Final Township Testing Nitrate Report:

Scott County 2018-2019

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Minnesota Department of Agriculture

Pesticide and Fertilizer Management Division

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 Scott County study area (four 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 488 wells representing an average response rate of 37 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, 1.4 percent 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 91 residents could be consuming well water with nitrate-N at or over the HRL.

The MDA completed follow-up sampling and well site visits at 91 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 30 (6.1 percent) wells were determined to be unsuitable and were removed from the dataset. The final well dataset had a total of 458 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 the percent of wells at or over the HRL ranged from 0.0 to 2.6 percent. No townships in Scott County had more than 10 percent of 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. Statewide more than 90,000 private well owners have been offered nitrate testing in 344 townships since 2013.

In 2018, four townships in Scott County were selected to participate in the Township Testing Program (Figure 1). Areas were chosen based on several criteria. Criteria used include: 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 Scott County occurred during 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

www.mda.state.mn.us/townshiptesting

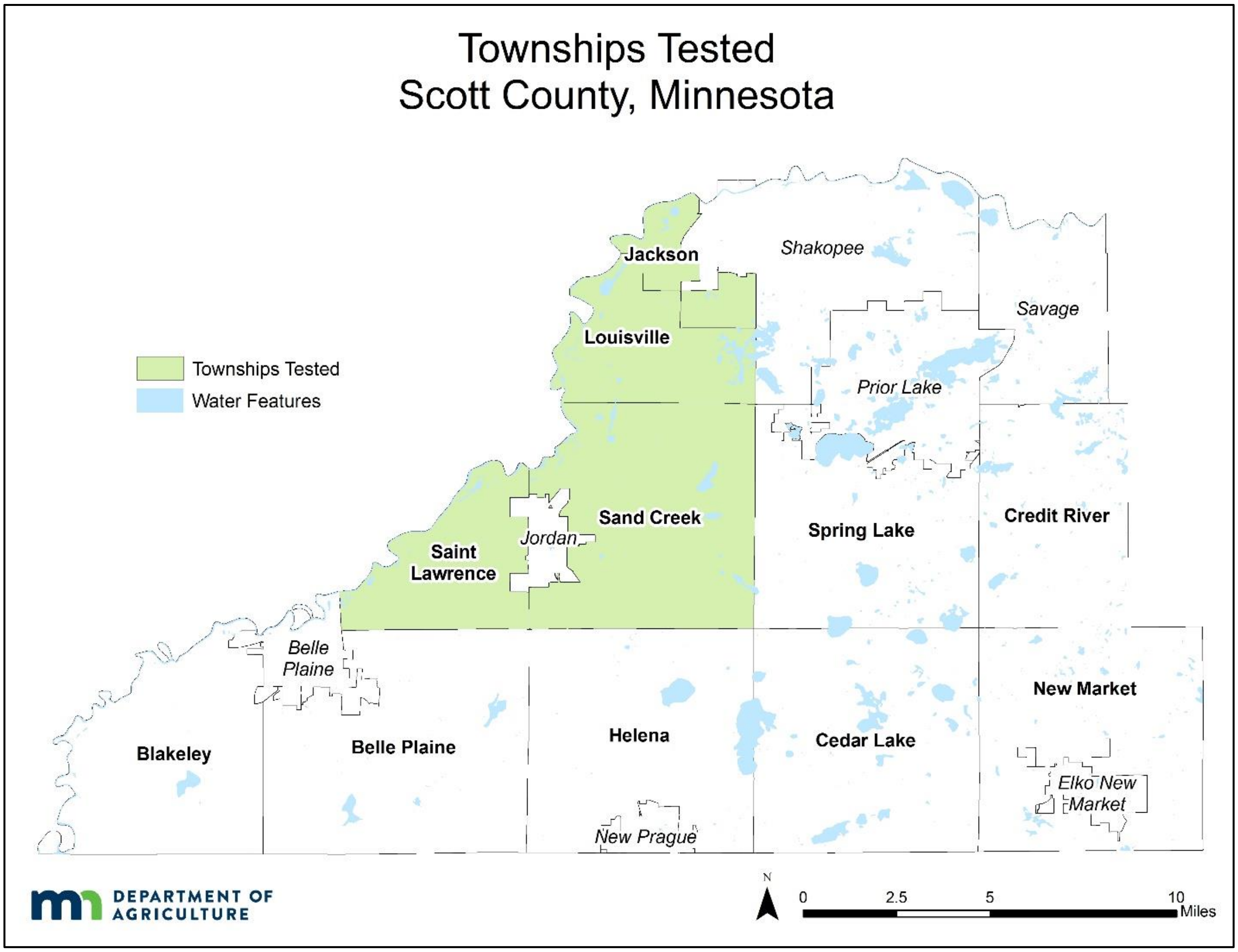

Figure 1. Townships Tested in Scott County

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 systems with gravelly geologic material close to the surface, such as parts of Scott County, contaminants such as nitrate can travel quickly to the aquifer (Tipping, 2006), leaving little chance for denitrification or other attenuating processes. As a result, certain areas of Scott County with gravelly geologic material and intensive row crop agriculture may be particularly vulnerable to elevated nitrate concentrations. It is important to note that 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).

Scott County, like most of the rest of Minnesota, was intermittently covered by glacial ice during the most recent glacial period, the Wisconsin, which occurred from about 75,000 years ago to 11,700 years ago (Lusardi & Dengler, 2017). Scott County was likely covered by ice at least two times during this period: once about 20,000 years ago as a portion of the larger glacier called the Superior lobe extended from the northeast and again about 14,000 years ago as another lobe, the Des Moines, extended northwest (Lusardi, 2006). The advances and retreats of these glacial lobes had a profound effect on the landscape of the region, creating glacial landforms such eskers, which are sinuous sandy ridges that form from ice melt beneath a glacier; moraine ridges, which are hills that form as sediment is deposited at the edge of a glacier; and kettle lakes, which are lakes that form as orphaned pieces of glacial ice melt (Lusardi, 2006).

These Des Moines and Superior glacial lobes also had a profound impact on the geology of Scott County, depositing a complex network of glacial sediment over the county (Figure 2). In all but the far north and northwestern portions of the county, geology is dominated by glacial till (Lusardi, 2006), which is mixed material (rocks, sand, silt, sand, and clay) that glaciers picked up as they move and deposited elsewhere. This till varies in composition, but tends to contain clay and silt, which slows groundwater flow and thus provides protection to aquifers below (Tipping, 2006).

In the far north and northeastern parts of the county near the Minnesota River, instead of till, there are terrace deposits at or near the surface. These terrace deposits were deposited by Glacial River Warren as it flooded with glacial meltwater from Glacial Lake Agassiz, a massive glacial lake that once covered over 300,000 square miles of northern Minnesota, North Dakota, and Canada (Jennings et al. 2012; Lusardi & Dengler, 2017). These terrace deposits tend to be coarse-grained, consisting of gravel, sandy gravel, and silty gravel (Lusardi, 2006; Tipping, 2006). This coarse-grained material allows for water to quickly travel through to aquifers, making shallow aquifers in areas covered with terrace deposits, including much of our study area, potentially more prone to pollution with contaminants including nitrate (Tipping, 2006). Even bedrock aquifers are vulnerable in these terrace-covered areas, as bedrock is often less than 50 feet below the surface, directly beneath terrace deposits (Runkel & Tipping, 2006; Tipping, 2006).

The composition of bedrock in parts of the Scott County study area enhances aquifer vulnerability. The topmost bedrock in Louisville and Jackson Township tends to be either the Prairie Du Chien Group or the Jordan Sandstone (Runkel and Mossler, 2006). The Prairie du Chien Group consist mostly of dolostone and sandstone. Where the Prairie Du Chien Group is the topmost bedrock layer (as it is in much of Louisville and Jackson Townships) the upper portion tends to have large voids in it caused by dissolution, and the lower portion is often fractured (Tipping & Runkel, 2007). These voids and fractures allow potentially contaminated water from the surface to travel into other aquifers below, such as the Jordan Sandstone (Tipping & Runkel, 2007). The Jordan Sandstone consists mostly of coarse-grained sandstone which also allows contaminated water to travel through (Tipping & Runkel, 2007).

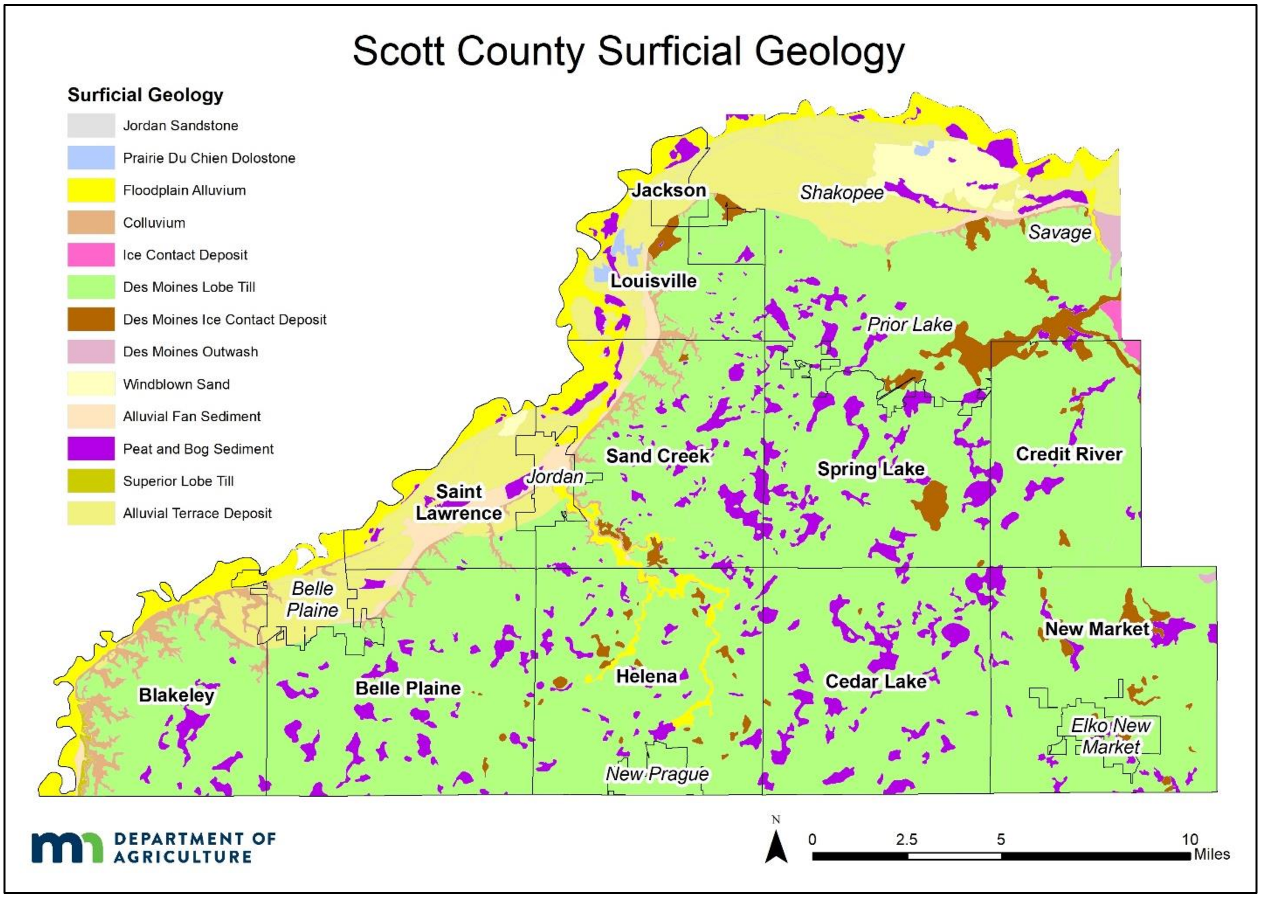

Figure 2. Surficial Geology in Scott County (Lusardi, 2006)

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 Scott 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 8,640 SSTS were reported in Scott County for 2018. Over a recent 17-year period (2002-2018), 2,499 construction permits for new, replacement, or repairs for SSTS were issued. Of all the reported septic systems in Scott County, 29 percent are newer than 2002 or have been repaired since 2002 (MPCA, 2019a). When new SSTS's are installed they are required to comply 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).

FEEDLOT

Manure produced on a feedlot can be a potential source of nitrogen pollution if improperly stored or spread. In the Scott County study area there are a total of six active feedlots. Of these, five are permitted to house more than 100 animal units (AU) (Appendix B; Figure 9). These feedlots are for beef cattle, dairy cattle, swine, and horses.

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 Scott County study area has one fertilizer storage license, a chemigation site located in Sand Creek Township (Appendix B; Table 11).

FERTILIZER SPILLS AND INVESTIGATIONS

One historic fertilizer spill and investigation occurred in the Scott County study area, which was an old emergency incident located in Jackson Township (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.

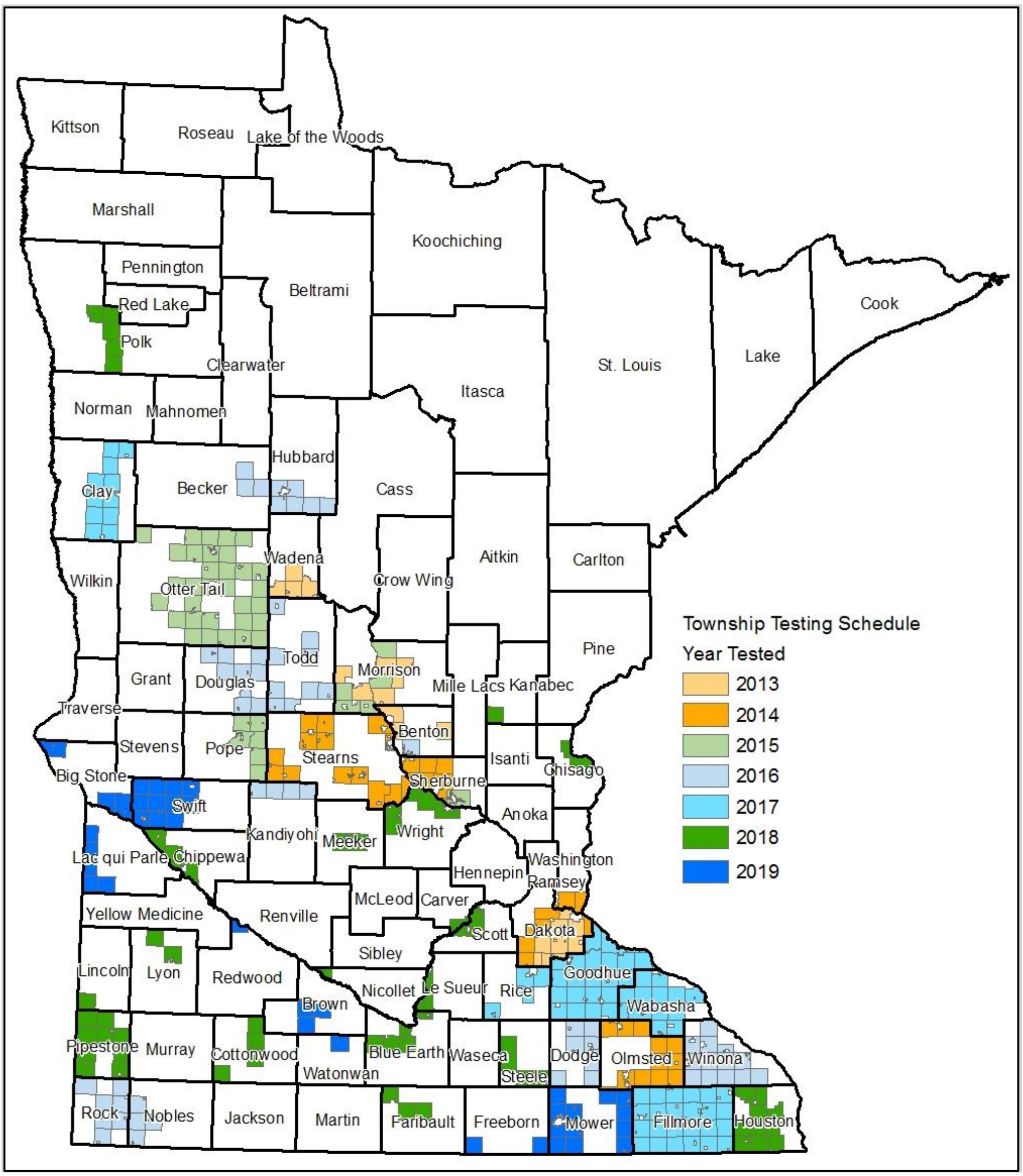

Figure 3. Minnesota Vulnerable Townships Tested for Nitrate in Private Wells.

Updated statewide sensitivity ratings from the Minnesota Department of Natural Resources (Adams, 2016) were 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, moderate, high and special conditions. Sensitivity ratings are described in Table 1. The ratings are based upon DNR's "Pollution Sensitivity of Near-Surface Materials" (Adams, 2016). A map of Scott County depicting the aquifer vulnerabilities is shown in Figure 4. The National Agriculture Statistics Service data (USDA NASS, 2013) on cropland was used to determine the percentage of row crop agriculture. A map and table depicting the extent of the cropland in Scott County can be found in Appendix C (Figure 11, Table 14). On average 27 percent of the land cover was row crop agriculture.

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 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 Scott 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

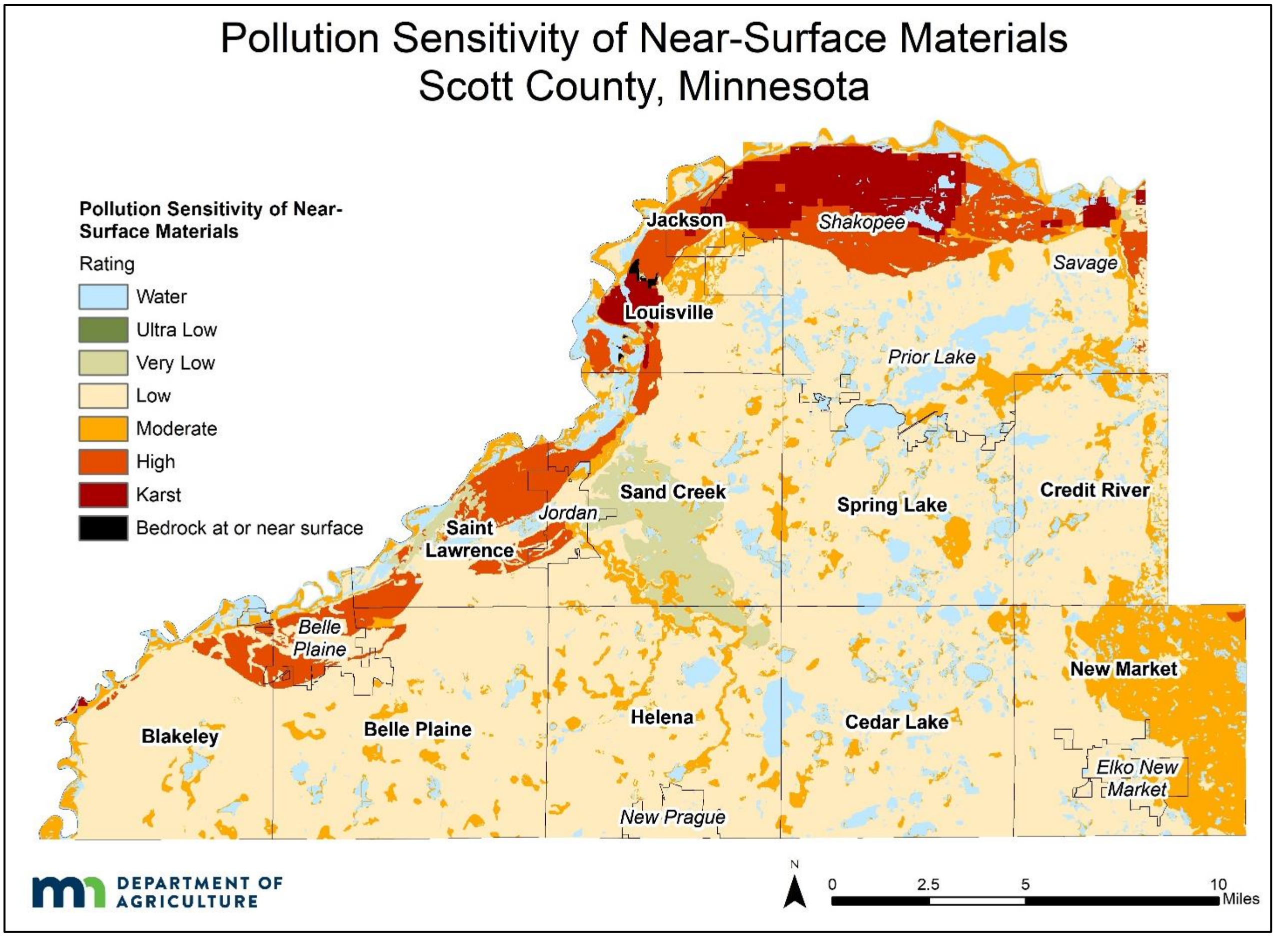

Figure 4. Pollution Sensitivity of Near Surface Materials (Adams, 2016) in Scott County.

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 488 homeowners using the mail-in kit (Table 2). These 488 samples are considered the "initial well dataset". On average, 37 percent of the homeowners in these townships responded to the free nitrate test offered by MDA.

All of the 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 were conducted in 2019 by MDA staff. A total of 91 follow-up samples were analyzed (Table 2).

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

Township	Kits Sent	Initial Well Dataset*	Well Site Visits & Follow-Up Sampling Conducted*
Jackson	213	81	31
Louisville	422	157	49
Sand Creek	505	187	6
St. Lawrence	173	63	5
Total	1,313	488	91

*The "Initial Well Dataset" includes six shared wells and a total of 22 sites. Five of those wells are shared with only one other neighbor from the township testing program and one well is a larger neighborhood well that serves 12 homes sampled in the township testing program. 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, 2018). 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).

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 30 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.

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.

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.

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.

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.

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.

SHARED WELL

Several homes in Scott County share their domestic drinking water wells. 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 488 well owners returned water samples for analysis across the four 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 5.3 to 16.5 mg/L, with Jackson Township having the highest result. Mean values ranged from 0.1 to 1.9 mg/L, with Louisville having the highest. The 90th percentiles ranged from 0.03 to 6.9 mg/L, with Louisville Township having the highest 90th percentile.

Initial results from the sampling showed that every township in the study area had less than 10 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.

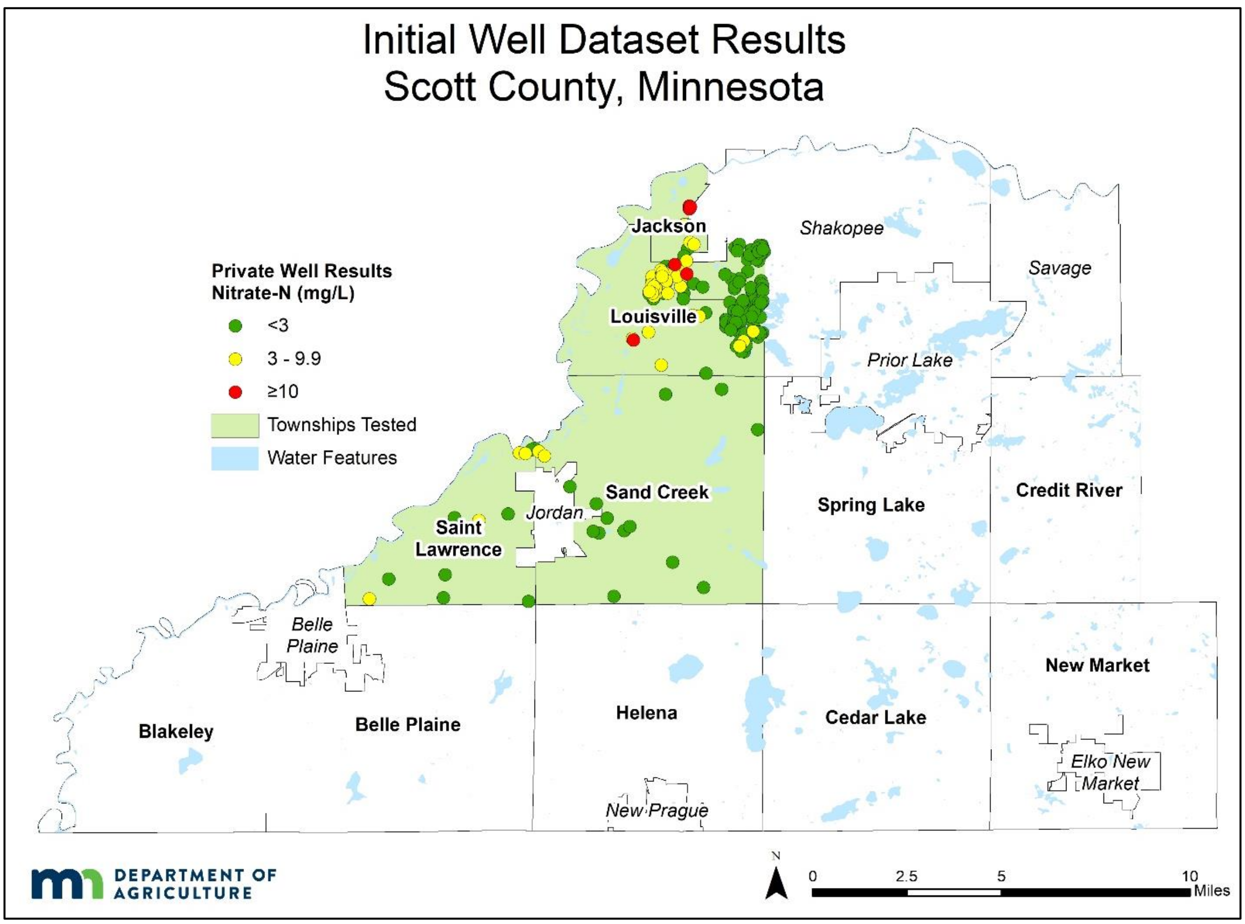

Figure 5. Well Locations and Nitrate Results from Initial Dataset in Scott County

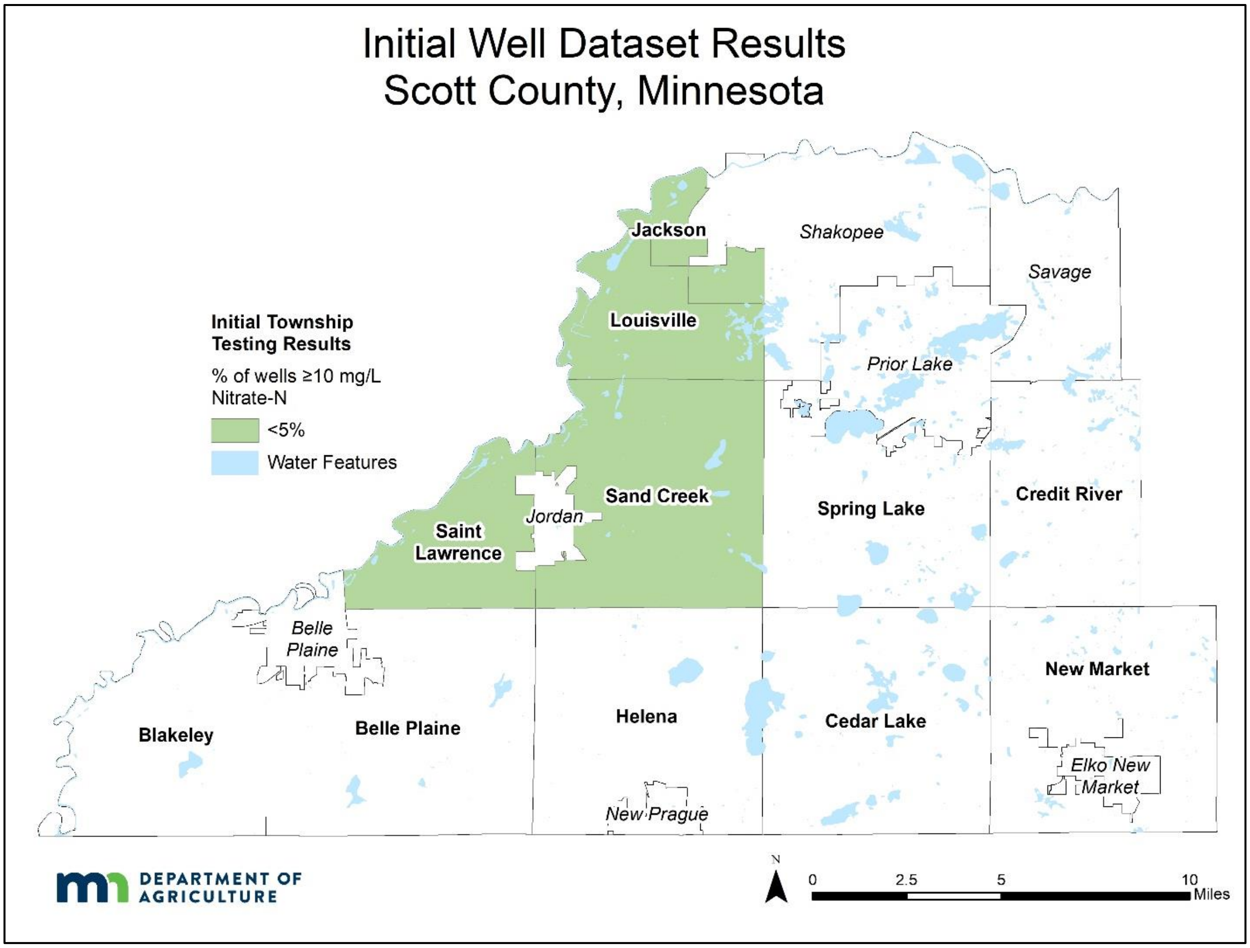

Figure 6. Results of Initial Testing by Township in Scott County

Table 3. Scott 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																	
Jackson	81	<0.03	16.5	1.6	0.5	1.5	6.5	7.6	15.9	72	6	9	5	3	88.9%	7.4%	11.1%	6.2%	3.7%
Louisville	157	<0.03	13.3	1.9	0.4	2.7	6.9	8.3	12.9	120	33	24	15	4	76.4%	21.0%	15.3%	9.6%	2.5%
Sand Creek	187	<0.03	5.3	0.1	<0.03	<0.03	0.03	0.2	3.7	185	2	1	0	0	98.9%	1.1%	0.5%	0.0%	0.0%
St. Lawrence	63	<0.03	8.6	0.5	<0.03	<0.03	1.3	4.2	8.2	59	4	3	1	0	93.7%	6.3%	4.8%	1.6%	0.0%
Total	488	<0.03	16.5	1.0	<0.03	0.5	3.5	6.7	11.1	436	45	37	21	7	89.3%	9.2%	7.6%	4.3%	1.4%

The 50th percentile (75th, 90th, 95th, and 99th) is the value below which 50 percent (75%, 90%, 95%, and 99%) of the observed values fall.

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. An estimated 91 people in Scott County's study area have drinking water over the nitrate HRL (Table 4).

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

Township	Estimated Households on Private Wells*	Estimated Population on Private Wells*	Estimated Population ≥10 mg/L Nitrate-N**
Jackson	508	1,517	56
Louisville	451	1,389	35
Sand Creek	574	1,671	0
St. Lawrence	165	499	0
Total	1,698	5,076	91

*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 (Setterholm, 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 289 documented wells (Table 5). Therefore, approximately 59 percent of the sampled wells had corresponding well logs with 235 having an aquifer identified. Thus, the data gathered on aquifers represents approximately 48 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. The average well depth was 290 feet. The Jordan Sandstone and Tunnel City aquifers were the most commonly utilized aquifers both for wells tested in the township testing program and for all wells in the study area (Appendix F, Table 19).

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

There were two classes of Quaternary aquifers that were utilized by MDA sampled wells according to the well log data. These aquifers are comprised of unconsolidated sand and gravel deposits (MPCA, 1999).

- Quaternary Buried unconfined (QBUA) aquifers are aquifers that have more than ten feet of confining material (typically clay) between the land surface and the well screen (MPCA, 1999).

- 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. Like the QBUA, the QBAA is found below confining material (NGWA, 1999).

There were also six categories of Paleozoic aquifers utilized in Scott County:

- The Jordan aquifers are within fine to medium grained sandstone. This sandstone ranges from massive or thick-bedded to thin bedded (MPCA, 1999).

- Much of the St. Lawrence Formation consists of dolomite-cemented sandstone and siltstone (Runkel and Mossler, 2006). It typically has low porosity, but in places there are fractures as well as holes and gaps caused by dissolution (Tipping & Runkel, 2007). Fractures are most common where the St. Lawrence Formation is near the surface (Tipping & Runkel, 2007).

- The Tunnel City Group, also called the Franconia Formation, consists of mostly of fine-grained sandstone with interbedded shale and dolomitic sandstone (MPCA, 1999). Although it is typically low-permeability, it can be used as an aquifer in some cases (MPCA, 1999).

- The Wonewoc Sandstone, also called the Ironton & Galesville Sandstone, consists of poorly-sorted sandstone in its upper reaches, and becomes better sorted deeper down (Mossler, 1995).

- The Mt. Simon Sandstone consists mostly of fine to coarse-grained sandstone and siltstone. The lower portion of the formation is consistently a relatively high productivity aquifer, while the upper portion of the aquifer has varying levels of productivity due to its inconsistent composition (Tipping & Runkel, 2007).

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 Unconfined	12	186.9	7	5	0	58.3%	41.7%	0.0%
Quaternary Buried Artesian	26	211.7	23	3	0	88.5%	11.5%	0.0%
Jordan Sandstone Formation	119	300.6	104	13	2	87.4%	10.9%	1.7%
St. Lawrence Formation	19	273.0	19	0	0	100.0%	0.0%	0.0%
Tunnel City	51	324.9	51	0	0	100.0%	0.0%	0.0%
Wonewoc Sandstone	3	373.7	3	0	0	100.0%	0.0%	0.0%
Mt. Simon Sandstone	1	597.0	1	0	0	100.0%	0.0%	0.0%
Multiple	4	396.3	3	1	0	75.0%	25.0%	0.0%
Not Available	54	281.2	48	5	1	88.9%	9.3%	1.9%
Total	289	290.1	259	27	3	89.6%	9.3%	1.0%

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 located in Appendix H at the end of this document (Tables 20-34).

The majority of wells in each township are located on “rural” property. The Township of Louisville had the most wells (15.9 percent) listed as being on “lake home” properties.

Approximately 72.3 percent of sampled wells are of drilled construction and 0.6 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 of fine-grained material 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. There were no hand dug wells sampled.

Most of the sampled wells (62.9 percent) are over 100 feet deep. Very few wells (4.5 percent) are less than 100 feet deep. Approximately 32.6 percent of homeowners did not know or did not respond to this question.

Most of the wells (65.0 percent) had not been tested for nitrate within the last ten years or homeowners were unsure if they had been tested. Approximately three 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.

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 15.2 percent of the properties.
- Agricultural fields are less than 300 feet from wells at about 24.6 percent of the properties.
- The majority of well owners (82.0 percent) across all the townships responded that they do not have livestock (greater than ten head of cattle or other equivalent) on their property.
- The majority of wells (59.6 percent) are over 300 feet from an active or inactive feedlot.
- Very few well owners (0.6 percent) across all townships store more than 500 pounds of fertilizer on their property.
- A small minority of wells (1.8 percent) are less than 50 feet away from septic systems.

FINAL RESULTS

FINAL WELL DATASET

A total of 488 well water samples were collected by homeowners across four townships. Thirty wells (6.1 percent) were found to be unsuitable and were removed to create the final well dataset. The final analysis was conducted on the remaining 458 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.

Table 6 shows the results for all townships sampled. The percent of wells at or over the HRL for the final well dataset ranged from 0.0 to 2.6 percent.

Table 6. Initial and Final Well Dataset Results, Scott County

Township	Initial Well Dataset	Final well Dataset	Final Wells ≥10 mg/L Nitrate-N	
			Count	Percentage
Jackson	81	76	2	2.6%
Louisville	157	137	2	1.5%
Sand Creek	187	186	0	0.0%
St Lawrence	63	59	0	0.0%
Total	488	458	4	0.9%

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 4.6 to 14.5 mg/L nitrate, with Jackson Township having the highest result. The 90th percentile ranged from <0.03 to 5.6 mg/L nitrate-N, with Sand Creek Township having the lowest results and Louisville Township having the highest result. Final results showed that every township in the study area had less than 5 percent of wells at or over 10 mg/L nitrate-N (Figure 8).

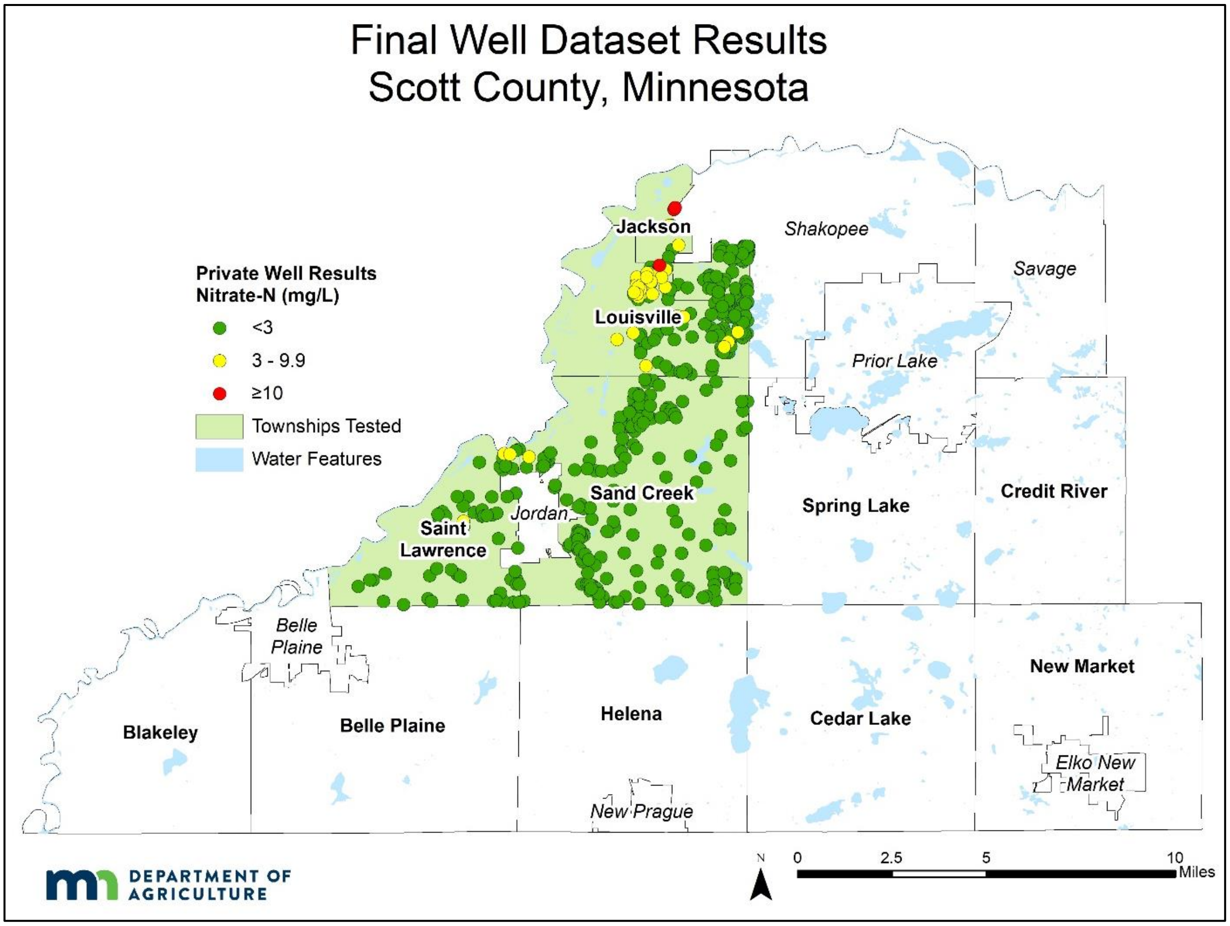

Figure 7. Well Locations and Nitrate Results from Final Well Dataset in Scott County

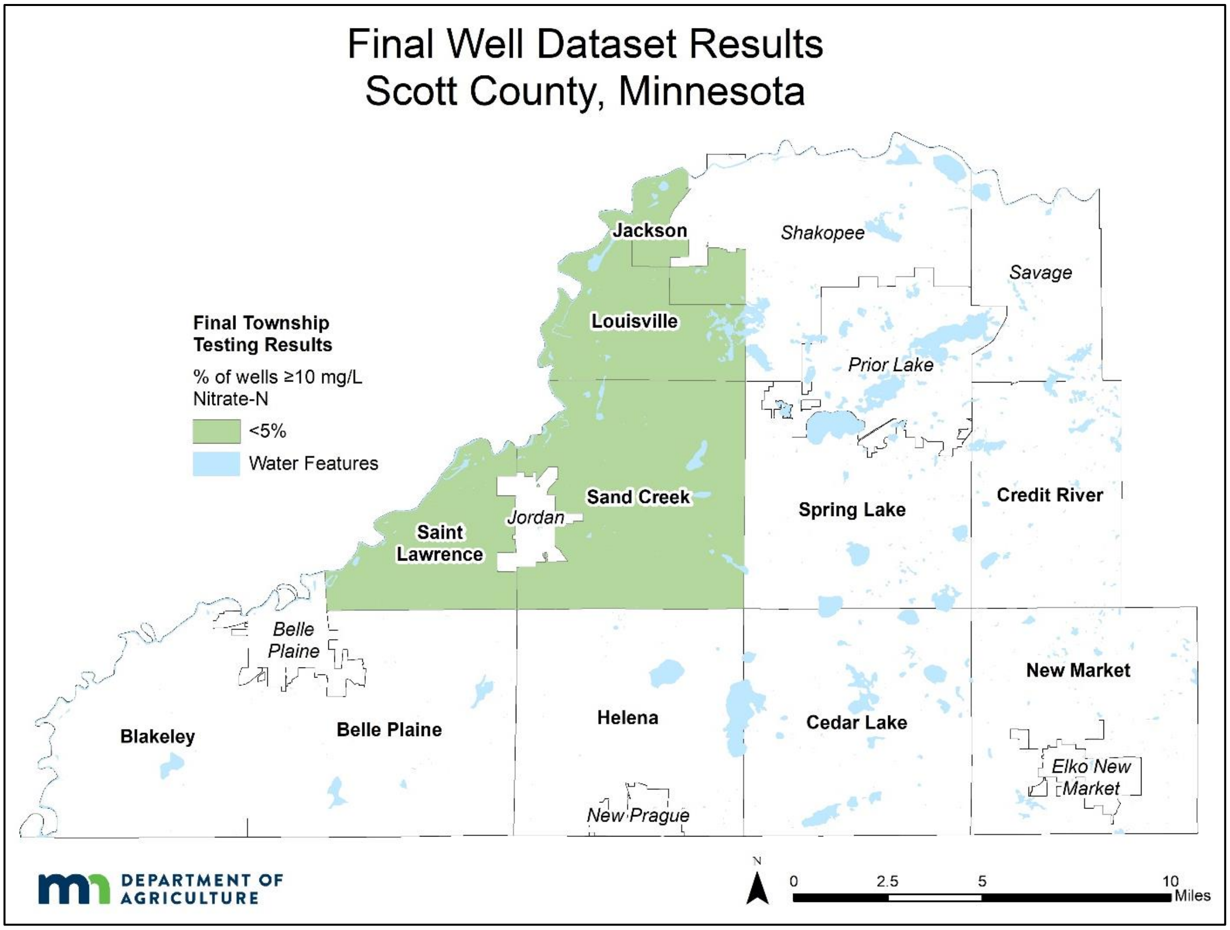

Figure 8. Results of Final Testing by Township in Scott County

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

Township	Total Wells	Values			Percentiles					Number of Wells					Percent of Wells				
		Min	Max	Mean	50th (Median)	75th	90th	95th	99th	<3	3<10	≥5	≥7	≥10	<3	3<10	≥5	≥7	≥10
		Nitrate-N mg/L or parts per million (ppm)																	
Jackson	76	<0.03	14.5	1.2	0.4	1.3	2.2	6.6	13.6	71	3	5	3	2	93.4%	3.9%	6.6%	3.9%	2.6%
Louisville	137	<0.03	13.3	1.7	0.4	2.4	5.6	7.7	13.0	108	27	16	10	2	78.8%	19.7%	11.7%	7.3%	1.5%
Sand Creek	186	<0.03	4.6	0.1	<0.03	<0.03	<0.03	0.2	1.7	185	1	0	0	0	99.5%	0.5%	0.0%	0.0%	0.0%
St. Lawrence	59	<0.03	5.6	0.4	<0.03	<0.03	0.9	3.2	5.5	56	3	2	0	0	94.9%	5.1%	3.4%	0.0%	0.0%
Total	458	<0.03	14.5	0.8	<0.03	0.4	2.4	5.0	9.6	420	34	23	13	4	91.7%	7.4%	5.0%	2.8%	0.9%

The 50th percentile (75th, 90th, 95th, and 99th, respectively) is the value below which 50 percent (75%, 90%, 95% and 99%) of the observed values fall.

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, Scott 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)	
Jackson	76	25%	54.9%	3.9%	2.6%
Louisville	137	18%	51.8%	7.3%	1.5%
Sand Creek	186	34%	16.6%	0.0%	0.0%
St Lawrence	59	18%	76.5%	0.0%	0.0%
Total	458	27%	40.5%	2.8%	0.9%

*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 Scott 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 (92 percent), and only two wells (<1 percent) were identified as sand point wells.
- The median depth of wells was 300 feet, and the deepest was 597 feet.
- The median year the wells were constructed in was 1998.

WELL WATER PARAMETERS

MDA staff conducted the follow-up sampling and well site surveys at 91 wells. Three follow-up wells were removed from the final dataset, and one did not have the dissolved oxygen for the field measurements collected, so a total of 87 wells were analyzed for well water parameters. 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 water sample 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 10.20 °C to 14.76 °C
- The median specific conductivity was 743 µS/cm, and was as high as 1,128 µS/cm
- The water from the wells had a median pH of 7.33
- The dissolved oxygen readings ranged from 0.13 mg/L to 10.06 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).

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).

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).

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_2). 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 Scott County. In order to prioritize testing, the MDA looked at townships with significant row crop production and vulnerable geology. Approximately 27 percent of the land cover is row crop agriculture and there are 10 acres (0.02 percent) of groundwater irrigation in the study area.

Four townships were sampled covering nearly 43,433 acres. The initial (homeowner collected) nitrate sampling resulted in 488 samples. The 488 households that participated represent approximately 37 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 91 wells.

The MDA conducted a nitrogen source assessment and identified wells near potential point sources and wells with poor construction. A total of 30 (6.1 percent) wells were found to be unsuitable and were removed from the final well dataset of 488 wells. The remaining 458 wells were wells believed to be impacted by nitrogen fertilizer and were included in the final well dataset.

In the final well dataset most wells (92 percent) are drilled; less than 1 percent are sand points. The median depth of the wells is 300 and depths range from 95 to 597 feet.

For the final well dataset, there were no townships that had more than 10 percent of wells at or over the nitrate Health Risk Limit of 10 mg/L. The percentage of wells at or over the nitrate Health Risk Limit in each township ranged from 0.0 to 2.6 percent.

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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

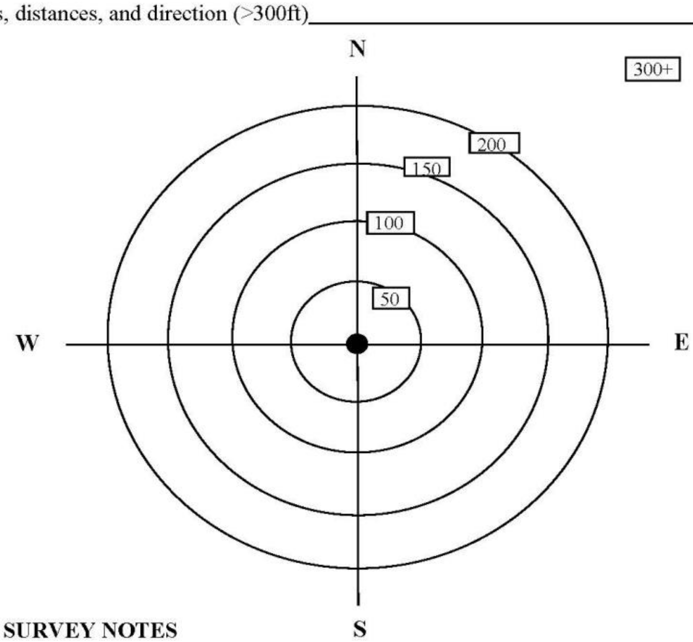
DIRECTIONS

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, 2019b).

In 2018 Scott County reported a total of 8,640 SSTS and 2.4 percent were inspected for compliance (MPCA, 2019a). Compliance inspections are required in Scott county when a new SSTS is installed, when adding a bedroom to a home, whenever a permit is requested to alter an existing system, when there is a change in use of the property, and when a system is changing form seasonal to year-round use. If the SSTS is determined to be an ITPHS, then it must be repaired or replaced within 10 months (Scott County, 2020).

FEEDLOT

The amount of nitrogen in manure depends on the species of animal. For example, there are 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 ($NH4+$) 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 (≥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 located 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, 2019c). A map and table of the feedlots located in the Scott County study area can be found below (Figure 9; Table 10).

Table 10. Feedlots and Permitted Animal Unit Capacity, Scott County

Township	Total Feedlots	Active Feedlots	Inactive feedlots	Average AU Permitted** Per Feedlot	Total Permitted** AU	Total Square Miles	Permitted** AU per Square Mile
Jackson	3	0	3	0	0	6	0
Louisville	4	0	4	0	0	15	0
Sand Creek	38	3	35	137	410	32	13
St. Lawrence	7	3	4	160	481	15	33
Total	52	6	46	*148	890	67	*13

*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 be have less livestock than permitted.

On average there are 13 AU per square mile (0.02 AU/acre) in the study area (Table 10). Manure is often applied to cropland so it is pertinent to look at the AU per cropland acre. In the Scott County study area livestock densities average 0.08 AU per acre of row crops (MPCA, 2019c; USDA NASS, 2013).

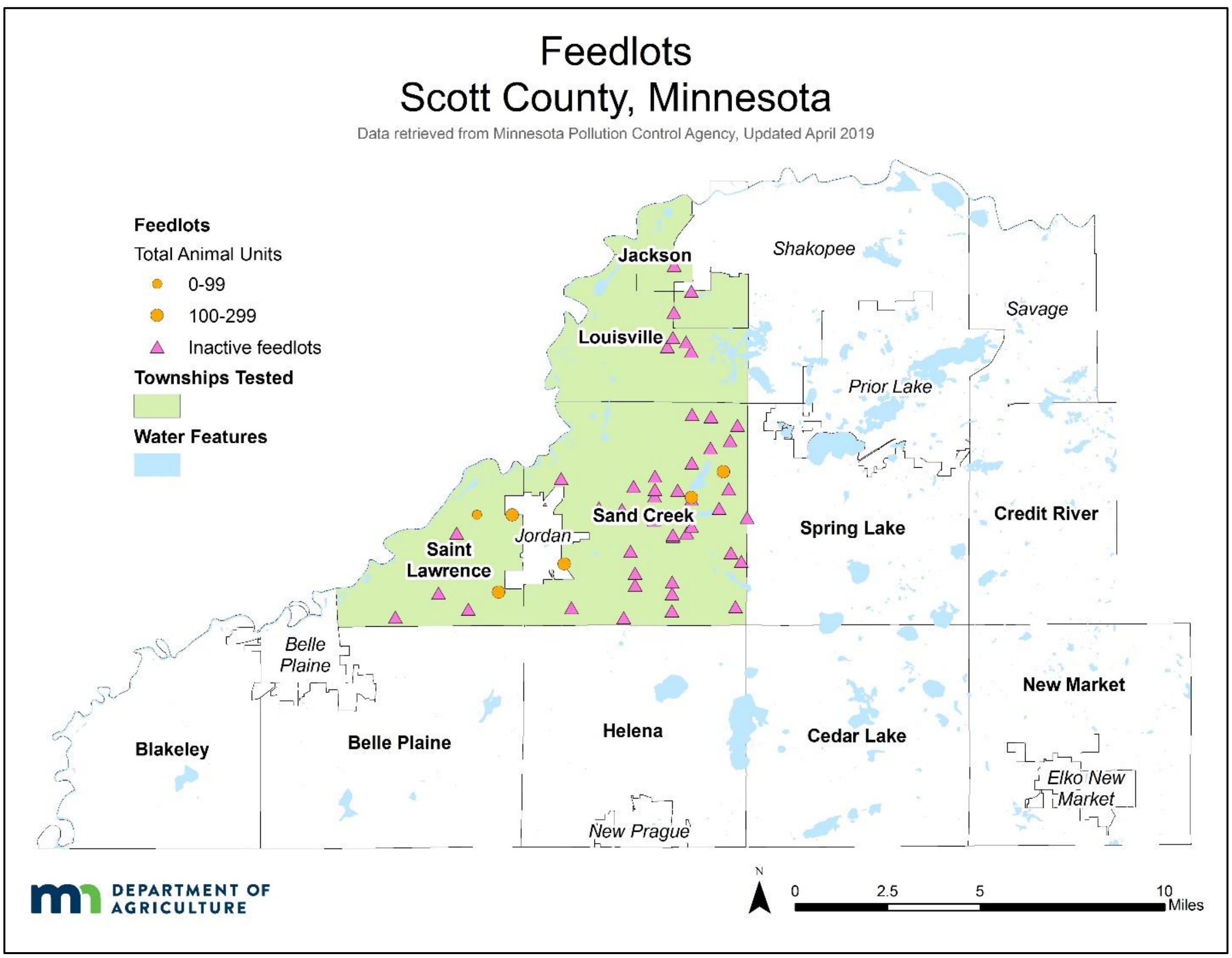


Figure 9. Feedlot Locations in Scott County (Minnesota Pollution Control Agency (MPCA, 2019c).

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, Scott County

Township	Bulk Fertilizer Storage	Anhydrous Ammonia	Chemigation Sites	Abandoned Sites	Total
Jackson	0	0	0	0	0
Louisville	0	0	0	0	0
Sand Creek	0	0	0	1	1
St. Lawrence	0	0	0	0	0
Total	0	0	0	1	1

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

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 Scott 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, 2019).

The MDA tracks several types of incidents. Incident investigations are typically for larger spills. There are none 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 1st, 2004 (MDA, 2019), 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 chemicals. 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, 2019). 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, Scott County

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

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

Township	Incidents and Spills
Jackson	1
Louisville	0
Sand Creek	0
St. Lawrence	0
Total	1

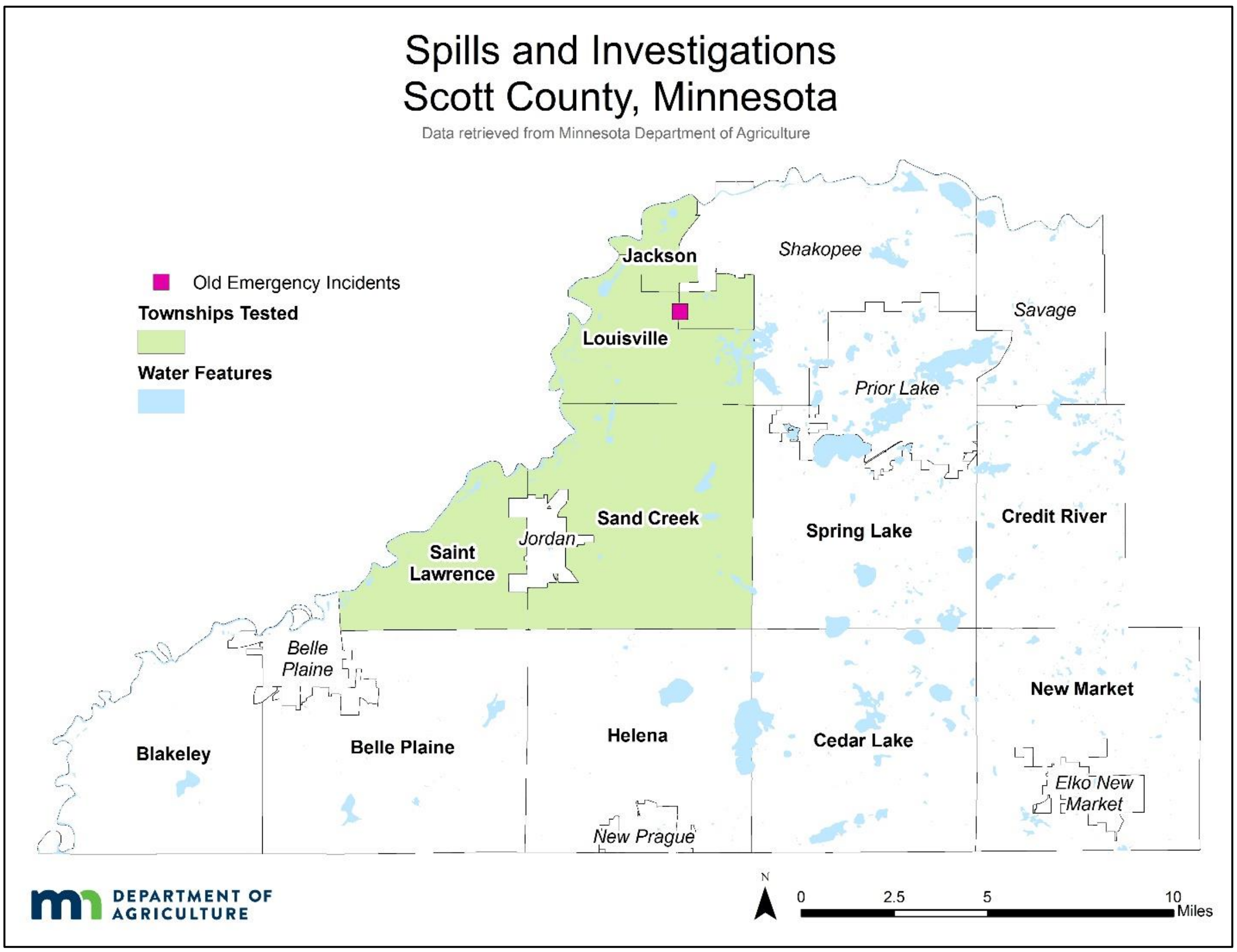


Figure 10. Fertilizer Spills and Investigations in Scott County (MDA, 2019)

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. Scott County is located on the southwest edge of the Twin Cities Metro area. The northeastern portion of the county is relatively highly developed, containing the cities of Prior Lake, Savage, and Shakopee. The rest of the county, including our study area, is primarily rural. The rural portion of Scott County has a significant amount of land devoted to 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.

Land cover in the tested townships consists primarily of agriculture, with 32 percent of the land cover dedicated to pasture or hay and 27 percent to row crop agriculture. Most of the rest of the land cover (21 percent) is forest. Relatively little land (6 percent) in the study area is considered developed (Figure 11; Table 14).

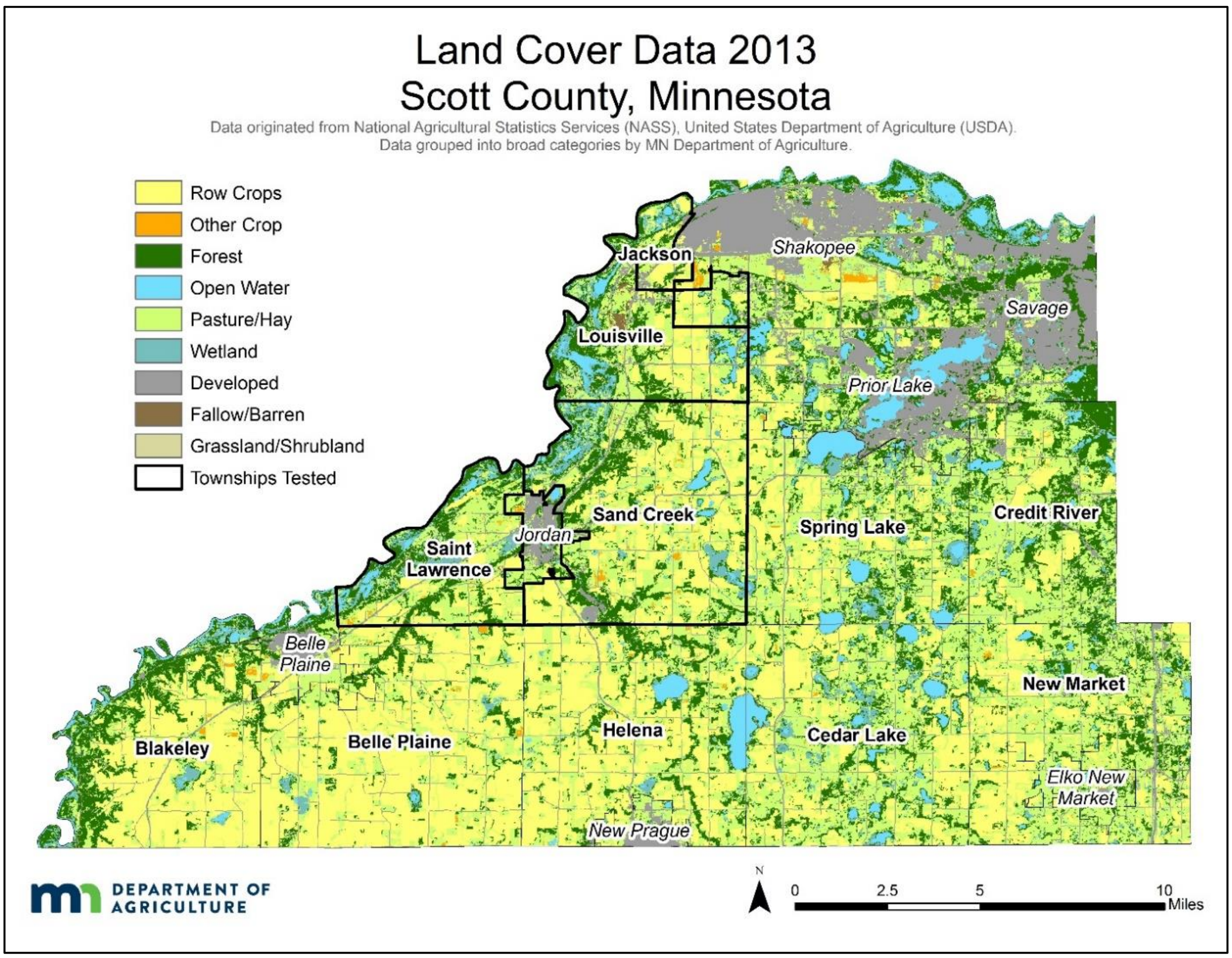


Figure 11. Land Cover in Scott County (USDA NASS Cropland Data Layer, 2013)

Table 14. Land Cover Data (2013) by Township, Scott 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
Jackson	4,057	25%	0%	19%	5%	31%	6%	12%	1%	1%
Louisville	9,291	18%	0%	24%	8%	31%	8%	7%	2%	3%
Sand Creek	20,774	34%	1%	19%	2%	31%	6%	6%	0%	1%
St. Lawrence	9,311	18%	1%	26%	4%	34%	10%	4%	0%	2%
Average	*43,433	27%	1%	21%	4%	32%	7%	6%	0%	2%

* 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 18 active groundwater well permits in the study area, two of which are used for agricultural irrigation (Figure 12). About 10 acres of cropland are permitted for groundwater irrigation in this area (Table 15). Most permitted wells are withdrawing groundwater from Paleozoic aquifers (Table 16; MDNR, 2018).

Table 15. Active Groundwater Use Permits by Township, Scott County

Township	Major Crop Irrigation Well Permits	Average Depth (feet)	Acres Permitted
Jackson	0	NA	0
Louisville	2	150	10
Sand Creek	0	NA	0
St. Lawrence	0	NA	0
Total	2	150	10

Table 16. Active Groundwater Use Permits by Aquifer, Scott County

Water Use Well Permits	Total	Average Depth (feet)	Aquifer		
			Water Table	Paleozoic	Not Classified
Major Crop Irrigation	2	150	0	2	0
Industrial Processing	3	338	0	1	2
Non-Crop Irrigation	2	405	0	2	0
Water Level Maintenance	2	400	0	2	0
Waterworks	9	251	2	7	0
Total	18	288	2	14	2

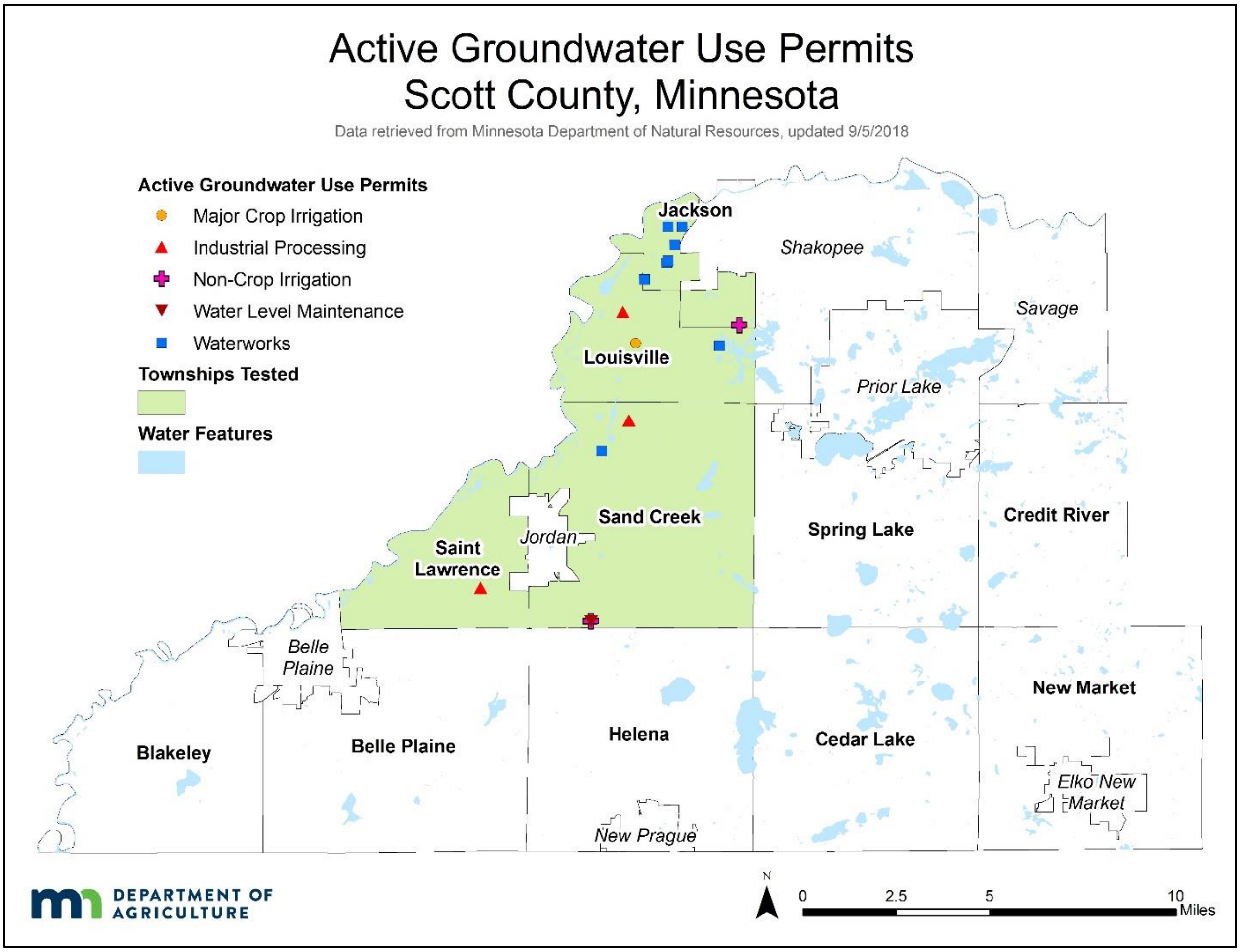


Figure 12. Active Groundwater Use Permits in Scott County (MDNR, 2018)

APPENDIX D

Nitrate Brochure

The Minnesota Department of Agriculture and the Scott 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.

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.***

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 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.

APPENDIX E

Table 17. Reasons Wells Were Removed from the Final Well Dataset by Township, Scott 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 Wells	Total
Jackson	0	1	0	0	1	0	2	1	5
Louisville	0	1	0	0	0	4	3	12	20
Sand Creek	0	0	0	0	0	1	0	0	1
St. Lawrence	1	0	0	0	0	0	0	3	4
Total	1	2	0	0	1	5	5	16	30

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

Township	Site Visit*	No Site Visit	Total
Jackson	3	2	5
Louisville	12	8	20
Sand Creek	0	1	1
St Lawrence	0	4	4
Total	15	15	30

* There are 6 shared wells in the study area. Five of those wells are shared with only one other neighbor from the township testing program and one well is a larger neighborhood well that serves 12 homes sampled in the township testing program. Only one site visit was conducted, and one follow-up sample collected per well, however all of the sites shared by the well are counted as having a site visit. Two of the six shared wells had a site visit. Thus, 16 sites with a shared well were removed from the final well dataset and six sites were left in the final well dataset to represent each of the six shared wells.

APPENDIX F

MINNESOTA WELL INDEX

The MWI was used to gather information about the four study area townships in Scott 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 773 documented (have a verified location in the MWI) drinking water wells:

- Most of these wells (75%) were completed in the Jordan Sandstone, the St. Lawrence Formation, or the Tunnel City Group. All these aquifers were deposited during the Cambrian period.
    - The most used aquifer in the study area was the Jordan sandstone, where 43% of wells were completed. These wells averaged 290 feet deep.
    - The second most used aquifer was the Tunnel City Group, where 21% of wells were completed. These wells averaged 322 feet deep.
- The Wonewoc Sandstone, Eau Claire Formation, and Mt. Simon Sandstone were all deposited during the Cambrian period as well, but they represent less than two percent of the completed wells.
- About 13 percent of wells were completed in Quaternary aquifers, which are the shallowest aquifers.
    - The most commonly used Quaternary aquifers were Quaternary buried artesian aquifers, where 9 percent of wells were completed. These wells averaged 206 feet deep. 3 percent of wells were completed in Quaternary buried unconfined aquifers (averaged 199 feet deep), and <1% were completed in Quaternary water table aquifers (averaged 123 feet deep).
        - Quaternary buried artesian aquifers and Quaternary buried unconfined aquifers are classified as having greater than 10 feet of confining material above them, while Quaternary water table aquifers have less than 10 feet of confining material (MPCA 1999).
- Two percent of wells were classified as being completed in multiple aquifers. These wells averaged 413 feet deep.
- For 7 percent of wells, the aquifer they were completed in was not available. The average depth of these wells was 271 feet.

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

Township	Quaternary Water Table	Quaternary Buried Artesian	Quaternary Buried Unconfined	Prairie Du Chien Group	Jordan Sandstone	St. Lawrence	Tunnel City	Wonewoc Sandstone	Eau Claire Formation	Mt. Simon Sandstone	Indeterminate	Multiple Aquifers	Not Available	Total
	Number of wells drawing water from an aquifer													
Jackson	0	0	0	1	126	1	0	0	0	0	2	1	9	140
Louisville	0	8	13	1	181	11	13	0	0	0	0	5	25	257
Sand Creek	5	60	11	0	23	59	83	5	2	1	0	10	15	274
St. Lawrence	1	2	1	0	0	15	69	7	0	0	0	1	6	102
Total	6	70	25	2	330	86	165	12	2	1	2	17	55	773
Average Well Depth (ft)	123	206	199	238	290	260	322	358	610	597	164	413	271	286

APPENDIX G

SWCD Logo

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 private 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 home from? Please choose only one.
   ☐ Sub-division ☐ Lake Home ☐River Home ☐ Country ☐Municipal/City* ☐ 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) ☐ Yes ☐ No
3. Do you mix or store fertilizer (500 lb. or more) on the farm site? ☐ Yes ☐ No
4. Does farming take place on this property? ☐ Yes ☐ No

WELL INFORMATION

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? ☐ Yes ☐ No ☐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**? ☐ Drilled ☐ Sand point ☐ Hand Dug Well ☐Don't Know ☐ Other
8. Year well was built? ☐ before 1975 ☐ 1975 to 1984 ☐ 1985 to 1993 ☐ 1994-Present ☐Don't Know
9. Approximate **depth** of your well? ☐ 0-15 Feet ☐ 16 - 49 Feet ☐ 50 -99 feet ☐ 100 - 299 feet ☐ >=300 feet
10. Distance to an active or inactive feedlot? ☐ 0 - 49 Feet ☐ 50 -99 feet ☐ 100 - 299 feet ☐ >=300 feet
11. Distance to a septic system? ☐ 0 - 49 Feet ☐ 50 -99 feet ☐ 100 - 299 feet ☐ >=300 feet
12. Distance to an agricultural field? ☐ 0 - 49 Feet ☐ 50 -99 feet ☐ 100 - 299 feet ☐ >=300 feet
13. Is this well currently used for human consumption (Drinking or Cooking)? ☐ Yes ☐ No
14. Please check any water treatment you have **other than a water softener**.
    ☐ None ☐ Reverse Osmosis ☐ Distillation ☐ Filtering system ☐ Other
15. When did you last have your well tested for nitrates?
    ☐ Never tested ☐ Within the last year ☐ Within the last 3 years
    ☐ Within the last 10 years ☐ Greater than 10 years ☐ Not sure
16. What was the result of your **last** nitrate test?
    ☐ <3 mg/L (ppm) ☐ 3<10 mg/L(ppm) ☐ >=10 mg/L (ppm) ☐ 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
Jackson	81	43.2%	0.0%	0.0%	0.0%	23.5%	4.9%	28.4%
Louisville	157	37.6%	1.3%	0.0%	15.9%	22.3%	3.8%	19.1%
Sand Creek	187	72.2%	0.0%	0.5%	0.0%	4.3%	2.7%	20.3%
St Lawrence	63	76.2%	0.0%	3.2%	0.0%	9.5%	0.0%	11.1%
Total	488	56.8%	0.4%	0.6%	5.1%	13.9%	3.1%	20.1%

Table 21. Well Construction Type

Township	Total	Drilled	Sand Point	Hand Dug	Other	Not Available
Jackson	81	65.4%	0.0%	0.0%	0.0%	34.6%
Louisville	157	70.7%	0.0%	0.0%	0.0%	29.3%
Sand Creek	187	75.9%	1.1%	0.0%	0.0%	23.0%
St Lawrence	63	74.6%	1.6%	0.0%	0.0%	23.8%
Total	488	72.3%	0.6%	0.0%	0.0%	27.0%

Table 22. Age of Well

Township	Total	1994 to Present	1985 to 1993	1975 to 1984	Before 1975	Not Available
Jackson	81	27.2%	16.0%	17.3%	12.3%	27.2%
Louisville	157	42.0%	10.2%	6.4%	16.6%	24.8%
Sand Creek	187	31.0%	9.6%	13.4%	23.0%	23.0%
St Lawrence	63	38.1%	7.9%	12.7%	20.6%	20.6%
Total	488	34.8%	10.7%	11.7%	18.9%	24.0%

Table 23. Depth of Well

Township	Total	0-15 feet	16-49 feet	50-99 feet	100-299 feet	≥300 feet	Not Available
Jackson	81	0.0%	1.2%	1.2%	28.4%	25.9%	43.2%
Louisville	157	0.0%	0.6%	1.3%	33.8%	31.2%	33.1%
Sand Creek	187	0.0%	0.0%	7.5%	48.1%	17.6%	26.7%
St Lawrence	63	0.0%	1.6%	3.2%	46.0%	14.3%	34.9%
Total	488	0.0%	0.6%	3.9%	40.0%	23.0%	32.6%

Table 24. Unique Well ID Known

Township	Total	No, Unique Well ID not known	Yes, Unique Well ID known	Not Available
Jackson	81	16.0%	17.3%	66.7%
Louisville	157	14.0%	16.6%	69.4%
Sand Creek	187	24.1%	10.2%	65.8%
St Lawrence	63	22.2%	25.4%	52.4%
Total	488	19.3%	15.4%	65.4%

Table 25. Livestock Located on Property

Township	Total	No Livestock	Yes Livestock	Not available
Jackson	81	79.0%	1.2%	19.8%
Louisville	157	82.8%	2.5%	14.6%
Sand Creek	187	80.7%	4.8%	14.4%
St Lawrence	63	87.3%	6.3%	6.3%
Total	488	82.0%	3.7%	14.3%

Table 26. Fertilizer Stored on Property

Township	Total	No Fertilizer Stored	Yes Fertilizer Stored	Not Available
Jackson	81	79.0%	1.2%	19.8%
Louisville	157	84.1%	0.0%	15.9%
Sand Creek	187	85.0%	0.5%	14.4%
St Lawrence	63	92.1%	1.6%	6.3%
Total	488	84.6%	0.6%	14.8%

Table 27. Farming on Property

Township	Total	No Farming	Yes Farming	Not available
Jackson	81	66.7%	13.6%	19.8%
Louisville	157	77.1%	6.4%	16.6%
Sand Creek	187	64.2%	20.9%	15.0%
St Lawrence	63	71.4%	22.2%	6.3%
Total	488	69.7%	15.2%	15.2%

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
Jackson	81	3.7%	2.5%	2.5%	50.6%	40.7%
Louisville	157	3.2%	1.9%	1.9%	65.6%	27.4%
Sand Creek	187	4.3%	2.7%	4.3%	59.4%	29.4%
St Lawrence	63	9.5%	4.8%	3.2%	57.1%	25.4%
Total	488	4.5%	2.7%	3.1%	59.6%	30.1%

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
Jackson	81	2.5%	22.2%	32.1%	12.3%	30.9%
Louisville	157	3.2%	19.1%	49.7%	8.3%	19.7%
Sand Creek	187	0.5%	22.5%	44.9%	13.9%	18.2%
St Lawrence	63	1.6%	19.0%	42.9%	22.2%	14.3%
Total	488	1.8%	20.9%	44.1%	12.9%	20.3%

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
Jackson	81	2.5%	3.7%	8.6%	51.9%	33.3%
Louisville	157	2.5%	1.9%	12.7%	59.2%	23.6%
Sand Creek	187	1.6%	8.0%	18.2%	48.7%	23.5%
St Lawrence	63	3.2%	14.3%	28.6%	42.9%	11.1%
Total	488	2.3%	6.1%	16.2%	51.8%	23.6%

Table 31. Drinking Water Well

Township	Total	Not Drinking Water	Yes, Drinking Water	Not Available
Jackson	81	0.0%	81.5%	18.5%
Louisville	157	0.6%	86.0%	13.4%
Sand Creek	187	1.6%	84.0%	14.4%
St Lawrence	63	0.0%	93.7%	6.3%
Total	488	0.8%	85.5%	13.7%

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

Township	Total	None	Distillation	Filtering System	Reverse Osmosis	Other	Not Available
Jackson	81	42.0%	0.0%	24.7%	3.7%	2.5%	27.2%
Louisville	157	37.6%	0.0%	22.9%	18.5%	1.9%	19.1%
Sand Creek	187	35.8%	0.0%	23.5%	18.2%	2.7%	19.8%
St Lawrence	63	42.9%	0.0%	25.4%	12.7%	6.3%	12.7%
Total	488	38.3%	0.0%	23.8%	15.2%	2.9%	19.9%

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
Jackson	81	1.2%	9.9%	2.5%	9.9%	28.4%	29.6%	18.5%
Louisville	157	3.8%	5.7%	8.9%	10.8%	28.0%	26.1%	16.6%
Sand Creek	187	3.7%	9.6%	8.0%	6.4%	30.5%	25.1%	16.6%
St Lawrence	63	3.2%	11.1%	6.3%	9.5%	27.0%	33.3%	9.5%
Total	488	3.3%	8.6%	7.2%	8.8%	28.9%	27.3%	16.0%

Table 34. Last Nitrate Test Result

Township	Total	<3 mg/L Nitrate-N	3<10 mg/L Nitrate-N	≥10 mg/L Nitrate-N	Not Available
Jackson	81	3.7%	1.2%	0.0%	95.1%
Louisville	157	3.8%	1.9%	0.6%	93.6%
Sand Creek	187	7.0%	1.1%	0.0%	92.0%
St Lawrence	63	3.2%	1.6%	0.0%	95.2%
Total	488	4.9%	1.4%	0.2%	93.4%

APPENDIX I

Table 35. Well Construction Type for Final Well Dataset

Township	Total Wells	Drilled	Sand Point	Not Available
Jackson	76	70	0	6
Louisville	137	133	0	4
Sand Creek	186	165	2	19
St Lawrence	59	53	0	6
Total	458	421	2	35

Data compiled from well logs and homeowner responses.

Table 36. Well Depth for Final Well Dataset

Township	Total Wells	Min	Max	Median	Mean
Jackson	50	220	380	303	305
Louisville	98	95	520	300	301
Sand Creek	95	96	597	281	280
St Lawrence	32	96	420	248	261
Total	275	95	597	300	290

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
Jackson	49	1973	2016	1994	1994
Louisville	97	1970	2014	1998	1997
Sand Creek	93	1966	2018	1999	1997
St Lawrence	32	1973	2012	1996	1995
Total	271	1966	2018	1998	1996

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 (^{o}F)______

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

Time	Temp ^{o}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
Jackson	29	10.37	13.31	10.94	11.18
Louisville	47	10.20	14.76	11.20	11.39
Sand Creek	6	10.24	11.15	10.81	10.76
St Lawrence	5	10.43	11.54	11.26	11.13
Total	87	10.20	14.76	11.09	11.26

Table 39. pH of Well Water for Final Well Dataset

Township	Samples	Min	Max	Median	Mean
Jackson	29	7.14	7.53	7.32	7.32
Louisville	47	7.10	7.60	7.30	7.31
Sand Creek	6	7.35	7.70	7.50	7.49
St Lawrence	5	7.44	7.81	7.52	7.56
Total	87	7.10	7.81	7.33	7.34

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

Township	Samples	Min	Max	Median	Mean
Jackson	29	538	831	714	718
Louisville	47	420	1,128	756	772
Sand Creek	6	557	965	702	734
St Lawrence	5	578	868	777	723
Total	87	420	1,128	743	748

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

Township	Samples	Min	Max	Median	Mean
Jackson	29	0.13	10.06	2.12	3.03
Louisville	47	0.15	9.43	1.59	2.75
Sand Creek	6	0.23	5.80	0.37	1.47
St Lawrence	5	0.17	6.04	3.60	2.98
Total	87	0.13	10.06	1.84	2.77