Hastings DWSMA Groundwater Protection Rule Summary

Groundwater, Nitrogen Fertilizer Management, and Nitrogen Loading Analysis

Published: 6-27-2023; Addendum added 5-15-2025

Introduction

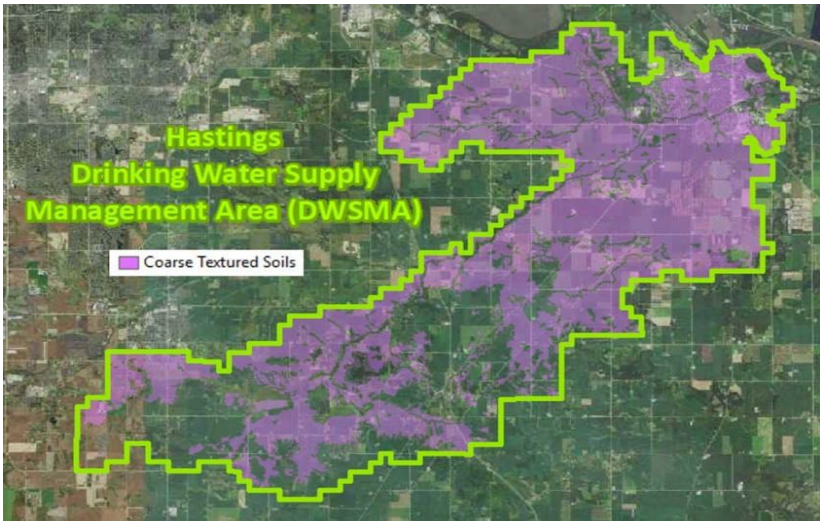
This document summarizes the Minnesota Department of Agriculture's (MDA) current understanding of the Hastings Drinking Water Supply Management Area (DWSMA) (Figure 1), public well nitrate-nitrogen levels, predominant land use, and nitrogen fertilizer management information. Also included is a summary of the MDA's estimate of nitrate-nitrogen loss below cropland within the DWSMA. Overall, this document provides the detail that the MDA used to determine whether the proposed list of nitrogen fertilizer best management practices (BMPs) and Alternative Management Tools (AMTs) will be protective of groundwater.

Figure 1. Map of Hastings DWSMA

DWSMA and Public Well DWSMA Nitrate-Nitrogen Data

The DWSMA boundary for the City of Hasting's public wells, as defined by the Minnesota Department of Health (MDH), covers 61,791 acres. This area includes the city of Hastings as well as other small cities and rural townships. The entire DWSMA is designated by the MDH as having high vulnerability. This suggests that water, and contaminants such as nitrate-nitrogen, may travel from the land surface to the City's aquifer within a time span of months to a few years. This is due to several factors relating to the area's hydrogeology.

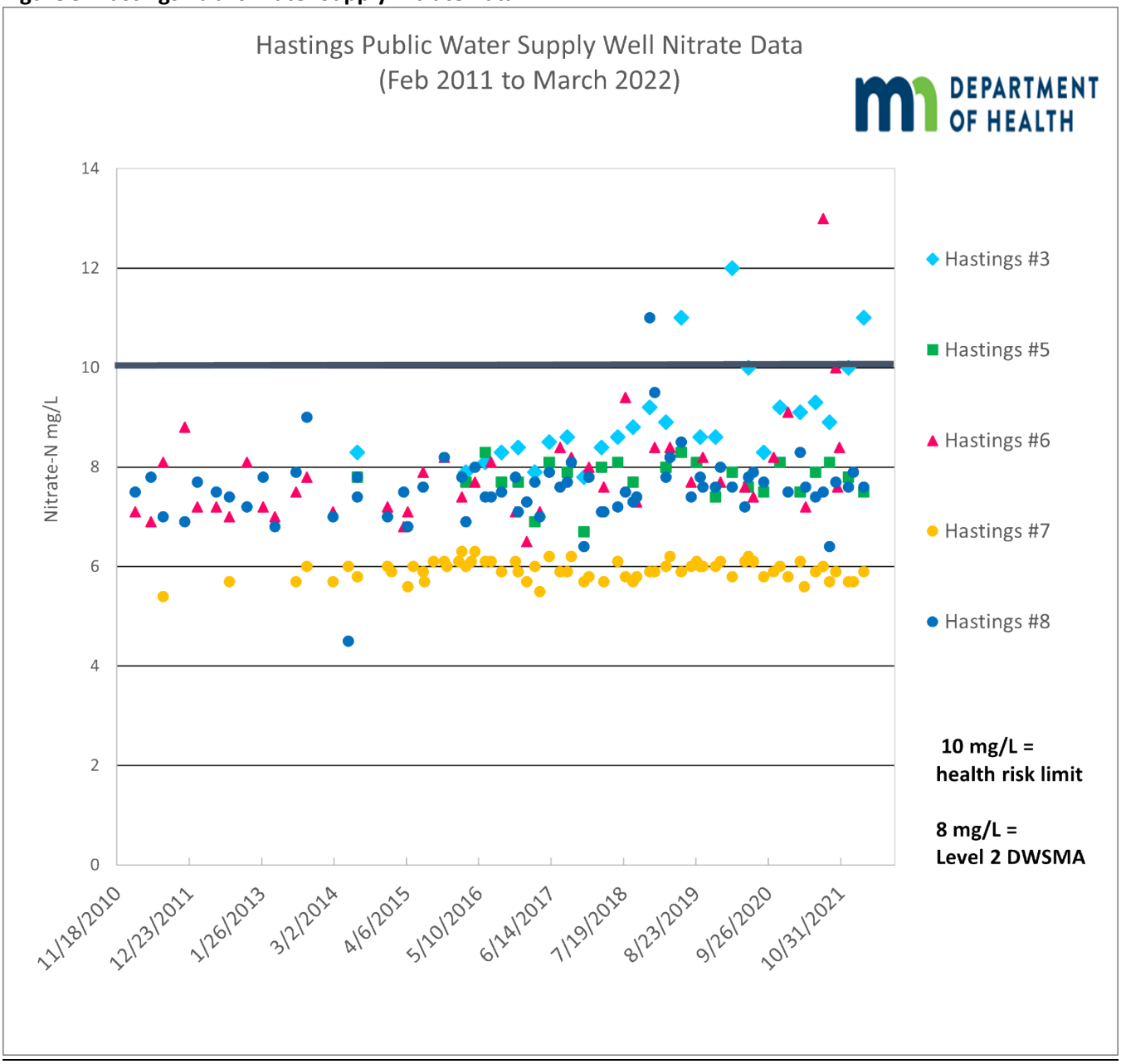
Figure 2. Map of coarse textured (sandy) soils in the Hastings



Common surface soil types include loam, silt loam, sandy loam, and sands. Sands and gravels are also widespread in the subsurface of many soils across the DWSMA. Therefore, a majority of the DWSMA is classified as having coarse textured soils (Figure 2). Additionally, shallow bedrock and karst geology can be found, all of which create an environment conducive to rapid groundwater leaching.

The MDA relies on the water quality data provided by the MDH to evaluate nitrate-nitrogen levels in the public water supply. The public well data provided for the Hastings public well system is shown in the graph below (Figure 3). The 8 mg/L nitrate-nitrogen level illustrated in the graph is a threshold for Mitigation Level 2 designation under the Groundwater Protection Rule (Minnesota Statute 1573.0040, Subp. 7, C, 2). The city of Hastings has six primary water supply wells. Wells 3, 5, 6, and 8 have exceeded the 8 mg/L nitrate-nitrogen level in the past ten years.

Figure 3. Hastings Public Water Supply Nitrate Data



The six public water supply wells draw water from the Jordan Sandstone aquifer between 188 and 400 feet below ground surface. With greater concern about nitrate in the well system, the city blends water and uses an anion-exchange treatment system.

Table 1. City of Hastings Public Well Information

Well Name	Unique Number	Status*	Year Constructed	Total Depth (ft.)	Casing Diameter (in.)	Casing Depth (ft.)	Well Vulnerability	Aquifer
Well 3	206333	P	1956	299	16	208	Vulnerable	Jordan Sandstone
Well 4	207993	P	1961	400	16	314	Vulnerable	Jordan Sandstone
Well 5	207639	P	1970	356	24	277	Vulnerable	Jordan Sandstone
Well 6	207643	P	1972	332	24	240	Vulnerable	Jordan Sandstone
Well 7	509053	P	1989	285	24	205	Vulnerable	Jordan Sandstone
Well 8	686266	P	2006	280	24	188	Vulnerable	Jordan Sandstone

* P = Primary water supply well

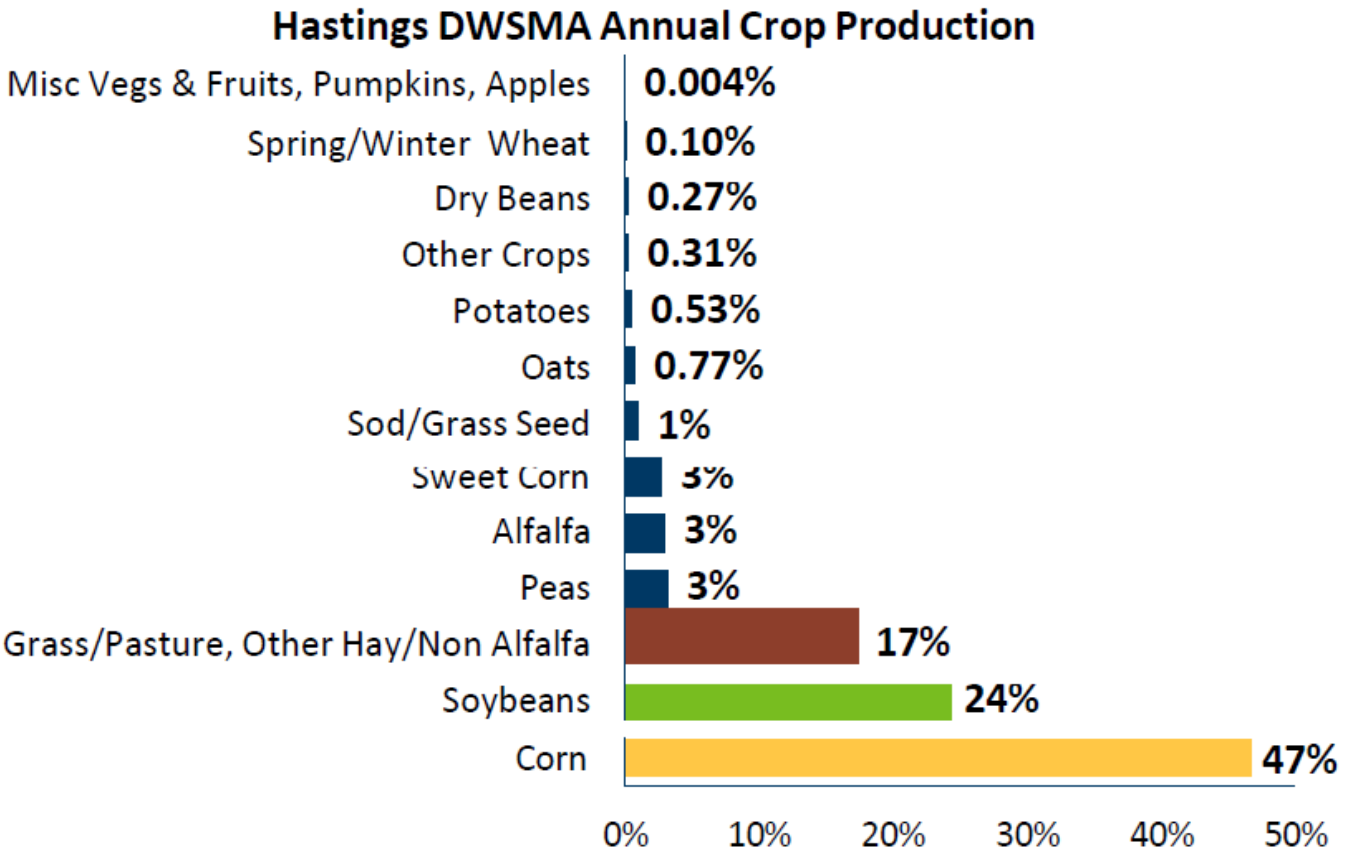
DWSMA Land Use and Potential Nitrate-Nitrogen Point Source Consideration

The MDA conducted a detailed review of potential contaminant sources in the area to determine whether a point source of nitrate-nitrogen could be the cause of a public well exceeding the criteria for mitigation level designation (Minn. Stat. 1573.0040, Subp. 3, C). Based on information from this review in the Hastings DWSMA, the MDA did not identify a potential point source of nitrate-nitrogen. With nitrate levels exceeding 8.0 mg/L within the past ten years and without a point source contribution, this DWSMA was designated as Mitigation Level 2 under the Groundwater Protection Rule on January 15, 2020 (Minn. Stat. 1573.0040, Subp. 7, C, 2).

Part 2 of the Groundwater Protection Rule responds to DWSMAs which already have elevated nitrate. The goal is to take action to reduce nitrate in groundwater in public wells that exceed the health standard for nitrate. In Level 2 DWSMAs, the MDA works with a local advisory team (LAT) including farmers, agronomists, and others to get input on management practices (BMPs and AMTs) that can reduce nitrate leaching in groundwater.

The Groundwater Protection Rule defines cropland as land used primarily for the production or harvest of annual or perennial field, forage, food, fiber, or energy crops including pasture but excluding forestland. A review of the publicly available USDA Cropland Data Layer in the Hastings DWSMA shows that the land use here is predominately cropland. An estimate of crops grown within the DWSMA is shown in Figure 4.

Figure 4. Crops raised in the Hastings DWSMA. (USDA – CropScape data – Estimated 5 yr. avg.)



Within the Hastings DWSMA the crops grown include corn, soybeans, peas, alfalfa, sweet corn, and other perennial crops and pasture, as well as cereal grains, potatoes, and other vegetables and fruits. A considerable amount of the cropland is grown to corn each year (approx. 47%). Of the corn acreage, approximately 6,700 acres are under irrigation and generally follow a corn/soybean or corn/corn rotation. Additionally, approximately 19,600 acres of corn are in dryland production and generally follow a corn/soybean or corn/corn rotation.

Nitrogen Fertilizer Use Survey

The MDA surveyed local agronomists and farmers to understand the nitrogen fertilizer management practices used in the Hastings area. Having current and accurate nitrogen fertilizer management data is critical to the discussion of BMPs and AMTs. With computer modeling the MDA compares nitrogen leaching loss below current management practices and under the nitrogen fertilizer BMPs proposed to protect groundwater. The farming practice information collected includes crop type, planting date, harvest date, and nitrogen fertilizer use information.

In August 2017, the MDA conducted in-person, on-site interviews with fertilizer dealerships and a fertilizer distributor that serve Castle Rock, Douglas, Empire, Hampton, Marshan, Nininger, Ravenna, and Vermillion Townships in Dakota County. Dealers were asked about timing of fertilizer applications. They reported the following percentages of nitrogen applied at different times of the year. All sources of commercial nitrogen were included.

- Fall nitrogen 5%
- Spring preplant nitrogen 55%
- At planting nitrogen 5%
- Post emergence nitrogen 35%

Over 60% of the farmers irrigated crops. The dealerships estimated that approximately 25 lbs. N/acre was typically applied through fertigation (approximately 10% of the irrigated acres).

An additional follow-up survey of local agronomists and farmers that operate within the DWSMA shows that most producers are currently following the University of Minnesota's nitrogen rate recommendations when factoring commodity price and fertilizer price. The maximum return to nitrogen (MRTN) value is the nitrogen rate that maximizes profitability while limiting environmental degradation. The recommended 0.1 MRTN rates are being followed within 15 lbs. N/acre by 79% of the producers operating irrigated corn acres. In addition, roughly 90% of the producers growing corn on dryland acres are within 15 lbs. of the University of Minnesota recommended 0.1 MRTN (Figures 5 and 6).

Choosing the correct nitrogen rate is generally the most important factor when managing nitrogen fertilizer to protect groundwater. The MDA identified the 0.1 MRTN rate in the list of BMPs required in the Hastings DWSMA to achieve a reduction in leaching. According to survey information and computer modeling output, nitrogen rates on 28% of irrigated corn acres would need to be reduced by 15 lbs./acre and the nitrogen rates on 16% of irrigated corn acres would be reduced by 25 lbs. N/acre to reduce nitrate leaching and protect groundwater. Approximately, 5% of irrigated corn acres would need to reduce by more than 25 lbs. N/acre (Figure 5). Similarly, to protect groundwater the nitrogen application rate on 53% of dryland corn acres would need to be reduced by up to 15 lbs. for corn following corn and up to 10 lbs. for corn following soybeans. Nitrogen rates on approximately 10% of the dryland corn acres would need to be reduced by up to 35 lbs. for corn following corn and up to 20 lbs. for corn following soybeans (Figure 6).

Figure 5. Nitrogen distribution on irrigated corn following soybean or corn

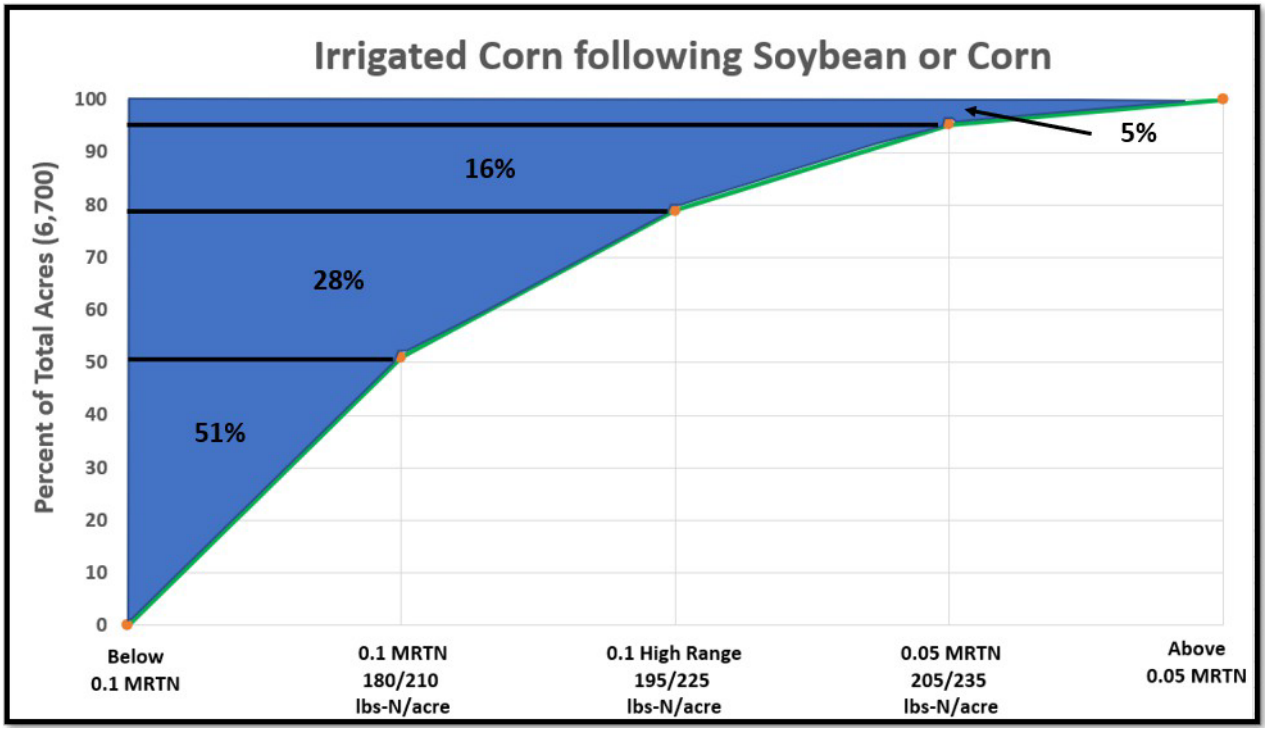
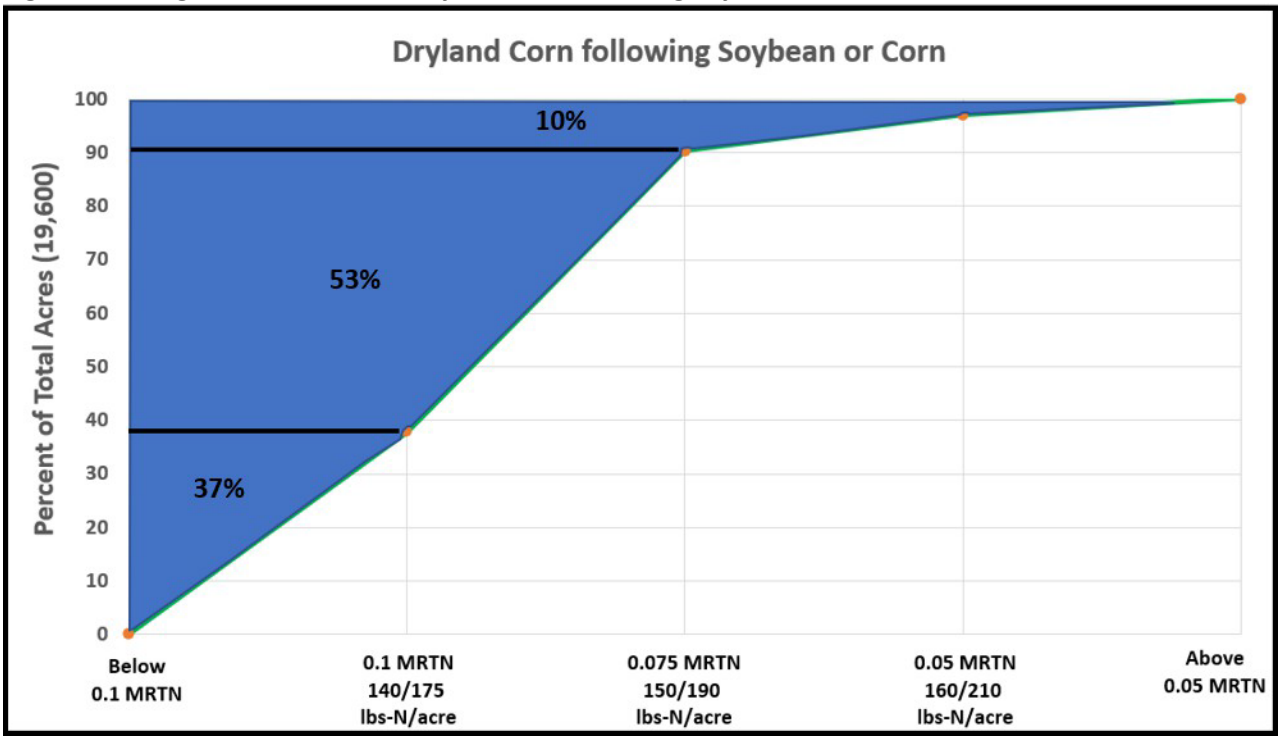


Figure 6. Nitrogen distribution on dryland corn following soybean or corn



DWSMA Nitrate-Nitrogen Loss Below Cropland

Using a crop and soil simulation model called "EPIC", the MDA estimated the nitrogen loss below the root zone in the Hastings DWSMA comparing the nitrogen management practices used in the recent past with the list of proposed nitrogen fertilizer BMPs for this DWSMA. The modeling estimated annual N leaching over a 10-year period in agricultural cropping systems of corn following corn and corn following soybean in irrigated and dryland conditions, over a range of N management practices (rate, timing, source, and placement), and with and without a cover crop. A perennial grass system was also simulated with the model to estimate current N leaching from existing perennial cover and also the potential impact of converting existing row crop fields to perennials.

The modeling information on the next page (Table 2) shows four rotations: 1) dryland corn following corn; 2) dryland corn following soybeans; 3) irrigated corn following corn; and 4) irrigated corn following soybeans. The table provides an estimate of the pounds of N leached per acre when comparing current N management practices with best management practices such as split application and the University of Minnesota recommended rates (0.1 MRTN) for corn under dryland or irrigated conditions.

Using modeling tools and crop management information from local surveys, the MDA looked for opportunities to improve groundwater in the Hastings DWSMA. The MDA determined that a small percent of producers were applying nitrogen at a rate above, and in a few cases well above, the 0.1 MRTN. The 0.1 MRTN is generally considered to be a more protective rate for coarse textured and vulnerable soils. Adoption of a lower rate of nitrogen (the 0.1 MRTN) across the DWSMA and split application on coarse textured soils will result in a meaningful reduction in nitrate leaching and an improvement in water quality. However, the MDA recognizes that some soils are highly productive and require a higher rate of nitrogen than the 0.1 MRTN. As an outcome, the MDA recommended rate for corn in the Hastings DWSMA is the 0.1 MRTN, but a higher nitrogen rate may be used if growers can demonstrate, using any one of several options listed as AMTs, that the soils are highly productive, and crops grown on these soils require a higher rate of nitrogen. The MDA will promote cover crops

and perennial vegetation including new cropping systems from the Forever Green Initiative, as a primary strategy to improve water quality in the Hastings DWSMA.

The LAT recommended that farmers be given options that allow for slightly higher rates of nitrogen in combination with the adoption of other protective practices. Also, the MDA sought to promote the adoption of cover crops, perennial crops and other recommended practices that will accelerate water quality improvement. These two goals were combined into several additional options where higher rates of nitrogen are allowed if cover crops or perennial crops are also grown. The MDA used computer modeling tools to determine that increased rates beyond the 0.1 MRTN, with the addition of cover crops and perennials, will still be beneficial to water quality.

Table 2. Management practices, N rate, and timing as it relates to nitrogen leaching

Management Practice*	Type of Management	Lbs. of N leached per acre	% Change from current
C/SB dryland current	100% preplant N	24.3	0
C/SB dryland 0.1 MRTN	100% urea preplant	23.1	-5%
C/SB dryland 0.1 MRTN	Preplant + 1 in-season application	22.8	-6%
C/C dryland current	100% urea preplant	24.9	0
C/C dryland 0.1 MRTN	100% urea preplant	22.8	-8%
C/C dryland 0.1 MRTN	Preplant + 1 in-season application	22.3	-10%
C/SB irrigated current	Preplant + 1 in-season application	19.1	0
C/SB irrigated 0.1 MRTN	Preplant + 1 in-season application	18.3	-4%
C/C irrigated current	Preplant + 1 in-season application	23.9	0
C/C irrigated 0.1 MRTN	Preplant + 1 in-season application	18.6	-12%

*C/C = corn on corn rotation, C/SB = corn on soybean rotation

MDA Recommended Nitrogen Fertilizer Best Management Practices for the Hasting DWSMA

The MDA based these recommended practices on surveys with local crop retailers, input from local farmers and agronomists, years of University of Minnesota research on nitrogen fertilizer best management practices (BMPs), and robust computer modeling that simulates the physical and chemical processes that occur in soil under agricultural management. Local advisory team priorities included flexibility in management options, the ability to use higher nitrogen rates and adjusting rates based on research, and funding support for implementation.

The MDA baseline recommendation is a set of fertilizer BMPs, including the use of the 0.1 MRTN fertilizer rate, which are applied based on the soil type, cropping system, and crop rotation across the DWSMA. The MDA also recommends options based on: the use of MDA approved Alternative Management Tools (AMTs); the adoption of vegetative cover; and, a whole farm review and approval of practices through the Minnesota Ag Water Quality Certified Program.

These four options are available for each farmer to consider:

1. **If farmers implement practices on the BMP list for the Hastings DWSMA, including the rates listed below, no additional practices are required.** The BMP list includes following the 0.1 MRTN from the nitrogen fertilizer application guidelines from the University of Minnesota. All sources of nitrogen need to be credited when determining rate. This includes manure, legumes, and other sources of nitrogen. Source, timing, and placement BMPs also need to be followed. See the document *BMPs for the Hastings DWSMA* for more detail.
    a. **Irrigated corn following corn**: up to the 0.1 MRTN (currently **210** lbs. N/ac)
    b. **Irrigated corn following soybean:** up to the 0.1 MRTN (currently **180** lbs. N/ac)
    c. **Dryland corn following corn**: up to the 0.1 MRTN (currently **175** lbs. N/ac)
    d. **Dryland corn following soybean:** up to the 0.1 MRTN (currently at **140** lbs. N/ac)
    e. **Irrigated potatoes:** follow rate, timing, and source practices on BMP list
    f. **For other crops and corn following other crops** grown within the DWSMA, nitrogen rates must follow the current University of Minnesota guidance applicable to that crop.
2. **Use Alternative Management Tools (AMTs).** AMTs are agricultural practices and solutions, other than nitrogen fertilizer BMPs, to address groundwater nitrate problems. AMTs may substitute for one or more of the BMPs required. In some cases, these practices allow higher rates of nitrogen on individual fields.
3. **Adoption of vegetative cover** allowing for higher nitrogen rates in Hastings DWSMA. Higher nitrogen rates can be applied to corn combined with the use of in-season applications, cover crops, and perennial vegetation. See the document *Hastings Drinking Water Supply Management Area Nitrogen Rate, Cover Crop, and Perennial AMT* for more detail. Table 3 provides *examples* of nitrogen rates combined with in-season nitrogen applications and the use of cover crops and/or perennial vegetation. Each line provides an option for dryland or irrigated corn acres specifying the higher nitrogen rate, number of in-season N applications, and either cover crop or perennials as a percentage of the acres in the corn/soybean rotation needed per year to gain similar benefit in nitrate leaching reductions. If a farmer elects to use the table below and apply a higher rate, they are still expected to follow all other BMPs applicable to their operation.
4. **Minnesota Agricultural Water Quality Certification Program (MAWQCP)**. Farmers certified through this program are deemed to be in compliance with new water quality rules or laws during the period of certification.

Table 3. Hastings DWSMA Options Nitrogen Rate AMT table

	N Rate Limit (lbs.-N/acre) Corn Following Soybean/Corn		In-season N application requirements		Cover Crop	Perennials
Option	Dryland	Irrigated	Fine-Textured Soils	Coarse-Textured Soils†	% Acres Per Year‡	% Acres Per Year‡
1	150 / 190	195 / 225	0	1	17%	0%
2	150 / 190	195 / 225	0	1	0%	10%
3	150 / 190	195 / 225	1	1	16%	0%
4	150 / 190	195 / 225	1	1	0%	9%
5	150 / 190	195 / 225	1	2	14%	0%
6	150 / 190	195 / 225	1	2	0%	8%
7	150 / 190	205 / 235	0	1	21%	0%
8	150 / 190	205 / 235	0	1	0%	12%
9	150 / 190	205 / 235	1	1	20%	0%
10	150 / 190	205 / 235	1	1	0%	11%
11	150 / 190	205 / 235	1	2	19%	0%
12	150 / 190	205 / 235	1	2	0%	10%

† A preplant N application of a polymer-coated urea fertilizer (ESN) can substitute for a one in-season application on coarse-textured soils

‡ Acres required are based on a farms total corn/soybean acres multiplied by the percent acres per year

Conclusion

The MDA has surveyed fertilizer dealers and agronomists, modeled nitrogen leaching estimates in the rootzone, and worked with a local advisory team to develop the options to reduce nitrate in the DWSMA. Modeling of nitrogen loss below cropland estimates a 6-12% reduction in nitrogen loss, depending on the soil type and cropping system, by following the MDA recommended nitrogen fertilizer best management practices. Increased adoption of cover crops and perennials, along with in-season applications, is estimated to lead to a larger reduction in nitrate leaching. The MDA will work with many partners to provide technical and financial assistance and encourage adoption of these practices.

Based on the understanding and information provided above, the MDA believes that the recommended nitrogen fertilizer BMPs within the Hastings DWSMA are appropriate and that over time nitrate-nitrogen loss below the cropland rootzone will be reduced following these practices.

References

"Part 2 of the Groundwater Protection Rule" - Part 2 of the Groundwater Protection Rule | Minnesota Department of Agriculture (state.mn.us)

"Nitrogen Fertilizer BMPs for Agricultural Lands" - Nitrogen Fertilizer BMPs for Agricultural Lands | Minnesota Department of Agriculture (state.mn.us)

"Alternative Management Tools" - Alternative Management Tools | Minnesota Department of Agriculture (state.mn.us)

"Approved AMTS" - Approved AMTs | Minnesota Department of Agriculture (state.mn.us)

"Mitigation Level Determination" - Mitigation Level Determination | Minnesota Department of Agriculture (state.mn.us)

"Community Public Water Supply" - Community Public Water Supply - MN Dept. of Health (state.mn.us)

"Hastings Water Quality Report" - Water Quality | City of Hastings, MN (hastingsmn.gov)

"Nitrate in Drinking Water" - Nitrate in Drinking Water - MN Dept. of Health (state.mn.us)

"Source Water Protection Web Map Viewer" - Source Water Protection Web Map Viewer - MN Dept. of Health (state.mn.us)

"Local Advisory Teams" - Local Advisory Teams | Minnesota Department of Agriculture (state.mn.us)

"CropScape and Cropland Data Layer – National Download" Ag Data Commons | Providing Central Access to USDA's Open Research Data

"MN Rules, Chapter 1573 – Department of Agriculture – Groundwater Protection" - Minnesota Rules 2019, Chapter 1573 (state.mn.us)

"University of MN – Fertilizer Guidelines for Agronomic Crops in Minnesota" - Fertilizer Guidelines for Agronomic Crops in Minnesota.pdf (umn.edu)

"Maximum Return to Nitrogen (MRTN) approach to corn N rate guidelines" - Maximum Return To Nitrogen (MRTN) approach to corn N rate guidelines (umn.edu)

"University of MN – Fertilizing Corn in Minnesota" - Fertilizing-Corn-in-Minnesota-2022.pdf - Google Drive

"Computer Modeling – MDA" - Computer Modeling | Minnesota Department of Agriculture (state.mn.us)

"EPIC" Texas A&M Environmental Policy Integrated Climate Model - EPIC | EPIC & APEX Models (tamu.edu)

Addendum: Updated Corn Nitrogen Fertilizer Rate Guidance
Added 5/15/25

This addendum explains changes to University of Minnesota nitrogen fertilizer rates for corn. Other text in the document has not been edited and reflects the University of Minnesota guidance available at the time this summary was published in June 2023.

In April 2025 the University of Minnesota (UMN) nitrogen rate recommendations for dryland corn were updated. The updated UMN corn nitrogen rate guidance is based on the latest research available in Minnesota. To align with the current guidance, the corn nitrogen rates included in the BMP list published for this DWSMA were updated. The tables below are adapted from the UMN rate guidance released in April 2025 and reflect the new rate guidance to which the BMPs published in this DWSMA will refer.

Guidelines for use of nitrogen fertilizer for corn grown following soybeans when supplemental irrigation is not used.

N Price/Crop Value Ratio	Maximum Return to Nitrogen	Acceptable Range
0.075	155	145-170
0.100	150	135-160
0.125	140	130-155
0.150	135	125-145

Guidelines for use of nitrogen fertilizer for corn grown following corn when supplemental irrigation is not used.

N Price/Crop Value Ratio	Maximum Return to Nitrogen	Acceptable Range
0.075	200	180-220
0.100	185	170-200
0.125	175	160-190
0.150	165	150-175

Adoption of the BMPs can be evaluated no sooner than three growing seasons after the DWSMA BMP list is published. For the Hastings DWSMA, the evaluation could occur as soon as 2026. Following that evaluation, the BMP list for the Hastings DWSMA may be adjusted considering water quality information, input from the LAT and any new Nitrogen Fertilizer BMP updates from the University of Minnesota.