



INITIAL TOWNSHIP TESTING OF NITRATE  
IN PRIVATE WELLS  
BENTON COUNTY 2013 SUMMARY

April 2015

Minnesota Department of Agriculture

Pesticide and Fertilizer Management Division

*In accordance with the Americans with Disabilities Act, this information is available in alternative forms of communication upon request by calling 651-201-6000. TTY users can call the Minnesota Relay Service a 711 or 1-800-627-3529. The MDA is an equal opportunity employer and provider.*

## ACKNOWLEDGEMENTS

### MDA PRIMARY AUTHOR

Kimberly Kaiser

### MDA CONTRIBUTORS AND REVIEWERS

Annie Felix-Gerth, Larry Gunderson, Heather Johnson, Brennon Schaefer, Bill VanRyswyk, and Margaret Wagner.



## TABLE OF CONTENTS

Acknowledgements .....	2
Executive Summary .....	5
Introduction .....	5
Background.....	6
Methods.....	18
Results.....	18
Summary .....	25
References .....	27
Appendix A .....	28
Appendix B .....	29

## LIST OF FIGURES

Figure 1. Statewide Geomorphology Layer, Sediment Association, Benton County .....	8
Figure 2. Water Table Aquifer Vulnerability for Benton County.....	9
Figure 3. Benton County Geologic Atlas Part B: Pollution Sensitivity Rating of the Near-Surface Materials.....	11
Figure 4. Central Sands Private Well Network 2011 Sampling Event.....	15
Figure 5. Townships with Vulnerable Groundwater and Row Crop Production.....	17
Figure 6. Benton County Private Well Township Sampling Results 2013 .....	20

## LIST OF TABLES

Table 1. Vulnerability Ratings Based on the Geomorphology of Minnesota, Sediment Association Layer .....	8
Table 2. Aquifer Type Distribution of Wells in the County Well Index .....	13
Table 3. Central Sands Private Well Network 2011 Results Summary .....	16
Table 4. Township Population, Households, Sample Kit Distribution and Return Rate.....	19
Table 5. Benton County Township Sampling Summary Statistics Including All Well Types .....	21

Table 6. Benton County Township Sampling Summary Statistics without Hand Dug Wells.....	21
Table 7. Township Nitrate Results Summary Related to Vulnerable Groundwater and Row Crop Production .....	22
Table 8. Aquifer Designation and Nitrate Results .....	24
Table 9. Property Setting for Well Location .....	29
Table 10. Well Construction Type .....	29
Table 11. Age of Well.....	30
Table 12. Depth of Well.....	30
Table 13. Unique Well ID Known .....	31
Table 14. Livestock Located on Property .....	31
Table 15. Fertilizer Stored on Property.....	31
Table 16. Farming on Property.....	32
Table 17. Distance to an Active Feedlot.....	32
Table 18. Distance to Septic System.....	33
Table 19. Distance to an Agricultural Field .....	33
Table 20. Drinking Water Well.....	34
Table 21. Treatment System Present.....	34
Table 22. Last Tested for Nitrate .....	35
Table 23. Last Nitrate Test Result.....	35

## EXECUTIVE SUMMARY

In 2013, three townships in Benton County were selected for private well nitrate sampling as a pilot project. Results showed that 15 percent of private wells sampled in Langola Township were above the health standard of 10 mg/L. In Watab Township, nine percent were above 10 mg/L, while in Maywood Township only one percent of private wells tested were above the 10 mg/L standard for nitrate.

Future work that will be considered by the Minnesota Department of Agriculture (MDA) includes the following: 1) resampling wells that had high nitrate results (greater than or equal to 5 mg/L) to verify high nitrate levels; 2) performing well site visits, when possible, to rule out well construction issues and obvious point sources of nitrate, such as septic systems, livestock, etc.; and 3) increasing efforts to obtain well log information for participating wells so that nitrate results and the aquifer designation can be compared in a more comprehensive fashion.

This pilot project conducted in Benton County will be used to guide future work as the MDA plans to offer nitrate tests to approximately 70,000 private well owners within approximately 250 to 280 townships, between 2013 and 2019. The actual number of townships may vary based on detailed county specific information. As of April 2014, 22 townships in four counties are completed.

## INTRODUCTION

The MDA is currently updating 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. One of the goals of the NFMP is to minimize or mitigate the source of pollution from nitrogen fertilizer. Updating the NFMP provides an opportunity to restructure the County's and the State's strategies for reducing nitrate contamination of water resources, with more specific, localized accountability for nitrate contamination associated with row crop agricultural production.

To effectively manage nitrate contamination of water resources it is appropriate to focus on areas of greatest risk. Testing of water from private wells for nitrate 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 the MDA works with local partners (counties and Soil and Water Conservation Districts) 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.

<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, and in some areas of the state (e.g., the Central Sands which is a 14 county area in central Minnesota), 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 (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 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, which means nitrite occurs very rarely in groundwater. 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. 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 Benton 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 Benton 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 is material consisting primarily of sand and gravel that was deposited by running water that flowed from melting ice during the last glacial period. 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. The Superior Lobe and Rainy lobe are the main sources of glacial deposits in this area (MPCA, 1998). Statewide geomorphological mapping conducted by the Minnesota Geological Survey and the University of Minnesota at Duluth (MGS and UMD, 1997) indicates the extent of glacial deposits in Benton County as presented in Figure 1. As the figure indicates, glacial outwash is present in every township in Benton County.

The same geologic mapping project presented in Figure 1 was used to classify the state into aquifer sensitivity ratings. There are three ratings for aquifer sensitivity: low, medium and high. Sensitivity ratings are described in Table 1. 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" (DNR, 1991) (Figure 2).

# Benton County Geomorphology-Sediment Association

Minnesota Geological Survey and the University of Minnesota at Duluth (1997)

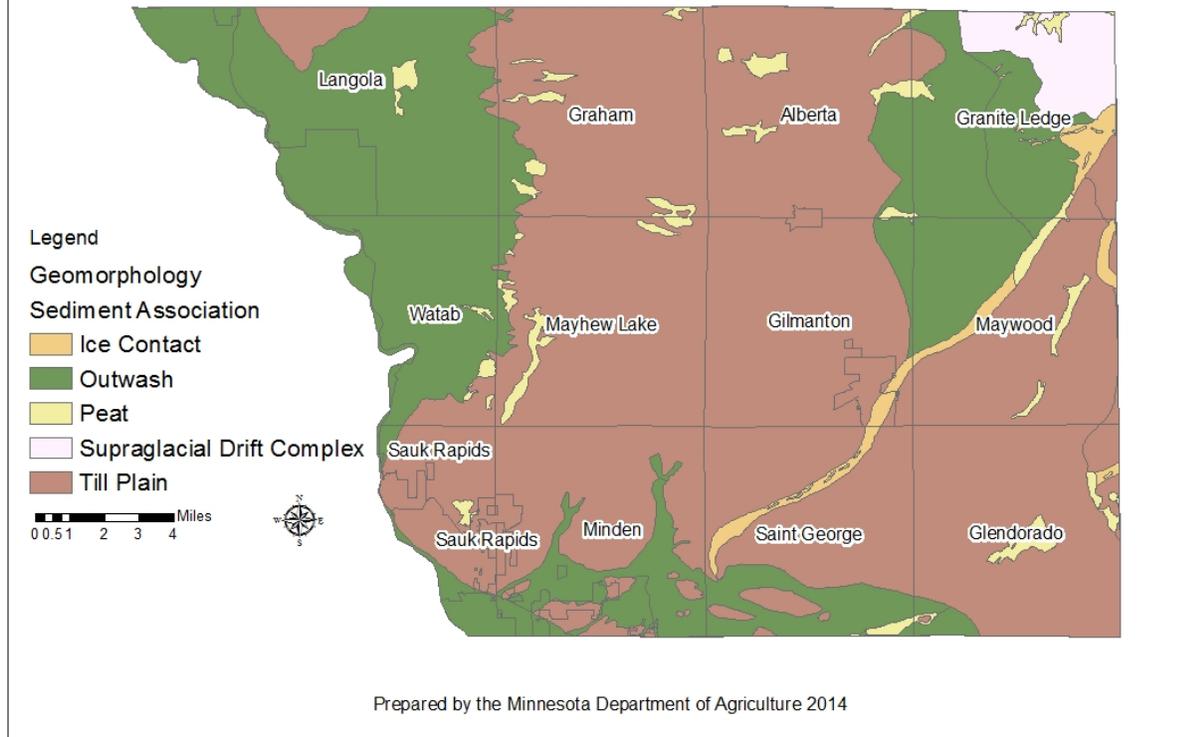
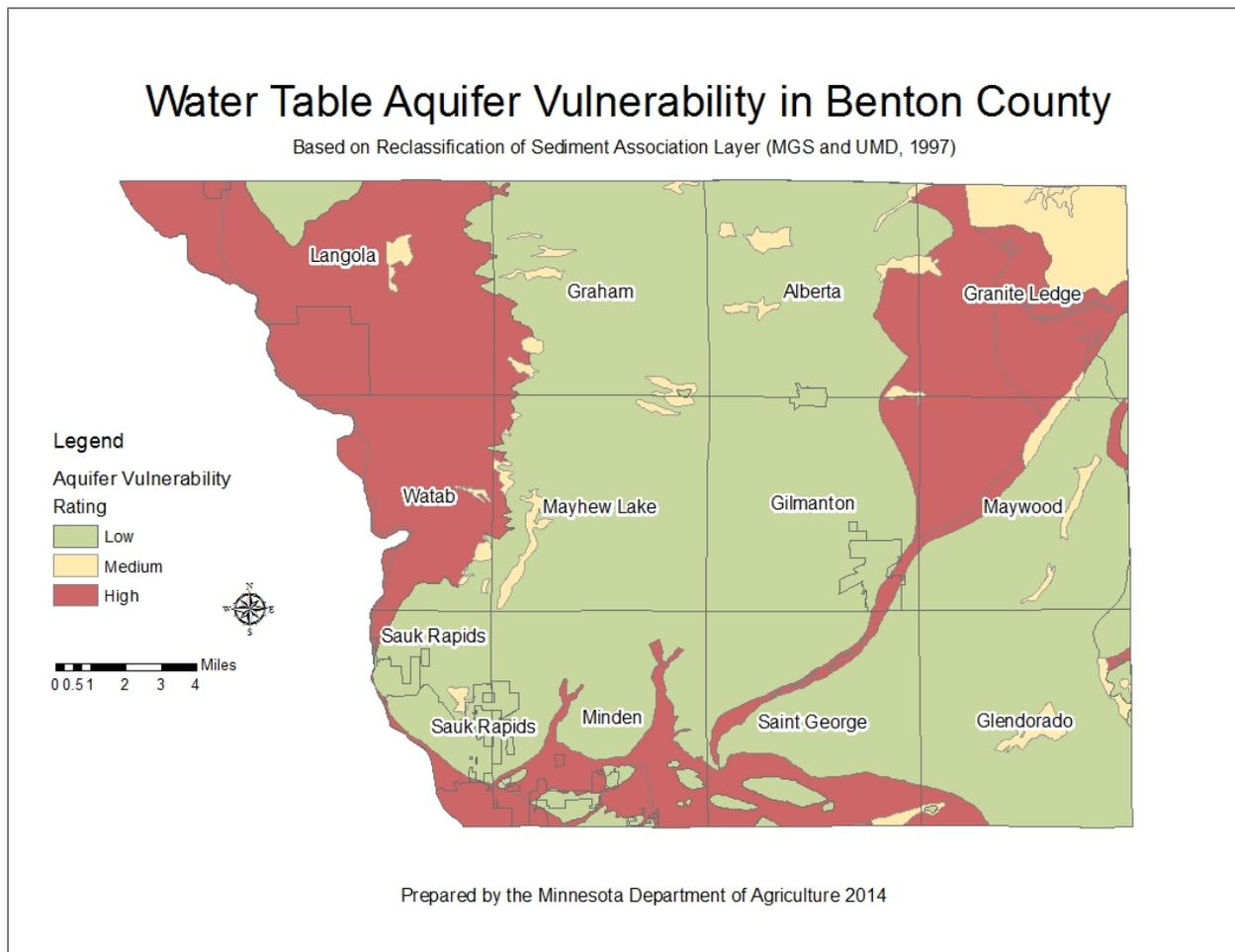


Figure 1. Statewide Geomorphology Layer, Sediment Association, Benton County

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

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



**Figure 2. Water Table Aquifer Vulnerability for Benton County**

### GEOLOGIC ATLAS

A County Geologic Atlas is a systematic study of a county's geologic and groundwater resources. The atlas defines aquifer properties and boundaries, as well as the connection of aquifers to the land surface and to surface water resources (MGS, 2014). This information is essential to sustainable management of groundwater resources and can help with activities such as monitoring, appropriation, permitting, remediation, and well construction.

A complete geologic atlas consists of two parts:

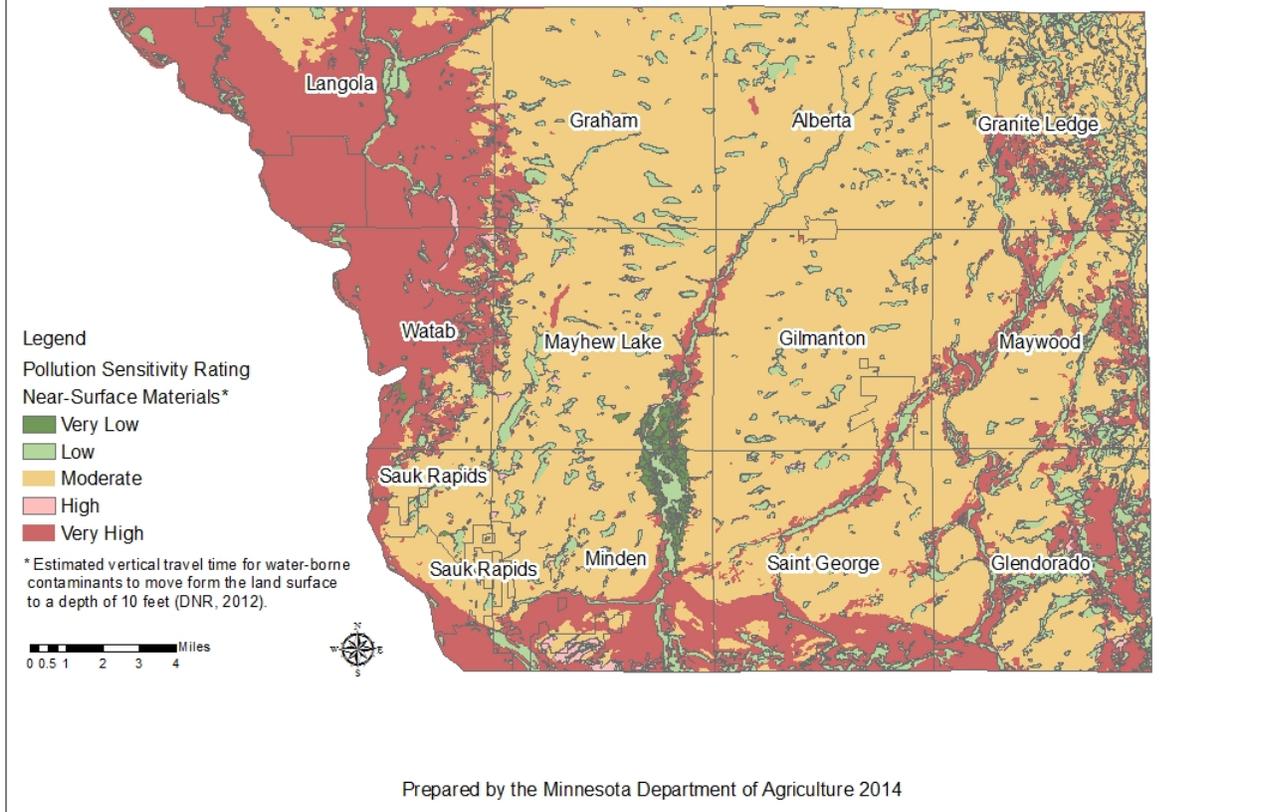
- Part A (prepared by Minnesota Geological Survey (MGS)), which includes the water well database and 1:100,000 scale geologic maps showing properties and distribution of sediments and rocks in the subsurface, and

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

According to the Benton County Geologic Atlas more than 95 percent of the wells are completed in sand and gravel aquifers, and the remaining five percent are completed in bedrock. Surficial (water table) sand and gravel aquifers are used in 15 percent of documented wells. The surficial aquifer in Benton County occurs in the northwest corner of the county and extends along the southern boundary of the county. Groundwater in surficial aquifers is very susceptible to nitrate contamination.

An important analysis provided by Part B of the Atlas is called the Pollution Sensitivity Rating of the Near Surface Materials. This rating is based on the time for water to travel from the land surface to a depth of 10 feet (Figure 3). The water table aquifer vulnerability map is very similar to the pollution sensitivity map when comparing at a one-dimensional level.

## Benton County Geologic Atlas Part B Pollution Sensitivity Rating of the Near-Surface Materials



**Figure 3. Benton County Geologic Atlas Part B: Pollution Sensitivity Rating of the Near-Surface Materials**

### COUNTY WELL INDEX

The County Well Index (CWI) 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 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. Most of the records in 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 through the cooperation of drillers and local government agencies for wells drilled before 1974 (MGS, 2014).

The CWI was used to gather information about the three townships in Benton County included in this Pilot 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, 2014):

In Langola Township, there are 400 “located” wells (those with location field-verified by MDH, MGS or other local partner):

- Thirty percent are completed in the shallow Quaternary Water Table Aquifer (QWTA) and are 66 feet deep on average.
  - QWTA wells are defined as having less than 10 feet of confining material (clay) between the land surface and the well screen (GWMAP 1998). When there is less than 10 feet of clay, it allows surface contaminants to travel more quickly to the water table aquifers. In general, shallower wells completed in the QWTA may be more susceptible to nitrate-nitrogen contamination.
- Sixty percent are completed in a Quaternary buried aquifer and are 86 feet deep on average.
  - Buried aquifer wells have more than 10 feet of confining material between the land surface and the well screen.
- Precambrian aquifers are utilized in less than one percent of the wells. The average depth is 177 feet deep.

In Maywood Township, there are 261 located wells:

- Three percent are completed in the shallow Quaternary Water Table Aquifer (QWTA) and are 38 feet deep on average.
- Seventy-three percent are completed in a Quaternary buried artesian and are 57 feet deep on average.
- Precambrian aquifers are utilized in 11 percent of the wells and the wells, on average, are 209 feet deep.

In Watab Township, there are 800 located wells:

- Thirty-seven percent are completed in the shallow QWTA and are 60 feet deep on average.
- Thirty-eight percent are completed in a Quaternary buried aquifer and are 73 feet deep on average.

- Precambrian aquifers are utilized in less than two percent of the wells. The average depths for the Precambrian aquifer wells range from 95-410 feet deep.

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

Township	Total Wells	Aquifer Type				
		Water Table	Quaternary Buried	Precambrian	Undesignated	Others
Langola	400	30.3%	59.8%	0.8%	7.3%	1.9%
Maywood	261	3.4%	72.8%	10.7%	7.3%	5.8%
Watab	800	36.5%	38.0%	1.8%	20.8%	3.0%

#### NITRATE PROBABILITY MAPPING

The Minnesota Department of Health (MDH) has developed nitrate probability maps 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. Benton 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/benton.pdf>

#### MDA PRIVATE WELL MONITORING

The Minnesota Department Agriculture 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 14 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 1555 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 14 counties combined showed that 88 percent of the 1555 wells had nitrate 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 (Kaiser, 2012). However, Benton County had the second highest percentage of wells greater than 10 mg/L compared to the other counties in the Central Sands Private Well Network. Because of this, Benton County was given a high priority in the Township Testing Program.

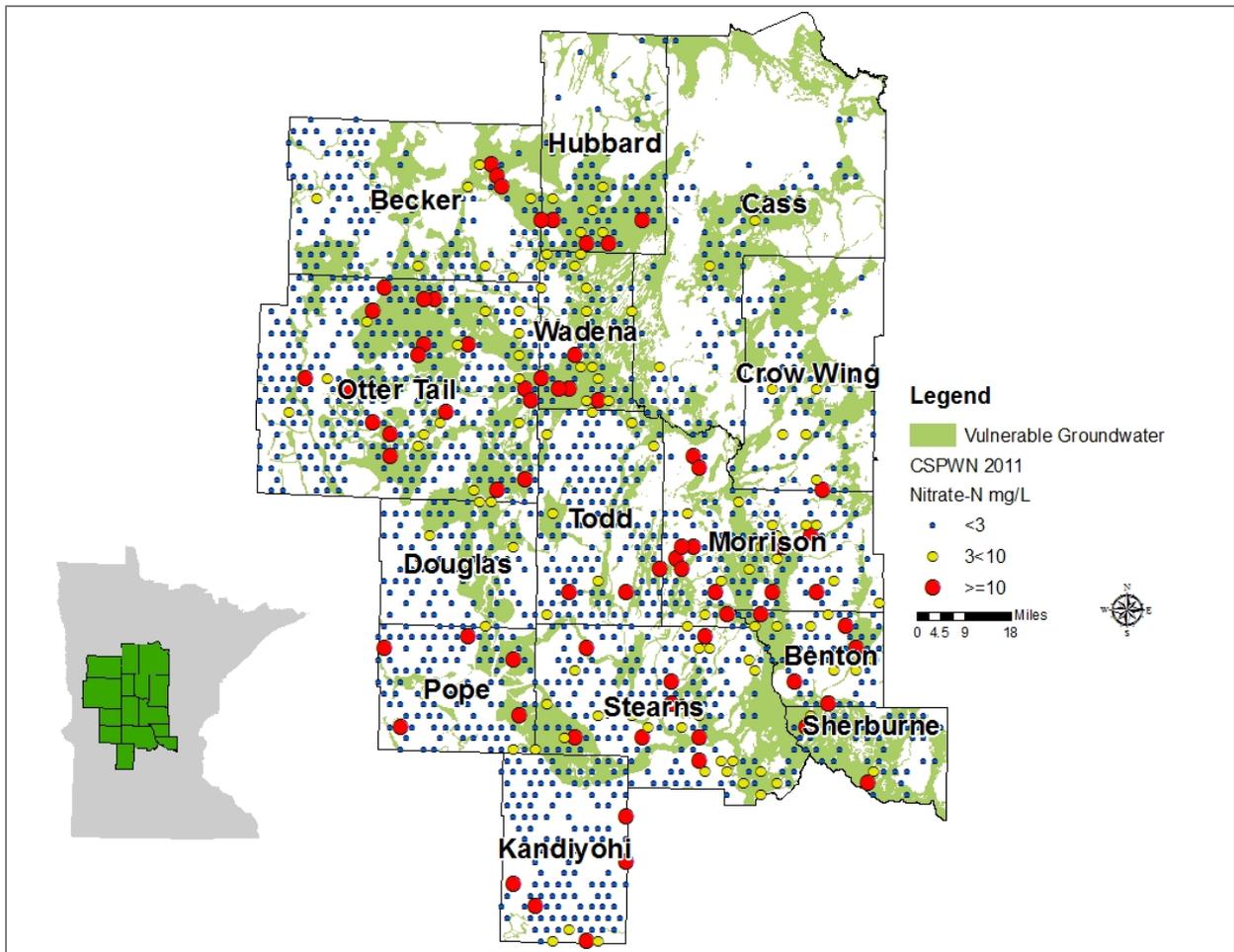


Figure 4. Central Sands Private Well Network 2011 Sampling Event

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

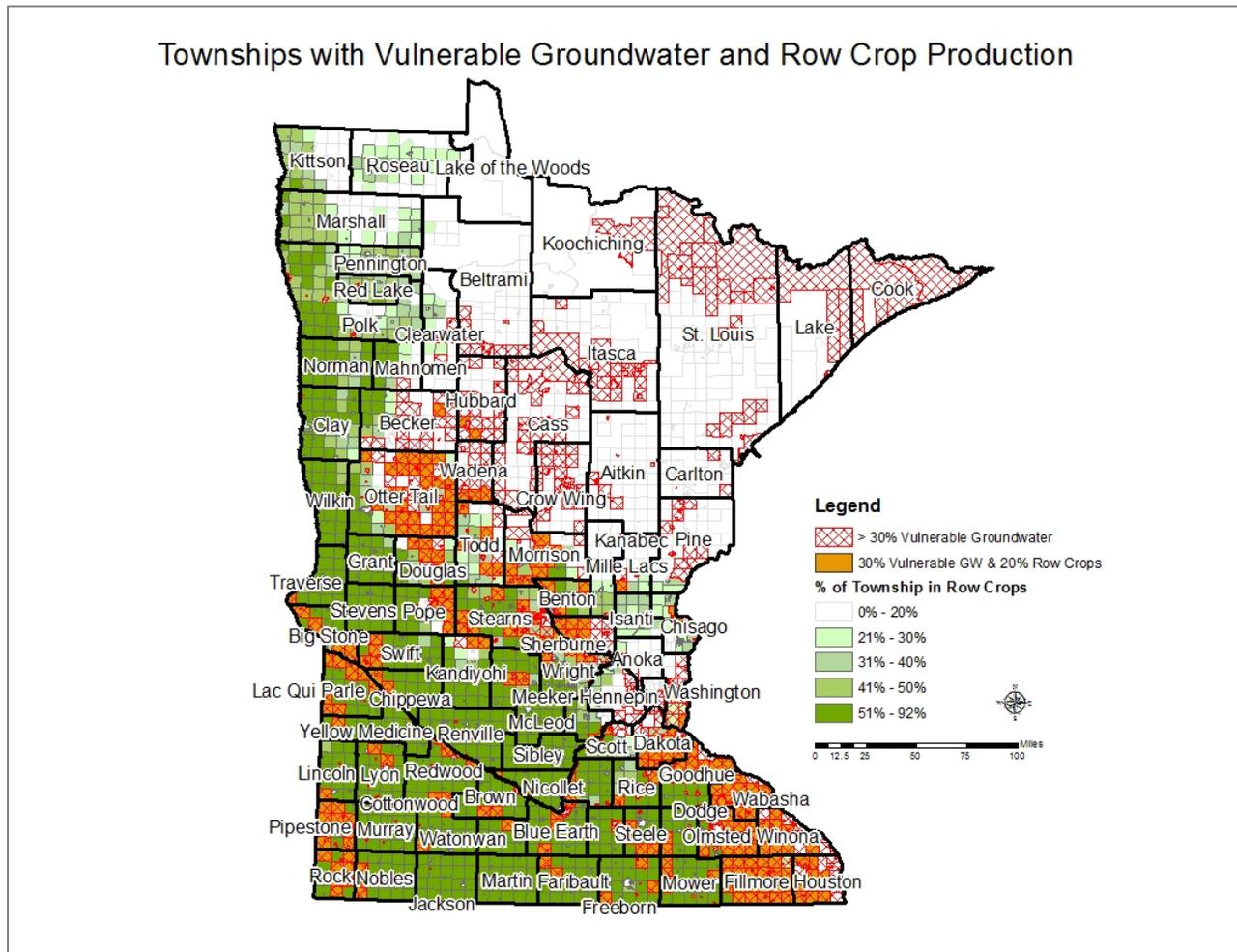
County	Number of Samples	2011 Results					
		Nitrate-N mg/L			Percent		
		Min	Median	Max	<3 (mg/L)	3<10 (mg/L)	≥10 (mg/L)
Becker	123	<.03	<.03	15.4	93%	5%	2%
Benton	57	<.03	<.03	15.6	79%	12%	9%
Cass	82	<.03	<.03	9.5	96%	4%	0%
Crow Wing	66	<.03	<.03	8.3	92%	8%	0%
Douglas	90	<.03	<.03	8.8	94%	6%	0%
Hubbard	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%

For more information about the Central Sands Private Well Network, please visit: <http://www.mda.state.mn.us/protecting/cleanwaterfund/gwdwprotection/characterizingnitrates.aspx>.

#### TOWNSHIP TESTING

The MDA is currently updating 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 will be 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

Langola and Maywood townships were chosen for sampling based on the high results from the 2011 Central Sands Private Well Network sampling event. Watab Township was chosen based on other criteria including local Soil and Water Conservation District (SWCD) expertise, vulnerable groundwater, and row crop production.

The goal of this program is to sample a majority of available wells in the selected townships. Most households with private wells received an invitation letter to participate in the free nitrate testing. Homeowners with private wells that agreed to participate were sent a free water sample kit (by a certified lab) which included a survey about their well, sample bottle, sample instructions and a pre-paid mailer. 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 included: Langola, Maywood and Watab.

## RESULTS

Approximately 502 well owners returned water samples for analysis across the three townships (Figure 6). On average, 35 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 are presented in two formats: all well construction types are shown in Table 5 and all well construction types *except* hand dug wells are shown in Table 6. Hand dug wells are often very shallow, just skimming the water table, and therefore are much more sensitive to local surface runoff contamination (feedlot runoff), point source pollution (septic systems effluent), or chemical spills. The following paragraphs provide a brief discussion of the statistics presented in Table 6, which does **not** include hand dug wells.

The minimum values for each township were less than the detection limit which is 0.03 mg/L. The maximum values ranged from 10.7 to 40.9 mg/L, with Watab Township having the highest result. Median values range from < 0.03 to 0.6 mg/L, with Watab Township having the highest median value. The 90<sup>th</sup> percentiles range from 2.9 to 17.6 mg/L, with Langola Township having the highest value.

Results from the sampling showed that in Langola Township, 16 percent of wells were greater than 10 mg/L. In Watab Township, nine percent of the wells were over 10 mg/L and in Maywood two percent were over 10 mg/L. Previous sampling of 57 wells in Benton County showed that nine percent of wells were at or over 10 mg/L

(Kaiser, 2012). This data suggests that private well water in Langola Township is more heavily impacted by nitrates than the other townships sampled. It should be noted that Langola Township also had the highest percent of vulnerable groundwater and highest percent of row crop production compared to the other two townships (Table 7).

With the exception of Maywood Township, 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). The differences in the study findings may be due to the higher row crop areas in the selected townships. Both studies indicate that nitrate concentrations can vary considerably over short distances.

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

Township	2012 Population	2012 Households	Kits Sent	Kits Returned	Return Rate
Langola	930	343	231	101	44%
Maywood	956	351	298	75	25%
Watab	3133	1170	922	326	35%
Total	5019	1864	1451	502	*35%

\* Note: This represents the average return rate.

# Benton County 2013 Township Sampling Results

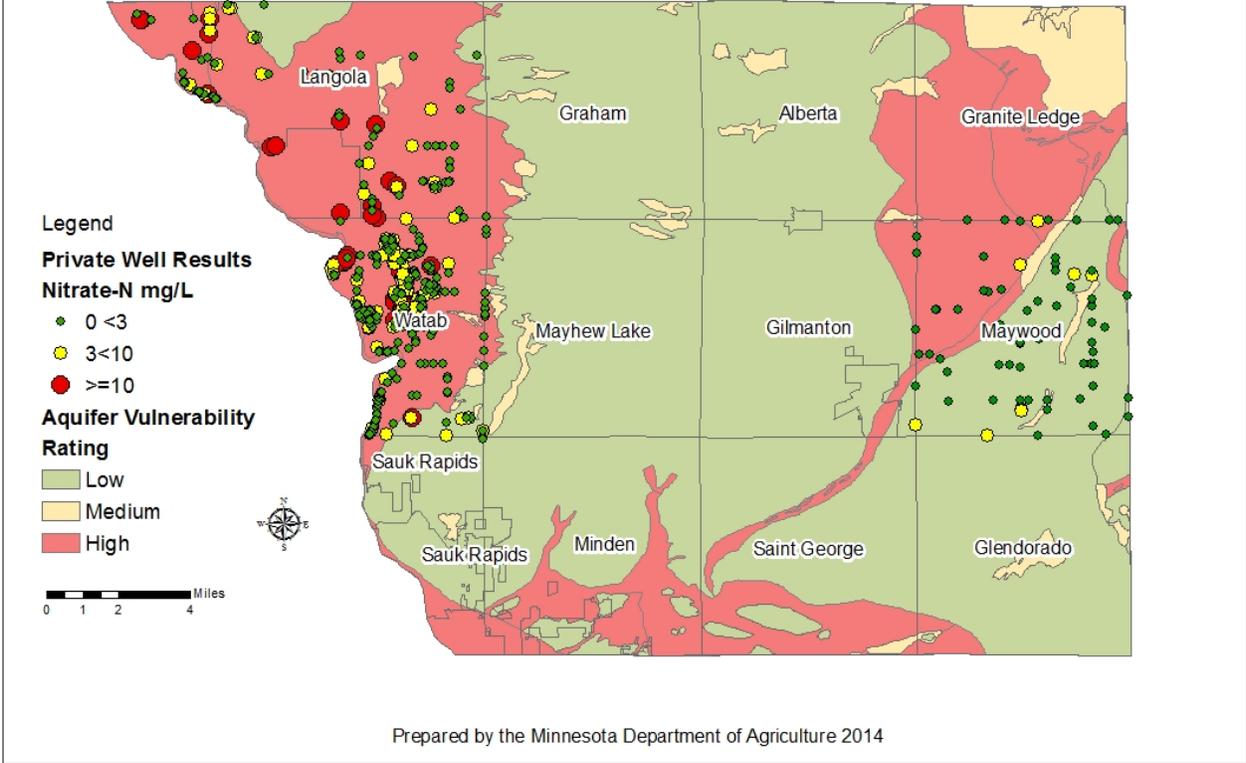


Figure 6. Benton County Private Well Township Sampling Results 2013

**Table 5. Benton County Township Sampling Summary Statistics Including All Well Types**

Township	Total Wells	Values			Percentiles					Number of Wells					Percent				
		Min	Max	Mean	50th (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 parts per million (ppm)																			
Langola	101	<DL	37.5	4.4	0.1	5.9	17.6	21.4	34.3	66	20	29	23	15	65%	20%	29%	23%	15%
Maywood	75	<DL	10.7	1.0	0.0	0.3	3.7	5.7	9.9	66	8	5	2	1	88%	11%	7%	3%	1%
Watab	326	<DL	40.9	3.5	0.6	4.4	8.4	16.4	35.7	216	82	68	44	28	66%	25%	21%	13%	9%

< 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. Benton County Township Sampling Summary Statistics without Hand Dug Wells**

Township	Total Wells	Values			Percentiles					Number of Wells					Percent				
		Min	Max	Mean	50th (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 parts per million (ppm)																			
Langola	101	<DL	37.5	4.4	0.1	5.9	17.6	21.4	34.3	66	20	30	24	16	65%	20%	29%	24%	16%
Maywood	66	<DL	10.7	0.8	<DL	0.2	2.9	4.9	10.2	60	5	3	2	1	91%	8%	5%	3%	2%
Watab	321	<DL	40.9	3.5	0.6	4.4	8.2	16.6	35.7	214	79	66	43	28	67%	25%	21%	13%	9%

< 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 7. Township Nitrate Results Summary Related to Vulnerable Groundwater and Row Crop Production**

Township	Total Wells*	Percent Vulnerable Aquifer	Percent Row Crop Production	Percent of Wells* Nitrate-N $\geq$ 10 mg/L	90th Percentile Nitrate-N mg/L
Langola	101	87%	54%	16%	17.6
Maywood	66	87%	22%	2%	2.9
Watab	321	31%	39%	9%	8.2

\* 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. Survey questions 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 9-23).

The majority of wells in each township are located on “rural” property. Approximately 82 percent of wells in these townships are of drilled construction and 6 percent are sand-point wells. In Maywood 12 percent of the wells sampled are hand dug wells.

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. The majority of wells are completed between 11 and 40 feet below ground surface. Well age does not seem to be as much of a factor in affecting nitrate concentrations as the well depth seems to be.

### WELL LOGS

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 designation for the well. In this case, 70 wells were identified in the CWI and well logs were obtained (Table 8).

In Langola Township, 23 well logs were obtained from the CWI. Ten of the wells were identified as water table wells and three of those exhibited nitrate concentrations greater than or equal to 10 mg/L. Thirteen were completed in buried sand and gravel aquifers and three of these were greater than or equal to 10 mg/L. There was also one well completed in a deeper bedrock aquifer with nitrate results less than detection, which was not included in the table.

In Watab Township, 33 well logs were obtained from the CWI. Fifteen of the wells were completed in the water table aquifer and six of those exhibited nitrate concentrations greater than or equal to 10 mg/L. Eighteen were completed in deeper buried aquifers protected by clay confining units and none of those were greater than or equal to 10 mg/L. However, 22 percent of the buried aquifer wells were in the 3 to less than 10 mg/L nitrate range. There was also one well completed in a deeper bedrock aquifer with a nitrate result of less than detection, which was not included in the table.

In Maywood Township, 15 wells were completed in a buried aquifer and one was in a deeper bedrock aquifer. None of these were above 10 mg/L. This information is consistent with the findings of the Geologic Atlas that states that there is not a productive water table aquifer in the eastern part of Benton County.

**Table 8. Aquifer Designation and Nitrate Results**

Township	Aquifer Designation*	Total Wells	Ave Depth (Feet)	Number			Percent		
				<3	3<10	≥10	<3	3<10	≥10
				Nitrate-N mg/L					
Langola	QWTA wells	10	57.5	7	0	3	70%	0%	30%
	QBAA wells	13	91.4	7	3	3	54%	23%	23%
Watab	QWTA wells	15	68.0	3	6	6	20%	40%	40%
	QBAA wells	18	68.4	14	4	0	78%	22%	0%
Maywood	QBAA wells	14	61.9	13	1	0	93%	7%	0%
All wells with well logs		70	69.4	44	14	12	63%	20%	17%

\* The aquifer designations were obtained from well logs in the CWI database.

QWTA = Quaternary Water table Aquifer

QBAA = Quaternary Buried Artesian Aquifer

---

## 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 9-23).

- On average only five percent of the well owners responded that they have livestock (greater than 10 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 (75 percent) are greater than 300 feet from an active or inactive feedlot or an agricultural field.
- The majority of wells are more than 50 feet away from septic systems (93 percent).
- Farming takes place on 25 percent of the properties.
- Agricultural fields are greater than 300 feet from wells at 55 percent of the properties.

## SUMMARY

Using aquifer (groundwater) vulnerability and row crop production as indicators for potential nitrate contamination in private wells seems to be a useful tool in targeting nitrate sampling. Results from this study in Langola Township and Watab Township indicated a greater nitrate detection frequency for concentrations above 10 mg/L (which is the state Health Risk Limit (HRL)) as compared to more regional sampling studies. Evaluation of this data suggests Langola Township is more heavily impacted by nitrate than either Watab or Maywood Townships. Langola Township had the highest percent of vulnerable groundwater and highest percent of row crop production compared to the other two townships (Table 7).

In approximately 70 instances (14%) well owners were able to provide Unique Well Identification Numbers for their wells in the three townships. When the correct Unique IDs are provided, a well log can be used to identify the well age, depth and the aquifer or formation in which the well is completed. This enables a summary of nitrate results by aquifer.

In Langola Township more than 10 percent of the wells completed in the water table aquifer and the buried aquifer groups exhibited nitrate concentrations over the 10 mg/L

HRL. In Watab Township, 40 percent of the water table aquifer wells indicated results over 10 mg/L. The buried aquifer wells had no results over 10 mg/L, however, 22 percent of results were in the impacted or human-caused ( $3 < 10$  mg/L) range of nitrates. Wells in these two townships are very vulnerable to nitrate contamination due to the outwash geology of the area and associated shallow aquifers where many of the wells are completed.

Future work that may be considered by the MDA includes the following: 1) resampling wells that had high nitrate results (greater than or equal to 5 mg/L) to verify high nitrate levels; 2) performing well site visits, when possible, to rule out well construction issues and obvious point sources of nitrate, such as septic systems, livestock, etc.; and 3) increasing efforts to obtain well log information for participating wells so that the nitrate results and the aquifer designation can be compared in a more comprehensive fashion.

## REFERENCES

- Kaiser, K., 2012. Central Sands Private Well Network 2011, Current Nitrate Conditions Summary. Minnesota Department of Agriculture, St. Paul, MN.
- Minnesota Department of Health, 2002. Benton County Nitrate-Nitrogen Probability, on-line PDF accessed on 3/11/14 at:  
<http://www.health.state.mn.us/divs/eh/water/swp/nitrate/reports/2002method/Benton.pdf>
- Minnesota Department of Health, County Well Index website accessed on 4/2/2014 at:  
<http://www.health.state.mn.us/divs/eh/cwi/>
- Minnesota Department of Natural Resources, 1991. Geologic Sensitivity Project Workgroup. Criteria and guidelines for assessing geologic sensitivity of ground water resources in Minnesota, Minnesota Department of Natural Resources, Division of Waters, St. Paul, Minn., 122 p.
- Minnesota Department of Natural Resources, 2012. Geologic Atlas of Benton County, Minnesota, County Atlas Series C-23, Part B.
- Minnesota Pollution Control Agency, 1998. Baseline Water Quality of Minnesota's Principal Aquifers, Region 2, North Central Minnesota.
- Minnesota Geological Survey, DNR and University of Minnesota –Duluth (1997). Geomorphology of Minnesota, geomorphology data describing a wide variety of conditions related to surficial geology within a hierarchical classification scheme that was devised for use within Minnesota, Scale 1:100,000.
- Minnesota Geologic Survey, County Atlas Website accessed on 4/2/2014 at:  
[http://www.mngs.umn.edu/county\\_atlas/countyatlas.htm](http://www.mngs.umn.edu/county_atlas/countyatlas.htm)
- Nolan, BT., and Stoner, J.D., 2000. Nutrients in Groundwaters of the Conterminous United States, 1992-95: Environmental Science and Technology, v. 34, no. 7, p. 1156-1165.
- U.S. Environmental Protection Agency, 2009. National Primary Drinking Water Regulations list, on-line PDF file accessed on 12/13/2011 at  
<http://water.epa.gov/drink/contaminants/upload/mcl-2.pdf>
- Warner, K.L., and Arnold, T.L., 2010. Relations that Affect the Probability and Prediction of Nitrate Concentration in Private Wells in the Glacial Aquifer System in the United States, A USGS National Water-Quality Assessment Program Scientific Investigations Report 2010.

### 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, Sandpoint, Hand dug, Other, Other, and don't know.
8. Approximate age (years) of your well?  
Answer choices: 0-9.9 years, 10-19.9 years, 20-39.9 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 300 or more feet.
10. Distance to an active or inactive feedlot  
Answer choices: 0-50 feet, 51-100 feet, 101-300 feet, and 300 or more feet.
11. Distance to a septic system  
Answer choices: 0-50 feet, 51-100 feet, 101-300 feet, and 300 or more feet.
12. Distance to an agricultural field  
Answer choices: 0-50 feet, 51-100 feet, 101-300 feet, and 300 or more 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, with 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 and greater, or don't know.

**Table 9. Property Setting for Well Location**

Property Setting				
Township	Langola	Maywood	Watab	Average
Total Wells	101	75	326	167
Setting	Percent			
Country	75%	96%	50%	74%
Lake	10%	0%	23%	11%
Sub-division	10%	0%	19%	10%
NA	5%	4%	8%	6%

**Table 10. Well Construction Type**

Well Construction Type				
Township	Langola	Maywood	Watab	Average
Total Wells	101	75	326	167
Well Type	Percent			
Drilled	86%	80%	80%	82%
Sand point	9%	1%	7%	6%
Hand dug well	0%	12%	1%	4%
NA	5%	7%	12%	8%

**Table 11. Age of Well**

Well Age				
Township	Langola	Maywood	Watab	Average
Total Wells	101	75	326	167
Age	Percent			
0-10 years	14%	24%	10%	16%
11-20 years	39%	35%	26%	33%
21-40 years	34%	19%	47%	33%
over 40 years	8%	17%	9%	11%
NA	6%	5%	8%	6%

**Table 12. Depth of Well**

Well Depth				
Township	Langola	Maywood	Watab	Average
Total Wells	101	75	326	167
Depth	Percent			
0-50 feet	15%	28%	14%	19%
51-100 feet	55%	53%	56%	55%
101-300 feet	22%	8%	13%	14%
over 300 feet	1%	1%	1%	1%
NA	7%	9%	16%	11%

**Table 13. Unique Well ID Known**

Does the Well have a Unique ID?				
Township	Langola	Maywood	Watab	Average
Total Wells	101	75	326	167
Unique ID	Percent			
No	22%	21%	26%	23%
Yes	10%	11%	16%	12%
NA	68%	68%	59%	65%

**Table 14. Livestock Located on Property**

Livestock on Property				
Township	Langola	Maywood	Watab	Average
Total Wells	101	75	326	167
Livestock	Percent			
No	85%	91%	88%	88%
Yes	6%	7%	1%	5%
NA	9%	3%	11%	8%

**Table 15. Fertilizer Stored on Property**

Fertilizer Stored on Property				
Township	Langola	Maywood	Watab	Average
Total Wells	101	75	326	167
Fertilizer	Percent			
No	94%	93%	91%	93%
Yes	3%	0%	0%	1%
NA	3%	7%	9%	6%

**Table 16. Farming on Property**

Does Farming take place on Property				
Township	Langola	Maywood	Watab	Average
Total Wells	101	75	326	167
Farming	Percent			
No	78%	44%	87%	70%
Yes	19%	51%	5%	25%
NA	3%	5%	8%	5%

**Table 17. Distance to an Active Feedlot**

Feedlot located on Property				
Township	Langola	Maywood	Watab	Average
Total Wells	101	75	326	167
Distance	Percent			
0-50 feet	5%	4%	3%	4%
51-100 feet	3%	7%	0%	3%
101-300 feet	8%	8%	2%	6%
over 300 feet	71%	76%	77%	75%
NA	13%	5%	19%	12%

**Table 18. Distance to Septic System**

Distance to Septic System				
Township	Langola	Maywood	Watab	Average
Total Wells	101	75	326	167
Distance	Percent			
0-50 feet	0%	0%	4%	1%
51-100 feet	36%	23%	38%	32%
101-300 feet	55%	59%	42%	52%
over 300 feet	5%	16%	7%	9%
NA	4%	3%	8%	5%

**Table 19. Distance to an Agricultural Field**

Distance to Agricultural Field				
Township	Langola	Maywood	Watab	Average
Total Wells	101	75	326	167
AgField	Percent			
0-50 feet	5%	8%	2%	5%
51-100 feet	4%	12%	2%	6%
101-300 feet	26%	41%	10%	26%
over 300 feet	57%	36%	73%	55%
NA	8%	3%	13%	8%

**Table 20. Drinking Water Well**

Is the Well used for Drinking Water				
Township	Langola	Maywood	Watab	Average
Total Wells	101	75	326	167
	Percent			
No	0%	0%	1%	0%
Yes	92%	96%	93%	94%
NA	8%	4%	6%	6%

**Table 21. Treatment System Present**

Treatment System used for Drinking Water				
Township	Langola	Maywood	Watab	Average
Total Wells	101	75	326	167
	Percent			
None	65%	75%	61%	67%
Filtering System	14%	15%	12%	14%
Reverse Osmosis	7%	7%	10%	8%
Distillation	2%	0%	1%	1%
Other	2%	0%	1%	1%
NA	10%	4%	15%	10%

**Table 22. Last Tested for Nitrate**

When was the Well Last Tested for Nitrate				
Township	Langola	Maywood	Watab	Average
Total Wells	101	75	326	167
Last tested	Percent			
Within the past year	3%	3%	3%	3%
Within the last 3 years	8%	8%	9%	8%
Within the last 10 years	25%	29%	23%	26%
Never Tested	17%	23%	20%	20%
Greater than 10 years	28%	21%	21%	23%
Not sure	16%	13%	18%	16%
NA	4%	3%	6%	4%

**Table 23. Last Nitrate Test Result**

Last Nitrate Result				
Township	Langola	Maywood	Watab	Average
Total Wells	101	75	326	167
Last Nitrate-N Result	Percent			
<3 mg/L	20%	24%	17%	20%
3-10 mg/L	17%	4%	7%	9%
> 10 mg/L	2%	0%	2%	1%
NA	61%	72%	74%	69%