



# Interim Report on Nitrate in Groundwater

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This interim report on Clean Water Funded activities to address nitrate in groundwater fulfills the requirements of Minnesota Laws 2013, Chapter 137, Article 2, Section 3(b).

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Pursuant to Minn. Stat. § 3.197, the cost of preparing this report was approximately \$2,000.

## Executive Summary

Groundwater contamination from nitrate-nitrogen represents a potential health risk in drinking water wells in vulnerable aquifers. This interim report demonstrates how Clean Water funding has been critical in allowing the Minnesota Department of Agriculture (MDA) to put forth steady and sequential ramping up of efforts to reduce nitrate from fertilizer in groundwater. The MDA works with local partners to assess groundwater in agricultural areas and collaborates with University of Minnesota researchers and other parties to develop, promote and provide education on nitrogen fertilizer Best Management Practices. Thus far, efforts have been dedicated to revising the Nitrogen Fertilizer Management Plan (NFMP), assessing vulnerable areas, increasing and refining efforts to prevent or minimize nitrate losses from nitrogen fertilizer, and developing and refining fertilizer use survey and assessment tools. The MDA is also, as directed by the legislature, sampling for pesticides in private wells which sampled positive for nitrate. The MDA will continue with these activities; and in addition, will begin developing a rule to: 1) restrict fall application and application to frozen ground of nitrogen fertilizer in areas that are vulnerable to groundwater contamination: and, 2) to put into law the approach outlined in the NFMP. Clean Water funding will not be used to development the rule. The MDA will also begin implementation of voluntary mitigation steps for those areas with elevated nitrate. The report recommends adequate funding and support to implement the revised NFMP and increased funding and support for actions that encourage and promote the use of reduced nitrogen input crops and vegetative cover in targeted high risk areas.

## Introduction

Nitrate from agricultural sources is one of the most common contaminants in groundwater in Minnesota and frequently exceeds health-based standards in areas where groundwater is vulnerable to contamination. Funding from the Clean Water Fund, which was created as an outcome of the Minnesota Clean Water, Land and Legacy Constitutional Amendment, is being used for activities that help identify potential sources of nitrate contamination, and to evaluate and implement practices and tools to reduce nitrate in groundwater. The Minnesota Department of Agriculture (MDA) works with local partners to assess groundwater in agricultural areas and works directly with local farmers, agri-business and other interested parties in the impacted or threatened areas. Work is conducted with University of Minnesota (U of M)\_researchers to develop, promote and provide education on nitrogen fertilizer Best Management Practices (BMPs). The MDA also conducts pesticide sampling in nitrate contaminated wells, as directed by the legislature.

## Background

Groundwater contamination from nitrate-nitrogen (nitrate) represents a potential health risk in drinking water wells. This is especially true for older wells that do not meet the well construction code in aquifers that are vulnerable to contamination. Approximately 75 percent of Minnesotans (four million) use groundwater for their drinking water. These residents are served by either private wells or public water supplies. If elevated nitrate levels are detected in drinking water, there may be an increased probability that other contaminants, such as bacteria or pesticides, may also be present. Livestock and aquatic ecosystems may also be impacted by nitrate contaminated groundwater.

The activities discussed in this report represent a steady and sequential ramping up of efforts to reduce nitrate from fertilizer in groundwater. The initial step was to revise the state Nitrogen Fertilizer Management Plan (NFMP). The next steps, currently underway, are the assessment of vulnerable areas, increased prevention activities, evaluation and demonstration of nitrogen fertilizer BMPs, and the evaluation of computer models to quantify nitrate losses from different BMPs and cropping systems. These will be followed by developing rules and implementing voluntary mitigation steps. The rules likely will take 2 -3 years to develop during which time the voluntary mitigation process will be implemented at high priority sites and further refined. Prevention activities will also be increased while monitoring and assessment activities will continue. After the rules are completed, regulatory actions may be taken, if necessary. Clean Water funding has been critical in making these activities possible.

The authority for the MDA's efforts on nitrate and regulation of fertilizer use to protect groundwater comes from the 1989 Groundwater Protection Act (Minn Stat Chap 103H) and the Minnesota Fertilizer, Soil Amendment, and Plant Amendment Law (Minn Stat Chap 18C). The Groundwater Protection Act defines a prevention goal and calls for protection of sensitive areas, the development of BMPs, groundwater quality monitoring and management of pollutants where groundwater is impacted.

## Program Development

The MDA is completing the revision of the Nitrogen Fertilizer Management Plan. The purpose of the NFMP is to prevent, evaluate and mitigate nonpoint source pollution from nitrogen fertilizer in groundwater. The NFMP provides the blue print for the MDA's activities to address nitrate in groundwater. Revising the NFMP involved a three-year process and included input from an advisory

committee and a public comment period with listening sessions across the state. Based on the comments, the MDA made numerous revisions to the NFMP including the decision to add a part to the proposed rule to restrict the fall application and application to frozen ground of nitrogen fertilizer in areas that are vulnerable to groundwater contamination; revising the plan every ten years; and, providing additional detail on prevention activities, alternative management tools, and local advisory teams.

With the completion of the NFMP, the MDA is moving forward with a sequential implementation of the guidance and processes outlined in the plan. These activities will require some piloting, evaluation and refining of the overall approach. This is particularly true given the large scale of activities to be conducted across the state. Many of these activities are currently being implemented and are described in more detail below.

The immediate next step is to begin development of a proposed rule to: 1) restrict fall application and application to frozen ground of nitrogen fertilizer in areas that are vulnerable to groundwater contamination; and, 2) to put into law the approach outlined in the Nitrogen Fertilizer Management Plan. Clean Water funding will not be used to develop the rule.

## Groundwater Monitoring and Assessment

In 1993, the MDA began to offer free walk-in style nitrate clinics where homeowners could have water from their private wells tested. Since then, the MDA and local partners have tested over 60,000 wells and provided educational materials to thousands of Minnesota families. The MDA continues to help local partners with nitrate testing clinics by providing nitrate testing equipment and supplies for use at county offices or events.

The MDA has also been working closely with other agencies on developing regional private well nitrate networks. Homeowners collect their own water sample and send it by mail to be tested by a laboratory or a county representative using MDA equipment at no cost to the homeowner. Homeowner volunteers are the cornerstone of the private well networks. This method has been developed from years of collaboration with other state and local agencies through pilot projects testing different methods of collection and sample delivery.

Building on the success of the past nitrate monitoring work, the MDA has developed a Township Testing Program to determine current nitrate concentrations in private wells on a township scale. Clean Water funds are used by counties and Soil and Water Conservation Districts (SWCDs) with MDA guidance to gather additional data on nitrate contamination from private wells. Sampling multiple wells in a township allows high nitrate areas to be identified and targeted practices implemented in these larger regions.

The MDA has identified townships throughout the state that are vulnerable to groundwater contamination and have significant row crop production. Private well sampling is focused in these vulnerable areas. Approximately 19 percent of Minnesota cropland overlies vulnerable groundwater. The MDA plans to offer free tests to approximately 70,000 well owners in 250 townships between 2014 and 2021.

In 2013, private wells in 22 townships from four counties were sampled. The initial sampling was conducted in areas that are highly vulnerable to groundwater contamination. Results for 2013 indicate

that in 18 townships, 10 percent or more of the wells had nitrate greater than 10 mg/L; in three townships, five percent or more of the wells had nitrate greater than 10 mg/L; and in one township, less than five percent of the wells had nitrate over 10 mg/L. In 2014, 36 townships in five counties were sampled. Results from 2014 are not yet available.

The MDA partners with the Minnesota Department of Health (MDH) in monitoring and assessing public water supplies for nitrate. The MDA and MDH are coordinating to develop procedures for conducting these assessments.

At the direction of the Minnesota Legislature, the MDA began sampling for pesticides in wells that had nitrate contamination. The initial pesticide sampling was conducted in private wells in Dakota County in August 2014. Collecting and analyzing water samples from private wells for pesticides is significantly more difficult and expensive than sampling for nitrate. The MDA has budgeted approximately \$1 million of the Clean Water Fund appropriation to sample for pesticides. The primary goal of this private well pesticide sampling project is to provide information to homeowners and the general public on the presence of pesticides in private drinking water wells in geologically sensitive agricultural areas of Minnesota.

In an effort to stay consistent with the legislative intent which specified “monitoring for pesticides when nitrates are detected,” the MDA offered pesticide sampling to all well owners who had participated in the Township Testing Program and had detectable concentrations of nitrate in their well water. Homeowners were sent a letter from MDA explaining the project and were required to return a consent form. MDA staff then called to schedule a time for sample collection for pesticides and nitrate.

Letters were sent to 410 homeowners in Dakota County beginning in August 2014. Sampling began in September 2014. Approximately 65 percent (267) of homeowners contacted requested pesticide sampling. During September, October and early November, MDA staff collected 256 pesticide and nitrate samples from private wells in Dakota County. Of the 256 samples collected, none of the samples indicated the presence of pesticides. The MDA will continue to sample for pesticides in private wells containing nitrate during the 2015 monitoring season in other sensitive geologic areas including the Central Sand Plains and southeastern Minnesota.

For wells high in nitrate where a single sample has been collected, the next step is to resample the wells and to perform a well site assessment to rule out poor well construction, subsurface sewage treatment systems and manure as possible sources of the elevated nitrate. The resampling of the wells, along with pesticide sampling, will be accelerated in 2015.

## Fertilizer Use Surveys

The MDA partners with the United States Department of Agriculture’s (USDA) National Agricultural Statistic Service (NASS) and University of Minnesota researchers to collect information about fertilizer use and management on regional and statewide scales. These detailed surveys are, to our knowledge, unique in the nation. The MDA plans to continue the surveys, collecting information on fertilizer application rates one year and BMP adoption the next.

A pilot fertilizer use survey was conducted for the 2009 crop year to obtain fertilizer rates on corn acres in Minnesota. Fifteen thousand farmers representing seven percent of the corn acres were involved in the survey process. After fine tuning the survey instrument, the survey was repeated in 2010, adding wheat

acres and manured corn acres. A total of 4,500 farmers were interviewed for the 2010 crop year covering ten percent of Minnesota's corn acres. In 2011, 2,100 farmers were surveyed on use of nitrogen BMPs on corn acres. The primary purpose of this particular survey was to evaluate the use of fall applied and sidedress (between the rows) applied nitrogen in Minnesota.

The most recent reports (2010 and 2011) and similar work conducted by the U of M and the USDA (Bierman, et al) suggest, in very general terms, that many of the U of M nitrogen fertilizer BMPs are being widely adopted by Minnesota farmers, although there are opportunities for improvement. The BMPs include timing of fertilizer applications, type of fertilizer product, and placement of fertilizer and application rates for corn following corn. One area needing significant improvement in some parts of the state, based on these surveys, is proper crediting for nitrogen sources other than fertilizer. Other nitrogen sources include soybean, alfalfa and manure. Nitrogen from these sources needs to be considered when determining how much fertilizer to apply to future crops. Proper crediting for manure appears to be the most significant nitrogen management practice needing improvement to protect groundwater. This information can be used to support and refine prevention activities in the NFMP.

The MDA will continue to refine the NASS surveys as a primary tool to evaluate fertilizer use practices and BMP adoption on a state and regional scale. The MDA will also pilot an accelerated survey tool to evaluate fertilizer use practices and BMP adoption on a local scale. This approach will be based on the existing Farm Nutrient Management Assessment Program (FANMAP) survey, previously developed by the MDA, however it will be significantly shortened and streamlined. These mini-FANMAPS will be used to provide a rapid but accurate assessment of the nitrogen fertilizer use practices in localized areas with elevated nitrate.

## Prevention

Activities to minimize the loss of nitrate to groundwater from the use of nitrogen fertilizer in order to prevent contamination from occurring are some of the most important under the NFMP. Prevention is emphasized because once contamination of groundwater occurs it is extremely difficult to address. It is intended that prevention activities will occur in all areas but with the greatest emphasis in those areas most vulnerable to groundwater contamination.

The following projects and activities emphasize prevention. Some involve growers demonstrating or changing management practices. Others involve using technology to support changes in practices. Many of the projects are located in central Minnesota in areas with sandy soils, and in southeastern Minnesota in areas with karst topography, both of which are vulnerable to groundwater contamination.

**Irrigation Water Quality Protection** – Clean Water funding supports an irrigation water quality specialist who develops guidance and provides education on irrigation and nitrogen BMPs. The position was requested by the irrigator community and is located at the University of Minnesota Extension

### **Irrigation Outreach and On-Farm Nitrogen Management in Central Minnesota -**

The MDA has partnered with the East Otter Tail SWCD to carry out a series of irrigation workshops and programs that promote proper water and nitrogen fertilizer management. The SWCD also offers an irrigation scheduling training program.

**On-Farm Nitrogen Management Program in Central Minnesota** - Partners are supporting an on-farm nitrogen management program that encourages producers to implement management actions,

monitor to observe the results of those actions, and use the results to update knowledge and adjust future management actions accordingly. This program is focused around the corn Basal Stalk Nitrate Test which evaluates how much nitrogen is leftover at the end of the growing season.

Stalk samples are collected based on aerial imagery during mid to late August when the corn crop is most likely to show stress. Each producer enrolled in the program receives a copy of the imagery and the stalk sample results from their field along with an annual summary of information collected from all participants. Following the end of the growing season, a winter meeting is held so that participants have a chance to review data and discuss possible management changes that could improve the efficiency of nitrogen use in their field. Partners in this project include fifty farm cooperators in 2014 as well as the following SWCDs: East Otter Tail, West Otter Tail, Becker, Hubbard, Wadena, Todd and the Natural Resources Conservation Service (NRCS).

**On-Farm Nitrogen Trials in Central Minnesota** - In conjunction with the guided stalk sampling, assistance in planning nitrogen strip trials is available. This may include evaluation of alternative nitrogen rate, timing, product, or placement. Producers decide on the nitrogen management practice they are interested in assessing, and technical assistance is provided to plan a replicated trial and collect the necessary data to determine whether the management change was beneficial.

**Ag Weather Station Network** - Eleven weather stations are currently located in central Minnesota: Pine Point, Hubbard, Perham, Otter Tail, Wadena, Staples, Parkers Prairie, Clarissa, Westport, Little Falls, and Rice. Information from the weather stations is used by growers to efficiently schedule their irrigation water applications.

**Southeast Region Grant** - The MDA is working with local partners to design on-farm nitrogen fertilizer BMP demonstrations; assess on-farm nitrogen management using up-to-date methods respected within industry; advanced scientific on-farm nitrogen fertilizer BMP trials; and, farmer-to-farmer nitrogen management learning groups. The karst geology found in southeastern Minnesota is fractured limestone bedrock overlaid by shallow soils. This combination allows for rapid nitrate movement downward into groundwater once it is below plant rooting depth. The partners include the Southeast Soil and Water Conservation District Joint Powers Board, the University of Minnesota, and University of Minnesota Extension - Winona County.

**Accelerated Revisions of the Commercial Manure Applicator Study Manual** – At the request of the commercial manure applicators and an advisory work group, the MDA revised its statutes and has conducted several activities to improve education and outreach materials for manure applicators, including updating reference manuals. A person may not commercially manage or apply animal wastes to the land for hire in Minnesota without a valid Commercial Animal Waste Technician Site Manager or Applicator license. The MDA issues licenses to Site Managers who qualify by passing a certification exam. The examination is based on training material contained in this study manual. The revisions will improve manure applicator education, provide better assurances of applicator competency and advance up-to-date training for commercial manure personnel.

**Nitrogen Fertilizer Education and Promotion Team** - The MDA will convene the Nitrogen Fertilizer Education and Promotion Team as outlined in the NFMP, with an initial focus on identifying and promoting practices that provide the greatest opportunity for protecting groundwater.

Survey work through NASS and other sources suggests that one of the greatest areas needing improvement to protect groundwater is proper crediting of other nitrogen sources such as corn following soybean and alfalfa, and especially manure. The mitigation strategy in the NFMP will ensure that BMPs,

including proper crediting, are adopted in areas with elevated nitrate either through voluntary or, if necessary, regulatory means. In addition, the mitigation strategy will involve the local agricultural community in problem solving to consider actions that go beyond the BMPs to address local nitrate concerns. Prevention activities will also need to consider how best to promote proper crediting for all nitrogen sources.

**Planning and Technical Support** - The MDA will continue to provide technical support for local water management teams and local water plans and participate on interagency coordination teams. Nitrate in groundwater is connected to other water quality and quantity issues so coordination of work between state agencies and local partners is important. Efforts under the NFMP will be coordinated to the greatest extent possible with related state and local plans and activities.

## Mitigation

The MDA developed mitigation criteria and a mitigation process in the Nitrogen Fertilizer Management Plan. The goal of mitigation is to minimize the source of pollution in an area with elevated nitrate to the greatest extent practicable and, at a minimum, reduce nitrate contamination to below health-based standards so that groundwater is safe for human consumption. Mitigation activities will be implemented at a high level of effort and intensity over a defined area. This may include intensifying and targeting education and outreach efforts for BMP adoption, developing and implementing Alternative Management Tools, and, when necessary, exercising regulatory authority. Local Advisory Teams, nitrate monitoring in public and private wells, inventories of BMP adoption, allowing time for adoption of the BMPs, and requiring practices when they are not voluntarily adopted are important parts of the mitigation process.

Moving forward, the MDA will assess public and private wells in high priority townships for formal designation of the appropriate level in the mitigation strategy and begin implementation of mitigation activities. Additionally, the MDA will explore the use of contractors to speed up the mitigation process.

## Development of BMPs and Assessment Tools

The Nitrogen Fertilizer Management Plan recognizes the importance of on-going evaluation, demonstration, and, where appropriate, the revision or development of nitrogen fertilizer BMPs. The following projects involve the evaluation and development of BMPs and related assessment tools:

**Byron Township Forest to Field Water Quality Study** - A multi-partner project is underway to study the amount of nitrate loss that is occurring below an agricultural field recently converted from forest to irrigated row crop production. Partners include RDO Farms; Central Lakes College, Staples; the Minnesota Department of Natural Resources; University of Minnesota Extension; North East Technical Services; Sustainable Farming Association of Minnesota; and, the NRCS. The landowner, RDO Farms, has made the property and their staff available to better understand the potential environmental impact of this type of land use change.

This study is unique. It is the first instance in the state, and perhaps nationally, where groundwater impacts from irrigated row crop agriculture on newly converted forest land will be studied long-term starting from the first year of conversion. Findings from the study will be valuable if additional forest land in Minnesota's Central Sands region is converted to irrigated crop land. The study will help

researchers, the agricultural industry, government and others understand the impact of such land use conversions and the effectiveness of existing fertilizer BMPs, and perhaps the need for additional BMPs for protecting groundwater in these sensitive areas.

### **Validating Nitrogen Recommendations and Water Quality Impacts Under Irrigated Agriculture -**

The MDA is working with partners on two projects that will provide a better understanding of nitrogen fertilizer management and the associated water quality impacts on irrigated, sandy soils. One project is located in Westport, Minnesota at the Rosholt Farm and the other is located in Dakota County.

The Rosholt Farm project is supported through a unique partnership between Pope and Stearns County Soil and Water Conservation Districts (SWCDs), Prairie Lakes Co-op, the University of Minnesota and the Minnesota Department of Agriculture. In Dakota County, partners include Dakota County Environmental Services and the University of Minnesota.

These projects evaluate corn crop response and water quality impacts of different nitrogen practices in highly vulnerable irrigated settings. Research sites feature three crop rotations: corn on corn, corn following soybeans, and soybeans following corn, and evaluate various nitrogen products, rates and application times. Plots are irrigated by a linear irrigation system at the Rosholt site and under a center pivot in Dakota County.

### **Develop Predictive Tools for Nitrate Losses from Crop Production in Minnesota –**

Although adoption of the nitrogen fertilizer BMPs is extremely important to protect groundwater, the available data suggests that adoption of the BMPs may not be enough to adequately protect groundwater and achieve water quality goals in vulnerable areas. To address this, the NFMP introduces the concept of Alternative Management Tools (AMTs), which are advanced practices that may be needed to protect groundwater and decrease groundwater contamination. It will be important to have appropriate tools and methods to help determine where the promotion of AMTs should occur.

To answer these questions about the BMPs, the MDA has identified a need for additional computer-based modeling tools to evaluate nitrate leaching losses to groundwater under multiple agricultural production systems. These tools will accommodate changes in production systems or climate variations, and be able to quantify the potential success of implementing BMPs and other changes in technology. The results will help guide the MDA in assessing the effectiveness of BMP implementation. In highly vulnerable areas where the modeling tools and other sources suggest that groundwater cannot be adequately protected through conventional BMP implementation, greater emphasis may need to be placed on the promotion and use of AMTs. In addition, the results from the modeling may help guide future funding decisions and help inform the public of the effects of specific actions during a planning process.

**Prioritization of BMPs** – The MDA will form a BMP technical review group as outlined in the NFMP. The committee will assist local advisory groups in prioritizing BMPs and assist the MDA in guiding funding to prioritize the development and revision of the nitrogen fertilizer BMPs.

## **Other Activities**

The MDA is funding an evaluation by the United States Geologic Survey (USGS) to investigate the potential for denitrifying conditions in groundwater in coordination with a similar study on the potential for arsenic in groundwater funded by the MDH. Available information suggests that there are

potentially large areas in Minnesota where nitrate is naturally and rapidly degraded from groundwater. This can occur in areas where there are chemically reducing conditions in the presence of a carbon source in an aquifer. In these areas it is not uncommon for nitrate to be significantly reduced over very short depths in an aquifer. Understanding the conditions under which nitrate would be naturally degraded is important to understand the health risk from nitrate in new and existing drinking water wells and for prioritizing prevention activities.

The MDA is developing a community readiness survey to help evaluate, in an organized and systematic manner, the specific issues, concerns and potential resources that need to be considered when working with a local community to address a local nitrate problem. The use of these surveys will be piloted in local communities during the mitigation process.

## Summary and Recommendations

The activities discussed in this report represent a steady and sequential ramping up of efforts to reduce nitrate from fertilizer in groundwater. These steps include: revising the NFMP; the assessment of vulnerable areas; increased efforts to prevent or minimize nitrate losses from nitrogen fertilizer; developing and refining survey and assessment tools; developing rules; implementing voluntary mitigation steps; and, if necessary, regulation. Clean water funding has been critical in making these activities possible.

The revision of the NFMP was a lengthy process which included consideration of a range of management options, including a public comment period, that ultimately were consolidated into the current plan. Because the revision of the NFMP is just being completed and much needs to be done to implement it, with one exception the MDA does not have significant recommendations beyond the need for adequate funding and support to implement all aspects of the revised NFMP.

The MDA recommends increased funding and support for actions that encourage and promote the use of reduced nitrogen input crops and vegetative cover in targeted high risk areas. This includes forage, perennial and cover crops. The MDA believes economically viable low nitrogen crops targeted to areas that are vulnerable to groundwater contamination is the most effective approach to reducing nitrate in groundwater.

This is a major strategy for both the prevention and mitigation components of the NFMP. In addition to reducing nitrate loss, these cropping systems potentially have other significant benefits including: reduced soil erosion and phosphorus loss, benefits to address climate change, and increased wildlife and pollinator habitat. However, these cropping systems must be economically viable if they are to be sustained in the long term without ongoing subsidies.

Efforts should focus on developing cropping systems which can be both profitable for farmers and benefit water quality. While this is a challenge, it is a long-term goal to which the state should commit. Funding should provide for research, demonstration projects, and evaluating approaches to develop these cropping systems. This should include efforts to capitalize on potential existing markets for forage, energy and other low nitrogen crops.