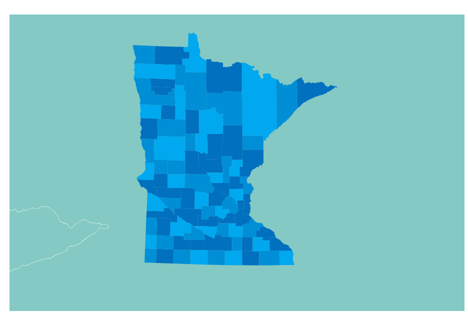
Wastewater Nitrogen Reduction

April 2024

Minnesota Wastewater Nitrogen Reduction and Implementation Strategy

A plan to reduce effluent nitrogen loads discharged by Minnesota’s wastewater sector to protect drinking water sources and aquatic life, and to achieve Nutrient Reduction Strategy goals.



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Minnesota wastewater nitrogen reduction and implementation strategy

Wastewater nitrogen reduction and implementation strategy that identifies the wastewater program's plan to work with municipal and industrial NPDES/SDS permittees to:

- Reduce nitrogen and make progress towards meeting current and proposed goals outlined in Minnesota's nutrient reduction strategy (NRS) draft nitrate-nitrogen water quality standards; and
- Develop actions and a plan to communicate and implement the new nitrogen effluent limits that will apply upon adoption of the aquatic life nitrate and ammonia water quality standards (WQS).

This wastewater nitrogen reduction and implementation Strategy (strategy) provides an evaluation of the existing nitrogen loads from wastewater treatment facilities (WWTFs) and the reduction needed to achieve MN's current goals. This strategy establishes plans to make progress towards achieving nitrogen reduction goals for the wastewater sector by:

a) Evaluating approaches to reduce nitrogen using non-regulatory methods (i.e., source reduction, WWTF optimization),

b) Identifying a strategy to start implementing the reduction efforts, and

c) Providing a nitrogen management plan template for permittees to utilize.

The implementation portion of this strategy includes the development of nitrogen water quality-based effluent limits (WQBELs) and TN concentration effluent limits in permits upon adoption of nitrate WQS and State Discharge Restriction (SDR) regulations; a plan to proactively communicate with NPDES permittees regarding their future nitrogen limits so that it can be factored into current facility upgrades; identification of flexible and cost effective permitting options to reduce nitrogen (i.e. water quality trading, development and implementation of nitrogen management plans, WWTF optimization); and identification of resources needed to support implementation of the nitrogen limits.

Background

Nitrogen in Minnesota surface waters

Concern about N in Minnesota's surface waters has grown in recent decades due to:

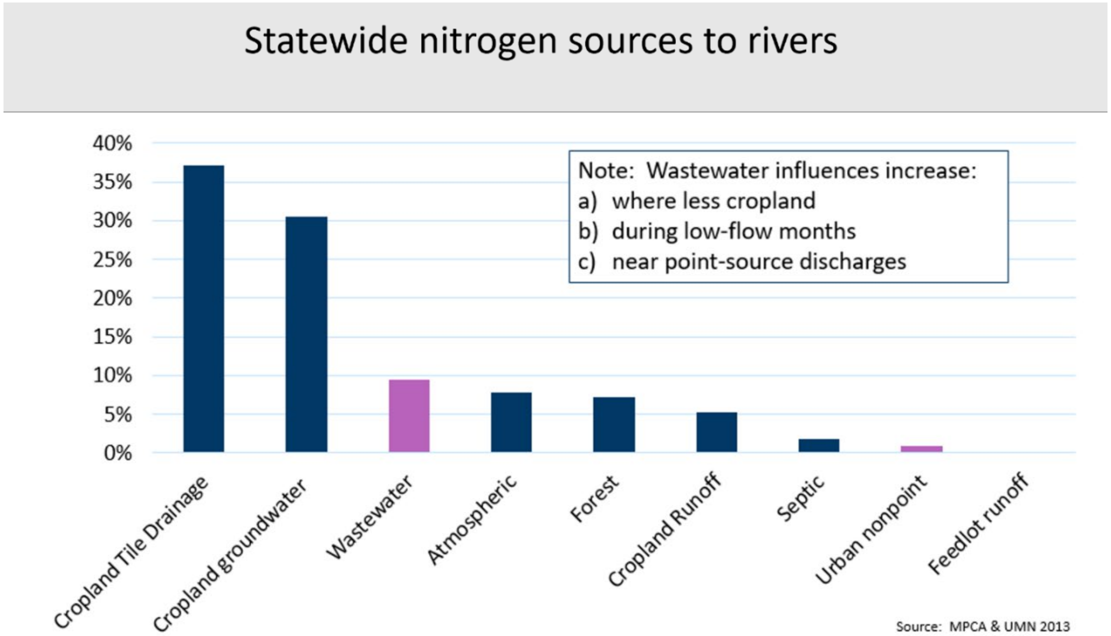
1. Toxic effects of nitrate on aquatic life.
2. Increasing nutrient concentrations and loads in the Mississippi River combined with nitrogen's role in causing a large oxygen-depleted zone in the Gulf of Mexico.
3. Excess nutrient concentrations and loads contributing to recurring harmful algal blooms in Lake Winnipeg and Manitoba.
4. Nitrate concentrations exceeding the 10 milligrams per liter (mg/l) drinking water standard in Minnesota and Iowa streams protected as drinking water sources.

Across much of Minnesota, nitrate levels in rivers have increased during recent decades, as reported by MPCA in 2020 (available at https://www.pca.state.mn.us/air-water-land-climate/reducing-nutrients-in-waters). More than one out of three river monitoring sites (38 across the state) showed nitrate increases, and the other sites did not show improvement but rather showed no significant detected trend.

The sources of nitrate and TN were documented in a comprehensive report released by the MPCA in 2013 and in the Minnesota Nutrient Reduction Strategy in 2014. The reports indicate that nitrate seepage through agricultural cropland soils to artificial subsurface drainage (cropland tile drainage) and underlying groundwater (cropland groundwater) are key sources of nitrogen pollution to rivers and streams (see diagram below). More than 70% of nitrogen in surface waters comes from cropland areas statewide. The remaining is mostly from sources such as WWTFs, septic and urban runoff. Additional sources are forests and the atmosphere.

Even though wastewater nitrogen is estimated to be less than 10% of the statewide nitrogen discharge into rivers on an annual basis, wastewater nitrogen reduction is important for meeting nitrogen reduction goals. There are a number of reasons for this:

- Wastewater is the second highest anthropogenic source to our statewide waters, after cropland.
- Wastewater is typically the highest source of nitrogen to waters in areas where there is relatively little cropland.
- Wastewater is the highest source of nitrogen discharging during low flow months.
- Many WWTFs discharge nitrate levels much higher than the receiving rivers and can especially impact water health near the area of discharge.
- The cost per pound of reducing wastewater nitrogen discharge may be similar or lower than agricultural treatment of nitrogen discharges (further study needed).
- Wastewater nitrogen reduction can be controlled with more certainty and predictability compared to the nonpoint source nitrogen reduction practices, which are more greatly affected by weather.
- All of the states and provinces in the Gulf of Mexico Hypoxia Task force and the International Red River Watershed Board are working to reduce nutrients from both point and nonpoint sources. Each state is developing its own strategies, rather than a national one-size-fits-all approach.
- Cropland nitrogen loss reduction is a major focus of NRS revision efforts, along with nitrogen loss reduction from wastewater. Addressing both sources will provide the best chance of successfully reaching the goals. Wastewater nitrogen reductions are needed to meet Minnesota's water quality goals and obligations to downstream jurisdictions.



In order to meet local and regional goals around nitrogen, all significant anthropogenic sources contributing nitrogen to Minnesota's waters need to reduce nitrogen concentrations and loads to levels that will collectively achieve the goals.

Current state level efforts

Minnesota is initiating several state-level efforts to reduce nitrogen in surface waters, the development of a nitrate WQS, an update of existing ammonia WQS, implementation of an updated and revised Minnesota NRS and this wastewater nitrogen reduction strategy. Additionally, the MPCA's Large Subsurface Treatment System (LSTS) Groundwater Nitrogen Policy is enforced through State Discharge System (SDS) permits. This policy is consistent with the groundwater health risk limits set by federal and state laws and requires LSTS systems to comply with either a 10 mg/L TN end of pipe limit or a 10 mg/L nitrate nitrogen limit at the property boundary or nearest receptor.

Water quality standards

Existing nitrogen water quality standards

Narrative water quality standards

Minnesota Rules Chapter 7050.0221. Specific water quality standards for Class 1 waters of the state; domestic consumption.

Subpart 6. Additional standards. In addition to the standards in subparts 2 to 5, no sewage, industrial waste, or other wastes from point or nonpoint sources, treated or untreated, shall be discharged into or permitted by any person to gain access to any waters of the state classified for domestic consumption so as to cause any material undesirable increase in the taste, hardness, temperature, chronic toxicity, corrosiveness, or nutrient content, or in any other manner to impair the natural quality or value of the waters for use as a source of drinking water.

Minnesota Rules Chapter 7050.0222. Specific water quality standards for Class 2 waters of the state; aquatic life and recreation.

Subpart 7. Additional standards; Class 2 waters. The following additional standards and requirements apply to all Class 2 waters.

A. No sewage, industrial waste, or other wastes from point or nonpoint sources shall be discharged into any of the waters of this category so as to cause any material change in any other substances, characteristics, or pollutants which may impair the quality of the waters of the state or the aquatic biota of any of the classes in subparts 2 to 6 or in any manner render them unsuitable or objectionable for fishing, fish culture, or recreational uses. Additional selective limits or changes in the discharge bases may be imposed on the basis of local needs.

Proposed water quality standards

The MPCA is proposing to update Minnesota's ammonia-nitrogen WQS based on EPA criteria to include a final acute value, maximum standard, and chronic standard in Minn. R. 7050. The MPCA's ammonia water quality standard webpage provides details of the proposed update.

The MPCA has determined that excessive NO_3-N concentrations in surface waters are harmful to aquatic organisms and has developed draft water quality criteria for the protection of aquatic life in Class 2A and 2B waters. The MPCA's Aquatic Life Water Quality Standards Draft Technical Support Document for Nitrate defines the basis for the development of new nitrate water quality standards for the protection of aquatic organisms.

Numeric water quality standards

Minnesota Rules Chapter 7050.0221. Specific water quality standards for Class 1 waters of the state; domestic consumption.

Minnesota's water quality standards (WQS) for Class 1 waters incorporate by reference the Environmental Protection Agency (EPA) drinking water standards, which include a 10 mg/L Nitrate-Nitrogen (NO_3-N) criterion.

- Class 1 waters are protected as sources for domestic consumption, including all waters of the state that are or may be used as a source of supply for drinking, culinary or food processing use, or other domestic purposes and for which quality control is or may be necessary to protect the public health, safety, or welfare.

Minnesota Rules Chapter 7050.0222. Specific water quality standards for Class 2 waters of the state; aquatic life and recreation.

Minnesota's WQS for Class 2 waters include the following un-ionized ammonia-nitrogen chronic aquatic life toxicity criteria:

- Class 2A waters – 16 µg/L
- Class 2Bd and Class 2B waters – 40 µg/L

Minnesota's Nutrient Reduction Strategy

Minnesota's NRS calls for point source and nonpoint source TN reductions in watersheds draining to the Mississippi River and in the Red River Basin. TN goals for the Lake Superior and Rainy River Basins are under consideration for the NRS revision process that is currently underway.

In 2014, the MPCA worked together with ten other organizations to complete a state-level Nutrient Reduction Strategy, which set nutrient reduction goals for reducing both point and nonpoint sources of nitrogen levels by 13 to 20% by 2025 and 45 to 50% by 2040, over much of the state. The NRS also identified actions that would be taken to advance programs and efforts to achieve the nutrient reduction goals, and ways to track progress toward the goals.

Since 2014, Minnesota's NRS has served as a large-scale framework for reducing nitrogen and phosphorus in Minnesota's waters. During the first five years of implementation, Minnesota had advanced most state and regional programs identified in the NRS. Significant progress has been achieved with respect to phosphorus reduction but, despite these successes, Minnesota is not on track to reach the needed scales of change to achieve nitrogen reduction goals in the agricultural and wastewater sectors [see 5-year Progress Report on Minnesota's Nutrient Reduction Strategy (MPCA 2020)]. Long periods of time will be needed to observe the more complete effects of programs and practice changes on the lands, and continued monitoring will be important.

Point source nitrogen loads

The 2014 NRS identified measures for reducing both point and nonpoint nitrogen loads to waters. The six steps identified for wastewater load reductions included:

1. Monitor influent & effluent nitrogen.
2. Evaluate nitrogen reduction optimization.
3. Develop nitrogen management plan templates.
4. Encourage voluntary nitrogen removal when upgrading a facility.
5. Establish nitrogen effluent limits – after nitrate WQS developed.
6. Develop point/nonpoint trading options.

Minnesota has made strides forward in monitoring, evaluating optimization, and developing trading options. Progress has also been made in encouraging voluntary nitrogen removal. However, much more needs to be done, including developing nitrogen management plan templates for permittees to utilize. Very few municipal WWTFs in Minnesota are designed to achieve significant decreases in TN or nitrate loads.

Non-point source nitrogen loads

The NRS-documented contributions from the nonpoint source sector are the dominant nitrogen loads in the Mississippi River and Red River/Rainy River (Lake Winnipeg) drainage areas. Cropland contributes, respectively, an estimated 79% and 53% of the TN load to those surface water basins. Other nonpoint sources – atmospheric deposition, urban runoff, other rural runoff, feedlot runoff and septic systems - contribute 12% (Mississippi) and 41% (Lake Winnipeg) of the total loads in these drainage areas.

Non-point sources include a range of regulated (through MN law and policy) and unregulated activities. Examples of regulated or potentially regulated activities that affect nitrogen loads include:

- Manure spreading onto cropland.
- Fall application of nitrogen fertilizer in vulnerable areas.
- Nitrogen fertilizer applications in high nitrate drinking water supply management areas without adequate BMP adoption.
- Riparian vegetated buffers.

Nonpoint sources are generally not controlled by the Federal Clean Water Act. Voluntary actions and incentives are needed to support the reductions, in addition to the State-regulated activities.

The NRS focuses on reducing nutrient loads from cropland sources and identifies specific load reduction goals for agriculture. While progress has been made with some best management practices, additional nonpoint efforts are needed to achieve milestone and final NRS nitrogen goals. Minnesota has begun work on a NRS update/revision, which is expected to be completed in 2025. Improved and new non-point source reduction approaches will be considered for the NRS revision. The U.S. Environmental Protection Agency is funding NRS updates and implementation, which will help support this work. Updating the NRS will involve multiple state agencies and stakeholders. Key approaches that will be added and identified for expansion in the revised NRS include:

- Evaluating mechanisms and recommending options to scale-up adoption of key agricultural practices. For example, this may include encouraging more use of the Minnesota agricultural water quality certification program.
- Improving understanding of the multiple benefits of practices that reduce nitrogen, and using creative funding programs and implementation partnerships to address multiple environmental needs with the same or similar BMPs. This could include climate-smart working lands strategies, regenerative agriculture practices, and market systems that monetize the combination of benefits (to society, landowners and farmers) from nutrient-reducing regenerative practices.
- Continuing to develop and support water quality trading.

Potential new approaches could include adding more water storage, as many water storage practices will also reduce water nitrate levels. Some new ideas and programs are likely needed to address nitrate coming from tile-drained row-cropped fields, to support in-field management practices and/or edge-of-field nitrate removal technologies on discharging drain-tile waters. Developing these approaches will require building local partnerships (private, corporate, local public, state public, NGOs etc.) and enhancing cooperation between the urban and agricultural sectors and other local partners. This could be facilitated through events such as the ongoing Ag/Urban Partnership Forum series coordinated by BWSR, MDA and the MPCA.

Education and outreach on voluntary actions that can be done to help achieve water quality improvement is also needed, such as through "We are Water" or other education partnerships.

Influent and effluent nitrogen monitoring at WWTFs

In response to the 2014 NRS, and due to the limited availability of influent and effluent nitrogen concentrations across the state, the MPCA increased the nitrogen monitoring frequencies in industrial and municipal wastewater NPDES/SDS permits. The increased monitoring provides a better understanding of nitrogen concentrations and loadings from WWTFs throughout the state to inform future reduction efforts. Additional background information on the first phase efforts of MN's nitrogen reduction efforts along with the specific monitoring frequencies being included in permits can be found in the 2014 document, " Minnesota NPDES Wastewater Permit Nitrogen Monitoring Implementation Plan (state.mn.us)".

Appendix A of the above referenced document provides a detailed explanation of the current monitoring requirements, a breakdown of the TN loads on a statewide level as well as within each of the four major drainage basins, and a summary of the TN effluent concentrations by facility classification and major/minor status.

Nitrogen and subsurface wastewater disposal

The MPCA's *Large Subsurface Treatment System Groundwater Nitrogen Policy (LSTS Nitrogen P*olicy) establishes nitrogen permit limits for certain classes of WWTFs whose disposal methods may impact groundwater. The LSTS nitrogen policy is consistent with the groundwater health risk limits set by federal and state laws. Under the LSTS nitrogen policy, permittees choose between two permitting options: Option 1 – requires the LSTS to meet an end-of-pipe limit of 10 mg/L TN as a calendar month average; or Option 2 – requires the LSTS to meet the 10 mg/L nitrate-nitrogen limit at the property boundary or nearest receptor, whichever is closer, and may also require the installation of a network of groundwater wells to monitor the effectiveness of the end of pipe limit. All LSTS permits must comply with either Option 1 or Option 2 of the LSTS nitrogen policy upon reissuance. Permits for any facilities found to be in noncompliance include compliance schedules which often include a requirements to upgrade the system. Additionally, facilities that are in enforcement actions due to nitrogen exceedances are required to provide a path leading to compliance with nitrogen limits which may also include a requirement to upgrade treatment systems. Most often, these systems are privately owned systems and do not qualify for the funding opportunities that municipally owned entities have.

Minnesota wastewater nitrogen effluent limits

Minnesota wastewater permits have historically included NO_3-N or TN limits to protect groundwater. More recently surface water TN effluent limits have also been developed for consistency with Total Maximum Daily Load (TMDL) wasteload allocations and to address whole effluent toxicity.

- The majority of the 126 wastewater permits with nitrogen limits are for domestic subsurface discharge facilities (110) covered under Minnesota's State Disposal Systems (SDS) permits.
- Seven domestic and three industrial permits include surface discharge station nitrogen limits.
- Six industrial permits include groundwater, land application or waste stream station nitrogen limits.

Table 1. Nitrite plus Nitrate as N permit limits

	Groundwater Stations	Land Application Stations	Surface Discharge Stations	Waste Stream Stations	**Total**
Domestic	71	0	0	0	**71**
Industrial	1	0	1	2	**4**
Total	**72**	**0**	**1**	**2**	**75**

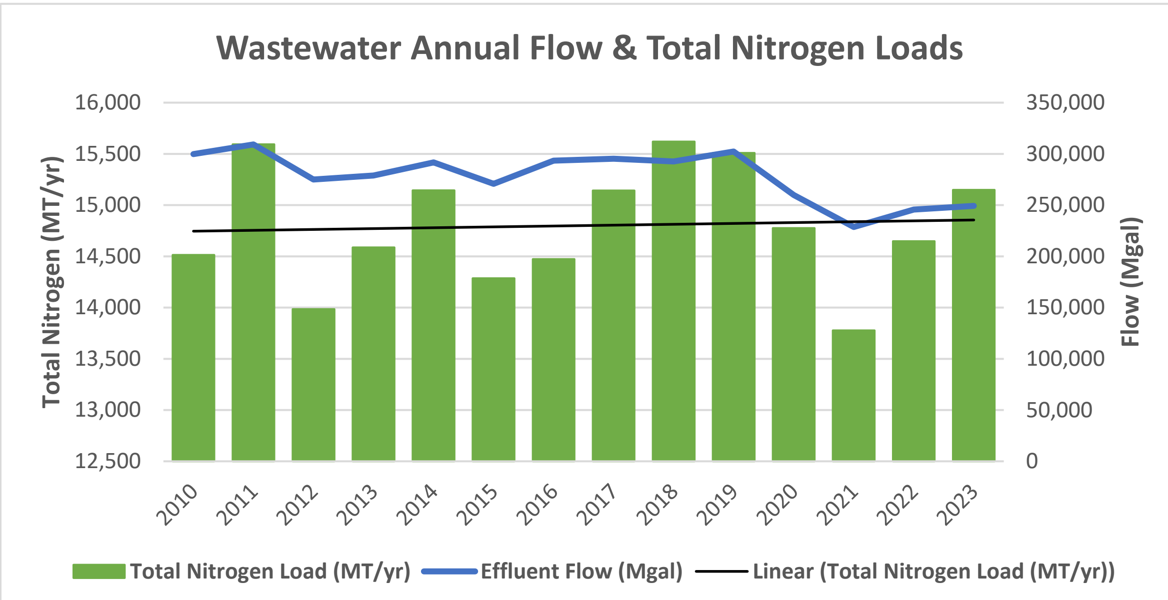
Table 2. Total nitrogen permit limits

	Groundwater Stations	Land Application Stations	Surface Discharge Stations	Waste Stream Stations	**Total**
Domestic	0	0	7	39	**46**
Industrial	0	3	2	0	**5**
Total	**0**	**3**	**9**	**39**	**51**

Total nitrogen loads

Wastewater effluent nitrogen concentrations and load reductions are needed to meet local and downstream water quality goals. Statewide TN loads discharged by Minnesota WWTFs have remained consistent from an average annual load of 14,697 metric tons per year (MT/yr) (2010-2012) to 14,525 MT/yr (2021-2023).

Figure 1. Annual wastewater effluent total nitrogen loads



A substantial majority of the annual effluent TN load is discharge by major municipal WWTFs.

Table 3. Distribution of annual effluent TN load

Facility type	Major facilities	Minor facilities
	Percent of annual effluent Total Nitrogen load	
Municipal	85%	5%
Industrial	7%	3%

Estimated TN load reductions resulting from implementation of draft NO3-N standard

Based on the draft NO_3-N aquatic life toxicity criteria, available discharge monitoring data and wastewater discharge location data, the MPCA estimates that future nitrogen reductions expected as a result of attainment of water quality-based effluent limits (WQBELs) alone will be insufficient to achieve the scale of TN reductions necessary to meet the Minnesota NRS's goals for the Mississippi and Red River Basins.

After full attainment of the WQBELs, an additional 2,208 MT/year TN reduction (28%) would be needed in the Mississippi River Basin and an additional 118.6 MT/year TN reduction (45%) would be needed in the Red River Basin. Wastewater TN load goals have not yet been determined for the Lake Superior and Rainy River Basins, but are anticipated with the NRS revision in 2025.

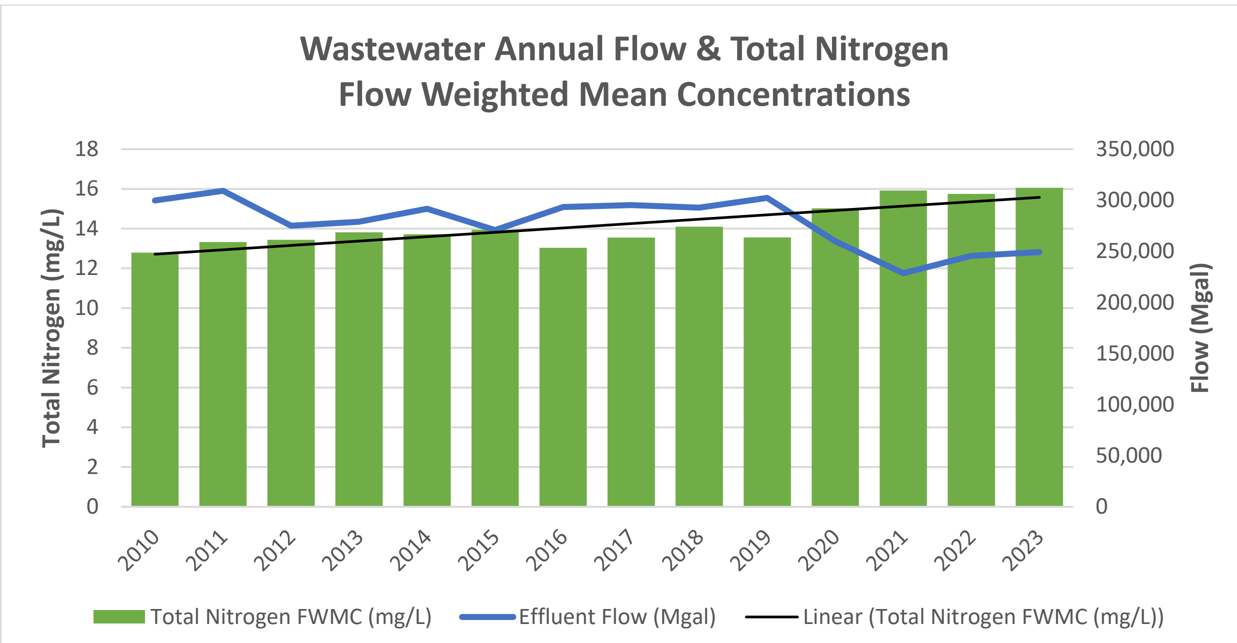
Table 4. Annual wastewater TN loads and load reductions expected from NO_3-N WQBELs – delivered to the state borders

	Annual end-of-pipe wastewater TN load (MT/year)	Annual wastewater TN load delivered to the state line (MT/year)	Estimated annual TN load reduction needed to meet NO_3-N WQBELs (MT/year)	Estimated NO_3-N WQBELs percent reduction at the state border (%)	Nutrient reduction strategy percent reduction goal from baseline (%)
Mississippi River	13,656	10,163	2,365	23%	45%
Red River	307	294	28.4	10%	50%
Lake Superior	785	785	94.3	12%	TBD
Rainy River	191	179	0.12	0.1%	TBD

Total nitrogen concentrations

Statewide flow weighted mean TN concentrations have increased steadily from 13.2 mg/L (2010-2012 average) to 15.9 mg/L (2021-2023 average).

Figure 2. Annual wastewater effluent Total Nitrogen concentrations



Typical TN effluent concentrations by facility class

Typical effluent TN concentrations vary by facility type and size. All municipal and a few industrial WWTFs are assigned to Classes A through D based on factors such as operational complexity, restrictiveness of effluent limits and influent wastewater variability characteristics. Most industrial permits authorize wastewater discharges that do not require biological wastewater treatment and are not assigned a facility classification. However, six unclassified industrial wastewater discharges contain significant TN concentrations.

Table 5. Evaluated permitted wastewater with 2018 – 2022 TN data

	Class A	Class B	Class C	Class D	High concentration industrial	Low concentration industrial
Municipal	81	98	84	311	0	0
Industrial	4	1	6	0	6	362
Major	65	11	1	2	0	19
Minor	20	88	89	309	6	343

Table 6. 2018 – 2022 total nitrogen effluent concentrations (mg/L)

	Class A	Class B	Class C	Class D	High concentration industrial	Low concentration industrial
Mean	19.8	19.0	20.5	4.4	44.0	2.3
Median	19.0	17.2	18.0	3.6	35.6	1.5
Max	54.0	53.0	73.0	14.0	160.0	8.1
Min	1.6	0.5	0.1	0.0	1.3	0.0
Standard dev.	10.5	10.5	14.8	3.1	33.0	1.9
Mean + standard dev.	**30.3**	**29.5**	**35.4**	**7.5**	**77.0**	**4.2**

For the purposes of this strategy, the threshold for distinguishing between high and low concentration discharges is the facility classification mean TN concentration plus one standard deviation, rounded to the nearest integer. The two exceptions are high concentration industrial facilities which are assigned the same concentration threshold as Class A and B facilities, and low concentration facilities which are adjusted up to the draft NO_3-N criterion for cold water streams.

Table 7. High vs. low concentration discharge threshold

	Class A	Class B	Class C	Class D	High concentration industrial	Low concentration industrial
High/low discharge TN concentration threshold	30 mg/L	30 mg/L	35 mg/L	8 mg/L	30 mg/L	5 mg/L

Municipal and industrial WWTFs exceeding the class-based thresholds shown in table seven are considered high concentration discharges.

Wastewater nitrogen reduction and implementation strategy

Wastewater nutrient reduction strategy – proposed reduction scenario

Minnesota's wastewater nitrogen reduction strategy is designed to achieve effluent NO_3-N and TN reductions consistent with local and downstream water quality goals by:

1. Implementation of water quality-based effluent limits (WQBELs) for WWTFs that have a reasonable potential to cause or contribute exceedances of future aquatic life nitrate-nitrogen WQS and/or to Index of Biotic Integrity (IBI) impairments for which NO_3-N has been identified as a stressor. Implementation of the WQBELs alone is not expected to achieve Minnesota's NRS targets for the wastewater sector.
2. Implementation of 10 mg/L TN effluent limits for major municipal WWTFs and high concentration minor municipal WWTFs and industrial TN discharges.

3. Permit requirements for development and implementation of nitrogen management plans for most wastewater dischargers.

These proposed reductions will meet the reduction goals called for by the 2014 Minnesota Nutrient Reduction Strategy (NRS) at state lines based on current flows and proposed effluent limit concentrations. The MPCA believes that this wastewater nitrogen reduction strategy's goals represent attainable and appropriate nitrogen management goals for the wastewater sector. We recognize that as populations increase, wastewater discharges may also increase, and that goals may need to be re-evaluated decades into the future to best align with any changes to goals set for the Gulf of Mexico, Lake Winnipeg and other downstream waters. Appendix B examines the original and updated NRS baseline TN loads and reduction goals for the wastewater sector and the current wastewater TN reductions needed to meet the original NRS goals for the sector. Also considered in Appendix B are the short-term and long-term wastewater load implications of the proposed wastewater TN reduction strategy as well as a proposed reduction scenario in which the wastewater baselines and goals delivered to Minnesota's border have been recalculated.

The MPCA is proposing to implement this wastewater nitrogen reduction strategy in three phases over multiple 5-year NPDES/SDS permit cycles:

Phase 1 (first permit cycle beginning on or after April 1, 2024)

- Implement MPCA guidance for new, expanding, and significantly upgraded[1] WWTFs:
  - For discharges which will cause or have a reasonable potential to cause or contribute to exceedances of:
    - NO_3-N drinking water standard in downstream waterbodies utilized as drinking water sources; or
    - NO_3-N causing biological stress to aquatic organisms.

  The MPCA will develop nitrogen effluent limits that ensure that downstream uses are protected. Effluent limits will be included in the WWTF's NPDES/SDS permit, and construction of all necessary treatment units will be required to achieve effluent denitrification to levels sufficient to protect downstream uses.
  - For all other discharges, project proposers will be required to submit facility plans that include design considerations for denitrification to levels sufficient to protect downstream uses and to achieve the future projected nitrogen.
- Begin administrative process to adopt NO_3-N aquatic life toxicity WQS and a 10 mg/L 12-month moving average or calendar year average[2] TN State Discharge Restriction (SDR) for major municipal WWTFs and high concentration minor municipal WWTFs municipal and industrial discharges.
  - SDR will include an optimization incentive – facilities that optimize operations to achieve 15 mg/L TN effluent concentrations as a 12-month moving average or calendar year average[2] during Phase 1 will have the 10 mg/L SDR limit deferred to the permit's second permit cycle

[1] Facilities are considered significantly upgraded when biological treatment units are replaced or substantially rebuilt.

[2] SDR limit type of 12-month moving average or calendar year average is dependent upon facility type at time of implementation.

following SDR adoption (i.e. Phase 3). Permittees will be made aware of this SDR optimization opportunity in Phase 1.

- High concentration municipal and industrial dischargers – reissued permit will include a requirement to develop and implement a nitrogen management plan (NMPs). See Table 3 above.
- All NPDES/SDS permitted facilities discharging upstream of a known Index of Biotic Integrity (IBI) impaired water with NO_3-N as a stressor – reissued permit will include a requirement to develop and implement an enhanced NMP.
- The MPCA will continue to develop WQBELs for discharges that cause or have a reasonable potential (RP) to cause or contribute to impairments based on existing nitrogen standards.
- Nitrogen WQBELs will be developed for NPDES/SDS permitted discharges that have RP to cause or contribute to a NO_3-N impaired Class 1 water.

Phase 2 (first permit cycle following adoption of NO3-N aquatic life toxicity WQS and adoption of a 10 mg/l SDR)

- All Phase 1 implementation steps will remain in effect except as modified by the implementation of Phase 2.
- Low concentration municipal and industrial dischargers will develop and implement NMPs if effluent concentrations exceed the concentration thresholds shown in Table 3 above.
- Permit limits.
  - Nitrogen WQBELs will be developed for NPDES/SDS permits found to have RP in accordance with the NO3-N aquatic life toxicity WQS.
  - 10 mg/L TN, 12-month moving average or calendar year average[2] SDR limits will be included in NPDES/SDS permits in accordance with the criteria of the SDR.
  - Optimization incentive – 10 mg/L TN effluent limits will be deferred to Phase 3 for facilities that have successfully optimized operation to achieve a 15 mg/L TN 12-month moving average or calendar year average[2] concentration during Phase 1 of this strategy.

Phase 3 (second permit cycle following adoption of NO_3-N aquatic life toxicity WQS and adoption of a 10 mg/l SDR)

- All Phase 1 and 2 implementation steps will remain in effect except as modified by implementation of Phase 3.
- 10 mg/L TN SDR 12-month moving average or calendar year average[2] effluent limits will be included in NPDES/SDS permits for major municipal wastewater facilities and high concentration minor municipal WWTFs and industrial dischargers that had successfully optimized operations per incentive.

[2] SDR limit type of 12-month moving average or calendar year average is dependent upon facility type at time of implementation.

Table 8. Wastewater nitrogen reduction strategy implementation summary		Major municipal WWTP	Major municipal WWTP	Minor municipal WWTP	Minor municipal WWTP	Industrial discharger	Industrial discharger
		Low concentration[1]	High concentration[1]	Low concentration[1]	High concentration[1]	Low concentration[1]	High concentration[1]
Phase 1 – First permit cycle starting April 1, 2024	MPCA	Begin administrative process to adopt 10 mg/l TN State Discharge Restriction (SDR) and NO_3-N WQS. Notify permittees of eligibility for deferred implementation of 10 mg/l SDR TN limits to Phase 3 if facilities have successfully optimized operations to a 15 mg/l annual average concentration during Phase 1.					
	All NPDES wastewater facilities		Develop & implement NMP		Develop & implement NMP		Develop & implement NMP
	New, expanded, and significantly upgraded facilities[3] with RP for drinking water and IBI impaired waters with NO_3-N stressors	Designed and built to meet N WQBELS	Designed and built to meet N WQBELS	Designed and built to meet N WQBELS	Designed and built to meet N WQBELS	Designed and built to meet N WQBELS	Designed and built to meet N WQBELS
	All other new, expanded, and significantly upgraded facilities[3]	Designed for denitrification	Designed for denitrification	Designed for denitrification	Designed for denitrification	Designed for denitrification	Designed for denitrification
	RP for exceedance of existing class 1 waters 10 mg/L NO_3-N WQS	TN WQBEL[2]	TN WQBEL[2]	TN WQBEL[2]	TN WQBEL[2]	TN WQBEL[2]	TN WQBEL[2]
	Facilities discharging upstream of IBI impaired waters with NO_3-N stressors	Develop & implement enhanced NMP[4]	Develop & implement enhanced NMP[4]	Develop & implement enhanced NMP[4]	Develop & implement enhanced NMP[4]	Develop & implement enhanced NMP[4–5]	Develop & implement enhanced NMP[4]
	TMDL wasteload allocation	TN WQBEL if discharge has RP[2]	TN WQBEL if discharge has RP[2]	TN WQBEL if discharge has RP[2]	TN WQBEL if discharge has RP[2]	TN WQBEL if discharge has RP[2]	TN WQBEL if discharge has RP[2]
Phase 2 – First permit cycle following adoption of 10 mg/l TN SDR and NO_3-N WQS [all Phase 1 requirements remain in effect except as modified by implementation of Phase 2]	MPCA	Begin implementation of 10 mg/L TN SDR & NO_3-N WQBELS					
	All NPDES wastewater facilities	Develop & implement NMP	Update & implement NMP	Develop & implement NMP	Update & implement NMP	Develop & implement NMP[5]	Update & implement NMP
	All NPDES wastewater facilities	10 mg/L SDR TN limit[7–8]	10 mg/L SDR TN limit[7–8]		10 mg/L SDR TN limit[7–8]		10 mg/L TN SDR limit[7–8]
	RP for exceedance of AQL NO_3-N WQS or IBI impairments with NO_3-N stressors	TN or NO_3-N WQBEL[6]	TN or NO_3-n WQBEL[6]	TN or NO_3-N WQBEL[6]	TN or NO_3-N WQBEL[6]	TN or NO_3-N WQBEL[6]	Tn or no_3-n wqbel[6]
Phase 3 – Second permit cycle following adoption of 10 mg/l SDR & NO_3-N WQS [all Phase 1 and 2 requirements remain in effect except as modified by implementation of Phase 3]	All NPDES wastewater facilities	Update & implement NMP	Update & implement NMP	Update & implement NMP	Update & implement NMP	Update & implement NMP[5]	Update & implement NMP
	All NPDES wastewater facilities	10 mg/L TN limit for facilities that have successfully optimized operations during Phase 1[8]	10 mg/L TN limit for facilities that have successfully optimized operations during Phase 1[8]		10 mg/L TN limit for facilities that have successfully optimized operations during Phase 1[8]		10 mg/L TN limit for facilities that have successfully optimized operations during Phase 1[8]

Table 8 footnotes

[1]High vs. low concentration determined based on facility class mean concentration + standard deviation (see Table 7).

[2]TN limit and limit type to be determined at permit issuance.

[3] Facilities considered to be significantly when biological treatment units are replaced or substantially rebuilt.

[4]Enhanced NMP is a goal-oriented optimization plan designed to achieve a specific effluent concentration target.

[5]Low concentration industrial dischargers to develop NMPs if effluent concentrations exceed threshold TN concentration (see Table 7).

[6]Limit parameter and limit type to be determined at permit issuance.

[7]Attainment of 10 mg/l TN limit deferred to the third permit cycle if the facility has successfully optimized operations to a 15 mg/l annual average concentration during Phase 1.

[8]10 mg/l TN limits implemented as 12-month moving average or calendar year average (depending on facility type) limit types.

Meeting nutrient reduction strategy goals

Estimated TN load reductions based on this proposed strategy is expected to achieve Minnesota's NRS goals at the State's borders for the Mississippi River Basin based on current flows. The updated and revised NRS may describe how to reconcile potential increases into the future.

Table 8. Wastewater nitrogen reduction strategy estimated wastewater load reductions

	Updated NRS wastewater baseline TN load at state line (MT/yr)	NRS reduction goal (%)	NRS wastewater TN load goal at state line (MT/yr)	Current wastewater TN load at state line (MT/yr)	Proposed TN load at state line with this strategy (MT/yr)	Proposed TN reduction from baseline with this strategy implemented (%)
Mississippi River Basin	8,721	45%	4,797	10,163	4,069	53%
Red River Basin	326	50%	163	294	127	61%
Lake Superior Basin	1,212	TBD	TBD	785	664	45%
Rainy River Basin	218	TBD	TBD	179	137	37%

Compliance schedules

All compliance schedules to meet nitrogen limits will be developed in accordance with applicable Federal and State Statutes and regulations.

- 40 CFR § 122.47 – requiring schedules of compliance to require attainment of final effluent limits as soon as possible.
- MN Stat. § 115.455 – providing, to the extent allowable under federal law, for a municipality that constructs a publicly owned treatment works to comply with a new or modified effluent limitation, compliance with any new or modified effluent limitation adopted after construction begins that would require additional capital investment is required no sooner than 16 years after the date the facility begins operating.
- MN Stat. § 115.456 – requiring the Pollution Control Agency to consider current debt service on existing municipal wastewater treatment infrastructure when developing compliance schedules for new effluent limits in municipal national pollutant discharge elimination system (NPDES) permits.
- MN Rule 7001.0150 – schedules of compliance to require compliance in the shortest reasonable period of time or by a specified deadline if required by Minnesota or federal statute or rule.

Optimization of wastewater treatment facilities

Wastewater treatment facility operations can be optimized for nitrogen reduction. Optimization allows wastewater operators to make adjustments to their existing facility's operations without having to make costly infrastructure upgrades and enables them to start making nitrogen reductions sooner rather than later.

However, there are instances where optimization may not be the right alternative. Things facilities will need to take under consideration when making this decision is if plants are at or near their design flow capacity. There may not be available hydraulic capacity to optimize operations for nitrogen removal. Treatment capacity lost in optimizing operations for denitrification could result in the need for future infrastructure updates and this could be seen as a "delayed capital investment." Also important is the possibility that optimizing operations for nitrogen removal may result in increasing effluent phosphorus concentrations. Facilities that are required to achieve low level effluent phosphorus concentrations and/or are operating close to permitted phosphorus effluent limits will need to pay close attention to the effects of optimization on treatment efficiency of other regulated pollutants.

Additionally, a risk that facilities could run into with optimizing is that, because they would be operating their plant in a manner that is different from what it was initially designed and approved to do, an engineer's signature may be required to operate the facility in this (optimized) manner.

Creation of an "optimization coordinator"

When the stakeholders were asked, "what could the Agency or should the Agency do to encourage optimization?" we heard a need for Agency experts to come out to the facilities at low or no cost to answer questions rather than the city's having to hire consulting engineers. A lot of facilities are able to utilize resources through rural water or the Minnesota technical assistance program (MnTAP) but it would be beneficial to have an Agency expert available to assist operators and communicate/show what has worked well at facilities and what are operational changes that could work at their facility.

Currently, there is some risk to wastewater operators and MPCA engineers in encouraging facilities to operate a plant in a manner that is different from what it was initially planned and approved for. There is risk if the optimization is not successful and/or there are violations of other pollutant parameters.

The nitrogen stakeholder group is recommending the Agency create a new position for an optimization coordinator. Ideally, this position would be an engineering position where the incumbent is an expert in plant operations and optimization.

This position would need to coordinate with multiple program areas within the Agency as well as externally. Internally, the optimization coordinator would need to work with MPCA compliance and enforcement staff as there is a risk of violating an effluent limit while making operational changes at the facility. Externally, the optimization coordinator would coordinate with representatives from rural water, MnTAP, operator's organizations and private consulting firms. The optimization coordinator would also coordinate training opportunities internally to MPCA staff as well as externally.

Water quality trading

Water quality trading is an option NPDES/SDS permitted dischargers can use to offset a portion of their nitrogen reduction responsibilities, allowing point source dischargers to enter into agreements under which a point source "offsets" its pollutant load by obtaining reductions in a pollutant load discharged by other point or nonpoint sources in the same watershed. The MPCA must establish specific conditions governing trading in the point source discharger's NPDES/SDS permit, or in a general permit that authorizes the point source discharge.

Trading may occur between two-point source dischargers (point-point trading) or point source dischargers and nonpoint source dischargers (point-nonpoint trading). Before a WWTF can participate in trading, MPCA will propose a draft permit that will establish conditions (including trade ratios) under which MPCA proposes to approve trading through its permit. The proposed draft permit will include a trading plan that MPCA believes ensures consistency with applicable Minnesota laws, WQS, TMDL WLAs, CWA provisions and EPA regulations.

Additional information regarding water quality trading can be found in Appendix C of this document and in the MPCA's Water Quality Trading Guidance.

Regulatory certainty

Minnesota Statutes Chapter 115.426 establishes incentives for municipalities and industries to install biological nutrient removal WWTFs. A municipality that installs a biological nutrient removal system on a voluntary basis and receives public funds to construct the biological nutrient removal system or an industrial NPDES/SDS permit holder that installs a biological nutrient removal system may request the regulatory certainty incentive.

A municipality with an existing WWTF that includes treatment technology that is designed for nitrogen removal on July 1, 2016, is eligible for the regulatory certainty incentive under this section if it agrees to meet water-quality-based permit limits for phosphorus and also voluntarily accepts a nitrogen limit determined by the commissioner based on agency review of its engineering plans and specifications and its existing facilities.

The commissioner of the MPCA may provide phosphorus and nitrogen regulatory certainty for an eligible municipality or industrial permit holder in a NPDES/SDS permit. Before the NPDES/SDS permit is finalized for an eligible municipality or industrial permit holder, the commissioner must determine whether to provide regulatory certainty, based on the system's effectiveness in removing nitrogen. If the commissioner will provide regulatory certainty, the commissioner and the municipality or industrial permit holder must execute an agreement recognizing the term and requirements relating to the regulatory certainty. The agreement becomes part of the NPDES/SDS permit. Regulatory certainty extends for the expected design life of the biological nutrient removal system or 20 years, whichever is shorter, as long as the system is properly maintained and operated by the municipality or industrial permit holder. A municipality or industrial permit holder may receive regulatory certainty only one time for each WWTF.

Applications must not be accepted under this section after December 31, 2031, or the day following US EPA approval of a MPCA-adopted nitrate-nitrogen aquatic life WQS, whichever occurs first.

Funding opportunities

The Clean Water Revolving Fund (CWRF) and Point Source Implementation Grant (PSIG) programs are well funded existing programs that are currently available for WWTF nitrogen reduction upgrades. These existing programs are probably sufficient to fund nitrogen treatment upgrades for minor and most major municipal facilities, but additional funding sources will be needed for very large major facilities.

- CWRF-Please note: Federal infrastructure investments and jobs act (IIJA) funds will be allocated through existing SRF funding programs formulas and deadlines.
  - Eligibility – Cities, counties, townships, sanitary districts, or other governmental subdivisions responsible for wastewater treatment are eligible.
  - Project requirements – Projects must be included on the MPCA's project priority list and the PFA's annual intended use plan. Projects must be certified by the MPCA before the PFA may approve a loan. Applicants must demonstrate the financial capacity to repay the loan and that complete financing of the project is in place. Borrowers must issue a general obligation bond to the PFA as security for the loan.

- Allowable costs – Allowable costs include site preparation, construction, engineering, equipment and machinery, bond issuance, and certain fees and contingency costs.
- Interest rates – Rates are determined by a market rate index (market scale) or the PFA's bond market rate (authority scale), whichever is higher, less a 1.0 percent discount approved by the PFA. Borrowers with a service area population under 2,500 may be entitled to additional discounts. The type of security pledged to the PFA, the loan term and principal schedule, and the presence of a significant user will affect the interest rate of the loan.
- Terms – Loans are amortized up to a maximum of 20 years or up to 30 years if the average annual residential cost would exceed 1.4 percent of median household income (MHI). Also see wastewater infrastructure fund for possible eligibility for supplementary affordability grant assistance.
- Applications – Applications are accepted within six months after the intended use plan is approved using the PFA's loan application forms. The IUP is compiled once a year but may be amended.
- Loan disbursement – Funds are disbursed on a monthly basis as costs are incurred.

- PSIG
  - Eligibility – provides grants to units of local government to assist with the cost of water infrastructure projects necessary to.
  - Meet WLA reductions prescribed under a TMDL plan required by Section 303(d) of the Federal Clean Water Act.
  - Reduce the discharge of total phosphorus to 1 mg/L or less.
  - Meet any other WQBEL established under section Minn. Stat. § 115.03, subd. 1, (e)(8), that is incorporated into a permit issued by MPCA that exceeds secondary treatment limits.
  - Meet a TN concentration, or corresponding mass limit, that requires discharging 10 mg/L or less at a permitted design flow.
  - Grants are for 80% of eligible costs up to a maximum of $7 million for eligible project costs.

- Optimization funding
  - No current funding programs.
  - LCCMR funded recent limited optimization efforts (MnTAP & MN rural water).
  - Optimization funding needed for consultants and minor facility modifications.
  - The MPCA is proposing to utilize the 2% technical assistance set-aside funding to hire credentialed staff to assist operators on site.
- Nonpoint source project funding for trading projects.
  - Clean Water Partnership – Zero or 1% interest loans. Program is not sufficiently capitalized.
  - Ag BMP Loan Program (Mn Department of Agriculture).
  - BWSR & Mn Agricultural Water Quality Certification Program.
- Greenhouse gas funding
  - Will widespread adoption of wastewater denitrification result in significant nitrous oxide (N2O) emissions reductions from the wastewater sector?
  - Are GHG reduction funding sources available for pilot testing, optimization, or upgrades?

Long-term efforts / contracted efforts

I. **Nitrogen management plan development**

The MPCA has been awarded Gulf Hypoxia Program (GHP) grant money from the EPA that could be used to either pay for internal staff or contract with an external entity to create a nitrogen management plan template.

The MPCA work plan for using the GHP grant specifies the work is to identify and document municipal WWTFs in Minnesota and in other states which have reduced nitrogen and optimized phosphorus and nitrogen treatment. The work would describe how they achieved the reductions technically and financially, and what prompted the nitrogen treatment. By using this information and other recently completed optimization analysis, a nitrogen management plan template can be created for facilities to utilize. The completion of a nitrogen management plan could be voluntary or could be a future permit requirement.

II. **Summaries of the costs and benefits of nitrogen reduction**

A cost/benefit analysis will need to be completed for the Statement of Need and Reasonableness (SONAR) during rulemaking of the standard.

We recommend the updated NRS include summaries of the costs and of the benefits of nitrogen reduction for both point sources and nonpoint sources. Additional resources may be needed to complete a detailed cost-benefit analysis.

- **Uses for cost/benefit analysis:** The Agency would use a cost/benefit analysis to develop the SONAR, though not all findings from the cost/benefit analysis are needed for this purpose.

  The results could also include a discussion of the benefits to the local water quality. Permittees can use results from the cost benefit analysis to assist in making on-site determinations regarding the best, cost/effective measures to take to reduce nitrogen as well as potential trading opportunities, watershed level projects, or other alternatives with nonpoint sources in their areas.

Appendix A.

Wastewater nutrient reduction strategy – monitoring data

1. Monitoring requirements

In accordance with 40 CFR 122.21 (j), domestic WWTPs with a design flow greater than or equal to 0.1 million gallons per day (mgd) are required to sample their effluent twice per year for Nitrite + Nitrate, Total Kjeldahl Nitrogen (TKN), Ammonia, and Total Dissolved Solids (TDS).

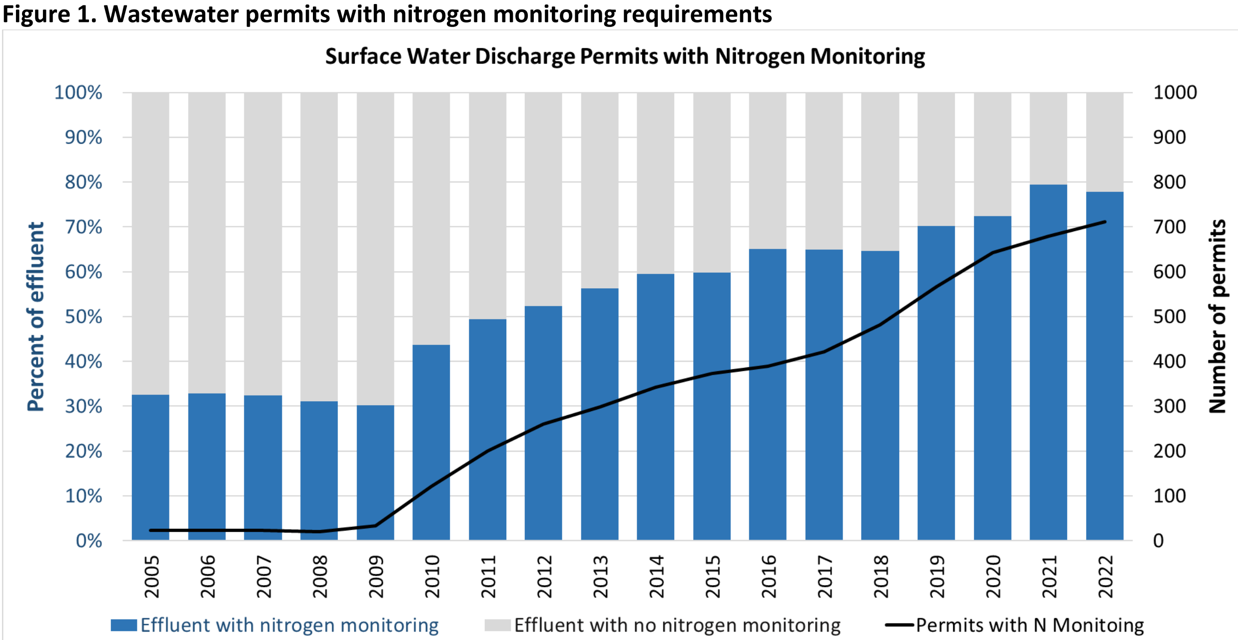
All major domestic WWTPs are required to sample once per month for ammonia to provide adequate data to determine toxicity of their effluent.

Industrial facilities are required to monitor regularly for Nitrite + Nitrate, TKN, Total Nitrogen (TN), and/or Ammonia if there is a potential for elevated nitrogen to exist in the waste stream such that those pollutants may contribute to water quality violations in the immediate surface receiving waters.

Following the publication of the 2014 Minnesota Nutrient Reduction Strategy influent and effluent monitoring for total nitrogen (Nitrite + Nitrate plus TKN) has been added or increased in municipal and industrial NPDES Permits.

The number NPDES permits with nitrogen monitoring began to increase in 2010 as the MPCA implemented the requirements of minimum monitoring requirements specified in 40 CFR 122.21 (j) and continued to increase following the publication of the Minnesota Nutrient Reduction Strategy. The number of permits containing nitrogen monitoring requirements has increased from 23 in 2005 to 711 in 2022. As of December 2022, 79% of Minnesota's NPDES permits include nitrogen monitoring requirements.

Figure 1. Wastewater permits with nitrogen monitoring requirements



The following tables specify Nitrogen monitoring requirements included in Minnesota's NPDES/SDS wastewater permits.

Abbreviation key

Parameter – full Tempo name	Abbreviation – table name
Nitrite Plus Nitrate, Total (as N);	Nitrite + Nitrate
Nitrogen, Kjeldahl, Total;	TKN
Nitrogen, Total (as N)	TN
Nitrogen, Ammonia, Total (as N)	Ammonia
Solids, Total Dissolved (TDS)	TDS

Municipal/domestic WWTPs nitrogen limits and monitoring requirements

Facility type & AWW design flow	Waste stream	Parameters	Frequency	Limit type	Sample type	Effective period
Major mechanical 10+ mgd	Influent	Nitrite + Nitrate, TKN	2xMonth	calendar month average	24-hour flow composite	Jan-Dec
		TN	2xMonth	calendar month average	Calculation	Jan-Dec
	Effluent	Nitrite + Nitrate, TKN	2xMonth	calendar month average	24-hour flow composite	Jan-Dec
		TN	2xMonth	calendar month average	Calculation	Jan-Dec
		Ammonia	1xMonth	calendar month average	24-hour flow composite	Jan-Dec
		TDS	1XMonth	calendar month average	24-hour flow composite	Mar, Sept
Major mechanical (1.0 – 9.99 mgd)	Influent	Nitrite + Nitrate, TKN	1xMonth	calendar month average	24-hour flow composite	Jan-Dec
		TN	1xMonth	calendar month average	Calculation	Jan-Dec

Facility type & AWW design flow	Waste stream	Parameters	Frequency	Limit type	Sample type	Effective period
	Effluent	Nitrite + Nitrate, TKN, Ammonia	1xMonth	calendar month average	24-hour flow composite	Jan-Dec
		TN	1xMonth	calendar month average	Calculation	Jan-Dec
		TDS	1XMonth	calendar month average	24-hour flow composite	Mar, Sept
Minor mechanical (0.1 mgd – 0.99)	Influent	Nitrite + Nitrate, TKN	1xQuarter	calendar month average	24-hour flow composite	Mar, Jun, Sep, Dec
		TN	1xQuarter	calendar month average	Calculation	Mar, Jun, Sep, Dec
	Effluent	Nitrite + Nitrate, TKN	1xQuarter	calendar month average	24-hour flow composite	Mar, Jun, Sep, Dec
		TN	1xQuarter	calendar month average	Calculation	Mar, Jun, Sep, Dec
		Ammonia, TDS	1xMonth	calendar month average	24-hour flow composite	Mar, Sep
Minor mechanical (less than 0.1 mgd)	Influent	Nitrite + Nitrate, TKN	1xMonth	calendar month average	24-hour flow composite	Mar, Sep
		TN	1xMonth	calendar month average	Calculation	Mar, Sep
	Effluent	Nitrite + Nitrate, TKN	1xMonth	calendar month average	24-hour flow composite	Mar, Sep

Facility type & AWW design flow	Waste stream	Parameters	Frequency	Limit type	Sample type	Effective period
		TN	1xMonth	calendar month average	Calculation	Mar, Sep
Pond (over 0.1 mgd)	Influent	Nitrite + Nitrate, TKN	1xQuarter	calendar month average	4-hour flow composite	Mar, Jun, Sep, Dec
		TN	1xQuarter	calendar month average	Calculation	Mar, Jun, Sep, Dec
	Effluent	Nitrite + Nitrate, TKN	1xMonth	calendar month average	Grab	Jan-Dec
		TN	1xMonth	calendar month average	Calculation	Jan-Dec
		Ammonia, TDS	1x half year	calendar month average	Grab	Jan-Dec
Pond (under 0.1 mgd)	Influent	Nitrite + Nitrate, TKN	1xMonth	calendar month average	4-hour flow composite	Mar, Sep
		TN	1xMonth	calendar month average	Calculation	
	Effluent	Nitrite + Nitrate, TKN	1x half year	calendar month average	Grab	Jan-Dec
		TN	1x half year	calendar month average	Calculation	Jan-Dec
Aerated pond major 10+mgd*	Influent	Nitrite + Nitrate, TKN	2xMonth	calendar month average	24-hour flow composite	Jan-Dec
		TN	2xMonth	calendar month average	Calculation	Jan-Dec

Facility type & AWW design flow	Waste stream	Parameters	Frequency	Limit type	Sample type	Effective period
		Nitrite + Nitrate, TKN	2xMonth	calendar month average	24-hour flow composite	Jan-Dec
		TN	2xMonth	calendar month average	Calculation	Jan-Dec
		Ammonia	1xMonth	calendar month average	24-hour flow composite	Jan-Dec
	Effluent	TDS	1XMonth	calendar month average	24-hour flow composite	Mar, Sept
Aerated pond major (1.0 – 9.99 mgd)*	Influent	Nitrite + Nitrate, TKN	1x Month	calendar month average	24-hour flow composite	Jan-Dec
		TN	1xMonth	calendar month average	Calculation	Jan-Dec
	Effluent	Nitrite + Nitrate, TKN, Ammonia	1xMonth	calendar month average	24-hour flow composite	Jan-Dec
		TN	1xMonth	calendar month average	Calculation	Jan-Dec
		TDS	1XMonth	calendar month average	24-hour flow composite	Mar, Sept
Aerated pond (0.1 – 0.99 mgd)*	Influent	Nitrite + Nitrate, TKN	1xQuarter	calendar month average	24-hour flow composite	Mar, Jun, Sep, Dec
		TN	1xQuarter	calendar month average	Calculation	Mar, Jun, Sep, Dec
	Effluent	Nitrite + Nitrate, TKN	1xQuarter	calendar month average	24-hour flow composite	Mar, Jun, Sep, Dec
		TN	1xQuarter	calendar month average	Calculation	Mar, Jun, Sep, Dec
		Ammonia, TDS	1xMonth	calendar month average	24-hour flow composite	Mar, Sep
Aerated pond (less than 0.1 mgd)*	Influent	Nitrite + Nitrate, TKN	1xMonth	calendar month average	24-hour flow composite	Mar, Sep
		TN	1xMonth	calendar month average	Calculation	Mar, Sep
	Effluent	Nitrite + Nitrate, TKN	1xMonth	calendar month average	24-hour flow composite	Mar, Sep

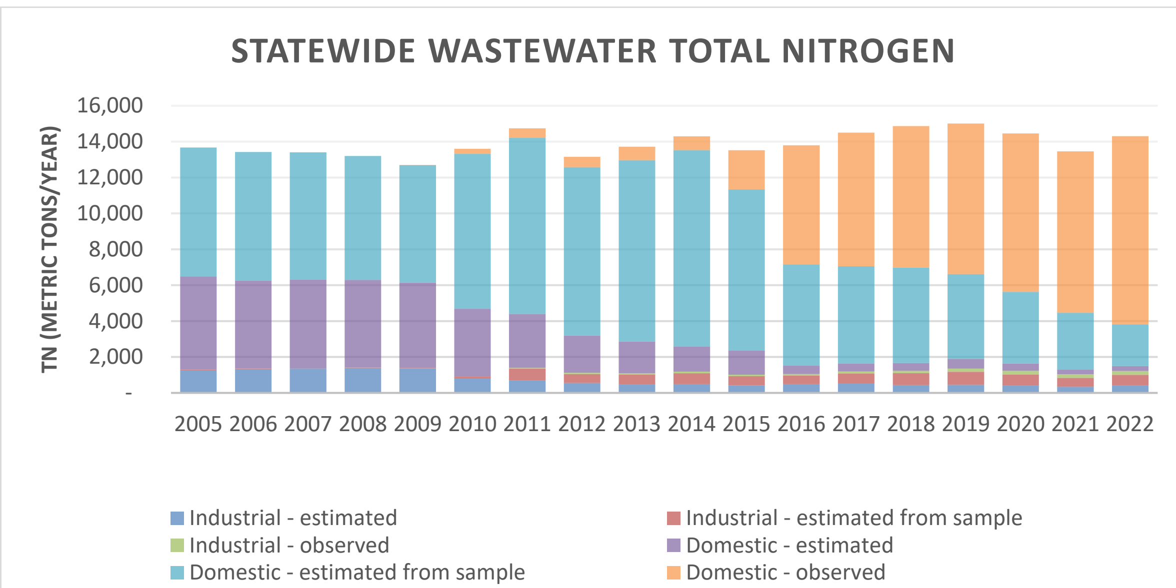
2. Total nitrogen effluent loads

A significant majority (85%) of Minnesota's wastewater TN load is discharged by domestic (aka municipal) major facilities. Smaller proportions of the overall wastewater TN load are discharged by industrial major facilities (7%), domestic minor facilities (5%) and industrial minor facilities (3%).

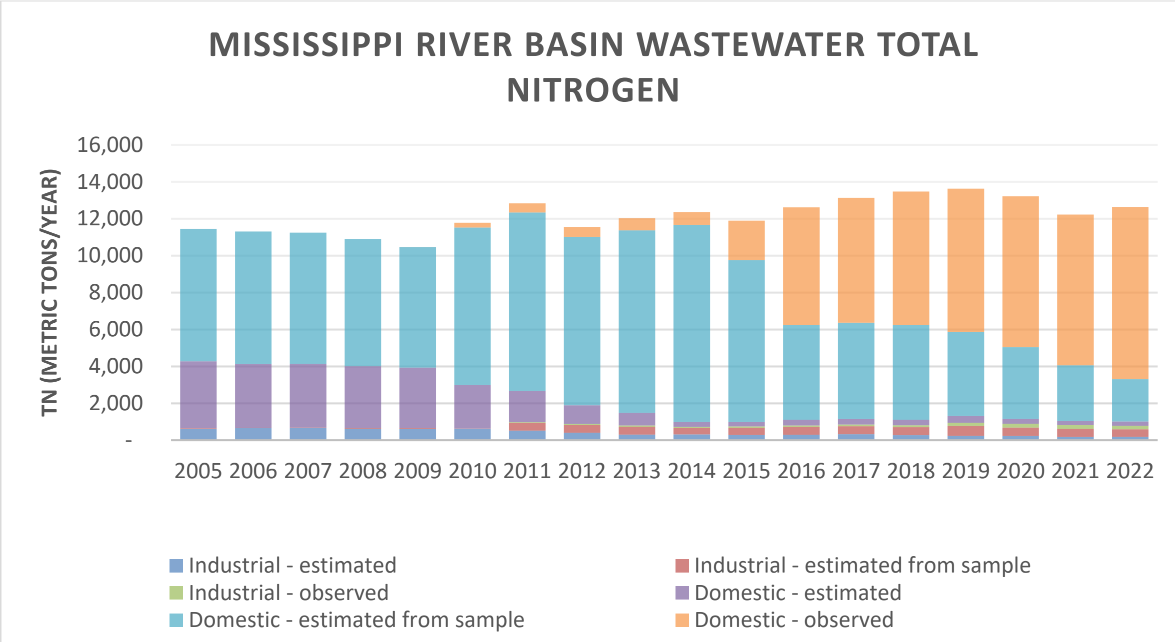
Facility type	% of Total wastewater load
Domestic	90%
Industrial	10%
Majors	92%
Minors	8%
Domestic Majors	85%
Industrial Majors	7%
Domestic Minors	5%
Industrial Minors	3%

Estimated TN loads are calculated from reported effluent flows and sector based typical TN concentrations or infrequent effluent data reported by facilities. Observed TN loads are calculated from reported effluent flows and monitored effluent TN data.

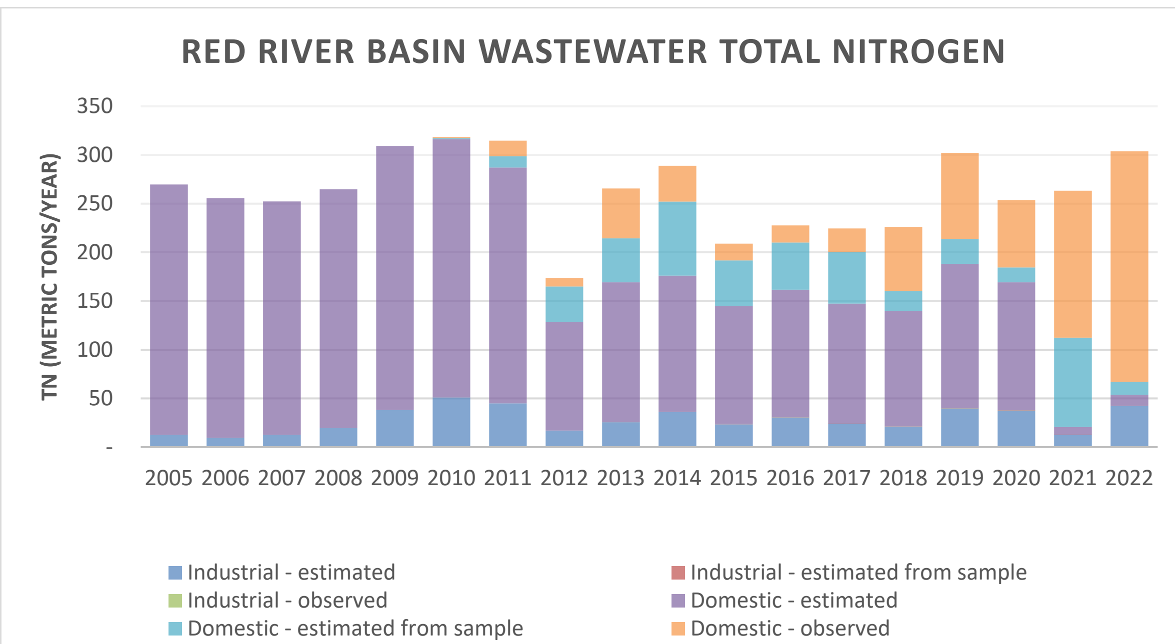
Statewide effluent monitoring data show that wastewater TN loads have increased from an estimated annual average of 13,584 metric tons/year from 2005 through 2015 to a mostly observed annual average of 14,343 metric tons/year from 2016 through 2022.



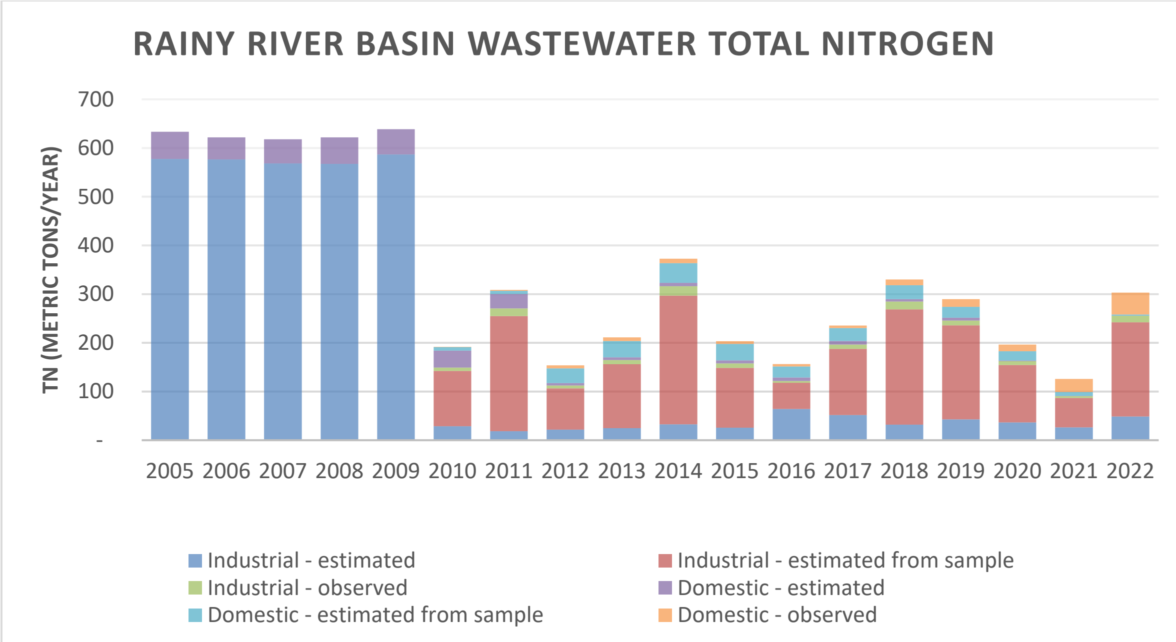
In Minnesota's HUC4 Basins draining to the Mississippi River (Cedar, Des Moines, Lower Mississippi, Minnesota, Missouri, Saint Croix and Upper Mississippi) effluent wastewater loads have increased from an estimated annual average of 11,620 metric tons/year from 2005 through 2015 to a mostly observed annual average of 12,988 metric tons/year from 2016 through 2022.



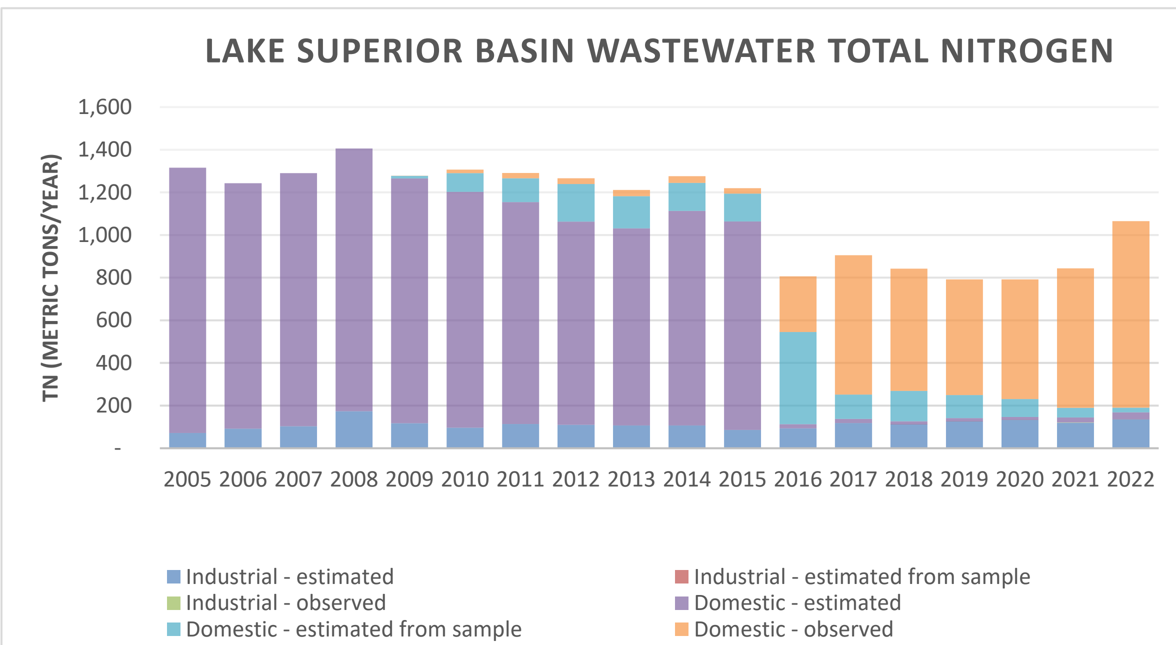
In Minnesota's portion of the Red River Basin effluent wastewater loads have increased from a largely estimated annual average of 260 metric tons/year from 2005 through 2020 to a mostly observed annual average of 284 metric tons/year from 2021 through 2022.



In Minnesota's portion of the Rainy River Basin effluent wastewater loads remain largely estimated. Average annual loads from 2010 through 2022 have been variable from a low of 126 metric tons/year in 2021 to a high of 373 metric tons/year in 2014. The long-term average annual load is estimated to be 237 metric tons/year.



In Minnesota's portion of the Lake Superior Basin effluent wastewater loads were largely estimated through 2016. Average annual loads from 2017 through 2021 have been relatively stable, averaging 835 metric tons/year but increased in 2022 to 1,065 metric tons/year.



3. Total Nitrogen Effluent Concentrations

Minnesota municipal WWTPs are assigned to four facility classes from A to D based on various rating values specified in Mn Rules Ch. 9400.0500. In general, class A or B facilities are larger and/or more complex continuous discharge (aka mechanical) WWTP. Class C facilities are typically smaller and/or less complex continuous discharge facilities. Class D facilities are almost exclusively controlled discharge stabilization pond WWTPs.

In addition to facility classifications, NPDES permitted WWTPs are also rated as major or minor facilities. Minnesota municipal WWTPs whose average wet weather design flow is ≥ 1 million gallons per day (mgd) are classified as major facilities. WWTPs whose average wet weather design flow is <1 mgd are classified as minor facilities. Industrial facility ranking is based on a classification system developed by the United States Environmental Protection Agency.

WWTP facility classes and major/minor facility rank are used to compare influent (waste stream) and effluent (surface discharge) wastewater TN concentrations reported by municipal and industrial wastewater facilities for 2022.

Influent and effluent municipal WWTP TN variability by facility class

Class A facilities have reported influent TN concentrations ranging from 7 mg/L to 199 mg/L with a median value of 46 mg/L. Effluent concentrations range from 1.6 mg/L to 90 mg/L with a median value of 21 mg/L.

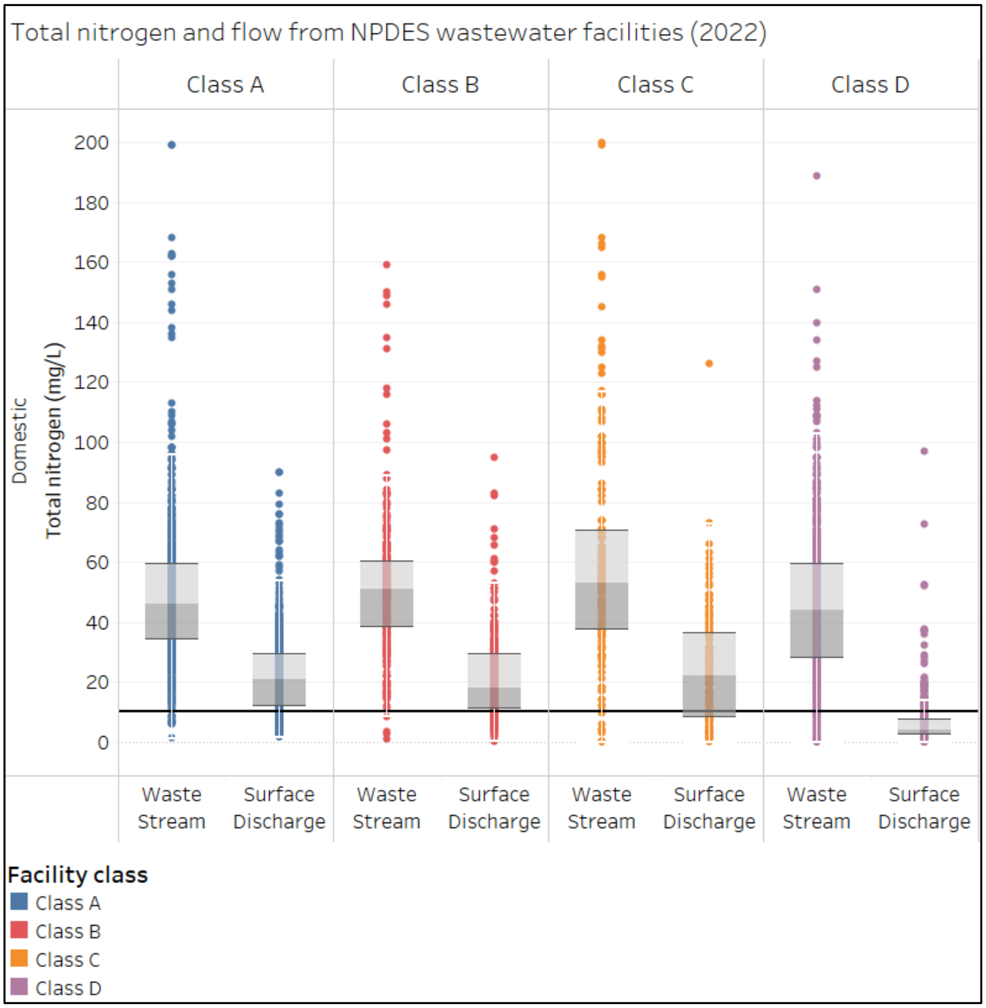
Class B facilities have reported influent TN concentrations ranging from 1 mg/L to 159 mg/L with a median value of 51 mg/L. Effluent concentrations range from 0.23 mg/L to 95 mg/L with a median value of 18 mg/L.

Class C facilities have reported influent TN concentrations ranging from 3 mg/L to 200 mg/L with a median value of 53 mg/L. Effluent concentrations range from 1.4 mg/L to 126 mg/L with a median value of 22 mg/L.

Class D facilities have reported influent TN concentrations ranging from 0.2 mg/L to 189 mg/L with a median value of 44 mg/L. Effluent concentrations range from 2.7 mg/L to 97 mg/L with a median value of 4 mg/L.

The ranges of influent concentrations are similar across all facility classes. Class D facilities report significantly lower TN concentrations than facilities in other classes. While the ranges of effluent concentrations discharged by mechanical facilities are similar, median TN concentrations discharged by Class B facilities are slightly lower than median concentrations discharged by Class A and Class C facilities.

Influent and effluent municipal WWTP TN variability by facility class



About the graph

The black horizontal line represents a 10mg/L TN for reference to effluent concentration goals. 50% of all observations fall within the grey boxes. The lower outline of the grey boxes represents the 25th percentile of the observations. The upper outline of the grey boxes represents the 75th percentile of the observations. The middle of the grey boxes represents the median value. Values above 200 mg/L have been excluded. The Waste Stream plots represent influent wastewater concentrations. The Surface Discharge plots represent effluent wastewater concentrations.

Mechanical facility influent and effluent TN variability by major/minor ranking

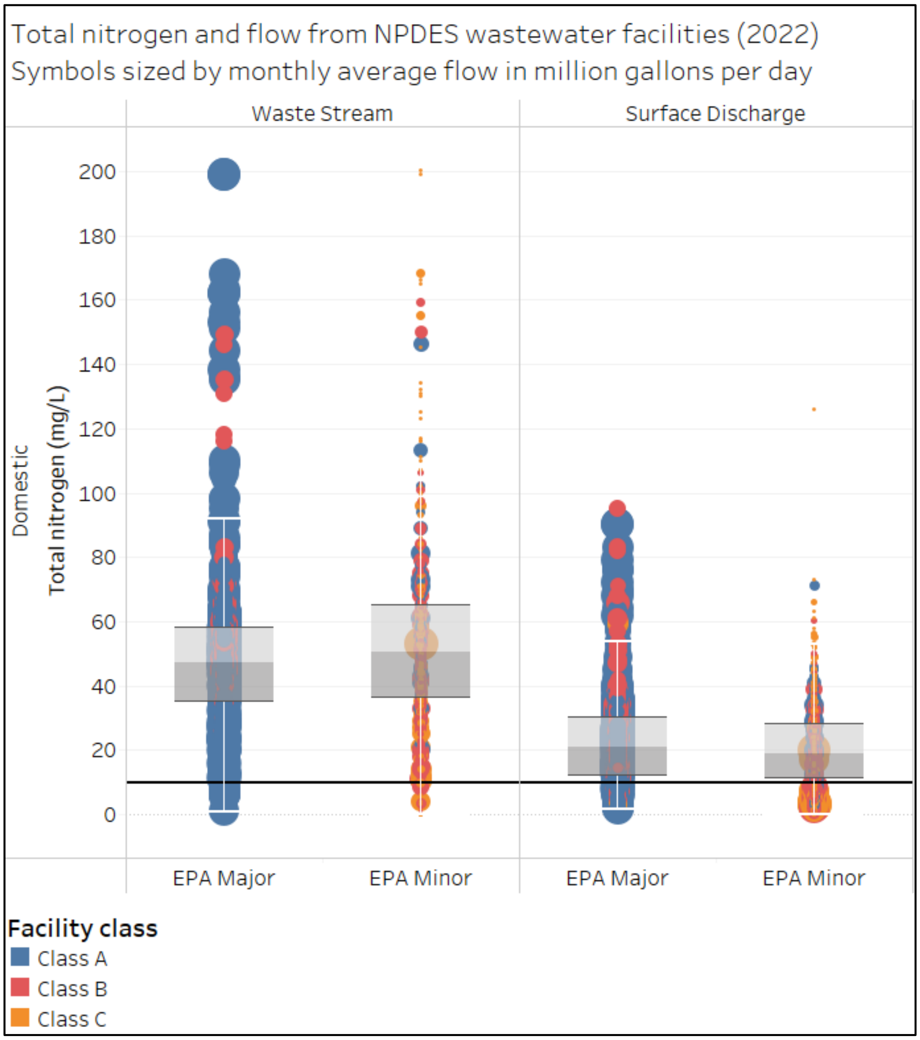
The black horizontal line represents a 10mg/L TN for reference to effluent concentration goals. Facility classes are represented by color. Average facility effluent flow is represented by symbol size.

Major and minor facility influent and effluent TN concentrations are shown. Class D facilities are not represented because the large number of low effluent concentration dischargers in that class skew the minor facility effluent data.

Major facilities have reported influent TN concentrations ranging from 1.1 mg/L to 199 mg/L with a median value is 47.1 mg/L. Effluent concentrations range from 1.6 mg/L to 95 mg/L with a median value of 21 mg/L.

Minor facilities have reported influent TN concentrations ranging from 2.65 mg/L to 200 mg/L with a median value is 50 mg/L. Effluent concentrations range from 1.2 mg/L to 126 mg/L with a median value of 19 mg/L.

The ranges and median values reported by major and minor facility influent concentrations are similar but small minor facilities report disproportionately high influent TN values. Similarly, effluent concentrations reported by major and minor facilities have similar ranges and median concentrations, but small minor facilities have higher TN concentrations than larger minor facilities.



About the graph

The black horizontal line represents a 10mg/L TN for reference to effluent concentration goals. Facility classes are represented by color. Average facility effluent flow is represented by symbol size. Half of all observations fall withing the grey boxes. The lower outline of the grey boxes represents the 25th percentile of the observations. The upper outline of the grey boxes represents the 75th percentile of the observations. The middle of the grey boxes represents the median value. Values above 200 mg/L have been excluded.

Appendix B.

Wastewater nitrogen reduction strategy – proposed reduction scenario

Minnesota's draft Wastewater Nitrogen Reduction Strategy proposes effluent Total Nitrogen (TN) reductions accomplished by:

1. Implementation of water quality based effluent limits (WQBELs) for wastewater treatment facilities (WWTP) that are expected to cause or have a reasonable potential to cause or contribute to exceedances of future aquatic life nitrate-nitrogen water quality standards[2].
2. Implementation of 10 mg/L TN effluent limits for major municipal WWTPs and high concentration minor municipal WWTFs and industrial TN discharges.
3. TN reduction requirements for other permitted wastewater discharges with disproportionately high effluent TN concentrations.

These proposed reductions will achieve the reduction goals called for by the 2014 Minnesota Nutrient Reduction Strategy (NRS)and the MPCA believes that they represent attainable and appropriate nitrogen management goals for the wastewater sector. The following is an examination of the original and updated NRS baseline TN loads and reduction goals for the wastewater sector and the current wastewater TN reductions needed to meet the original NRS goals for the sector.

A. NRS reduction goals for the wastewater sector

The 2014 NRS developed reduction goals for Total Phosphorus (TP) and TN delivered to the State's borders.

Figure 1. Major drainage basins in Minnesota.

The 2020 5-year Progress Report on Minnesota's Nutrient Reduction Strategy updated reduction goals for the Red River Basin to reflect nutrient reduction goals consistent with the 2019 recommendations by the International Joint Red River Board (IRRB)

[2] Nitrate aquatic life water quality standards have not yet been adopted. A Technical Support Document for the proposed standards was published in October 2022

. In May 2020, the International Joint Commission (IJC) forwarded the IRRB forwarded its support of the IRRB's proposed nutrient concentration objectives and nutrient load targets to the United States Department of State and Global Affairs Canada. On October 12, 2022, the United States Department of State and Global Affairs Canada approved the IJC's recommendation to add the proposed nutrient concentration objectives and load targets to the IRRB's list of Water Quality Objectives.

Table 1. Timeline for reaching goals and milestones.

Major basin	Milestone 2014 to 2025	Final Goal 2025 to 2040
1. **Mississippi River** (Also includes Cedar, Des Moines, and Missouri Rivers)	**12%** reduction in phosphorus (33% reduced prior to 2014)	Achieve **45%** total reduction from 1980- 96 baseline and meet in-state lake and river water quality standards
	20% reduction in nitrogen	Achieve **45%** total reduction from 1980-96 baseline
2. Red River (Lake Winnipeg Basin)	**10%** reduction in phosphorus	Achieve final reductions identified through joint efforts with Manitoba (about 50% from 1998 to 2001) [a]
	13% reduction in nitrogen	
3. Lake Superior	Maintain protection goals, no net increase from 1970s	
Groundwater/Source Water	Meet the goals of the 1989 Groundwater Protection Act	

a. The 2014 NRS noted that the International Red River basin water quality committee had suggested revised Red River nutrient reduction goals as high as 50% reductions from baselines. In September 2019, the International Red River Board agreed to pass along the proposed loading targets for the Red River at the US/Canada Boundary onto the International Joint Commission. The new load targets on the Red River at the Minnesota/Canadian Border are 1,400 MT of total phosphorus and 9,525 MT of total nitrogen. These load targets represent 48% and 52% of phosphorus and nitrogen 5-year rolling average loads during the 1998 to 2001 baseline timeframe, respectively. 5-year rolling average loads during recent years have averaged about 2,200 MT for phosphorus and 13,000 MT for nitrogen.

The 2020 5-year progress report on Minnesota's NRS also included revised existing nitrogen loads from permitted WWTPs. The 2014 NRS' wastewater baseline loads were derived from the USGS' SPAtially Referenced Regression On Watershed attributes (SPARROW) model to represent the 2005-2006 time period. The updated wastewater baselines represent 2010-2012 effluent TN loads.

Table 2. Revised existing nitrogen loads from permitted wastewater.

	Nitrogen			
	2014 NRS wastewater baseline load (SPARROW representing the 2005-2006 time period) (MT/yr)	**Updated wastewater baseline load (average 2010-2012) (MT/yr)**	**2014 NRS wastewater baseline load (SPARROW representing the 2005-2006 time period) (MT/yr)**	**Change since updated baseline**
Statewide	10,879	13,824	14,327	+4% (503 MT/yr)
Mississippi River	9,363	11,718	12,593	+7% (875 MT/yr)
Red River	304	487	469	-4% (18 MT/yr)
Lake Superior	1,212	1,645	1,109	-33% (536 MT/yr)

The values shown for the Red River include Minnesota WWTPs in both the Red River Basin and the Rainy River Basin. The following table reports separate TN loads for the Red River Basin and the Rainy River Basin. It is noteworthy that effluent TN concentrations for the 2010-2012 time period were still largely estimated from typical pollutant concentrations and that more reliable effluent data did not become available until 2016 for the Mississippi River Basin and 2021 for the Red River Basin.

Table 3. Revised existing nitrogen loads from permitted wastewater separating the Red and Rainy River Basins.

Major Basin	Updated wastewater baseline load (average 2010-2012) (MT/yr)	2014-2025 Milestone Reduction Goals	2014-2025 Milestone Effluent Loading Goals	2025-2040 Final Reduction Goals	2025-2040 Final Effluent Loading Goals
		%	MT/yr	%	MT/yr
Mississippi River	11,718	20%	9,374	45%	6,445
Red River	340	13%	296	50%	170
Rainy River	218	TBD	TBD	TBD	TBD
Lake Superior	1212[1]	No net increase	1,212	No net increase	1,212

[1]The 2005-2006 SPARROW baseline is used for the Lake Superior Basin because it is closer in time to the 1970s and 2010-2012 baseline wastewater TN loads for the Basin are largely based on estimated effluent concentrations.

Current wastewater effluent TN loads for the Mississippi River Basin are higher than baseline levels while current loads in the Red River, Rainy River and Lake Superior Basins are the same or lower than baseline levels. As a result, the wastewater reduction percentages needed from current loads to meet NRS goals have increased for the Mississippi River Basin and decreased for the Red River Basin. Lake Superior loads remain below the NRS goal and reduction goals for the Rainy River Basin have not yet been determined.

Table 4. TN wastewater load reductions needed from current effluent loads to meet NRS goals

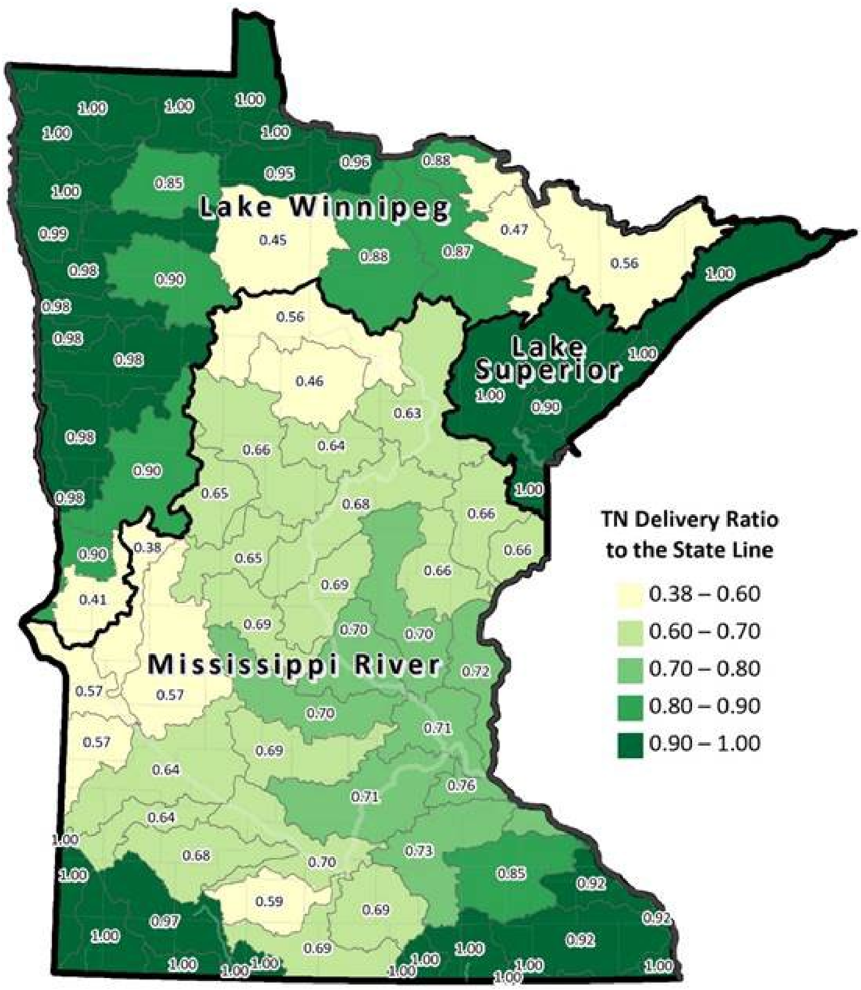
Major Basin	Updated wastewater baseline load (2010-2012)	2025-2040 final effluent TN loading goals	Current (2021-2022) wastewater TN loads	Percent reduction needed from current TN loads
	(MT/yr)	MT/yr	(MT/yr)	%
Mississippi River	11,718	6,445	13,656	53%
Red River	340	170	307	45%
Lake Superior	1,212	1,212	785	TBD
Rainy River	218	TBD	191	TBD

B. Watershed delivery to state borders

The NRS' overall nutrient loads and goals are calculated as delivered to the State borders using the USGS' SPARROW model, the updated wastewater baseline loads, current loads and reduction goals are based on end-of-pipe estimates.

Applying HUC8 watershed TN delivery coefficients derived from SPARROW to the locations of wastewater outfalls, 74% of the TN loads discharged by Minnesota WWTPs in Mississippi River drainage areas and 96% of the TN loads discharged in the Red River Basin are estimated to be delivered to the State's borders.

Figure 2. SPARROW model total nitrogend delivery coefficients



C. Recalculated wastewater baselines and goals delivered to Minnesota's border

Applying watershed assimilation coefficients from the SPARROW model to effluent wastewater TN reduces baseline loads from 11,718 MT/year to 8,721 MT/year for the Mississippi River Basin and from 340 Mt/year to 326 Mt/year for the Red River Basin. Similarly, final effluent TN loading goals are reduced from 6,445 MT/year to 4,796 MT/year for the Mississippi River Basin and from 170 MT/year to 163 MT/year for the Red River Basin.

Table 5. 2014 NRS TN Reduction Goals

	2014 NRS Percent Reduction Goal (%)	Updated Wastewater Baseline Load at State Line (MT/yr)	Updated Wastewater Load Goal at State Line (MT/yr)
Mississippi River	45%	8,721	4,795
Red River	50%	326	163
Lake Superior	*	1,212	TBD
Rainy River	TBD	168	TBD

*Lake Superior Nitrogen Reduction Goal is qualitative – continued implementation of specific nutrient management programs

Meeting nutrient reduction strategy goals

Estimated TN load reductions based on this proposed strategy would achieve Minnesota's NRS goals at the State's borders for the Mississippi River Basin based on current flows. The Minnesota NRS goal for the Lake Superior Basin is currently being met and the proposed wastewater strategy would ensure that it will continue to be met in the future. The Minnesota NRS has not yet established TN reduction goals for the Rainy River Basin.

Table 6. Wastewater TN baseline and current TN loads and reductions

	Updated NRS Wastewater Baseline TN Load at State Line (MT/yr)	NRS Reduction Goal (%)	NRS WW TN Load Goal at State Line (MT/yr)	Current WW TN Load at State Line (MT/yr)	Proposed TN Load at State Line with this Strategy (MT/yr)	Proposed WW TN Reduction From Baseline (%)	Proposed WW TN Reduction From Current Load (%)
Mississippi River	8,721	45%	4,795	10,163	4,069	53%	60%
Red River	326	50%	163	294	127	61%	57%
Lake Superior	1,212	Maintain	1,212	785	664	45%	15%
Rainy River	218	TBD	TBD	179	137	37%	23%

Due to changes in wastewater effluent TN loads since baseline loads were established, wastewater reductions needed from current (2021-2022) loads to meet proposed targets at the State borders would be 2,903 MT/year (31% reduction) for the Mississippi River Basin and 19 MT/year (11% reduction) for the Red River Basin.

Appendix C.

Wastewater nitrogen reduction and implementation strategy – water quality trading alternatives

- Individual permit-based trading
  - Point-point trading.
  - Point-nonpoint trading.
- Nitrogen Reduction Strategy (NRS) vs. Water Quality Based Effluent Limits (WQBEL) trading
  - NRS Option 1. Trading to reduce load at the immediate receiving water. All credit generating reductions would have to occur upstream of the buyer's receiving water. The size of trading watersheds would be restricted.
  - NRS Option 2. Trading to reduce load at the waterbody of interest. For NRS trading purposes these would be at the state borders (Mississippi River at the MN/IA border, Red River at the MN/MB border, Lake Superior). Credit value would be determined based on pollutant reduction benefit at the border by accounting for watershed pollutant load assimilation. The size of trading watersheds would be large.
  - The waterbody of interest for WQBEL trading purposes would be the immediate receiving water or the first downstream water with potential to exceed a nitrate water quality standard.
  - Trading relationships could exist between facilities whose limits are based on different reduction targets (i.e. NRS vs. WQBEL or WQBELs derived from different waterbodies) as long as the credit generating reductions benefit both target waterbodies .
- Point-point vs. Point-nonpoint trading
  - Point source nitrogen credits can be generated by facilities that make reductions beyond permit requirements.
  - Relatively simple transactions based on contracts between point source dischargers.
  - Sellers' permit limits are adjusted down, buyers' permit limits are adjusted up for the duration of the trade.
  - Point-point trade ratios are lower due to low uncertainty.
  - Point-point trades tend to be of limited duration because treatment facility capacity is ultimately limited, and sellers are unlikely to forfeit permitted load over the long term.
  - Point-point trades typically involve reduction in permitted load capacity rather than new pollutant load reductions. Credits are available based on a seller's ability to discharge pollutant loads at levels that are better than applicable permit limits and development of new trading agreements do not usually result in additional reductions by the credit generating facility.
  - Nonpoint source credits can be generated by the implementation of best management practices (BMPs) that result in pollutant load reduction from a baseline.
  - Point-nonpoint trades are typically more complex and BMPs take more time to establish.
  - Contractual agreements between buyers and sellers are required.
  - Permittee is responsible for ensuring that credit generating BMPs remain effective for the life of the credit. Credits remain effective as long as BMPs are functioning as designed.
  - Point-nonpoint trade ratios are higher due to greater uncertainty.

    - Point-nonpoint trading could incentivize and accelerate adoption of BMPs designed for nitrogen reduction.
- Minimum control level
    - A minimum level of treatment or management needs to be established. MCLs are minimum levels of treatment or management an NPDES permitted entity must provide on-site to be eligible to participate in water quality trades or offsets.
    - NPDES permitted sources must demonstrate compliance with MCL requirements in order to be eligible to use water quality trading credits to meet permit limits. If unavailable at the time when a trade is proposed, the MPCA will establish MCL requirements in NPDES permits using Best Professional Judgment and considering generally accepted practices and achievable effluent levels for similar sources.
- Delivery coefficients
    - Watershed assimilation is a critical consideration for the calculation of water quality trading credits.
    - Hydrological Simulation Program - Fortran (HSPF) models have been developed for most of Minnesota's major (HUC8) watersheds. MPCA may be able to develop TN delivery coefficient data from any point source and/or the subwatershed location of any BMP to a waterbody of concern.

Trading tools not currently in development

- Web based trading dashboard.
    - The development of web-based water quality trading tools could be useful.
    - Buyers could post credit demand; sellers could post available credits for sale.
    - Web based credit calculation tools.
    - Mapping.
    - Tracking current and historical trades.
    - Credit costs.
    - Forms, model contracts.
- Total Nitrogen general NPDES permits designed to facilitate trading could provide efficient trading markets.
    - Basin (HUC4) or Major Basin (HUC2) scale.
- Smaller scale options may also be of interest.
    - Not clear if Major Basin scale trading could occur between dischargers with different drainage pathways to the state's borders (i.e. Windom and Winona). Potentially subject to greater trade ratios due to increased uncertainty.

Minnesota's HUC2 Major Basins, HUC4 Basins and Major WWTPs