



# Report on Nitrate in Groundwater

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This 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). The funding was available from July 1, 2013 through June 30, 2016.

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

## Executive Summary

Elevated levels of nitrate-nitrogen in groundwater represent a public health risk in situations where it is used as a source of drinking water. The risk of groundwater contamination depends on land use, soil and geology, climate and other factors. One potential source of contamination is nitrate-nitrogen from agricultural fertilizers.

This report demonstrates how Clean Water funding has been critical in allowing the Minnesota Department of Agriculture (MDA) to target and increase efforts to reduce groundwater contamination from nitrogen fertilizer. The MDA works with local partners to assess groundwater in agricultural areas and collaborates with University of Minnesota researchers, federal and state agencies, agricultural commodity groups and other stakeholders to develop, promote and provide education on Nitrogen Fertilizer Best Management Practices (BMPs).

Thus far, efforts have been dedicated to revising the Nitrogen Fertilizer Management Plan (NFMP), identifying areas where groundwater is vulnerable to nitrate contamination from fertilizer, increasing and refining efforts to prevent or minimize nitrate losses from nitrogen fertilizer use, developing and refining fertilizer use survey and assessment tools, and sampling private wells for nitrate and pesticides where nitrate is detected. The MDA is developing a rule to: 1) restrict nitrogen fertilizer application in fall and to frozen soils in areas that are vulnerable to groundwater contamination; and, 2) put into law the approach outlined in the NFMP. The MDA will begin implementation of voluntary steps for those areas with elevated nitrate concentrations in the groundwater.

This report recommends the allocation of adequate funding and support to implement the revised NFMP and increased funding and support for specified activities that encourage and promote nitrogen BMPs and Alternative Management Tools, such as the use of crops that require less nitrogen fertilizer and vegetative cover in targeted high risk areas.

## Introduction

Nitrate-nitrogen (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. The Minnesota Department of Agriculture (MDA) is using Clean Water Fund dollars to support activities that help identify potential sources of nitrate contamination and to evaluate and implement practices and tools to reduce nitrate in groundwater. The MDA works with local partners to assess groundwater in agricultural areas and works directly with farmers, agri-business and other interested parties in the impacted or threatened areas. The MDA collaborates with University of Minnesota (U of M) researchers to develop, promote and provide education on Nitrogen Fertilizer Best Management Practices (BMPs). The MDA also samples private wells for pesticides where nitrate was detected, as directed by the legislature.

## Background

Groundwater contamination from nitrate represents a potential health risk in drinking water wells. The drinking water standard for nitrate-nitrogen is 10 mg/L. Above this level, nitrate can have negative effects on human health, especially for infants under the age of six months. Older wells that do not meet the well construction code in aquifers that are vulnerable to contamination are of special concern. 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 an increased effort on reducing groundwater contamination from nitrogen fertilizer. The initial step was to revise the Nitrogen Fertilizer Management Plan (NFMP). The next steps, currently underway, are the assessment of vulnerable groundwater areas, increased prevention activities, evaluation and demonstration of Nitrogen Fertilizer BMPs, the evaluation of computer models to quantify nitrate losses from different cropping scenarios and developing a Nitrogen Fertilizer Rule. 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.

Additional information on the NFMP and many of the activities described in this report is available at [www.mda.state.mn.us/nfmp](http://www.mda.state.mn.us/nfmp)

## Program Development

The MDA completed the revision of the NFMP in 2015. The purpose of the NFMP is to prevent, evaluate and mitigate nonpoint source pollution from nitrogen fertilizer in groundwater. The NFMP is the state's blueprint to address nitrate pollution in groundwater. The three-year revision process included input from an advisory committee and the public via a public comment period, as well as listening sessions

across the state. Based on public input, the MDA made numerous revisions to the NFMP including adding a part to the proposed rule to restrict nitrogen fertilizer application in fall and to frozen soils in areas that are vulnerable to groundwater contamination; updating the plan every ten years; adding new prevention activities, defining alternative management tools; and defining monitoring, assessment and mitigation activities.

The MDA is moving forward using the guidance outlined in the plan. These activities will require some piloting, evaluation and refining of the overall approach. Many of these activities are currently being implemented and are described in more detail below.

The MDA is developing a Nitrogen Fertilizer Rule that will: 1) restrict nitrogen fertilizer application in fall and to frozen soils in areas that are vulnerable to groundwater contamination; and, 2) put into law the approach outlined in the NFMP. The rule will take 2 -3 years to develop. In the interim time period, voluntary aspects of the mitigation process will be further refined and implemented in high priority areas.

## Groundwater Monitoring and Assessment

The MDA has supported different levels of groundwater monitoring and assessment. This includes walk-in nitrate clinics, regional nitrate monitoring networks and the Township Testing Program.

**Nitrate Clinics** – In 1993, the MDA began to offer free walk-in 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. Although the MDA no longer directly hosts these clinics, we continue to help local partners with nitrate testing clinics by providing testing equipment, training and supplies for use at county offices or events.

**Regional Monitoring Networks** – The MDA works closely with other agencies to develop regional private well nitrate monitoring networks. Monitoring networks provide a better understanding of nitrate trends in a region and the results are used to educate private well owners about the quality of their drinking water. Homeowners collect their own water sample and send it by mail to be tested by a laboratory or a county collaborator using MDA equipment at no cost to the homeowner. 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.

**Township Testing Program** – Building on the success of the past nitrate monitoring work, the MDA has developed the 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 of private wells. Sampling private wells at a township scale allows the MDA to identify high nitrate areas where targeted practices can be implemented.

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 tests at no cost to approximately 70,000 well owners in 250-300 townships by 2019. Homeowners receive a sample bottle and are instructed how to collect and ship their sample to the participating lab.

Private wells in 104 townships from 10 counties were sampled from 2013-2015. The initial sampling was conducted in areas that are highly vulnerable to groundwater contamination. Results indicated that in 42 townships, 10 percent or more of the wells had nitrate-nitrogen concentrations greater than 10 mg/L; in 28 townships, between 5 and 10 percent of the wells had nitrate greater than 10 mg/L; and in 34 townships, less than 5 percent of the wells had nitrate over 10 mg/L. The percent of wells over 10 mg/L will be used to determine the MDA's response in each township.

The MDA offers homeowners a resampling opportunity if nitrate is detected in the first sample. A hydrologist will visit the location, collect the second sample and assess the area around the well for point sources of nitrate such as a feedlot, septic system or bulk storage of nitrogen fertilizer. The hydrologist gathers data on the well from the County Well Index and other sources. This information is used to remove wells from the dataset if the MDA believes there may be a point source of nitrogen polluting the well or if the well's construction is inadequate (loose well cap, cracked casing, etc.). Additionally, the water sample is tested for pesticides as discussed in the next section. Additional information on the Township Testing Program is available at [www.mda.state.mn.us/townshiptesting](http://www.mda.state.mn.us/townshiptesting)

**Private Well Pesticide Sampling** – At the direction of the Minnesota Legislature, the MDA began sampling for pesticides in wells that had nitrate detected as part of the MDA's Township Testing Program. Collecting and analyzing water samples from private wells for pesticides is significantly more difficult and expensive than sampling for nitrate. The primary goal of the Private Well Pesticide Sampling (PWPS) project is to provide information to homeowners and the general public regarding the presence of pesticides in private drinking water wells in geologically sensitive agricultural areas of Minnesota.

Beginning in 2014, and through the monitoring season (May-October) of 2015, MDA staff sampled 1,841 private wells for pesticides and nitrate in Benton, Dakota, Morrison, Olmsted, Sherburne, Stearns, Wadena and Washington Counties. The MDA will continue to sample for pesticides in private wells containing nitrate during the 2016 monitoring season in other sensitive geologic areas, including the Central Sand Plains and southeastern Minnesota. The MDA has contracted with a laboratory capable of analyzing for more pesticides at lower concentrations for the 2016 monitoring season.

**Sampling Public Water Supplies for Nitrate** – The MDA partners with the Minnesota Department of Health (MDH) in monitoring and assessing public water supplies for nitrate. "Raw" groundwater is used prior to blending for use in a public water supply. The MDA and MDH are coordinating to develop procedures for conducting these assessments.

## Fertilizer Use Surveys

The assessment of the adoption of nitrogen BMPs is a critical element of the NFMP. Statewide and regional assessments help focus educational messages for prevention activities. For this reason, 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 surveys can be focused on particular crops or practices.

A pilot fertilizer use survey was conducted for the 2009 crop year to obtain fertilizer rates on corn acres in Minnesota. A total of 2,700 farmers representing seven percent of the corn acres participated 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 10 percent of Minnesota's corn acres. The fertilizer use survey was repeated for the 2012 crop year and a total 1,600 farmers representing five percent of the corn acres were involved in the survey process. This was the first year that the survey was performed at the NASS national call center in St. Louis.

In 2011, 2,100 farmers were surveyed regarding the use of nitrogen BMPs on corn acres. The primary purpose of this particular survey was to evaluate the use of fall applied and sidedress (post emergence) applied nitrogen in Minnesota. The nitrogen BMP survey was repeated in 2013 and 1,700 farmers were surveyed for the corn acres, again on fall-applied and sidedress applied nitrogen.

Survey results 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, placement of fertilizer and application rates for 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 manure and legumes such as soybean and alfalfa. 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.

In addition to regional and statewide surveys, the MDA is developing an accelerated survey tool to evaluate fertilizer use practices and BMP adoption at a local scale. This approach will be based on the existing Farm Nutrient Management Assessment Program (FANMAP) survey, previously developed by the MDA. However, the surveys will be significantly shortened and streamlined. The survey will be used to determine the nitrogen fertilizer use practices in localized areas with elevated nitrate in private wells. A survey instrument was tested with fertilizer dealers in several townships in Wadena and Pipestone Counties in 2016.

Additional information on the nutrient management surveys is available here:

<http://www.mda.state.mn.us/protecting/cleanwaterfund/gwdwprotection/nutrientmgmtsurvey.aspx>

## Prevention

Some of the most important activities in the NFMP involve minimizing the loss of nitrate to groundwater in order to prevent contamination. Once groundwater is contaminated, it is expensive and challenging to address. Prevention activities will be promoted in all areas with the greatest emphasis in locations most vulnerable to groundwater contamination.

The following projects and activities emphasize prevention. This includes working with farmers individually and through demonstration sites that result in improved nitrogen management practices. Others involve using technology to support changes in practices. Many of the projects are located in central Minnesota in areas with coarse-textured (sandy) soils and in southeastern Minnesota in areas with karst topography, both of which are vulnerable to groundwater contamination.

Additional information on prevention activities is available here:

<http://www.mda.state.mn.us/protecting/cleanwaterfund/gwdwprotection.aspx>



**Irrigation Management for Water Quality Protection** – MDA Clean Water Funding supports an irrigation water quality specialist at the University of Minnesota Extension. This position develops guidance and provides education on irrigation and nitrogen BMPs. The position was encouraged by the irrigator community and provides programming statewide.

**Irrigation Outreach and On-Farm Nitrogen Management in Central Minnesota** – The MDA has partnered with Benton and Pope Counties, the East Otter Tail SWCD and University of Minnesota Extension to carry out a series of irrigation workshops and programs that promote proper water and nitrogen fertilizer management. The SWCDs also offer farmers technical support programs on irrigation scheduling and calibration. During the winter of 2015-16, over 200 producers and industry professionals attended workshops held in Rice, Ottertail, and Glenwood with over 80 percent indicating the information provided would help them better manage irrigation water.

**Ag Weather Station Network** – Twelve weather stations are currently located in central Minnesota: Becker, Clarissa, Hubbard, Little Falls, Ottertail, Parkers Prairie, Perham, Pine Point, Rice, Staples, Wadena, and Westport. Information from the weather stations is used by farmers and irrigation scheduling technicians to efficiently schedule irrigation water applications. The stations are a collaborative effort between MDA, SWCDs and University of Minnesota Extension.

**Central Minnesota Nitrogen Best Management Practices Promotion** – MDA and local partners are supporting an on-farm nitrogen management program that encourages producers to implement management actions, monitor results, and adjust future management accordingly.

One program conducts corn basal stalk nitrate tests, which evaluate how much nitrogen is left at the end of the growing season. Stalk samples are collected “post mortem” 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. 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 used in their fields. Partners in this project include 52 farm cooperators in 2015 who enrolled 3,652 acres, as well as the East Otter Tail, West Otter Tail, Becker, Hubbard, Todd, and Wadena SWCDs. Ninety-four percent of the producers enrolled indicate that they are making nitrogen management changes based on the program.

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. Farmers 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.

The MDA is conducting nitrogen fertilizer BMP field demonstrations in municipal drinking water source water supply areas for the cities of Cold Spring, Park Rapids, Perham, Rice and Verndale. In Park Rapids, Perham, Rice and Verndale, the demonstrations are on crop fields of cooperating farmers and evaluate soil water nitrate levels under different nitrogen fertilizer management practices. Cold Spring is unique in that it is evaluating nitrate loss under turfgrass in a city park. The Cold Spring demonstration is being done in conjunction with the city, the Stearns County SWCD and University of Minnesota Extension. An annual education event has taken place each of the last four years in the neighborhood closest to the city wells that focuses on proper nitrogen fertilizer rates for turf.

**Southeast Region Nitrogen Best Management Practices Promotion** – The MDA and local partners are implementing on-farm nitrogen fertilizer BMP demonstrations; assessing on-farm nitrogen management; and advanced scientific on-farm nitrogen fertilizer BMP trials. 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. Included counties are Fillmore, Goodhue, Houston, Olmstead, Wabasha, and Winona. This program is related to the statewide Nutrient Management Initiative (on-farm strip trials for farmers to compare nitrogen management practices).

Dakota County is on the north end of Minnesota's southeast region and has geology similar to the outwash, coarse-textured soils of central Minnesota. The MDA is conducting nitrogen fertilizer BMP field demonstrations in the municipal drinking water source water supply area for the City of Hastings. Demonstrations are in place on crop fields of cooperating farmers and on turfgrass areas of the city's playing fields to evaluate soil water nitrate levels under different nitrogen fertilizer management practices.

**Nutrient Management Initiative** - The Nutrient Management Initiative was developed to assist farmers and crop advisers in evaluating alternative nutrient management practices on their own fields. Participating farmers work with a crop adviser to set up field trials on their own farms. Field trials are used to compare different nitrogen rates, timing and stabilizers. In 2015 and 2016, approximately 95 farmers and 35 crop advisers participated in the Nutrient Management Initiative program. This program has been at full capacity the past two years, requiring a waiting list for interested farmers.

**Southwest Region Nitrogen Best Management Practice Promotion** – The MDA is partnering with the Nobles, Pipestone and Rock SWCDs to address public water supplies experiencing high concentrations of nitrate in groundwater. Affected aquifers are located in river valleys where cropland production occurs. Typically, the cropland is on soils underlain by sand and gravel which are porous materials prone to rapid leaching, including the rapid leaching of nitrate from nitrogen fertilizer. This project is helping farmers reduce loss of nitrate to groundwater by making wider use of BMPs including: 1) following recommended nitrogen fertilizer rates based on crop and conditions; 2) using slow-release nitrogen fertilizers; 3) timing nitrogen fertilizer applications closer to crop uptake; and 4) use of nitrification inhibitors.

The MDA is conducting nitrogen fertilizer BMP field demonstrations in the municipal drinking water supply area for the City of Luverne and Rock County Rural Water. Demonstrations are located on crop fields of cooperating farmers to evaluate soil water nitrate levels under different nitrogen fertilizer management practices.

**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. Site Managers 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 has convened 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. The team is comprised of the University of Minnesota, agricultural organizations such as the Minnesota Corn Growers Association, agencies, industry and others. Priorities include packaging the Minnesota Nitrogen BMPs into a 4R format and developing educational messages for crediting nitrogen from other sources such as manure and alfalfa. The ag industry developed the 4R nutrient stewardship concept, which promotes the use of the right fertilizer source at the right rate at the right time in the right place.

**Nitrogen Fertilizer BMP Technical Advisory Team** – The MDA has established a Nitrogen Fertilizer BMP Technical Advisory Team. The role of this team is to advise and assist the MDA in reviewing the existing Nitrogen Fertilizer BMPs and propose new BMPs. Members include the University of Minnesota, the International Plant Nutrition Institute, agronomists, industry experts and the NRCS.

**Planning and Technical Support** – The MDA has and will continue to provide technical support for local water management teams, local water plans and participate with 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 within the NFMP will be coordinated to the greatest extent possible with related state and local plans and activities.

**Nitrogen and Nutrient Conferences** – The MDA, University of Minnesota Extension and the Minnesota Agricultural Water Resources Center hold two one-day educational conferences annually. One focuses on nitrogen management and the other on nutrients. The Minnesota Ag Water Resources Center organizes the conferences.

**U of M Extension Ag Water Quality Positions** – The positions, which started in early 2016, will develop and deliver educational programs and processes to assist farmers in adopting Nitrogen Fertilizer BMPs and Alternative Management Tools. The prevention strategy in the NFMP relies on education to promote awareness and increase the adoption of the BMPs. The two staff are located in St. Cloud and Rochester.

## Mitigation

The MDA developed a mitigation process in the NFMP. 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. The key is to engage local farmers in the mitigation process to address the nitrate issue. The MDA can exercise regulatory authority if nitrate concentrations are high and farmers do not adopt the nitrogen fertilizer BMPs.

Moving forward, the MDA will assess public and private wells in high priority areas for formal designation of the appropriate response level in the mitigation strategy and begin implementation of mitigation activities. This will include forming local advisory teams to advise the MDA on locally viable solutions and education initiatives to accelerate BMP adoption in mitigation areas. The following activities will help the MDA to prepare for and work with the local advisory teams:

**Community Readiness Survey** – The survey involves conversations with local partners to identify and evaluate the specific issues, concerns and potential resources that need to be considered when working with a community to address a local nitrate problem. The MDA conducted a pilot survey in 2015 and revised the tool based on the results.

**Nitrogen Fertilizer BMP Adoption Survey** – this survey collects localized data on the adoption of Nitrogen Fertilizer BMPs in areas determined to be impacted by nitrate. This is also discussed in this report in the fertilizer use surveys section.

**Leadership Development and Civic Capacity Building** – The University of Minnesota Extension is training MDA staff for developing and maintaining effective local advisory teams. This includes consultation on advisory team membership and recruitment, facilitation and evaluation. The University will provide meeting process design and facilitation for the first local advisory team meetings.

## Development of BMPs and Assessment Tools

The NFMP 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 Managed Timber to Row Crop Agriculture Water Quality Study** - A multi-partner project is underway to study nitrate movement that occurs below an agricultural field recently transitioned from managed timber production to irrigated row crop production. Partners include R.D. Offutt Company; Central Lakes College - Staples; University of Minnesota Extension; Northwest AqwaTek Solutions; and Sustainable Farming Association of Minnesota. The landowner, R.D. Offutt Company, has made the property and their staff available to better understand the movement of water and nitrate through the soil following this type of land use transition.

This study is unique. It is the first instance in the state, and perhaps nationally, where groundwater impacts from irrigated agriculture have been studied from the first year of production. Findings from the study will be valuable if additional timber land in Minnesota's Central Sands region is transitioned for other purposes. The study will help researchers, the ag industry, and government better understand the potential groundwater quality impact of such land use transitions, and the study results are informing researchers on management practices to mitigate any impacts.

**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 Pope County at the Rosholt Research Farm and the other is located in Dakota County on land of cooperating farmers. The Pope County project has run continuously since 2012; the Dakota County site ran from 2012-2014 and will resume in 2017. Data from the two projects have been used by the University of Minnesota for the 2015 revision of the nitrogen fertilizer rate guidelines for irrigated corn grown on coarse-textured soils. Starting in 2016 and 2017, the projects will focus on the potential benefits of cover crops on nitrogen management and groundwater quality in a corn-soybean rotation.

The Pope County project is supported through a unique partnership between the Pope and Stearns County SWCDs, CHS-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.

**Develop Predictive Tools for Nitrate Losses from Crop Production in Minnesota** – Although adoption of the Nitrogen Fertilizer BMPs is extremely important to protect groundwater, available data suggests that adoption of the BMPs may not be enough to adequately protect groundwater and achieve water quality goals in some 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. This may include cover crops and precision agriculture. It will be important to have appropriate tools and methods to help determine where the promotion of AMTs should occur.

To answer questions about the effectiveness of BMPs, the MDA has identified a need for additional computer-based modeling tools to evaluate and quantify nitrate leaching losses to groundwater under different agricultural production systems. These models are being developed by the University of Minnesota under contract with the MDA. The models 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 planning processes.

**Nitrogen Rate Trials** – In 2015, the University of Minnesota Extension released new guidelines for nitrogen rates for corn grown on sandy soils under irrigation. The guidelines are important because more than half of the 600,000 acres under irrigation on coarse textured soils in Minnesota is used for corn production. Since the release of the guidelines, public concerns have been expressed in regard to the environmental impacts of increased nitrogen fertilizer application on coarse textured soils. The purpose of this project is to use the updated rates in a demonstration project while monitoring corn yield and impacts to water quality below the root zone. The project, located at the Central Lakes College in Staples, will quantify the amount of nitrogen used by the plants and the amount remaining in the soil under dry land corn production as well as determine the fate of the nitrogen if it is not used by the corn crop. The MDA is partnering with the Central Lakes College in Staples and the University of Minnesota Extension.

## Other Activities

The MDA has funded an evaluation by the United States Geologic Survey (USGS) to investigate the potential for denitrifying conditions in groundwater. The study was coordinated with a similar study on the potential for arsenic in groundwater funded by the Minnesota Department of Health (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.

In Phase 1, the project cataloged known sources of nitrate analyses and evaluated the current state of knowledge regarding nitrate transport and denitrification processes in Minnesota groundwater. The USGS completed the evaluation in November 2015 and provided four proposed projects, known as a Phase 2 proposal. Based on MDA's nitrogen work priorities, MDA selected "Project 2: Township Testing Program: Redox chemistry pilot program." The objective is to determine the redox state of several counties that were part of the Township Testing Program by using a spreadsheet tool along with a comprehensive geochemical dataset (dissolved oxygen, nitrate, manganese, iron and sulfate). Funding for this project is pending.

## Summary and Recommendations

The activities discussed in this report represent a targeted and increased effort to reduce nitrate from fertilizer in groundwater. To maximize their impact, the activities have been designed and established as multi-year efforts.

The MDA recommends continued funding for these activities, including: implementing the NFMP; refining the identification and assessment of vulnerable areas; accelerating the testing of private wells for nitrate; increasing efforts to prevent or minimize nitrate losses from nitrogen fertilizer; developing and refining survey and assessment tools, including advanced computer-aided modeling tools; and implementing voluntary mitigation steps. Clean Water Funding has been critical in making these activities possible.

In addition, the MDA recommends increased funding and support for activities that encourage and promote the use of nitrogen BMPs and Alternative Management Tools, including reduced nitrogen input crops and vegetative cover in targeted high risk areas. This includes forage crops, perennial vegetation 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 markets for these cropping systems. This should include efforts to capitalize on potential existing markets for forage, energy and other low nitrogen input crops.