



# Final Township Testing Nitrate Report: Faribault County 2018-2019

December 2020

Minnesota Department of Agriculture

Pesticide and Fertilizer Management Division

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## ACKNOWLEDGEMENTS

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## EXECUTIVE SUMMARY

Nitrate is a naturally occurring, water soluble molecule that is made up of nitrogen and oxygen. Although nitrate occurs naturally, it can also originate from sources such as fertilizer, animal manure, and human waste. Nitrate is a concern because it can be a risk to human health at elevated levels. The Minnesota Department of Health (MDH) has established a Health Risk Limit (HRL) of 10 mg/L nitrate-N as nitrogen (nitrate-N) for private drinking water wells in Minnesota.

In response to health concerns over nitrate-N in drinking water the Minnesota Department of Agriculture (MDA) developed the Nitrogen Fertilizer Management Plan (NFMP). The NFMP outlines a statewide plan to assess vulnerable areas for nitrate in groundwater known as the Township Testing Program.

The primary goal of the Township Testing Program is to identify areas that have high nitrate concentrations in their groundwater. The program also informs residents about the health risk of their well water. Areas were selected based on historically elevated nitrate conditions, aquifer vulnerability and row crop production. More than 90,000 private well owners have been offered nitrate testing in 344 townships since 2013. This is one of the largest nitrate testing efforts ever conducted and completed.

In 2018, private wells in the Faribault County study area (three townships) were sampled for nitrate-N. Samples were collected from private wells using homeowner collection and mail-in methods. These initial samples were collected from 134 wells representing an average response rate of 50 percent of homeowners. Well log information was obtained when available and correlated with nitrate-N results. Initial well dataset results showed that across the study area, none of private wells sampled were at or above the health standard of 10 mg/L for nitrate-N. Based on the initial results, it is estimated that no residents are consuming well water with nitrate-N at or over the HRL.

The MDA completed follow-up sampling and well site visits at six wells in 2019. A follow-up sampling was offered to all homeowners with wells that had a detectable nitrate-N result.

A well site visit was conducted to identify wells that were unsuitable for final analysis. The final well dataset is intended to only include private drinking water wells potentially impacted by applied commercial agricultural fertilizer. Therefore, wells that had nitrate-nitrogen results over 5 mg/L were removed from the initial dataset to form the final dataset if a potential non-fertilizer source or well problem was identified, there was insufficient information on the construction or condition of the well, or for other reasons which are outlined in Appendix E. Point sources of nitrogen can include: feedlots, subsurface sewage treatment systems, fertilizer spills, and bulk storage of fertilizer. A total of two (1.5 percent) wells were determined to be unsuitable and were removed from the dataset. The final well dataset had a total of 132 wells.

The final well dataset was analyzed to determine the percentage of wells at or over the HRL of 10 mg/L nitrate-N. When analyzed at the township scale there were no wells at or over the HRL.

## INTRODUCTION

The Minnesota Department of Agriculture (MDA) is the lead agency for nitrogen fertilizer use and management. The Nitrogen Fertilizer Management Plan (NFMP) is the state's blueprint for prevention or minimization of the impacts of nitrogen fertilizer on groundwater. The MDA revised the NFMP in 2015. Updating the NFMP provided an opportunity to restructure county and state strategies for reducing nitrate contamination of groundwater, with more specific, localized accountability for nitrate contamination from agriculture. The NFMP outlines how the MDA addresses elevated nitrate levels in groundwater. The NFMP has four components: prevention, monitoring, assessment and mitigation.

The goal of nitrate monitoring and assessment is to develop a comprehensive understanding of the severity, magnitude, and long-term trends of nitrate in groundwater as measured in public and private wells. The MDA established the Township Testing Program to determine current nitrate concentrations in private wells on a township scale. This program is designed to quickly assess a township in a short time window. Monitoring focuses on areas of the state where groundwater nitrate contamination is more likely to occur. This is based initially on hydrogeologically vulnerable areas where appreciable acres of agricultural crops are grown. More than 90,000 private well owners have been offered nitrate testing in 344 townships since 2013.

In 2018, three townships in Faribault County were selected to participate in the Township Testing Program (Figure 1). Areas were chosen based on several criteria. Criteria used includes: professional knowledge shared by the local soil and water conservation district (SWCD) or county environmental departments, past high nitrate as nitrogen (nitrate-N) results, vulnerable groundwater, and the amount of row crop production. Initial water samples were collected from private wells by homeowners and mailed to a laboratory. Sample results were mailed by the laboratory to the participating homeowners. The sampling, analysis, and results were provided at no cost to participating homeowners and paid for by the Clean Water Fund.

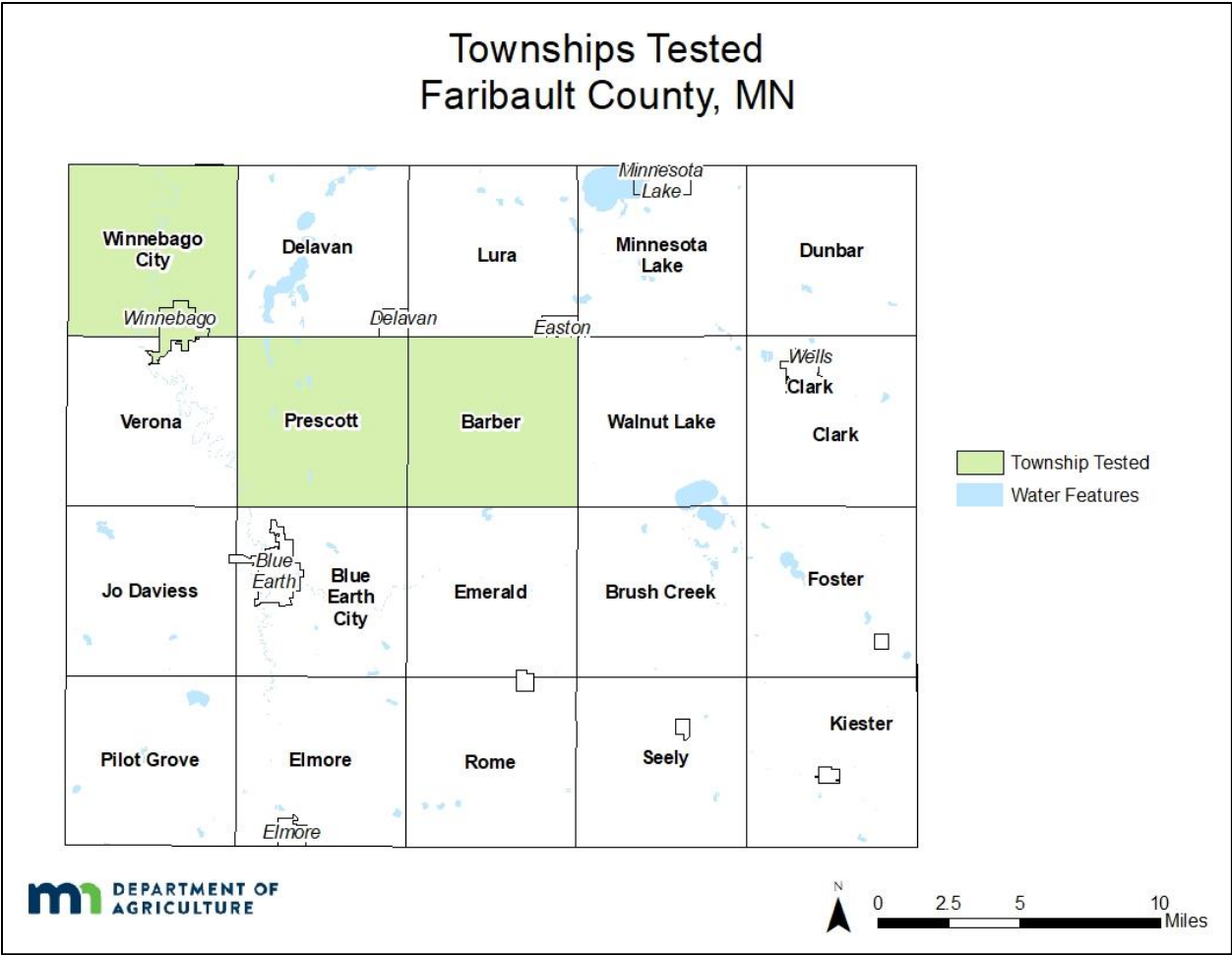
Well owners with detectable nitrate-N results were offered a no cost pesticide sample and a follow-up nitrate-N sample collected by MDA staff. The MDA began evaluating pesticide presence and concentrations in private water wells at the direction of the Minnesota Legislature. The follow-up pesticide and nitrate-N sampling in Faribault County occurred in 2019. The follow-up included a well site visit (when possible) in order to rule out well construction issues and to identify potential point sources of nitrogen (Appendix B).

Wells that had nitrate-nitrogen results over 5 mg/L were removed from the initial dataset to form the final dataset if a potential non-fertilizer source or well problem was identified, there was insufficient information on the construction or condition of the well, or for other reasons which are outlined in Appendix E. After the unsuitable wells were removed, the nitrate-N concentrations of well water were assessed for each area.

For further information on the NFMP and Township Testing Program, visit the following webpages:

[www.mda.state.mn.us/nfmp](http://www.mda.state.mn.us/nfmp)

[www.mda.state.mn.us/townshiptesting](http://www.mda.state.mn.us/townshiptesting)



**Figure 1. Townships Tested in Faribault County**

## BACKGROUND

In many rural areas of Minnesota, nitrate is one of the most common contaminants in groundwater, and in some localized areas, a significant number of wells have high nitrate levels.

Nitrate is a naturally occurring, water soluble molecule that is made up of nitrogen and oxygen. Although nitrate occurs naturally, it can also originate from other sources such as fertilizer, animal manure, and human waste. Nitrate is a concern because it can have a negative effect on human health at elevated levels. The United States Environmental Protection Agency has established a drinking water Maximum Contaminant Level (MCL) of 10 mg/L for nitrate-N (US EPA, 2009) in municipal water systems. The Minnesota Department of Health (MDH) has also established a Health Risk Limit (HRL) of 10 mg/L nitrate-N for private drinking water wells in Minnesota.

Nitrogen present in groundwater can be found in the forms of nitrite and nitrate. In the environment, nitrite generally converts to nitrate, which means nitrite occurs very rarely in groundwater. The nitrite concentration is commonly less than the reporting level of 0.01 mg/L, resulting in a negligible contribution to the nitrate plus nitrite concentration (Nolan and Stoner, 2000). Therefore, analytical methods generally combine nitrate plus nitrite together. Measurements of nitrate plus nitrite as nitrogen and measurements of nitrate as nitrogen will hereafter be referred to as “nitrate”.

## NITRATE FATE AND TRANSPORT

Nitrate is considered a conservative anion and is highly mobile in many shallow coarse-textured groundwater systems. Once in groundwater, nitrate is often considered very stable and can move large distances from its source. However, in some settings nitrate in groundwater may be converted to nitrogen gas in the absence of oxygen and the presence of organic carbon through a natural process called denitrification. Denitrification occurs when oxygen levels are depleted and nitrate becomes the primary oxygen source for microorganisms (Dubrovsky et al., 2010). In karst environments, such as Faribault County, rapid flowing pathways in the geology allow for nitrate contaminated surface leachate to quickly reach aquifers (MPCA, 2019c). The time it takes for contaminated water to leach to aquifers is short in karst systems, and therefore there is limited opportunity for denitrification (Katz, 2012). As a result, areas with karst geology and intensive row crop agriculture, like much of Faribault County, are particularly vulnerable to groundwater nitrate contamination. However, geochemical conditions can be highly variable within an aquifer or region and can also change over-time (MPCA, 1999).

## GEOLOGY AND HYDROGEOLOGY

From approximately 2.5 million years ago to 11,700 years ago, much of the northern Hemisphere, including Minnesota, was intermittently covered by sheets of slowly moving ice known as glaciers (Lusardi & Dengler, 2017). During colder times, the glaciers would grow and move farther south, sometimes covering most of Minnesota, and during warmer times the glaciers would melt and retreat farther north, away from Minnesota (Lusardi & Dengler, 2017). As these glaciers moved, they moved the earth beneath them and deposited it in other places, destroying old landscapes and creating new ones in their place (Lusardi & Dengler, 2017).

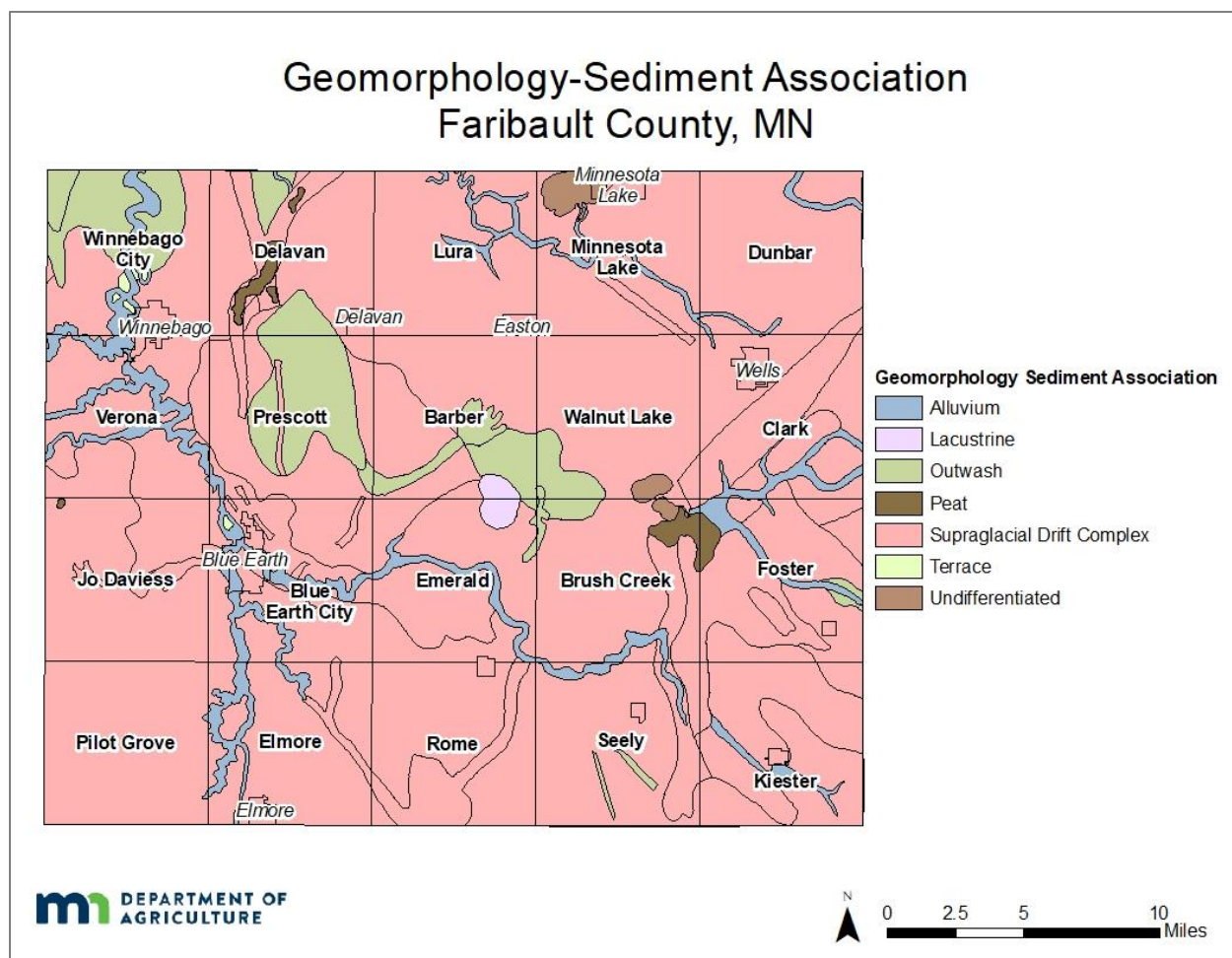
During the most recent glacial period much of the northwestern half of Faribault County was covered by Glacial Lake Minnesota. This glacial lake deposited fine-grained clay and silt sediment through much of the northwestern portion of Faribault County. The rest of the county was mostly covered by stagnation

moraine deposits as temperatures warmed and the glaciers stalled. These moraines are formed by sediment released from glaciers and can form irregular and hummocky topography. Scattered amongst the glacial lake and moraine deposits are pockets of glacial outwash deposited by glacial meltwater (Lusardi et al., 2019).

These glacial sediments together cover all of Faribault county, ranging from 50 to over 200 ft thick. The thickest sediments occur where glacial sediment has filled in ancient bedrock valleys. The thinnest sediments are in river valleys (Mankato State University Water Resources Center, 1991) where the river systems have eroded through glacial sediment and replaced it with coarser-grained alluvium (Lusardi et al., 2019). This coarser-grained alluvium allows water to travel through more easily than other glacial sediments, making shallow wells in these river valleys potentially the most vulnerable to contamination (Adams, 2016). The locations of the alluvium can be seen in Figure 2.

Below these glacial deposits lie bedrock aquifers. Throughout most of southeast Faribault County, the uppermost bedrock aquifers are the Maquoketa and Galena Limestones, which are commonly used as water sources (Mankato State University Water Resources Center, 1991). This limestone dissolved over time, resulting in fractures and tunnels within the aquifers collectively known as karst features. These karst features allow quick flow of water through karstic aquifers (Bakalowicz, 2005). Under the Galena limestone is the Decorah Shale, which acts as a confining layer, restricting the flow of contaminant laden water into the underlying aquifers, such as the St. Peter and Prairie du Chien Formations (Mankato State University Water Resources Center, 1991).

However, in the northwestern portion of the county, the Galena Group and the Decorah Shale have eroded away, leaving the St. Peter Formation and the Prairie du Chien formations as the topmost bedrock (Mankato State University Water Resources Center, 1991). Both layers do little to stop contaminated water from flowing downward: the St. Peter formation is sandy, allowing water to easily flow through, and the Prairie du Chien contains karst features (Mankato State University Water Resources Center, 1991). Thus, the level of groundwater vulnerability in these aquifers depends on the thickness and composition of the overlying glacial sediment: where the glacial sediment is thick and fine-grained aquifers are protected while where the glacial sediment is thin and coarser grained, such as in the river valleys, aquifers are more susceptible to contamination (Adams, 2016).



**Figure 2. Statewide Geomorphology Layer, Sediment Association in Faribault County (MDNR, MGS, and UMD, 1997)**

## NITROGEN POINT SOURCES

The focus of the Township Testing Program is to assess nitrogen contamination in groundwater as a result of commercial nitrogen fertilizer applied to cropland. Any wells potentially impacted by point sources were removed from the final well dataset. Potential point sources such as subsurface sewage treatment systems (more commonly known as septic systems), feedlots, bulk storage of fertilizer, and fertilizer spills are considered in this section. Below is a brief overview of these sources in Faribault County. Further details are in Appendix B.

### SUBSURFACE SEWAGE TREATMENT SYSTEM

Subsurface sewage treatment systems (SSTS) can be a potential source for contaminants in groundwater such as nitrate and fecal material (MDH, 2014). A total of 2,096 SSTS were reported in Faribault County for 2018. Over a recent 17-year period (2002-2018), 1,284 construction permits for new, replacement, or repairs for SSTS were issued. Of all the reported septic systems in Faribault County, 61 percent are newer than 2002 or have been repaired since 2002 (MPCA, 2019b). When new SSTS's are installed they

are required to be in compliance with the rules at the time of installation. Newer systems meet modern SSTs regulations and must comply with the current well code; which requires a 50-foot horizontal separation from the well (MDH, 2014).

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## FEEDLOT

Manure produced on a feedlot can be a potential source of nitrogen pollution if improperly stored or spread. In the Faribault County study area, there are a total of 47 active feedlots. Of these, 33 (70 percent) are permitted to house more than 100 animal units (AU) and 16 (34 percent) are permitted to house more than 300 AU (Appendix B; Figure 9). Most feedlots in the study area are for swine.

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## FERTILIZER STORAGE LOCATION

Bulk fertilizer storage locations are potential point sources of nitrogen because they store large concentrations of nitrogen-based chemicals. Licenses are required for individuals and companies that store large quantities of fertilizer. The Faribault County study area has a total of five fertilizer storage licenses, all of which are in Winnebago City Township. (Appendix B; Table 11).

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## FERTILIZER SPILLS AND INVESTIGATIONS

A total of seven historic fertilizer spills and investigations occurred in the Faribault County study area. The majority of these were incident investigations. (Appendix B; Table 13).

## TOWNSHIP TESTING METHODS

### VULNERABLE TOWNSHIPS

Well water sampling is focused on areas that are considered vulnerable to groundwater contamination by commercial nitrogen fertilizer. Typically, townships and cities are selected for sampling if more than 30 percent of the underlying geology is considered vulnerable and more than 20 percent of the land cover is row crop agriculture. These are not rigid criteria but are instead used as a starting point for creating an initial plan. Additional factors such as previous nitrate results and local knowledge of groundwater conditions were used to prioritize townships for testing. A statewide map of townships that were chosen for testing is shown in Figure 3.

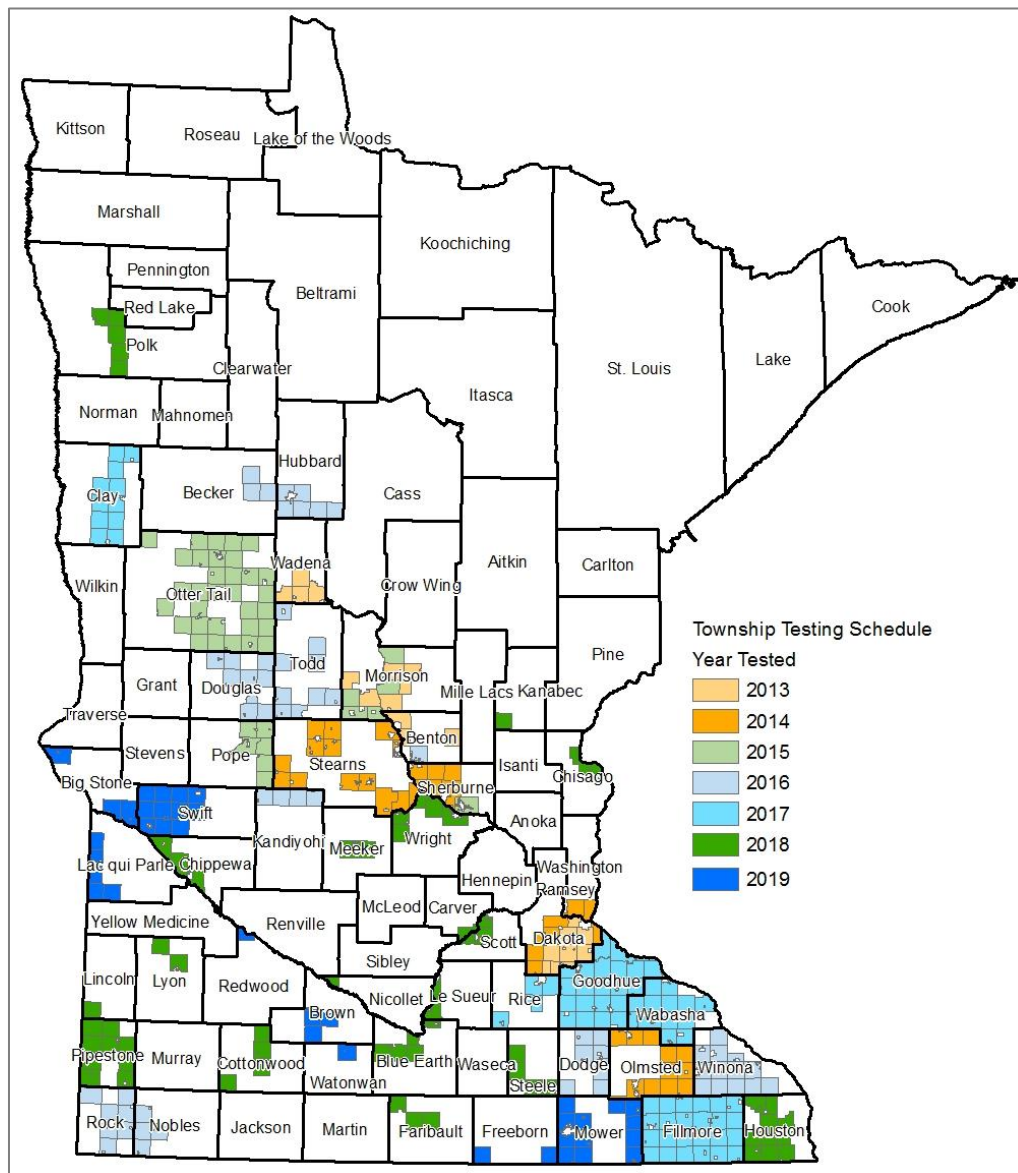


Figure 3. Minnesota Vulnerable Townships Tested for Nitrate in Private Wells.

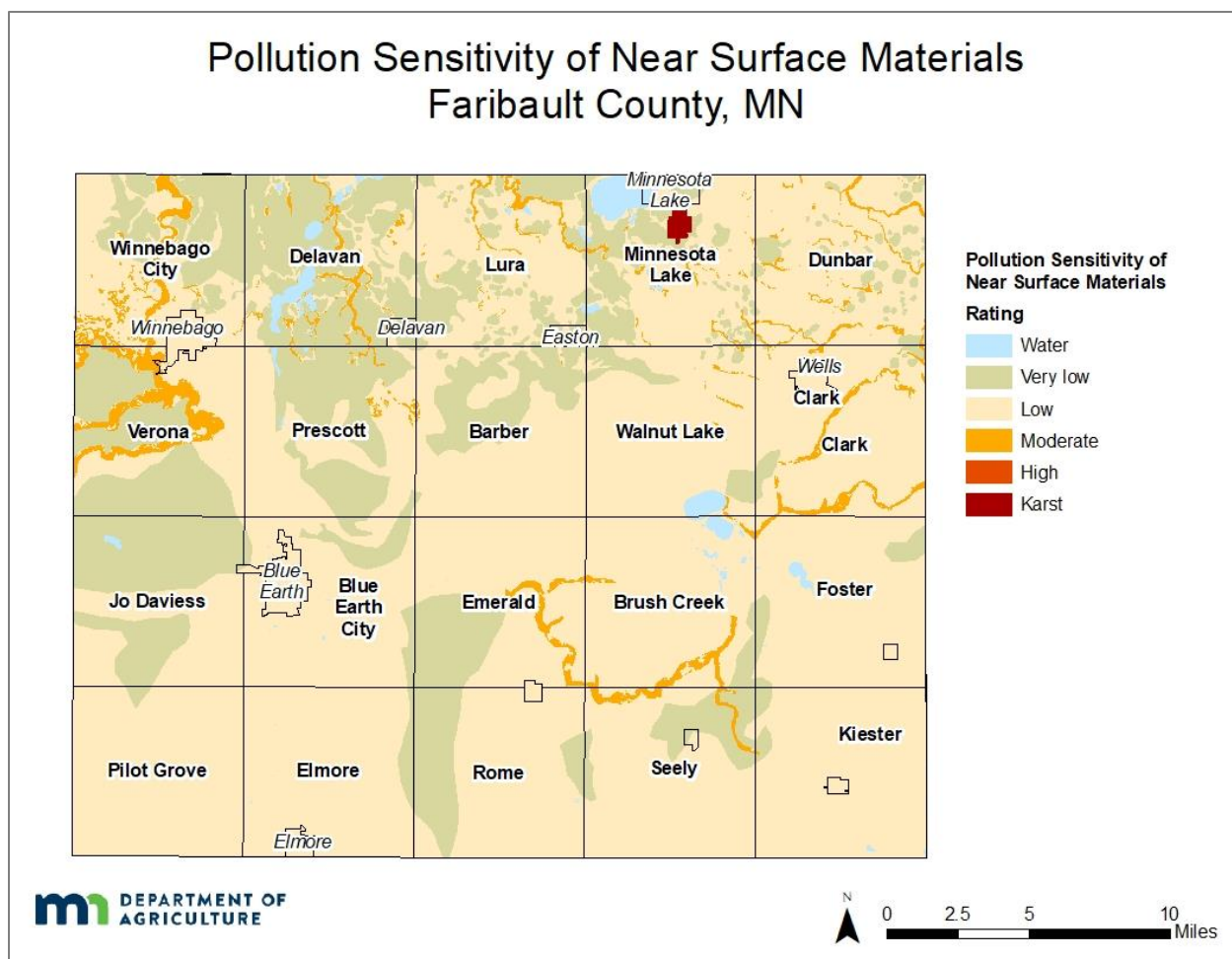
An updated statewide sensitivity rating from the Minnesota Department of Natural Resources (Adams, 2016) was used to estimate the percentage of geology vulnerable to groundwater contamination when it became available. There are several ratings for aquifer sensitivity: ultra-low, very low, low, moderate, and high. Sensitivity ratings are described in Table 1. The ratings are based upon DNR’s “Pollution Sensitivity of Near-Surface Materials” (Adams, 2016).

There are several “special conditions” classifications in the statewide sensitivity ratings where unique geological environments occur (Figure 4). The special conditions include: karst, bedrock at or near surface, peatlands, and disturbed lands. Karst is defined as “terrain with distinctive landforms and hydrology created primarily from the dissolution of soluble rocks”. Distinctive features such as sink holes, springs and caves are visual evidence of karst activity on the land’s surface. Karst features are important when discussing groundwater because these features can allow rapid water flow from the surface to the groundwater, which can allow contaminants to move quickly as well (Adams, Barry, & Green, 2016). Bedrock at or near the surface can have unpredictable and variable transmission rates for water due to local macro features such as fractures, and voids. Peatlands are located in north central Minnesota. They are composed of saturated organic materials that are 6 to 175 feet thick. Since the model to determine the sensitivity ratings only uses unsaturated conditions the peatlands do not fit this model. Disturbed lands include areas such as mining pits, or other large areas disturbed by humans. However, this does not include urban areas, which are undifferentiated on the map.

A map of Faribault County depicting the aquifer vulnerabilities and special conditions is shown in Figure 4.

**Table 1. Pollution Sensitivity of Near-Surface Materials, (Adams, 2016)**

Near-Surface Pollution Sensitivity	Time of Travel	Description
High	≤ 170 hours	Hours to a week
Moderate	>170–430 hours	A week to weeks
Low	>430–1600 hours	Weeks to months
Very Low	>1600–8000 hours	Months to a year
Ultra-Low	>8000 hours	More than a year



**Figure 4. Pollution Sensitivity of Near Surface Materials (Adams, 2016) in Faribault County**

#### PRIVATE WELL SAMPLING - NITRATE

The testing is done in two steps in each township: “initial” sampling and “follow-up” sampling. The initial nitrate sampling was conducted in 2018. In the initial sampling, all private well owners in the selected townships are sent a nitrate test kit. These kits include instructions on how to collect a water sample, a sample bottle, a voluntary survey, and a prepaid mailer. Each homeowner was mailed the nitrate result for their well along with an explanatory nitrate brochure (Appendix D). Well water samples were collected by 134 homeowners using the mail-in kit (Table 2). These 134 samples are considered the “initial well dataset”. On average, 50 percent of the homeowners in these townships responded to the free nitrate test offered by MDA.

All homeowners with a nitrate detection from the initial sampling were asked to participate in a follow-up well site visit and sampling. The well site visit and follow-up sampling was conducted in 2019 by MDA staff. A total of six follow-up samples were analyzed (Table 2).

**Table 2. Homeowner Participation in Initial and Follow-Up Well Water Sampling, Faribault County**

Township	Kits Sent	Initial Well Dataset**	Well Site Visits & Follow-Up Sampling Conducted
Barber	102	53	0
Prescott	82	46	3
Winnebago City*	86	35	3
Total	270	134	6

\*Includes City of Winnebago

\*\*The “Initial Well Dataset” includes 12 sites that share wells with other sites. The “Well Site Visits & Follow-Up Sampling Conducted” includes only one well site visit and one follow-up sample per well; even if multiple sites share the same well. Shared wells will be removed from the final well dataset, leaving only one representative result per well in the final well dataset.

Each follow-up visit was conducted at the well site by a trained MDA hydrologist. Well water was purged from the well for 15 minutes before a sample was collected to ensure a fresh water sample. Additionally, precautions were taken to ensure no cross-contamination occurred. A more thorough explanation of the sampling process is described in the sampling and analysis plan (MDA, 2018b). As part of the follow-up sampling, homeowners were offered a no cost pesticide test. As pesticide results are finalized, they will be posted online in a separate report ([www.mda.state.mn.us/pwps](http://www.mda.state.mn.us/pwps)).

The well site visit was used to collect information on potential nitrogen point sources, well characteristics (construction type, depth, and age), and the integrity of the well construction. Well site visit information was recorded on the Private Well Field Log & Well Survey Form (Appendix A). Starting in 2018 a digital version of this form was utilized.

## WELL ASSESSMENT

All wells testing higher than 5 mg/L were carefully examined for potential well construction, potential point sources, and other potential concerns.

Using the following criteria, a total of two wells were removed to create the final well dataset. See Appendix E (Tables 17 and 18) for a summary of the removed wells.

### HAND DUG

All hand dug wells were excluded from the dataset, regardless of the nitrate concentration. Hand dug wells do not meet well code and are more susceptible to local surface runoff contamination. Hand dug wells are often very shallow, typically just intercepting the water table, and therefore are much more sensitive to local surface runoff contamination (feedlot runoff), point source pollution (septic system effluent), or chemical spills.

### POINT SOURCE

Well code in Minnesota requires wells to be at least 50 feet away from most possible nitrogen point sources such as SSTs (septic tanks and drain fields), animal feedlots, etc. Wells with a high nitrate (>5 mg/L) concentration that did not maintain the proper distance from these point sources were

removed from the final well dataset. Information gathered from well site visits was used to assess these distances. If a well was not visited by MDA staff, the well survey information provided by the homeowner and aerial imagery was reviewed.

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#### WELL CONSTRUCTION PROBLEM

The well site visits allowed the MDA staff to note the well construction of each well. Some wells had noticeable well construction problems. For instance, wells with a cap missing or a crack in the cap makes the groundwater in that well susceptible to pollution. Other examples include wells buried underground or wells with cracked casing. Wells with significant problems such as these were excluded from the final well dataset.

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#### UNSURE OF WATER SOURCE OR KNOWN NON DRINKING WATER SOURCE

If the water source of the sample was uncertain, or from an unwanted source, then data pertaining to the sample was removed. For example, these samples include water that may have been collected from an indoor tap with a reverse osmosis system. Water samples that were likely collected from a municipal well were also removed from the dataset. This study examines raw well water not treated water or municipal water.

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#### SITE VISIT COMPLETED - WELL NOT FOUND & CONSTRUCTED BEFORE 1975 OR AGE UNKNOWN & NO WELL ID

Old wells with no validation on the condition of well construction were removed from the dataset. These wells were installed before the well code was developed in Minnesota (mid-1975), did not have a well log, and MDA staff could not locate the well during a site visit. Additionally, if the age of the well could not be determined it was assumed to be an older well.

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#### NO SITE VISIT & CONSTRUCTED BEFORE 1975 OR AGE UNKNOWN & NO WELL ID

If no site visit was conducted, and the well is an older well (pre-1975), the well would not be used in the final analysis. If the age of the well could not be determined these were again assumed to be older wells.

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#### NO SITE VISIT & INSUFFICIENT DATA & NO WELL ID

Wells that were clearly lacking necessary background information were also removed from the final well dataset. These wells did not have an associated well log, were not visited by MDA staff, and the homeowner did not fill out the initial well survey or the address could not be found.

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#### SHARED WELL

If homes shared a domestic drinking water well, only one result per well was kept in the final dataset and any additional samples from the same well were removed.

## INITIAL RESULTS

### INITIAL WELL DATASET

A total of 134 well owners returned water samples for analysis across the three townships (Figure 5). These wells represent the initial well dataset. The following paragraphs provide a brief discussion of the statistics presented in Table 3.

The minimum values of nitrate for all townships were less than the detection limit (<DL) which is 0.03 mg/L. The maximum values ranged from 0.31 to 5.41 mg/L, with Prescott Township having the highest result. The 90th percentiles ranged from 0.01 to 1.09 mg/L, with Winnebago City Township having the highest 90th percentile.

Initial results from the sampling showed that every township in the study area had less than 5 percent of wells at or over 10 mg/L nitrate-N (Figure 6). The township testing results are similar to findings from a 2010 USGS report on nitrate concentrations in private wells in the glacial aquifer systems across the upper United States (US) in which less than five percent of sampled private wells had nitrate concentrations greater than 10 mg/L (Warner and Arnold, 2010). Both the USGS and the township testing studies indicate that nitrate concentrations can vary considerably over short distances.

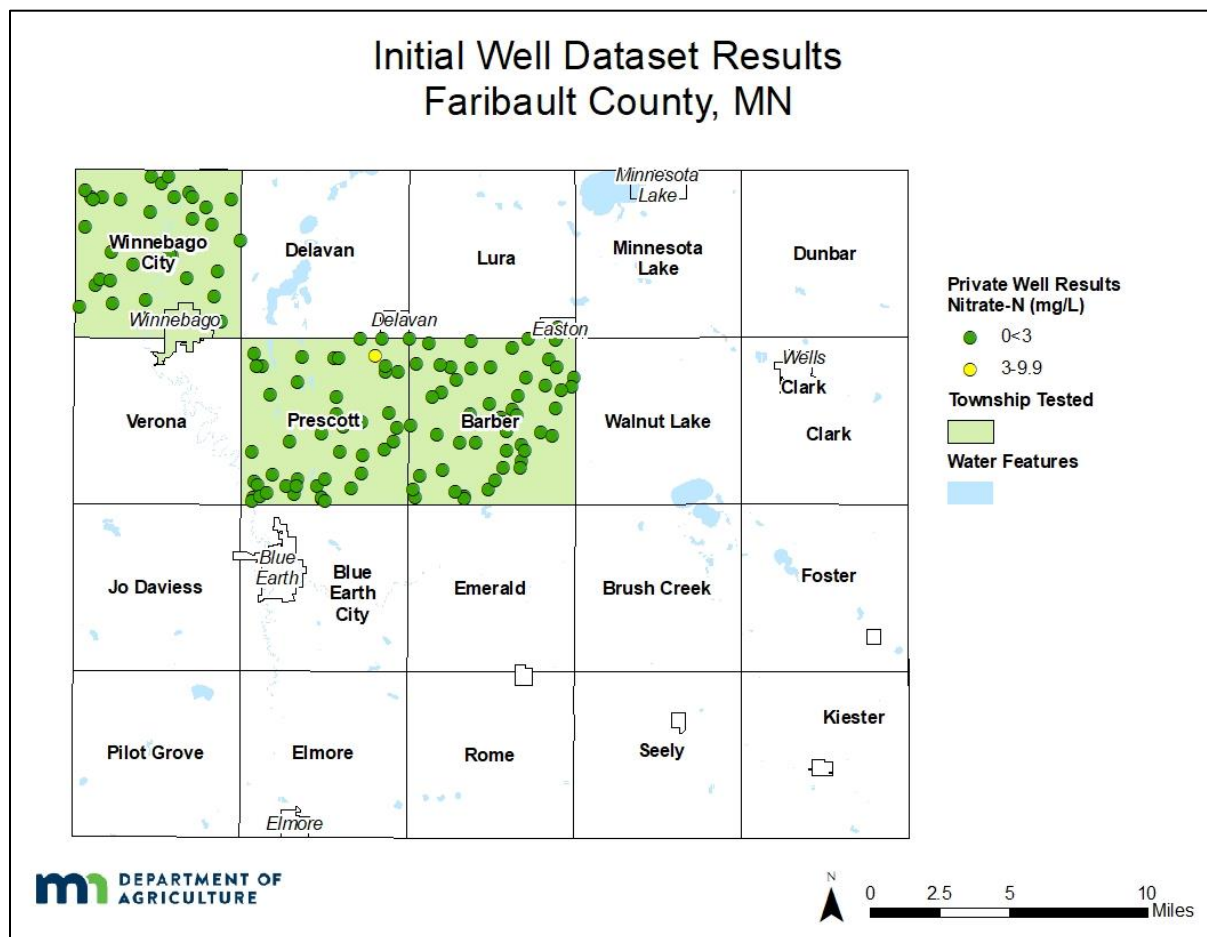


Figure 5. Well Locations and Nitrate Results from Initial Dataset in Faribault County

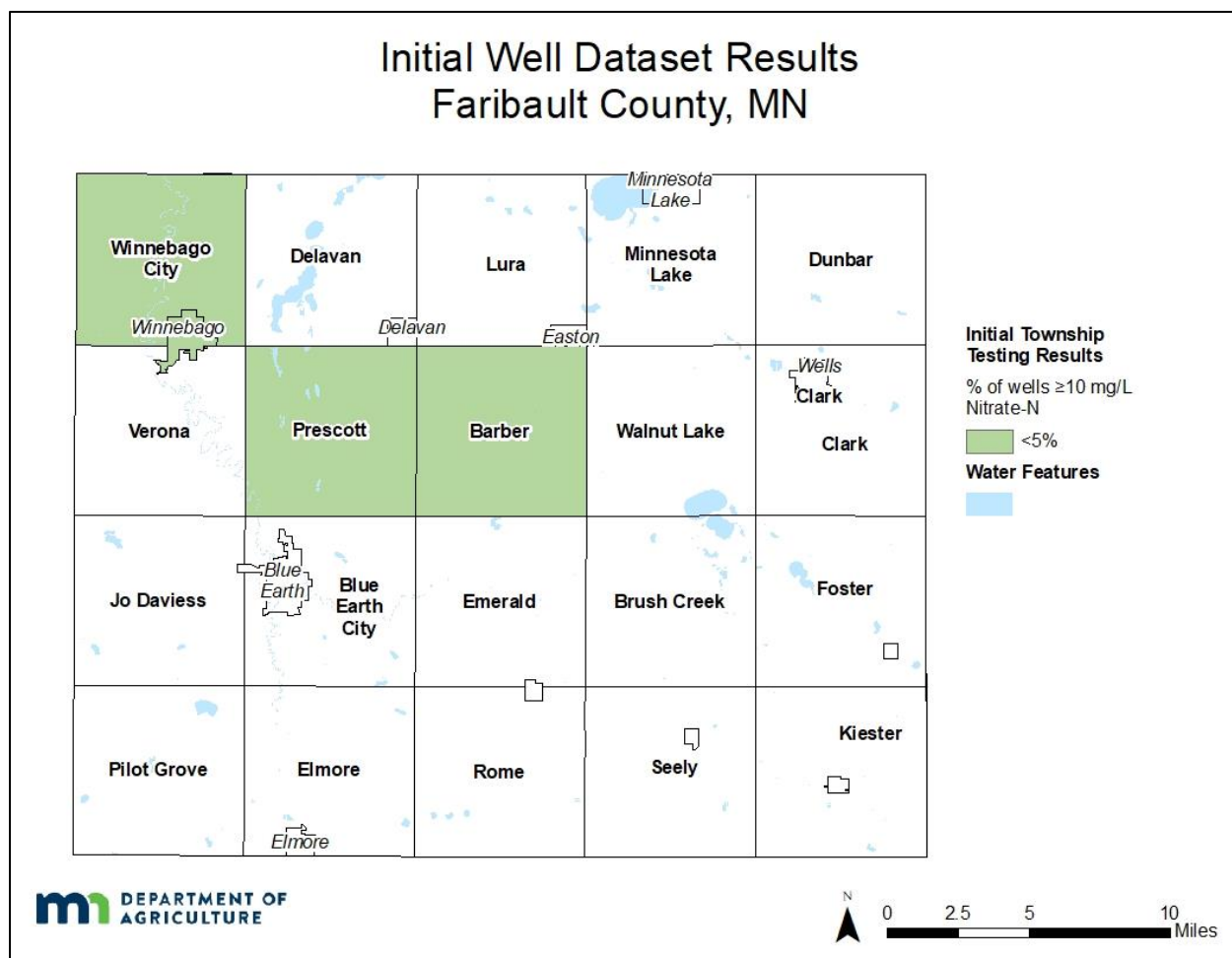


Figure 6. Results of Initial Testing by Township in Faribault County

**Table 3. Faribault County Township Testing Summary Statistics for Initial Well Dataset**

Township	Total Wells	Values				Percentiles				Number of Wells					Percent of Wells				
		Min	Max	Mean	Median	75th	90th	95th	99th	<3 mg/L	3<10 mg/L	≥5 mg/L	≥7 mg/L	≥10 mg/L	<3 mg/L	3<10 mg/L	≥5 mg/L	≥7 mg/L	≥10 mg/L
		Nitrate-N mg/L or PPM																	
Barber	53	<DL	0.31	0.01	<DL	<DL	0.01	0.04	0.31	53	0	0	0	0	100%	0.0%	0.0%	0.0%	0.0%
Prescott	46	<DL	5.41	0.17	<DL	<DL	0.12	0.74	5.41	45	1	1	0	0	97.8%	2.2%	0.0%	0.0%	0.0%
Winnebago City*	35	<DL	2.16	0.17	<DL	<DL	1.09	1.30	2.16	35	0	0	0	0	100%	0.0%	0.0%	0.0%	0.0%
Total	134	<DL	5.41	0.11	<DL	<DL	0.04	0.58	2.68	133	1	1	0	0	99.3%	0.7%	0.7%	0.0%	0.0%

<DL stands for less than a detectable limit. This means results are less than 0.03 mg/L. The 50<sup>th</sup> percentile (75<sup>th</sup>, 90<sup>th</sup>, 95<sup>th</sup>, and 99<sup>th</sup>) is the value below which 50 percent (75%, 90%, 95%, and 99%) of the observed values fall.

\*Includes City of Winnebago

## ESTIMATES OF POPULATION AT RISK

The human population at risk of consuming well water at or over the HRL of 10 mg/L nitrate-N was estimated based on the sampled wells. Since no wells had a nitrate concentration over the HRL, it is estimated that zero people in Faribault County's study area have drinking water over the nitrate HRL (Table 4). However, MDA only tested a portion of wells in the area so it is possible that some homeowners could have drinking water above the HRL. Nitrate contamination in wells is not a widespread problem for Faribault County homeowners.

**Table 4. Estimated Population with Water Wells Over 10mg/L Nitrate-N, Faribault County**

Township	Estimated 2018 Households on Private Wells**	Estimated 2018 Population on Private Wells**	Estimated Population ≥10 mg/L Nitrate-N***
Barber	92	227	0
Prescott	69	153	0
Winnebago City*	81	182	0
Total	242	562	0

\*Includes City of Winnebago

\*\*Data collected from the Minnesota State Demographic Center (2020)

\*\*\*Estimates based off the 2018 estimated households per township gathered from Minnesota State Demographic Center and percentage of wells at or over the HRL from the initial well dataset

## WELL SETTING AND CONSTRUCTION

### MINNESOTA WELL INDEX AND WELL LOGS

The Minnesota Well Index (MWI) (formerly known as the "County Well Index") is a database system developed by the Minnesota Geological Survey and the Minnesota Department of Health (MDH) for the storage, retrieval, and editing of water-well information. The database contains basic information on well records (e.g. location, depth, static water level) for wells constructed in Minnesota.

The database also contains information on the well log and the well construction for many private drinking water wells. The MWI is the most comprehensive Minnesota well database available but contains only information for wells in which a well log is available. Most of the records in MWI are for wells drilled after 1974, when water-well construction code required well drillers to submit records to the MDH (MGS, 2012). The MWI does contain data for some records obtained by the MGS through the cooperation of drillers and local government agencies for wells drilled before 1974 (MDH, 2019).

In some cases, well owners were able to provide unique well identification numbers for their wells. When the correct unique IDs are provided, a well log can be used to identify the aquifer that the well withdraws water from. The well logs were obtained from the MWI for 23 documented wells (Table 5). Therefore, approximately 17 percent of the sampled wells had corresponding well logs with 3 having an aquifer identified. Thus, the data gathered on aquifers represents approximately 2 percent of the total sampled wells.

The aquifers in Table 5 are arranged from the geologically youngest units on the top to the older units. According to the well log data of the documented wells sampled, most wells do not have an associated aquifer. The average well depth was 131 feet. The two most common aquifers utilized across Faribault County are the Quaternary Buried Artesian and St. Peter Sandstone aquifers (Appendix F, Table 19).

Below is a brief description of the aquifers characterized in Table 5.

The Quaternary Buried Artesian aquifer (QBAA) are defined as having more than ten feet of confining material (typically clay) between the land surface and well screen. Quaternary Buried Artesian aquifers (QBAA) are under pressure so when a well is constructed in the aquifer the water rises above where it was first found (MPCA, 1999).

The St. Peter Sandstone aquifer consists of fine to medium grained, well sorted, quartzose sand. This layer of sand is easily eroded so it is not often exposed at the surface (MPCA, 1999)

**Table 5. Nitrate Concentrations within Sampled Groundwater Aquifers**

Aquifer Group/Formation	Total Wells	Ave Depth (Feet)	Number of wells			Percent of wells		
			<3	3<10	≥10	<3	3<10	≥10
			Nitrate-N mg/L					
Quaternary Buried Artesian	2	143	2	0	0	100%	0%	0%
St. Peter Sandstone	1	160	1	0	0	100%	0%	0%
Not Available	20	129	20	0	0	100%	0%	0%
Total	23	131	23	0	0	100%	0%	0%

## WELL OWNER SURVEY

The private well owner survey, sent out with the sampling kit, provided additional information about private wells that were sampled. The survey included questions about the well construction, depth and age, and questions about nearby land use. A blank survey from the initial sampling in 2018 can be found in Appendix G. It is important to note that well information was provided by the well owners and may be approximate or potentially erroneous. The following section is a summary of information gathered from the well owner survey. Complete well survey results are in Appendix H at the end of this document, (Tables 20-34).

Most wells in each township are located on “country” property. The Township of Winnebago City had the most wells (5.7 percent) located on river home properties.

Approximately 72 percent of sampled wells are of drilled construction and 0.7 percent are sand point wells. Sand point (also known as drive-point) wells are typically completed at shallower depths than drilled wells. Sand point wells are also usually installed in areas where sand is the dominant geologic material and where there are no thick confining units such as clay. This makes sand point wells more vulnerable to contamination from the surface. As mentioned previously, hand dug wells are also shallow

and more sensitive to local surface runoff contamination than deeper drilled wells. Hand dug wells represented 0.7 percent of the total.

Most of the sampled wells (42.5 percent) are between 100-299 feet deep, and very few wells (three percent) are over 300 feet deep. Approximately 29 percent of homeowners did not know or did not respond to this question.

Most of the wells (70.9 percent) had not been tested for nitrate within the last ten years or homeowners were unsure if they had been tested. Less than two percent of homeowners responded that their well had been tested for nitrate in the last year. Therefore, the results most homeowners receive from this study will provide new information.

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#### POTENTIAL NITRATE SOURCE DISTANCES

The following summary relates to isolation distances of potential point sources and non-point sources of nitrate that may contaminate wells. This information was obtained from the well surveys completed by the homeowner. Complete well survey results are located in Appendix H at the end of this document (Tables 20-34).

- On average, farming takes place on 48.5 percent of the properties.
- Agricultural fields are less than 300 feet from wells at about 52.2 percent of the properties.
- Most well owners (70.9 percent) across all the townships responded that they do not have livestock (greater than ten head of cattle or other equivalent) on their property.
- Most wells (61.2 percent) are over 100 feet from an active or inactive feedlot.
- Few well owners (4.5 percent) across all townships store more than 500 pounds of fertilizer on their property.
- A small minority of wells (three percent) are less than 50 feet away from septic systems.

## FINAL RESULTS

### FINAL WELL DATASET

A total of 134 well water samples were collected by homeowners across three townships. Two wells (1.5 percent) were found to be unsuitable and were removed to create the final well dataset. The final analysis was conducted on the remaining 132 wells (Table 6). The wells in the final well dataset represent drinking water wells potentially impacted by applied commercial agricultural fertilizer.

### WELL WATER NITROGEN ANALYSIS

The final analysis was based on the number of wells at or over the nitrate HRL of 10 mg/L. of 10 mg/L.

Table 6 shows the results for all townships sampled. None of the wells in the final dataset were at or over the HRL of 10 mg/L.

**Table 6. Initial and Final Well Dataset Results, Faribault County**

Township	Initial Well Dataset	Final well Dataset	Final Wells ≥10 mg/L Nitrate-N Count	Percentage
Barber	53	53	0	0%
Prescott	46	44	0	0%
Winnebago City*	35	35	0	0%
Total	134	132	0	0%

\*Includes City of Winnebago

The individual nitrate results from this final well dataset are displayed spatially in Figure 7.

The final well dataset summary statistics are shown in Table 7. The minimum values were all below the detection limit. The maximum values ranged from 0.3 to 2.2 mg/L nitrate, with Winnebago City Township having the highest result. The 90th percentile ranged from 0.01 to 1.1 mg/L nitrate-N, with Barber Township having the lowest result and Winnebago City Township having the highest result. Final results showed that every township in the study area had less than five percent of the wells at or over 10 mg/L nitrate-N (Figure 8).

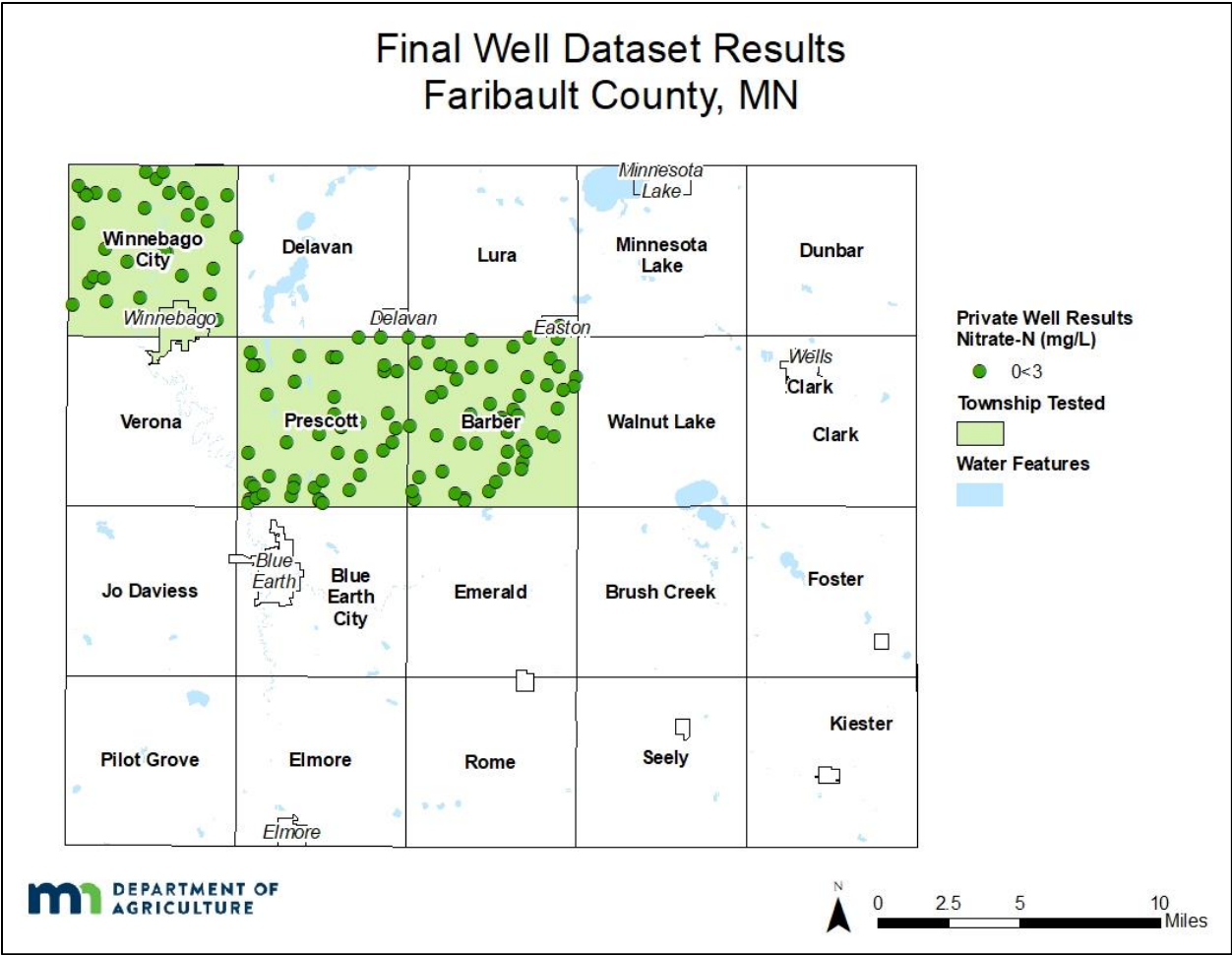


Figure 7. Well Locations and Nitrate Results from Final Well Dataset in Faribault County

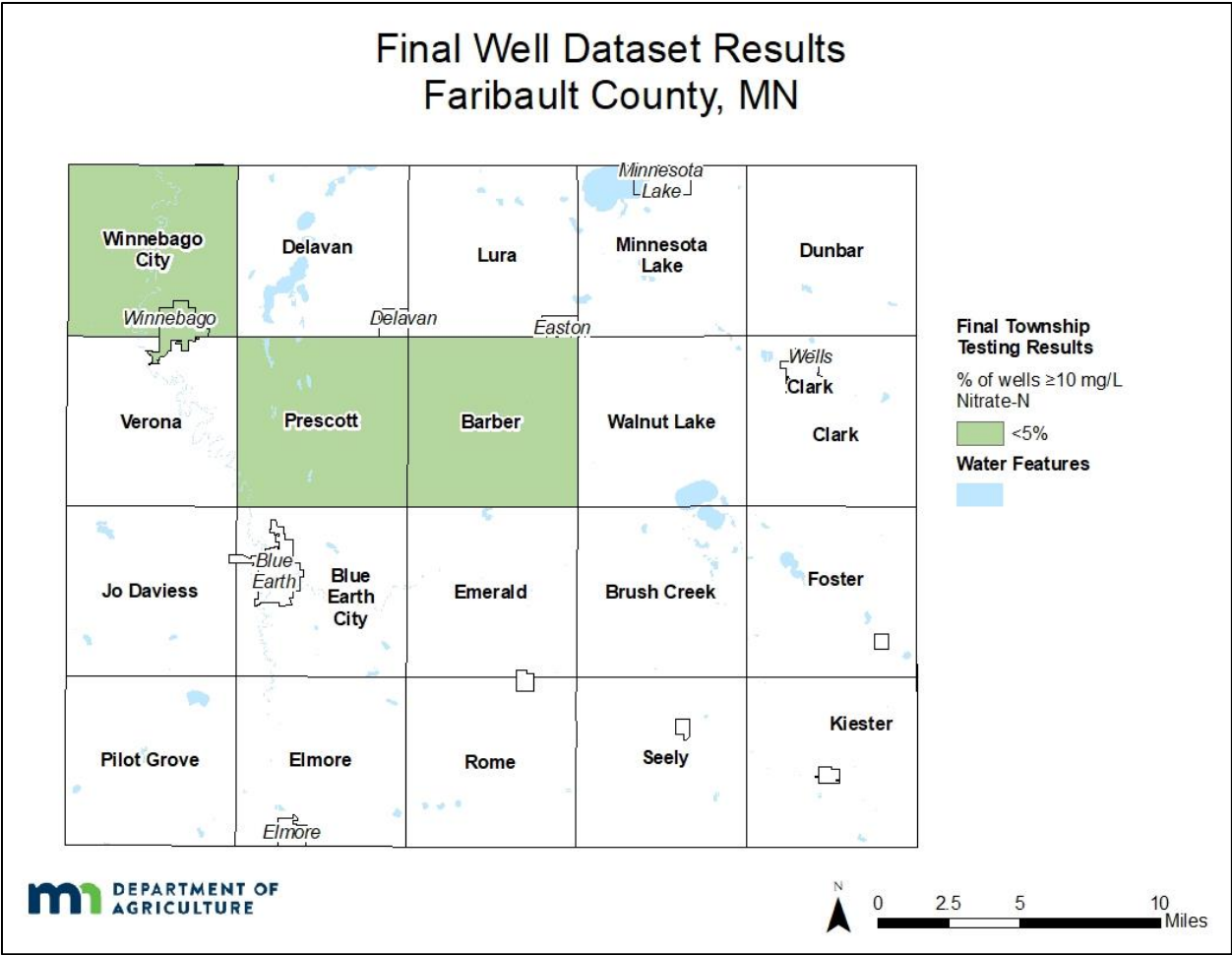


Figure 8. Results of Final Testing by Township in Faribault County

**Table 7. Faribault County Township Testing Summary Statistics for Final Well Dataset**

Township	Total Wells	Values			Percentiles					Number of Wells					Percent of Wells				
		Min	Max	Mean	50 <sup>th</sup> (Median)	75 <sup>th</sup>	90 <sup>th</sup>	95 <sup>th</sup>	99 <sup>th</sup>	<3	3<10	≥5	≥7	≥10	<3	3<10	≥5	≥7	≥10
		Nitrate-N mg/L or parts per million (ppm)																	
Barber	53	<DL	0.3	0.01	<DL	<DL	0.01	0.04	0.3	53	0	0	0	0	100.0%	0.0%	0.0%	0.0%	0.0%
Prescott	44	<DL	1.1	0.1	<DL	<DL	0.1	0.4	1.1	44	0	0	0	0	100.0%	0.0%	0.0%	0.0%	0.0%
Winnebago City*	35	<DL	2.2	0.2	<DL	<DL	1.1	1.3	2.2	35	0	0	0	0	100.0%	0.0%	0.0%	0.0%	0.0%
Total	132	<DL	2.2	0.1	<DL	<DL	0.04	0.31	1.5	132	0	0	0	0	100.0%	0.0%	0.0%	0.0%	0.0%

<DL stands for less than detectable limit. The detectable limit is <0.03 to nitrate-N. The 50<sup>th</sup> percentile (75<sup>th</sup>, 90<sup>th</sup>, 95<sup>th</sup>, and 99<sup>th</sup>, respectively) is the value below which 50 percent (75%, 90%, 95% and 99%) of the observed values fall

\*Includes City of Winnebago

As discussed previously, the areas selected were deemed most vulnerable to nitrate contamination of groundwater. Table 8 compares the final results to the percent of vulnerable geology (Adams, 2016) and row crop production (USDA NASS, 2013) in each township. The percent land area considered vulnerable geology and in row crop production was estimated using a geographic information system known as ArcGIS.

**Table 8. Township Nitrate Results Related to Vulnerable Geology and Row Crop Production, Faribault County**

Township	Final Well Dataset	Percent of Land in Row Crop Production 2013**	Percent of Land in Vulnerable Geology***	Percent ≥7 mg/L	Percent ≥10 mg/L
				Nitrate-N mg/L or parts per million (ppm)	
Barber	53	89.7%	0.0%	0.0%	0.0%
Prescott	44	86.1%	0.0%	0.0%	0.0%
Winnebago City*	35	79.8%	7.6%	0.0%	0.0%
Total	132	85.2%	2.5%	0.0%	0.0%

\*Includes City of Winnebago

\*\*Data retrieved from USDA NASS Cropland Data Layer, 2013.

\*\*\* The DNR Pollution Sensitivity of Near Surface Materials was used determine vulnerability (ratings of High, Karst, Moderate and Bedrock at or close to surface are included in this "vulnerable" rating)

## WELL AND WATER CHARACTERISTICS

### WELL CONSTRUCTION

Unique identification numbers from well logs were compiled for the wells in the Faribault County final well dataset. The well logs provided information on the well age, depth, and construction type (MDH Minnesota Well Index Database; <https://apps.health.state.mn.us/cwi/>). These well characteristics for the final well dataset were also provided by some homeowners. The well characteristics are described below, and a more comprehensive view is provided in Appendix I (Tables 35-37).

- Most wells were drilled (75 percent), and only one well (0.8 percent) was identified as sand point.
- The median depth of wells was 129 feet, and the deepest was 210 feet.
- The median year the wells were constructed in was 2003.

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## WELL WATER PARAMETERS

MDA staff conducted the follow-up sampling and well site surveys at six wells. None of these wells were removed, leaving all follow-up wells included in the final well dataset. Field measurements of the well water parameters were recorded on the Private Well Field Log & Well Survey Form (Appendix J). Starting in 2018 a digital version of this form was utilized. The measurements included temperature, pH, specific conductivity, and dissolved oxygen. The well was purged for 15 minutes, so that the measurements stabilized, ensuring a fresh sample of water was collected. The stabilized readings for the final well dataset are described below and a more comprehensive view is available in Appendix K (Tables 38-41).

- The temperatures ranged from 10.11 °C to 11.04 °C
- The water from the wells had a median pH of 7.33
- The median specific conductivity was 780 µS/cm, and was as high as 1,550 µS/cm
- The dissolved oxygen readings ranged from 0.12 mg/L to 7.19 mg/L

Water temperature can affect many aspects of water chemistry. Warmer water can facilitate quicker chemical reactions, and dissolve surrounding rocks faster; while cooler water can hold more dissolved gases such as oxygen (USGS, 2016).

The United States Environmental Protection Agency has set a secondary pH standard of 6.5-8.5 in drinking water. These are non-mandatory standards that are set for reasons not related to health, such as taste and color (40 C.F.R. §143).

Specific conductance is the measure of the ability of a material to conduct an electrical current at 25°C. Thus, the more ions present in the water, the higher the specific conductance measurement (Hem, 1985). Rainwater and freshwater range between 2 to 100 µS/cm. Groundwater is between 50 to 50,000 µS/cm (Sanders, 1998).

Dissolved oxygen concentrations are important for understanding the fate of nitrate in groundwater. When dissolved oxygen concentrations are low (<0.5 mg/L) (Dubrovsky et al., 2010), bacteria will use electrons on the nitrate molecule to convert nitrate into nitrogen gas (N<sub>2</sub>). Thus, nitrate can be removed from groundwater through the process known as bacterial denitrification (Knowles, 1982).

## SUMMARY

The focus of this study was to assess nitrate concentrations in groundwater impacted by commercial agricultural fertilizer in selected townships in Faribault County. In order to prioritize testing, the MDA looked at townships with significant row crop production and vulnerable geology. Approximately 84 percent of the land cover is row crop agriculture and 140 acres (less than one percent of land cover) of groundwater irrigation in the study area.

Three townships were sampled covering 69,807 acres. The initial (homeowner collected) nitrate sampling resulted in 134 samples. The 134 households that participated represent a 50 percent return rate of homeowner offered sampling kit. The initial well dataset represents private well drinking water regardless of the potential source of nitrate. Well owners with measurable nitrate results were offered a follow-up nitrate sample and a pesticide sample. The MDA visited and collected follow-up samples at six wells.

The MDA conducted a nitrogen source assessment and identified wells near potential point sources and wells with poor construction. A total of two (1.5 percent) wells were found to be unsuitable and were removed. The remaining 132 wells were wells believed to be impacted by nitrogen fertilizer and were included in the final well dataset.

In the final well dataset, most of the wells (75 percent) are drilled; and less than one percent are sand point. The median depth of the wells is 129 feet and depths range from 67 to 210 feet.

For the final well dataset, there were no townships that had more than five percent of wells at or over the nitrate Health Risk Limit of 10 mg/L.

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## APPENDIX A

### Well information and Potential Nitrate Source Inventory Form

Site ID \_\_\_\_\_ Unique ID \_\_\_\_\_ Date \_\_\_\_\_

#### MDA -Private Well Field Log & Well Survey Form

##### Water Treatment Information

1. Is this well used for drinking water? ☐ Yes ☐ No
2. Is there an indoor water treatment system? ☐ Yes ☐ No  
 If yes, check system: ☐ Activated Carbon ☐ Distilled ☐ Iron Filter  
☐ Reverse Osmosis ☐ Sediment Filter ☐ Softened  
☐ Other \_\_\_\_\_
3. Is there water treatment on the outdoor spigot? ☐ Yes ☐ No  
 If yes, what type? \_\_\_\_\_

##### Well Construction Information

	HO Survey	Homeowner or Observation (circle one or both)	Well Log
Construction Type			
Construction Date			
Well Depth			
Well Diameter			
Well/Pump Installer			

1. Have you made any changes to your well in the last year? ☐ Yes ☐ No  
 If yes, what type? ☐ Upgraded Well Casing ☐ Raised Well ☐ Replaced Piping  
☐ Replaced Pump ☐ Replaced Well ☐ Other \_\_\_\_\_

##### Field Survey Information

1. Are there any other wells on this property? ☐ Yes ☐ No  
 If yes, list well type, use, and UID if available \_\_\_\_\_
2. Is fertilizer stored on this property? ☐ Yes ☐ No  
 If yes, what is the distance and direction from the well? \_\_\_\_\_
3. Historical fertilizer storage? ☐ Yes ☐ No  
 If yes, what is the distance and direction from the well? \_\_\_\_\_
4. Historic/Abandoned septic system? ☐ Yes ☐ No  
 If yes, what is the distance and direction from the well? \_\_\_\_\_
5. Have pesticides been used in the last month? ☐ Yes ☐ No  
 If yes, what type/brand name, when, and location \_\_\_\_\_

Updated: March, 2017

Site ID \_\_\_\_\_ Unique ID \_\_\_\_\_ Date \_\_\_\_\_  
**MDA -Private Well Field Log & Well Survey Form**

**DIRECTIONS**

Describe the type, position and distance to potential nitrate sources within 300 feet of the well. Use the bullseye to draw in and label nitrate sources relative to the well (center dot). Indicate house location when applicable.

AFL: Animal Feedlot  
 AGG: Dry Well, Leaching Pit, Seepage Pit,  
       Injection Well, Ag Drainage Well  
 APB: Animal/Poultry Building  
 DRA: Drain field - Above or Below Grade  
 FIELD: Agricultural Field  
 FSA: Fertilizer Storage Area

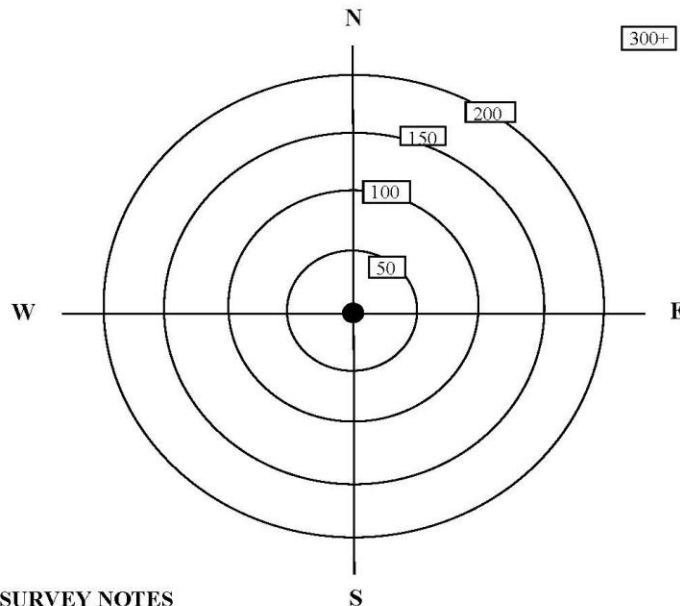
FWP: Feeding or Watering Area  
 GOLF: Golf Course  
 LAP: Land Application of Manure, Septage, Sewage  
 MSA: Manure Storage Area  
 PRV: Privy (Old Outhouse)  
 SAA: Small Animal Area (chicken coop, rabbit pen, etc)  
 SET: Septic Tank

6. Does water drain toward the well? ☐ Yes ☐ No
7. Which direction does the landscape slope? (Draw arrow across bullseye through well)
8. Is the slope: ☐ Steep ☐ Shallow ☐ Flat
9. Are there any *obvious* problems with the well? ☐ Yes ☐ No ☐ No Access ☐ Not Found  
       Describe any well issues seen \_\_\_\_\_

10. Distance from ground surface to bottom of well cap (round to nearest inch) \_\_\_\_\_

11. Source codes, distances, and direction (<300ft) \_\_\_\_\_  
 \_\_\_\_\_

12. Source codes, distances, and direction (>300ft) \_\_\_\_\_



**ADDITIONAL SURVEY NOTES**

Updated: March, 2017

## APPENDIX B

### SUBSURFACE SEWAGE TREATMENT SYSTEM

Most homes that have private wells also have private subsurface sewage treatment systems (SSTS). These treatment systems can be a potential point source for contaminants such as nitrate, and fecal material. To protect drinking water supplies in Minnesota, SSTS septic tanks and the associated drain fields are required to be at least 50 feet away from private drinking water wells. The minimum required distance doubles for wells that have less than ten feet of a confining layer or if the well has less than 50 feet of watertight casing (MDH, 2014).

Technical and design standards for SSTS systems are described in Minnesota Rules Chapter 7080 and 7081. Some local government units (LGU) have their own statutes that may be more restrictive or differ from these standards.

Many LGUs collect information on the condition of SSTS in their jurisdiction. Often information is collected when a property is transferred, but inspections can occur at other times as well. A SSTS inspection determines if a system is compliant or non-compliant. A non-compliant treatment system can be further categorized as “failing to protect groundwater (FTPGW)” or “imminent threat to public health and safety (ITPHS)”. A system is considered FTPGW if it is a seepage pit, cesspool, the septic tanks are leaking below their operating depth, or if there is not enough vertical separation to the water table or bedrock. A system is considered ITPHS if the sewage is discharging to the surface water or groundwater, there is sewage backup, or any other condition where the SSTS would harm the health or safety of the public (Minnesota Statutes, section 115.55.05; MPCA, 2019a).

In 2018 Faribault County reported a total of 2,096 SSTS and 1.3 percent were inspected for compliance (MPCA, 2019b). Compliance inspections must be completed by a license inspector. Certificates of compliance are valid for three years unless evidence of noncompliance is found. Property owners are required to repair and maintain the SSTS according to minimum standards set by the State (Subsurface Sewage Treatment System (SSTS) Ordinance Faribault County, MN, 2014).

### FEEDLOT

The amount of nitrogen in manure depends on the species of animal. For example, there is approximately 31 pounds of nitrogen in 1,000 gallons of liquid dairy cow manure, and 53-63 pounds in 1,000 gallons of liquid poultry manure. Most of the nitrogen in manure is in organic nitrogen or in ammonium (NH<sub>4</sub><sup>+</sup>) forms (Hernandez and Schmitt, 2012).

Under the right conditions organic nitrogen can be converted into ammonium and then eventually transformed into nitrate. Nitrate is a highly mobile form of nitrogen that can move into groundwater and become a contamination concern (MPCA, 2013).

Government agencies regulate feedlots to reduce the risk of contamination to water resources. Rules pertaining to feedlots have been in place since the 1970's; they were revised in 2000 and 2014 (MPCA, 2017b). The degree of regulation of a feedlot is dependent on the amount of manure that is produced; measured in animal units (AU) (MPCA, 2011). One AU is equal to the amount of manure produced by one beef cow (Table 9) (MPCA, 2017b).

**Table 9. Animal Unit Calculations (MPCA, 2017b)**

Animal Type	Number of Animal Units (AU)
Mature dairy cow (over 1,000 lbs.)	1.4
Cow/calf pair	1.2
Stock cow/steer	1.0
Horse	1.0
Dairy heifer	0.7
Swine (55-300 lbs.)	0.3
Sheep	0.1
Broiler (over 5 lbs., dry manure)	0.005
Turkey (over 5 lbs.)	0.018

Animal feedlots with 1-300 AU require a 50-foot setback from private water wells. Larger feedlots ( $\geq 300$  AU) must be at least 100 feet away from private water wells. The minimum required distance doubles for wells that have less than ten feet of a confining layer or if the well has less than 50 feet of watertight casing (MDH, 2014).

Farmers must register a feedlot through the Minnesota Pollution Control Agency (MPCA) if they have at least 50 AU, or 10 AU if the feedlot is located near shoreline. Larger feedlots must follow additional regulations. Feedlots with more than 300 AU must submit a manure management plan if they do not use a licensed commercial applicator. Feedlots with more than 1,000 AU are regulated through federal National Pollutant Discharge Elimination (NPDES) permits (MPCA, 2011) and must submit an annual manure management plan as part of their permit (MPCA, 2015).

As part of new feedlot construction, an environmental assessment must be completed for feedlots with a proposed capacity of greater than 1,000 AU. If the feedlot is in a sensitive area the requirement for an environmental assessment is 500 AU (MPCA, 2017b). Farmers must register their feedlot if it is in active status. Feedlots are considered active until no animals have been present on the feedlot for five years. To register, farmers fill out paperwork which includes a chart with the type and maximum number of animals on the feedlot (MPCA, 2017a). Registration is required to be completed at least once during a set four-year period; the current period runs from January 2018 to December 2021. As of November 2017, approximately 24,000 feedlots were registered in Minnesota (MPCA, 2017b). A map and table of the feedlots located in the Faribault County study area can be found below (Figure 9; Table 10).

**Table 10. Feedlots and Permitted Animal Unit Capacity, Faribault County**

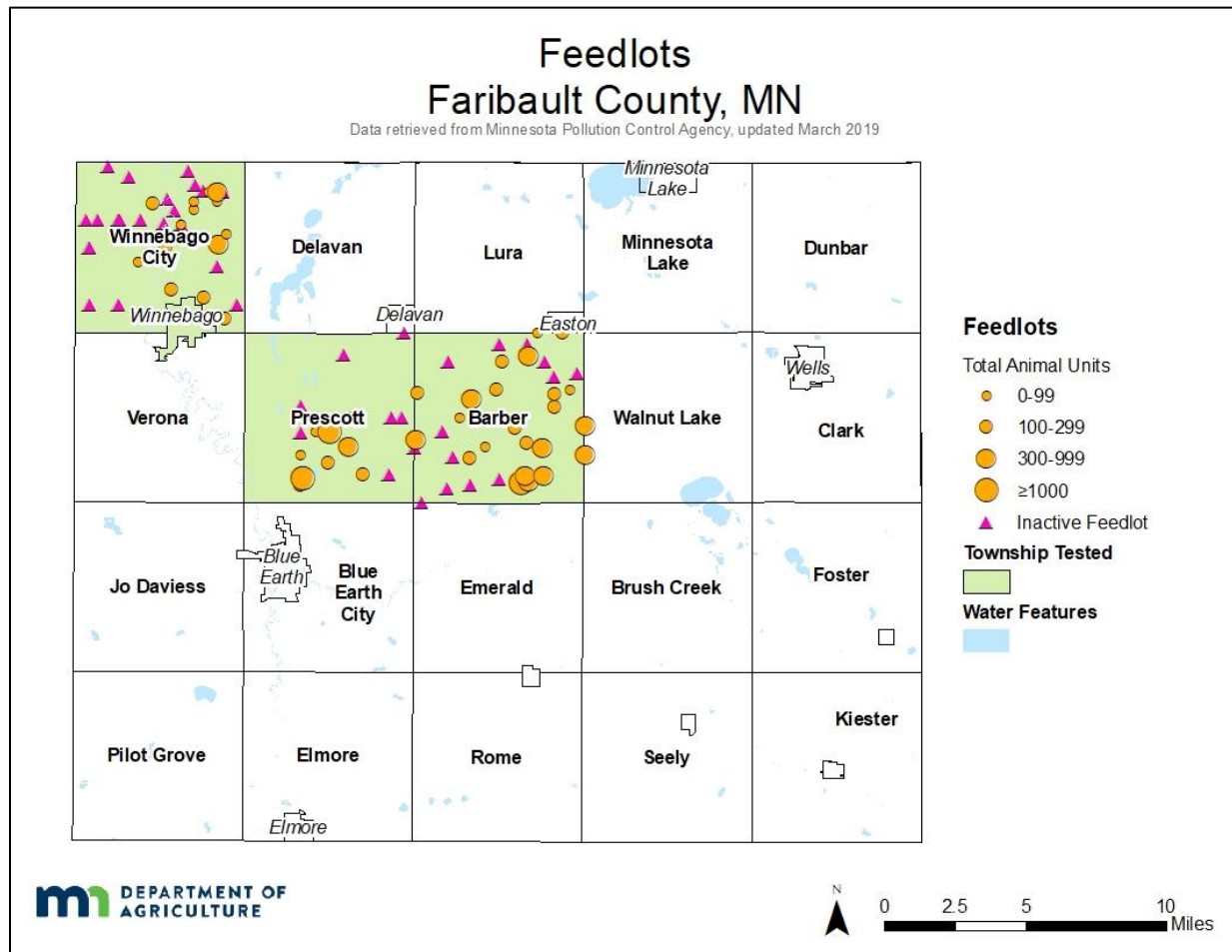
Township	Total Feedlots	Active Feedlots	Inactive Feedlots	Average AU Permitted*** Per Feedlot	Total Permitted*** AU	Total Square Miles	Permitted*** AU per Square Mile
Barber	39	24	15	390	9,354	36	259
Prescott	17	9	8	465	4,181	36	116
Winnebago City*	36	14	22	197	2,753	34	80
Total	92	47	45	**347	16,289	109	**149

\*Includes City of Winnebago

\*\*Represents an average value

\*\*\*Animals permitted may not be the actual animals on site. The total animals permitted is the maximum number of animals that are permitted for a registered feedlot. It is common for feedlots to have less livestock than permitted.

On average there are 149 AU per square mile (0.23 AU/acre) over the entire study area (Table 10). Manure is often applied to cropland, so it is pertinent to look at the AU per cropland acre. In the Faribault County study area livestock densities average 0.28 AU per acre of row crops (MPCA, 2018; USDA NASS, 2013).



**Figure 9. Feedlot Locations in Faribault County (MPCA, 2019)**

## FERTILIZER STORAGE LOCATION

MDA tracks licenses for bulk fertilizer storage facilities, anhydrous ammonia, and chemigation sites (Table 11). Abandoned sites are facilities that once housed fertilizer chemicals. These sites are also noted and tracked by the MDA as they are potential contamination sources.

**Table 11. Fertilizer Storage Facility Licenses and Abandoned Sites, Faribault County**

Township	Bulk Fertilizer Storage	Anhydrous Ammonia	Chemigation Sites	Abandoned Sites	Total
Barber	0	0	0	0	0
Prescott	0	0	0	0	0
Winnebago City*	3	0	2	0	5
Total	3	0	2	0	5

Data retrieved from MDA Pesticide and Fertilizer Management Division, 2018; updated March 2018

\*Includes City of Winnebago

## SPILLS AND INVESTIGATIONS

The MDA is responsible for investigating any fertilizer spills within Minnesota. Figure 10 shows the locations of mapped historic fertilizer spills within the Faribault County study area. While other types of spills are recorded, only sites that are potential point sources of nitrogen to the groundwater are reported here (MDA, 2018a).

The MDA tracks several types of incidents. Incident investigations are typically for larger spills. There are six in the study area. Contingency areas are locations that have not been remediated because they were inaccessible or the contaminant could not be removed for some other reason. They are often a part of an incident investigation. There are no contingency areas in this study area. Old emergency incidents were closed prior to March 1<sup>st</sup>, 2004 (MDA, 2018a), but they can still be a point source. At most of these older sites, the contaminants are unknown and their location may not be precise. There is one in the study area. Small spills and investigations are typically smaller emergency spills such as a truck spilling chemical. There are none in the study area. It is important to note that while the locations of the incidents described are as accurate as possible, it is an incomplete dataset (MDA, 2018a). A breakdown of chemical type of these incidents can be found in Table 12. A breakdown of the fertilizer specific spills and investigations, by township, can be found in Table 13.

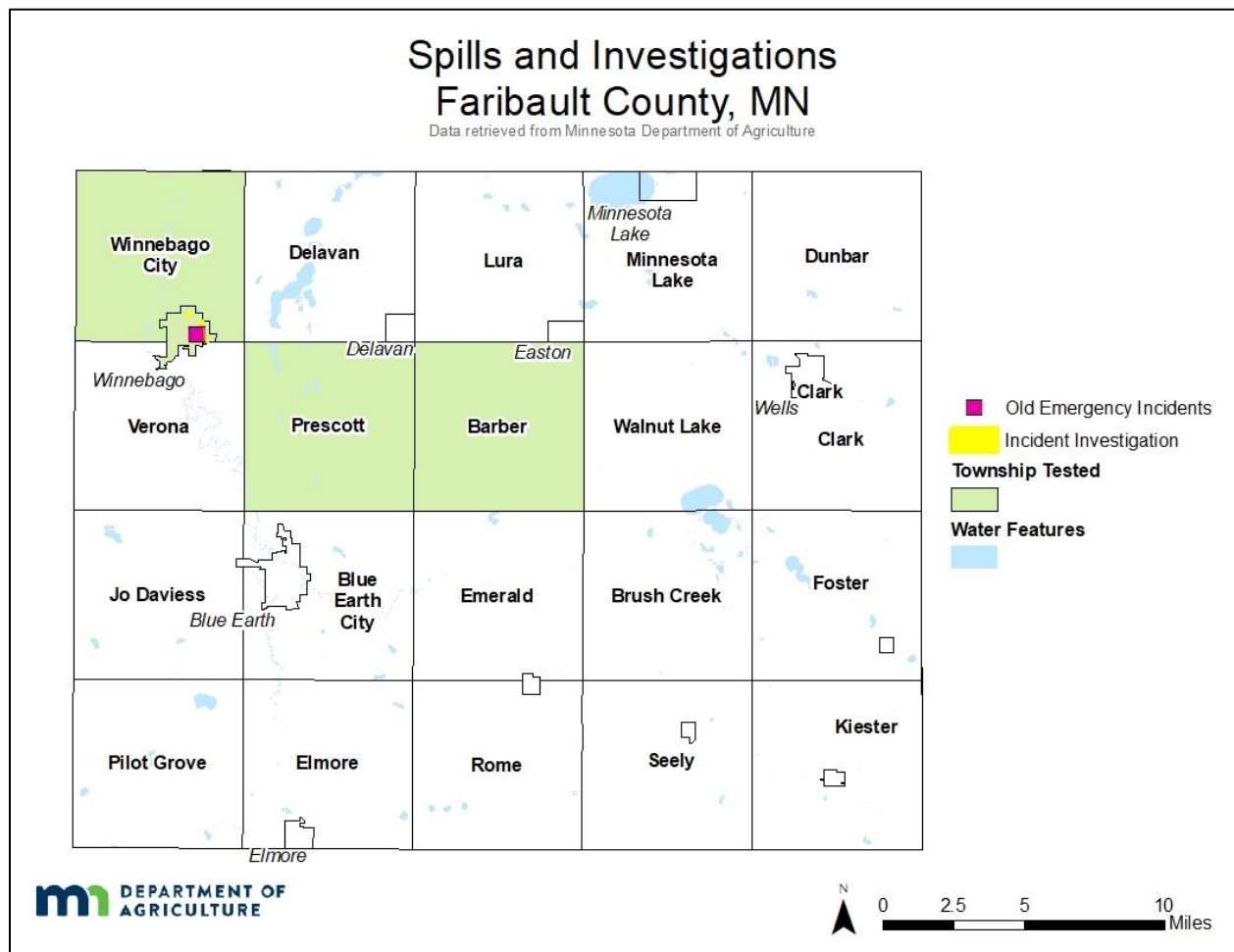
**Table 12. Spills and Investigations by Chemical Type, Faribault County**

Contaminant	Incident Investigations	Contingency Areas	Small Spills and Investigations	Old Emergency Incidents	Total
Fertilizer	1	0	0	0	1
Pesticides & Fertilizer	5	0	0	1	6
Anhydrous Ammonia	0	0	0	0	0
Total	6	0	0	1	7

**Table 13. Fertilizer Related Spills and Investigations by Township, Faribault County**

Township	Incidents and Spills
Barber	0
Prescott	0
Winnebago City*	7
Total	7

\*Includes City of Winnebago



**Figure 10. Fertilizer Spills and Investigations in Faribault County (MDA, 2018a)**

## APPENDIX C

### LAND AND WATER USE

#### LAND COVER

Typically, locations were selected for the Township Testing Program if at least 20 percent of the land cover was in row crop production. Faribault County is mostly rural and is dominated by row crop agriculture (Figure 11; Table 14). Row crops can include: corn, sweet corn, soybeans, alfalfa, sugar beets, potatoes, durum wheat, dry beans and double crops involving corn and soybeans.

Faribault County is in south-central Minnesota. It is located west of Albert Lea and shares a border with Iowa. The land use of the three tested townships is primarily agricultural, with 84 percent used for row crops. Land not in row crop production is mostly wetlands (three percent), grasslands (two percent), or used for pasture or hay (two percent). Relatively little land (seven percent) in the study area is considered developed (Figure 11; Table 14).

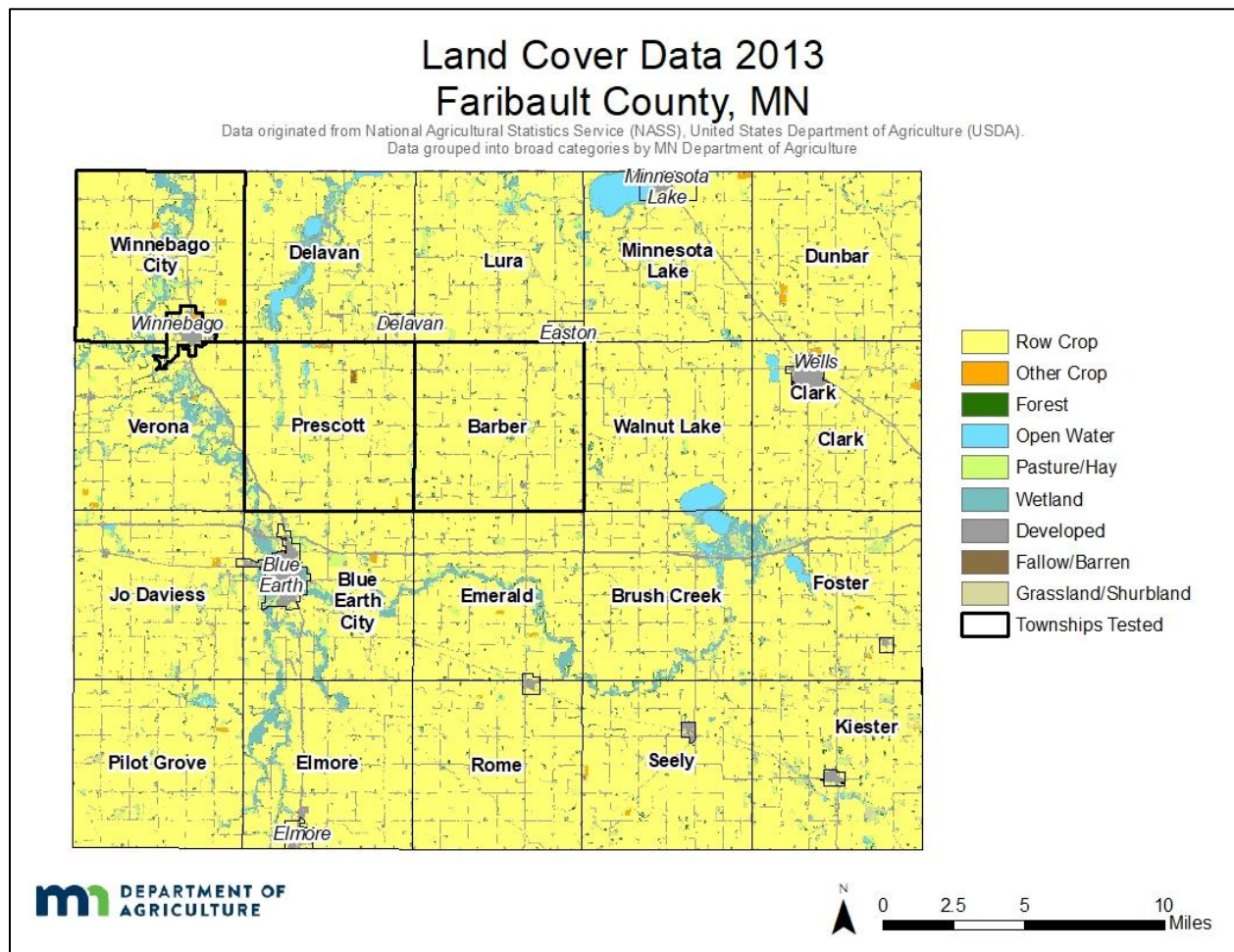


Figure 11. Land Cover in Faribault County (USDA NASS Cropland Data Layer, 2013)

**Table 14. Land Cover Data (2013) by Township, Faribault County (USDA NASS Cropland Data Layer, 2013)**

Township	Total Acres	Row Crop	Other Crops	Forest	Open Water	Pasture/ Hay	Wetland	Developed	Fallow/ Barren	Grassland/ Shrubland
Barber	23,128	90%	0%	1%	0%	1%	1%	6%	0%	1%
Prescott	23,071	86%	0%	1%	0%	3%	2%	5%	0%	2%
Winnebago City*	23,608	77%	1%	1%	0%	3%	7%	8%	0%	3%
Average	**69,807	84%	0%	1%	0%	2%	3%	7%	0%	2%

\*Includes City of Winnebago

\*\* Represents a total

## WATER USE

Water use permits are required for wells withdrawing more than 10,000 gallons of water per day or 1,000,000 gallons of water per year (MDNR, 2019). There are a total of seven active groundwater well permits in the study area, one of which is used for major crop irrigation (Figure 12). About 140 acres of cropland are permitted for groundwater irrigation in this area (Table 15). All permitted wells are withdrawing groundwater from Paleozoic aquifers (Table 16; MDNR, 2018).

**Table 15. Active Groundwater Use Permits by Township, Faribault County**

Township	Major Crop Irrigation Well Permits	Average Depth (feet)	Acres Permitted
Barber	1	402	140
Prescott	0	0	0
Winnebago City*	0	0	0
Total	1	402	140

\*Includes City of Winnebago

**Table 16. Active Groundwater Use Permits by Aquifer, Faribault County**

Water Use Well Permits	Total	Average Depth (feet)	Aquifer
			Paleozoic
Major Crop Irrigation	1	402	1
Industrial Processing	4	447	4
Water Supply	2	365	2
Total	7	417	7

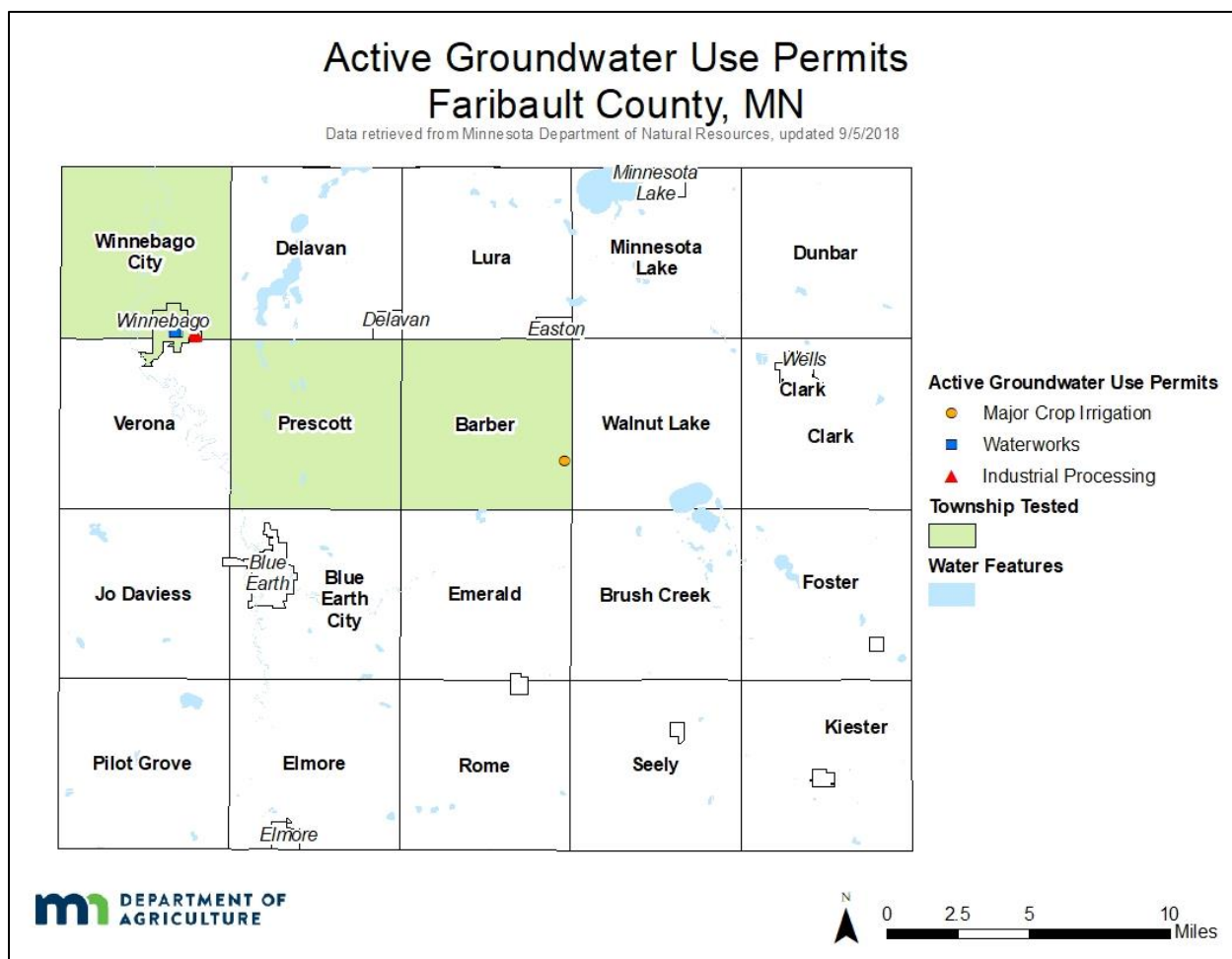


Figure 12. Active Groundwater Use Permits in Faribault County (MDNR, 2018)

## APPENDIX D

### Nitrate Brochure

The Minnesota Department of Agriculture and the Faribault County SWCD would like to **thank you** for participating in the private well volunteer nitrate monitoring. The results of your water sample are enclosed. Results from this sampling event will be reviewed and summarized and a summary report will be issued to the counties. In addition, the data will be used to determine the need and the design of a long-term monitoring network. Below is general information regarding nitrate result ranges.

#### **If the Nitrate result is between 0 to 4.9 mg/L:**

- Continue to test your water for nitrate every year or every other year.
- Properly manage nitrogen sources when used near your well.
- Continue to monitor your septic tank. Sewage from improperly maintained septic tanks may contaminate your water.
- Private wells should be tested for bacteria at least once a year. A Minnesota Department of Health (MDH) certified water testing lab can provide nitrate and bacteria testing services. Search for the lab nearest you at [www.health.state.mn.us/labsearch](http://www.health.state.mn.us/labsearch).

#### **If the Nitrate result is between 5 to 9.9 mg/L:**

- Presently the nitrate nitrogen level in your water is below the nitrate health standard for drinking water. However, you have a source of contamination which may include: contributions from fertilized lawns or fields, septic tanks, animal wastes, and decaying plants.
- Test annually for both nitrate and bacteria. As nitrate levels increase, especially in wells near cropped fields, the probability of detecting pesticides also increases. MDA monitoring data indicates that pesticide levels are usually below state and federal drinking water guidelines. For more information on testing and health risks from pesticides and other contaminants in groundwater go to: <http://www.mda.state.mn.us/protecting/waterprotection/pesticides.aspx>
- In addition to pesticides, high nitrate levels may suggest an increased risk for other contaminants. For more information go to: <http://www.health.state.mn.us/divs/eh/wells/waterquality/test.html>

#### **If the Nitrate result is above 10 mg/L:**

- **Do not allow this water to be consumed by infants**, Over 10 mg/L is not safe for infants younger than 6 months of age
- **Pregnant women** also may be at risk along with **other people with specific metabolic conditions**. Find a safe alternative water supply.
- Consider various options including upgrading the well if it was constructed before the mid 1970's.
- Be sure to retest your water prior to making any significant financial investment in your existing well system. See link to MDH certified labs listed above.
- ***Boiling your water increases the nitrate concentration in the remaining water.***

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Infants consuming high amounts of nitrates may develop Blue Baby Syndrome (Methemoglobinemia). This disease is potentially fatal and first appears as blue coloration of the fingers, lips, ears, etc. Seek medical assistance immediately if detected

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If you have additional questions about wells or well water quality in Minnesota, contact your local Minnesota Department of Health office and ask to talk with a well specialist or contact the Well Management Section Central Office at [health.wells@state.mn.us](mailto:health.wells@state.mn.us) or at 651-201-4600 or 800-383-9808. If you have questions regarding the private well monitoring contact Nikol Ross at 651-201-6443 or [Nikol.Ross@state.mn.us](mailto:Nikol.Ross@state.mn.us).



## APPENDIX E

**Table 17. Reasons Wells Were Removed from the Final Well Dataset by Township, Faribault County**

Township	Point Source	Well Construction Problem	Hand Dug Well	Unsure of Water Source or Known Non Drinking Water source	Site Visit Completed - Well Not Found & Constructed before 1975 or Age Unknown & No Well ID	No Site Visit & Constructed before 1975 or Age Unknown & No Well ID	No Site Visit & Insufficient Data & No Well ID	Shared Well	Total
Barber	0	0	0	0	0	0	0	0	0
Prescott	0	0	1	0	0	0	0	1	2
Winnebago City*	0	0	0	0	0	0	0	0	0
Total	0	0	1	0	0	0	0	1	2

\*Includes City of Winnebago

**Table 18. Completed Site Visits for Wells Removed from the Final Well Dataset by Township, Faribault County**

Township	Site Visit	No Site Visit	Total
Barber	0	0	0
Prescott	0	2	2
Winnebago City*	0	0	0
Total	0	2	2

\*Includes City of Winnebago

## APPENDIX F

### MINNESOTA WELL INDEX

The MWI was used to gather information about the three study area townships in Faribault County. This section includes all documented drinking water wells in the study area, not just wells MDA sampled. Table 19 summarizes the general aquifer types, while the following is a brief summary of the major aquifer types with the average well depth. According to the information from the MWI (MDH, 2019):

In these townships, there are 84 documented (have a verified location in the MWI) drinking water wells:

- The majority of wells (34.5%) were completed in Quaternary Aquifers. These are the shallowest aquifers in Faribault County.
  - The Quaternary Water table represent about 1.2 percent of wells within the Faribault County study area townships. These wells have an average depth of 87 feet.
  - 1.2 percent were completed in Quaternary Buried Unconfined aquifer, averaging 135 feet deep.
  - The majority of wells (32 percent) were completed in Quaternary Buried Artesian Aquifer. These are the deepest of the Quaternary aquifer wells, averaging 130 feet deep.
- 32 percent of wells were completed in Ordovician bedrock aquifers. The Ordovician aquifers include the Galena group (six percent of total wells), the Platteville aquifers (1.2 percent), the St. Peter Sandstone (14.3 percent) and the Prairie Du Chien group (10.7 percent).
- Two wells (2.4 percent) were completed in the Jordon Sandstone aquifer.
- 13 wells were completed in multiple aquifers. The average depth of these wells is 251 feet.
- Approximately 15.5 percent of wells with a well log did not have a defined aquifer.

**Table 19. Aquifer Type Distribution of Active Drinking Water Wells in Minnesota Well Index by Township, Faribault County**

Township	Quaternary Water Table	Quaternary Buried Unconfined	Quaternary Buried Artesian	Galena Group	Platteville	St. Peter Sandstone	Prairie Du Chien Group	Jordan Sandstone	Multiple Aquifers	Not Available	Total
	Number of wells drawing water from an aquifer										
Barber	0	0	4	5	0	4	0	0	10	3	26
Prescott	1	0	8	0	1	3	0	0	1	1	15
Winnebago City*	0	1	15	0	0	5	9	2	2	9	43
Total	1	1	27	5	1	12	9	2	13	13	84
Average Well Depth (feet)	87	135	130	146	300	225	335	258	251	138	191

\*Includes City of Winnebago

## Example – “Participation Letter and Well Survey”

**Private Well Survey for Township Testing Program**

The Minnesota Department of Agriculture appreciates you taking the time to answer a few questions about your well. These questions are voluntary, but will help in the analysis of your nitrate results and provide information as to nitrate concentrations across Minnesota. Your name, addresses, telephone numbers, and e-mail addresses are considered private under Minnesota Statutes Chapter 13. Only data from sample results, general location data and unique well number are considered public. Only people with a need to access your data in support of the private well nitrate sampling program will have authority to access your data unless you provide MDA with an informed consent to release the data, upon court order or provided to the state or legislative auditor to review the data. If you don't know an answer to a question, skip it and go on to the next question. Please make corrections to contact information if needed.

First name _____ Last name _____	
Parcel Number _____ Township _____	
Physical address _____	City _____ State _____ Zip _____
Mailing address _____	City _____ State _____ Zip _____
Phone number _____ (in case we have questions about your survey) Email _____	
1. What setting did the water sample come from? Please choose only one.	
<input type="checkbox"/> Sub-division <input type="checkbox"/> Lake Home <input type="checkbox"/> River Home <input type="checkbox"/> Country <input type="checkbox"/> Municipal/City* <input type="checkbox"/> Other	
* If municipal/City well, stop here, your well will not be included in the private well sampling.	
2. Are there livestock on this property?	
(more than 10 head of cattle, 30 head of hogs or an equivalent number of other livestock)	
<input type="checkbox"/> Yes <input type="checkbox"/> No	
3. Do you mix or store fertilizer (500 lb. or more) on the farm site?	
<input type="checkbox"/> Yes <input type="checkbox"/> No	
4. Does farming take place on this property?	
<input type="checkbox"/> Yes <input type="checkbox"/> No	
<b>WELL INFORMATION</b>	
It is extremely helpful if you can go to your well and look for the Unique Well Number - this is a 6 digit number found on a metal tag attached to your well casing.	
5. Does your well have a Unique Well ID number?	
<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Don't Know	
6. If yes, what is the Unique Well ID? _____ (6 digit number found on a metal tag attached to your well casing)	
7. Type of well construction? <input type="checkbox"/> Drilled <input type="checkbox"/> Sand point <input type="checkbox"/> Hand Dug Well <input type="checkbox"/> Don't Know <input type="checkbox"/> Other	
8. Approximate age of your well?	
<input type="checkbox"/> 0 - 10 years <input type="checkbox"/> 11 - 20 years <input type="checkbox"/> 21 - 40 years <input type="checkbox"/> over 40 years	
9. Approximate depth of your well?	
<input type="checkbox"/> 0 - 49 Feet <input type="checkbox"/> 50 - 99 feet <input type="checkbox"/> 100 - 299 feet <input type="checkbox"/> >=300 feet	
10. Distance to an active or inactive feedlot?	
<input type="checkbox"/> 0 - 49 Feet <input type="checkbox"/> 50 - 99 feet <input type="checkbox"/> 100 - 299 feet <input type="checkbox"/> >=300 feet	
11. Distance to a septic system?	
<input type="checkbox"/> 0 - 49 Feet <input type="checkbox"/> 50 - 99 feet <input type="checkbox"/> 100 - 299 feet <input type="checkbox"/> >=300 feet	
12. Distance to an agricultural field?	
<input type="checkbox"/> 0 - 49 Feet <input type="checkbox"/> 50 - 99 feet <input type="checkbox"/> 100 - 299 feet <input type="checkbox"/> >=300 feet	
13. Is this well currently used for human consumption (Drinking or Cooking)?	
<input type="checkbox"/> Yes <input type="checkbox"/> No	
14. Please check any water treatment you have other than a water softener.	
<input type="checkbox"/> None <input type="checkbox"/> Reverse Osmosis <input type="checkbox"/> Distillation <input type="checkbox"/> Filtering system <input type="checkbox"/> Other	
15. When did you last have your well tested for nitrates?	
<input type="checkbox"/> Never tested <input type="checkbox"/> Within the last year <input type="checkbox"/> Within the last 3 years	
<input type="checkbox"/> Within the last 10 years <input type="checkbox"/> Greater than 10 years <input type="checkbox"/> Not sure	
16. What was the result of your last nitrate test?	
<input type="checkbox"/> <3 mg/L (ppm) <input type="checkbox"/> 3<10 mg/L(ppm) <input type="checkbox"/> >=10 mg/L (ppm) <input type="checkbox"/> Don't Know	

## APPENDIX H

**Table 20. Property Setting for Well Location**

Township	Total	Country	Municipal	River Home	Lake Home	Sub-division	Other	Not Available
Barber	53	84.9%	0.0%	0.0%	0.0%	0.0%	1.9%	13.2%
Prescott	46	71.7%	0.0%	4.3%	0.0%	0.0%	4.3%	19.6%
Winnebago City*	35	77.1%	0.0%	5.7%	0.0%	0.0%	0.0%	17.1%
Total	134	78.4%	0.0%	3.0%	0.0%	0.0%	2.2%	16.4%

\*Includes City of Winnebago

**Table 21. Well Construction Type**

Township	Total	Drilled	Sand Point	Hand Dug	Not Available
Barber	53	81.1%	1.9%	0.0%	17.0%
Prescott	46	60.9%	0.0%	2.2%	37.0%
Winnebago City*	35	71.4%	0.0%	0.0%	28.6%
Total	134	71.6%	0.7%	0.7%	26.9%

\*Includes City of Winnebago

**Table 22. Age of Well**

Township	Total	1994 to Present	1985 to 1993	1975 to 1984	Before 1975	Not Available
Barber	53	18.9%	5.7%	9.4%	35.8%	30.2%
Prescott	46	15.2%	4.3%	13.0%	32.6%	34.8%
Winnebago City*	35	20.0%	8.6%	2.9%	31.4%	37.1%
Total	134	17.9%	6.0%	9.0%	33.6%	33.6%

\*Includes City of Winnebago

**Table 23. Depth of Well**

Township	Total	0-15 Feet	16-49 Feet	50-99 Feet	100-299 Feet	≥300 Feet	Not Available
Barber	53	0.0%	0.0%	20.8%	54.7%	3.8%	20.8%
Prescott	46	0.0%	2.2%	26.1%	39.1%	0.0%	32.6%
Winnebago City*	35	0.0%	0.0%	28.6%	28.6%	5.7%	37.1%
Total	134	0.0%	0.7%	24.6%	42.5%	3.0%	29.1%

\*Includes City of Winnebago

**Table 24. Unique Well ID Known**

Township	Total	No, Unique Well ID Not Known	Yes, Unique Well ID Known	Not Available
Barber	53	18.9%	9.4%	71.7%
Prescott	46	28.3%	10.9%	60.9%
Winnebago City*	35	14.3%	5.7%	80.0%
Total	134	20.9%	9.0%	70.1%

\*Includes City of Winnebago

**Table 25. Livestock Located on Property**

Township	Total	No Livestock	Yes Livestock	Not Available
Barber	53	66.0%	22.6%	11.3%
Prescott	46	78.3%	4.3%	17.4%
Winnebago City*	35	68.6%	11.4%	20.0%
Total	134	70.9%	13.4%	15.7%

\*Includes City of Winnebago

**Table 26. Fertilizer Stored on Property**

Township	Total	No Fertilizer Stored	Yes, Fertilizer Stored	Not Available
Barber	53	79.2%	5.7%	15.1%
Prescott	46	73.9%	6.5%	19.6%
Winnebago City*	35	82.9%	0.0%	17.1%
Total	134	78.4%	4.5%	17.2%

\*Includes City of Winnebago

**Table 27. Farming on Property**

Township	Total	No Farming	Yes Farming	Not Available
Barber	53	37.7%	47.2%	15.1%
Prescott	46	28.3%	52.2%	19.6%
Winnebago City*	35	37.1%	45.7%	17.1%
Total	134	34.3%	48.5%	17.2%

\*Includes City of Winnebago

**Table 28. Distance to an Active or Inactive Feedlot**

Township	Total	0-49 Feet to Feedlot	50-99 Feet to Feedlot	100-299 Feet to Feedlot	≥300 Feet to Feedlot	Not Available
Barber	53	3.8%	7.5%	37.7%	35.8%	15.1%
Prescott	46	6.5%	10.9%	39.1%	17.4%	26.1%
Winnebago City*	35	11.4%	17.1%	22.9%	25.7%	22.9%
Total	134	6.7%	11.2%	34.3%	26.9%	20.9%

\*Includes City of Winnebago

**Table 29. Distance to Septic System**

Township	Total	0-49 Feet to Septic	50-99 Feet to Septic	100-299 Feet to Septic	≥300 Feet to Septic	Not Available
Barber	53	1.9%	13.2%	50.9%	18.9%	15.1%
Prescott	46	2.2%	21.7%	34.8%	13.0%	28.3%
Winnebago City*	35	5.7%	40.0%	17.1%	17.1%	20.0%
Total	134	3.0%	23.1%	36.6%	16.4%	20.9%

\*Includes City of Winnebago

**Table 30. Distance to an Agricultural Field**

Township	Total	0-49 Feet to Field	50-99 Feet to Field	100-299 Feet to Field	≥300 Feet to Field	Not Available
Barber	53	3.8%	7.5%	37.7%	35.8%	15.1%
Prescott	46	6.5%	10.9%	39.1%	17.4%	26.1%
Winnebago City*	35	11.4%	17.1%	22.9%	25.7%	22.9%
Total	134	6.7%	11.2%	34.3%	26.9%	20.9%

\*Includes City of Winnebago

**Table 31. Drinking Water Well**

Township	Total	Not Drinking Water	Yes, Drinking Water	Not Available
Barber	53	1.9%	84.9%	13.2%
Prescott	46	8.7%	71.7%	19.6%
Winnebago City*	35	0.0%	82.9%	17.1%
Total	134	3.7%	79.9%	16.4%

\*Includes City of Winnebago

**Table 32. Treatment System Present (Treatment System Used for Drinking Water)**

Township	Total	None	Distillation	Filtering System	Reverse Osmosis	Other	Not Available
Barber	53	32.1%	1.9%	28.3%	18.9%	5.7%	13.2%
Prescott	46	37.0%	4.3%	19.6%	17.4%	0.0%	21.7%
Winnebago City*	35	25.7%	2.9%	28.6%	22.9%	0.0%	20.0%
Total	134	32.1%	3.0%	25.4%	19.4%	2.2%	17.9%

\*Includes City of Winnebago

**Table 33. Last Tested for Nitrate**

Township	Total	Within the Past Year	Within the Last 3 Years	Within the Last 10 Years	Greater Than 10 Years	Never Tested	Homeowner Unsure	Not Available
Barber	53	3.8%	3.8%	11.3%	11.3%	26.4%	32.1%	11.3%
Prescott	46	0.0%	4.3%	2.2%	19.6%	34.8%	15.2%	23.9%
Winnebago City*	35	0.0%	5.7%	2.9%	11.4%	25.7%	37.1%	17.1%
Total	134	1.5%	4.5%	6.0%	14.2%	29.1%	27.6%	17.2%

\*Includes City of Winnebago

**Table 34. Last Nitrate Test Result**

Township	Total	<3 mg/L Nitrate-N	3<10 mg/L Nitrate-N	≥10 mg/L Nitrate-N	Don't Know	Not Available
Barber	53	3.8%	0.0%	0.0%	64.2%	32.1%
Prescott	46	0.0%	0.0%	0.0%	47.8%	52.2%
Winnebago City*	35	0.0%	0.0%	0.0%	42.9%	57.1%
Total	134	1.5%	0.0%	0.0%	53.0%	45.5%

\*Includes City of Winnebago

## APPENDIX I

**Table 35. Well Construction Type for Final Well Dataset**

Township	Total Wells	Drilled	Sand Point	Not Available
Barber	53	43	1	9
Prescott	44	29	0	15
Winnebago City*	35	27	0	8
Total	132	99	1	32

\*Includes City of Winnebago

Data compiled from well logs and homeowner responses.

**Table 36. Well Depth for Final Well Dataset**

Township	Total Wells	Min	Max	Median	Mean
Barber	8	67	210	156	157
Prescott	8	71	177	118	116
Winnebago City*	6	75	175	111	119
Total	22	67	210	129	131

\*Includes City of Winnebago

Data compiled from well logs only; homeowner responses are not included.

**Table 37. Year of Well Construction for Final Well Dataset**

Township	Total Wells	Min	Max	Median	Mean
Barber	8	1994	2016	2002	2004
Prescott	8	1995	2016	2001	2002
Winnebago City*	6	1994	2017	2006	2007
Total	22	1994	2017	2003	2004

\*Includes City of Winnebago

Data compiled from well logs only; homeowner responses are not included. Most wells do not have a well log if they were constructed before 1974.

## APPENDIX J

### Private Well Field Log

Site ID \_\_\_\_\_ Unique ID \_\_\_\_\_ Date \_\_\_\_\_  
**MDA -Private Well Field Log & Well Survey Form**

Sample# \_\_\_\_\_

Duplicate# \_\_\_\_\_ Field Blank# \_\_\_\_\_

Additional Samples \_\_\_\_\_

#### Well Owner Contact Information

Name \_\_\_\_\_

Address \_\_\_\_\_

Phone # \_\_\_\_\_ Township \_\_\_\_\_ County \_\_\_\_\_

#### Sampling Information

Sampler \_\_\_\_\_ Time Arrived \_\_\_\_\_

Pump Start Time \_\_\_\_\_ Discharge Rate \_\_\_\_\_ Time Collected \_\_\_\_\_

Sample Point Location \_\_\_\_\_

Well Location \_\_\_\_\_

GPS Location \_\_\_\_\_ UTM Easting (X) \_\_\_\_\_ UTM Northing (Y) \_\_\_\_\_

Weather \_\_\_\_\_ Wind Speed/Direction (mph) \_\_\_\_\_ Air Temp (°F) \_\_\_\_\_

Nearest possible pesticide source (type, dist., dir.) \_\_\_\_\_ ☐ None noticeable

Time	Temp °C (1.0)	Specific Cond µs/cm (10%)	DO mg/L (10%)	pH (0.1)	Appearance/Odor/Notes

**Field Comments - sample specific notes**

Updated: March, 2017

## APPENDIX K

**Table 38. Temperature (°C) of Well Water for Final Well Dataset**

Township	Samples	Min	Max	Median	Mean
Barber	0	NA	NA	NA	NA
Prescott	3	10.39	11.04	10.59	10.67
Winnebago City*	3	10.11	10.57	10.34	10.34
Total	6	10.11	11.04	10.48	10.51

\*Includes City of Winnebago

**Table 39. pH of Well Water for Final Well Dataset**

Township	Samples	Min	Max	Median	Mean
Barber	0	NA	NA	NA	NA
Prescott	3	7.40	7.55	7.45	7.47
Winnebago City*	3	6.75	7.25	6.94	6.98
Total	6	6.75	7.55	7.33	7.22

\*Includes City of Winnebago

**Table 40. Specific Conductivity (µS/cm) of Well Water for Final Well Dataset**

Township	Samples	Min	Max	Median	Mean
Barber	0	NA	NA	NA	NA
Prescott	3	644	777	730	717
Winnebago City*	3	783	1,550	935	1,089
Total	6	644	1,550	780	903

\*Includes City of Winnebago

**Table 41. Dissolved Oxygen (mg/L) of Well Water for Final Well Dataset**

Township	Samples	Min	Max	Median	Mean
Barber	0	NA	NA	NA	NA
Prescott	3	0.12	3.99	0.79	1.63
Winnebago City*	3	0.69	7.19	1.62	3.17
Total	6	0.12	7.19	1.21	2.40

\*Includes City of Winnebago