phosphorus 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 proposed RES. If it is assumed that these reaches need reductions to meet the local phosphorus target (despite a lack of local response), and then these reaches would need to be reduced by 44 percent. Of the 44 reaches, only 3 actually meet the phosphorus variable of the proposed RES. The target for these reaches would be to maintain local targets. A proposed approach to managing phosphorus in the Minnesota River subbasin would be to meet the 150 µg/L target at the watershed outlets (HUC8s) including the Lower Minnesota River watershed. There are some additional considerations for the metropolitan portion of the

Minnesota River and Lake Pepin, but these will be addressed in a basin-wide plan, such as the Lake Pepin TMDL.

There are also 112 lakes in the Minnesota River subasin that need in-lake concentrations reduced by an average of 47 percent from average phosphorus concentration monitored from 2003–2012 for each individual lake. The watersheds for these lakes are relatively small, so the impact of meeting lake standards in the subbasin 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 HUC8 watershed scale.

Reductions needed throughout the Minnesota River subbasin for turbidity/TSS impairments, LES, and RES 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 point source loads have occurred throughout the subbasin due to a low DO TMDL, along with additional requirements for Lake Pepin. Key watersheds that contribute to downstream loading include the Greater Blue Earth River watershed and Lower Minnesota River Watershed. These watersheds have greater water and phosphorus yields than the western portion of subbasin 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 wadable streams. Minnesota has proposed eutrophication standards of 100 µg/L phosphorus and 18 µg/L chl-a for the tributaries of the Mississippi River.

Turbidity impairments are prevalent in the Lower Mississippi subbasin. A large portion of the subbasin is in the driftless area ecoregion, which has steeper slopes that are vulnerable to erosion. Management of turbidity/TSS impairments throughout the subbasin 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 subbasin include Lake Pepin, Lake Byllesby (Cannon River Watershed), and Lake Zumbro (Zumbro watershed). Reductions to meet LES, 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 which might not exceed the response variable of RES, and thus no local reductions will be necessary. Some streams in the Root River watershed do not exceed the phosphorus variable of RES 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 subbasin 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 subbasins where 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 subbasin.

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

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

St. Croix River

Lake St. Croix is located at the outlet of this subbasin. 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 subbasin to meet local LES and RES will be key to meeting standards in Lake St. Croix and Lake Pepin. The northern portion of the subbasin has fewer eutrophication and TSS impairments. Any slight reductions needed in the northern portion of the subbasin will have limited impact on downstream loading.

St. Croix River Photo Credit: MPCA

2.3.2 Winnipeg Basin

Red River

Phosphorus is high in the Red River subbasin, but there are relatively few local impacts. There are some LES and RES issues in the headwaters of the subbasin. Once phosphorus loads enter the mainstem of the Red River, turbidity limits algal production. Reductions in TSS should help dramatically lower phosphorus loads. Downstream goals for Minnesota regarding Lake Winnipeg are expected to change in the near future.

Rainy River

The Rainy River subbasin generally meets the applicable LES and RES. The main driver for this subbasin 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 proposed RES. River reaches that exceed the proposed phosphorus variable of RES in the subbasin would need an average of 12 percent. The Lake of the Woods TMDL will ultimately determine the best approach to reducing phosphorus loading in the subbasin.

2.3.3 Lake Superior Basin

This basin is also in relatively good condition in term of phosphorus. The phosphorus and nitrogen levels in Lake Superior are very low, and only a small improvement is necessary. MPCA has recently recommend a lower phosphorus limit for Western Lake Superior Sanitary District (wastewater facility for greater Duluth area) to comply with Wisconsin's RES. The facility has also been improving its ability to minimize bypass events at the facility caused by inflow and infiltration in its collection system.

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. The chapter begins with a discussion of factors that affect nutrient loads considered during the source assessment. The chapter continues with discussions of the water quality trends of nutrient concentrations and loads and discussions of the sources of nutrient loads by major basin.

3.1 Environmental and Land Use Factors Affecting Nutrient Loading

Several factors influence long-term trends in nutrient loading, including changes in climate, land use, and management practices. An understanding of these factors provides important perspective on 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 an increasing trend, while examination of a longer 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 climate has on year-to-year variability in pollutant loads, the evidence suggests that climate change is resulting in increased annual 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. Reducing loads and discerning trends in the face of such large-scale changes are important challenges to be addressed by future iterations of the *Minnesota Nutrient Reduction Strategy* (Strategy). It should be noted that current flows are similar to or less than baseline flows in all three basins. Predicting future trends in flow is beyond the scope of this Strategy, but it is an active area of research and debate in Minnesota.

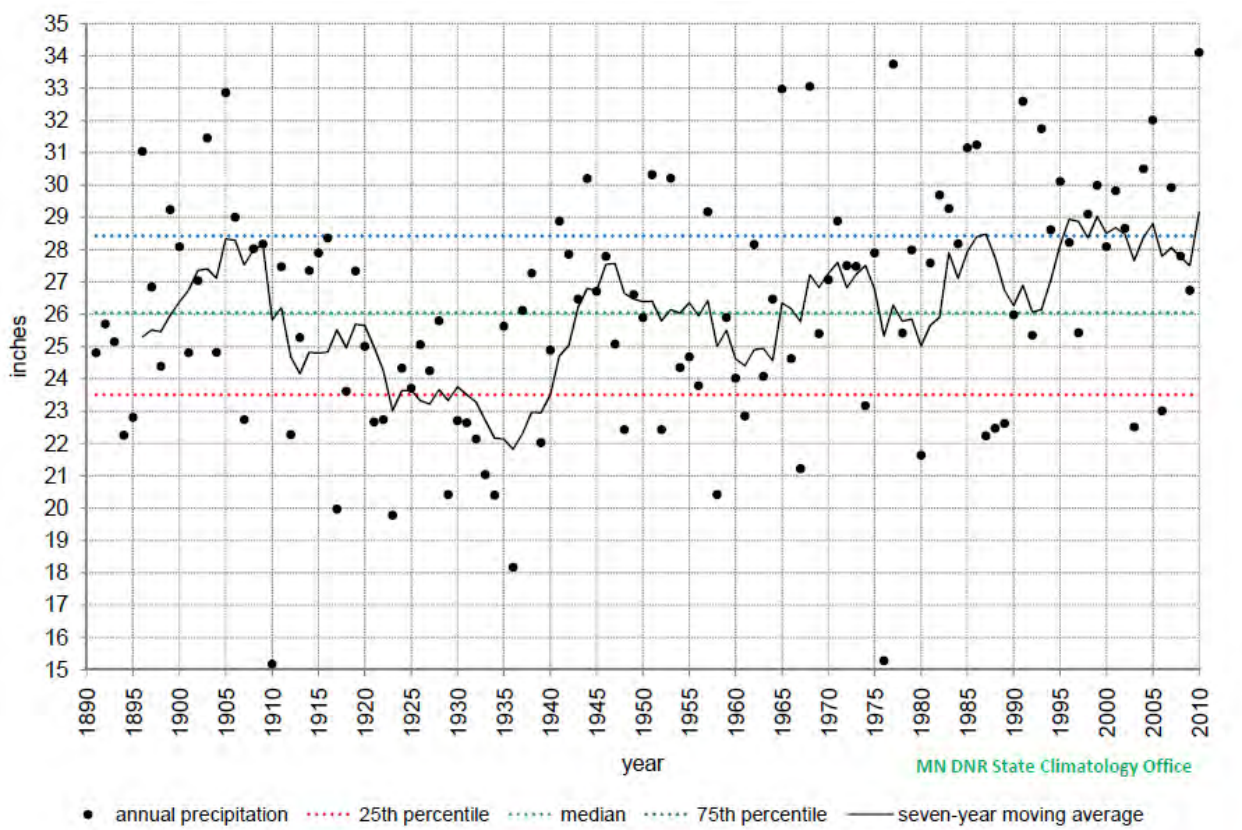


Figure 3-1. Minnesota state-averaged annual precipitation (Minnesota Climatology Working Group 2013).

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 2000 and 2010 censuses. The greatest population increases by county occurred within the Mississippi River Basin, and all three 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 and wastewater produced, although these increases are relatively small at the statewide level and have been mitigated, in part, by improved wastewater treatment, stormwater management, and other nutrient reduction activities.

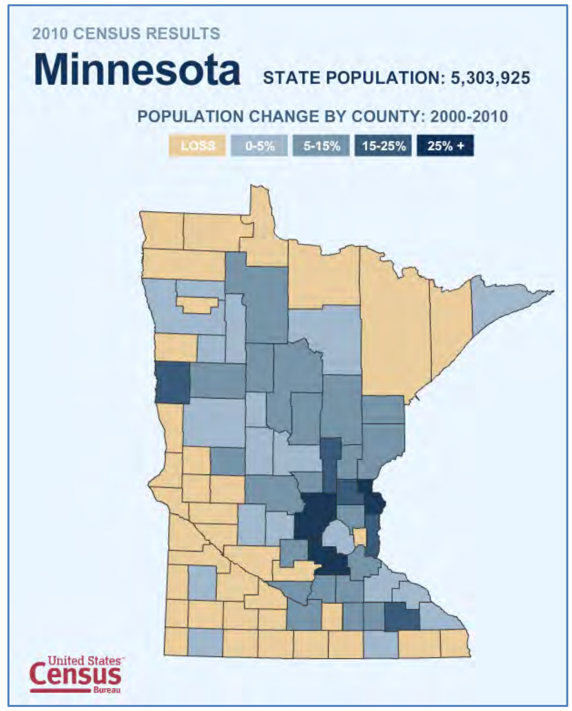


Figure 3-2. Population increase in Minnesota by county (Minnesota State Demographic Center 2013).

3.1.3 Agricultural Practices

Agricultural activities are expected to have a strong influence on nutrient loading in the Lake Winnipeg and Mississippi River basins and less of an impact in the Lake Superior Basin. Across the entire state, about 50 percent of Minnesota's land is used for agriculture (USDA 2011). The two most produced crops are corn and soybeans, although Minnesota is also known for its production of sugar beets and wheat (USDA 2011). 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 has generally increased, while the number of cattle has decreased. Livestock on farms has gone through a period of consolidation, with fewer livestock farms having larger livestock enterprises. Table 3-1 provides select historical acreages from the Census of Agriculture (USDA 2012a). The amount of land in pasture increased over this time period, but remained a much smaller portion of all agricultural land. During the same time period, the land enrolled in the Conservation Reserve, Wetlands Reserve, Farmable Wetlands, or Conservation Reserve Enhancement Programs increased. However, as noted in the following paragraphs, the amount of land in these programs is believed to have dropped since 2007.

Table 3-1. Selected statistics from the Agricultural Census, Minnesota (USDA 2012a)

Sector	1997	2002	2007
Land in farms	27,560,621	27,512,270	26,917,962
Harvested cropland	19,794,078	19,398,309	19,267,018
Pasture	1,035,159	1,187,082	1,469,816
Cropland used only for pasture or grazing [a]	1,033,959	728,593	725,403
Woodland turned to pasture	799,123	642,571	527,233
Land enrolled in Conservation Reserve, Wetlands Reserve, Farmable Wetlands, or Conservation Reserve Enhancement Program	1,466,373	1,628,796	1,929,007

Units of measure are acres.

a. The agricultural census indicates this category includes rotation pasture and land used only for grazing or pasture, but that the operator considered could have been used for crops without additional investment.

Recent Agricultural and Rural Land Changes

While statewide agricultural statistics capture overall trends, valuable insight can be gained using satellite imagery for land use and land cover. A shift from grassland to corn/soybean production is evident in a comparison of Cropland Data Layers 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 have incentivized the switch from ecosystem conservation of 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). In 2012, 88,834 acres of Conservation Reserve Program (CRP) lands expired, with only 10,723 acres of new lands enrolled (USDA 2012b). While the fates of the CRP-expired lands are unknown, based upon the grassland-to-corn/soybean conversion it is likely that some CRP-expired lands were converted into agricultural production. This has important implications for nutrient loading; in general, cropland is expected to generate larger loads of phosphorus and nitrogen than grassland.

Spring Corn Field in Minnesota Photo Credit: MPCA

A May 2013 news release by the Minnesota Department of Natural Resources (DNR) states the following:

> *Since its beginning in 1985, CRP has contributed to improving Minnesota's water quality and done more for grassland wildlife than any other conservation program. At one point, there were 1.9 million acres of CRP in Minnesota; today that amount is about 1.4 million acres. Since 2007, however, Minnesota has lost 425,000 acres of CRP. Another 625,000 acres of CRP in the state is scheduled to expire over the next 5 years.*

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 promote leaching and rapid transport of soluble nutrients, especially inorganic nitrogen. Tile drain outlets are also sometimes associated with gully formation that erodes soil and 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 Strategy's goals.

3.2 Sources of Nutrients

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 upon the following: (1) the *Detailed Assessment of Phosphorus Sources to Minnesota Watersheds* (Barr Engineering 2004) and associated updates for point source and atmospheric contributions, (2) the watershed-scale yields estimated from Minnesota Pollution Control Agency (MPCA) data, and (3) the U.S. Geological Survey (USGS) Spatially Referenced Regressions on Watershed (SPARROW) model. Atmospheric deposition loads were updated in 2007 and point source data have been updated to reflect 2011 conditions. The loadings do not represent the sources of phosphorus reaching the basin outlets, but rather the sources of phosphorus to waters in each basin. Atmospheric deposition values were adjusted by subtracting the phosphorus load to wetlands due to uncertainty and to provide comparable results with the nitrogen source assessment.

The following are sources of phosphorus to surface waters:

- Cropland and pasture runoff
- Atmosphere
- 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

The MPCA has completed a nitrogen study (MPCA 2013a) that comprehensively assesses the science concerning nitrogen in Minnesota waters (*http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/nutrient-reduction/nitrogen-study-looks-at-sources-pathways.html*) characterizing nitrogen loading to Minnesota's surface waters by assessing conditions, trends, sources, pathways, and potential ways to reduce nitrogen loads. The nitrogen study, along with watershed-scale yields estimated from MPCA data and the USGS SPARROW model, is the basis for the nitrogen source assessment summary.

The following are sources of nitrogen to Minnesota waters:

- Agricultural tile drainage
- Cropland groundwater (nitrogen leached to shallow groundwater beneath cropland, which later reaches surface waters through groundwater baseflow)
- NPDES permitted wastewater discharges
- Atmospheric deposition into lakes, rivers, and streams
- Forest
- Cropland runoff
- Individual sewage treatment systems
- Urban runoff
- 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 watersheds associated with both phosphorus and nitrogen; the table is color coded to indicate the higher loading sources (green) and sources which 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 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	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%	0.10%	0%	0.30%	0%
Roadway deicing	1%	--	2%	--	2%	--
Cropland groundwater [e]	--	31%	--	9%	--	35%
Forest	--	4%	--	38%	--	19%

Notes: P = phosphorus; N = nitrogen

a. Source percentages do not represent what is delivered to the basin outlets.

b. Atmospheric deposition is to lakes and rivers.

c. Nutrient loads in the Lake Superior Basin are lower than other 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 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 eroision. These four sources are 71 percent, 76 percent, and 83 percent of the phosphorus load under dry, average, and wet years, respectively.
- During dry conditions, point sources 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 Minnesota River, Upper Mississippi River, Lower Mississippi River, and Red River basins contributed the highest loads in the state. The Upper Mississippi River Basin (upstream of confluence with St. Croix) contributes the largest loadings under all flow conditions.

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

Nitrogen findings:

- 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.
- The Minnesota River, Upper Mississippi River, and Lower Mississippi River basins contribute the highest nitrogen loads in the state. During average and wet conditions, the Minnesota River Basin contributes the highest loads, and during dry conditions the Upper Mississippi River contributes the highest loads, mainly due to point source discharges.
- During wet years, tile drainage in the Minnesota River Basin has the single highest contribution to nitrogen loading.
- The most significant nitrogen sources by basin include: agricultural tile drainage and cropland groundwater in the Mississippi River Basin; forest and permitted point sources in the Lake Superior Basin; and cropland groundwater, forest, and atmospheric deposition and in the Lake Winnipeg Basin. These sources do not necessarily represent the proportion of nutrient sources at the basin outlets.

3.3 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 3-3 presents the nitrate concentrations in groundwater. It is important to note that these data represent many different aquifers and depths of wells.

The following excerpt summarizes the key findings:

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.

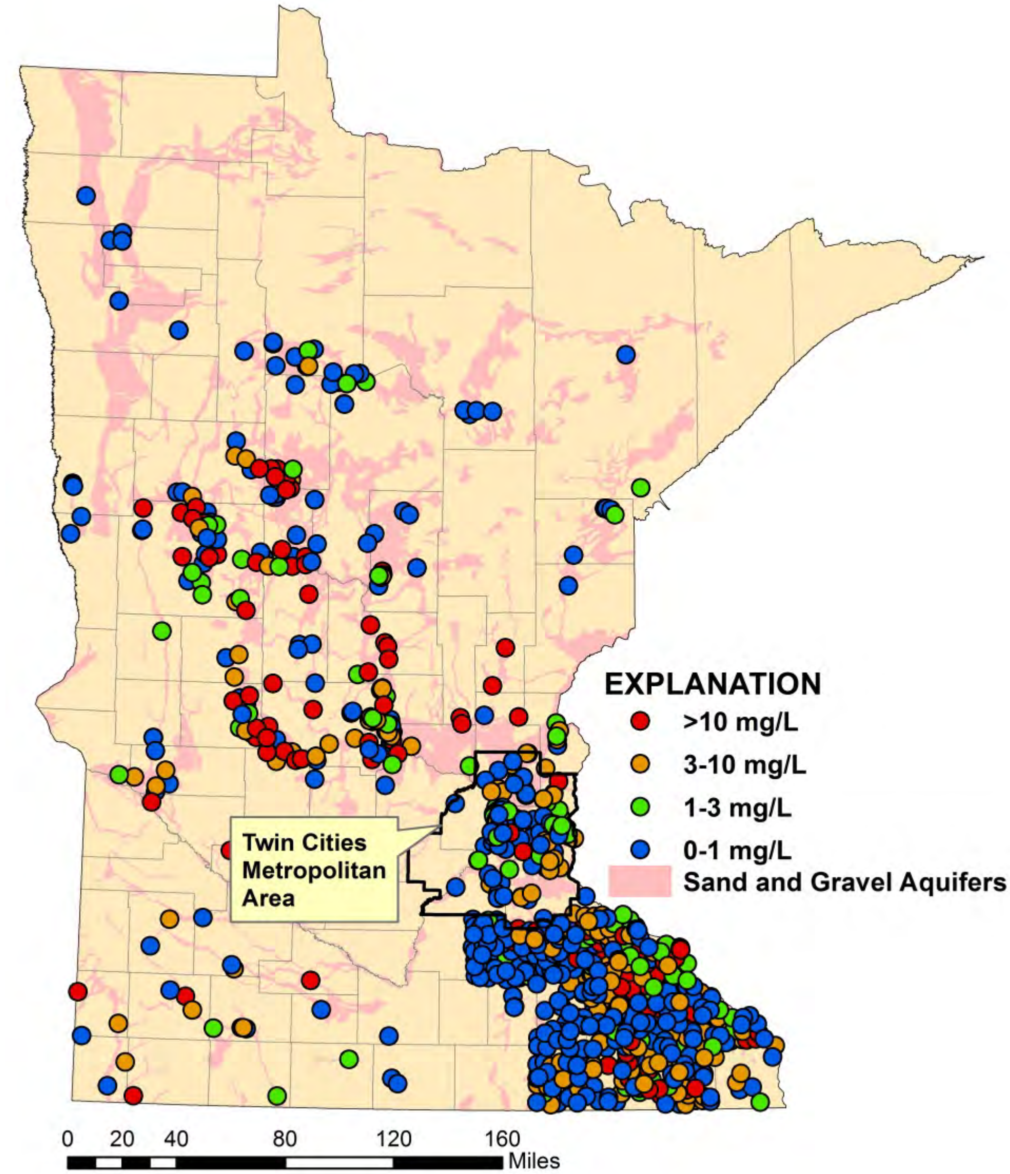


Figure 3-3. Nitrate concentrations in Minnesota's ambient groundwater, 2007–2011 (MPCA 2013b).

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 Strategy.

Potential trends were evaluated in three 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.
- **Program quantification.** Quantification of program data is intended to provide an assessment of the recent progress achieved through implementation of best management practices (BMPs) and wastewater treatment. This metric 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]).

Each metric has its own advantages and disadvantages. 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 address the issue of flow variability, but determining trends can still be difficult if there are inadequate data, lag times, and in-stream transformations. Program quantification addresses most of the issues with the two in-stream measures, and also provides information on the sector from which the reductions have been achieved. 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 following sections discuss the results of the loading and FWMC analysis, and Chapter 4.4 presents the program quantification analysis. In some cases, the results from each measure generally agree,

[1] The most appropriate data to represent the 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 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 Basin or the Rainy River portion of the Lake Winnipeg Basin. Considerable nutrient processing occurs after the Rainy River flows into Lake of the Woods, which makes it difficult assess the ultimate impact of the Rainy River on Lake Winnipeg.

whereas in other cases they do not. As discussed in Chapter 7, no one measure is considered the best and the Strategy will ultimately be successful when they are each moving in the same direction. The recent progress shown on the Strategy Summary figures in Chapter 5 is based on program quantification because that is the only measure that allows one to assess performance by sector.

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 point source update, which incorporates updated point source data from MPCA (updated for 2005–2006 for nitrogen and 2005–2009 for phosphorus) and is assumed to approximate current 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. In the future, results from the Watershed Pollutant Load Monitoring Network (WPLMN) can be used to describe watershed loadings. At this time, multiyear averages are not available for all 8-digit hydrologic unit code (HUC8) watersheds.

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

- Point source loads
- 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 Strategy primarily to assess the relative difference in loads by source and over different time periods.

Figure 3-4 and Figure 3-5 show the modeled yields by HUC8 watershed. Yields are used to understand the relative differences in loading between the watersheds and are a product of land cover, land use, precipitation, and flow conditions.

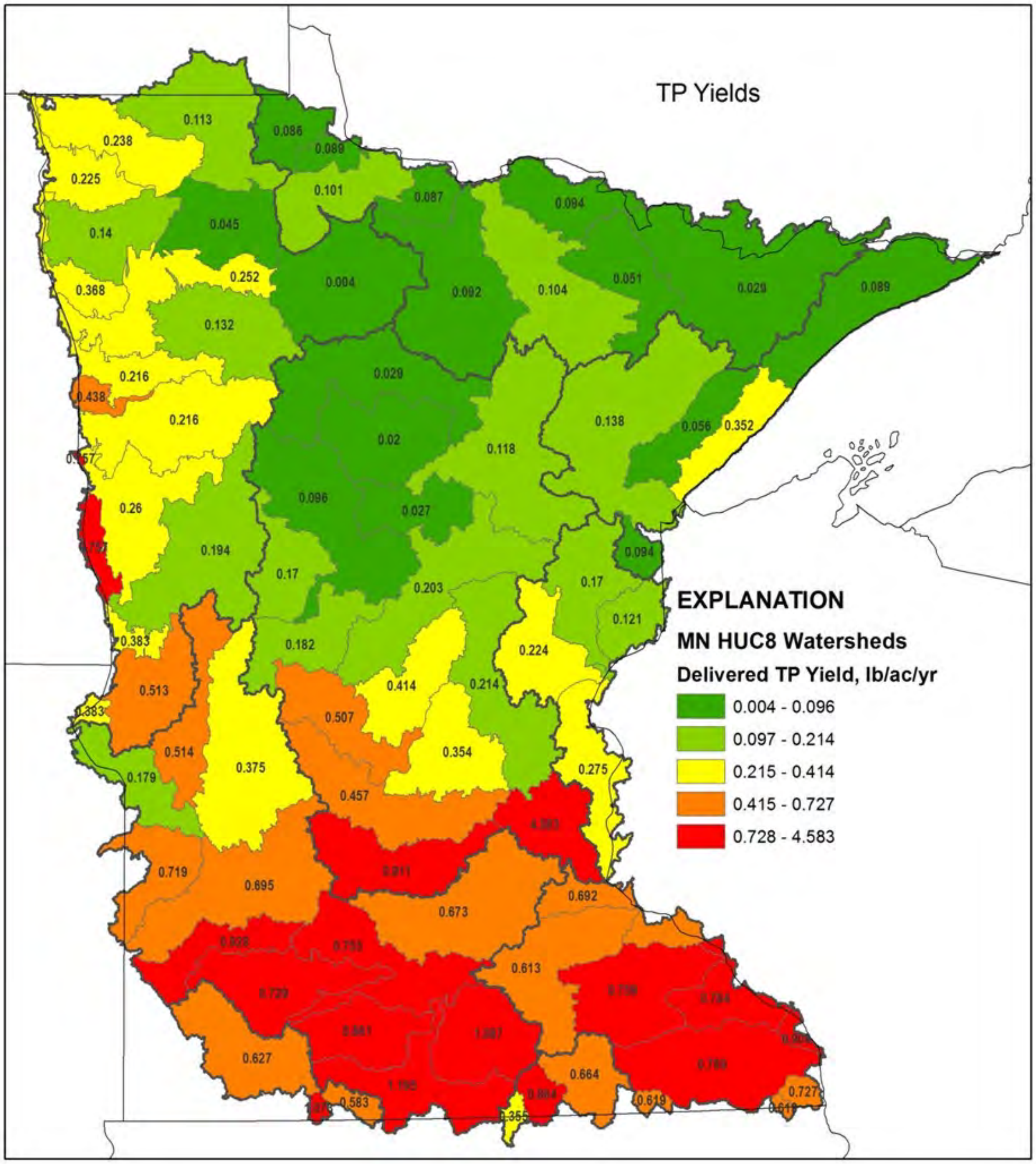


Figure 3-4. Annual phosphorus yield delivered to HUC8 watershed outlets in pounds/acre/year (Robertson and Saad 2011).

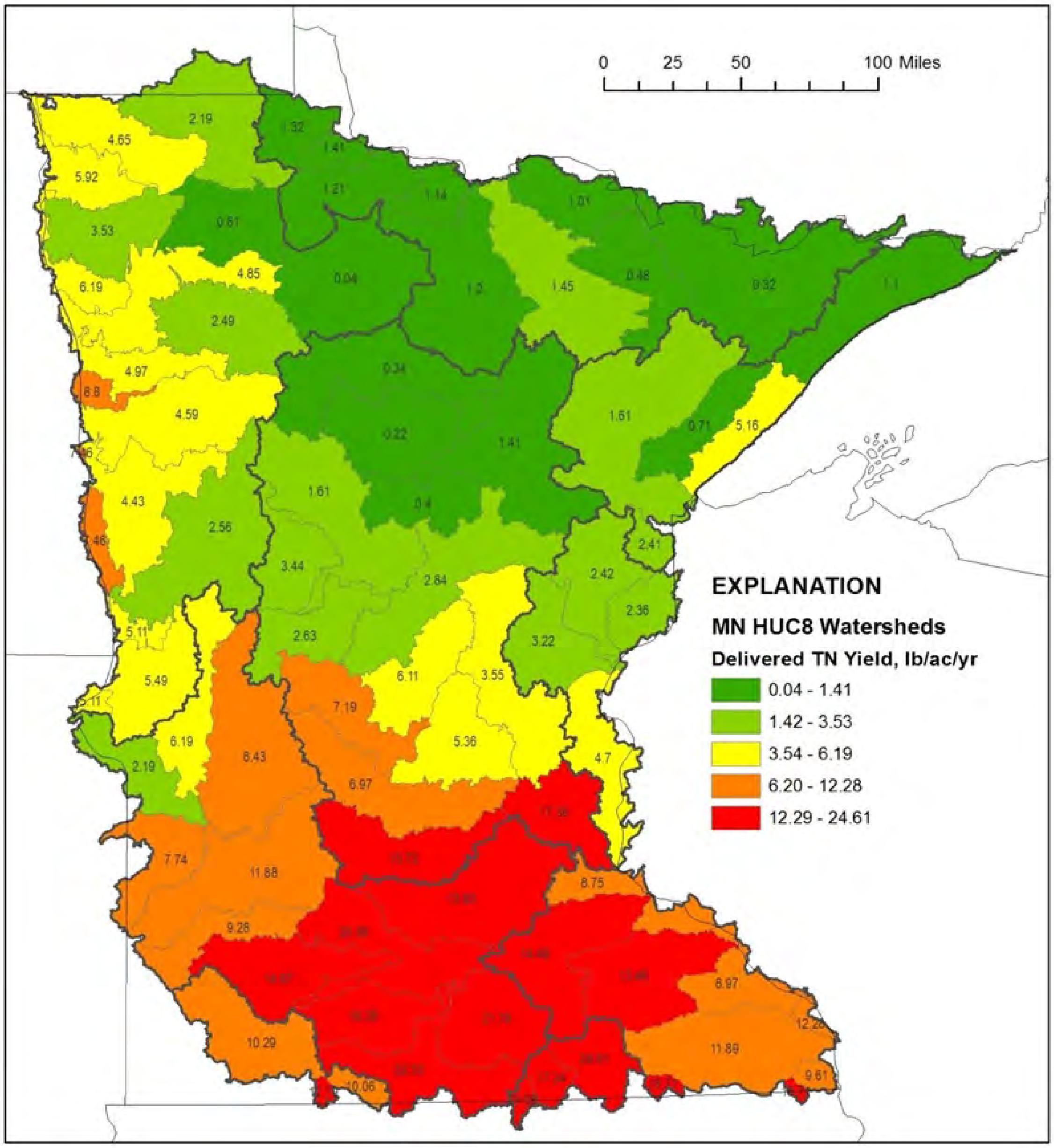


Figure 3-5. Annual nitrogen yield delivered to HUC8 watershed outlets in pounds/acre/year (Robertson and Saad 2011).

3.4.2 Lake Superior Basin

The Lake Superior Basin in northeastern Minnesota is approximately 6,200 square miles. Major watersheds include the Cloquet, Nemaji, and St. Louis River systems, as well as the North Shore tributaries to Lake Superior. Over 93 percent of the basin is forest, wetlands, and open water. Duluth and the surrounding area comprise the majority of the urban development in this basin. Open-pit mining is common along the basin divide between Hibbing and Virginia. Many high-quality streams and large forested areas, along with Lake Superior, provide for significant recreational opportunities.

Excess nutrients within this 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 basin may also contribute to excess nutrients.

In-stream loading estimates were not available for this basin, therefore USGS's SPARROW modeling results were used to evaluate nutrient loading. SPARROW results are similar to load estimates made using land use data and yields representing the late 70s and early 80s. Therefore, SPARROW load estimates were determined to appropriately represent the 1979 baseline condition for the Lake Superior Basin. The SPARROW results with point sources updated in 2009 were used for the current conditions load. Table 3-3 provides phosphorus loading results for the Lake Superior Basin.

A goal of 248 metric tons/year of phosphorus is proposed to represent "holding the line" at 1979 conditions. A 3 percent reduction from current conditions would be required to achieve the loading goal, and according to the SPARROW analysis, the increase above baseline conditions is due to an increase in point source loads since 1979. The nitrogen loading goal for the Lake Superior Basin is qualitative (no specific load reductions identified) and, therefore, nitrogen loading was not evaluated for this basin.

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

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

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

NPDES wastewater sources contribute the majority of anthropogenic phosphorus and nitrogen to the Lake Superior Basin. This indicates that dry periods are especially important for Lake Superior nutrient reduction. 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 Basin

The Lake Winnipeg Basin includes both the Red River of the North subbasin and the Rainy River subbasin. The Minnesota portion of the Red River subbasin 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 subbasin 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 subbasin 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 watershed 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 subbasin, 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 point sources within the Red River subbasin. In-stream loading estimates were not available for the Rainy River subbasin, and because there are limited anthropogenic sources of nutrients in this subbasin and likely substantial nutrient losses in Lake of the Woods, loading analysis concentrated on the Red River.

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 3-6 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 point sources under low flow conditions.

To illustrate progress needed to achieve the load reduction goal, the dashed lines in Figure 3-6 represent the estimated outcome of a 10 percent 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.

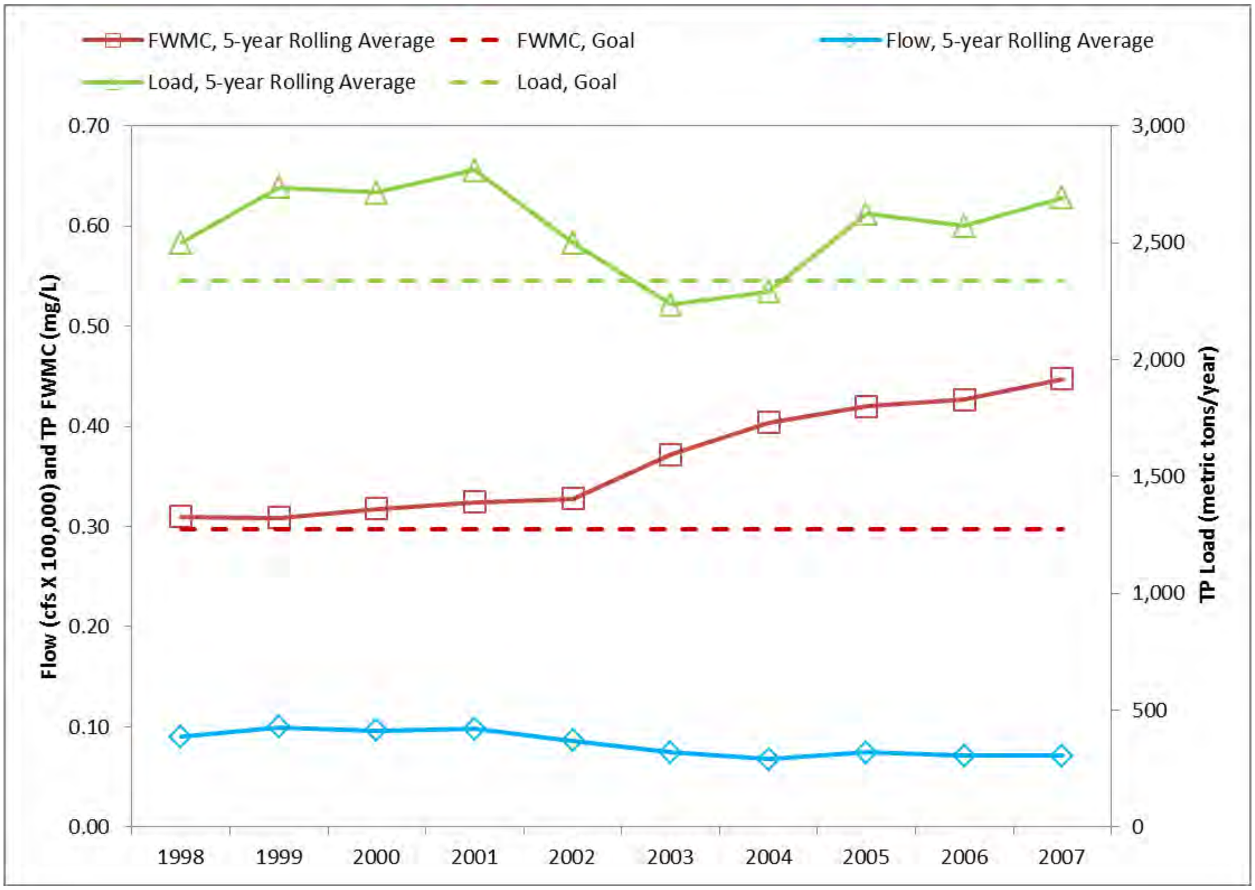


Figure 3-6. Phosphorus loading analysis, Red River near Emerson, Manitoba.

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 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.

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

Data set	Baseline 1999–2003	Goal load (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

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

Figure 3-7 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 deceased. 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 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.

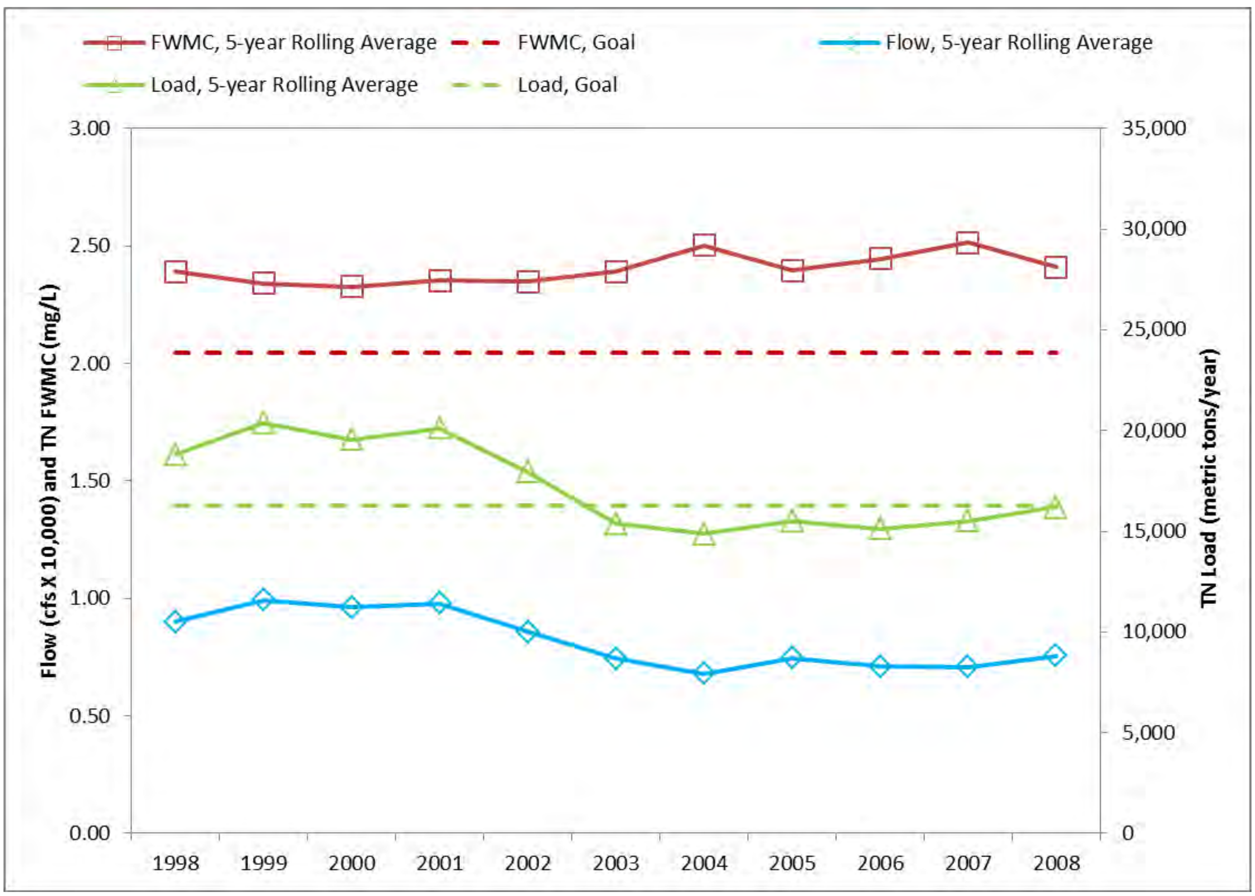


Figure 3-7. Nitrogen loading analysis, Red River near Emerson, Manitoba.

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 Basin. The goal load estimated for the Minnesota portion of the basin can be used to assess reductions achieved within Minnesota as a secondary measure of achieving the loading goal.

Table 3-5. Nitrogen loading results, Lake Winnipeg (concentration in mg/L; loads in metric tons/year)

Data set	Baseline 1999–2003	Goal load (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

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

3.4.4 Mississippi River Basin

The Mississippi River Basin comprises 60 percent of the state and includes the following seven major subbasins: Upper Mississippi River, Minnesota River, St. Croix River, Lower Mississippi River, Cedar River, Des Moines River, and Missouri River. The Upper Mississippi River subbasin 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 subbasin. The Minnesota River discharges to the Mississippi River near Fort Snelling and drains approximately 16,770 square miles. This subbasin contains very fertile soils and is predominantly agricultural upstream of the Metro Area. Nutrient reduction has been a focus in this subbasin as a result of a phosphorus total maximum daily load (TMDL) that was approved in 2012. The St. Croix River subbasin is approximately 3,500 square miles in Minnesota and includes the state's only National Wild and Scenic River (St. Croix River). The subbasin is typically forested in the upper portion with agriculture becoming more prominent in the lower portion. The Lower Mississippi River subbasin is characterized by bluffs, springs, caves, and many cold-water streams. Lake Pepin is a natural lake along the Mississippi River within this subbasin, has been the subject of many studies, and a TMDL is being developed to address excessive nutrients. Agriculture is the predominant land use in this watershed. Agriculture accounts for 84 percent of the combined Cedar River, Des Moines River, and Missouri River subbasins.

To evaluate basin loading, loading data were obtained for a variety of locations (Table 3-6 and Figure 3-8). Data for the Mississippi River Basin 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 3-8. 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 also eliminates these factors from the evaluation. 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 Basin			
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 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 this time of this report.

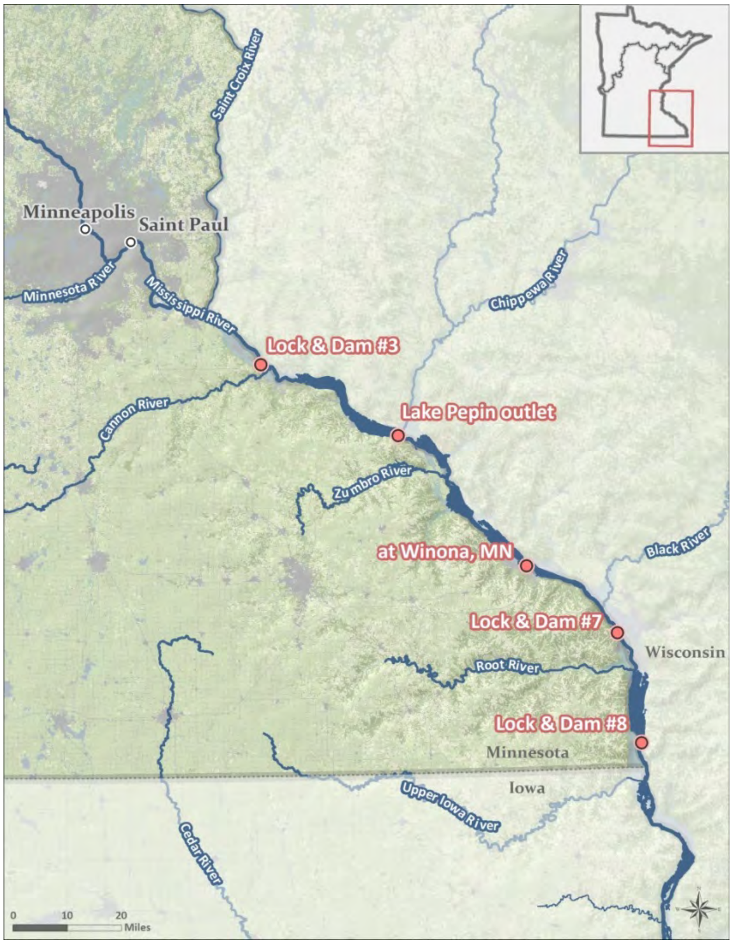


Figure 3-8. Monitored locations with available nutrient load estimates.

The loading analysis for the Mississippi River 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 3-9 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 achieved 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. Lake Pepin, pools behind locks and dams, and backwaters of the Mississippi River likely affect the lag time.

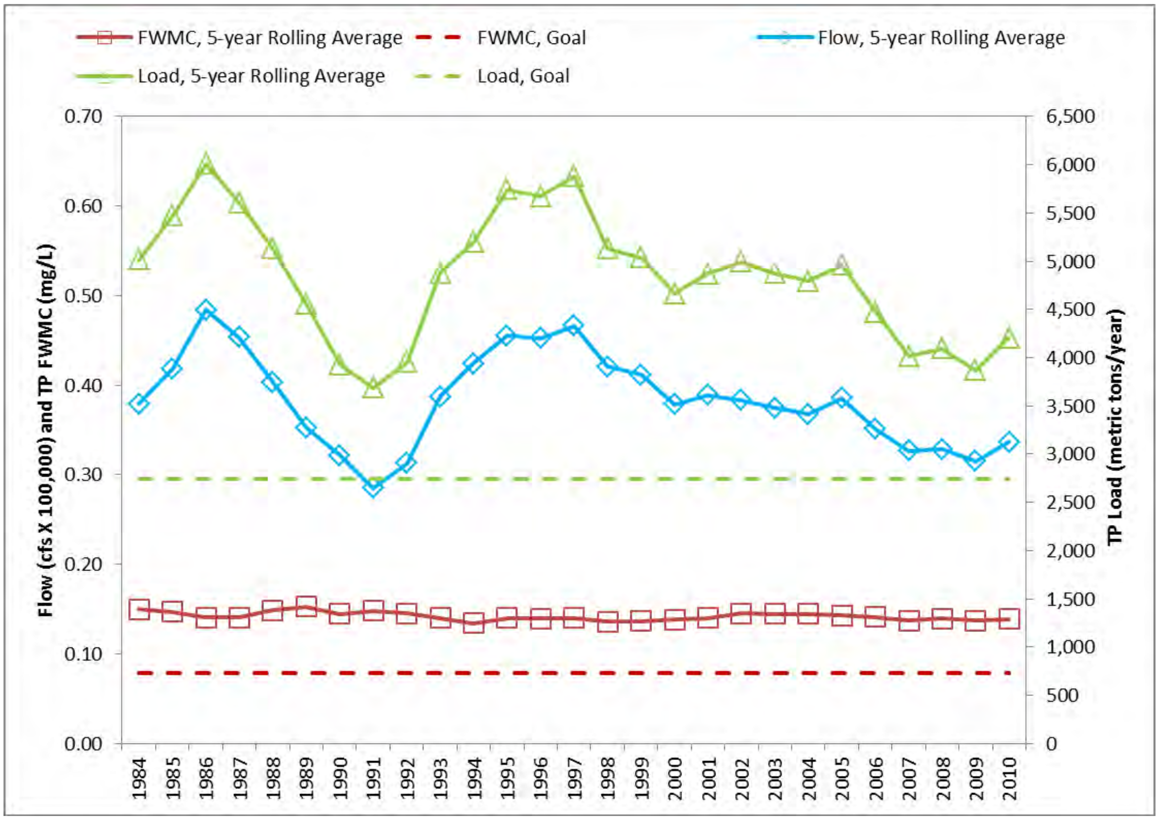


Figure 3-9. Phosphorus loading analysis, Mississippi River near the Minnesota border.

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 Basin. The goal load estimated for the Minnesota portion of the 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 no long-term annual loading data were available for the Cedar, Des Moines, and Missouri River drainages, the approximate load for these small basins was proportioned from the Mississippi in-stream loads (Minnesota portion). The goal load (437 metric tons of phosphorus per year) can serve as a nutrient reduction goal until more reliable loading data are available.

As noted earlier, 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 load (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
Cedar, Des Moines, and Missouri River (proportional load based on Mississippi load, Minnesota portion)	795	437	658	Minnesota drainage area only

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

Figure 3-10 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.

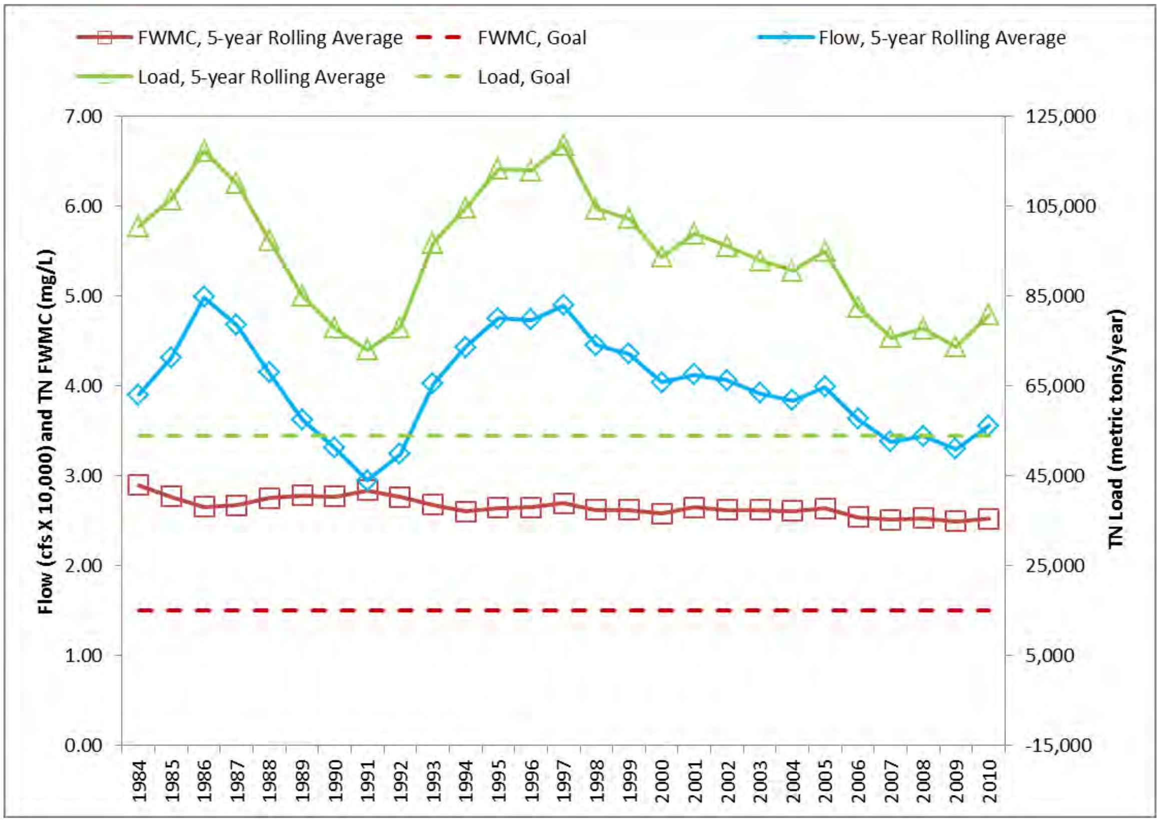


Figure 3-10. Water Quality Measures Comparison: Nitrogen, Mississippi River near the Minnesota border.

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 Basin. The goal load estimated for the Minnesota portion of the 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.

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

Data set	Baseline 1980–1996	Goal load (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
Cedar, Des Moines, and Missouri River (proportional load based on Mississippi load)	15,612	8,587	12,460	Minnesota drainage area only

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

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 (2009-11) years are lower than the baseline period (1980–1996) (Figure 3-11). This is especially true during lower flows when point sources generally have the most impact on phosphorus concentration. Major point source reductions upstream of this station started in 2003 and stabilized from 2009–2011. Between 2000 and 2010, phosphorus loads from point sources upstream of Lock and Dam 3 reduced from 1,653 metric tons per year in to 445 metric tons per year. Monitored nitrogen concentration at Lock and Dam 3 also show a decrease under low flows (Figure 3-12). There are insufficient data to evaluate high flow conditions.

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 3-13 and Figure 3-14). 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 Strategy 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 in the Strategy. Unfortunately, water quality data sets needed to evaluate these trends are not available at the outlets of the state's three major basins.

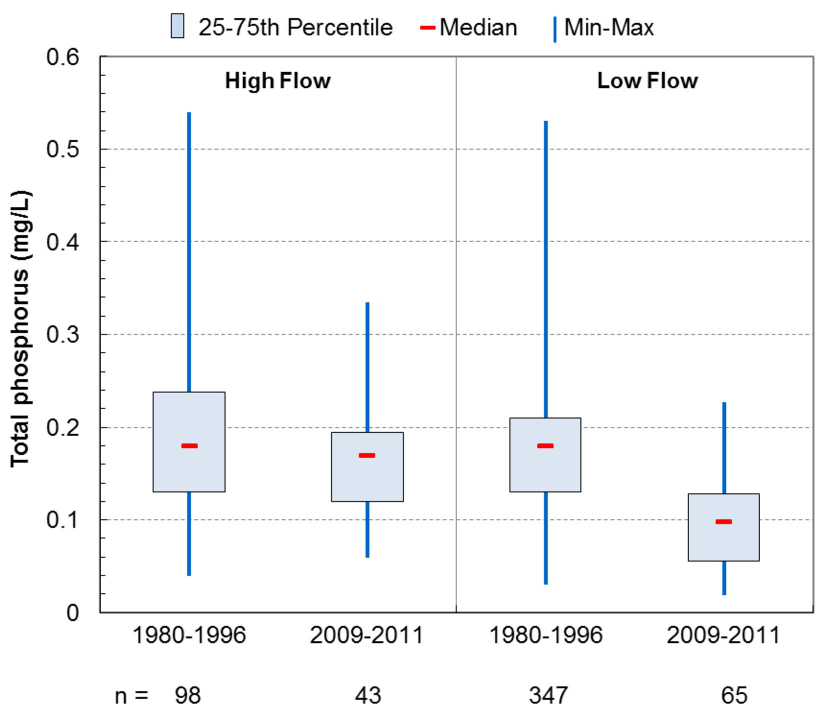


Figure 3-11. Monitored phosphorus concentration at Lock and Dam 3 during baseline (1980–1996) and recent conditions (2009–2011) for three flow conditions. *High Flow* represents flows that are exceeded from 0–20 percent of the time; *Low Flow* represents flows that are exceeded 21–100 percent of the time.

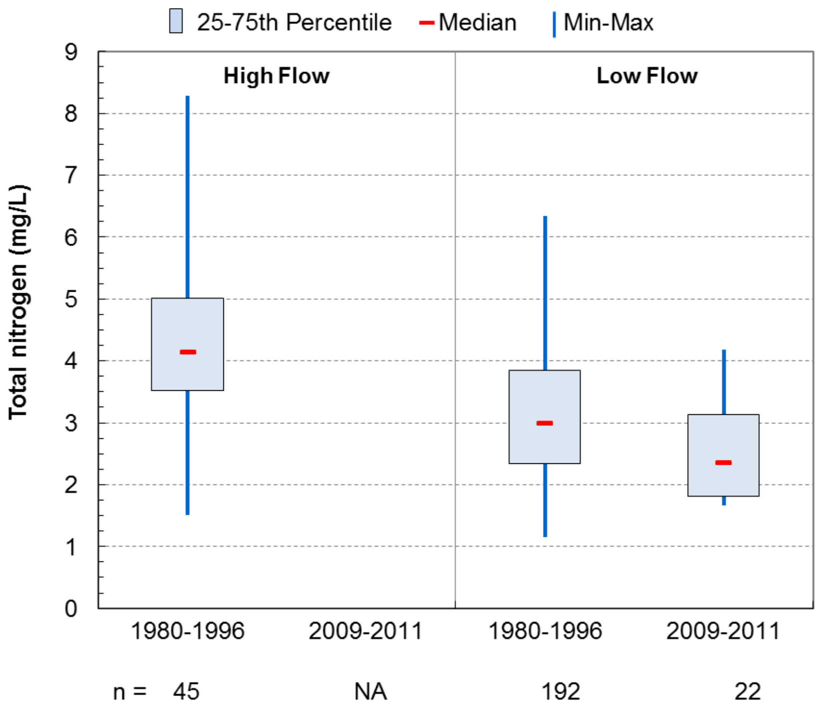


Figure 3-12. Monitored nitrogen concentration at Lock and Dam 3 during baseline (1980–1996) and recent conditions (2009–2011). *High Flow* represents flows that are exceeded from 0–20 percent of the time; *Low Flow* represents flows that are exceeded 21–100 percent of the time.

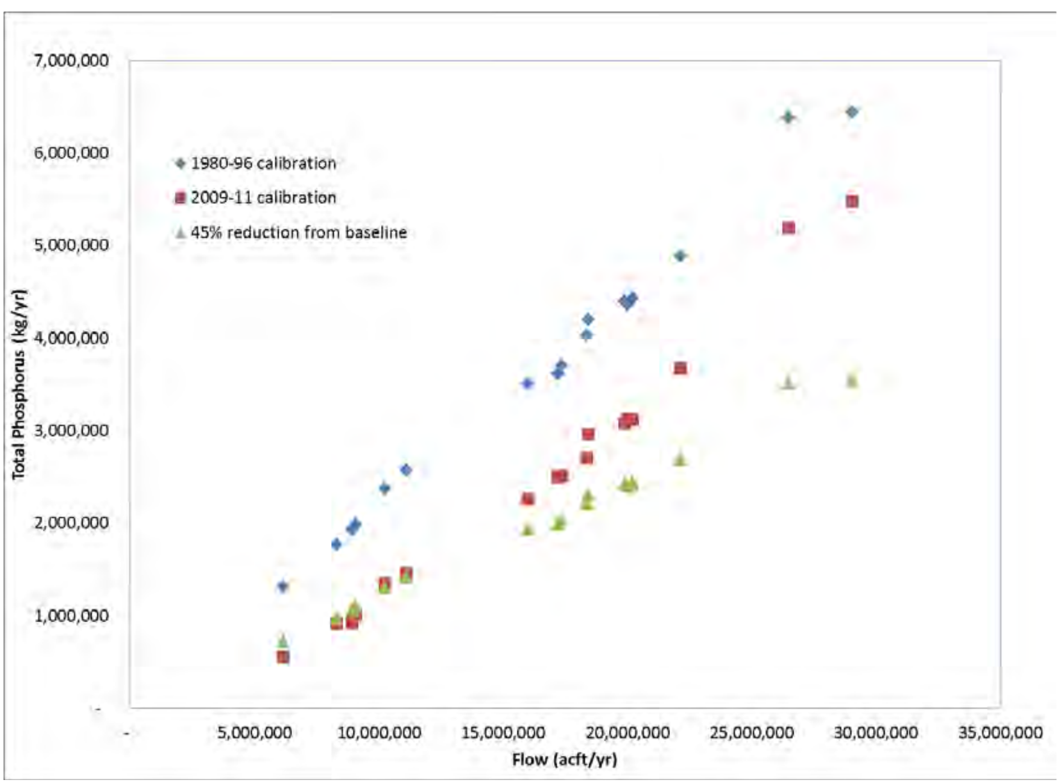


Figure 3-13. Estimated annual phosphorus loads for baseline years based on baseline and recent calibration verses observed flow.

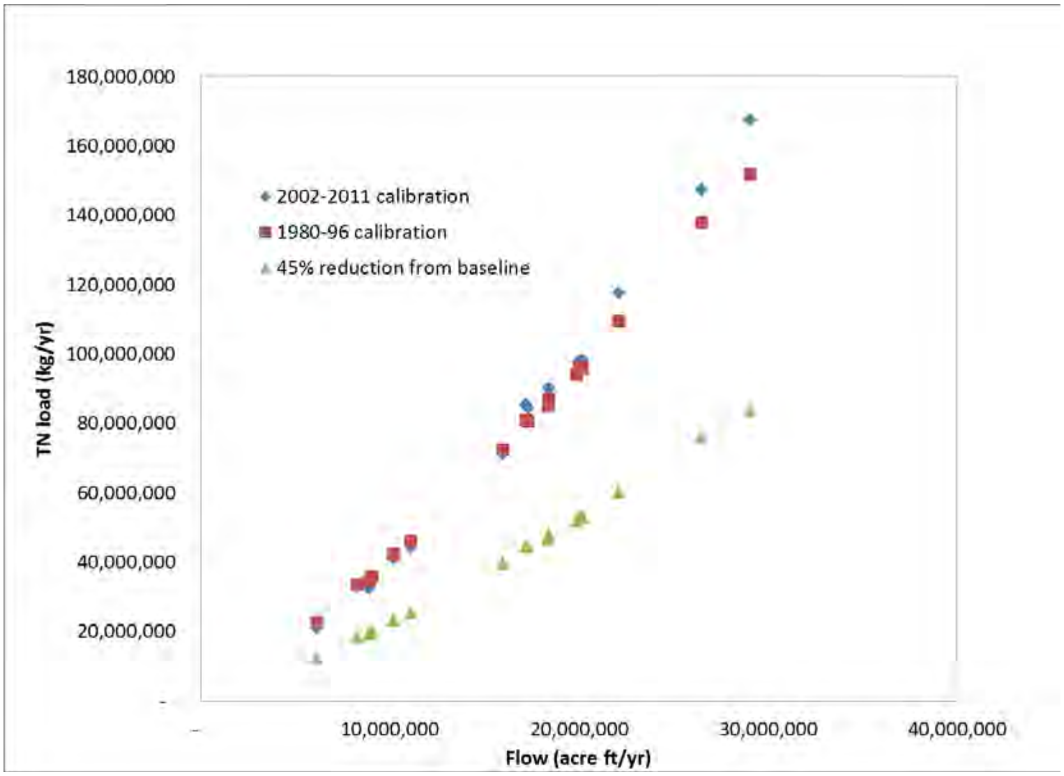


Figure 3-14. Estimated annual phosphorus loads for baseline years based on baseline and recent calibration verses observed flow.

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 Strategy 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)

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)

Basin	Goal	Load target		Notes
		P	N	
Lake Superior	Maintain loading at 1979 conditions	248	NA	MN drainage area only; includes point source loads; 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
Mississippi River near State Border	45% from average 1980–1996 conditions	4,989	53,898	In-stream loads; includes out-of-state drainage area
Cedar, Des Moines, and Rock River (sum of loads to state border)	45% from average 1980–1996 conditions	437	8,587	Mississippi 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.

Headwaters to the Mississippi River Photo Credit: MPCA

Chapter 4

Management Priorities and Recent Progress

A function of the *Minnesota Nutrient Reduction Strategy* (Strategy) is to identify the nutrient reduction goals and milestones and provide a path to achieve those reductions over time. This 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 Strategy's watershed prioritization process and resulting prioritized watersheds for nitrogen and phosphorus. This chapter also presents a list of key nutrient reduction programs to address key nutrient sources, and presents the results of a program quantification analysis to assess recent progress in nitrogen and phosphorus source load reduction. Ultimately, the Strategy should provide the information necessary to align priority watersheds and priority programs to help programmatic staff at the local, state, and federal levels to better target key program resources.

4.1 Watershed Priorities

Spatially Referenced Regressions on Watershed (SPARROW)-modeled yields and a comparison of available data to the proposed river eutrophication standards (RES), serve as the foundation for watershed 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 between the HUC8 outlet and the state border. This yield is used to determine which HUC8s have the highest nutrient loading per acre. Watersheds with higher nutrient loading per acre are considered higher priority over lower yielding HUC8 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 Strategy—especially in the Mississippi River Basin and the Lake Winnipeg Basin—cannot be achieved through implementation in a limited number of high-priority watersheds.

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 proposed RES were in place. To be considered impaired, the RES require both the phosphorus concentration and a response variable to exceed the criteria. The watershed prioritization process assigns a high-priority ranking to watersheds that have phosphorus concentrations higher than the proposed RES. For those watersheds without monitoring data, watershed prioritization is based on the SPARROW-modeled yields alone.

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

Table 4-1. Watershed prioritization criteria

Nutrient yield		Stream monitoring	Prioritization
Highest 25% yielding nitrogen or phosphorus HUC8s	OR	Of the reaches with monitoring data, greater than or equal to 50% of the reaches are estimated as exceeding proposed RES.	**High**
HUC8s with highest 25%–50% yielding nitrogen or phosphorus		Of the remaining reaches with monitoring data, greater than or equal to 50% of the reaches are either exceeding proposed standards or have elevated phosphorus levels.	**Medium**
All remaining HUC8 watersheds			**Protection**

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

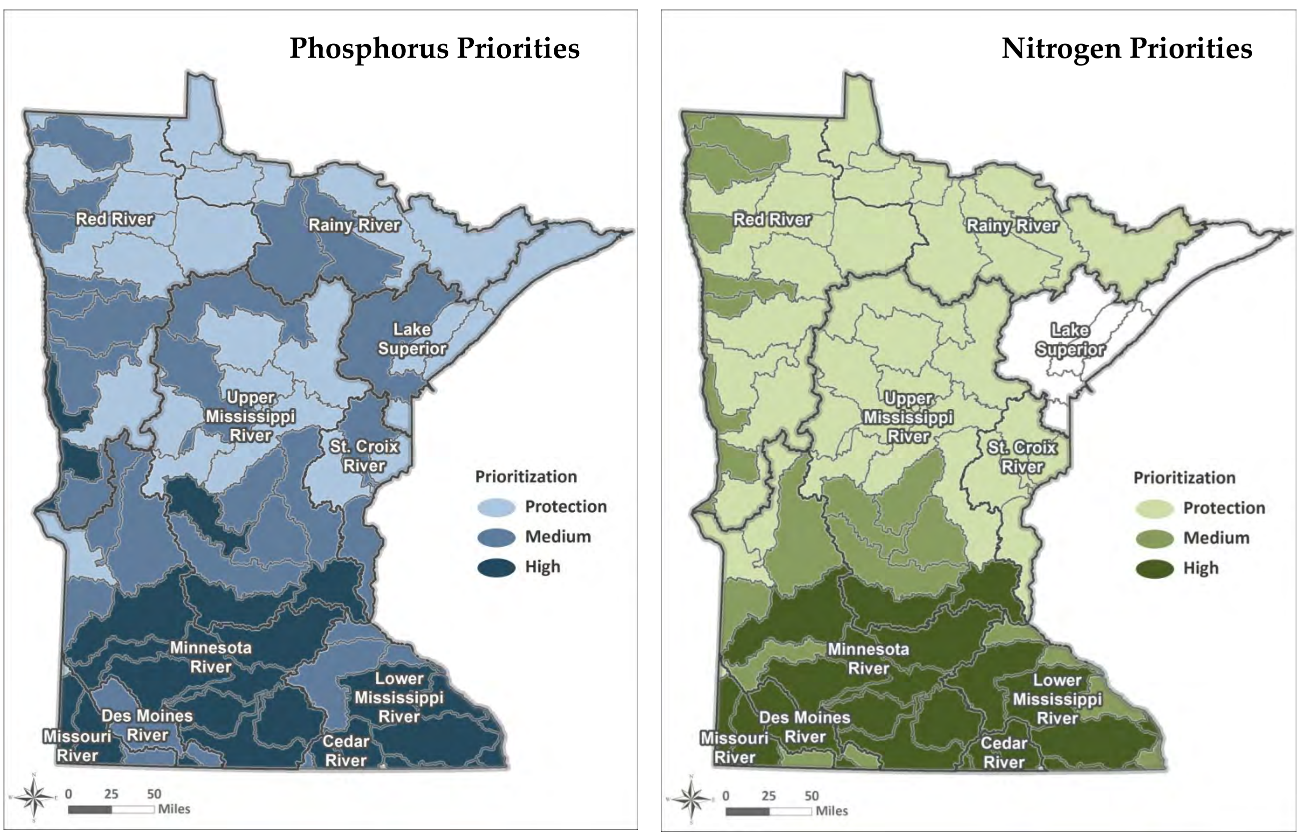


Figure 4-1. HUC8 watershed priorities: on left, priorities for phosphorus loading; on right, priorities for nitrogen loading (Lake Superior Basin not evaluated for nitrogen).

The prioritization of watersheds will vary depending on the purposes. The above analysis focuses mostly on priorities based on contributions to downstream loads, considering also potential RES impairments. The priority watersheds for groundwater protection of nitrate pollution will be quite different compared to surface water protection priorities. Additionally, priorities for protection of water quality will 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 watersheds also have numerous individual lakes impaired by eutrophication, but they do not contribute appreciably to downstream nutrient loads. Such watersheds may be a higher priority when considering lake protection and restoration. Future iterations of this Strategy should consider these and other ways of prioritizing watersheds at the state level.

4.2 Source Priorities

The source assessment presented in Chapter 3 identifies the most significant sources of reducible nutrients in Minnesota (Table 4-2). Priority sources are determined on the 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 at that scale. For example, individual sewage treatment systems are not identified as a significant source of nutrients at the 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

Basin	Priority phosphorus sources	Priority nitrogen sources
Mississippi River	Cropland runoff, permitted point sources, and streambank erosion	Agricultural tile drainage and cropland groundwater [b]
Lake Superior	Nonagricultural rural runoff [a], permitted point sources, and streambank erosion	Permitted point sources
Lake Winnipeg	Cropland runoff and nonagricultural rural runoff	Cropland groundwater

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

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

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 which 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 Strategy. It is possible with additional research that a portion of the atmospheric deposition phosphorus load can 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 Key Programs and Recent Progress

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 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 best management practices (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 program tracking (Maryland Department of Agriculture 2011). 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. There are many other organizations, which either help to support these programs (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). These entities are not specifically identified in the Strategy; 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 District 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 from 8 to 16 percent of their current application. The use of nitrofication 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.

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, the MCES reduces nutrient loads through wastewater treatment plant (WWTP) technology upgrades and has phosphorus removal technologies at six of its seven plants which 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. This report will be available by the end of 2013. Information on stream, river and wastewater treatment loads are available on the Council's web site at *http://es.metc.state.mn.us/eims/ExcelLoads/index.asp*. Annual stream and river report summaries are available on the Council's web site at *http://www.metrocouncil.org/environment/ESReports/index.htm*.
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 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 County 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 land 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 2013)	The NFMP is a strategy for protecting Minnesota's water resources from nitrogen fertilizer use. Originally developed in 1990 and updated in 2013, 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. MDA's Farm Nutrient Management Assessment Program (FANMAP) plays a key role in documenting adoption of voluntary BMPs. Information on FANMAP is available at *http://www.mda.state.mn.us/protecting/soilprotection/fanmap.aspx*. In 2010, MDA initiated a process to revise the NFMP. As part of the revision process, MDA has compiled a review of the past 20 years of the NFMP implementation. More information is available at *http://www.mda.state.mn.us/chemicals/fertilizers/nutrient-mgmt/nitrogenplan.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, although there were no measured improvements in waters quality as a result. More information is available at *http://www.mda.state.mn.us/phoslaw.*
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 applies or manages manure on a for-hire basis, although it does not apply to farmers who apply manure to their own fields. Licensing requires passing a tech which is based on proper animal waste management and application. More information is available at: *http://www.mda.state.mn.us/licensing/licensetypes/cawt.aspx*.

Program (date of program initiation)	Program activities
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 required 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*.
Minnesota Pollution Control Agency (MPCA)	
Feedlot Program (Rules revised in 2000)	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 CWA Section 319 grants which 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 55 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*.

Program (date of program initiation)	Program activities
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 on ISTS 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*.
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 limit of 1 mg/L for new and expanded WWTPs above 1,800 lbs/yr. 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 were likely reduced through pre-treatment programs over the past several decades. Good 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, eleven categories of industrial activities, and construction activities. Most stormwater permits contain narrative effluent limitations expressed as best management practices (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 this document 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 (TMDL) 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 required 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 allowable pollutant load 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 program-level technical assistance. A key aspect of the program is the watershed approach—a 10-year rotation for assessing Minnesota's major watersheds. The primary feature of the watershed approach is that it provides a unifying focus on the water resource as the starting point for water quality assessment, planning, and results measures. 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 RES 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 RES 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* and *http://www.pca.state.mn.us/index.php?option=com_k2&Itemid=131&id=3312&layout=item&view=item*.
Department of Natural Resources	
Programs within Divisions of Fish & Wildlife and Ecological and Water Resources	DNR drafts the state's shoreland zoning rules, though implementation is the responsibility of local government units. The LGUs are required to adopt DNR standards as the minimum but may include more conservative provisions if they wish. LGUs would need to estimate nutrient load reductions from the implementation of these rules. 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 also responsible for the development of a statewide comprehensive wetlands management plan which sets direction for managing and regulating the state's wetlands. Further research is required to determine how nutrient reductions could be tracked or estimated.

Program (date of program initiation)	Program activities
Farm Service Agency (FSA)	
Conservation Reserve Program (CRP) (1986)	CRP is a voluntary 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. In 2012, 290,000 acres of Minnesota agricultural land enrolled in CRP expired, with only 148,000 acres re-enrolled. This is the largest CRP expiration. 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*.
Conservation Reserve Enhancement Program (CREP) (1998)	CREP is a voluntary land retirement 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. The program is currently in maintenance status. County data on CRP (see above) takes CREP acreage into account.
Natural Resources Conservation Service (NRCS)	
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 stared 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 296 active contracts with 104, 448 acres. Approximately 394 contracts have been completed under this program with 113,881 acres in these completed contracts. More information about this former program is available at *http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/programs/?&cid=stelprdb 1047061*.
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. CStewardshipP contracts last five years. More information is available at *http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/csp/*.

Program (date of program initiation)	Program activities
Environmental Quality Incentives Program (EQIP) (1996)	EQIP is a voluntary program 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*.
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 (In development)	A new state and federal partnership intended to enhance Minnesota's water quality by accelerating the voluntary adoption of on-farm conservation practices. Collaborators include MDA, 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 (In development)	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, Watershed Restoration and Protection Strategies (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.

As Chapter 3 describes, in-stream nutrient loads at the Minnesota state line have not shown much 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 and tile drainage, and point source loads of nitrogen have 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 point source 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 in stream sediments, as well as in Lake Pepin and Mississippi River backwaters, it will take time to see the full benefit at the state border of what has been accomplished at the downstream stations. 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 certain BMPs and wastewater treatment. This recent progress can be applied to meeting basin reduction goals and milestones. Appendix A provides detailed methods and assessment results from the program quantification.

The key nutrient-reducing programs identified in Table 4-3 implement or fund numerous structural and nonstructural BMPs. The National 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 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 only addresses those programs with applicable data on a HUC8 scale and includes the following:

- Nutrient Management
- Forage and Biomass Planting
- Residue Management
- Conservation Easements
- Nonpoint Source BMPs

Strip Till in Rice County Photo Credit: USDA NRCS

Data for Nutrient Management, Forage and Biomass Planting, and Residue Management were obtained from the Environmental Quality Incentives Program (EQIP), while data for Conservation Easements were obtained from the BWSR Reinvest in Minnesota (RIM) program. Data for Nonpoint Source BMPs were provided through the eLINK system, which BWSR maintains. 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. In addition to these agricultural BMPs, recent trends in point source loads (wastewater) were also quantified.

Load reductions from wastewater were determined for 2000 to present using monitoring data as summarized in the SPARROW model (Appendix A). The reductions as a percentage were then compared to baseline conditions (e.g., 1980–1996 for the Mississippi River Basin), which Table 4-4 presents.

Table 4-4. Summary of recent progress by sector as compared to overall load in each basin

	Percent in load change by agricultural and nonpoint source BMPs		Percent in load change by wastewater		Recent progress (as % of total load delivered)	
Basin	**P**	**N**	**P**	**N**	**P**	**N**
Mississippi River	-8%	-1%	-19%	+1%	-27%	0%
Lake Winnipeg	-3%	0%	-0.5%	0%	-3.5%	0%

Basin	Percent in load change by agricultural and nonpoint source BMPs		Percent in load change by wastewater		Recent progress (as % of total load delivered)	
	P	N	P	N	P	N
Lake Superior	-0.8%	NA	+2.8%	NA	-0.8% [a]	NA

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

Available data indicate that point source nitrogen loads in the Lake Superior 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.

Figure 4-2 and Figure 4-3 provide a graphical summary of the recent progress in phosphorus and nitrogen load reductions as a net result of certain government programs and recent point source changes. Progress is shown in comparison to goals and Phase 1 Milestones. Note that only provisional goals have been assigned for the Mississippi River and Lake Winnipeg basins (see Chapter 2).

Data are limited for evaluating the reductions resulting from agricultural fertilizer BMPs, and the estimates used for estimating nutrient reductions in figures 4-2 and 4-3 likely underestimate the totality of reductions. Yet, the water quality findings in the Mississippi River south of the Twin Cities are generally similar 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.

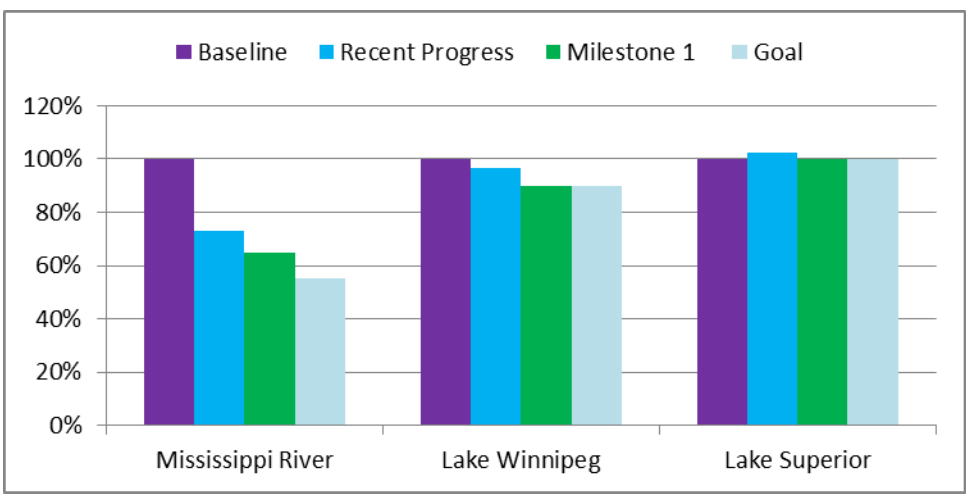


Figure 4-2. Summary of recent progress in phosphorus source loads by major basin.

Notes:
Recent progress is the percent of baseline load remaining after accounting for reductions since 2000.
Lake Winnipeg Milestone 1 and Goal are expected to change in the near future, resulting in additional load reduction needs.

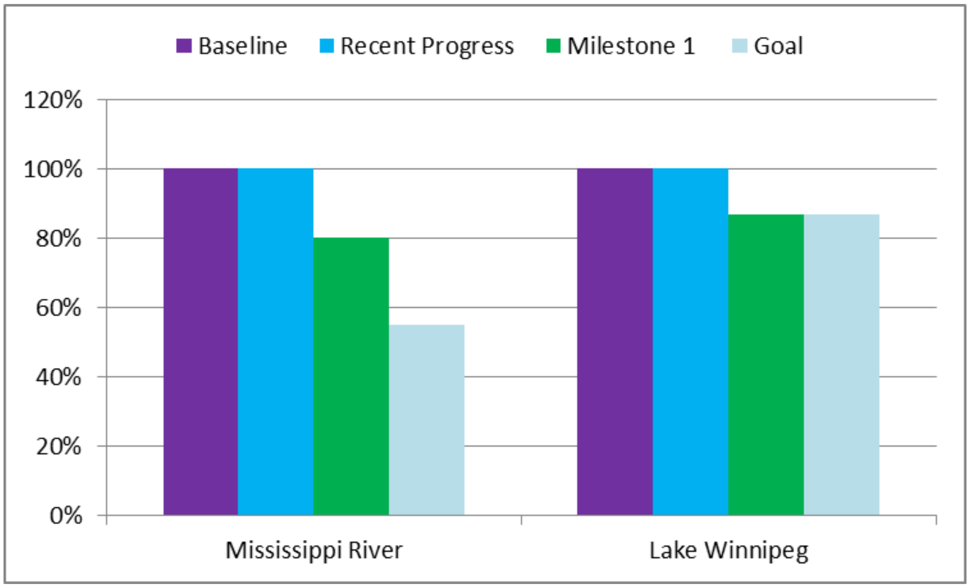


Figure 4-3. Summary of recent progress in nitrogen source loads by major basin.

Notes:
There is not a reduction goal for nitrogen assigned in the Lake Superior Basin.
Recent progress is the percent of baseline load remaining after accounting for reductions since 2000.
Lake Winnipeg Milestone 1 and Goal are expected to change in the near future, resulting in additional load reduction needs.

Efforts between 2000 and present have resulted in significant progress in reducing phosphorus loads in the Mississippi River Basin, due to both agricultural BMPs and wastewater treatment plant upgrades. There have also been reductions in phosphorus load to the Lake Winnipeg Basin, while loads in the Lake Superior Basin (which point sources dominate) have increased. In contrast, little to no progress has been made in reducing nitrogen loads across all basins, which is consistent with in-stream water quality data.

Interim tracking of progress toward the 2025 milestones will be conducted in accordance with the strategies in Chapter 7 and consistently with the Clean Water Fund Performance reporting. For the Mississippi River Basin, interim tracking will ensure environmental progress between recent conditions and the milestone and provisional 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 Phase 1 Milestone, but additional strategies will be necessary to reduce loading from both agriculture and wastewater to achieve that milestone. For nitrogen, there has been some recent progress in agriculture, but point source loads have generally increased. A new focus on reducing nitrogen loads from both agriculture and 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* (Strategy) milestones which are also Table 5-1. Achieving the Phase 1 Milestones for phosphorus and nitrogen by 2025 will depend on increased implementation of ongoing programs and practices by key sources in targeted areas. This chapter describes practices and technology that can be used to address phosphorus and nitrogen from key sources and presents example scenarios projected to meet the nutrient reduction milestones.

Table 5-1. Milestones

Basin	Pollutant	Phase 1 Milestone	Phase 2 Milestone	Phase 3 Milestone
Mississippi River (Includes the Cedar, Des Moines, and Missouri Rivers)	Phosphorus	Achieve 35% reduction from baseline by 2025 [a]	Achieve 45% reduction goal	Meeting goals, no net increase
	Nitrogen	Achieve 20% reduction from baseline by 2025 [b]	Achieve 30% reduction from baseline	Achieve 45% reduction goal
Lake Winnipeg [c] (Red River Only)	Phosphorus	Achieve 10% reduction goal by 2025	Adapt goals, if necessary, based on international joint efforts with Canada	
	Nitrogen	Achieve 13% reduction goal by 2025	Adapt goals, if necessary, based on international joint efforts with Canada	
Lake Superior	Phosphorus	Achieve 3% reduction goal by 2025	Meeting goals, no net increase	
	Nitrogen	Maintain Protection		
Statewide Groundwater/ Source Water	Nitrogen	Meet Goals of 1989 Groundwater Protection Act		

a. It is important to note that active phosphorus reduction began with the completion of the *Detailed Assessment of Phosphorus Sources to Minnesota Watersheds* (Barr Engineering 2004) and Phosphorus Strategy adopted by MPCA's Citizens' Board in 2000.

b. While the baseline for nitrogen reduction is established as prior to 2000, no active strategy has been established since that time to coordinate actions.

c. Milestones to be revised upon completion of the Red River/Lake Winnipeg strategy.

To reach the Phase 1 Milestone (2025), and eventually basin-wide goals, additional best management practices (BMPs), wastewater treatment, and other nutrient reduction activities will be needed. The Strategy includes select BMPs and treatment options to guide implementation; however, any combination of BMPs and treatment options which 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 Strategy. Research will be critical to progress strategies in future phases.

5.1 SPARROW Model

U.S. Geological Survey (USGS) Spatially Referenced Regressions on Watershed (SPARROW) modeling provides a common reference point for evaluating BMP scenarios across the state, representing land use conditions of 2002 (with a subsequent update for point source loads only). The 2002 SPARROW output is used to support (1) program quantification for BMPs installed over the period since 2000 (presented in Chapter 4), and (2) evaluation of scenarios to achieve future loading reduction milestones. When used for the evaluation of scenarios, the BMP adoption rates combine already instituted BMPs tabulated under program quantification and future additional BMPs. The future additional BMP effort can be estimated by subtracting the recent program quantification BMPs from the total BMP adoption rate in the future scenario.

The 2002 SPARROW results are used to provide a common reference point for the evaluation of watershed loads and BMP scenarios. Table 5-2 summarizes the loading results from SPARROW, both "at source" and as delivered to the Minnesota state line. The "at source" loads represent the loads generated in each basin and do not account for any attenuation. The "delivered" loads represent the loads at the state line, accounting for attenuation due to decay, settling, and other mechanisms as SPARROW specifies.

Table 5-2. SPARROW loading results by basin

Basin	Nitrogen load at source (metric tons/year)	Nitrogen load at state line (metric tons/year)	Phosphorus load at source (metric tons/year)	Phosphorus load at 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

The following key assumptions apply to the SPARROW loads:

- The SPARROW model approximates nonpoint source loading for the 2000–2002 period.
- These loads reflect the point source update, which incorporates updated point source data from the Minnesota Pollution Control Agency (MPCA) (updated point sources to 2005–2006 for

nitrogen and 2005–2009 for phosphorus) and is assumed to approximate current 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 watersheds 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 for a portion of the lake)
  - 07080102 (Upper Wapsipinicon – Part of the Cedar River Basin, but 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.

5.2 Recommended Wastewater Reductions

There has been a focus on wastewater treatment in Minnesota since 2000 with the adoption of the Phosphorus Strategy. While phosphorus loads 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 modeling. The following strategies are provided to achieve the Phase 1 Milestone, as well as future 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-N to nitrate-N, to reduce aquatic toxicity and oxygen demand. Nitrate removal will be a new treatment consideration in Minnesota. Some facilities in Minnesota are required to meet a 10 mg/L nitrogen effluent limit to protect groundwater sources of drinking water. These facilities are relatively small in size and few in number.

Two primary methods of nitrogen removal from wastewater include Biological Nutrient Removal (BNR) and Enhanced Nutrient Removal (ENR). A third tier of nutrient removal, called Limit of Technology (LOT), is also sometimes considered (Iowa Department of Agriculture and Land Stewardship et al. 2013).

BNR is most commonly associated with sequenced combinations of aerobic, anoxic, and anaerobic processes, which facilitate biological denitrification via conversion of nitrate to nitrogen gas. Effluent limits achievable using BNR at wastewater treatment plants (WWTPs) that treat primarily domestic wastewater are approximately 10 mg/L nitrogen (Iowa Department of Agriculture and Land Stewardship et al. 2013). For a mechanical WWTP the typical type of treatment is activated sludge, which could be in the form of an oxidation ditch, sequencing batch reactor, or "regular" aeration tanks. Another common option is a trickling filter followed by contact stabilization. Contact stabilization is achieved using tanks similar to aeration tanks. Adequate detention time is a key factor in achieving BNR and nitrogen removal. A 41 percent reduction in nitrogen loads is estimated statewide if all WWTPs incorporate BNR.

ENR typically uses BNR along with filtration to achieve lower effluent nitrogen levels. This could also involve chemical addition. Effluent limits achievable using ENR at WWTPs are approximately 6 mg/L nitrogen (Iowa Department of Agriculture and Land Stewardship et al. 2013). For a mechanical WWTP the typical type of treatment would be similar to BNR with the addition of a denitrification filter; adequate detention time is a key factor. An estimated 62 percent reduction in nitrogen loads could occur if all WWTPs incorporate ENR.

LOT is generally associated with the lowest effluent concentrations that can be achieved using any treatment technology or combination of technologies. Potential technologies might include tertiary chemical addition with filtration, advanced effluent membrane filtration, and ion exchange. There is no consensus on establishing specific treatment requirements for LOT or on what effluent values could be achieved. The effluent values would be less than the 6 mg/L nitrogen value associated with ENR. There is a lack of consensus surrounding LOT removal efficiencies.

5.2.2 Phosphorus Wastewater Reductions to Achieve Phase 1 Milestones

Substantial progress has been made in reducing point source loads of phosphorus in the Mississippi River Basin, particularly in the Minnesota River Basin and in the Metro Area. The focus now is to move forward to achieve the Phase 1 Milestones by pursuing additional point source reductions in the remaining basins with particular attention on the Cedar, Des Moines, Lower Mississippi, and Red River subbasins, as well as further decreasing agricultural sources by 2025.

Minnesota has established point source 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, 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).

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 basin outlets. See Chapter 4 for a summary of modeled loads delivered to basin outlets.

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

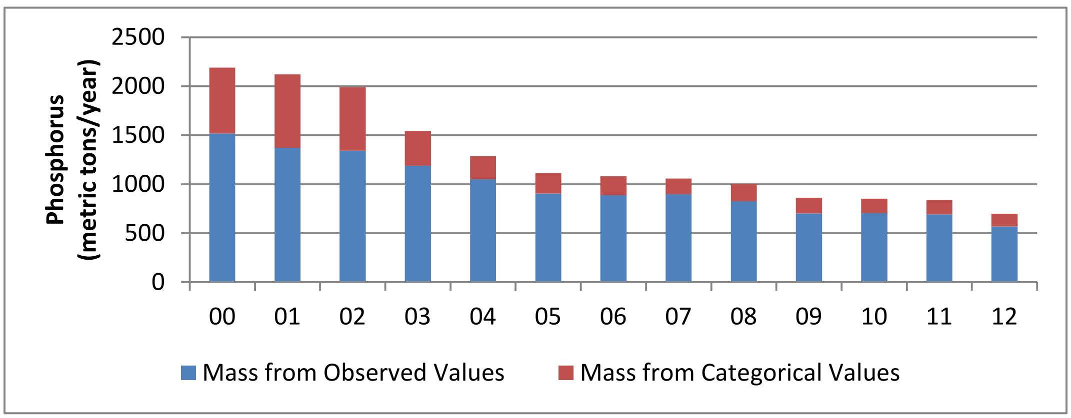


Figure 5-1. Confidence measure for effluent phosphorus data by year.

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%

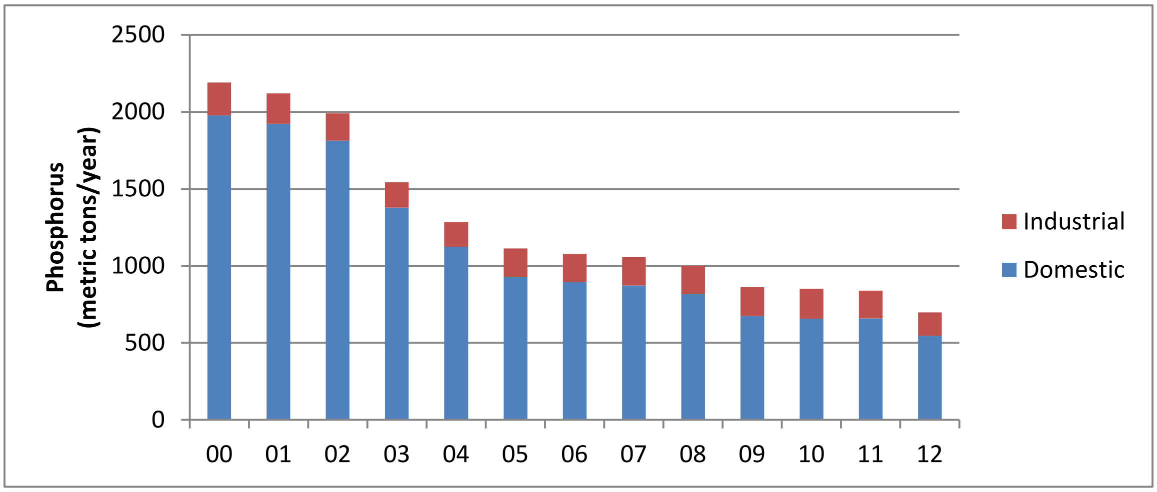


Figure 5-2. Comparison of annual industrial and municipal wastewater phosphorus loads.

Reduction percentages were calculated from 3-year loading averages to account for annual flow variability. The baseline load for the 2000–2002period was 2,099 metric tons per year and the load for the 2010–2012period 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 basin outlet) 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 point source 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 point source 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 (RES) will likely result in additional point source 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.

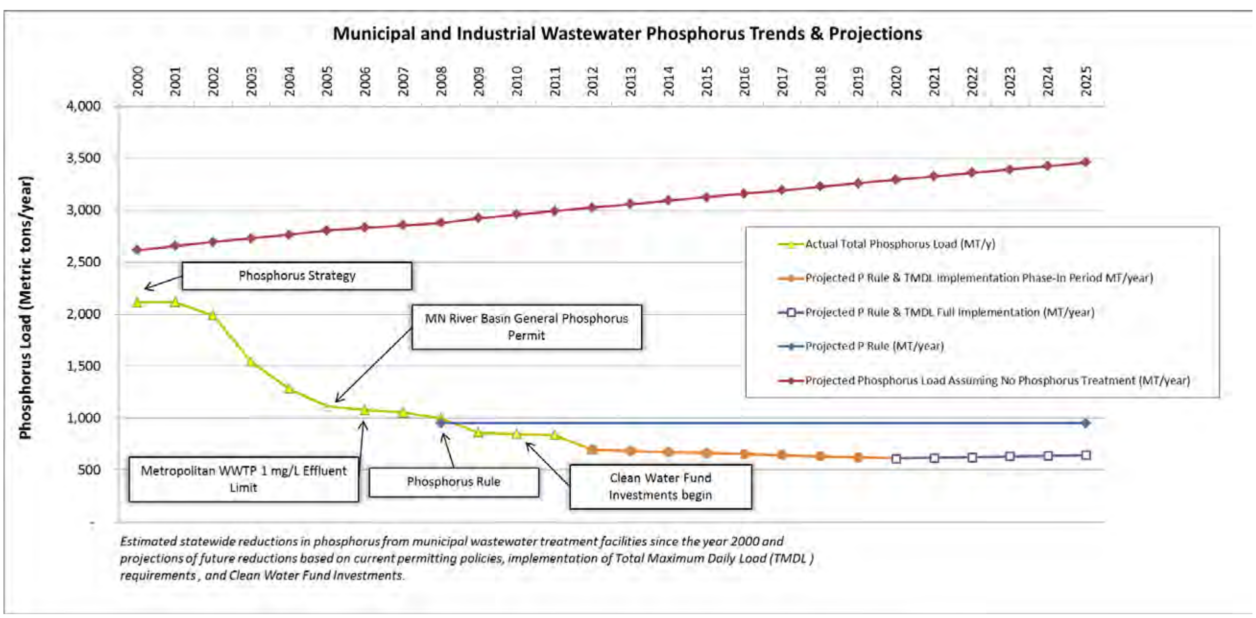


Figure 5-3. Domestic and industrial wastewater phosphorus loading trends and projections.

Table 5-6. Domestic and and industrial wastewater phosphorus loading trends and projections by basin

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 basin outlets.

Table 5-7 presents planned reductions in phosphorus loads from WWTPs, as included in the Strategy. Values in this table represent loads delivered to basin outlets.

Table 5-7. Summary of expected wastewater phosphorus reductions for Phase 1 Milestone implementation

Basin	Strategy wastewater phosphorus load reductions for Phase 1 Milestone (metric tons)
Mississippi River	34.4
Lake Winnipeg	14.9
Lake Superior	3.5

5.2.3 Nitrogen Wastewater Reductions to Achieve Phase 1 Milestones

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 Basin, and 6 percent of the nitrogen load in the Lake Winnipeg 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.

There are limited monitoring data on influent and effluent nitrogen concentrations; therefore, categorical concentrations are used for estimating nitrogen loading. Larger facilities generally have higher effluent concentration than smaller facilities based on data from Minnesota and other states.

Table 5-8 includes assumed categorical nitrogen concentrations used to estimate statewide nitrogen loads when data are not available for a given facility.

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 basin outlet).

Table 5-9. Point source loads by basin, derived from SPARROW

Basin	Point source nitrogen delivered to basin outlet (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 subbasin; therefore, point source loads for the Missouri subbasin are derived from MPCA estimates.

A 20 percent reduction in wastewater nitrogen loads is assumed as part of the Phase 1 Milestone for nitrogen. This reduction roughly equates to half of the wastewater load being treated to a 10 mg/L effluent limit. Table 5-10 summarizes the anticipated load reductions by basin. Values in this table represent loads delivered to basin outlets. 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 wastewater nitrogen reductions for Phase 1 Milestone implementation

Basin	Strategy wastewater nitrogen load reductions for Phase 1 Milestone (metric tons)
Mississippi River	1,884.7
Lake Winnipeg	54.8
Lake Superior	NA

5.3 Recommended Agricultural Reductions

Based on the SPARROW model and the source attributions developed in the *Detailed Assessment of Phosphorus Sources to Minnesota Watersheds* (Barr Engineering 2004), agricultural sources contribute an estimated 38 percent of the statewide phosphorus load. A large part of the remaining phosphorus load is due to stream channel erosion, much of which is indirectly affected by agricultural runoff and intensive drainage practices (Schottler et al. 2013). Based on the *Nitrogen in Minnesota Surface Waters* study (MPCA 2013a), 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 and strategy options for promoting adoption of the BMPs to address phosphorus and nitrogen are provided below.

Constructed Wetland under Construction Photo Credit: Tetra Tech

5.3.1 Agricultural Best Management Practices

Phosphorus in fields is predominantly attached to enriched 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 in soil, and can also be transported as soluble phosphorus from soils with elevated soil phosphorus levels. For example, past over-application of phosphorus—which is especially likely to occur when manure is used as a fertilizer—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 reduce the soil phosphorus concentration and decreasing soil erosion to reduce the risk of phosphorus loading from fields to water bodies. The literature provides evidence, however, that soluble phosphorus losses can increase with reduced tillage, particularly where subsurface drainage is practiced. The magnitude of this increase will vary depending on factors such as the crop grown, nutrient management practices used, soils, and the distribution of surface versus subsurface discharge.

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 with determining 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 key step in agricultural management for phosphorus loading is to encourage wider use of the MN P Index. The USDA Natural Resource Conservation Service (NRCS) Code 590 Nutrient Management practice standard, for example, specifies use of the MN P Index within phosphorus-impaired watersheds for fields receiving only commercial fertilizer applications. Table 3 of the Code 590 practice standard summarizes specific restrictions for application of manure and other organic byproducts.

While excessive phosphorus is often identified as a pollutant in lakes and rivers, it is also a necessary nutrient for plant growth. Producers need to maintain adequate, but not excessive, soil phosphorus concentrations while minimizing erosion risk. Adequate soil phosphorus is defined in terms of soil test phosphorus; for example, the general recommendation for crop production is to maintain a soil test phosphorus (based on the Bray-1 soil test) of 21 ppm. 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. As a result, the first step is to implement nutrient management to lower the soil phosphorus concentrations to target levels, while taking steps to prevent soil erosion through practices such as conservation tillage.

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 groundwater beneath cropland or is picked up in subsurface tile drainage and redirected to surface waters. 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 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 and groundwater discharges to reduce nitrogen transport off-site can all be effective control strategies. 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. 2013) summarizes the efficacy of most of the well-developed BMPs available for nitrogen removal.

A variety of management practices are available to address agricultural nutrient loads. Selection of BMPs should be based on the specific characteristics of individual watersheds and fields. Similarly, the performance of individual BMPs can vary widely depending on local soils, slopes, and other conditions. A challenge for developing a statewide Strategy is describing approximate representations of the efficacy of BMPs across the entire state. A representative suite of BMP types is used for this purpose, along with literature-based pollutant removal efficiencies, to provide a statewide perspective. However, these averaged results are approximations only, and BMP planning and efficacy is expected to vary significantly at the local scale.

Potential agricultural BMPs for this Strategy 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 Strategy. 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)

Effectiveness and cost of BMPs depends on many site-specific factors. Representative values are used for this statewide analysis; Table 5-11 includes costs and effectiveness for various example BMPs. Appendix B includes additional agricultural BMPs that could be used for reducing nutrients.

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 actually save money by reducing application of fertilizer to sustainable soil levels). 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. Representative BMP summary, including nutrient load reduction efficiencies in the BMP-treated area

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.
Recommended rates (i.e., corn after soybeans and proper manure crediting)	($11)[3]	16%[1]	17%[2]	For phosphorus, based on no phosphorus applied until soil test phosphorus drops to optimum.
Spring and sidedress applications with 30-pound nitrogen rate reduction	$8[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	$56[3]	51%[1]	29%[2]	Minnesota has a 20% establishment success rate for cover crops.
Perennial energy crops	$30–$390[2,3]	95%[1]	34%[2]	
Perennial buffers in riparian areas (replacing row crops)	$340[3]	95%[1]	58%[2]	See discussion of area treated in below.
Hayland in marginal cropland (replacing row crops)	$30–$390[2,3]	95%[1]	59%[2]	
Conservation easements and land retirement	$30–$390[2,3]	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.

BMP	Lifecycle cost ($/acre/year)	Nitrogen reduction efficiency	Phosphorus reduction efficiency	Notes
Drainage Water Retention and Treatment				
Constructed wetlands	$39[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]	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)

Using appropriate application rates is the 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. Lazarus et al. (2013) assume 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 phase of 141 pounds per acre (lbs/acre). The commercial fertilizer application for corn following soybeans is then equal to 111 lbs/acre, after the ~30 lbs/acre credit for soybeans. It should be noted that 111 lbs/acre represents an average fertilizer rate, and additional modifications (increases or decreases) might be required based on different soil factors.

Data on current nitrogen fertilizer rates are available through Minnesota Department of Agriculture (MDA) based on the 2009 growing season. Data are provided by county, were converted to the HUC8 level, and represent the current nitrogen fertilizer rate (lbs/acre) for fields with corn following soybeans. In 2009 there were 1,119 fields with corn following soybean surveyed across the state (MDA 2009). The highest reported nitrogen fertilizer rate in 2009 was 162 lbs/acre (Chisago County), and the lowest rate was 111 lbs/acre (Clay County).

The target average fertilizer rate of 111 lbs/acre was subtracted from the current fertilizer rate for each HUC8 to determine the necessary rate reduction to meet the recommended rate. The rate reduction was converted to a percent reduction, and the percent reduction was multiplied by the nitrogen load from agriculture (from SPARROW) to calculate the corresponding nitrogen load reduction (metric tons/year) achieved as a result of meeting the nitrogen fertilizer rate recommendation. This approach assumes that all corn is part of corn-soybean rotations, which is not the rotation everywhere, but is a reasonable assumption given available data. Per MDA (2009), the 2009 survey of nitrogen fertilizer use on corn in Minnesota was collected from 1,495 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. 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.

As an additional component of nitrogen management, a shift from fall to spring application and to sidedress (versus preplant) techniques with a 30-pound nitrogen rate reduction was evaluated. Load reduction applies only to corn grain and silage acres fertilized in the fall. Corn acreage was quantified using the Cropland Data Layer (CDL), and then intersected with the percentage of area utilizing fall application based on information in Bierman et al. (2011), who conducted a survey of nitrogen fertilizer use on corn. Acres of corn with fall application corresponds to approximately 5 percent of the total land area in the state, and the 6 percent reduction efficiency for this practice only applies to those areas.

Unlike nitrogen, a single recommended fertilizer application rate not assumed for the phosphorus BMP analysis. For phosphorus, the 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. Ideally the goal is to get MN P Index as low as possible, since it is associated with runoff and erosion potential. However, MN P Index is also associated with soil test phosphorus, and a certain soil test phosphorus must be maintained for adequate crop growth. Phosphorus is persistent in the soil, and soil test phosphorus is directly related to the MN P Index such that phosphorus goals should be based on achieving a target MN P Index rather than a particular phosphorus application rate. Birr and Mulla (2001) recommend a target MN P Index of 25 for the Red River Basin and 32 for all other Minnesota basins.

Because phosphorus is particle reactive, erosion control is the primary BMP class for phosphorus; however, improvements due to increasing fertilizer use efficiencies are also evaluated. A minimum soil test phosphorus must be maintained so as not to inhibit crop production. Barr Engineering (2004) states that "as a general guideline, the University of Minnesota does not recommend application of phosphorus fertilizer for crop production if Bray soil test phosphorus levels exceed 21 ppm." For our purposes, 21 ppm is retained as the minimum Bray soil test phosphorus that is to be maintained. Barr Engineering (2004) also reports that soil test phosphorus (based on Bray-1 soil test) can be related to MN P Index by a factor of 0.75. Therefore, a Bray soil test phosphorus of 21 ppm corresponds to a MN P Index of approximately 16. Unfortunately, statewide coverage of the MN P Index was not available; however, SPARROW agricultural loading rates were used to back calculate a MN P Index (see Field Erosion Control below). Loads which resulted in the MN P Index being greater than 16 were assumed to be reducible by better phosphorus fertilization practices. Subsurface banding of phosphorus served as a representative BMP for fertilization practices, while conservation tillage (30 percent residue) is used as a representative BMP for erosion control (see Field Erosion Control below).

There are no data available on a 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 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 since the early 1990s across the state. The BMPs and crop genetics leading to this increased efficiency may 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

Suitable areas for riparian buffers are determined using the following assumptions/methods: buffers reflect 30 meters of buffer on either side of all perennial and intermittent streams in the Minnesota Department of Natural Resource's 1:24,000 scale maps intersected with cropland and pasture/hayland (based on the 2006 National Land Cover Database). The analysis assumes that none of the riparian areas have buffers. We recognize that buffers exist near many waters, but data are not available to quantify the amount of buffers currently existing.

The reduction for nitrogen only applies to the area of the buffer itself and is a result of land conversion (from corn 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. A 3-to-1 ratio is assumed for the buffer area to the area of the adjacent cropland that the buffer effectively treats for phosphorus because sheet flow is maintained and flow has not become sufficiently concentrated to pass through the buffer with minimal reductions.

Cover crops are also considered under this heading. No data were available on the current extent of cover crop usage, but it is believed to be low, so all current agricultural land was considered potentially available for cover crops. However, based on data Lazarus et al. (2013) presents, it was also assumed that cover crops only have an establishment success rate of 20 percent, so the actual applicable area is 20 percent of the current cropland.

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 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 tweaks to existing management practices (e.g., perennial buffers replacing row crops, hayland in marginal cropland). For this analysis, land retirement is implemented in which row crops are removed from production. Land retirement applies to areas currently characterized as cultivated cropland.

Field Erosion Control

Field erosion control is one of the most effective practices for limiting export of phosphorus, although it does not affect loading of dissolved phosphorus through tile drains. 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, such that the phosphorus export can be estimated by dividing the MN P Index by a factor of 65. 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. 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 a residue cover on the surface. Reducing erosion also reduces the transport of adsorbed phosphorus. However, conservation tillage can also have an adverse effect on phosphorus load if the practice results in less soil mixing and greater phosphorus concentrations near the surface, which can increased dissolved phosphorus export in runoff – unless surface runoff amounts are also reduced. 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 phosphorus concentrations and encourage infiltration, rather than runoff, of water.

For the Strategy, the recommended efficiency of conservation tillage is accepted and assumed to apply to all crop land to which the practice is applied. However, achieving this efficiency will only occur if conservation tillage is combined with other practices to manage soil test phosphorus concentrations. Thus reductions, attributed in shorthand form 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, and have re-apportion part of the phosphorus reduction associated with the assumed efficiency of conservation tillage to the fertilizer use efficiency category. The following logic is used to make an approximate attribution of the reductions associated with reduced erosion and increased fertilizer use efficiency:

1. Potentially applicable acres for conservation tillage are those croplands in which 30 percent residue management is not currently maintained.

2. The reduction efficiency of 63 percent is applied to all new acres with conservation tillage. This efficiency is applied to the fraction of crop lands without conservation tillage, multiplied by the SPARROW estimate of total phosphorus derived from agriculture that is currently transported to the state line.

3. If current the agricultural phosphorus export rate (from SPARROW) is greater than the phosphorus export rate this implied from the MN P Index associated with the recommended soil test phosphorus, the fraction of the reduction in phosphorus load simulated for conservation tillage that is attributable to reducing soil test phosphorus to the recommended level is assigned to the fertilizer use efficiency category.

4. The remaining reduction in phosphorus load simulated for conservation tillage is assigned to the erosion control category.

5. Additional reductions in phosphorus loading associated with improved fertilizer use efficiency are calculated by applying the reduction efficiency associated with the representative BMP of subsurface banding to the portion of the total phosphorus load that is due to soil test phosphorus exceeding recommended levels that is left over after reductions achieved by conservation tillage.

This approach is a rough approximation of the complexities involved in managing 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 which is where these BMPs would be applied.

Applicable areas 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 Crop Data Layer 2009 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. Bioreactors could also be suitable for nitrogen removal from tile drainage; however, controlled drainage is used as a more cost-effective measure.

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 Strategy 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 Phase 1 Milestones

As Chapter 4 discussed, recent efforts by both agricultural sources and wastewater treatment facilities have resulted in substantial decreases in phosphorus load in the Mississippi River Basin. Other basins have not made similar progress. Statewide nitrogen loads from point sources have increased slightly due to population growth. The focus now is to move forward to achieve the Phase 1 Milestones by further decreasing agricultural sources by 2025 and pursuing upgrades to point sources.

Milestones can be achieved by various combinations of BMPs. Further, not all BMPs are compatible with one another. For instance, conservation tillage wouldn't be applicable if the land was switched to perennial energy crops. For purposes of illustration, example BMP scenarios to achieve the milestones were developed, paying attention to both effectiveness and cost of BMPs. 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 30 percent residue where not already applied (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, grass waterways, 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 35 percent reduction milestone for phosphorus in the Mississippi River Basin and the 10 percent reduction milestone in the Red River portion of the Lake Winnipeg Basin through the application of more intensive agricultural BMPs (after accounting for recent and planned changes in WWTP discharges). Agricultural strategies are of lesser importance in the Lake Superior Basin where agriculture contributes only about 6 percent of the phosphorus load.

Table 5-12 summarizes the results of this analysis, which suggest that the Phase 1 Milestones could be achieved, but only through a combination of BMPs. Specifically, for the Mississippi River Basin the milestone could be achieved if the majority of applicable agricultural land modified fertilization practices to achieve the recommended target soil test phosphorus and instituted 30 percent residue conservation tillage where not already employed. In addition, 30-meter buffers were instituted on both sides of 25 percent of perennial and intermittent streams along with an increase in Conservation Reserve Program lands. The net increase in BMP application area (after accounting for recent progress) is approximately 10 million acres. Alternatively, some of the reduction in agricultural load could be achieved through greater application of BMPs, such as riparian buffers or conversion to perennial energy crops. Substantially lower levels of effort will be necessary in the Lake Winnipeg Basin to achieve the milestone. 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 no incremental gain from increasing fertilizer use efficiency for phosphorus.

Table 5-12. Example BMP scenario for achieving the phosphorus Phase 1 Milestones 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	90%	1.9	0%	0
Increase and Target Living Cover	Riparian buffers	25%	0.3	60%	0.3
	Cover crops	10%	0.3	20%	0.2
	Conservation reserve	3%	0.2	0.6%	0
Field Erosion Control	Conservation tillage	85% of available area; 90.7% net	7.2	53% of available area, 63.5% net	1.4

Notes:

Adoption rates are expressed as a percentage of the total area on which a practice is applicable, with the exception of conservation tillage, which is expressed as a fraction of the area not currently in conservation tillage. A cumulative adoption rate for conservation tillage is also shown.

Acreage from program quantification for 2000–2013 is excluded from total future acres where applicable. Adoption rate percentages are relative to suitable areas and represent the percentage of land in total that would require the BMP. The SPARROW model is assumed to reflect 2000 agricultural conditions.

It is important to note that approximately 15 percent of the phosphorus load in the Mississippi River Basin is derived from streambank erosion (Barr Engineering 2004), while ravine erosion causes a portion of the agricultural load. Streambank and ravine erosion have worsened in southern Minnesota in response to more intensive drainage (Schottler et al. 2013). Mitigating streambank and ravine erosion by reducing erosive flows is not considered in the agricultural BMP scenario described above, but could be an important part of the ultimate solution. Another 16 percent of the phosphorus load is estimated to come from atmospheric deposition of dust. The extent to which atmospheric deposition of phosphorus can be reduced through better cover and tillage practices within Minnesota is not known.

For the Lake Superior Basin, the goal is a 3 percent decrease in phosphorus loads. Agriculture is estimated to contribute only 6 percent of the phosphorus load in this basin, and many agricultural BMPs for phosphorus are not particularly useful because of low soil phosphorus concentrations. The major sources of phosphorus in this basin are point sources (24 percent), nonagricultural runoff (e.g., forest, mining, urban at 32 percent), and streambank erosion at 15 percent. The needed 3 percent reduction in the Lake Superior Basin is expected to come from a combination of point source reductions and miscellaneous nonpoint runoff reductions.

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

5.3.3 Agricultural BMPs to Achieve the Nitrogen Phase 1 Milestones

As Chapter 4 discussed, while recent efforts by agricultural sources have achieved nitrogen reduction, the reductions are considerably smaller than those made for phosphorus and have been offset by slight increases in nitrogen from wastewater. The focus remains on the Phase 1 Milestone for nitrogen, which is working toward a 20 percent reduction in the Mississippi River Basin and meeting the provisional goals in the Lake Winnipeg Basin. There are no goals for nitrogen reductions in the Lake Superior Basin.

An example scenario was created to investigate what it would take to achieve the Phase 1 Milestone for nitrogen through more intensive application of agricultural BMPs after accounting for planned changes in wastewater discharges that include significant reductions in nitrogen loads. Note that the implementation of riparian buffers, cover crops, and conservation reserve is constrained to match the phosphorus scenario. 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 5-13 summarizes the results of this analysis, which suggest that the Phase 1 Milestone could be achieved in the Mississippi River Basin (including the Cedar, Des Moines, and Missouri subbasins) with a mix of BMPs. The net increase in BMP application area in the Mississippi River Basin amounts to approximately 15 million acres. Moving beyond this milestone for nitrogen will require use of additional BMPs, such as improvements in nitrogen application methods and timing, use of saturated buffers, constructed wetlands to intercept tile-drain flow, controlled drainage, and cover crops.

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 Basin will require a focus on reducing baseline loads of nitrogen through increased fertilizer efficiency, as well as a strategy that includes wetland treatment, bioreactors 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 5-13. Example BMP scenario for achieving nitrogen Phase 1 Milestone through cropland BMPs

		Mississippi River		Lake Winnipeg (Red River Only)	
BMP category	Example BMP	Future adoption rate	New total acres (million acres)	Future adoption rate	New total acres (million acres)
Increasing Fertilizer Use Efficiencies	Use recommended fertilizer application rates	80%	13.2	95%	6.0
Increase and Target Living Cover	Cover crops	10%	0.3	20%	0.2
	Riparian buffers	25%	0.3	60%	0.3
	Conservation reserve	3%	0.2	0.10%	0
Drainage Water Retention and Treatment	Wetlands and controlled drainage	18%	1.1	25%	0.001

Notes:

Adoption rates are expressed as a percentage of the total area on which a practice is applicable.

Acreage from program quantification for 2000–2013 is excluded from future acres where applicable. Adoption rate percentages are relative to the area for which a given practice is suitable and represent the percentage of land in total that would require the BMP. The SPARROW model is assumed to reflect 2000 agricultural conditions.

5.4 Strategy Reduction Summaries

The overall strategies to achieve nutrient reduction milestones are summarized in Figure 5-4 through Figure 5-8. Each of the graphics includes suggested reductions by source for each of the BMP categories 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 Strategy Reductions are summarized above in Chapter 5.

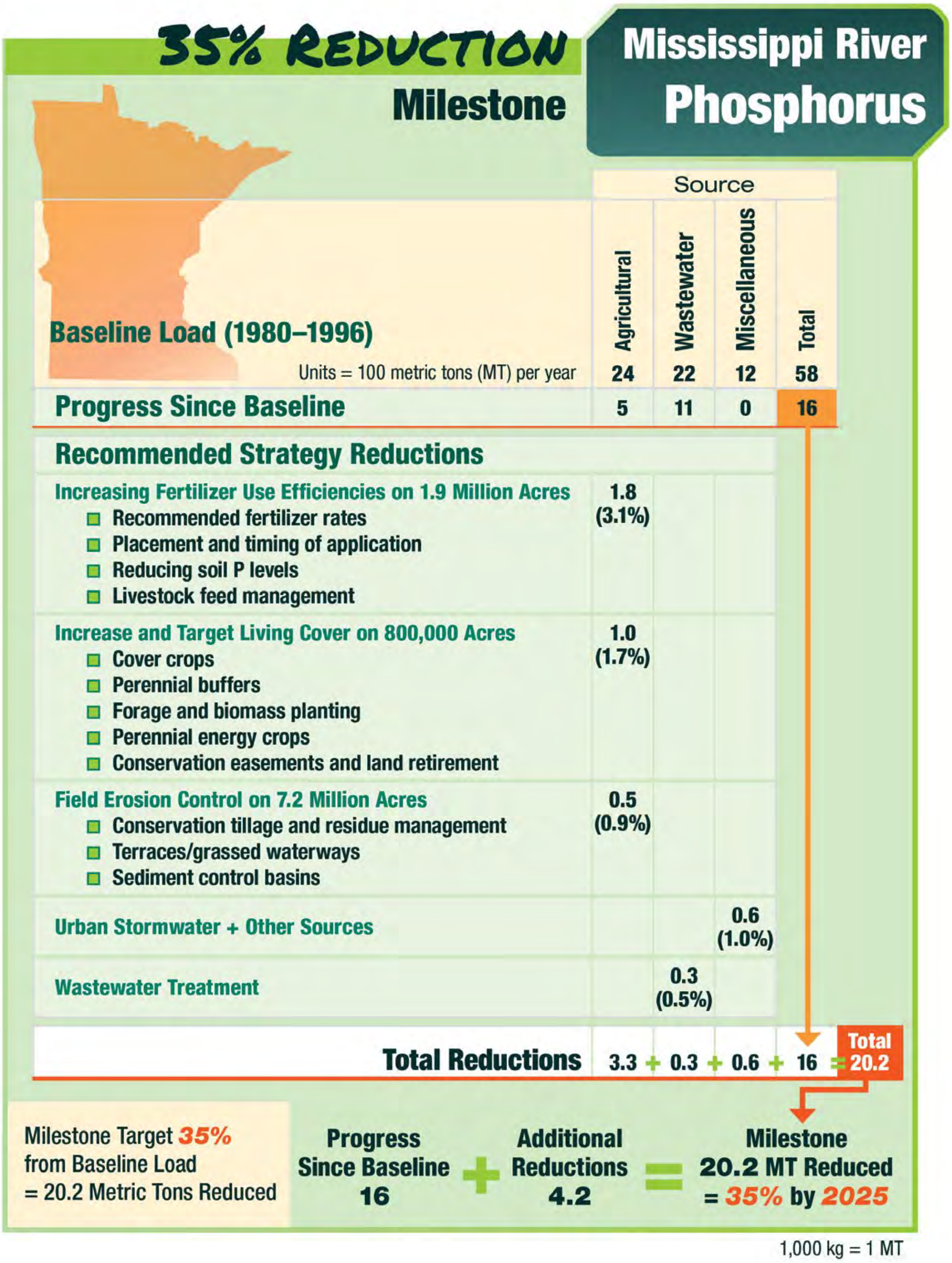


Figure 5-4. Phosphorus Milestone Strategy Reductions for Mississippi River Basin.

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 5-12 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.

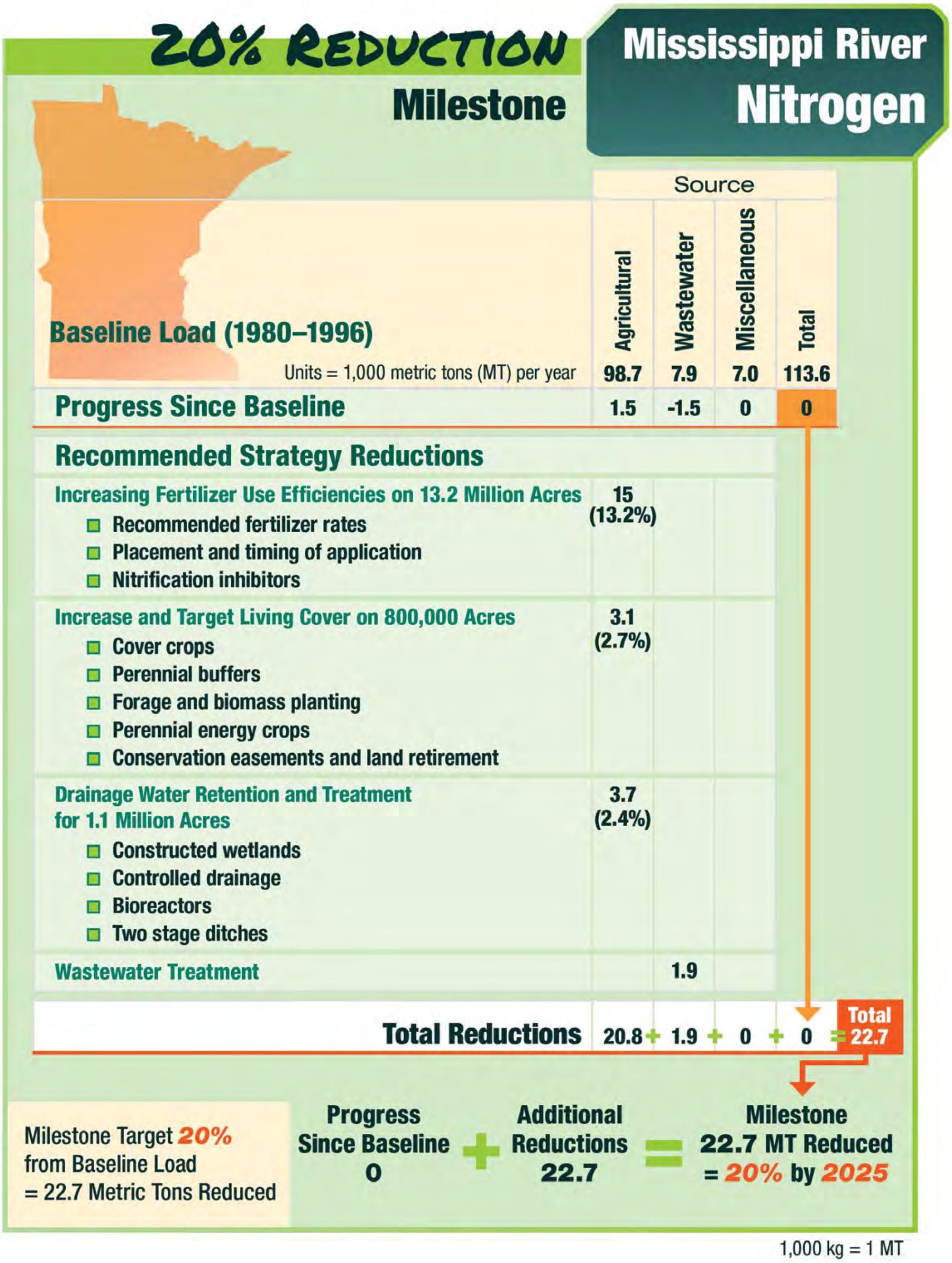


Figure 5-5. Nitrogen Milestone Strategy Reductions for Mississippi River Basin.

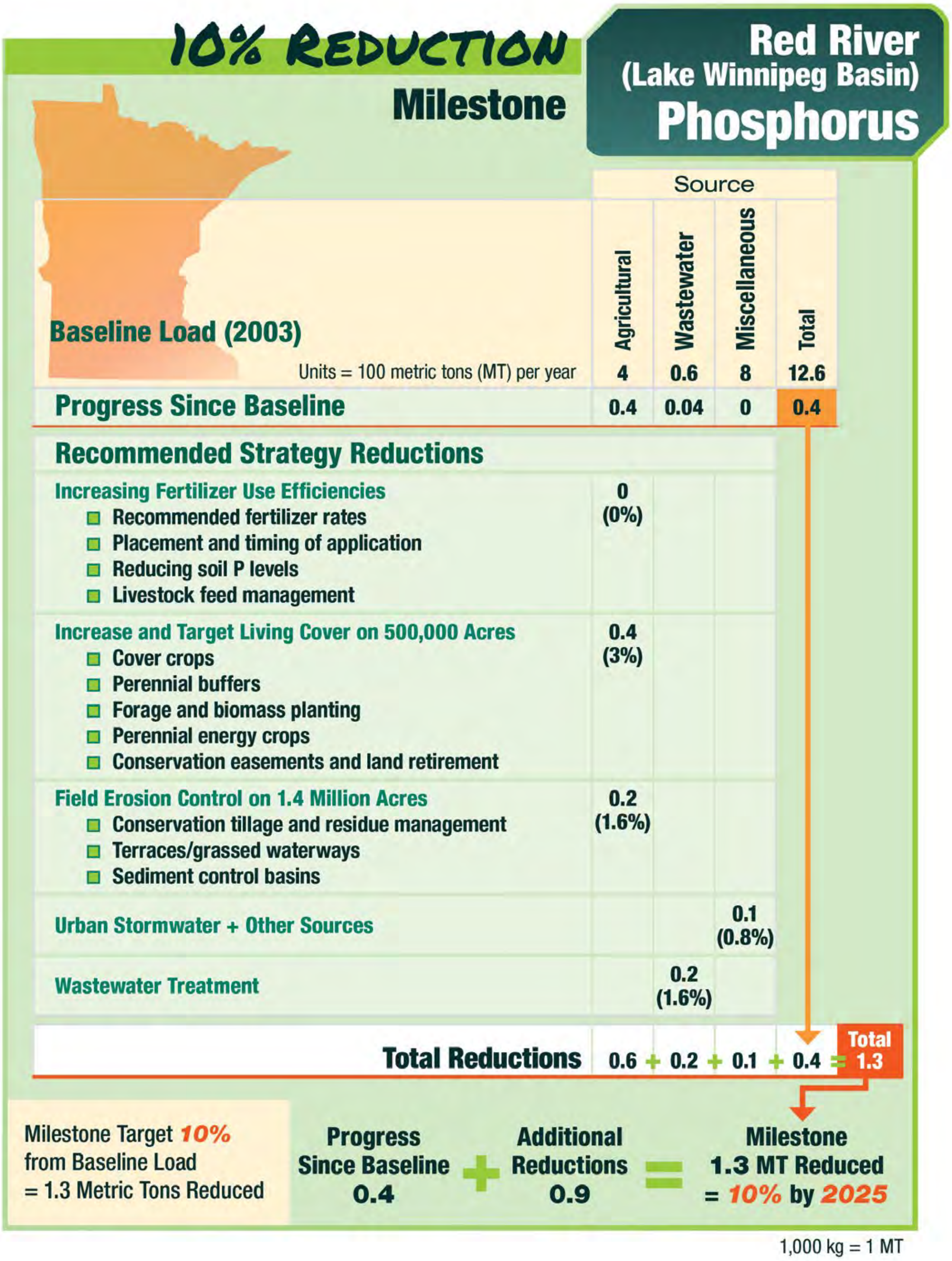


Figure 5-6. Phosphorus Milestone Strategy Reductions for Red River/Lake Winnipeg Basin.

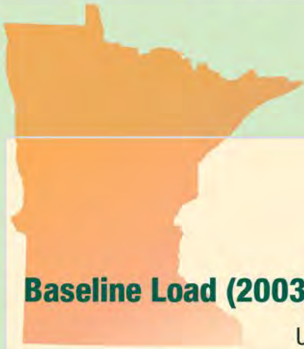
Notes:

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 5-12 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.

13% REDUCTION Milestone

Red River (Lake Winnipeg Basin) Nitrogen



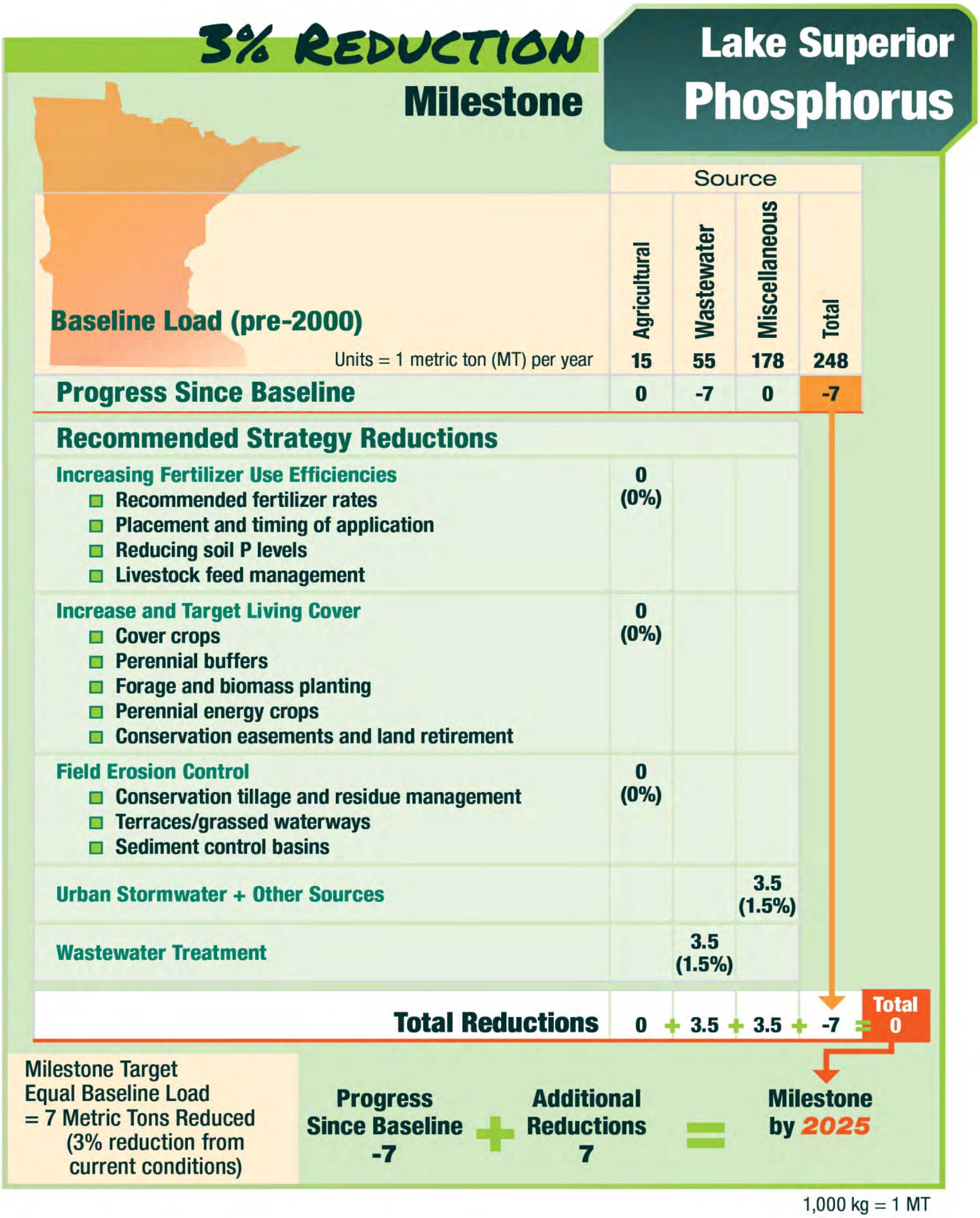
Baseline Load (2003) Units = 1,000 metric tons (MT) per year	Source: Agricultural	Wastewater	Miscellaneous	Total
	15.2	0.3	3.1	18.6
Progress Since Baseline	0	0	0	0
Recommended Strategy Reductions				
Increasing Fertilizer Use Efficiencies on 6 Million Acres ▪ Recommended fertilizer rates ▪ Placement and timing of application ▪ Nitrification inhibitors	1.5 (8%)			
Increase and Target Living Cover on 500,000 Acres ▪ Cover crops ▪ Perennial buffers ▪ Forage and biomass planting ▪ Perennial energy crops ▪ Conservation easements and land retirement	0.9 (5%)			
Drainage Water Retention and Treatment ▪ Constructed wetlands ▪ Controlled drainage ▪ Bioreactors ▪ Two stage ditches	0 (0%)			
Wastewater Treatment		0.1 (0.5%)		
Total Reductions	2.4 +	0.1 +	0 +	0 = Total 2.5

Milestone Target *13%* from Baseline Load = 2.5 Metric Tons Reduced

Progress Since Baseline 0 + **Additional Reductions 2.5** = **Milestone 2.5 MT Reduced = *13%* by *2025***

1,000 kg = 1 MT

Figure 5-7. Nitrogen Milestone Strategy Reductions for Red River/Lake Winnipeg Basin.



1,000 kg = 1 MT

Figure 5-8. Phosphorus Milestone Strategy Reductions for Lake Superior Basin.
Notes: Baseline loads and percentages derived from SPARROW model.

5.5 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.

5.5.1 Wastewater

Costs for the vast majority (over 90 percent) of residents receiving municipal wastewater treatment range from $7 to $11 per pound 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 5-17 presents the annual removal costs to treat wastewater (assumed influent concentrations of 1 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 5-14. Summary of wastewater annual removal costs

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

5.5.2 Agricultural BMPs

Present value terms were used when reporting the results of the agricultural BMP cost-benefit analysis. The present value is the current value of the projected stream of costs throughout a project's lifetime, and the process of calculating present value is known as *discounting*. The money allocated to future costs could earn an average return in another investment, and discounting simply reflects the time preference for consumption. Although not synonymous with the interest rate, for governments it often reflects the rate at which funds can be borrowed and loaned.

The cost-benefit results are presented both as annualized and total 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 (NPV) 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.

For each BMP, the NPV was then annualized assuming a discount rate of 4 percent and a project lifetime of 50 years. 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 Chapter 5.3.1 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 milestones. To estimate total costs, the total NPV was calculated for the suite of BMPs using a discount rate of 4 percent and a project lifetime of 50 years. Table 5-18 presents the annualized and total NPV results for the achieving the milestones. Table 5-19 provides the annualized values by BMP.

The breakdown in costs by BMP category relate directly to the load reductions Figure 5-4 through Figure 5-8 present. For example, the achievement of the load reductions from increasing fertilizer use efficiencies is estimated to achieve the reported load reductions for both nitrogen and phosphorus. However, the implementation acres for conservation tillage in Table 5-12 were reported differently. For the purposes of directly reporting the total acres of implementation needed, Table 5-12 reports total acres associated with conservation tillage under field erosion control. Although the load reductions and costs can be associated with the fertilizer reduction and erosion control aspects of conservation tillage, only a total area in conservation tillage can be reported intuitively.

Table 5-15. Cost-benefit analysis results for agricultural BMPs to achieve milestones

Scenario	Mississippi River Basin	Lake Winnipeg Basin
Annualized ($/year)	$79,700,000	$53,400,000
Total NPV (50 years)	$1,712,100,000	$1,147,100,000

Table 5-16. Cost-benefit analysis results by BMP, annualized values

BMP category	Example BMP	Mississippi River Basin	Lake Winnipeg Basin
Increasing fertilizer use efficiencies	Achieve target soil test phosphorus and use subsurface banding [a]	-$103,900,000	-$63,800,000
Increase and target living cover	Cover crops	$15,900,000	$13,000,000
	Riparian buffers	$102,600,000	$105,400,000
	Conservation reserve [b]	$45,700,000	$0
Drainage water retention and treatment	Wetlands and controlled drainage	$20,100,000	$20,000
Field erosion control	Conservation tillage [a]	-$600,000	-$1,300,000

a. The fertilizer use efficiency costs include 61.5 percent and 13.3 percent of the total cost of conservation tillage for the Mississippi River and Lake Winnipeg basins, based on the percent of load reductions from conservation tillage that are attributable to reduced fertilizer use. The remaining percentages represent the percent attributable to field erosion control, reflected in the field erosion control cost.
b. Reflects the average of a widely ranging cost ($30 to $390 per acre; Table 5-11) depending on site or program-specific details.

The results indicate that a net cost would be realized in the Mississippi River and Lake Winnipeg basins. BMPs providing increased fertilizer use efficiencies are estimated to provide the greatest net benefit (nearly $170 million per year statewide), while riparian buffers are estimated to provide the greatest net cost (about $210 million per year statewide). In the Mississippi River Basin, the cost savings from the increased fertilizer use efficiency and conservation tillage BMPs offset greatly the net costs of the other BMPs on a statewide basis. 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.

Chapter 6

Nutrient Reduction Strategies

The *Minnesota Nutrient Reduction Strategy* (Strategy) is not a vehicle to prescribe best management practices (BMPs) and management actions. It is intended to provide a roadmap as to the type of implementation activities that could be used to achieve the goals and phased milestones for phosphorus and nitrogen. It is recognized that there will be additional planning activities necessary at the source and program levels, statewide and locally, to provide more specificity on nutrient reduction actions. The additional planning activities will be necessary to optimize ongoing efforts, collect additional water quality data, and promote change.

Many of the actions this chapter identifies are contingent on a variety of factors, such as collection of appropriate data, financial and staff resources, and timing with other key initiatives and regulatory actions. As a result, an adaptive management approach to implementing the strategies this chapter presents will be used to guide and adjust implementation efforts over time. Chapter 7 of the Strategy provides more detail on the adaptive management approach for implementation to gauge progress as all stakeholders work toward meeting the Phase 1 Milestones.

6.1 Recommended Overarching Actions to Support Nutrient Reduction Strategy Implementation

Development of this initial iteration of the Strategy builds on previous implementation efforts in the state. Working toward the 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. These recommendations include the following:

- **Create accountability team and coordinating mechanism.** Teamwork through the interagency coordination team (ICT) was integral to Strategy development and teamwork will continue to be integral to Strategy implementation as a means to identify and execute program optimization activities, communicate Strategy-related progress to agency staff and stakeholder groups, and continue to provide technical input on progress tracking and reporting to support adaptive management. This will require a commitment from every participating agency within the ICT, as well as stakeholder organization representatives. Where possible, existing clean water coordinating mechanisms should play a role in this so that nutrient strategy implementation is coordinated with other clean water goals and approaches. Key to this will be identifying programs for the various elements of the Strategy and working with those program managers to develop program Step Up Plans (see Chapter 6.3 for more information on Step Up Plans). The accountability team could be a person or small group of implementation coordinators who would oversee the implementation of Strategy-related communication with input from critical program managers, represent Strategy interests at a statewide level, lead tracking and reporting efforts, and oversee adaptive management adjustments to the Strategy over time.

- **Develop a statewide nutrient reduction strategy education/outreach campaign.** A significant portion of the nutrient reductions to be achieved through the Strategy rely on voluntary actions from key sources, such as the agricultural community. As a result, effective education and involvement is imperative to the success of the overall Strategy. To be effective and efficient, the Strategy Project Team and the ICT should work with communications staff from all agencies to develop and implement a coordinated Strategy outreach campaign that is integrated with other efforts to promote statewide stewardship of water resources. For example, the Nitrogen Fertilizer Management Plan (NFMP) is also calling for a multi-organization team to develop a prevention strategy to promote groundwater protection BMPs associated with nitrogen fertilizer use throughout the state. The Strategy Project Team and the ICT developed a stakeholder Involvement and Education (I&E) Plan to guide communication activities during the Strategy development phase. As the Strategy moves into the implementation phase, the existing I&E Plan can evolve to identify outreach and involvement activities to communicate Strategy-related messages and information to key audiences. Communication tools can include a statewide coordinated ad 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.

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

- **Integrate basin reduction goals with watershed planning efforts.** An expected outcome of the Watershed Approach Chapter 1 describes includes strategies for nutrient reduction, which are tailored to the 8-digit hydrologic unit code (HUC8) watershed 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 watershed management plan is locally developed, which further defines the more specific actions, measures, roles, and financing for accomplishing the water resource goals. The WRAPS and associated 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). This Strategy establishes HUC8 nonpoint source nutrient load reductions proportional to the Strategy's Phase 1 Milestones. Point source load reductions will be achieved through total maximum daily load (TMDL) wasteload allocations and corresponding permit limits.

  Recognizing that the capacity for making nutrient reductions varies by watershed, the milestones for downstream needs should be adjusted up or down depending on the following considerations:

  – Where a large fraction of the land consists of undisturbed or minimally disturbed landscapes where nutrient reductions cannot be achieved (i.e., forests and grassland), reductions should be adjusted downward.
  – Where a large fraction of the watershed includes land uses with opportunities to achieve relatively large reductions from BMPs (i.e., tile-drained row crop loads), additional reductions should be considered.
  – Where an existing downstream nutrient reduction target for a specific in-state water body has reduction requirements exceeding those of this Strategy, reductions should be increased to be consistent with the most restrictive downstream needs.

  Developing a form of nutrient reduction trading should be considered to help focus reductions to those local areas where they can be made most efficiently and effectively. Further analysis of watershed-specific reductions should be undertaken in future revisions of the Strategy to determine the most cost-effective approach.

- **Integrate nutrient reduction strategy tracking considerations into key program databases and tracking tools.** There are a variety of ongoing information technology-related activities taking place within the Minnesota Pollution Control Agency (MPCA) and other key agencies throughout the state. 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 Watershed Approach. WDIP is also working to develop a template for the TMDL and WRAP 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 Strategy. It is likely that similar data management projects and initiatives are taking place within other federal and state agencies that are key to tracking the Strategy's progress. Ongoing and planned information technology-related efforts provide an opportunity to integrate the Strategy's tracking needs into the new system's design and development phases. Similar considerations are necessary for other Minnesota agencies with key nutrient reduction programs, such as the Board of Water and Soil Resources (BWSR) and Minnesota Department of Agriculture (MDA). Additional information on tracking and associated tracking approaches is provided in Chapter 7 on adaptive management.

- **Create effective statewide nutrient reduction incentives for voluntary or industry-led BMP adoption.** As previously mentioned, many of the nutrient reductions will depend on increased adoption of voluntary BMPs. Cost-share programs, such as Farm Bill programs administered by the U.S. Department of Agriculture (USDA) Farm Service Agency (FSA) and Natural Resource Conservation Service (NRCS), have historically provided economic incentives for conservation practices. However, recent information shows that enrollment in set-aside programs is declining due to increases in commodity prices. For example, cumulative Conservation Reserve Program (CRP) acreage in Minnesota has decreased steadily from about 1.8 million acres in 2007 to 1.2 million acres in 2013 (*http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=rns-css*). Further, land unit acres under nutrient management for water quality purposes under the Environmental Quality Incentives Program (EQIP) decreased from about 295,000 acres in 2007 to about 238,000 acres in 2010, but increased to 304,000 acres in 2012 (*http://soils.usda.gov/survey/rca/viewer/reports/fb08_cp_eqip.html*). As a result, there is a need for a review of the state-level incentive programs' ability to motivate the adoption of voluntary BMPs in priority watersheds where nutrient reductions are most needed to achieve basin goals. New incentive programs do not have to focus primarily on economic incentives, but could also include other types of incentives such as technical assistance, risk mitigation, improved business certainty and social based recognitions such as awards.

- **Develop mechanisms to improve state agency and federal agency data sharing and coordination.** Federal programs play an important role in promoting adoption of agricultural conservation practices using key BMPs. Specifically, BMPs installed under FSA's CRP and

NRCS's EQIP programs are currently captured within the Strategy. FSA and NRCS track these BMPs at the county level, but there are challenges in obtaining these data in a manner that easily supports Strategy tracking. There is a need to develop mechanisms that allow for improved federal agency data sharing and changes to existing federal databases to support Strategy tracking over time. Many of these recommendations will need state legislature and federal agency support. Since downstream nutrient strategies and Minnesota water quality needs are being addressed, a federal-state partnership should be the primary implementation driver. Consideration should be given to seek an innovative 75:25 federal to state block grant from USDA to provide enhanced implementation through a closely coordinated federal-state program initiative. This block grant should support the goals and strategies described in the Strategy.

- **Commit to an adaptive management plan for the Strategy.** Adaptive management of the Strategy will require a commitment from state agencies, as well as federal and local partners, to provide data and information, engage in discussions about successes and challenges, and identify feasible adjustments to achieve further reductions in priority geographic areas by key sources. Research on innovative and improved nutrient reduction methods should be supported as part of ongoing activities. Planning for improvement and for acquiring the data and information needed to support improvement should be integrated into implementation. Chapter 7 outlines the approach for adaptive management.

These overarching recommendations will provide the infrastructure necessary to support Strategy implementation and tracking over time. The subsequent sections focus on phosphorus- and nitrogen-specific activities and strategies from key sources to achieve the Phase 1 Milestones.

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 (RES) 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 (Chapter 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 are competing processes, and implementation of biological nutrient removal could compromise phosphorous removal efficiencies. Additional research and testing will be needed to develop cost-effective solutions for both phosphorus and nitrogen removal from wastewater.

Metropolitan Wastewater Treatment Plant Photo Credit: Metropolitan Council

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

There are limited available data in Minnesota on influent and effluent nitrogen concentrations. Monitoring has been limited to ammonia primarily due to permit requirements. Those facilities with ammonia concentration or load requirements are providing treatment to convert ammonia to nitrate-nitrite nitrogen, but are not reducing 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 [TKN], 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 data for developing performance standards for various facility types.

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 wastewater treatment plants (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 (Figure 1). The WWTP now consistently achieves less than 1 mg/L total phosphorus in the effluent.

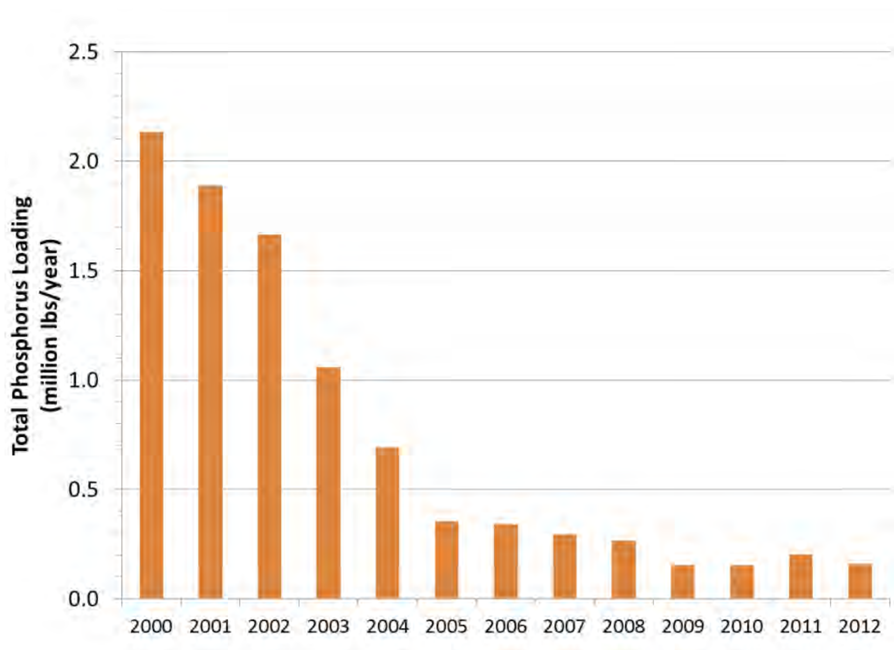


Figure 2. Metro WWTP Phosphorus Loadings

Data provided by Metropolitan Council

Strategy: 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 any 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 3 years with plan development following. The first round of nitrogen management plans could be completed by 2020.

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

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 is expected to be low due to the low number of streams designated for drinking water (see Chapter 2).

Incorporating WQBELs for nitrogen is primarily dependent on adoption of nitrogen standards to protect aquatic life. Adoption of these standards is anticipated in the next 2–4 years. At that time, WQBELs will be incorporated into permit renewals as needed.

Due to many unknowns, the milestone assumes an overall reduction of 20 percent nitrogen loads from point sources by 2025. This reduction is based on achieving a 10 mg/L nitrogen concentration in effluent for approximately half of the existing nitrogen load from point sources, which could be accomplished through biological nutrient removal. It is critical for the state's largest facilities to reduce their nitrogen effluent to achieve the milestone. Consideration should be given to meeting the Phase 1 Milestone schedule for environmental improvement in rolling out effluent limits for point sources.

Strategy: Add Nitrogen Removal Capacity with Facility Upgrade. Establish a technology-based threshold to achieve 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.

Strategy: Point Source to Nonpoint Source Trading. Work with other Mississippi River Basin states to determine the viability of an interstate nitrogen trading network. Create an in-state trading framework that allows for nitrogen point source to nonpoint source trading. The trading framework would need to identify trading ratios that achieve load reductions (through an additionality mechanism such as a retirement ratio), determine allowable nonpoint sources for trades (e.g., tile drains which function in a similar way to point source discharges), define geographic regions, and create tracking mechanisms.

Water quality trading is a market-based approach to promote the protection and restoration of surface waters in conjunction with other existing voluntary, regulatory, and financial assistance programs. Trading can also be an effective way to offset new or expanded discharges that otherwise would add additional loads to waters that might already be impacted. The water quality trading concept is based on the fact that businesses, industries, wastewater treatment facilities, urban stormwater systems, agricultural operations, and other watershed sources of pollutants might face substantially different pollution control costs. Sources facing high pollution control costs could realize substantial cost savings by securing environmentally equivalent, or superior, pollutant reductions by purchasing water quality credits generated by sources with substantially lower pollutant reduction costs.

Depending on the credit generation methods, ancillary benefits such as restored wildlife habitat, wetland creation, streambank stabilization, and carbon sequestration might also result from water quality trading. These might not have been specifically purchased by the buyer in the transaction but might result in ecosystem benefits and, potentially, additional economic benefits for the seller who may be able to sell these credits in other markets.

The majority of water quality trading in Minnesota has occurred in the Minnesota River Basin between point sources through an area-wide permit for phosphorus reduction; however, there are two longstanding examples of point to nonpoint source trades as well. Nonpoint sources are the major sources of nitrogen to surface waters within Minnesota and in other Mississippi River Basin states. Trading should address three primary policy needs: (1) additionality, or the idea that additional water quality benefits are generated; (2) equivalence, which means that nutrient reduction credits from point sources are equalized to account for differences in form from nutrient loads associated with nonpoint sources; and (3) accountability, ensuring that trades are certified, quantified, and tracked over time. Other states have expressed some interest in an interstate trading network for nitrogen. There are risks associated with a point source to nonpoint source trading program, such as changes in landowners and changes in nitrogen markets. In addition, trading other than to facilitate new source offsets will likely need to wait until the adoption of nitrogen standards for protection of aquatic life.

6.3 Strategies to Implement Recommended Agricultural BMPs

Simply identifying potentially effective agricultural BMPs is not enough. To achieve the Phase 1 nitrogen and phosphorus milestones, it is essential to develop strategies to increase adoption of the BMPs identifies in Chapter 5.3. Strategies fall into the following categories: Optimization, Economic, Education/Involvement, Demonstration, and Research.

6.3.1 Optimization Strategies

Several federal, state, and local programs currently focus on promoting and supporting implementation of many of the agricultural BMPs in Chapter 5.3. Where programs exist, it is necessary for program staff to identify optimization opportunities to improve the rate of BMP adoption in targeted areas where additional phosphorus and nitrogen reductions are most necessary to achieve the Phase 1 Milestones.

Strategy: State Program Step Up Plan. Any state program (e.g., MDA's Agricultural Best Management Practices Loan Program, BWSR's Erosion Control and Water Management Program/State Cost-Share Program) that delivers the agricultural BMPs listed in Chapter 5.3 should develop a Step Up Plan within 1–3 years of the nutrient reduction strategy implementation kickoff date. The plans should identify the BMPs that the program delivers and in what capacity (cost-share funding, technical assistance, education) and identify actions to (1) increase the delivery of those services to promote increased BMP adoption; (2) target efforts to the priority HUC8s in priority basins; and (3) quantify associated nutrient load reductions from those BMPs. The goal of these plans is to optimize nutrient reductions using existing program frameworks and are not project specific.

Strategy: Federal Program Step Up Plan. Work with federal partners delivering agricultural BMPs listed in Chapter 5.3 to develop Step Up Plans for federal programs, such as NRCS and FSA, within 1–3 years of the nutrient reduction strategy implementation kickoff date.

Strategy: Increase Delivery and Track Implementation of Industry-Led BMPs. 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 key to Strategy success. Because they are not tracked in the same manner as BMPs funded through state and federal programs, these improvements and conservation efforts have the potential to be under-represented, as shown by a recent Maryland initiative to inventory local BMPs (Maryland Department of Agriculture 2011). An inventory of locally led conservation efforts would not only help improve implementation data for tracking toward nitrogen and phosphorus milestones, but also assist in creating reliable and effective mechanisms for capturing this type of information on a regular basis. Agricultural census and surveys of management have been conducted for many years; however, inclusion of nutrient-related management and regular reporting and access to this information is critical to appropriate progress tracking. A concerted effort should occur, starting with MDA and USDA agricultural census and statistical surveys to help track overall changes that are occurring.

6.3.2 Economic Strategy Options

Historically, cost-share programs have been one of the most significant mechanisms for voluntary agricultural BMP adoption. However, increasing commodity prices and constrained federal resources are affecting enrollment in these programs. There is a need to develop new economic strategies to create incentives for achieving nutrient reductions, as well as disincentives for actions that could result in increased nutrient loads.

Strategy: Crop Yield Insurance Program. Insurance programs can be created to reduce a farmer's risk cost 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 risky practice. If the yield is not reduced, the insurer pockets the payment from the farmer.

No Till Field Photo Credit: NRCS

A pilot study was conducted 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 their state's extension service agronomic recommendations and BMPs for nitrogen, and the program provided insurance in the case that yield potential was less than optimal. In this case, a nutrient management plan was required to purchase the endorsement. A similar program could be further evaluated and implemented in Minnesota.

The American Farmland Trust has also adopted this basic approach in its *BMP Challenge for Nutrient Management* and *BMP Challenge for Reduced Tillage,* under which it pays farmers cash if yield and income are reduced while participating in the BMP Challenge (*http://www.farmland.org/programs/environment/solutions/bmp-challenge.asp*). Unique performance guarantees allow 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.

Traditional fertilizer rates or tillage practices are used on a check strip in each enrolled field. The BMP fertilizer rates or tillage practices are used on the balance of the field. Crop yields are assessed at harvest, and any farmer experiencing lower yields with the BMP fertilizer application rate or tillage practice will be reimbursed the difference. In any one year, BMPs might not result in maximum yields, but they are designed to deliver maximum economic returns over time. Farmers in Minnesota who grow corn for grain and silage are eligible for the program. More information is available at *www.bmpchallenge.org.*

Strategy: Develop Markets and Technologies for Use of Perennials. Growing perennial energy crops can have as much as 95 percent removal efficiency for nitrogen. As a result, research to develop the appropriate perennials and marketable uses needs to receive priority. Until these marketable uses are established, application of this BMP will be limited in achieving the Phase 1 nitrogen milestone. Development and support of 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 a federal research focus on energy crops will likely be critical to reaching our Phase 2 Milestones. As a result, it is necessary to develop, strengthen, and support existing markets for products of currently available perennial crops. Research should include use of a profitable third crop to act as a cover crop within corn and soybean rotations. Research should also include crop genetics and crop establishment techniques.

Strategy: Quantify Public Environmental Benefits of Reducing Nutrient Levels in Water. This type of information can be used in a variety of messaging to educate the agricultural community and other stakeholders about ecosystem benefits of nutrient reduction and create support for economic incentives for conservation practices.

Strategy: Nonpoint to Point Source Trading. Water quality trading is a tool that can create economic incentive for adoption of BMPs to generate tradable nutrient reduction credits. Since meeting the goals requires reductions from both wastewater and nonpoint sources, to make progress toward milestones, trading has to provide a net reduction in loads rather than just changing the source of the loads. Trading can provide enhanced nutrient reduction beyond what is called for in a TMDL or this strategy by including a retirement ratio as part of the trading framework to overcome scientific uncertainty and achieve greater nutrient reductions.

6.3.3 Education and Involvement Strategies

BMP adoption requires agricultural producers to change behavior that is 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 related to 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 prevention strategy's referenced Nitrogen Fertilizer BMP Education and Promotion Team. All motivational approaches should be considered including economic benefits and stewardship.

Strategy: Targeted Outreach and Education Campaign. Use current survey data to develop a targeted outreach and education campaign for agricultural producers and identify what motivates behaviors and factors that might influence behavior change affecting BMP adoption rates. The information provided in the completed survey, once made publicly available, should serve as the basis for an education and outreach campaign targeting agricultural producers and promoting BMP implementation where needed most. Outreach and education should also be targeted to absentee landowners (those landowners leasing agricultural lands to others).

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 forthcoming Agricultural Water Quality Certification program. This program will promote 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 Phase I Milestones in the Strategy.

Strategy: Focus Education and Technical Assistance to Co-Op Agronomists and Certified Crop Advisors. Agricultural producers rely on fertilizer dealers, co-op agronomists, and certified crop advisors for 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 (e.g., co-op agronomists and certified crop advisors) of key soil and water quality approaches for reducing nutrients, as is taught through the American Society of Agronomists online course (*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 advisor certification program should be developed.

Strategy: Involve Agricultural Producers in Identifying Feasible Strategies. During the draft Strategy development process, agricultural experts and researchers who have worked directly with farmers were asked to provide input on potential BMPs and strategies to address nitrogen and phosphorus. In this public review phase, farmers will be asked directly about feasible strategies. As the Strategy shifts to the implementation phase, it is imperative to have further discussions with agricultural producers and their business associations about BMPs and strategies to address nitrogen and phosphorus to better understand producers' perspectives and concerns and 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 and can champion nutrient reduction BMPs 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 Soil and Water Conservation Districts 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 Soil and Water Conservation Districts and University of Minnesota Extension to Increase Education and Involvement. Work with county soil and water conservation district (SWCD) staff and the University of Minnesota Extension to determine opportunities for improving education/involvement with agricultural producers. County SWCD staff provides technical, educational, and financial assistance to promote conservation activities on private lands. Under this strategy, SWCD staff would evaluate current education and involvement efforts targeting agricultural producers and identify opportunities to evaluate and improve delivery of these services.

Strategy: Share Nutrient Reduction Success Stories. Develop and distribute nutrient reduction success stories through the agricultural community's trusted messengers that include economic benefits to the producer. Minnesota could highlight successful nutrient reduction projects as a way to provide credit for innovative projects and educate other agricultural producers on potential projects they can adopt. A series of success stories can be a component of the overall outreach campaign targeted toward agricultural producers.

Strategy: Focus Initiatives on Soil Health. Initiatives for BMP promotion and education should begin or continue for practices that improve soil health and increased soil organic matter (i.e., cover crops), improve livestock feed efficiencies to reduce nutrients in manure, and increase water storage.

6.3.4 Research Strategies

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

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

- Research on cover crops to increase the success rate for establishment and use of a profitable cover crop. Current success rates are approximately 20 percent in Minnesota based on limited research. Research should include crop genetics and crop establishment techniques.
- Research on forages for livestock.
- 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 removing nutrients from tile drainage waters, including use of saturated buffers, two-stage ditches, etc.

- Development of approaches that will reduce soluble phosphorus, as well as BMPs which can address multiple nutrients.
- 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, which provides cost per pound of nitrogen reduced for BMPs. The tool could be adapted to also include phosphorus reduction BMPs.

6.3.5 Demonstration Strategies

Learning by doing is a powerful tool to educate and change perception about nutrient reduction practices, particularly for 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: Demonstration Projects. Develop on-farm trials/demonstration projects for BMPs that agricultural producers perceive to have uncertainty, risk, or other constraints. One way to provide agricultural producers with proof about new practices is to provide opportunities for on-farm trials and demonstrations. Continue and expand MDA- and NRCS-initiated on-farm-demonstration programs. An approach similar to the Discovery Farms Minnesota (*http://www.discoveryfarmsmn.org/*) model could be used 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.

6.4 Recommended Miscellaneous Reductions and Strategies

Miscellaneous sources (neither wastewater nor agricultural) represent 46 percent of the statewide phosphorus load and 10 percent of the statewide nitrogen load in a typical year, as delivered to the state line. Much of the 46 percent phosphorus load is a result of streambank erosion, which is tied in part to agricultural activities. 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 basins, respectively.

Significant new strategies are not suggested at this time to reduce loads from these sources; however, existing programs have strategies in place that allow for systematic reductions in loads from individual sewage treatment systems (also referred to as Subsurface Sewage Treatment Systems [SSTS]) , stormwater, and feedlots. 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. A one percent reduction in total load from miscellaneous sources is assumed for phosphorus in the Mississippi River Basin and a 1.7 percent reduction for phosphorus is assumed in the Lake Superior Basin.

6.4.1 Subsurface Sewage Treatment Systems Strategies

Of the approximate 450,000 septic systems across the state, slightly less than 100,000 of them are estimated to be failing and could be sources of pollution to Minnesota's water resources. A failing system is one that does not provide adequate separation between the bottom of the drain field and seasonally saturated soil or otherwise discharges to surface water. SSTS discharge treated sewage into the ground, which ultimately travels to groundwater. Therefore, SSTS must be properly sited, designed, built, and maintained to minimize the potential for disease transmission and contamination of groundwater and surface waters.

As described in the *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 Animal 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, permitting, technical assistance, and record keeping are all used to protect water quality.

The Animal 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.

Implementation of the Feedlot Program operational measures serves as strategies to reduce nutrient loads from feedlots. Additional information on the Animal 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 strategies. For more information, go to *www.pca.state.mn.us/stormwater*.

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 six 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.

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 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 defined 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.

Minimal Impact Design Standards

In addition to stormwater permits, Minnesota began development of Minimal Impact Design Standards (MIDS) in 2009. The 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). MIDS represents the next generation of stormwater management and contains three main elements that address current challenges:

- **A higher 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 final MIDS package was not complete at the time of this publication, but is expected in 2013.

6.4.4 Sediment Reduction Strategies

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. Drainage systems can contribute to high peak flows that may accelerate bank 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. Additionally, the MPCA is drafting a strategy to reduce sediment in the Mississippi and Minnesota rivers. The strategy will emphasize targeting watersheds contributing high levels of sediment and reducing flow, which is driving the near channel sources of sediment. Many practices put in place to reduce nutrients can also help reduce sediment, especially those BMPs related to field erosion control. Practices such as perennial vegetation and water storage will reduce flow, and therefore decrease streambank, bluff and ravine erosion, along with nutrients.

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

6.5 Protection Strategies

Protection strategies are needed in watersheds that are facing development pressures and changes in agricultural and land use practices, as well as vulnerable groundwater drinking water supplies in Minnesota. The Watershed Approach, as Chapter 1 described, requires protection strategies as part of WRAP development, and therefore should address the potential for increased nutrient loads at a watershed scale. Ensuring that nitrogen is addressed as part of WRAPS development is necessary.

6.5.1 Red River Drainage Mitigation

Tile drainage is expected to increase rapidly in the Red River subbasin in the coming years. As a result, an increased load of nitrogen is anticipated. 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 subbasin within the next 5 years.

The current analysis of suitable acreage for wetlands and bioreactors in the Red River subbasin does not take into account future tiling, and therefore there are limited suitable acres identified in this Strategy. 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 subbasin 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.

6.5.2 Lake Superior Nitrogen Load

Although there is not an existing goal or milestone for nitrogen load reductions in the Lake Superior Basin, increases in nitrogen loading to Lake Superior should be limited when practical. Future strategies should be considered as new research is conducted on the effect of nitrogen in the Great Lakes.

6.5.3 Groundwater Protection Strategies

The Draft *Nitrogen Fertilizer Management Plan* (NFMP) is the state'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 Strategy 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 this Strategy:

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.

Chapter 7

Adaptive Management and Tracking Progress

While the Draft *Minnesota Nutrient Reduction Strategy* (Strategy) is based on strong science given careful consideration, there is always a need to improve and refine based on new information and input from key stakeholders and partners. Even when made final, the Strategy will be frequently evaluated and periodically updated. Establishing a coordinated strategy that provides an efficient and effective pathway to achieving statewide goals is the first step in an iterative process of planning, implementing, assessing, and adjusting. This iterative process is often referred to as *adaptive management* (Figure 7-1). In essence, it 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. To facilitate an adaptive management process, it is necessary to have an adaptive management plan that documents the procedures for assessing progress over time and the triggers for updating the Strategy to achieve the nutrient reduction goals and milestones.

The Strategy 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 Strategy milestones and goals, it is imperative to have an adaptive management plan that will guide an evaluation of the Strategy's progress over time. The basic components of the Strategy's adaptive management plan are as follows:

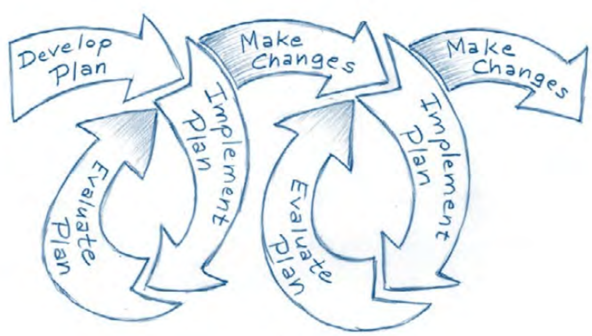


Figure 7-1. Adaptive management iterative process (USEPA 2008).

- Identify data needed to track progress toward Strategy goals and milestones.
- Create a system or approach for collecting data and information needed to track progress toward Strategy goals and milestones.
- Evaluate trends.
- Adjust the Strategy as necessary.

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

7.1 Identify Data Needed to Track Progress toward Strategy Goals and Milestones

Both action and environmental outcome data will be necessary to track progress toward Strategy goals and milestones. Implementation data provides early indicator information about nitrogen and phosphorus reductions that, over time, should translate to in-stream nutrient reductions. Each type of data and a corresponding evaluation approach is described below.

7.1.1 Program and BMP Implementation Evaluation

The implementation evaluation piece of the Strategy's adaptive management process focuses on implementation of best management practices (BMPs) and management actions through the strategies Chapter 5 and 6 discuss. The objective of the implementation evaluation (program and BMP) is to determine progress toward the milestones and final goals Chapter 2 presents. The emphasis of this initial version of the Strategy is on the Phase 1 Milestone for all basins 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 Phase 1 Milestones while tracking environmental outcomes helps to inform strategies to achieve environmental goals. Quantifying changes in both program implementation and water quality outcomes are complementary parts of the Strategy. It is imperative that the approach for quantifying these changes is meaningful, sustainable, and replicable.

A streamlined approach is used to track program implementation. This approach involves the development and tracking of program measures to quantify implementation progress over time. Each of the selected key programs that Chapter 4 identifies implement a variety of structural and nonstructural BMPs. Quantifying nutrient reductions for every BMP associated with each program would not be a sustainable and replicable approach to show progress toward Strategy goals over time, and it is likely that the amount of data and information this approach would generate would dilute the significance in the context of assessing progress toward Strategy goals.

A suite of program measures have been developed in an effort to narrow down the potential BMPs under each identified program to focus on a few that are the most meaningful indicators of readily available data on statewide nutrient reduction progress. Tracking the implementation information associated with the selected program measures provides the pulse of key implementation programs. While these programs are a high priority and promote BMPs that are integral to achieving nutrient reductions, it is expected that a larger suite of practices and strategies, such as those Chapter 5 and 6 discuss, will be needed to meet the necessary load reductions. Nutrient reduction trends for the selected program measures will show progress related to specific BMP implementation. Integrating nutrient reduction trends related to implementation activities with water quality outcomes (see Chapter 7.2) provides a snapshot of nutrient reduction with an overall picture of program success. This is similar to the approach used for the Clean Water Legacy Fund Performance Report. 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 (see Appendix C for program recommendations). It is anticipated that through Strategy assessments, additional measures will be developed in the future to track implementation success related to additional programs and other implementation-related activities. For example, additional measures could include assessing changes in civic engagement and improvements in working with local partners to track voluntary, nongovernmental program-based BMP implementation over time.

Each program measure has a corresponding metadata worksheet (see Appendix D). 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 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

Program	Measure for quantification	Indicator BMPs
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) (FSA)	Implementation of priority CRP conservation practices and estimated nutrient load reductions	1. Filter strips (CP 21) 2. Riparian forested buffers (CP 22)
Conservation Reserve Enhancement Program (CREP) (FSA)	Captured in CRP	
Conservation Security Program (CSP) (NRCS)	No measure; focusing on EQIP	
Conservation Stewardship Program (CStP) (NRCS)	No measure; focusing on EQIP	
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; Focusing on EQIP	
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	Program in development, 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

It is important to note that the selected program measures reflect government programs and do not capture voluntary or industry-led conservation activities. There is the possibility that voluntary conservation activities that are not related to a specific government program can contribute a significant percentage of overall BMP adoption. As a result, while the selected program measures are strong indicators of program implementation trends, they are conservative indicators of statewide BMP adoption.

The Minnesota Accountability Act of 2013 will guide tracking efforts and 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 for program results, mid-strategy for Strategy pace, and 10 years for reassessment, starting with the Strategy implementation kickoff date and working toward the Phase I Milestone year 2025. Reporting will be led by the Accountability Team identified in Chapter 6 strategies and may report findings to the Clean Water Council or Minnesota Legislature.

Two-year tracking and reporting (2014–2016)

- Review progress toward milestones using existing technologies.
- Update research for feasible measures (e.g., cover crops and biomass crops).
- Evaluate implementation progress reported through the 2013 Clean Water Legacy Accountability Act to determine relevance to Strategy progress reporting and tracking.
- Review progress toward program optimization activities outlined in Step Up Plans.
- Review effectiveness of comprehensive Strategy outreach campaign and adjust as necessary.
- Compile water quality monitoring/modeling information to evaluate in-stream loads.

Five-year tracking and reporting (2019 and 2024)

- Assess implementation progress through other reporting (e.g., 2013 Clean Water Legacy Accountability Act).
- Report on success of Step Up Plans and identify needed program adjustments to achieve milestones.
- Survey key target audiences to gauge behavior change associated with comprehensive Strategy outreach campaign.
- Compile water quality monitoring and modeling information to evaluate in-stream loads.
- Continue to assess voluntary and industry-led implementation activities and associated nutrient reductions.

Ten-year Strategy reassessment tracking and reporting (2024)

- Evaluate milestones for Phase 2 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.

7.1.2 Water Quality Evaluation

Future water quality evaluations will rely upon the Watershed Pollutant Load Monitoring Network and efforts to complete statewide 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.

Watershed Pollutant Load Monitoring Network

The Watershed Pollutant Load Monitoring Network (WPLMN) is a multi-agency effort that the Minnesota Pollution Control Agency (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 8-digit hydrologic unit code (HUC8) 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 that the Metropolitan Council Environmental Services, local monitoring organizations, and MPCA staff collect to compute annual pollutant loads at river monitoring sites across Minnesota. The WPLMN is summarized at *www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/streams-and-rivers/watershed-pollutant-load-monitoring-network.html*.

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 7-2). 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.

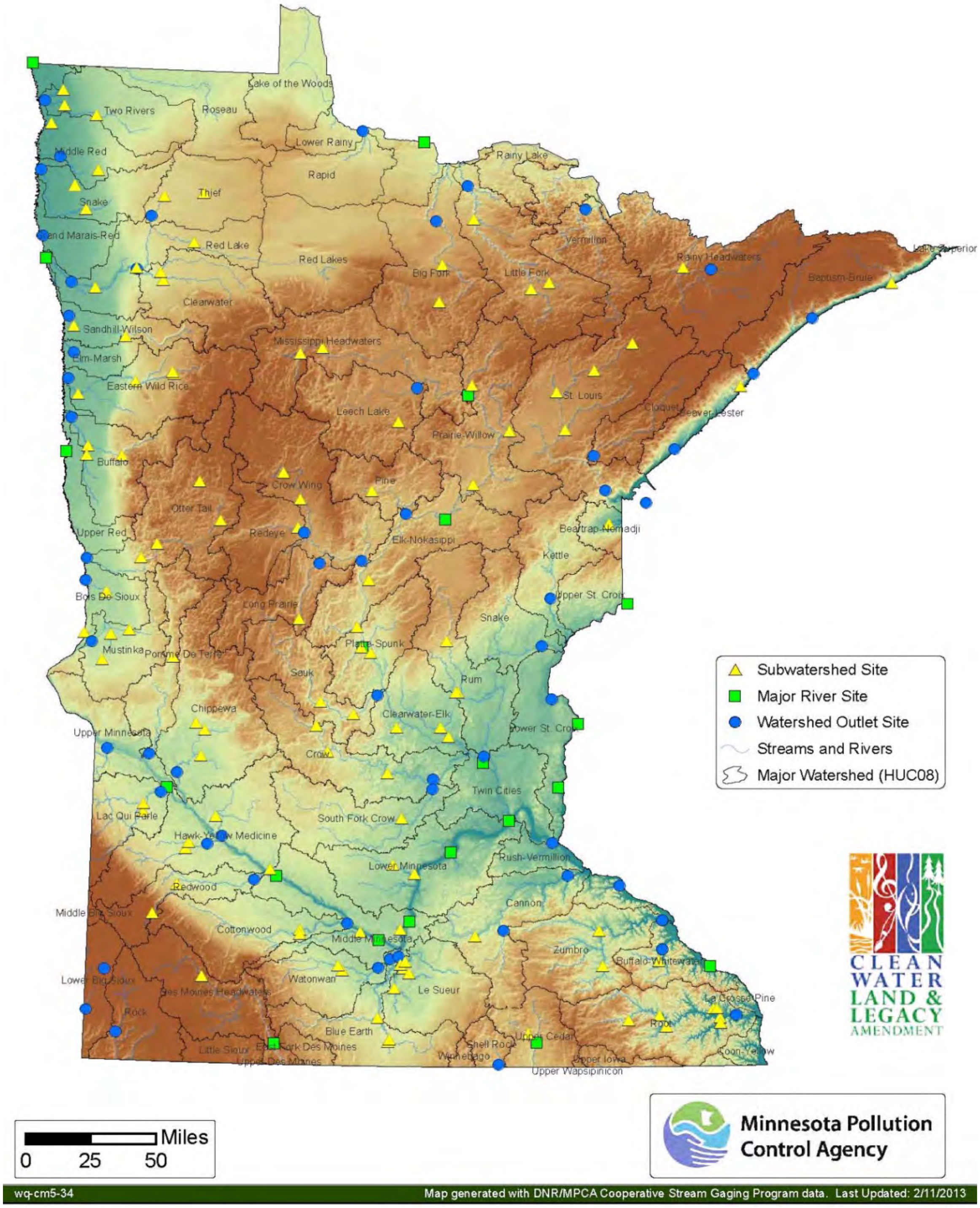


Figure 7-2. WPLMN monitoring sites.

Annual water quality and daily average discharge data are coupled in the Flux32pollutant load model, originally developed by Dr. Bill Walker and recently upgraded by the U.S. Army Corp of Engineers and the MPCA, 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 (DOP), nitrate plus nitrite nitrogen (NO3+NO2-N) and total Kjeldahl nitrogen (TKN). The NO3+NO2-N is added to TKN to represent nitrogen.

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

Statewide Watershed Modeling

The Hydrological Simulation Program - FORTRAN (HSPF) model supports statewide watershed analysis. The HSPF model is a comprehensive model for simulating watershed hydrology and water quality for both conventional pollutants such as nutrients, and toxic organic pollutants. HSPF allows the integrated simulation of land and soil contaminant runoff processes with in-stream hydraulic and sediment-chemical interactions. The result of this simulation is a time history of the runoff flow rate, sediment load, and nutrient and pesticide concentrations, along with a time history of water quantity and quality at the outlet of any subwatershed.

Figure 7-3 provides a summary of the current status of HSPF modeling in the state (current through August 2013).

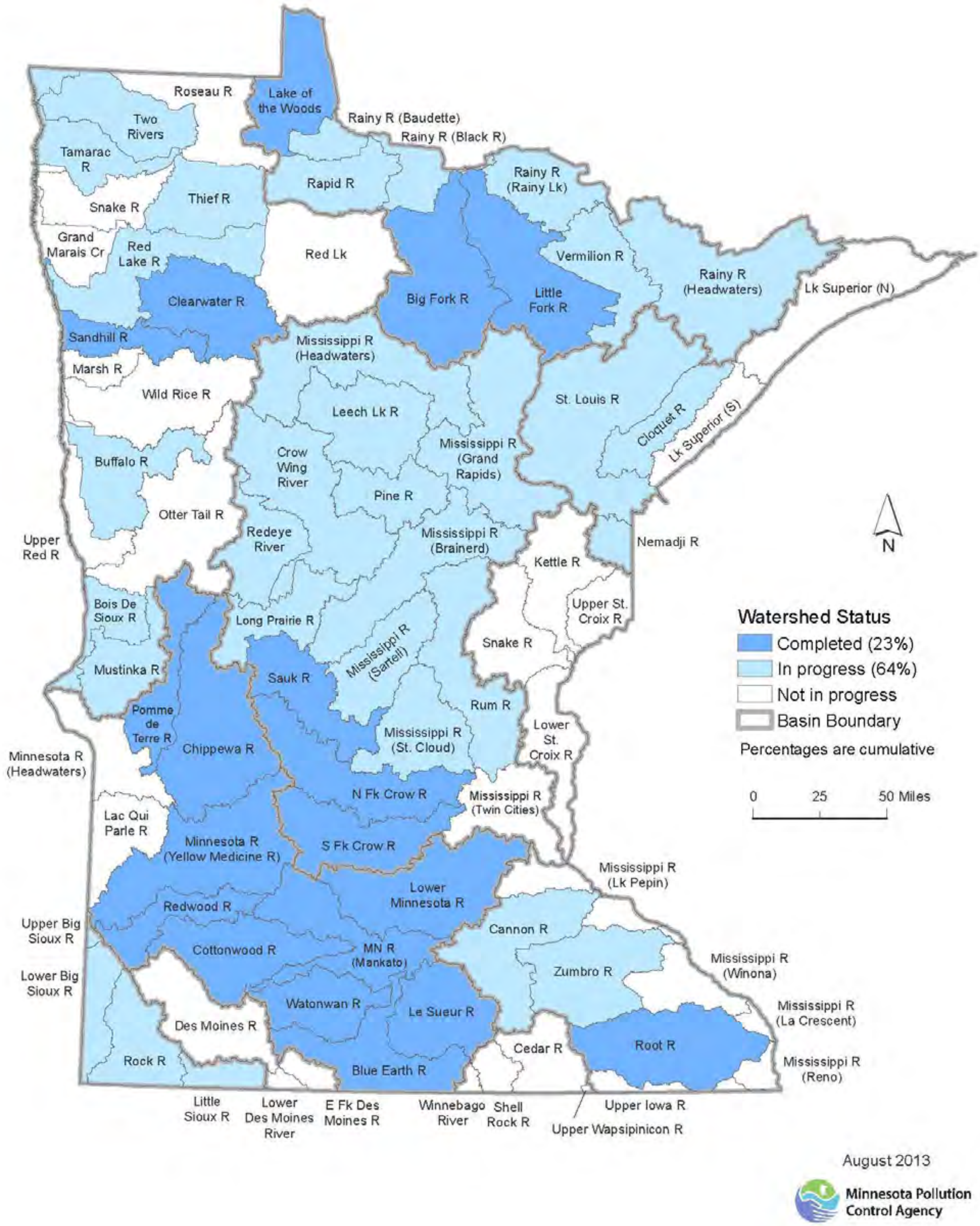


Figure 7-3. Status of HSPF modeling (August 2013).

7.2 Create a System or Approach for Collecting Data and Information Needed to Track Progress toward Strategy Goals and Milestones

Tracking progress toward the Strategy 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 Strategy 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 D. Data from several nutrient reduction programs are tracked through grant or program-specific systems such as the Board of Water and Soil Resources (BWSR's) eLink database. Over time, an interagency, integrated tracking tool will provide a more systematic approach for compiling the data from the various programs to support regular assessments of the Strategy's progress and reporting to key stakeholders within and outside of Minnesota.

7.2.1 Approach for Tracking Progress

A systematic approach for collecting and analyzing the output and outcome data and information is necessary to track progress over time. As Chapter 7.1 describes, outcome data are generated through existing MPCA monitoring and modeling activities and rely on established procedures for data collection. Strategy output data related to BMP implementation, however, does not have a similar existing set of procedures due to the dispersed nature of the information. The measure metadata worksheets in Appendix D provide an initial mechanism for capturing key output information about the suite of Strategy 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 strategies Chapter 6 identified. This will require a crosswalk between the BMPs identified on the Strategy Reduction Summary for each basin presented in Chapter 5 with the BMPs associated with the quantified program measures at the HUC8 and basin scales. The crosswalk of these two components of the Strategy will illustrate where BMPs have been implemented through existing government-based programs and where additional BMPs are necessary.

The approach for tracking progress needs to also account for nongovernment-affiliated BMP implementation. This will start with an initial inventory of BMP implementation developed with assistance from county soil and water conservation districts (SWCDs) to establish a baseline level of nongovernment-affiliated, voluntary BMP implementation that can then be evaluated at the HUC8 and basin scales to supplement the information tracked through the program measures. A preferred approach would be a national census of conservation practices that provides a consistent methodology and statistical representation of current conservation practices. Until such time as this is established and reported at the watershed scale, Minnesota should continue to work with state and national agricultural statistic services to conduct such a census periodically.

7.2.2 Tools for Tracking Progress

There is currently no integrated tool that will allow for automated tracking of Strategy 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.

A Strategy 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 to Strategy success. The recommended approach for a Strategy 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 Strategy 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 Strategy tracking tool is provided below. Appendix E provides more detailed information on the preliminary requirements of this type of 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 Strategy 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.

Task 3: Analyze Existing Data Management Systems to Support Data Extraction and Integration. The Strategy 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 Strategy tracking tool.

Task 4: Identify Data Sources or Approaches for Obtaining Voluntary or Industry-Led BMP Information. The Strategy 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 Strategy tracking tool team would verify the preliminary tracking tool requirements and, as necessary, add other requirements to inform tool development.

Task 6: Develop Nutrient Strategy Tracking and Accounting System Web Page. The final comprehensive system requirements analysis would then allow the Strategy 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 Strategy 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 Strategy tracking tool.

The timing of the Strategy 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 Strategy's tracking needs into other ongoing system development and refinement projects. Examples of ongoing system development opportunities that could integrate Strategy 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 (TMDL) and watershed restoration and protection strategy (WRAPS) program staff to develop a data capture tool to meet a 2016 court-ordered 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, Minnesota Department of Agriculture (MDA), Minnesota Department of Health, DNR, and the Metropolitan Council.

There is also a need for improved data collection among Minnesota agencies and key federal agencies working within the state, specifically Farm Service Agency (FSA) and Natural Resource Conservation Service (NRCS). There is also 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.

7.3 Evaluate Trends

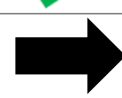
Assessing trends in the data allows for an evaluation of progress toward Strategy goals and milestones. The suite of program and water quality measures developed for this initial iteration of the Strategy will provide the primary trends to assess progress over time. For program output measures, trends are documented in the measure metadata worksheets and communicated in the Program Output Report card. For water quality measures, trends are documented in Chapter 3. In addition, quantitative BMP tracking is needed to determine implementation progress toward the Strategy goals and milestones over time. The strategy summary figures in Chapter 5 identify the load reductions needed for each basin to reach Phase 1 Milestones, and the suggested suite of BMPs and other reduction measures. Progress since Baseline should be updated periodically to determine progress toward phased milestones for each basin. These quantitative summaries can be used in the future to track BMP implementation over time and will provide the big picture of the Strategy's progress.

7.3.1 Program Output

The Program Output Scorecard is similar in concept to the report card 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 will provide both a qualitative and quantitative approach to reporting on progress toward nutrient reduction goals (Table 7-2). For example, a program measure that is showing negative implementation trends (e.g., diminished voluntary participation or significant exceedances of a mass limit) will be represented by a red symbol on the Strategy report card. A yellow symbol will represent programs that have no change in implementation over time. A green symbol will represent programs that demonstrate progress toward programmatic nutrient reduction goals over time. As Strategy implementation actions are further derived, specific targets can be added to the measures, and the report card can be updated to reflect quantitative targets. For example, if a strategy is developed as part of the program Step Up Plans that includes an increase in Reinvest in Minnesota (RIM) permanent easement acreage by 2 percent per year for the next 20 years, progress toward this milestone could be tracked in the report card as either on track or not on track to meet the milestone. The measure would include the quantitative information to support the score.

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 D). 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 Strategy 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 Strategy implementation.

At this time, specific targets are not provided for programmatic measures. In the future, as Step UP Plans are developed, targets can 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. Developing appropriate implementation targets for programmatic measures is an important component of Step Up Plans to ensure measures can support adaptive management of the Strategy.

Table 7-3. Strategy report card, program output measures

Measures	Status	BMP Adoption Trend	Description
Program Output Measures			
Implementation of priority Environmental Quality Incentives Program (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 Reinvest in Minnesota (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 Conservation Reserve Program (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		

Measures	Status	BMP Adoption Trend	Description
Program Output Measures			
Implementation of conservation tillage funded through Agricultural BMP (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.
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.

7.3.2 Water Quality Outcomes

Although the program measures will provide an indication of implementation progress, the Water Quality Outcome Measures will provide a more significant yardstick for measuring progress toward Strategy milestones over time. Water quality and flow analysis include trends in total load and flow weighted mean concentrations (FWMC) (see Chapter 3). Both measures are important toward understanding changes in load over time and tracking progress toward milestones and goals. These measures will both require improvement in order to show progress at the basin level. Progress toward achieving eutrophication standards in lakes and flowing waters also provides a measure for how well the Strategy addresses in-state load reduction goals. These three factors, along with additional statistical evaluations and groundwater monitoring and evaluation (see Chapter 3), can be combined to present a reasonable picture of water quality outcome progress in the state. In summary, the measures are defined as:

- Trend in actual load
- Trend in FWMC
- Progress toward meeting eutrophication standards
- Statistical comparisons of baseline loads and concentrations at low, medium and high flow periods with comparable flow periods during recent years

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.

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.

- Progress toward reducing groundwater nitrate in high-nitrate areas, including those watersheds where nitrate coming from groundwater currently impairs surface waters

These measures are similar in nature to those being used as part of the Clean Water Fund implementation tracking work and will likely complement that work. These measures could be summarized in metadata worksheets and report cards in the future.

The location of the monitoring evaluations is also important for understanding progress made in reducing nutrients in waters. Some locations will have a longer lag time before the effects of BMPs are evident in monitoring-based information. Some locations have better historical data from which to make trend evaluations. Also, it is important to understand which watersheds are making progress and which are not. Monitoring is needed at multiple points in the state, including outlets of HUC8 watersheds, major basins, and state boundaries. Wells and springs should also be monitored at numerous locations.

7.4 Adjust Strategy

The ultimate step of the adaptive management process is adjusting the Strategy implementation activities based on the data collection and trend evaluation process to ensure progress toward the Strategy goals and milestones. Adjustments to the Strategy could include recommendations for optimizing program implementation, guided by the trends seen in the suite of programmatic measures. An initial set of recommendations for program improvements were compiled during the Strategy development phase and could be used to during the first adaptive management evaluation point in 2016. Appendix C presents these program improvement recommendations.

In addition, adjustments to the Strategy could include modifications to the milestones based on implementation information and new water quality modeling/monitoring information. It will be necessary to document the rationale for any adjustments to the Strategy on the basis of programmatic and water quality data compiled to support the Strategy. Where adjustments are recommended, updated versions of the Strategy will be necessary to document the changes.

Figure 7-3 provides an example adaptive management schedule for the Mississippi River Basin.

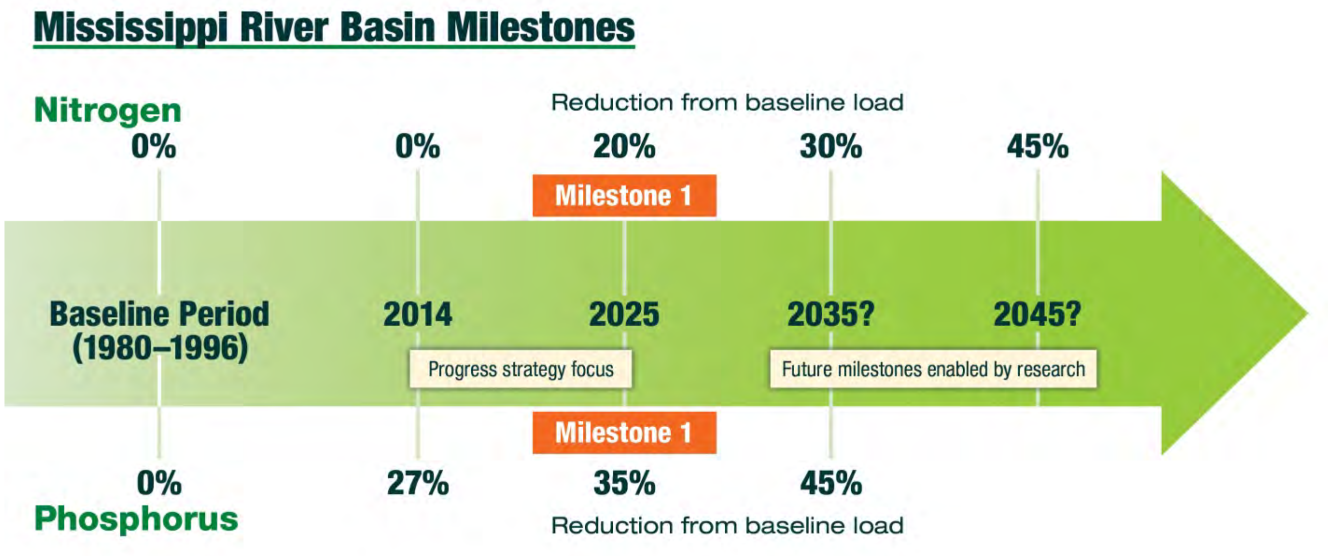


Figure 7-4. Example adaptive management schedule for the Mississippi River Basin.

Using the steps described above, a Strategy Evaluation Report will be prepared that presents updated trend information, compares trends against milestones to identify potential challenges toward the next set of milestones, and provides recommended adjustments to the Strategy, with a schedule and estimates of necessary resources. The Strategy Evaluation Report will also present assumptions and, if available, supporting data to describe why expected progress is limited, as well as future research and data needs.

Chapter 8

References and Literature

Barr Engineering. 2004. *Detailed Assessment of Phosphorus Sources to Minnesota Watersheds.* Prepared for Minnesota Pollution Control Agency, by Barr Engineering Company, Minneapolis, MN. Accessed February 2013. http://www.pca.state.mn.us/index.php/water/water-monitoring-and-reporting/water-quality-and-pollutants/phosphorus/detailed-assessments-of-phosphorus-sources-to-minnesota-watersheds.html.

Bierman, P., C. Rosen, R. Venterea, and J. Lamb. 2011. Survey of Nitrogen Fertilizer Use on Corn in Minnesota. 27 pp.

Birr, A.S. and D.J. Mulla. 2001. Evaluation of the Phosphorus Index in Watersheds at the Regional Scale. *Journal of Environmental Quality* 30(6): 2018-2025.

Busman, L. and G. Sands. 2002. Agricultural Drainage. University of Minnesota Extension Service. College of Food, Agricultural and Natural Resource Sciences, St. Paul, MN.

Fabrizzi, K. and D. Mulla. 2012. *Effectiveness of Best Management Practices for Reductions in Nitrate Losses to Surface Waters in Midwestern U.S. Agriculture*. Prepared for the Minnesota Pollution Control Agency.

Hirsch, R.M., D.L. Moyer, and S.A. Archfield. 2010. Weighted Regressions on Time, Discharge, and Season (WRTDS), with an Application to Chesapeake Bay River Inputs. *Journal of American Water Resources Association* 46 (5): 857-871.

Huang, W. 2002. Using Insurance to Enhance Nitrogen Fertilizer Application Timing to Reduce Nitrogen Losses. *Journal of Agricultural and Applied Economics* 34 (1): 131-148.

Iowa Department of Agriculture and Land Stewardship, Iowa Department of Natural Resources, and the Iowa State University College of Agriculture and Life Sciences. 2013. Iowa Nutrient Reduction Strategy.

Iowa State University. 2013. Iowa Science Assessment of Nonpoint Source Practices to Reduce Nitrogen and Phosphorus Transport in the Mississippi River Basin. Section 2 in *Iowa Nutrient Reduction Strategy.* Iowa Department of Agriculture and Land Stewardship, Iowa Department of Natural Resources, and Iowa State University College of Agriculture and Life Sciences, Ames, IA.

Lazarus, W., G. Kramer, D. Mulla, and D. Wall. 2013. Watershed Nitrogen Reduction Planning Tool (NBMP.xlsm) for Comparing the Economics of Practices to Reduce Watershed Nitrogen Loads. University of Minnesota, St. Paul, MN. 54 pp. http://www.mda.state.mn.us/protecting/cleanwaterfund/gwdwprotection/~/media/Files/protecting/cwf/2009nitrocorn.ashx.

LTI (LimnoTech Incorporated). 2009. *Upper Mississippi River-Lake Pepin Water Quality Model: Development, Calibration and Application*. Prepared for Minnesota Pollution Control Agency, by LimnoTech Incorporated, Ann Arbor, MI.

Loehr, R.C., C. S. Martin, and W. Rast. 1980. Phosphorus Management Strategies for Lakes. In *Proceedings of the 1979 Conference*, Ann Arbor Science Publishers Inc., Ann Arbor, MI. 490 pp.

Magdalene, S. 2009. Lake St. Croix Total Phosphorus Loading Study. St. Croix River Basin Water Resources Planning Team Implementation Committee.

Manitoba Water Stewardship Division. 2003. Lake Winnipeg Action Plan. http://www.gov.mb.ca/waterstewardship/water_quality/lake_winnipeg/action_plan.html

Maryland Department of Agriculture, USDA-Maryland Natural Resources Conservation Service, Kent Soil and Water Conservation District, Queen Anne's Soil Conservation District, and Maryland Department of Natural Resources Forestry Service. 2011. *Upper Chester River Showcase Watershed Project Farm Assessment Report*. http://www.upperchester.com/UC_Assessment.pdf.

MDA (Minnesota Department of Agriculture). 2008. Sesquicentennial Agricultural History Timeline. Minnesota Department of Agriculture, St. Paul, MN.

MDA (Minnesota Department of Agriculture). 2009. 2009 Survey of Nitrogen Fertilizer Use on Corn in Minnesota. Minnesota Department of Agriculture, St. Paul, MN. 25 pp.

MDA (Minnesota Department of Agriculture). 2012. Ethanol Program. Minnesota Department of Agriculture, St. Paul, MN. http://www.mda.state.mn.us/Ethanol.

MDA (Minnesota Department of Agriculture). 2013. *Nitrogen Fertilizer Management Plan* (DRAFT). Minnesota Department of Agriculture, St. Paul, MN.

Miller, T.P., J.R. Peterson, C.F. Lenhart, and Y. Nomura. 2012. *The Agricultural BMP Handbook for Minnesota*. Prepared for the Minnesota Department of Agriculture. www.eorinc.com/documents/AG-BMPHandbookforMN_09_2012.pdf.

Minnesota Climatology Working Group. 2013. Minnesota State-Averaged Annual Precipitation. State Climatology Office, Department of Natural Resources, Division of Ecological and Water Resources, University of Minnesota. Accessed February 2013. http://climate.umn.edu/pdf/minnesota_state_averaged_precipitation.pdf

Minnesota State Demographic Center. 2013. Census 2010. Accessed February 2013. http://www.demography.state.mn.us/.

Mississippi River/Gulf of Mexico Watershed Nutrient Task Force. 2008. *Gulf Hypoxia Action Plan 2008 for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico and Improving Water Quality in the Mississippi River Basin*. Accessed October 2012. http://water.epa.gov/type/watersheds/named/msbasin/actionplan.cfm.

Moncrief, J., P. Bloom, N. Hansen, D. Mulla, P. Bierman, A. Birr, and M. Mozaffari. 2006. *Minnesota Phosphorus Site Risk Index, Technical Guide*. Department of Soil, Water and Climate, University of Minnesota, St. Paul, MN.

MPCA (Minnesota Pollution Control Agency). 1989. Ground Water Contamination Susceptibility in Minnesota. (Posted announcement). Minnesota Pollution Control Agency, St. Paul, MN.

MPCA (Minnesota Pollution Control Agency). 2000. Phosphorus Strategy. Minnesota Pollution Control Agency, St. Paul, MN. http://www.pca.state.mn.us/index.php/water/water-monitoring-and-reporting/water-quality-and-pollutants/phosphorus/mpca-phosphorus-strategy.html.

MPCA (Minnesota Pollution Control Agency). 2004. *Lower Minnesota River Dissolved Oxygen Total Maximum Daily Load Report*. Minnesota Pollution Control Agency, St. Paul, MN. http://www.pca.state.mn.us/index.php/view-document.html?gid=7994.

MPCA (Minnesota Pollution Control Agency). 2011. *Lake Pepin Site Specific Eutrophication Criteria*. Minnesota Pollution Control Agency, St. Paul, MN. Accessed October 2012. http://www.pca.state.mn.us/index.php/view-document.html?gid=14921.

MPCA (Minnesota Pollution Control Agency). 2012. *Lake St. Croix Nutrient Total Maximum Daily Load*. Prepared by the Minnesota Pollution Control Agency and Wisconsin Department of Natural Resources. Accessed October 2012. http://www.pca.state.mn.us/index.php/view-document.html?gid=18736.

MPCA (Minnesota Pollution Control Agency). 2013a. *Nitrogen in Minnesota Surface Waters, Conditions, Trends, Sources, and Reductions*. Minnesota Pollution Control Agency, St. Paul, MN. http://www.pca.state.mn.us/index.php/view-document.html?gid=19622.

MPCA (Minnesota Pollution Control Agency). 2013b. *The Condition of Minnesota's Groundwater, 2007–2011*. Minnesota Pollution Control Agency, St. Paul, MN. http://www.pca.state.mn.us/index.php/view-document.html?gid=19743.

NASS (National Agricultural Statistics Service). 2013. Cropland Data Layer. U.S. Department of Agriculture. http://nassgeodata.gmu.edu/CropScape/.

NOAA (National Oceanic and Atmospheric Administration). 2013. *Ecology of the Northeast U.S. Continental Shelf: Climate Influences*. Northeast Fisheries Science Center, National Oceanic and Atmospheric Administration. Accessed February 2013. http://www.nefsc.noaa.gov/ecosys/ecology/Climate/.

Preston, S. D., R.B. Alexander, G.E. Schwarz, and C.G. Crawford. 2011. Factors Affecting Stream Nutrient Loads: A Synthesis of Regional SPARROW Model Results for the Continental United States. *Journal of the American Water Resources Association* 47(5): 891–915.

RRBC (Red River Basin Commission). 2005. *Restoring the Health of Lake Winnipeg, Canada's Sixth Great Lake*. Lake Winnipeg Implementation Committee. Accessed October 2012. http://www.redriverbasincommission.org/lake_wpg_final.pdf.

RRBC (Red River Basin Commission). 2011. *A Proposed Approach to Developing a Basin-Wide Nutrient Management Strategy for the International Red River Watershed*. Accessed October 2012. http://www.redriverbasincommission.org/Reports/Approach_for_a_Nutrient_Management_Strategy_for_the_Red_River_Watershed.September_7-_2011.pdf.

Robertson, D.M. and D. A. Saad. 2011. Nutrient Inputs to the Laurentian Great Lakes by Source and Watershed Estimated Using SPARROW Watershed Models. *Journal of the American Water Resources Association* 47:1011–1033.

Sands, G. 2010. Drainage Fact Sheet. University of Minnesota Extension Service.

Schottler, S.P., J. Ulrich, P. Belmont, R. Moore, J.W. Lauer, D.R. Engstrom, and J.E. Almendinger. 2013. Twentieth Century Agricultural Drainage Creates More Erosive Rivers. *Hydrological Processes*, doi: 10:1002/hyp.9738.

Simpson, T. and S. Weammert. 2009. *Developing Best Management Practice Definitions and Effectiveness Estimates for Nitrogen, Phosphorus and Sediment in the Chesapeake Bay Watershed: Final Report*. Chesapeake Bay Program, Annapolis, MD.

Tetra Tech. 2009. Upland Practice Identification for Agriculture, Lake Pepin Implementation Support. Memorandum prepared for Minnesota Pollution Control Agency and U.S. Environmental Protection Agency, Region 5, by Tetra Tech, Inc., Research Triangle Park, NC.

Thomas, N.A., A. Robertson, and W.C. Sonzogni. 1980. Review of Control Objectives: New Target Loads and Input Controls. Chapter 4 in *Phosphorus Management Strategies for Lakes, Proceedings of the 1979 Conference*, eds. Loehr, R.C., C.S. Martin, and W. Rast, Ann Arbor Science, Ann Arbor, MI.

UMRBA (Upper Mississippi River Basin Association). 2011. *Upper Mississippi River Nutrient Monitoring, Occurrence, and Local Impacts: A Clean Water Act Perspective*. Accessed October 2012. http://www.umrba.org/wq/umr-nutrients.pdf.

University of Minnesota. 2011. Minnesota Water Sustainability Framework. Prepared by the University of Minnesota Water Resource Center, for the Minnesota State Legislature, St. Paul, MN.

U.S. Census Bureau. 2013. American Fact Finder. Accessed February 2013. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

USDA (United States Department of Agriculture). 2011. *State Agriculture Overview: Minnesota*. National Agricultural Statistics Service.

USDA (United States Department of Agriculture). 2012a. 2007 Census Volume 1, Chapter 1: State Level Data. Census of Agriculture. U.S. Department of Agriculture. Accessed February 2013. http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_1_State_Level /Minnesota.

USDA (United States Department of Agriculture). 2012b. The Conservation Reserve Program, 43rd Signup. County-by-County Statistics.

EPA (United States Environmental Protection Agency). 2008. *Lake Superior Lakewide Management Plan (LaMP) 2008*. Lake Superior Binational Program. Accessed October 2012. http://www.epa.gov/greatlakes/lamp/ls_2008/index.html.

EPA (United States Environmental Protection Agency). 2012. *Midwest Impacts and Adaptation*. U.S. Environmental Protection Agency, Accessed February 2013. http://www.epa.gov/climatechange/impacts-adaptation/midwest.html.

Wright, C.K., and M.C. Wimberly. 2013. Recent Land Use Change in Western Corn Belt Threatens Grassland and Wetlands. In *Proceedings of the National Academy of Sciences*, Geographic Information Science Center of Excellence, South Dakota State University.

Appendix A: Recent Progress 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 implementation of best management practices (BMPs) and wastewater treatment. Many of the nutrient reducing programs (see Chapter 4) contain numerous structural and non-structural BMPs implemented as part of these programs. Quantifying nutrient reductions associated with every BMP implemented through each program would not be a sustainable and replicable approach to show progress toward Strategy milestones and goals over time, and it is likely that the amount of data and information this approach would generate would dilute the significance in the context of assessing progress toward Strategy goals.

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
- Forage and Biomass Planting
- Residue Management
- Conservation Easements
- Nonpoint Source BMPs

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. 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.

In addition to these agricultural BMPs, recent trends in point source loads (wastewater) were also 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

SPARROW results, combined with NLCD land cover data, were used to estimate the nutrient loads by HUC8 watershed for 2002 land use conditions. SPARROW nitrogen loads attributed to agriculture were calculated for each HUC8 using the summed loads for manure, other agricultural sources, and atmospheric deposition for nitrogen. As atmospheric deposition of nitrogen applies to all land uses and not just agriculture, this load was 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.

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 "back out" the loads reduced by existing BMPs by implementing our findings regarding BMP load reduction efficiencies.

As noted in the main text, 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 BMP based on recent literature review efforts by the MPCA, MDA, and Iowa State University (Table A-1). Removal efficiencies were selected from these efforts with a focus on studies in the Midwest, with Minnesota-based studies receiving the highest priority.

Table A-1. BMP Removal Efficiencies

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

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.

Results

Table A-2 and Table A-3 present a summary of program quantification results for nitrogen and phosphorus, respectively. The loads presented in these tables represent the loads generated within Minnesota by basin or subbasin. The total loads from all sources presented in the tables (second column in each table) reflect the recent point source update to SPARROW. Percent nitrogen and phosphorus reduced (final two columns in each table) are presented both as percent of agricultural load and percent of total load based on SPARROW results.

The results of the program quantification analysis suggest that recent implementation of agricultural BMPs has not achieved a significant nitrogen load reduction relative to conditions in 2000, as represented by SPARROW. For nitrogen load about a 1.5 percent reduction of agricultural nitrogen load (which equates to just over 1 percent reduction of the entire nitrogen load) was estimated. For phosphorus, it appears that modest load reductions have recently been achieved (approximately 19 percent reduction of agricultural phosphorus load and 7 percent reduction of the entire phosphorus load).

Table A-2. Summary of Recent Progress for Nitrogen Loads (Total to State Line)

Basin	Current Conditions N with Point Source Update (metric tons/yr)	N from Agriculture (metric tons/yr)	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 from Ag. (metric tons/yr)	% of Ag. N Reduced	% of All N Reduced by Ag. BMPs
Cedar River	6,918	6,457	16	1	0	53	70	1.1%	1.0%
Des Moines River	4,507	4,278	36	1	0	36	73	1.7%	1.6%
Lake Superior	3,656	185	0	0	0	0	0	0.0%	0.0%
Mississippi River[a]	99,441	82,953	476	47	0	837	1,361	1.6%	1.4%
Missouri River	5,208	4,980	34	3	0	16	52	1.1%	1.0%
Rainy River	2,606	302	1	3	0	0	4	1.2%	0.1%
Red River	16,822	15,231	90	30	0	40	159	1.0%	0.9%
Total	**139,159**	**114,386**	**654**	**85**	**0**	**981**	**1,719**	**1.5%**	**1.2%**

a. Loads for the Mississippi River basin are tabulated at De Soto, WI downstream of the MN/IA state line, using SPARROW

Table A-3. Summary of Recent Progress for Phosphorus Loads (Total to State Line)

Basin	Current Conditions P with Point Source Update (metric tons/yr)	P from Agriculture (metric tons/yr)	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 Nonpoint Source BMPs (metric tons/yr)	Net P Reduction from Ag. (metric tons/yr)	% of Ag. P Reduced	% of All P Reduced by Ag. BMPs
Cedar River	242	92	0	0	1	1	3	5	5.9%	2.3%
Des Moines River	251	95	1	0	1	1	7	10	10.1%	3.8%
Lake Superior	255	15	0	0	0	0	2	2	12.6%	0.8%
Mississippi River[a]	5,553	2,110	18	1	28	13	418	478	22.7%	8.6%
Missouri River	290	110	1	0	1	0	11	14	12.7%	4.8%
Rainy River	204	86	0	1	1	0	5	6	7.4%	3.1%
Red River	949	398	4	0	6	1	28	39	9.8%	4.1%
Total	**7,742**	**2,907**	**24**	**2**	**39**	**15**	**474**	**554**	**19.1%**	**7.2%**

a. Loads for the Mississippi River basin are tabulated at De Soto, WI downstream of the MN/IA state line, using SPARROW

Table A-4 and Table A-5 present recent trends in 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. In general, there have been treatment improvements (especially for phosphorus in the Minnesota River, part of the Mississippi basin), but also offsetting increases in discharge volumes. Nitrogen loads from point sources have increased in most basins.

Table A-4. Summary of Recent Trends in Point Source Nitrogen at MN State Line

Basin	2002 Basis N (metric tons/yr)	N with Point Source Update (metric tons/yr)	Recent Change in Point Source N (metric tons/yr)	Percent Change in all N Due to Point Source Changes
Cedar River	6,839	6,918	+79	+1.2%
Des Moines River	4,485	4,507	+23	+0.5%
Lake Superior	3,245	3,656	+411	+12.7%
Mississippi River[a]	98,077	99,441	+1,364	+1.4%
Missouri River	5,182	5,208	+26	+0.5%
Rainy River	2,603	2,606	+4	+0.1%
Red River	16,881	16,822	-59	-0.3%
Total	**137,311**	**139,159**	**+1,848**	**+1.3%**

a. Loads for the Mississippi River basin are tabulated at De Soto, WI downstream of the MN/IA state line, using SPARROW

Table A-5. Summary of Recent Trends in Point Source Phosphorus at MN State Line

Basin	2002 Basis P (metric tons/yr)	P with Point Source Update (metric tons/yr)	Recent Change in Point Source P (metric tons/yr)	Percent Change in Total P Load Due to Point Source Changes
Cedar River	205	242	+37	+17.9%
Des Moines River	277	251	-27	-9.7%
Lake Superior	248	255	+7	+2.8%
Mississippi River[a]	6,644	5,553	-1,092	-16.4%
Missouri River	321	290	-31	-9.7%
Rainy River	204	204	+1	+0.4%
Red River	953	949	-4	-0.5%
Total	**8,852**	**7,742**	**-1,110**	**-12.5%**

a. Loads for the Mississippi River basin are tabulated at De Soto, WI downstream of the MN/IA state line, using SPARROW

A significant reduction in point source phosphorus load has been recently achieved in the Mississippi basin. The SPARROW results indicate that approximately 50 percent of the point source phosphorus load (delivered to the MN state line) has been reduced, although this is still only a small fraction of the total load from nonpoint sources. The reduction in Mississippi basin point source loads corresponds to a statewide reduction of approximately 13 percent of the phosphorus load from all point sources, as shown in Table A-5. However, SPARROW results also indicate that a slight increase of approximately 1 percent statewide in point source nitrogen has occurred, as shown in Table A-4. Based on the SPARROW results, the greatest *increase* in point source nitrogen occurred in the Lake Superior basin. Further, the greatest *increase* in point source phosphorus occurred in the Cedar River basin. The greatest *decrease* in point source phosphorus occurred in the Mississippi River basin.

Appendix B: 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 C: Program Recommendations

Table C-1 presents a summary of short, medium, and long-term recommendations for improving the performance of the program, as well as tracking information to support the Strategy. Much of this information is derived from program managers and staff. Short-term is defined as the next 12 months. Medium term is defined as the next 2-5 years. Long term is defined as the next 5-10 years.

Table C-1. Program recommendations

Program	Short-term improvements	Medium-term improvements	Long-term improvements
Erosion Control and Water Management Program/State Cost-Share Program (BWSR)	Include high priority watersheds in the state for nutrient reduction in the overall criteria for funding Add nitrogen removal as a required input for reporting in eLINK Complete Step Up Plan	Continue to fund research related to BMPs and projects in high priority watersheds.	
Reinvest in Minnesota (RIM) Reserve Program (BWSR)	Incorporate a mechanism for estimating nutrient load reductions associated with RIM conservation easements as part of the RIM database Complete Step Up Plan	Connect RIM database to other statewide tracking efforts Include constructed wetlands in RIM (similar to the CRP CP-39 program)	Modify program to promote harvesting biomass in strategic locations in the easement which could reduce the potential for vegetation to reach water courses and wetlands
Nonpoint Source Management Program (Section 319) (MPCA)	Include high priority watersheds in the state for nutrient reduction in the overall criteria for funding Add nitrogen removal as a required input for reporting in eLINK Complete Step Up Plan	Continue to fund research related to BMPs and projects in high priority watersheds.	Consider effect of amendment funding coming to an end and develop a plan to continue implementation activities
Nitrogen Fertilizer Management Plan (NFMP) (MDA)	Include number of fields and associated acreage by county captured in statewide nutrient fertilizer survey to allow analysis of results at the 8-digit HUC scale Compile FANMAP data into a searchable database Complete Step Up Plan	Incorporate a mechanism for estimated nutrient load reductions associated with nitrogen fertilizer BMPs captured in survey results	

Program	Short-term improvements	Medium-term improvements	Long-term improvements
Clean Water Land and Legacy Program (BWSR)	Include high priority watersheds in the state for nutrient reduction in the overall criteria for funding Add nitrogen removal as a required input for reporting in eLINK Complete Step Up Plan	Continue to fund research related to BMPs and projects in high priority watersheds.	Consider effect of amendment funding coming to an end and develop a plan to continue implementation activities
Conservation Reserve Program (CRP) (FSA)	Report county-specific information for each practice over time to allow the acreage information to be incorporated into the Strategy's 8-digit HUC analysis of implementation Work with state partners to improve outreach/education to agricultural community on benefits of riparian buffers to promote increased participation Complete Step Up Plan		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.
Conservation Reserve Enhancement Program (CREP) (FSA)	Captured in CRP		
Conservation Security Program (CSP) (NRCS)	Determine method for quantifying nutrient reductions to support new measures for future iterations of the Strategy Complete Step Up Plan		
Conservation Stewardship Program (CSP) (NRCS)	Determine method for quantifying nutrient reductions to support new measures for future iterations of the Strategy Complete Step Up Plan		

Program	Short-term improvements	Medium-term improvements	Long-term improvements
Environmental Quality Incentives Program (EQIP) (NRCS)	Work with state agencies to identify other incentive mechanisms to increase enrollment in EQIP when commodity prices create an incentive for unenrollment Consider additional indicators BMPs such as Cover Crops to inform program measure Complete Step Up Plan		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.
Wetland Reserve Program (WRP) (NRCS)	Determine method for quantifying nutrient reductions to support new measures for future iterations of the Strategy Complete Step Up Plan		
Agricultural Best Management Practices (AgBMP) Loan Program (MDA)	Develop approach to include AgWaste projects in the Strategy measure and estimate associated nutrient load reductions Complete Step Up Plan	Develop and implement mechanism to verify the actual acreage under conservation tillage as a result of loans	
Commercial Animal Waste Technicians (CAWT Program) (MDA)	Determine method for quantifying nutrient load reductions associated with technician certification for new measures to include in future iterations of the Strategy Complete Step Up Plan		

Program	Short-term improvements	Medium-term improvements	Long-term improvements
Minnesota Agricultural Water Quality Certification Program	Ensure that on-going program development activities address the issue of nutrient load reduction associated with activities eligible for certification and ensure a way to track nutrient removal with these activities Complete Step Up Plan		
Industrial/Municipal Wastewater NPDES Permitting (MPCA)	Continue efforts focused on reducing inflow and infiltration along with reducing flow from individual users as techniques to reduce flow from WWTPs. Continue to implement Phosphorus Strategy. Begin monitoring of nitrogen species at WWTPs. Complete Step Up Plan	Provide additional operational assistance to WWTP operators to aide in maximizing phosphorus and nitrogen removal using existing treatment units. Develop Nitrogen Management Plans at select facilities Conduct a pilot study of BNR or ENR to determine the best technology for a targeted plant and the actual nitrogen reductions associated with the technology	Consider requiring nitrogen management plans in the future to minimize sources of TN to WWTPs and optimize operation at WWTPs. Start implementing nitrogen removal as needed to comply with effluent limits Assess point source-nonpoint source trading feasibility to achieve additional nutrient load reductions.

Implementation of Nonpoint Source (NPS) Best Management Practices (BMPs) Tracked via eLink and Estimated Nutrient Load Reductions

Measure Background

Visual Depiction

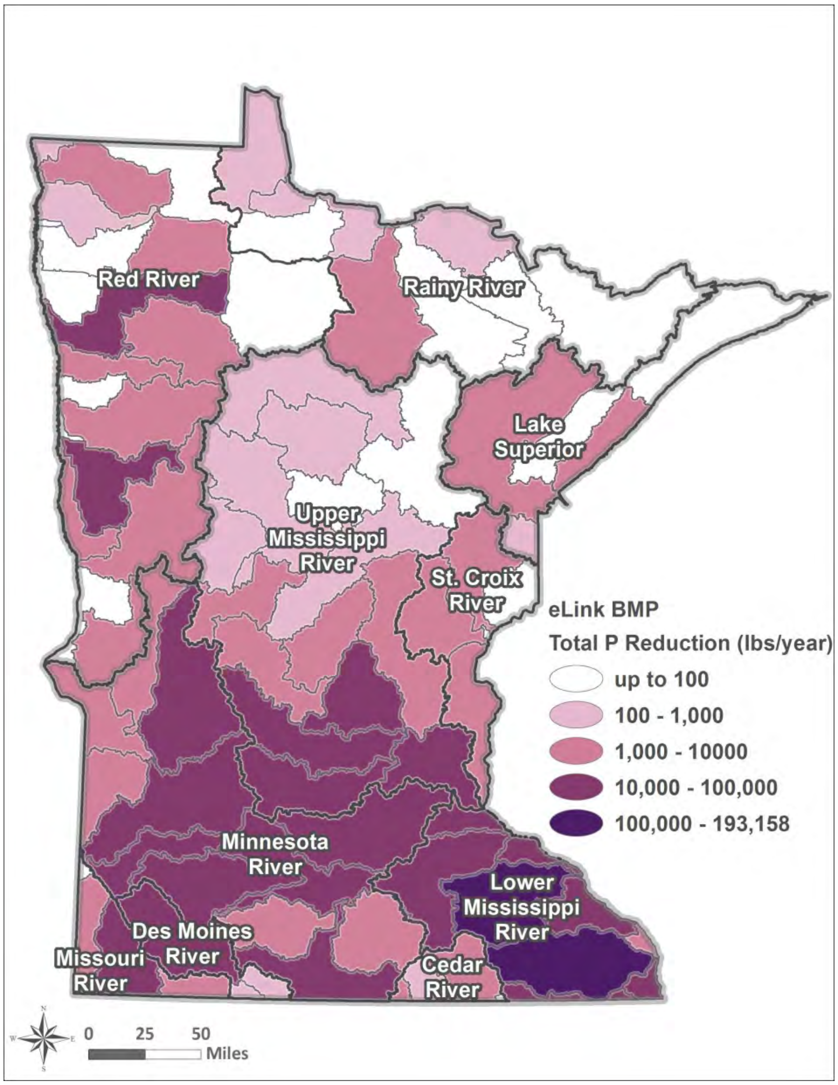


Figure 1. TP load reductions as reported in eLINK, data retrieved March 2013.

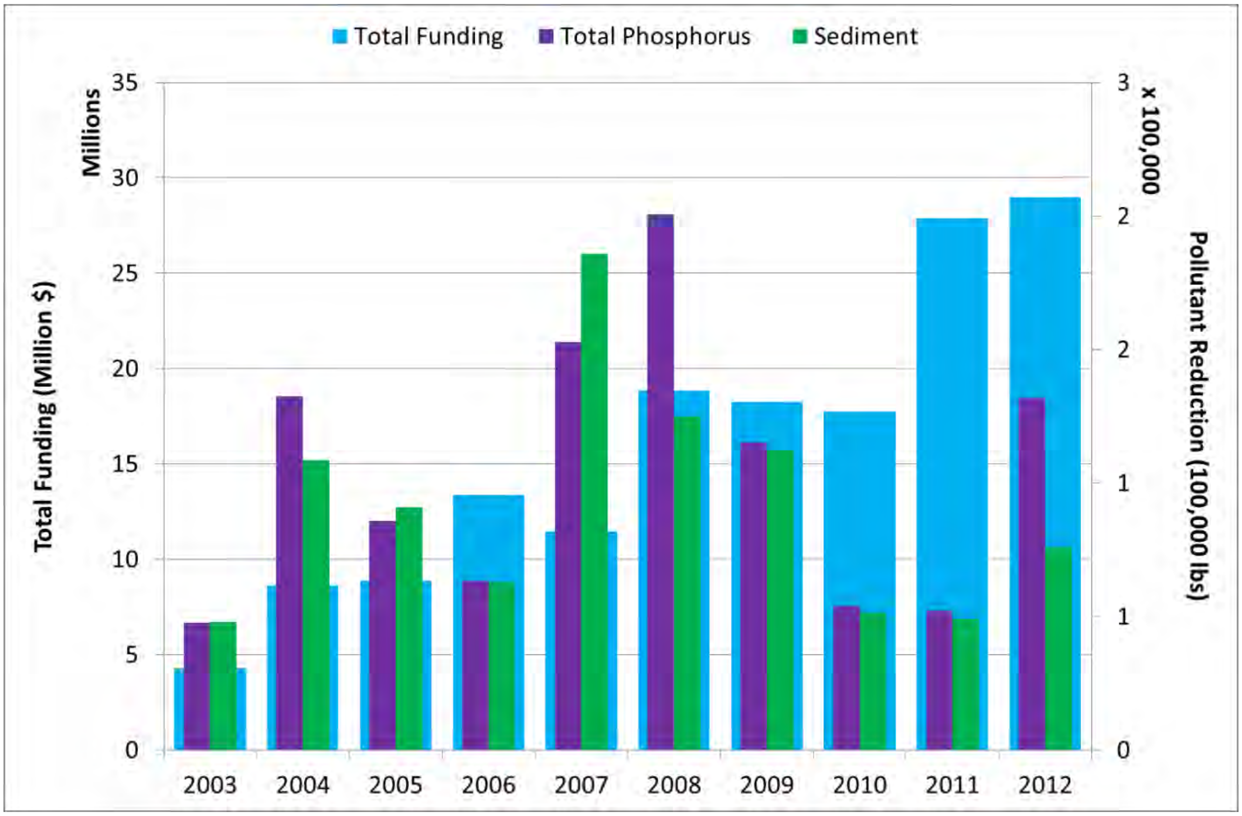


Figure 2. Annual total funding for NPS projects, as reported in eLINK, 2003- 2012.
Note – Annual total funding is a combination of multiple fund sources including Federal and local dollars, dates are based on the project year included in the database. Any other reported years were ignored in Figure 2, 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 pollutant estimators for eLINK based on soil erosion (sheet, rill, gully and stream channel). Sediment reduction estimates in eLINK are 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 are derived from sediment reduction estimates. Detailed information on the calculations used in eLINK for estimating pollutant load reductions is available at ftp://ftp.bwsr.state.mn.us/elink/Manual2006/19PolRedCalc.pdf.

For programs administered by BWSR, local grant recipients are required to enter BMP data in eLINK. More information on eLINK is available at www.bwsr.state.mn.us/outreach/eLINK/manual/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% 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

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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.

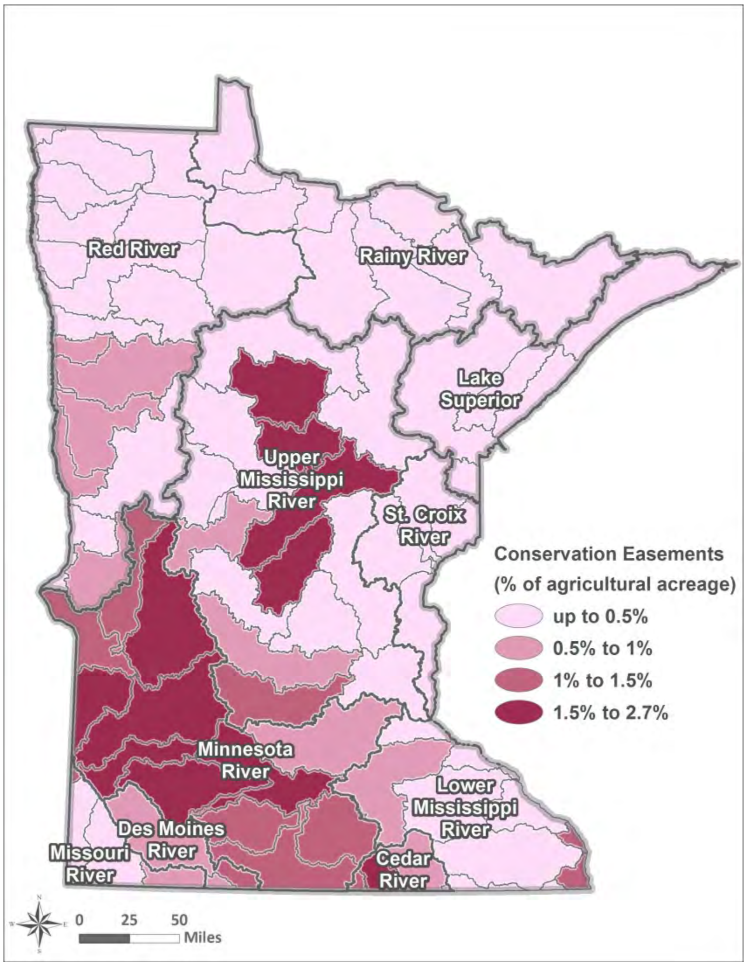

Figure 1. Percentage of permanent conservation easements of total agricultural acreage by 8-digit HUC.

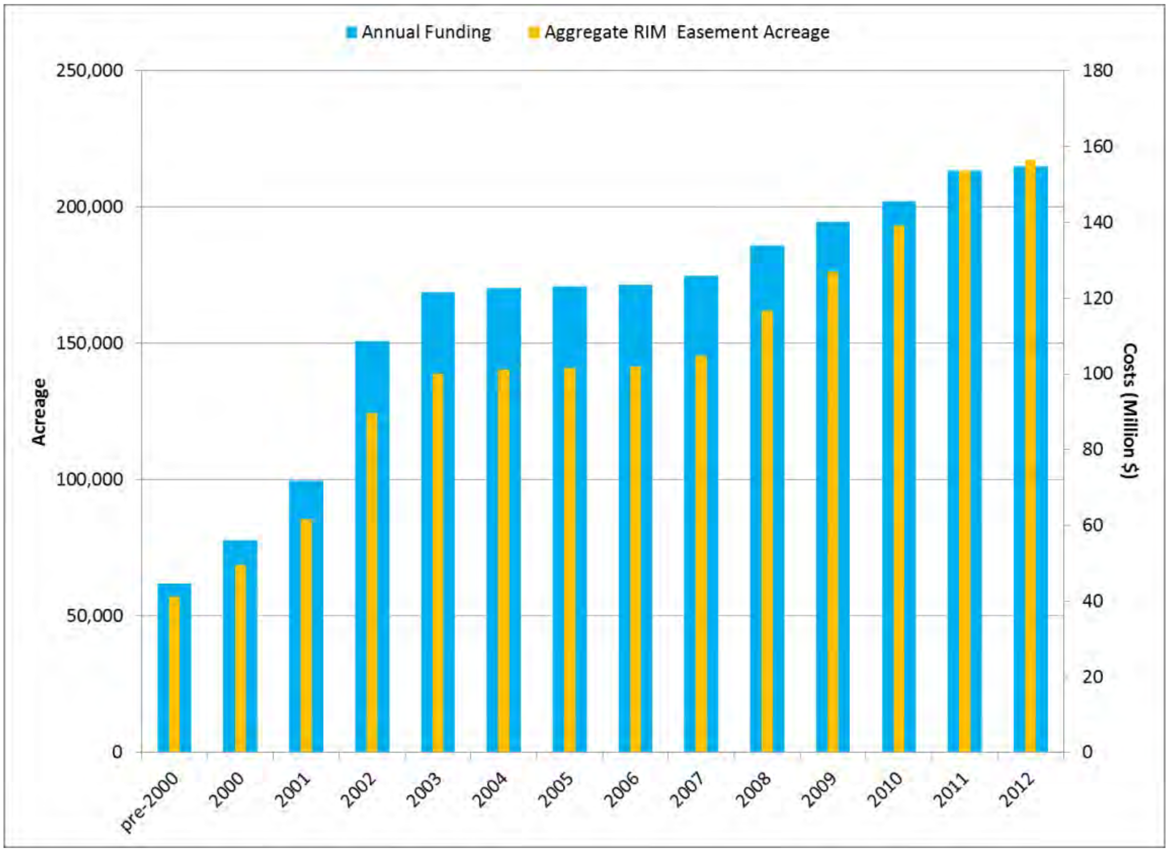

Figure 2. Aggregated annual RIM permanent conservation easement acreage and annual RIM funding.

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

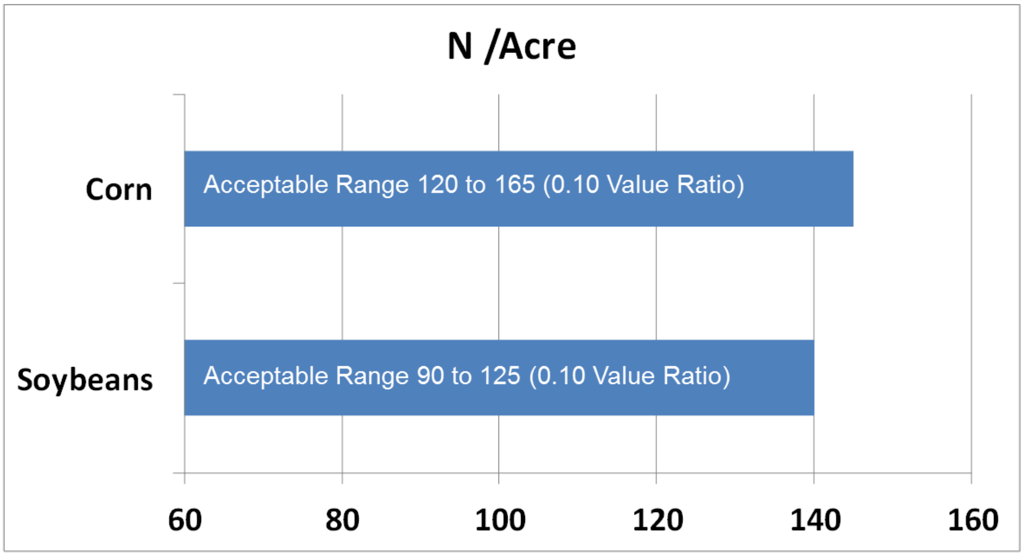

Figure 1. Nitrogen fertilizer application rates on non-manured corn following different crops in 2009 by surveyed farmers reporting on an average field

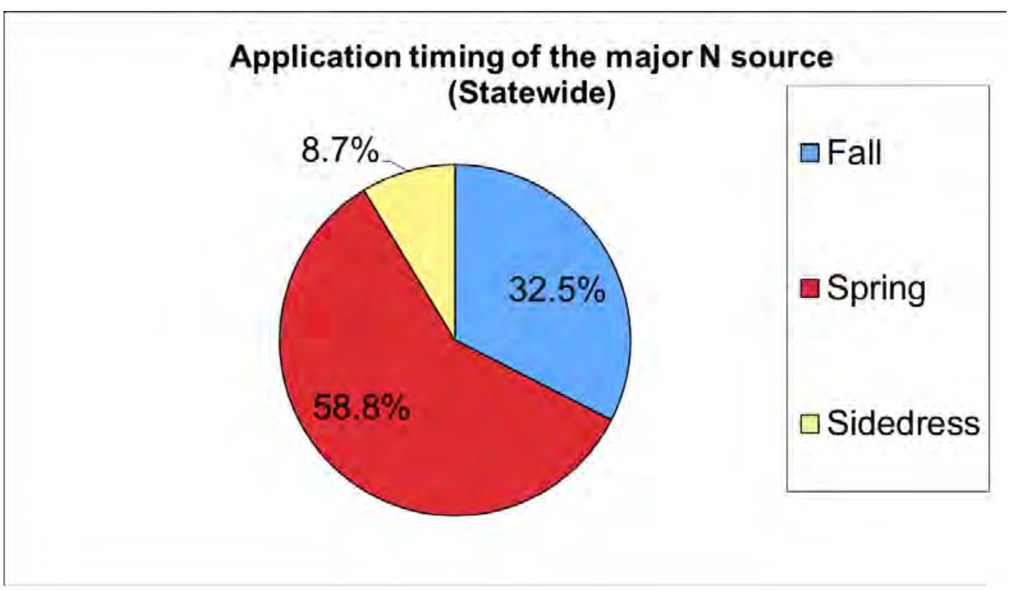

Figure 2. Statewide 2009 nitrogen fertilizer application timing on corn

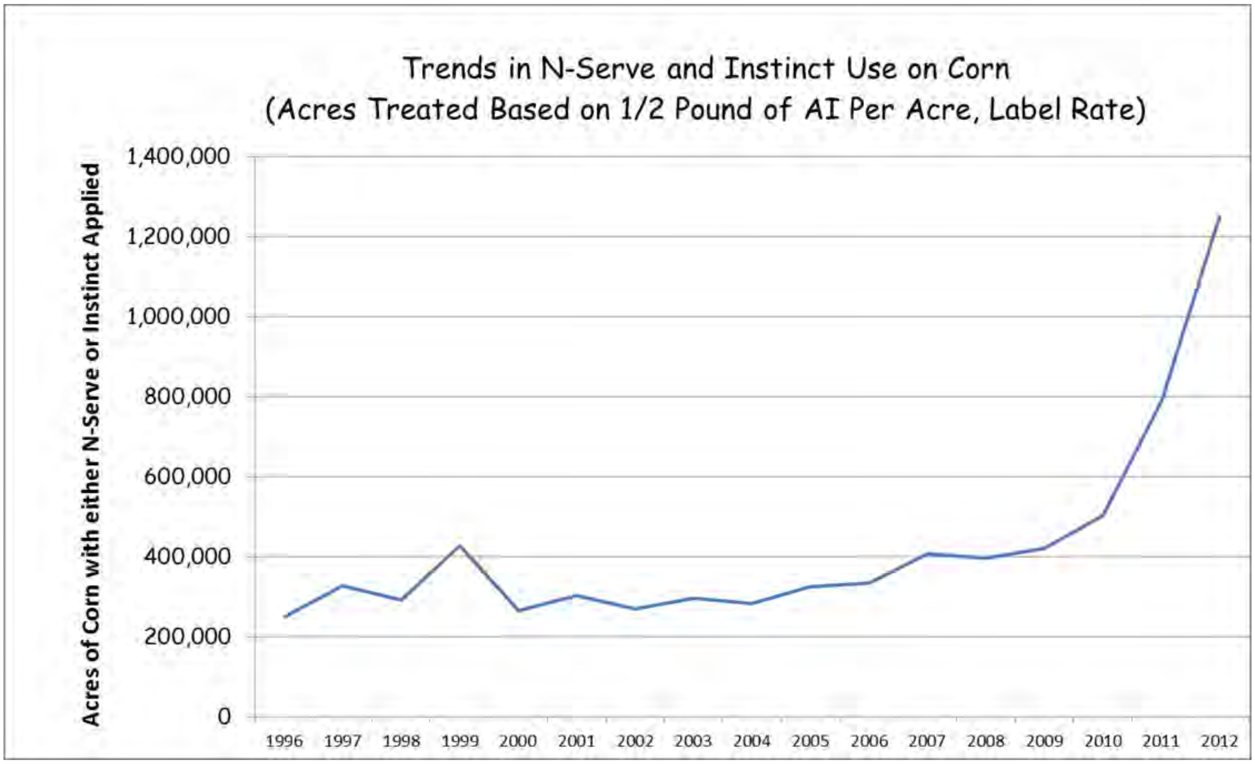

Figure 3. Statewide trends in nitrogen inhibitor use on corn

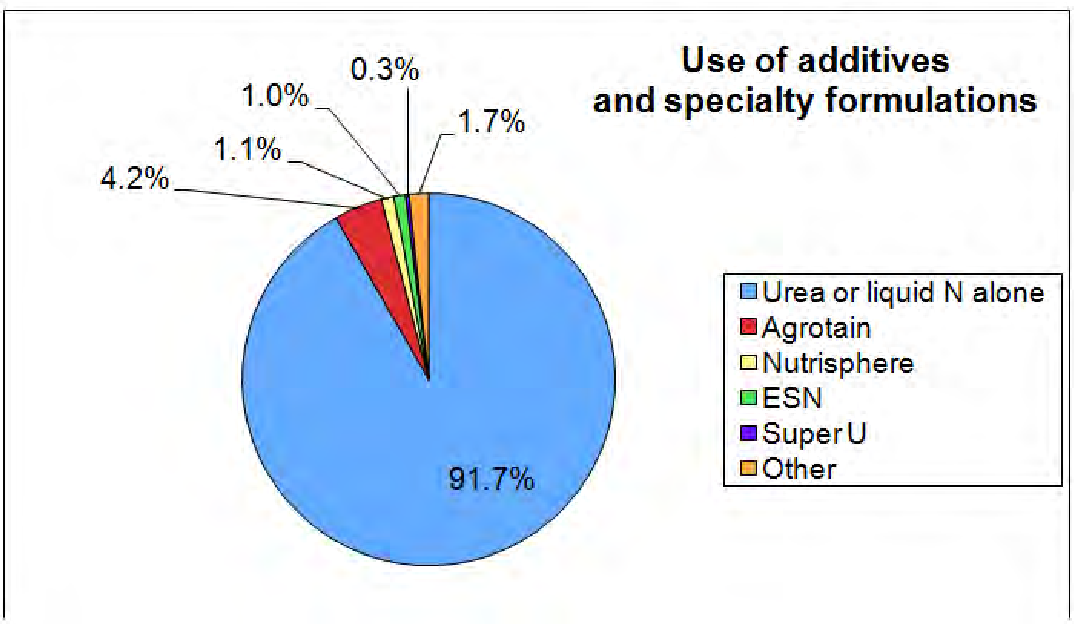

Figure 4. Use of additive and specialty formulations of urea and liquid nitrogen fertilizers applied to corn in 2009 by surveyed farmers reporting on average farm fields.

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, 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.

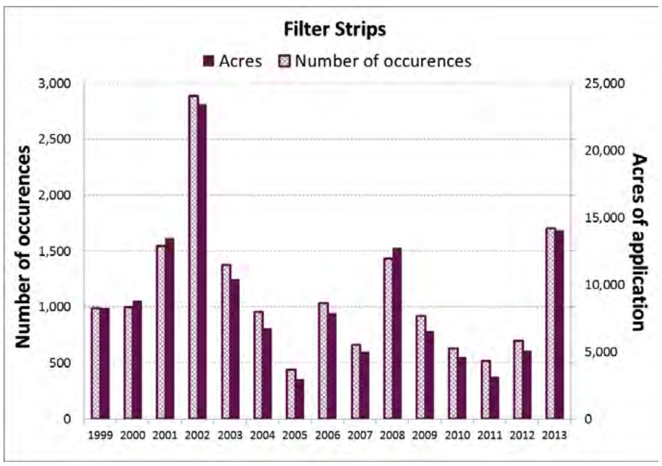

Figure 2. Number of occurrences and acres of application for filter strips funded by CRP from 1999-2013

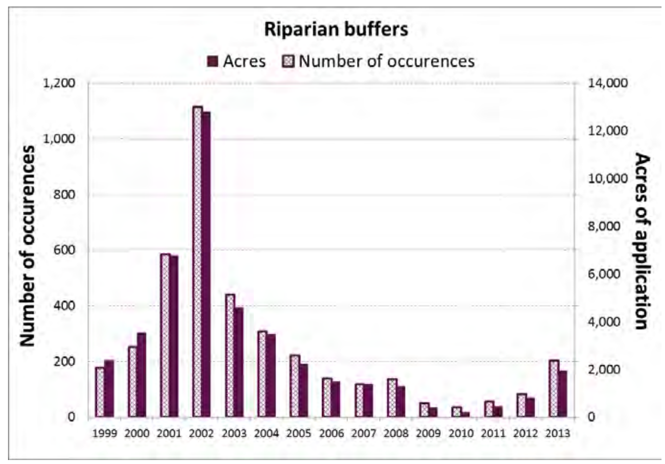

Figure 1. Number of occurrences and acres of application for riparian forested buffers funding by CRP from 1999-2013

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.

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.

Miller, T.P., J.R. Peterson, C.F. Lenhart, and Y. Nomura. 2012. The Agricultural BMP Handbook for Minnesota. Minnesota Department of Agriculture. Accessed June 2013. http://www.eorinc.com/documents/AG-BMPHandbookforMN_09_2012.pdf

MPCA. 2013. D1 Nitrogen Sources to Land and Waters - Results Overview. DRAFT 2013 (Dave Wall, David J. Mulla, and Steve Weiss, MPCA).

Waidler, D., M. White, E. Steglich, S. Wang, J. Williams, C.A. Jones, and R. Srinivasan. 2009. Conservation Practice Modeling Guide for SWAT and APEX. USDA Agricultural Research Service, Blackland, TX.

Measure Points of Contact

Agency Information

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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.

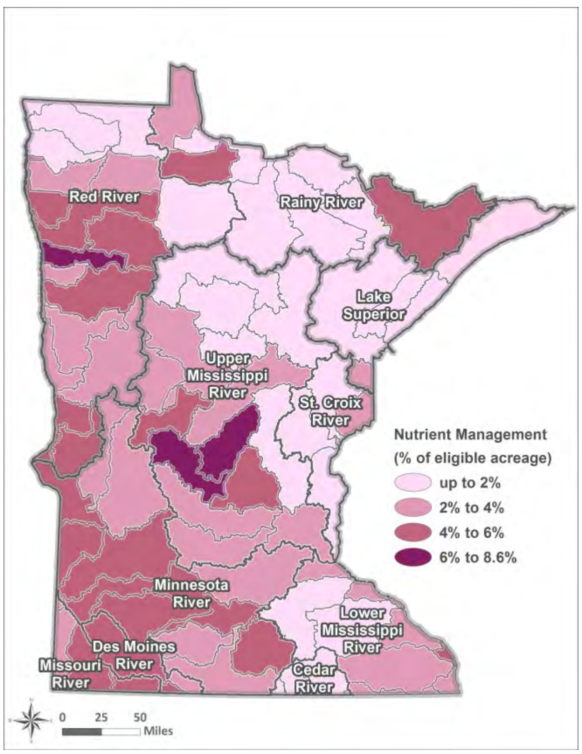

Figure 1. Percent of eligible acreage implementing nutrient management through EQIP by 8-digit HUC

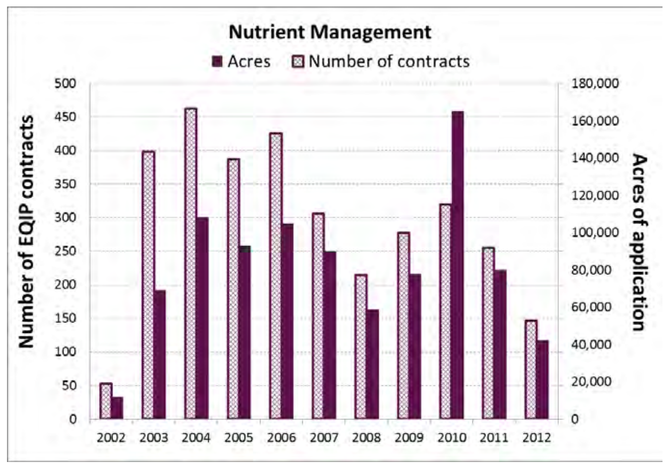

Figure 2. Annual trends in nutrient management implementation through EQIP by acres of application and number of EQIP contracts

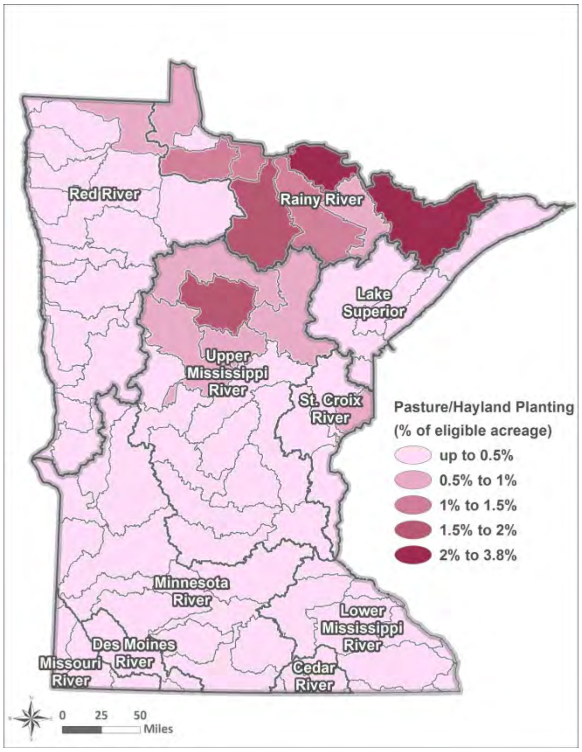

Figure 4. Percent of eligible acreage implementing forage and biomass (pasture/hayland) planting through EQIP by 8-digit HUC

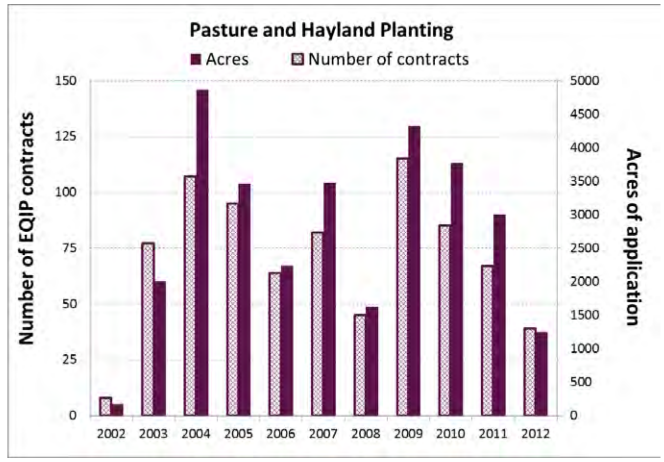

Figure 5. Annual trends in forage and biomass (pasture/hayland) planting implementation through EQIP by acres of application and number of EQIP contracts

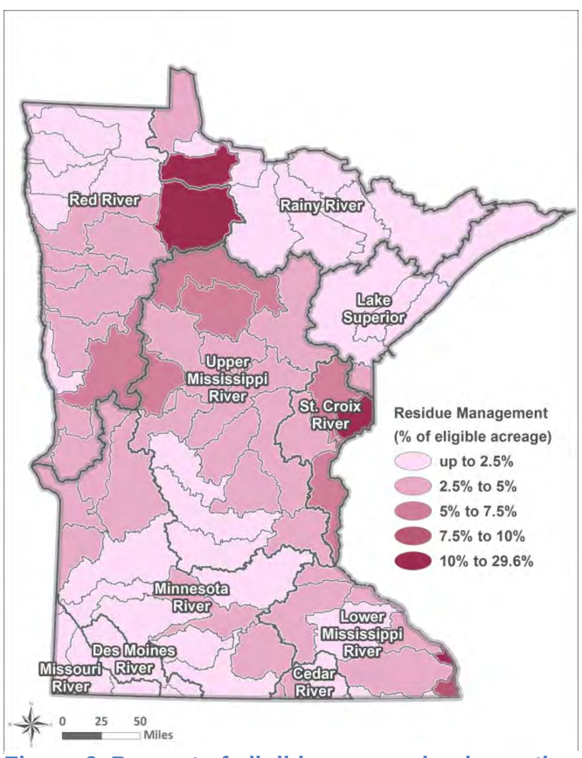

Figure 6. Percent of eligible acreage implementing residue management through EQIP by 8-digit HUC

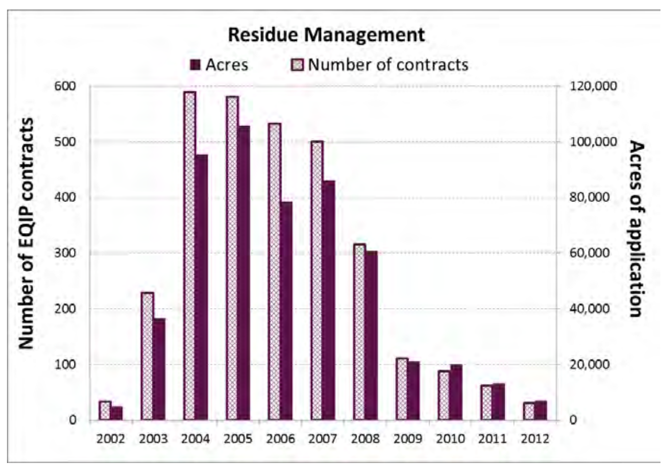

Figure 3. Annual trends in residue management implementation through EQIP by acres of application and number of EQIP contracts

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.

References

Haith, D.A., R. Mandel, and R.S. Wu. 1992. GWLF, Generalized Watershed Loading Functions, Version 2.0, User's Manual. Dept. of Agricultural & Biological Engineering, Cornell University, Ithaca, NY.

HRWCI. 2005. Agricultural Phosphorus Management and Water Quality in the Midwest. Heartland Regional Water Coordination Initiative. Iowa State University, Kansas State University, the University of Missouri, the University of Nebraska–Lincoln and the USDA Cooperative State Research, Education and Extension Service.

Miller, T.P., J.R. Peterson, C.F. Lenhart, and Y. Nomura. 2012. The Agricultural BMP Handbook for Minnesota. Minnesota Department of Agriculture. Accessed June 2013. http://www.eorinc.com/documents/AG-BMPHandbookforMN_09_2012.pdf

MPCA. 2013. Draft Nitrogen Study.

Measure Points of Contact

Agency Information

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Implementation of Conservation Tillage Funded through AgBMP Loans

Measure Background

Visual Depiction

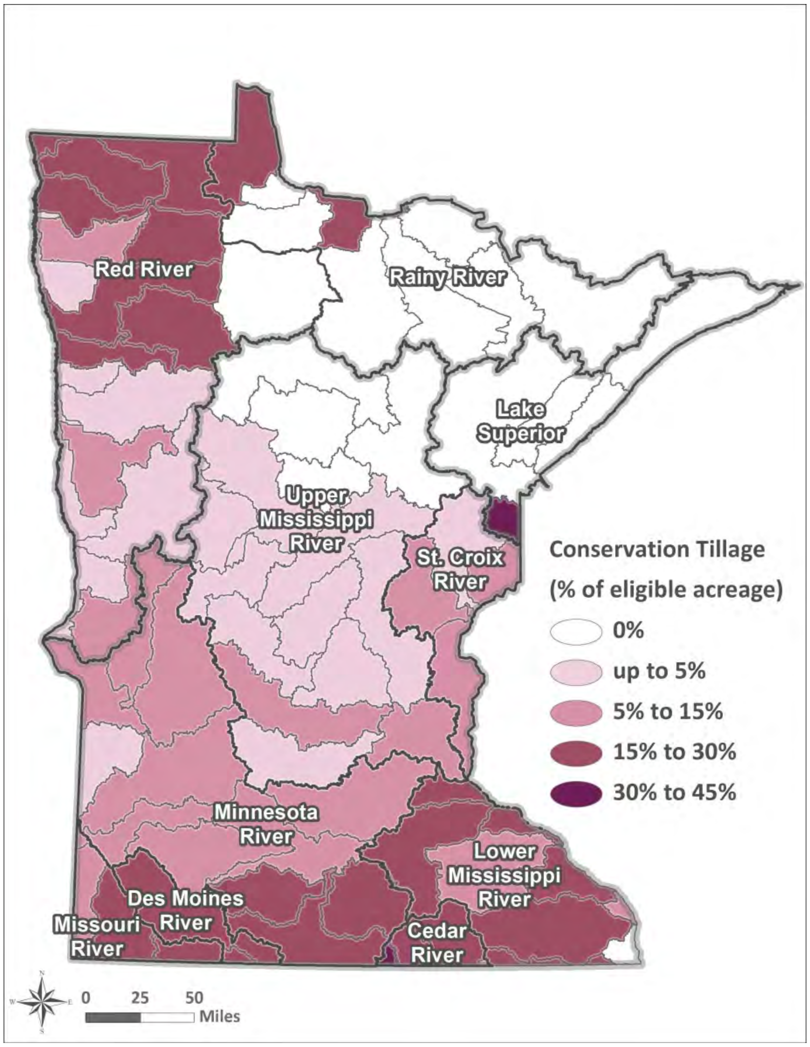

Figure 1. Percentage of agricultural acreage under conservation tillage funded through the AgBMP Loan Program by 8-digit HUC

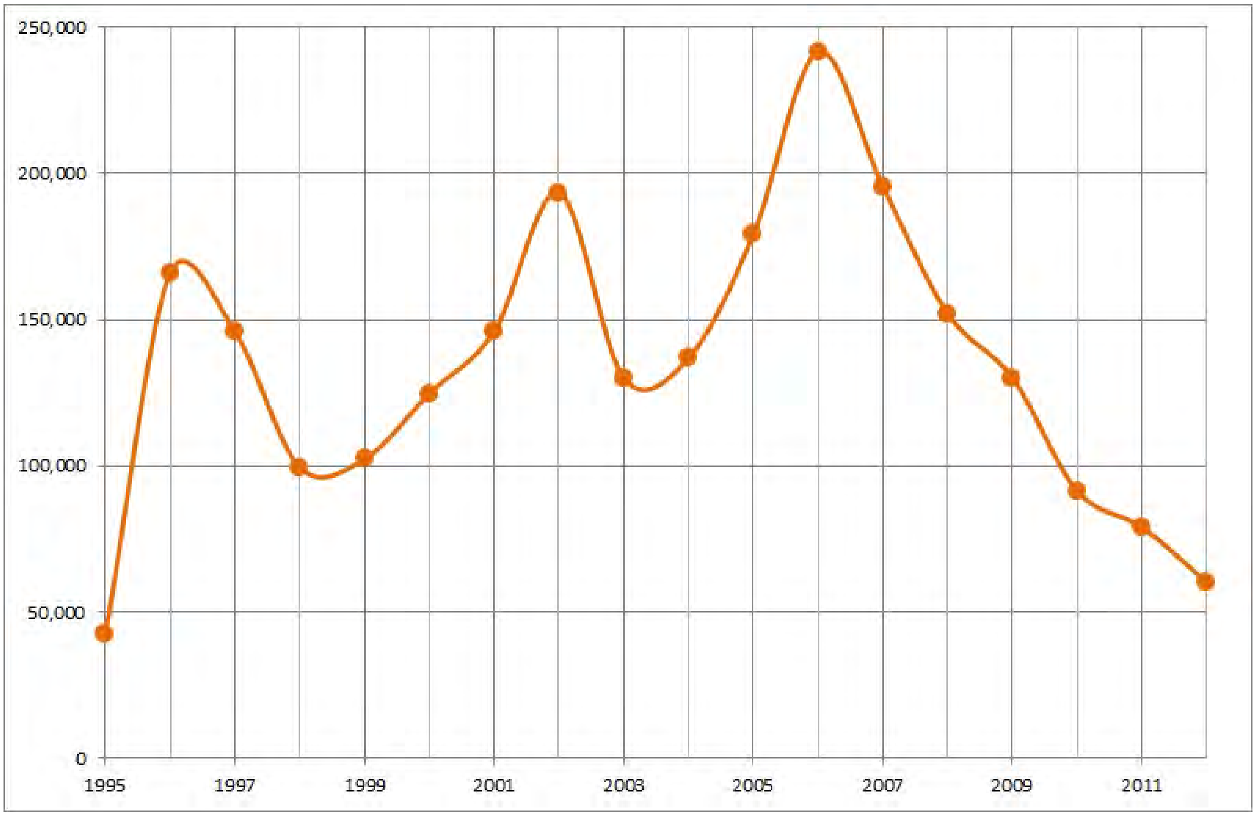

Figure 2. Acreage of agricultural land in Minnesota under conservation tillage through AgBMP Loan Program by year

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

Czapar, G.F., J.M. Laflen, G.F. McIsaac, D.P. McKenna. 2006. *Effects of Erosion Control Practices on Nutrient Loss*, University of Illinois.

Gold, A.J, and T.L. Loudon. 1989. Tillage effects on surface runoff water quality from artificially drained cropland. *Transactions of the American Society of Agricultural Engineers*, 32(4): 1329-1334.

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.

Miller, T.P., J.R. Peterson, C.F. Lenhart, and Y. Nomura. 2012. *The Agricultural BMP Handbook for Minnesota*. Minnesota Department of Agriculture. Accessed June 2013.
http://www.eorinc.com/documents/AG-BMPHandbookforMN_09_2012.pdf

Simpson, T. and S. Weammert. 2009. Developing Best Management Practice Definitions and Effectiveness Estimates for Nitrogen, Phosphorus and Sediment in the Chesapeake Bay Watershed: Final Report. December 2009, Chesapeake Bay Program, Annapolis, MD.

USEPA. 2003. National Management Measures to Control Nonpoint Source Pollution from Agriculture. EPA 841-B-03-004, July 2003.

Measure Points of Contact

Agency Information

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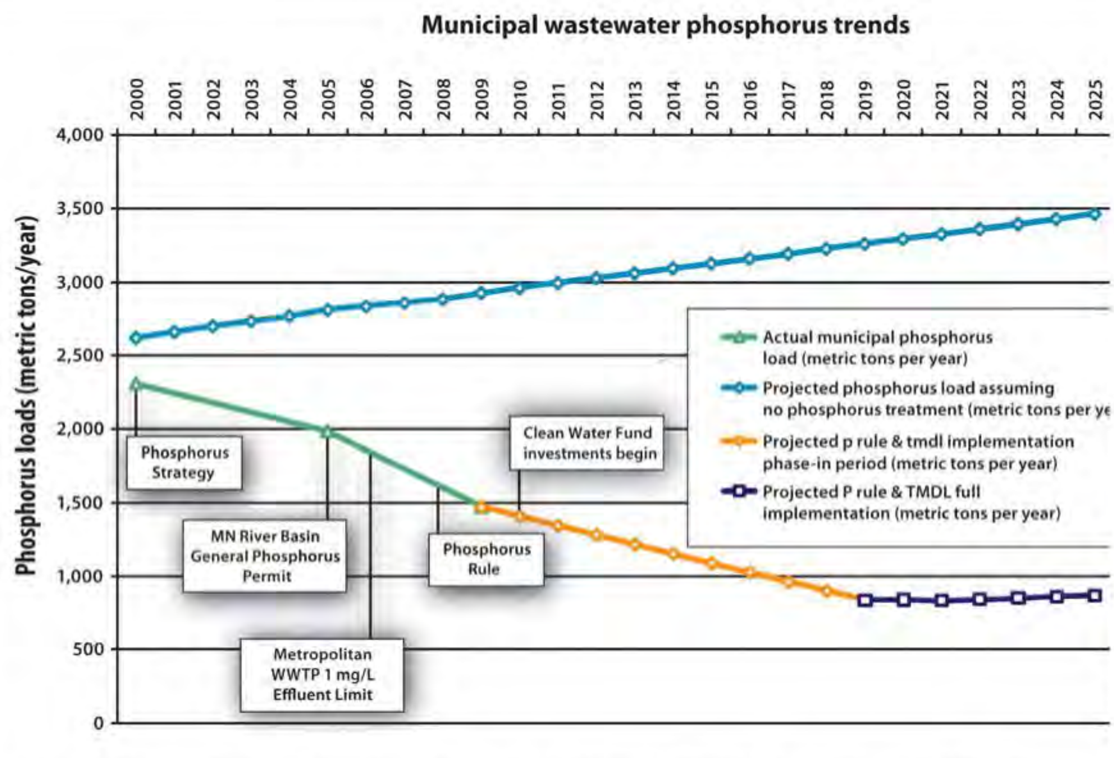
Municipal Wastewater Phosphorus Trends (excerpt from the Clean Water Fund Report)

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.

About the graph:

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

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Appendix E: Tracking Tool Recommendations

Purpose of this Document

Tracking progress toward the Minnesota Nutrient Reduction Strategy (Strategy) 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 Strategy 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 Y of the draft Strategy. 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 Strategy's progress and reporting to key stakeholders within and outside of Minnesota.

This document provides an overview of the preliminary requirements for a Strategy 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 Strategy tracking tool. It concludes with recommendations on the type of tracking tool Minnesota should consider to support progress tracking and reporting for the Strategy goals and milestones, with both short- and long-term proposed tasks and estimated costs for tool development.

Preliminary Strategy 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 Strategy. 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 Strategy 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 Strategy tracking tool. They explain the compelling reasons for the Strategy 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 Strategy 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 Strategy's tracking needs.

Table 1. Preliminary High-level Business Requirements and Priority for the Strategy Tracking Tool

BR ID	High-level business requirements	Priority
BR1	Track BMP implementation related to the Strategy, 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 goals	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 Strategy tracking tool, user requirements include tracking specific BMPs in the program measures, using pre-determined effectiveness values for N and P 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 Strategy 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 Strategy 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 Strategy	BR1, BR3
UR2	The system should use pre-determined effectiveness values for P and N 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 goals for each basin as documented in the Strategy to support updating of Strategy scorecards.	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 Strategy 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 Strategy 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 Strategy 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 Strategy Tracking Tool and Associated Category

NFR ID	Nonfunctional Requirement	Category
NFR1	The system should be consistent with the Strategy 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 Strategy. More constraints would be identified in a comprehensive system requirements analysis.

Table 5. Preliminary List of Constraints for the Strategy 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 Strategy Tracking Tool Conceptualization

The timing of the Strategy and the associated data tracking needs coincides with several other tracking and reporting efforts taking place within the state. This allows for the Strategy's tracking needs to be incorporated into other ongoing system development and refinement projects. Examples of ongoing system development opportunities that could integrate Strategy 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 Strategy 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 Strategy, the Strategy 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.

Strategy Tracking Tool Development Recommendations

Based on the review and understanding of the preliminary requirements of the Strategy 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 Nutrient Reduction Strategy 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 Strategy tracking tool.

The functionality of the Strategy 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 Strategy 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 Strategy tracking tool are described below.

TASK 1: IDENTIFY TRACKING TOOL TEAM

The initial task for development of the Strategy 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 Strategy 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 Strategy tracking tool team will review the existing program measures in Appendix Y of the Strategy and identify those that require updating or refinement. Data gaps in existing water quality and programmatic measures are identified in the Appendix Z of the Strategy.

To focus efforts and demonstrate utility from development to web reporting, the number of program measures used in the initial Strategy tracking tool should be limited to 3-5. This will allow for piloting the Strategy 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 Strategy 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 Strategy 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 Strategy 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 Strategy 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 Strategy 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 Strategy 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 Strategy 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 Strategy tracking tool would include an enterprise database. The Strategy 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 Strategy tracking tool Public Module would display Strategy 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 Strategy goals and milestones. The agency hosting the Strategy 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 Strategy 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 Strategy tracking tool, which will provide key features and benefits in meeting the requirements identified for Strategy 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 Strategy 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 Strategy and opportunities to be engaged and provides information relevant to those responsible for implementing various aspects of the Strategy 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 Strategy'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 Strategy tracking tool Planning and Management Module would be designed for users who are responsible for the planning, management, and oversight of the Strategy implementation activities. This would include Minnesota agency staff, partner agency staff, and other people that are recording information related to specific Strategy 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 Strategy, or future Strategy 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 Strategy 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 Strategy.

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 N and P.
- ✓ 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 Strategy tracking tool so that implementing parties can prioritize their activities and report on progress toward meeting Strategy Phase I 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 Strategy 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 Strategy goals and milestones, including WWTP N and P loads, agricultural N and P 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 STRATEGY TRACKING TOOL PLAN

In support of the production deployment of the Strategy 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 Strategy 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 Strategy 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 Strategy 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 Strategy 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