



INITIAL TOWNSHIP TESTING OF NITRATE  
IN PRIVATE WELLS  
STEARNS COUNTY 2014 SUMMARY

January 2016

Minnesota Department of Agriculture

Pesticide and Fertilizer Management Division

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## ACKNOWLEDGEMENTS

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## EXECUTIVE SUMMARY

In 2014, fourteen townships were selected to participate in a large scale nitrate assessment of private wells. The townships were chosen based on several criteria such as expertise from the local Soil and Water Conservation District (SWCD), past high nitrate results, vulnerable groundwater, and row crop production. Samples were collected from private wells using homeowner collection and mail-in methods.

According to the County Well Index (CWI) the Quaternary buried aquifers are more readily used than the water table aquifers in the selected townships. Samples were collected from 1,894 wells representing a 29 percent response rate from homeowners.

Results showed that across the fourteen townships, seven percent of private wells sampled were above the health standard of 10 mg/L for nitrate as nitrogen (nitrate-N). In Brockway, Grove and Wakefield Township, greater than 10 percent of wells were above 10 mg/L nitrate-N.

This initial homeowner collected sampling was followed by a second sampling offered to homeowners with wells that had a detectable nitrate result. The second sampling collected by the Minnesota Department of Agriculture will be discussed further in a follow-up report in 2016.

## INTRODUCTION

The Minnesota Department of Agriculture (MDA) has recently updated the 1990 Nitrogen Fertilizer Management Plan (NFMP), which is the state's blueprint for prevention or minimization of the impacts of nitrogen fertilizer on groundwater. To effectively manage nitrate contamination of water resources, it is appropriate to focus on areas of greatest risk. Testing for nitrate in private wells is one method for identifying areas and wells at greatest risk. For this, the MDA has developed the "Township Testing Program". In the Township Testing Program (TTP), the MDA works with local partners (counties and SWCDs) to collect and analyze water samples from private drinking water wells within townships that either had high nitrate results previously or exist in an area with high aquifer vulnerability and a high percentage of row crop production.

This testing conducted in Stearns County is part of a statewide assessment as the MDA plans to offer nitrate tests to approximately 70,000 private well owners (within 250-350 townships) between 2014 and 2019. As of spring 2015, 60 townships in eight counties have been completed.

For further information on this program, please visit the project webpage at: <http://www.mda.state.mn.us/protecting/cleanwaterfund/gwdwprotection/townshiptesting.aspx>

## BACKGROUND

In many rural areas of the state, nitrate is one of the most common contaminants in Minnesota's groundwater. In some areas of the state 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 man-made 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 U.S. Environmental Protection Agency (USEPA) has established a drinking water Maximum Contaminant Level (MCL) of 10 mg/L for nitrate as nitrogen (nitrate-N) (U.S. 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. Nitrite concentration is commonly less than the reporting level of 0.01 mg/L, resulting in negligible contribution to the nitrate plus nitrite concentration (Nolan and Stoner, 2000). In the environment, nitrite generally converts to nitrate quickly, which means nitrite occurs very rarely in groundwater. 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 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. Shallow groundwater in coarse-textured soils (glacial outwash) generally has low concentrations of organic carbon and is well oxygenated, so denitrification is often limited in these conditions. As a result areas like Stearns County with extensive glacial outwash aquifers and intensive row crop agriculture are particularly vulnerable to elevated nitrate concentrations. However, geochemical conditions can be highly variable within an aquifer or region and can also change over-time (MPCA, 1998).

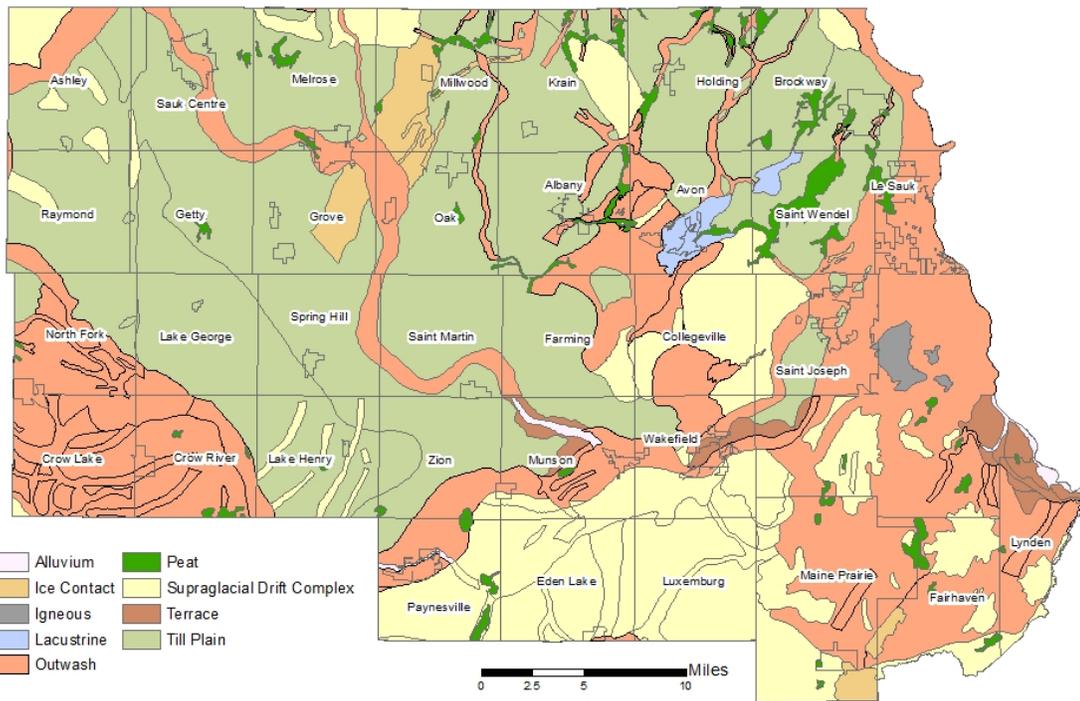
## GEOLOGY AND HYDROGEOLOGY

The geology in Stearns County is heavily influenced by glacial till and outwash plains. Glacial outwash is relatively coarse-textured compared to other glacial deposits such as till and drift deposits. Outwash consists primarily of sand and gravel deposited by running water that flowed from melting ice during the last glacial period. This region's deposits are associated with the Des Moines Lobe and the Superior Lobe glacial ice advances. The outwash sand and gravel is typically deposited in a stratified (layered) fashion as the glacial melt conditions change. The coarse-textured deposits associated with glacial outwash often allow contaminants from the surface to travel rapidly to the water table aquifers. Statewide geomorphological mapping conducted by the Minnesota Department of Natural Resources (MDNR), the Minnesota Geological Survey (MGS) and the University of Minnesota at Duluth (MDNR, MGS and UMD, 1997) indicates the extent of glacial deposits in Stearns County as presented in Figure 1.

Only one third of Stearns County is underlain by water table aquifers. These aquifers can be found in the Brooten-Belgrade area (southwest corner) or meandering along the Sauk and Mississippi Rivers. The majority the county is underlain by Quaternary confined aquifers that are generally more than ten feet thick (MNDNR, 1998).

The same geologic mapping project presented in Figure 1 was used to classify the state into aquifer sensitivity ratings. Sensitivity ratings are described in Table 1. There are three ratings for aquifer sensitivity: low, medium and high (Figure 2). The ratings are based upon guidance from the Geologic Sensitivity Project Workgroup's report "Criteria and Guidelines for Assessing Geologic Sensitivity in Ground Water Resources in Minnesota" (MDNR, 1991).

## Stearns County Geomorphology-Sediment Association



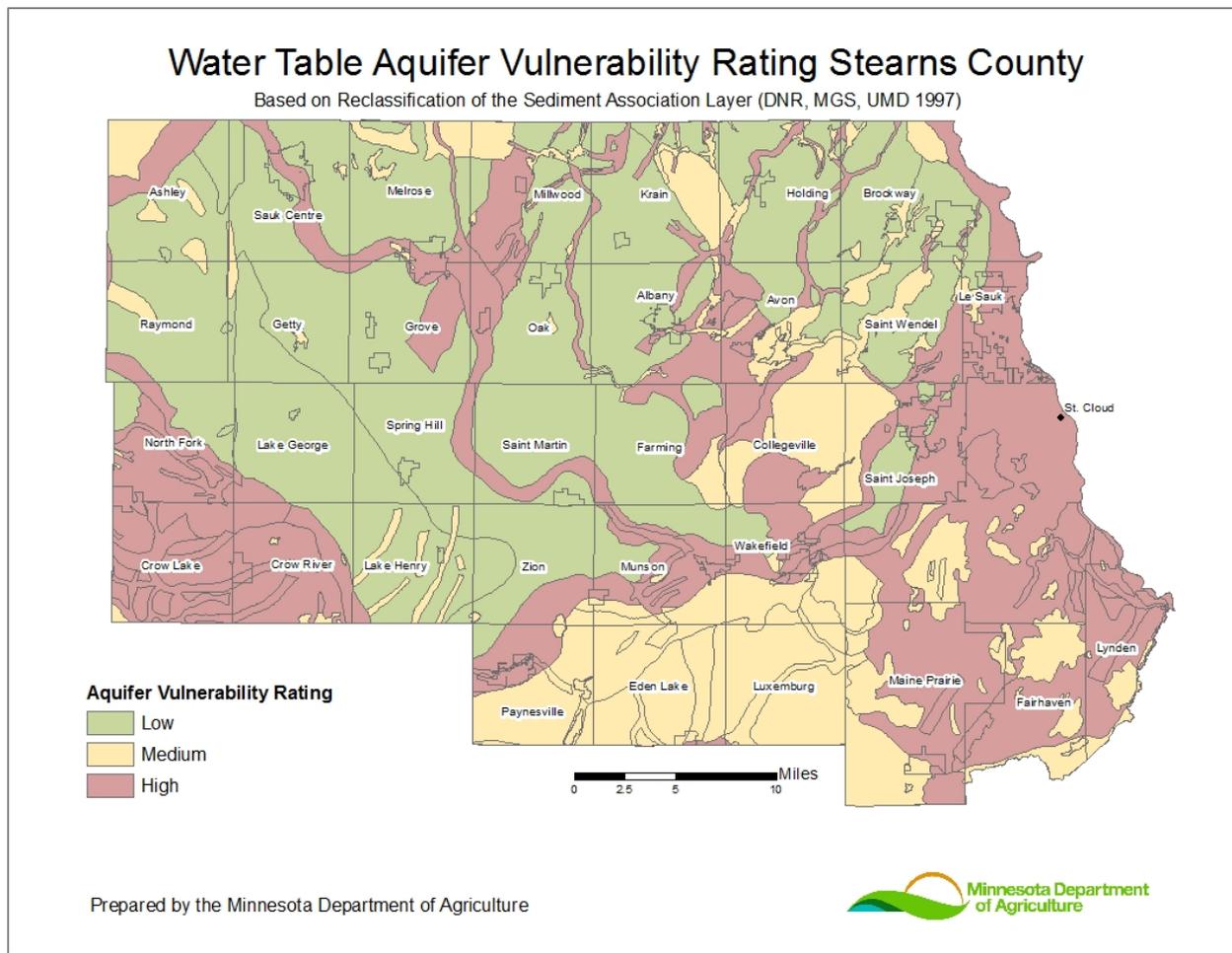
Prepared by the Minnesota Department of Agriculture



Figure 1. Stearns County Geomorphology from the Sediment Association (DNR, MGS, UMD 1997).

Table 1. Vulnerability Ratings Based on the Geomorphology of Minnesota, Sediment Association Layer.

Sediment Association	Sensitivity/Vulnerability Rating
Alluvium, Outwash, Ice Contact, Terrace, Bedrock: Igneous, Metamorphic, and Sedimentary	High
Supraglacial Drift Complex, Peat, Lacustrine	Medium
Till Plain	Low



**Figure 2. Water Table Aquifer Vulnerability Rating for Stearns County.**

## GEOLOGIC ATLAS

The County Geologic Atlas examines a county's geology and groundwater aquifers. The atlas describes bedrock and surficial geology, hydrogeology of the aquifer and the connection of land surface to groundwater (MGS, 2015). This information is an important resource for groundwater management. It can aid in activities such as monitoring, appropriation, permitting, remediation, and well construction.

A complete geologic atlas consists of two parts:

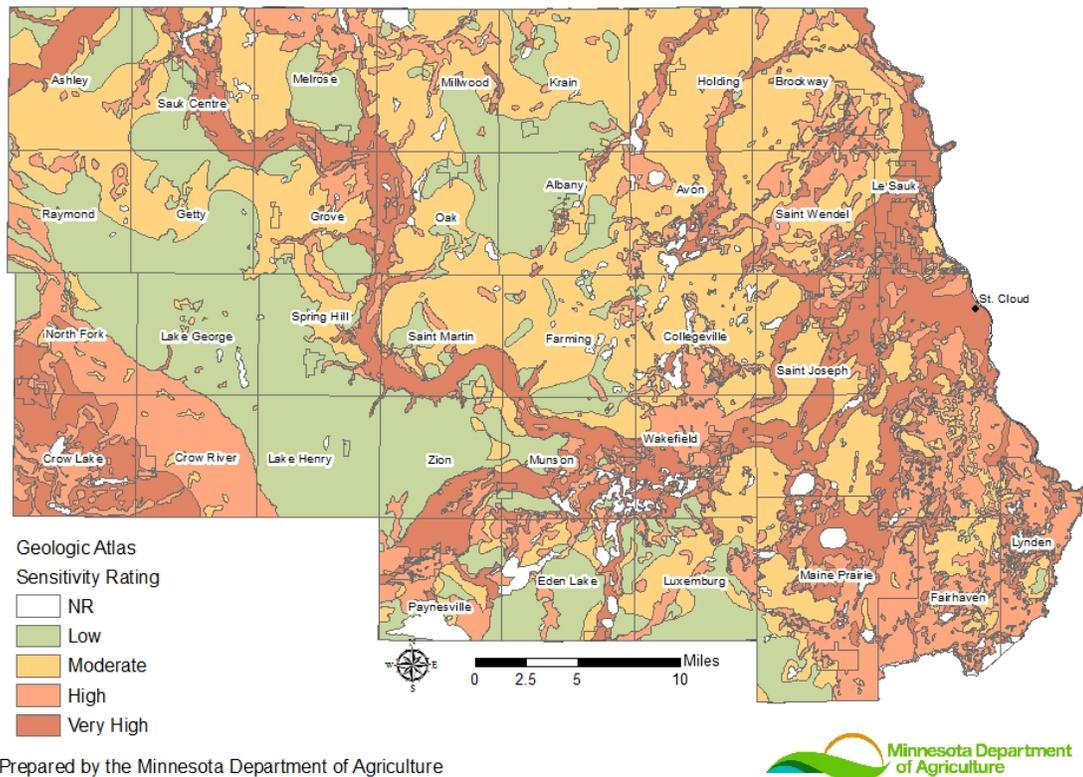
- Part A (prepared by MGS), which includes the water well database and 1:100,000 scale geologic maps. These maps focus on the geology of the county, and

- Part B (developed by the Minnesota Department of Natural Resources Division of Waters) which includes maps of water levels in aquifers, direction of groundwater flow, water chemistry, and sensitivity to pollution.

According to the Stearns County Geologic Atlas more than half of the wells are completed in confined aquifers and the remaining wells are completed in surficial sand and gravel aquifers. Groundwater in surficial aquifers is very susceptible to nitrate contamination (Meyer, 1995).

An important analysis provided by Part B of the Atlas is called the “Sensitivity of Ground-Water Systems to Pollution” (MDNR, 1998). This rating is based on the time for water to travel from the land surface to a depth of ten feet (Figure 3). The water table aquifer vulnerability map (Figure 2) is somewhat similar to the Part B map when comparing at a one-dimensional level, however, the Part B map has a higher level of detail.

## Stearns County Geologic Atlas Part B: Sensitivity of Ground-Water Systems to Pollution



**Figure 3. Stearns County Geologic Atlas Part B: Sensitivity of Ground-Water Systems to Pollution (MDNR, 1998).**

### COUNTY WELL INDEX

The County Well Index (CWI) is a database system developed by the MGS and the MDH for the storage, retrieval, and editing of well information. The database contains basic information on well records (e.g. location, depth, static water level) for wells drilled in Minnesota. The database also contains information on the well log and the well construction for many private drinking water wells. The CWI is instrumental in the development of the Geologic Atlas described in the previous section. The CWI is the most comprehensive Minnesota well database available, but contains only information for wells in which a well log is available. It is important to note that most records in the CWI are for wells drilled after 1974, when water well construction code required well drillers to submit records to the MDH. The CWI does contain data for some records obtained by the MGS for wells drilled before 1974 (MGS, 2015).

The CWI was used to gather information about the fourteen townships in Stearns County included in this study. Table 2 summarizes the general aquifer types, while the

following section is a brief summary of the major aquifer types with the average well depth. According to the information from the CWI (MDH, 2015):

In the selected townships there are 2,001 wells with known locations:

- Seventeen percent are completed in the shallow Quaternary Water Table Aquifer (QWTA) and average 60 feet deep.
  - QWTA wells are defined as having less than ten feet of confining material (clay) between the land surface and the well screen (MPCA, 1998). When there is less than ten feet of clay, it allows surface contaminants to travel quickly to the water table aquifers. In general, shallower wells completed in the QWTA may be more susceptible to nitrate contamination.
- Forty-nine percent are completed in a Quaternary buried aquifer and average 78 feet deep.
  - Buried aquifer wells have more than ten feet of confining material between the land surface and the well screen.
- One percent are designated as Quaternary undifferentiated, which means the only information available is that the well is completed in a Quaternary deposit.
- Cretaceous aquifers are utilized in six percent of the wells. The average depth is 131 feet deep.
  - These sedimentary rocks have been eroded by glacial events and remain mostly in the eastern part of the county (Meyer, 1995).
- Precambrian aquifers are utilized in only two percent of the wells. The average depth is 198 feet deep.
  - Generally Precambrian rocks are dense and are not considered aquifers. However, in a few locations fractures in the rock or weathered zones allow for some water storage (MNDNR, 1998).

**Table 2. Aquifer Type Distribution of Wells in Stearns County from the County Well Index.**

Totals Wells	Aquifer Type						
	QWTA	Quaternary Buried	Quaternary Undifferentiated	Cretaceous	Precambrian	Undesignated	Other
2,001	17%	49%	1%	6%	2%	22%	3%

## NITRATE PROBABILITY MAPPING

In many areas nitrate probability maps have been developed by the MDH to assist in local water quality planning efforts. These maps identify areas of a county with relatively high, moderate, and low probability of having elevated nitrate concentrations in ground water. The goal of nitrate probability mapping is to help protect public and private drinking water supplies, help prevent further contamination by raising awareness and assist in local planning and prevention. The nitrate probability map is similar in appearance compared to the updated aquifer vulnerability map; however it shows less area categorized in the high rating. Stearns County's report was published in 2002 and can be accessed here:

<http://www.health.state.mn.us/divs/eh/water/swp/nitrate/reports/2002method/stearns.pdf>

## MDA PRIVATE WELL MONITORING

The MDA has two primary approaches to monitoring for nitrate in private drinking water wells. The first approach is to use a statistically designed private well regional network that incorporates more than one county into a region. The Central Sands Private Well Network is considered a regional network; it includes a fourteen county area in the central area of Minnesota. Results are considered to reflect levels of nitrate contamination across the region. The second approach is monitoring on a township level; the Township Testing Program. The two approaches are discussed separately below.

## CENTRAL SANDS PRIVATE WELL NETWORK RESULTS

In the spring of 2011, a total of 1,555 private drinking water wells were sampled for nitrate concentrations (Figure 4 and Table 3). Homeowners from 14 counties were systematically selected to participate in this project and had their private well water tested for free. Overall, results from the fourteen counties combined showed that 88 percent of the 1,555 wells had nitrate-N concentrations less than 3 mg/L, seven percent ranged from 3-9.9 mg/L and five percent of wells had concentrations greater than 10 mg/L (MDA, 2012).

For more information about the Central Sands Private Well Network, please visit:

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

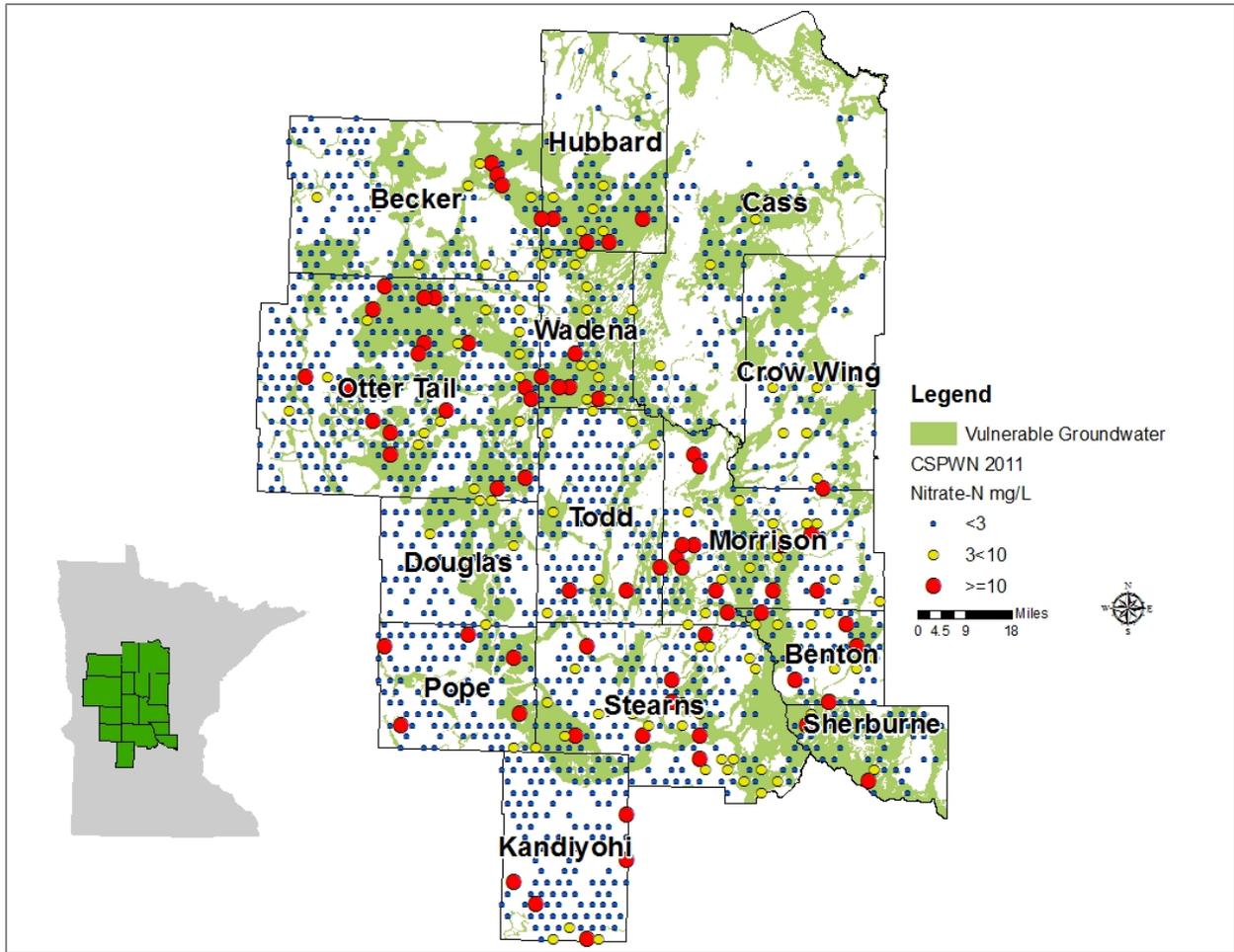


Figure 4. Results from the Central Sands Private Well Network 2011 Sampling Event.

**Table 3. Central Sands Private Well Network 2011 Results Summary.**

County	Number of Samples	2011 Results					
		Nitrate-N mg/L			Percent		
		Min	Median	Max	<3 (mg/L)	3<10 (mg/L)	≥10 (mg/L)
Becker	123	<.03	<.03	15.4	93%	5%	2%
Benton	57	<.03	<.03	15.6	79%	12%	9%
Cass	82	<.03	<.03	9.5	96%	4%	0%
Crow Wing	66	<.03	<.03	8.3	92%	8%	0%
Douglas	90	<.03	<.03	8.8	94%	6%	0%
Hubbard	65	<.03	<.03	29.3	85%	8%	8%
Kandiyohi	117	<.03	<.03	38.7	93%	3%	4%
Morrison	124	<.03	<.03	33.9	78%	11%	11%
Ottertail	320	<.03	<.03	32.7	90%	4%	5%
Pope	93	<.03	<.03	35.0	94%	1%	5%
Sherburne	42	<.03	<.03	40.0	91%	5%	5%
Stearns	167	<.03	<.03	49.8	82%	13%	4%
Todd	137	<.03	<.03	81.0	93%	5%	2%
Wadena	72	<.03	0.09	49.2	75%	17%	8%
Average	1,555 <i>total samples</i>	<.03	0.01	31.9	88.6%	6.8%	4.6%

## TOWNSHIP TESTING

The MDA has recently updated the 1990 Nitrogen Fertilizer Management Plan (NFMP). The NFMP is the state’s blueprint for prevention or minimization of the impacts of nitrogen fertilizer on groundwater. Updating of the NFMP provides an opportunity to restructure county and the state strategies for reducing nitrate contamination of groundwater, with more specific, localized accountability for nitrate contamination from agriculture. In order to effectively reduce nitrate contamination of groundwater resources, it is necessary to identify areas of concern. Areas of concern tend to be fairly

localized and therefore township boundaries were selected for nitrate testing. Factors such as aquifer vulnerability, row crop production and previous nitrate results are used to prioritize townships for sampling. Townships with at least 30 percent of the area characterized with vulnerable groundwater and at least 20 percent of the area in row crop production are shown in Figure 5. This map serves as a starting point for planning sample locations and is modified based on local expertise.

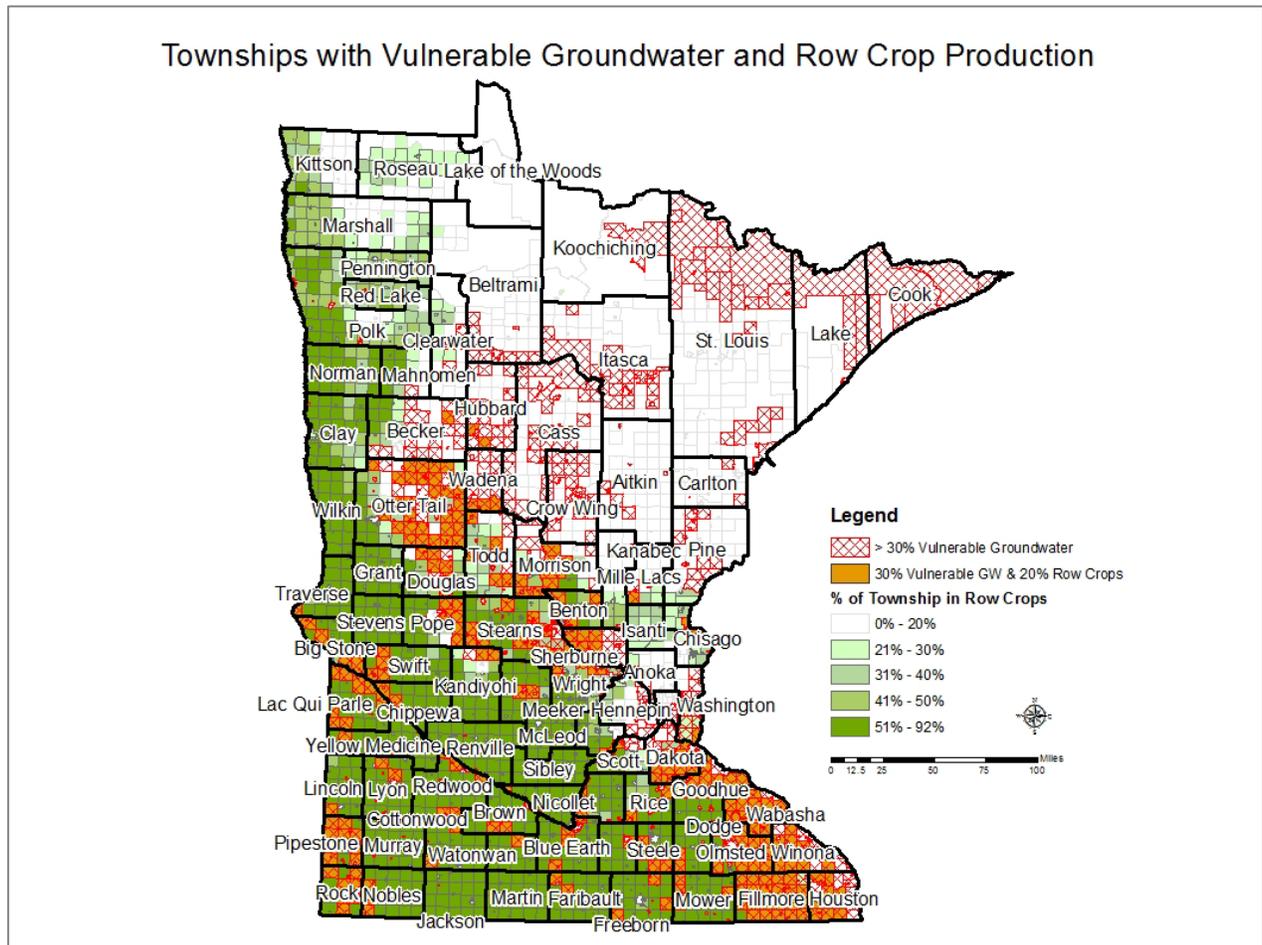


Figure 5. Townships with Vulnerable Groundwater and Row Crop Production.

## METHODS

Fourteen townships were chosen for sampling based on the following criteria: local expertise from the Stearns Soil and Water Conservation District (SWCD), past high nitrate results, vulnerable groundwater, and row crop production. In the spring of 2014, households with private wells received an invitation letter from the Stearns SWCD to participate in the free nitrate testing supported by MDA. Homeowners with private wells were sent a water sample kit (by a certified lab) which included a survey about their

well, sample bottle, sample instructions, and a pre-paid return mailer. All costs of the kit were paid by the MDA using Clean Water Funds. Homeowners were asked to complete the well survey, fill the sample bottle, and mail the sample to the certified lab in the prepaid mailer. Once the sample was analyzed, the lab sent homeowners their results in the mail. The selected townships are listed in Table 4.

**Table 4. Township Population, Households, Sample Kit Distribution and Return Rate.**

Township Name	2013 Population**	2013 Households**	Kits Sent	Water Samples returned to Lab	Return Rate
Brockway	2,690	987	967	267	28%
Crow Lake	330	138	137	34	25%
Crow River	352	118	125	46	37%
Fairhaven	1,558	569	572	153	27%
Grove	472	168	165	48	29%
Le Sauk	1,582	566	497	165	33%
Lynden	1,968	698	722	234	32%
Maine Prairie	1,908	703	689	204	30%
Melrose	817	280	276	68	25%
Millwood	1,020	354	356	88	25%
Munson	1,363	559	683	201	29%
North Fork	266	98	84	20	24%
Oak	605	197	186	53	28%
Wakefield	2,973	1,045	1,046	314	30%
Total	17,904	6,480	6,505	1,894	*29%

\* Represents the average return rate.

\*\* Minnesota State Demographic Center and the Metropolitan Council, 2013.

## RESULTS

Homeowners returned 1,894 water samples for analysis across the 14 townships (Figure 6). On average, 29 percent of households in these townships responded to the free nitrate test offered by the MDA (Table 4). The results of the township nitrate sampling are displayed in Figure 6.

The summary statistics for all well construction types *except* known hand dug wells are shown in Table 5. There were 11 known hand dug wells in the initial returned samples. 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. The following paragraphs provide a brief discussion of the statistics presented in Table 5, which does *not* include hand dug wells.

The minimum values for each township were less than the detection limit (DL) which is 0.03 mg/L. The maximum values ranged from 9.2 to 69.8 mg/L, with Melrose Township having the highest result. Median values range from less than the DL to 0.6 mg/L, with Brockway Township having the highest median value. The 90th percentiles range from 1.3 to 13.8 mg/L, with Grove Township having the highest 90th percentile.

Results from the sampling showed that in Brockway, Grove, and Wakefield Townships ten percent or more of the wells were over 10 mg/L. Previous sampling of 167 wells in Stearns County showed that only four percent of wells sampled county wide were at or over 10 mg/L (MDA, 2012). This data suggests that private well water in Brockway, Grove and Wakefield Townships are more heavily impacted by nitrate than other areas of Stearns County. Table 6 shows township results compared with percent of the area in row crop production and in vulnerable geology.

These results contrast findings from a 2010 USGS report on nitrate concentrations in private wells in the glacial aquifer systems across the upper United States in which less than five percent of sampled private wells had nitrate concentrations greater than 10 mg/L (Warner and Arnold, 2010). Both studies indicate that nitrate concentrations can vary considerably over short distances.

## Stearns County 2014 Initial Township Testing Results

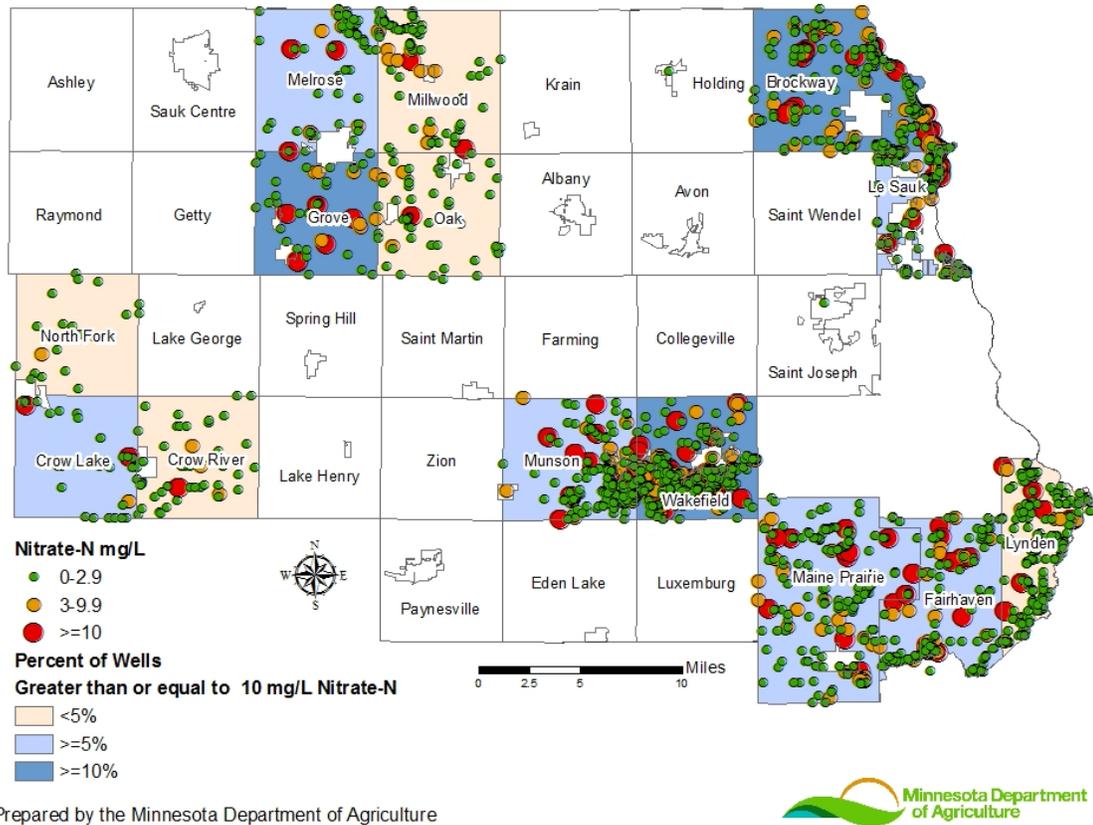


Figure 6. Stearns County 2014 Initial Township Testing Results.

**Table 5. Stearns County Initial Township Testing Summary Statistics, does not Include Known Hand Dug Wells.**

Township	Total Wells	Values			Percentiles					Number of Wells					Percent				
		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 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 parts per million (ppm)																	
Brockway	263	< DL	36.4	3.1	0.6	3.7	10.2	16.0	27.6	193	43	53	38	27	73%	16%	20%	14%	10%
Crow Lake	34	< DL	32.7	1.9	< DL	0.3	2.5	15.4	32.7	31	1	3	2	2	91%	3%	9%	6%	6%
Crow River	46	< DL	31.4	1.3	< DL	0.3	2.4	9.7	31.4	42	3	3	3	1	91%	7%	7%	7%	2%
Fairhaven	152	< DL	51.2	2.9	< DL	1.8	8.8	13.2	36.2	118	21	29	22	13	78%	14%	19%	14%	9%
Grove	46	< DL	27.2	3.6	< DL	3.9	13.8	20.8	27.2	32	8	9	8	6	70%	17%	20%	17%	13%
Le Sauk	164	< DL	36.8	2.6	< DL	3.2	7.7	13.3	24.2	120	31	30	20	13	73%	19%	18%	12%	8%
Lynden	233	< DL	23.0	0.8	< DL	0.1	1.3	6.0	14.6	214	12	14	10	7	92%	5%	6%	4%	3%
Maine Prairie	204	< DL	30.3	2.0	< DL	1.1	7.4	10.7	23.3	162	30	33	25	12	79%	15%	16%	12%	6%
Melrose	67	< DL	69.8	2.8	< DL	1.2	8.0	11.2	61.2	55	8	11	8	4	82%	12%	16%	12%	6%
Millwood	87	< DL	15.0	1.1	< DL	0.3	3.5	7.3	14.1	77	8	8	5	2	88%	10%	10%	6%	2%
Munson	201	< DL	41.2	1.8	< DL	0.5	6.5	12.1	23.3	170	19	25	18	12	85%	9%	12%	9%	6%
North Fork	20	< DL	9.2	0.7	< DL	0.5	1.8	5.5	9.2	19	1	1	1	0	95%	5%	5%	5%	0%
Oak	52	< DL	21.5	0.9	< DL	< DL	1.4	6.4	21.2	48	3	3	2	1	92%	6%	6%	4%	2%
Wakefield	314	< DL	31.2	3.5	0.3	5.4	10.9	14.6	24.4	207	70	89	60	37	66%	22%	28%	19%	12%
Total	1883	< DL	32.6*	2.1*	0.07*	1.7*	6.2*	11.6*	26.5*	1488	258	311	222	137	79%	14%	17%	12%	7%

\* Represents an average value  
 < 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.

**Table 6. Initial Township Nitrate Results Summary Related to Vulnerable Groundwater and Row Crop Production.**

Township Name	Total Wells*	Percent of Land in Row Crop Production	Percent of Land in Vulnerable Geology	Percent of Wells* Nitrate-N $\geq$ 10 mg/L	90th Percentile
Brockway	263	41%	20%	10%	10.2
Crow Lake	34	51%	99%	6%	2.5
Crow River	46	57%	86%	2%	2.4
Fairhaven	152	37%	60%	9%	8.8
Grove	46	54%	30%	13%	13.8
Le Sauk	164	38%	79%	8%	7.7
Lynden	233	30%	84%	3%	1.3
Maine Prairie	204	53%	58%	6%	7.4
Melrose	67	45%	11%	6%	8.0
Millwood	87	48%	36%	2%	3.5
Munson	201	47%	44%	6%	6.5
North Fork	20	54%	63%	0%	1.8
Oak	52	60%	28%	2%	1.4
Wakefield	314	40%	37%	12%	10.9
Total	1883	47%	52%	7%	6.1

\* Does not include known hand dug wells

## WELL SETTING AND CONSTRUCTION

### WELL OWNER SURVEY

The 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 can be found in Appendix A. 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 B at the end of this document, Tables 8-22).

The majority of wells in each township are located on “rural” property. Approximately 79 percent of the wells in these townships are drilled construction and eight percent are sand point wells. There were 11 hand dug wells sampled in these townships, however, the surveys from those wells are not included in the summary.

Sand point (drive-point) wells are typically completed at shallower depths than drilled wells. Whether a steel or plastic casing is installed, the well code requires that it be watertight and extend at least 15 feet below the ground surface. 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. A confining layer can create a physical barrier to vertical nitrate movement from the water table to deeper portions of the aquifer. These factors make sand point wells more vulnerable to contamination from the surface.

Most wells in these townships are less than 100 feet deep, with the majority of wells between 51 and 100 feet below ground surface. Most of the wells had not been tested for nitrate within the last ten years or homeowners were unsure if they had been tested. Therefore, the results most homeowners receive from this study will provide new information.

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#### POTENTIAL NITRATE SOURCE DISTANCES

The following response summary relates to isolation distances of potential 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 B at the end of this document, Tables 8-22).

- Overall only eight percent of the well owners responded that they have livestock (greater than ten head of cattle or other equivalent) on their property.
- Few well owners (one percent) across all townships store more than 500 pounds of fertilizer on their property.
- Most wells (76 percent) are greater than 300 feet from an active or inactive feedlot.
- The majority of wells are more than 50 feet away from septic systems (89 percent).
- Farming takes place on 19 percent of the properties.
- Agricultural fields are greater than 300 feet from wells at 61 percent of the properties.

## WELL LOGS

In some cases, well owners were able to provide Unique Well Identification Numbers (Unique IDs) 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 CWI for 296 documented wells, however only 27 of the well logs had recorded aquifer designations (Table 7). Approximately 16 percent of the sampled wells had corresponding well logs, and only 1.4 percent had aquifer designations. Thus, the data gathered on aquifers only represents a small portion of the total sampled wells.

Based upon the well logs available, the Quaternary buried aquifer is the most common aquifer utilized in this sampling area. This is consistent with the County wide data presented in Table 2. The QWTA and the Cretaceous aquifer only had one well each.

**Table 7. Nitrate Concentrations within Sampled Aquifers.**

Aquifer	Total Wells	Ave Depth** (Feet)	Number			Percent		
			<3	3<10	≥10	<3	3<10	≥10
			Nitrate-N mg/L					
QWTA	1	21	1	0	0	100%	0%	0%
Quaternary Buried	22	98	21	1	0	95%	5%	0%
Cretaceous	1	170	0	1	0	0%	100%	0%
Undesignated	269	86	226	28	14	84%	10%	5%
Other	3	79	3	0	0	100%	0%	0%
Total	296	87*	251	30	14	85%*	10%*	5%*

\* Represents a weighted average value.

\*\*The depths were obtained from well logs in the CWI database

## SUMMARY

Fourteen townships were chosen for sampling based on the following criteria: local Soil and Water Conservation District (SWCD) expertise, past high nitrate results, vulnerable groundwater, and row crop production. According to the County Well Index (CWI) the Quaternary buried aquifers are more readily used than the water table aquifers in the selected Townships. Samples were collected from 1,894 private wells using homeowner collection and mail-in methods. This represents a 29 percent response rate from homeowners.

Results showed that across the 14 townships, seven percent of private wells sampled were above the health standard of 10 mg/L for nitrate as nitrogen (nitrate-N). In Brockway, Grove and Wakefield Township, greater than 10 percent of wells were above 10 mg/L nitrate-N.

## FUTURE WORK

Well owners with detectable nitrate results from this township testing were offered a free pesticide sample and a follow-up nitrate sample taken by MDA staff. At the time of this resampling a well site visit was performed (when possible) in order to rule out well construction issues and likely point sources of nitrate. The follow-up nitrate sampling in Stearns County occurred during the summer of 2015 and results from this effort will be available in 2016.

The testing conducted in Stearns County is part of a statewide assessment of vulnerable areas as the MDA plans to offer nitrate tests to approximately 70,000 private well owners (within 250-350 townships) between 2014 and 2019. As of spring 2015, 60 townships in eight counties had been completed.

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## Private Well Survey Questions

1. What setting did the water sample come from? Please choose only one.  
Answers choices: Sub-division, Lake Home, River Home, Country, Municipal/city, or Other.
2. Are there livestock on this property? Yes or No
3. Do you mix or store fertilizer (500lbs or more) on this property? Yes or No
4. Does farming take place on this property? Yes or No

### Well Information Section

5. Does your well have a Unique Well ID number? Yes or No
6. If yes, what is the Unique ID?  
(6 digit number found on a metal tag attached to your well casing)
7. Type of well construction?  
Answer choices: Drilled, Sand point, Hand dug, Other, and Don't Know.
8. Approximate age (years) of your well?  
Answer choices: 0-9 years, 10-19 years, 20-39 years, and 40 or more years old.
9. Approximate depth of your well  
Answer choices: 0-50 feet, 51-100 feet, 101-300 feet, and more than 300 feet.
10. Distance to an active or inactive feedlot  
Answer choices: 0-50 feet, 51-100 feet, 101-300 feet, and more than 300 feet.
11. Distance to a septic system  
Answer choices: 0-50 feet, 51-100 feet, 101-300 feet, and more than 300 feet.
12. Distance to an agricultural field  
Answer choices: 0-50 feet, 51-100 feet, 101-300 feet, and more than 300 feet.
13. Is this well currently used for human consumption? Yes or No
14. Please check any water treatment you have other than a water softener.  
Answer choices: None, Reverse Osmosis, Distillation, Filtering System and Other.
15. When did you last have your well tested for nitrates?  
Answer choices: Never, within the last year, within the last 3 years, the last 10, or 10 or more.
16. What was the result of your last nitrate test?  
Answer choices: 0<3, 3<10, 10 or greater, or Don't Know.

## APPENDIX B

**Table 8. Property Setting for Well Location.**

Property Setting							
Township	Total	Country	Lake	River Home	Sub-division	Other	Not available
		Percent					
Brockway	263	70.3%	0.0%	12.5%	8.4%	1.9%	6.8%
Crow Lake	34	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Crow River	46	91.3%	0.0%	0.0%	2.2%	4.3%	2.2%
Fairhaven	152	59.9%	25.0%	0.0%	5.3%	4.6%	5.3%
Grove	46	89.1%	0.0%	2.2%	0.0%	2.2%	6.5%
Le Sauk	164	45.7%	0.0%	17.7%	23.8%	6.7%	6.1%
Lynden	233	62.7%	13.7%	5.6%	7.3%	3.0%	7.7%
Maine Prairie	204	60.3%	34.3%	0.0%	1.0%	2.0%	2.5%
Melrose	67	55.2%	32.8%	0.0%	3.0%	3.0%	6.0%
Millwood	87	43.7%	41.4%	0.0%	1.1%	2.3%	11.5%
Munson	201	33.3%	51.2%	6.5%	3.0%	1.5%	4.5%
North Fork	20	95.0%	0.0%	0.0%	0.0%	0.0%	5.0%
Oak	52	69.2%	19.2%	5.8%	0.0%	1.9%	3.8%
Wakefield	314	37.3%	31.2%	8.9%	16.6%	1.0%	5.1%
Total	1883	55.8%	21.7%	6.4%	8.0%	2.5%	5.6%

**Table 9. Well Construction Type.**

Well Construction Type					
Township	Total	Drilled	Sand point	Other	Not available
		Percent			
Brockway	263	84.8%	3.0%	0.4%	11.8%
Crow Lake	34	67.6%	29.4%	0.0%	2.9%
Crow River	46	69.6%	26.1%	0.0%	4.3%
Fairhaven	152	77.6%	9.9%	0.7%	11.8%
Grove	46	82.6%	6.5%	0.0%	10.9%
Le Sauk	164	78.7%	6.1%	0.0%	15.2%
Lynden	233	79.8%	6.4%	0.0%	13.7%
Maine Prairie	204	77.9%	12.3%	1.0%	8.8%
Melrose	67	76.1%	10.4%	4.5%	9.0%
Millwood	87	86.2%	2.3%	0.0%	11.5%
Munson	201	75.6%	11.9%	0.0%	12.4%
North Fork	20	75.0%	15.0%	5.0%	5.0%
Oak	52	80.8%	9.6%	0.0%	9.6%
Wakefield	314	77.7%	6.4%	0.3%	15.6%
Total	1883	79.0%	8.4%	0.5%	12.1%

**Table 10. Age of Well.**

Well Age						
Township	Total	0-10 years	11-20 years	21-40 years	Over 40 years	Not available
		Percent				
Brockway	263	16.0%	23.6%	43.0%	11.4%	6.1%
Crow Lake	34	35.3%	29.4%	23.5%	8.8%	2.9%
Crow River	46	17.4%	26.1%	52.2%	2.2%	2.2%
Fairhaven	152	25.0%	29.6%	25.7%	13.8%	5.9%
Grove	46	6.5%	26.1%	26.1%	34.8%	6.5%
Le Sauk	164	6.7%	16.5%	47.0%	24.4%	5.5%
Lynden	233	9.9%	24.0%	48.9%	8.2%	9.0%
Maine Prairie	204	21.6%	28.4%	36.3%	9.8%	3.9%
Melrose	67	17.9%	16.4%	43.3%	17.9%	4.5%
Millwood	87	17.2%	25.3%	27.6%	23.0%	6.9%
Munson	201	18.4%	30.8%	31.8%	13.4%	5.5%
North Fork	20	20.0%	10.0%	50.0%	20.0%	0.0%
Oak	52	25.0%	25.0%	30.8%	13.5%	5.8%
Wakefield	314	9.6%	28.3%	42.7%	13.7%	5.7%
Total	1883	15.5%	25.5%	39.2%	14.0%	5.8%

**Table 11. Depth of Well.**

Well Depth						
Township	Total	0-50 feet	51-100 feet	101-300 feet	Over 300 feet	Not available
		Percent				
Brockway	263	19.4%	49.0%	16.0%	2.3%	13.3%
Crow Lake	34	35.3%	17.6%	38.2%	2.9%	5.9%
Crow River	46	23.9%	23.9%	47.8%	0.0%	4.3%
Fairhaven	152	19.7%	47.4%	19.1%	1.3%	12.5%
Grove	46	21.7%	45.7%	21.7%	2.2%	8.7%
Le Sauk	164	17.7%	54.3%	9.8%	0.6%	17.7%
Lynden	233	10.3%	51.5%	15.5%	1.3%	21.5%
Maine Prairie	204	20.6%	51.5%	16.2%	1.0%	10.8%
Melrose	67	20.9%	49.3%	22.4%	0.0%	7.5%
Millwood	87	12.6%	37.9%	33.3%	4.6%	11.5%
Munson	201	18.4%	31.3%	31.3%	1.0%	17.9%
North Fork	20	15.0%	40.0%	45.0%	0.0%	0.0%
Oak	52	23.1%	48.1%	17.3%	1.9%	9.6%
Wakefield	314	21.0%	36.0%	27.7%	2.5%	12.7%
Total	1883	18.7%	44.0%	21.9%	1.6%	13.8%

**Table 12. Unique Well ID Known.**

Does the Well Have a Unique ID				
Township	Total	No	Yes	Not available
		Percent		
Brockway	263	22.8%	21.7%	55.5%
Crow Lake	34	38.2%	32.4%	29.4%
Crow River	46	26.1%	10.9%	63.0%
Fairhaven	152	20.4%	21.1%	58.6%
Grove	46	37.0%	15.2%	47.8%
Le Sauk	164	22.0%	11.6%	66.5%
Lynden	233	23.2%	18.5%	58.4%
Maine Prairie	204	24.5%	23.5%	52.0%
Melrose	67	22.4%	26.9%	50.7%
Millwood	87	20.7%	18.4%	60.9%
Munson	201	31.8%	14.9%	53.2%
North Fork	20	55.0%	10.0%	35.0%
Oak	52	25.0%	19.2%	55.8%
Wakefield	314	22.3%	15.9%	61.8%
Total	1883	24.6%	18.5%	56.9%

**Table 13. Livestock Located on Property.**

Livestock on Property				
Township	Total	No	Yes	Not available
		Percent		
Brockway	263	89.7%	3.0%	7.2%
Crow Lake	34	82.4%	17.6%	0.0%
Crow River	46	63.0%	30.4%	6.5%
Fairhaven	152	92.1%	3.9%	3.9%
Grove	46	54.3%	32.6%	13.0%
Le Sauk	164	94.5%	0.6%	4.9%
Lynden	233	87.6%	4.3%	8.2%
Maine Prairie	204	86.3%	9.3%	4.4%
Melrose	67	74.6%	19.4%	6.0%
Millwood	87	83.9%	10.3%	5.7%
Munson	201	87.6%	6.0%	6.5%
North Fork	20	70.0%	30.0%	0.0%
Oak	52	71.2%	23.1%	5.8%
Wakefield	314	91.7%	3.2%	5.1%
Total	1883	86.6%	7.5%	5.9%

**Table 14. Fertilizer Stored on Property.**

Fertilizer Stored On Property				
Township	Total	No	Yes	Not available
		Percent		
Brockway	263	92.8%	0.8%	6.5%
Crow Lake	34	100.0%	0.0%	0.0%
Crow River	46	91.3%	4.3%	4.3%
Fairhaven	152	95.4%	0.0%	4.6%
Grove	46	87.0%	4.3%	8.7%
Le Sauk	164	95.1%	0.0%	4.9%
Lynden	233	91.4%	0.9%	7.7%
Maine Prairie	204	93.6%	2.5%	3.9%
Melrose	67	94.0%	0.0%	6.0%
Millwood	87	95.4%	0.0%	4.6%
Munson	201	93.0%	0.5%	6.5%
North Fork	20	90.0%	10.0%	0.0%
Oak	52	88.5%	3.8%	7.7%
Wakefield	314	94.6%	0.3%	5.1%
Total	1883	93.4%	1.0%	5.6%

**Table 15. Farming on Property.**

Does Farming Take Place on Property				
Township	Total	No	Yes	Not available
		Percent		
Brockway	263	76.0%	17.5%	6.5%
Crow Lake	34	70.6%	29.4%	0.0%
Crow River	46	41.3%	52.2%	6.5%
Fairhaven	152	76.3%	21.1%	2.6%
Grove	46	34.8%	56.5%	8.7%
Le Sauk	164	91.5%	3.7%	4.9%
Lynden	233	79.8%	12.9%	7.3%
Maine Prairie	204	68.6%	27.5%	3.9%
Melrose	67	62.7%	31.3%	6.0%
Millwood	87	74.7%	19.5%	5.7%
Munson	201	82.6%	11.9%	5.5%
North Fork	20	25.0%	75.0%	0.0%
Oak	52	53.8%	38.5%	7.7%
Wakefield	314	87.6%	7.3%	5.1%
Total	1883	76.0%	18.6%	5.4%

**Table 16. Distance to an Active or Inactive Feedlot.**

Feedlot Located on Property						
Township	Total	0-50 feet	51-100 feet	101-300 feet	Over 300 feet	Not available
		Percent				
Brockway	263	1.9%	3.8%	1.5%	78.7%	14.1%
Crow Lake	34	0.0%	17.6%	8.8%	61.8%	11.8%
Crow River	46	4.3%	15.2%	4.3%	73.9%	2.2%
Fairhaven	152	4.6%	7.2%	0.7%	76.3%	11.2%
Grove	46	8.7%	19.6%	17.4%	43.5%	10.9%
Le Sauk	164	6.1%	1.2%	0.6%	78.7%	13.4%
Lynden	233	4.3%	2.6%	4.3%	75.1%	13.7%
Maine Prairie	204	1.5%	5.9%	2.0%	80.4%	10.3%
Melrose	67	1.5%	13.4%	6.0%	71.6%	7.5%
Millwood	87	2.3%	12.6%	3.4%	69.0%	12.6%
Munson	201	4.5%	4.5%	2.5%	75.1%	13.4%
North Fork	20	5.0%	35.0%	20.0%	35.0%	5.0%
Oak	52	7.7%	9.6%	3.8%	69.2%	9.6%
Wakefield	314	1.6%	3.2%	1.3%	80.9%	13.1%
Total	1883	3.3%	6.1%	2.9%	75.5%	12.2%

**Table 17. Distance to Septic System.**

Distance to Septic System						
Township	Total	0-50 feet	51-100 feet	101-300 feet	Over 300 feet	Not available
		Percent				
Brockway	263	3.4%	28.1%	49.8%	11.8%	6.8%
Crow Lake	34	2.9%	23.5%	58.8%	2.9%	11.8%
Crow River	46	8.7%	34.8%	47.8%	4.3%	4.3%
Fairhaven	152	6.6%	27.0%	48.7%	12.5%	5.3%
Grove	46	6.5%	15.2%	52.2%	17.4%	8.7%
Le Sauk	164	6.1%	39.6%	40.9%	7.9%	5.5%
Lynden	233	3.0%	33.5%	45.9%	10.3%	7.3%
Maine Prairie	204	5.4%	34.3%	48.0%	7.8%	4.4%
Melrose	67	3.0%	35.8%	44.8%	9.0%	7.5%
Millwood	87	2.3%	29.9%	48.3%	13.8%	5.7%
Munson	201	5.0%	35.3%	44.8%	9.5%	5.5%
North Fork	20	0.0%	10.0%	75.0%	10.0%	5.0%
Oak	52	0.0%	25.0%	50.0%	19.2%	5.8%
Wakefield	314	5.7%	28.3%	51.0%	7.0%	8.0%
Total	1883	4.6%	31.0%	48.1%	9.8%	6.4%

**Table 18. Distance to an Agricultural Field.**

Distance to an Agricultural Field						
Township	Total	0-50 feet	51-100 feet	101-300 feet	Over 300 feet	Not available
		Percent				
Brockway	263	6.5%	4.6%	17.9%	65.0%	6.1%
Crow Lake	34	8.8%	11.8%	32.4%	44.1%	2.9%
Crow River	46	10.9%	8.7%	37.0%	41.3%	2.2%
Fairhaven	152	5.9%	11.2%	15.1%	59.2%	8.6%
Grove	46	13.0%	15.2%	34.8%	32.6%	4.3%
Le Sauk	164	4.9%	4.3%	14.6%	68.3%	7.9%
Lynden	233	2.1%	6.0%	19.7%	62.7%	9.4%
Maine Prairie	204	9.3%	9.3%	28.4%	48.0%	4.9%
Melrose	67	6.0%	7.5%	22.4%	58.2%	6.0%
Millwood	87	5.7%	9.2%	13.8%	60.9%	10.3%
Munson	201	3.0%	4.5%	21.4%	63.7%	7.5%
North Fork	20	5.0%	0.0%	40.0%	50.0%	5.0%
Oak	52	7.7%	7.7%	34.6%	40.4%	9.6%
Wakefield	314	3.5%	3.2%	13.1%	72.0%	8.3%
Total	1883	5.5%	6.4%	20.1%	60.7%	7.3%

**Table 19. Drinking Water Well.**

Is the Well Used for Drinking Water				
Township	Total	No	Yes	Not available
		Percent		
Brockway	263	0.8%	93.9%	5.3%
Crow Lake	34	5.9%	94.1%	0.0%
Crow River	46	4.3%	93.5%	2.2%
Fairhaven	152	5.3%	92.1%	2.6%
Grove	46	2.2%	91.3%	6.5%
Le Sauk	164	1.2%	95.1%	3.7%
Lynden	233	0.9%	93.1%	6.0%
Maine Prairie	204	2.5%	94.1%	3.4%
Melrose	67	0.0%	97.0%	3.0%
Millwood	87	2.3%	93.1%	4.6%
Munson	201	2.0%	93.5%	4.5%
North Fork	20	0.0%	100.0%	0.0%
Oak	52	0.0%	96.2%	3.8%
Wakefield	314	0.0%	94.9%	5.1%
Total	1883	1.6%	94.1%	4.4%

**Table 20. Treatment System Present.**

Treatment System Used for Drinking Water							
Township	Total	None	Filtering System	Reverse Osmosis	Distillation	Other	Not available
		Percent					
Brockway	263	59.3%	16.3%	8.0%	0.4%	2.7%	13.3%
Crow Lake	34	76.5%	11.8%	2.9%	0.0%	2.9%	5.9%
Crow River	46	58.7%	17.4%	4.3%	6.5%	4.3%	8.7%
Fairhaven	152	65.8%	14.5%	5.9%	0.0%	3.9%	9.9%
Grove	46	58.7%	4.3%	8.7%	4.3%	8.7%	15.2%
Le Sauk	164	50.6%	22.6%	11.6%	0.6%	5.5%	9.1%
Lynden	233	61.4%	18.5%	4.3%	0.0%	3.4%	12.4%
Maine Prairie	204	60.3%	19.1%	6.4%	1.5%	2.9%	9.8%
Melrose	67	73.1%	11.9%	9.0%	1.5%	0.0%	4.5%
Millwood	87	64.4%	18.4%	8.0%	2.3%	1.1%	5.7%
Munson	201	63.7%	18.9%	5.0%	1.5%	2.0%	9.0%
North Fork	20	65.0%	15.0%	5.0%	0.0%	5.0%	10.0%
Oak	52	61.5%	19.2%	11.5%	1.9%	0.0%	5.8%
Wakefield	314	58.0%	15.6%	10.8%	1.6%	3.5%	10.5%
Total	1883	60.8%	17.1%	7.6%	1.2%	3.2%	10.1%

**Table 21. Last Tested for Nitrate.**

When was the Well 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	Not available
		Percent					
Brockway	263	3.8%	7.2%	18.6%	28.9%	15.2%	26.2%
Crow Lake	34	5.9%	5.9%	23.5%	17.6%	29.4%	17.6%
Crow River	46	4.3%	6.5%	21.7%	8.7%	21.7%	37.0%
Fairhaven	152	1.3%	9.9%	15.8%	23.0%	30.3%	19.7%
Grove	46	0.0%	6.5%	19.6%	34.8%	19.6%	19.6%
Le Sauk	164	4.3%	7.9%	20.7%	19.5%	16.5%	31.1%
Lynden	233	0.9%	5.2%	15.0%	25.3%	27.5%	26.2%
Maine Prairie	204	6.4%	6.4%	15.7%	21.6%	22.5%	27.5%
Melrose	67	3.0%	7.5%	17.9%	29.9%	25.4%	16.4%
Millwood	87	3.4%	10.3%	8.0%	17.2%	26.4%	34.5%
Munson	201	2.0%	5.0%	18.4%	19.9%	23.4%	31.3%
North Fork	20	0.0%	5.0%	5.0%	10.0%	25.0%	55.0%
Oak	52	3.8%	9.6%	28.8%	17.3%	17.3%	23.1%
Wakefield	314	3.5%	7.0%	20.7%	25.2%	20.7%	22.9%
Total	1883	3.2%	7.0%	18.0%	23.2%	22.2%	26.4%

**Table 22. Last Nitrate Result.**

What was the Last Nitrate Result					
Township	Total	<3 mg/L	3<10 mg/L	≥ 10 mg/L	Not available
		Percent			
Brockway	263	10.3%	4.9%	3.0%	81.7%
Crow Lake	34	14.7%	0.0%	0.0%	85.3%
Crow River	46	8.7%	2.2%	0.0%	89.1%
Fairhaven	152	7.2%	3.9%	2.6%	86.2%
Grove	46	13.0%	2.2%	2.2%	82.6%
Le Sauk	164	12.8%	6.1%	0.6%	80.5%
Lynden	233	8.2%	3.0%	0.9%	88.0%
Maine Prairie	204	8.3%	5.9%	1.0%	84.8%
Melrose	67	16.4%	0.0%	1.5%	82.1%
Millwood	87	6.9%	1.1%	0.0%	92.0%
Munson	201	6.5%	1.5%	0.5%	91.5%
North Fork	20	5.0%	0.0%	0.0%	95.0%
Oak	52	11.5%	1.9%	1.9%	84.6%
Wakefield	314	9.6%	4.8%	1.0%	84.7%
Total	1883	9.4%	3.7%	1.3%	85.6%