Minnesota Department of Health Contribution to Final Report
Southeast Minnesota Voluntary Nitrate Monitoring Network

MDH—Source Water Protection Program
October, 2009

General

As discussed elsewhere in this report, this project assembled a network of domestic wells, selected from 675 search areas ("buffers") uniformly distributed over the nine-county study area (Figure 1). The network is referred to as the "voluntary nitrate monitoring network" (VNMN). The county well coordinators attempted to enroll one randomly selected domestic well from within each buffer of the network.

MDH In-Kind Contributions to the VNMN

Introduction. Since 2006, Minnesota Department of Health (MDH) Source Water Protection Unit staff contributed over 600 in-kind hours to the VNMN project as follows:

- Attended approximately ten project meetings.
- Developed and delivered several technical presentations.
- Developed and presented training materials to well network coordinators on May 21, 2007, and August 9, 2007. The training materials are included on the CD enclosed with this report, and consist of:
    - Overview of well construction and aquifers in southern Minnesota
    - Summary of procedures for collecting well information during site visits
        - Well information form
        - Potential nitrate source inventory form
    - Procedure for collecting location data using the Garmin GPS12 Receiver
        - Instructions for downloading, processing, and editing Garmin GPS12 data
        - GPS waypoint log
- Developed and distributed MS-Access water quality databases to counties.
- Received and assembled project data into ArcMap-ready tables:
    - Well information, including aquifer designation where necessary
    - GPS or other location data
    - Potential nitrate source data
    - Nitrate data

Procedure for designating aquifer. During the enrollment of volunteer well owners into the network, the well network coordinators recorded critical information (in particular, the unique number, and well construction and geological information) on the Well Information Form for each well. They also recorded well owners' responses to a questionnaire designed to provide additional information needed for estimating well completion for wells lacking drilling records. After receiving the completed Well

Information Forms from well network coordinators, MDH staff performed the following tasks to ensure the integrity of the collected well data:

- Eliminated discrepancies arising from the possible presence of more than one well at the enrollment location:
    - When present, blue identifying tags containing well unique numbers assured the correct well was identified.
    - For wells lacking blue tags, photographs and other submitted information (e.g., casing diameter) helped guarantee well identity.
    - Searched County Well Index (CWI; CWI.c5ix or wells.shp database layer in ArcMap) to check for other nearby wells possibly mistaken for the selected well.
    - Contacted well network coordinators to resolve discrepancies.
- Checked Universal Transverse Mercator (UTM) coordinates of selected wells against existing coordinates, and updated if necessary.
- For wells lacking unique numbers, assigned a unique number, and entered into CWI the collected information about the well, including location and well depth.
- Reviewed or assigned aquifer designation for each well:
    - For wells with unique numbers, reviewed the stratigraphic and casing depth information, and modified the aquifer designation if necessary.
    - Wells lacking unique numbers commonly lack geologic logs. In these cases, the aquifer designation was estimated by drawing geologic cross sections using nearby wells with geologic logs to estimate the aquifer of completion for the selected well.
- Updated CWI with the new information: owners' name, address, well depth, aquifer, and alternate identification.

Data entry. MDH staff entered the data from the well information form into the ArcMap shapefile **regional_675_buffer_B.shp** (included on the data CD submitted with this report). In the shapefile, blank cells or negative numbers indicate no information was received. In the fields corresponding to nitrate concentrations measured for rounds 1, 2 and 3 (NO3_R1, NO3_R2, and NO3_R3), zeroes indicate the value recorded by the well network coordinators at the time of water analysis, and are assumed to indicate a measured value of 0 mg/L nitrate. To map the information in the table, joined it to County Well Index based on the [RELATEID] field. Shapefile field names are defined in Table 1.

Network wells for certain buffers have changed since monitoring began. Such changes may be due to: 1) well replacement; 2) a new volunteer; or 3) other reasons. The project has not yet resolved how to manage nitrate data in buffers where the sampled well has changed. However Table 2 archives the known network well changes as of October 13, 2009.

MDH staff also reviewed the potential nitrate source inventory information that the well network coordinators submitted, and entered it into an existing MDH database called the "potential contaminant source inventory" (PCSI). An excerpt from the PCSI for the wells of the VNMN is included on the report CD. PCSI field names are defined in Table 3.

Work Products and Results

For each well, MDH developed information which was entered into the following fields of the **regional_675_buffer_B.shp** shapefile:

Field name [AQUIFER]. The project database contains 42 distinct aquifer codes for 472 wells, with undetermined aquifer codes for 203 wells. Table 4 defines the aquifer codes for wells in this study. Figure 2 shows 452 buffers where aquifer assignment was possible, and where the aquifer is unambiguously within one of the following groups: Quaternary, Devonian, Galena through Maquoketa, St. Peter, Prairie du Chien-Jordan, Franconia-Ironton-Galesville. Twenty wells did not fit within these categories (e.g., “MTPL”, “CJFR”, “CJIG”, etc.) and are not shown on the map.

Field name [INFO]. After designating an aquifer, MDH staff assigned a rating of 0, 1 or 2 (see field name descriptions, Table 1) to indicate the confidence of the aquifer assignment. Figure 3 shows the distribution of aquifer assignment confidence levels.

Field name [MATRIX]. During database assembly, MDH recorded the geologic material intersected by the well screen or open hole interval (see Table 1). Figure 4 shows the distribution of geologic materials of well completion for 472 well completions across the study area for which we have geological information.

Field name [PROTECTION]. Some settings provide an overlying fine-grained geologic layer expected to retard the downward flow of water and surface contaminants towards the well screen or open-hole interval. MDH staff recorded where the presence of such layers could be verified (Figure 5). If the presence of an overlying geologically protective layer could not be verified, it was assumed to be absent.

Field name [WELLCODE]. Many well casings are installed into an oversize hole, and the annulus is then pressure-grouted to tightly seal it. Other wells attain a tight casing seal through the use of cable-tool drilling techniques. Wells with a tight casing seal prevent surface contaminants from flowing down the casing and entering the well. CWI records whether a tight grouted seal was installed during well construction, and this information was entered into the project database. Figure 6 shows the distribution of wells where such a seal can be verified (172 wells). Wells where a grout seal could not be verified were assumed to have no such seal.

Field name [RECHARGE2GW]. Contaminant entry to a well is minimized if the ground surface around the casing directs water away from the well, rather than toward it. During site visits, well network coordinators determined the direction of ground surface slope (Figure 7).

Nitrate data. As of October 13, 2009, four rounds of nitrate samples have been collected:

- Round 1, February 2008 (field name [NO3_R1]);
- Round 2, August 2008 (field name [NO3_R2]);
- Round 3, February 2009 (field name [NO3_R3]); and
- Round 4, August 2009 (field name [NO3_R4]).

However results are available for only the first three rounds. The following total number of samples was received during each of the first three sampling rounds:

- Round 1 (523 samples)
- Round 2 (511 samples)
- Round 3 (490 samples)

Samples were collected at 552 wells (82% of 675) during round 1, round 2, or round 3. See Figure 8 for buffer locations where samples have been received.

Figures 9, 10 and 11 show the nitrate concentration data throughout the network for sampling rounds 1, 2 and 3. Figure 12 shows nitrate concentrations for only wells completed in the St. Peter-Prairie du Chien-Jordan Aquifer system during round 3. Table 5 contains nitrate concentration data averaged by major aquifer for the first three sampling rounds.

Recent Samples from Baseline Wells

During 1992-1993, the Minnesota Geological Survey (MGS) sampled 159 domestic wells across the present study area and analyzed water for nitrate and many other compounds (Tipping, 1994). The 1994 study, informally called the "baseline study," provides early nitrate data against which the more recent sample results from this study can be compared.

Less than one-third of the original baseline wells were re-sampled in the current project. Round 2 sampling produced the highest number of re-sampled baseline wells (46), and round 2 results are shown in Figure 13. The change in nitrate concentration between the initial measurement in 1994 and round 2 (August 2008) is shown in Figure 14. Nitrate was not detected (0 mg/L) for the initial samples at the two wells with the largest increase in nitrate concentration (unique numbers 213365, +14 mg/L, and 418608, +4.6 mg/L). Increasing nitrate concentrations in these wells suggest a change in wellhead integrity (e.g., unintentional damage) since 1994, perhaps combined with a change in the arrangement of nearby nitrate sources. Such changes could render initially protective wellhead completions ineffective.

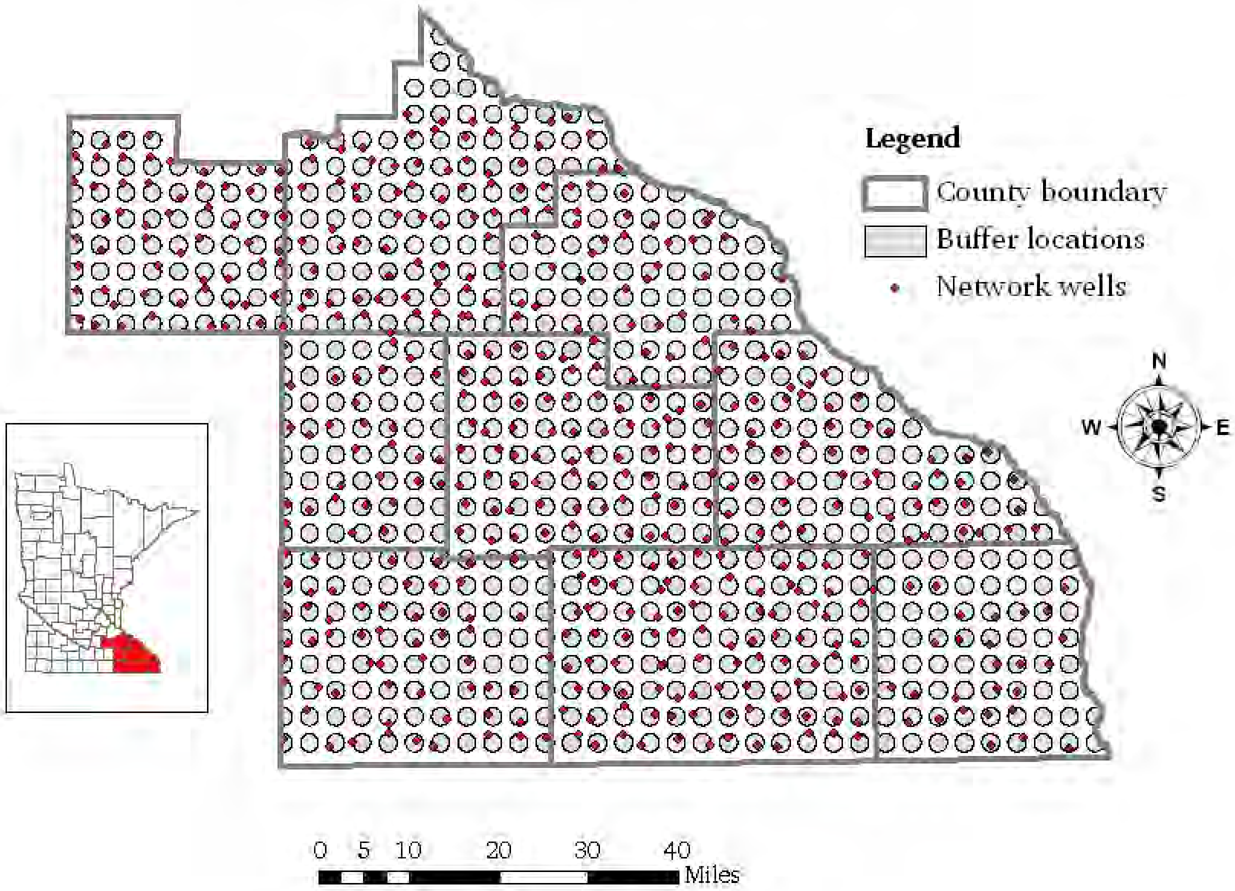
References

Minnesota Department of Natural Resources (MDNR), 1991, "Criteria and guidelines for assessing geologic sensitivity of ground water resources in Minnesota", Division of Waters, June 1991, 122 pp.

Tipping, Robert G., 1994, Southeastern Minnesota regional ground water monitoring study, a report to the Southeast Minnesota Water Resources Board, Minnesota Geological Survey Open-File Report 94-1, April 29, 1994, St. Paul, Minnesota.

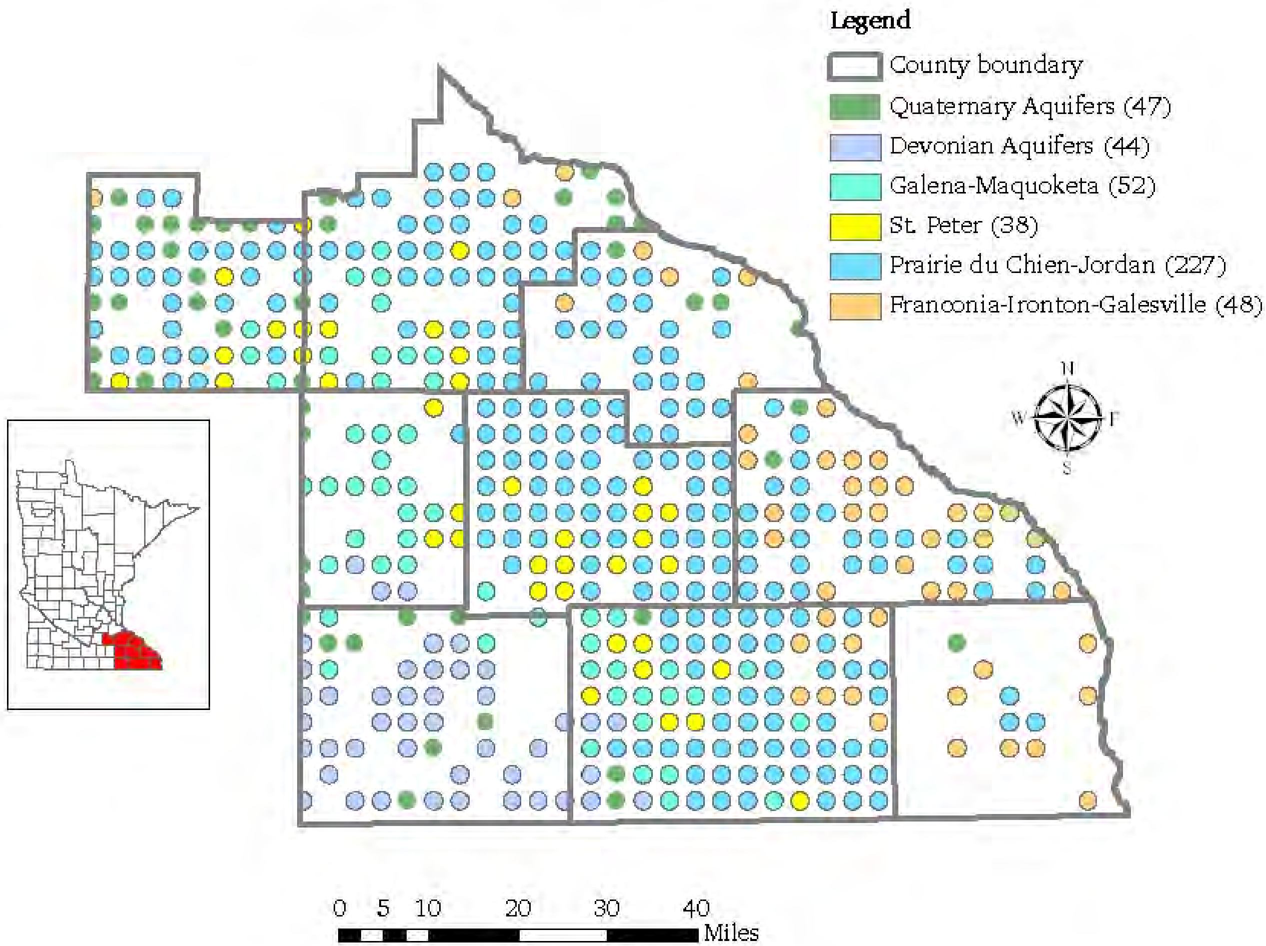
Southeast Minnesota Nitrate Monitoring Network
Figure 1: Buffers and Network Well Locations

Prepared by Minnesota Department of Health, September 2009



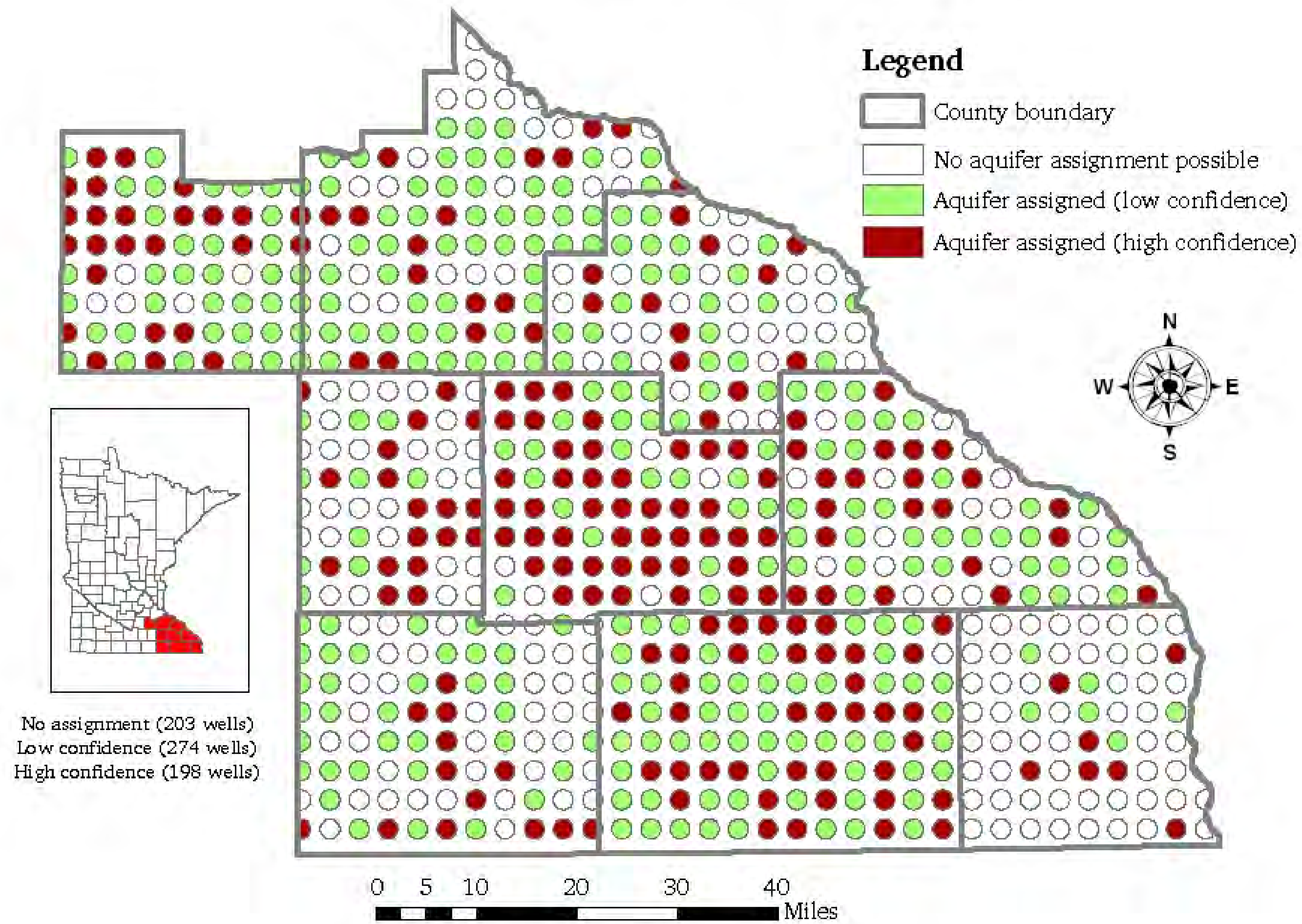
Southeast Minnesota Nitrate Monitoring Network
Figure 2: Aquifers of Well Completion

Prepared by Minnesota Department of Health, August 2009



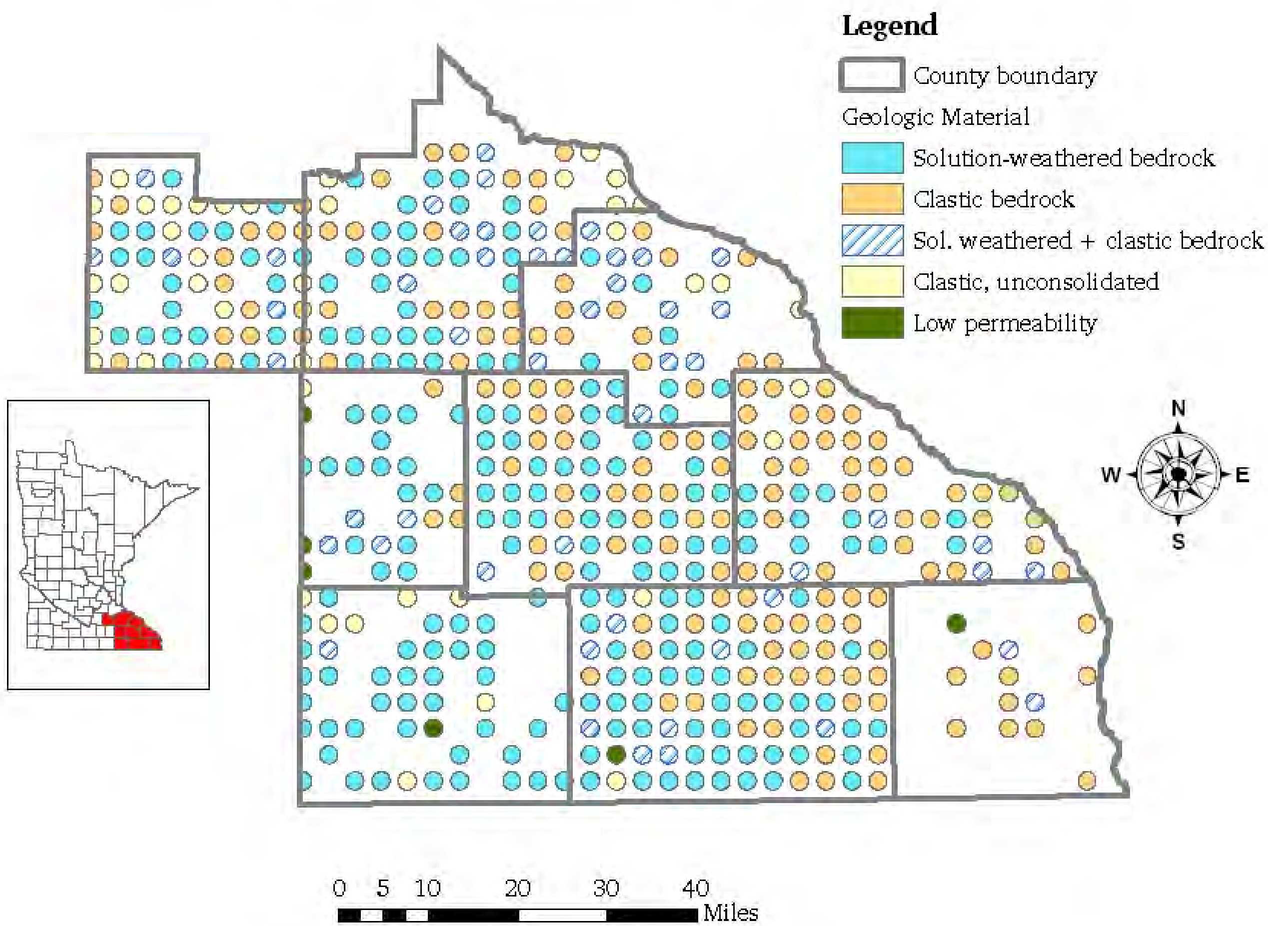
Southeast Minnesota Nitrate Monitoring Network
Figure 3: Confidence of Aquifer Assignment

Prepared by Minnesota Department of Health, August 2009



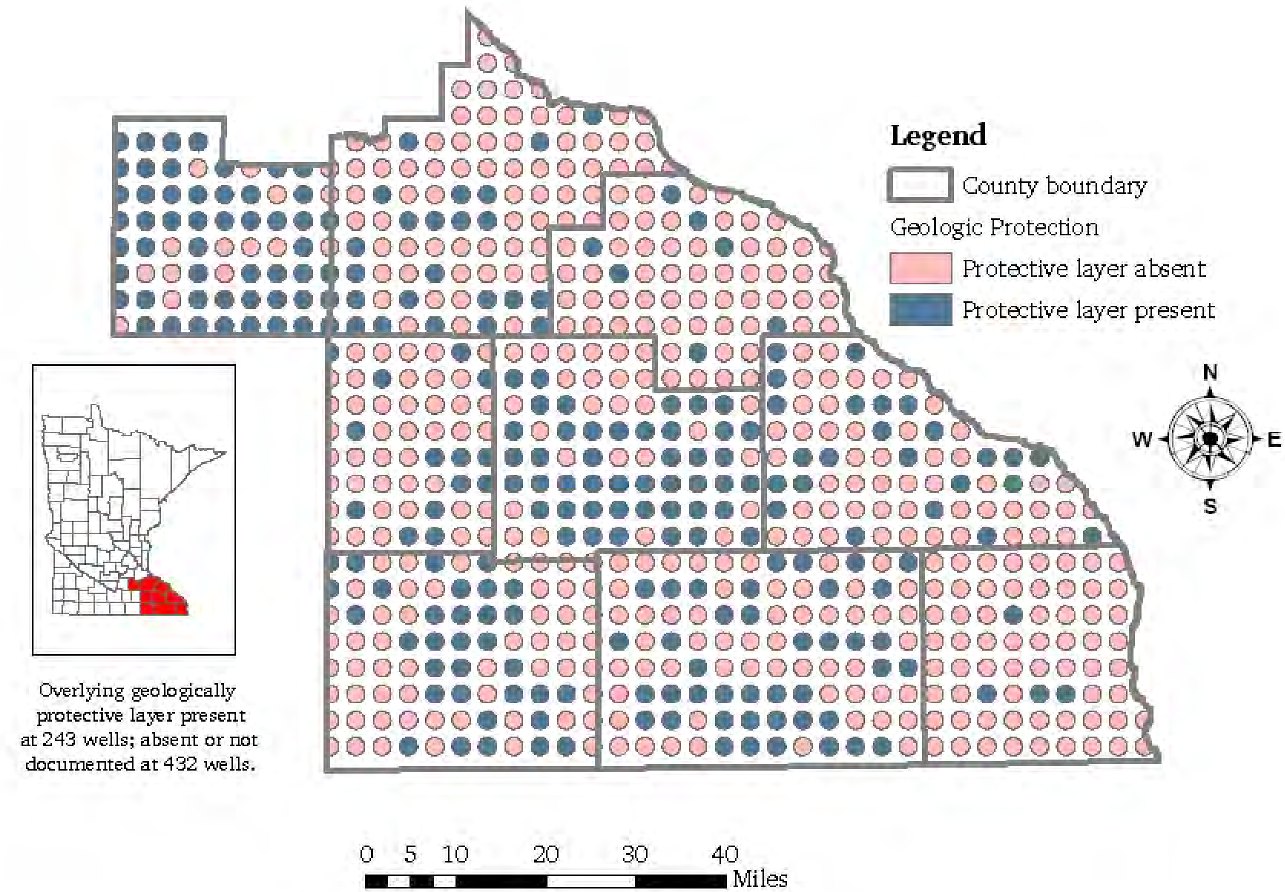
Southeast Minnesota Nitrate Monitoring Network
Figure 4: Geologic Material of Well Completion

Prepared by Minnesota Department of Health, August 2009



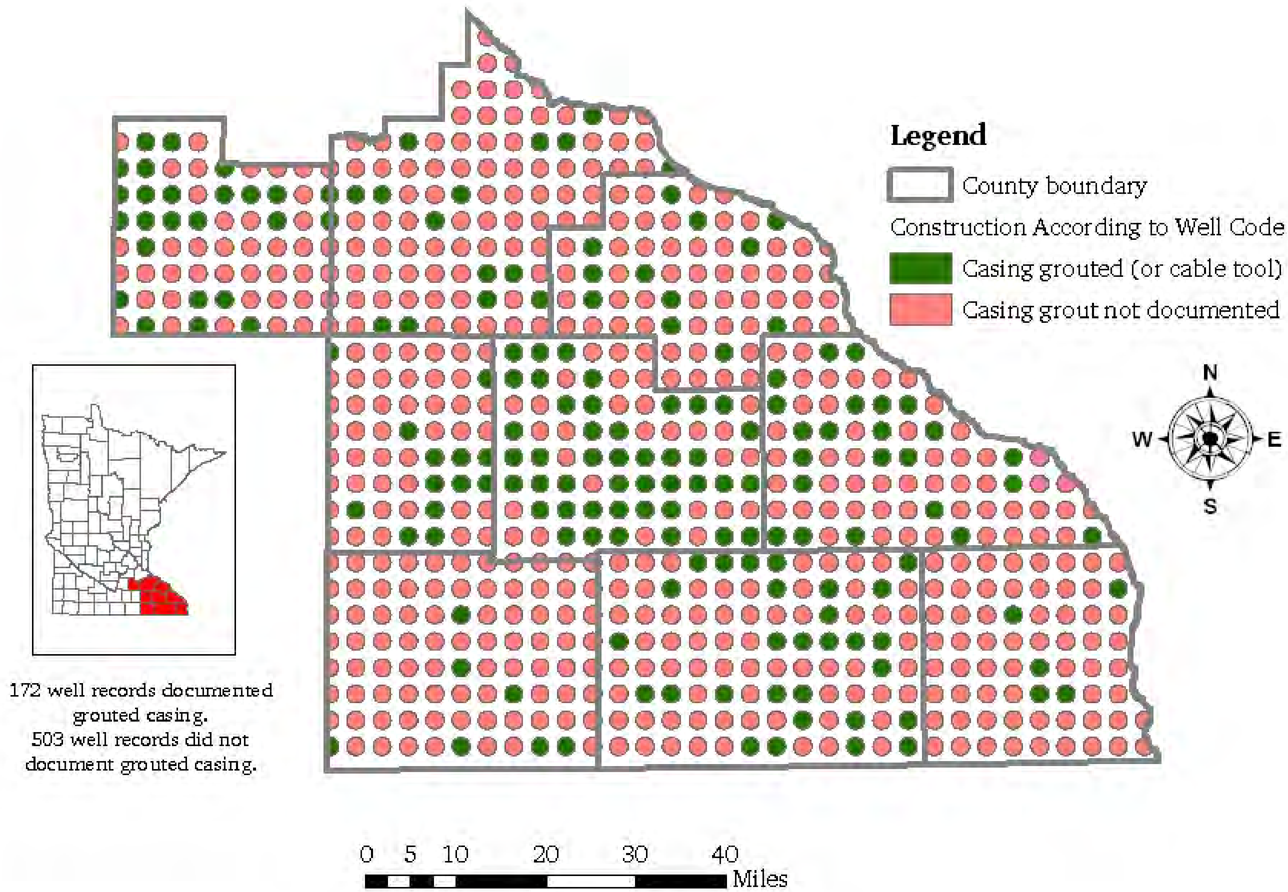
Southeast Minnesota Nitrate Monitoring Network
Figure 5: Overlying Geologically Protective Layers

Prepared by Minnesota Department of Health, August 2009



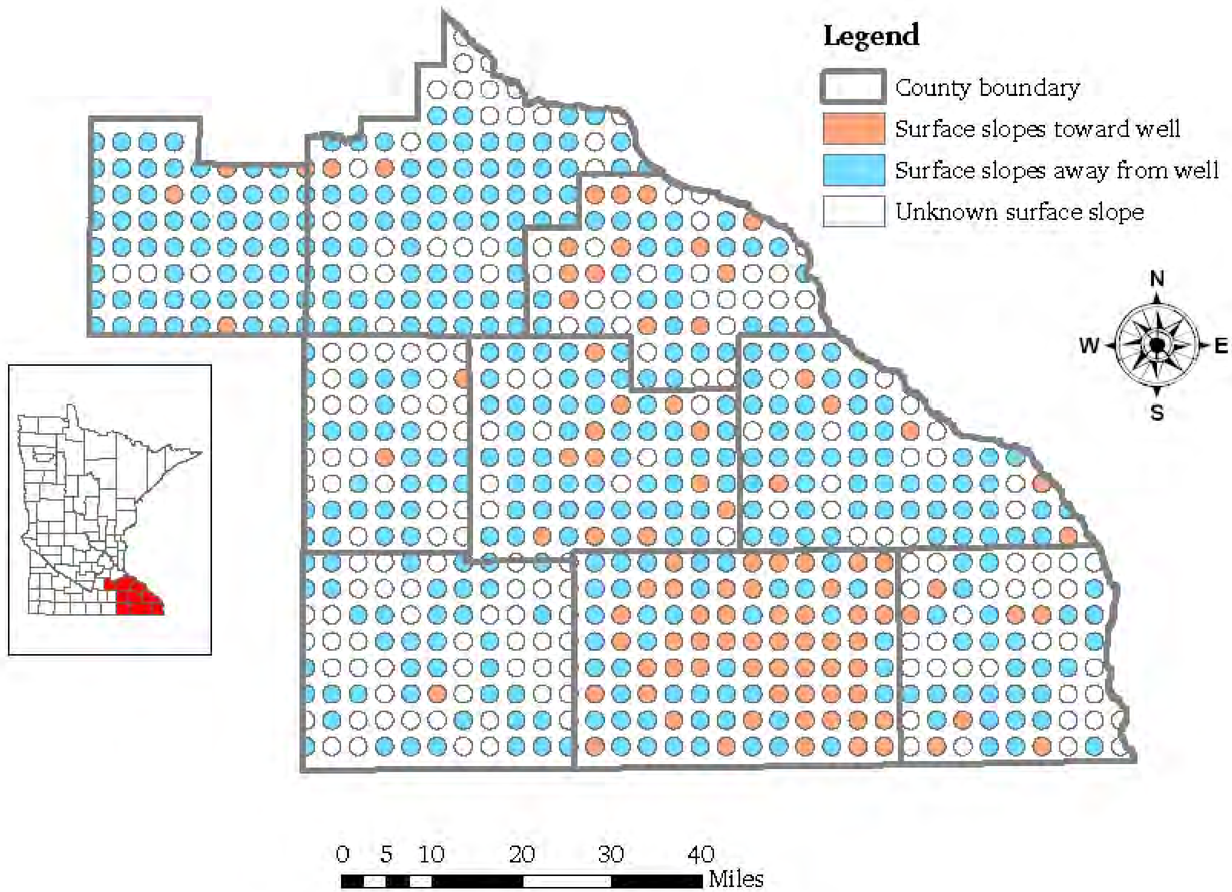
Southeast Minnesota Nitrate Monitoring Network
Figure 6: Wells With Casing Grouted Into Place

Prepared by Minnesota Department of Health, August 2009



Southeast Minnesota Nitrate Monitoring Network
Figure 7: Ground Surface Slope Toward or Away from Well Casing

Prepared by Minnesota Department of Health, August 2009



Southeast Minnesota Nitrate Monitoring Network
Figure 8: Buffers Where Nitrate Samples Were Received

Prepared by Minnesota Department of Health, August 2009

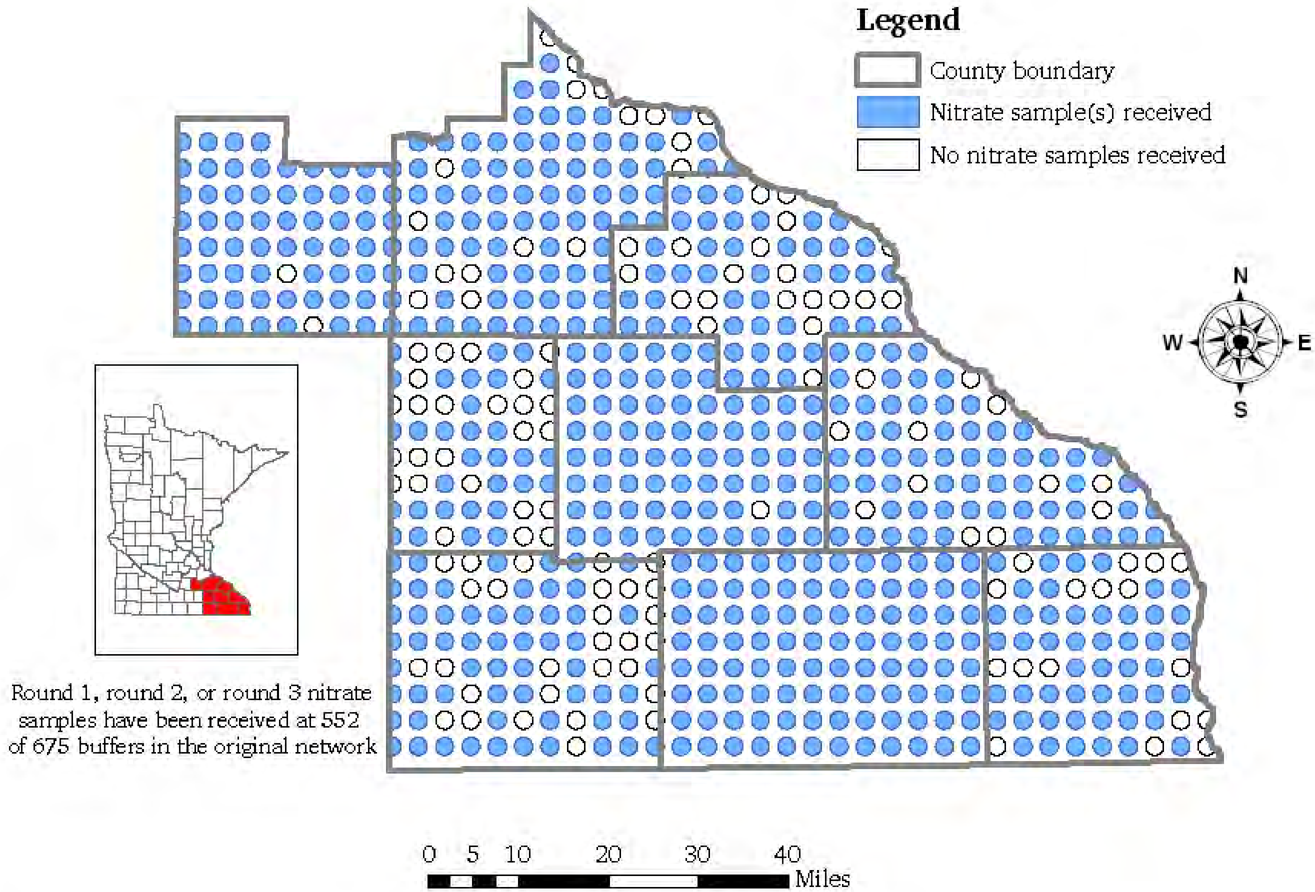


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Figure 9: Nitrate Concentration, Round 1 February 2008

Prepared by Minnesota Department of Health, August 2009

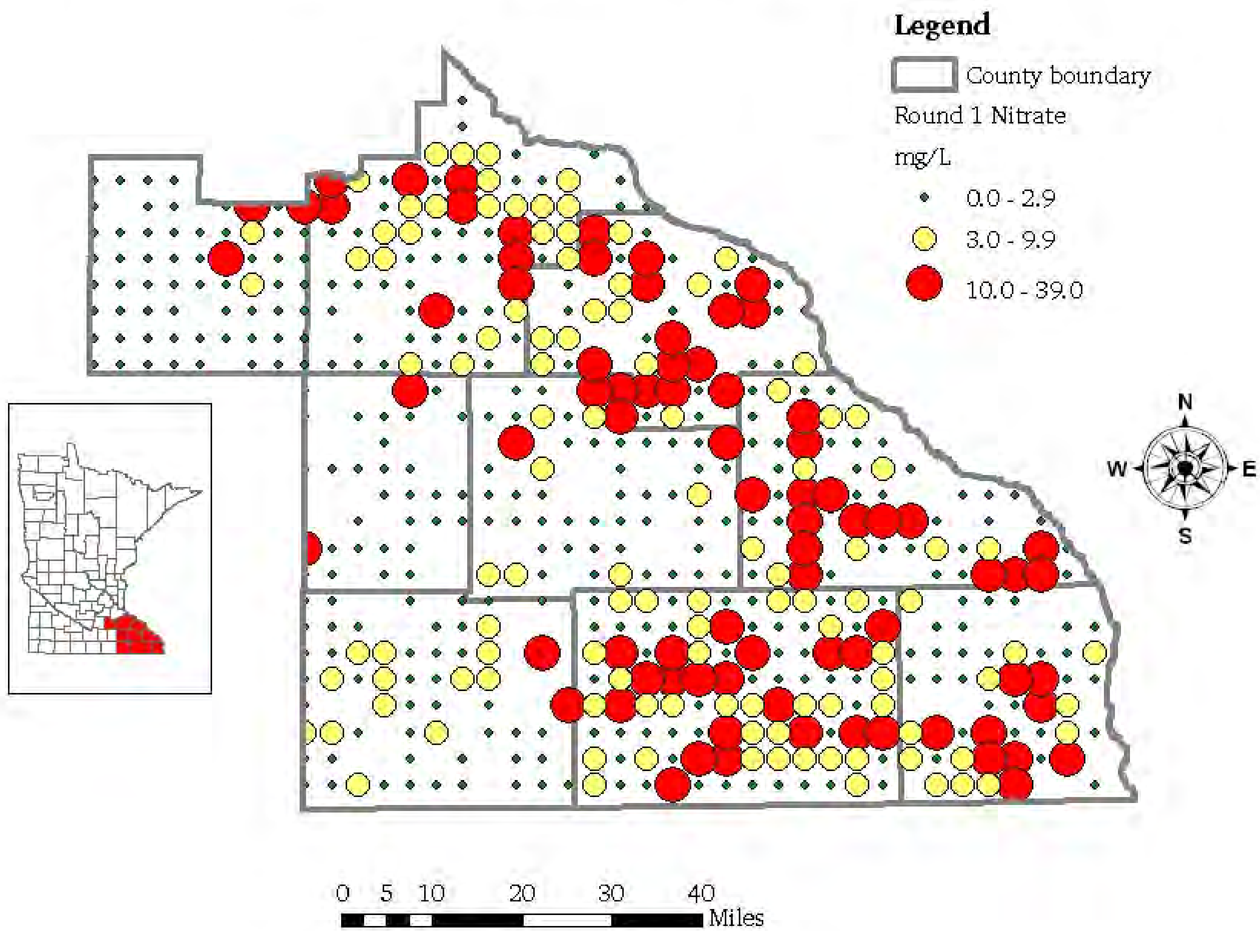

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Figure 10: Nitrate Concentration, Round 2 August 2008

Prepared by Minnesota Department of Health, August 2009

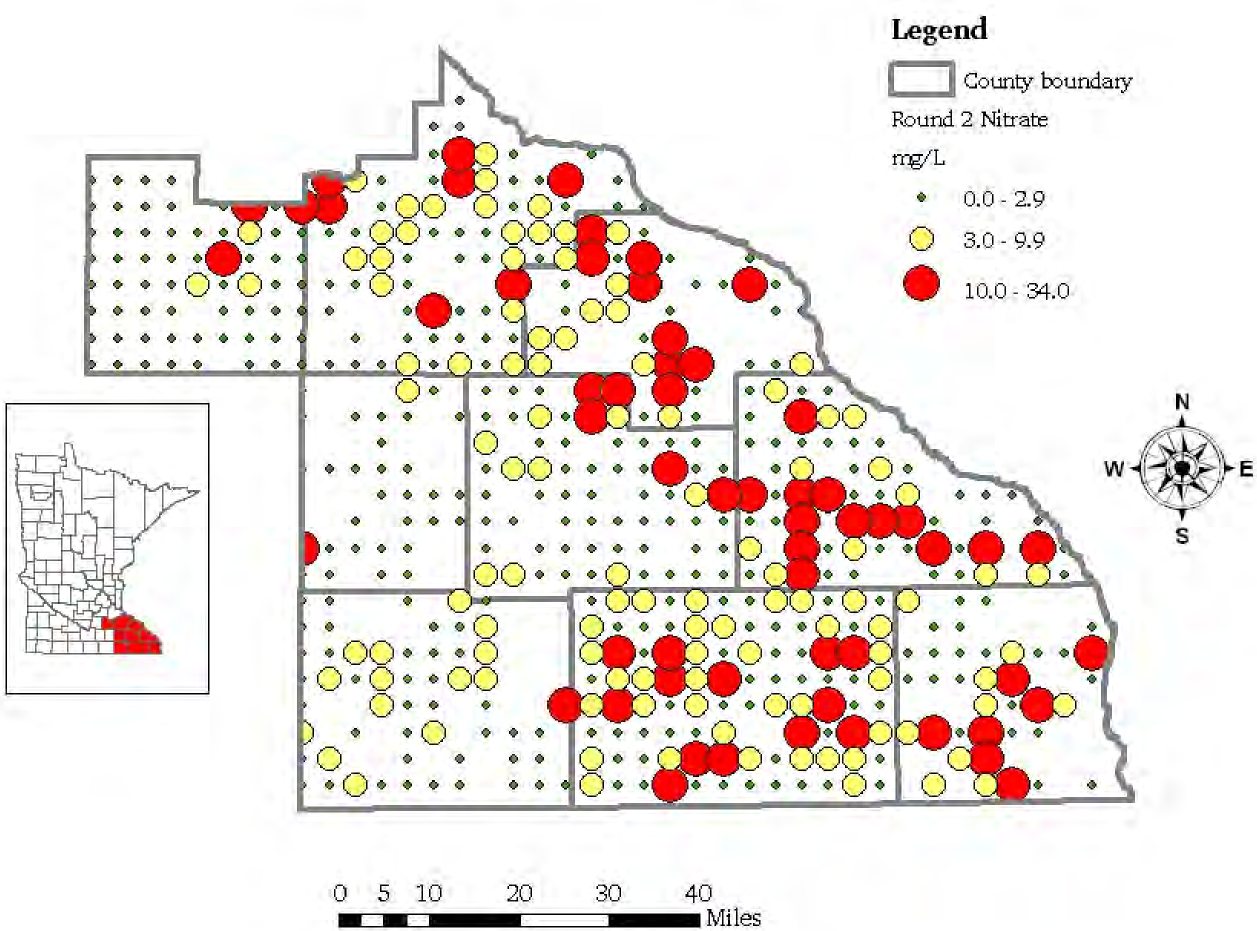

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Figure 11: Nitrate Concentration, Round 3 February 2009

Prepared by Minnesota Department of Health, August 2009

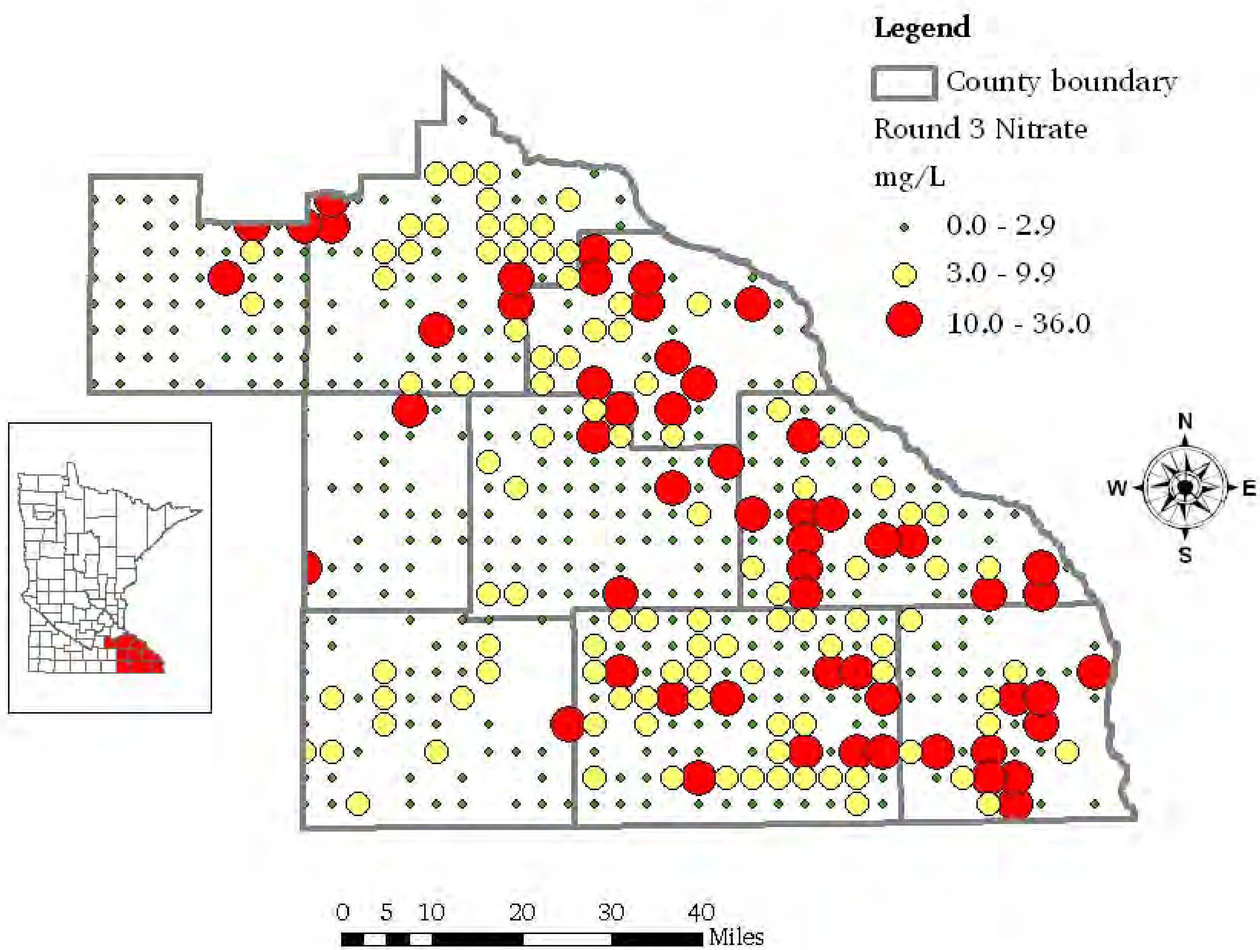

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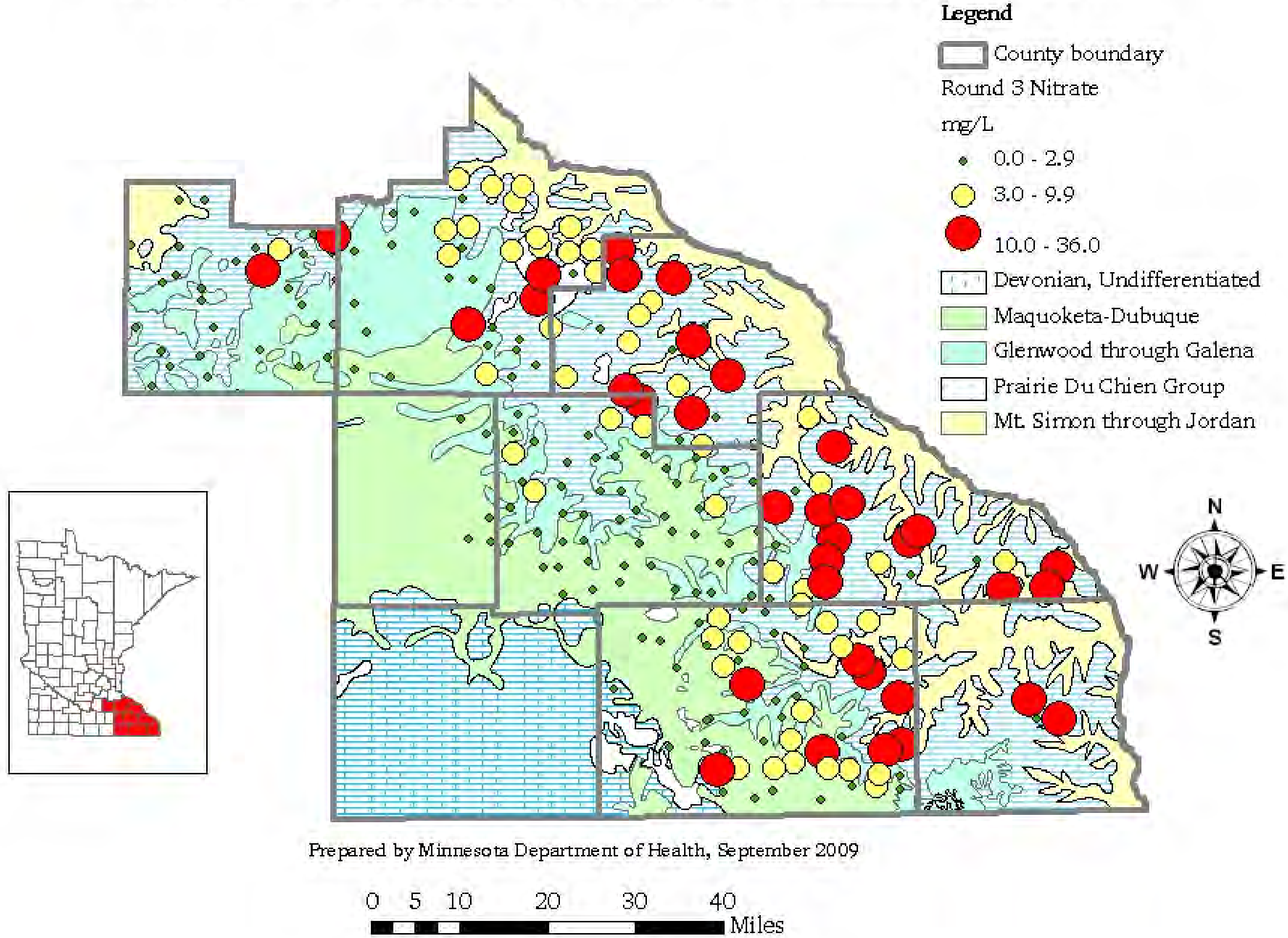
Figure 12: St. Peter-Prairie du Chien-Jordan Aquifer System
Nitrate Concentration, Round 3, February 2009



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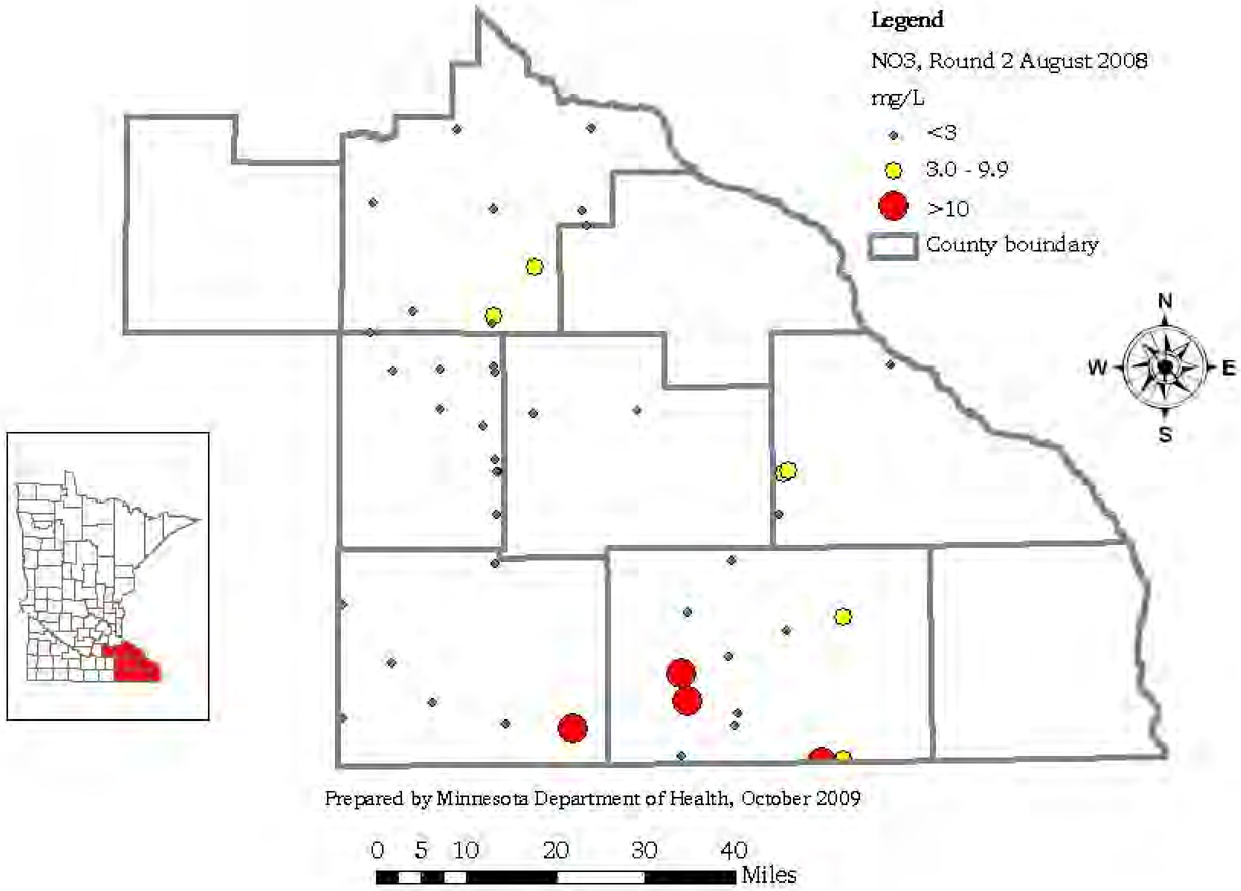
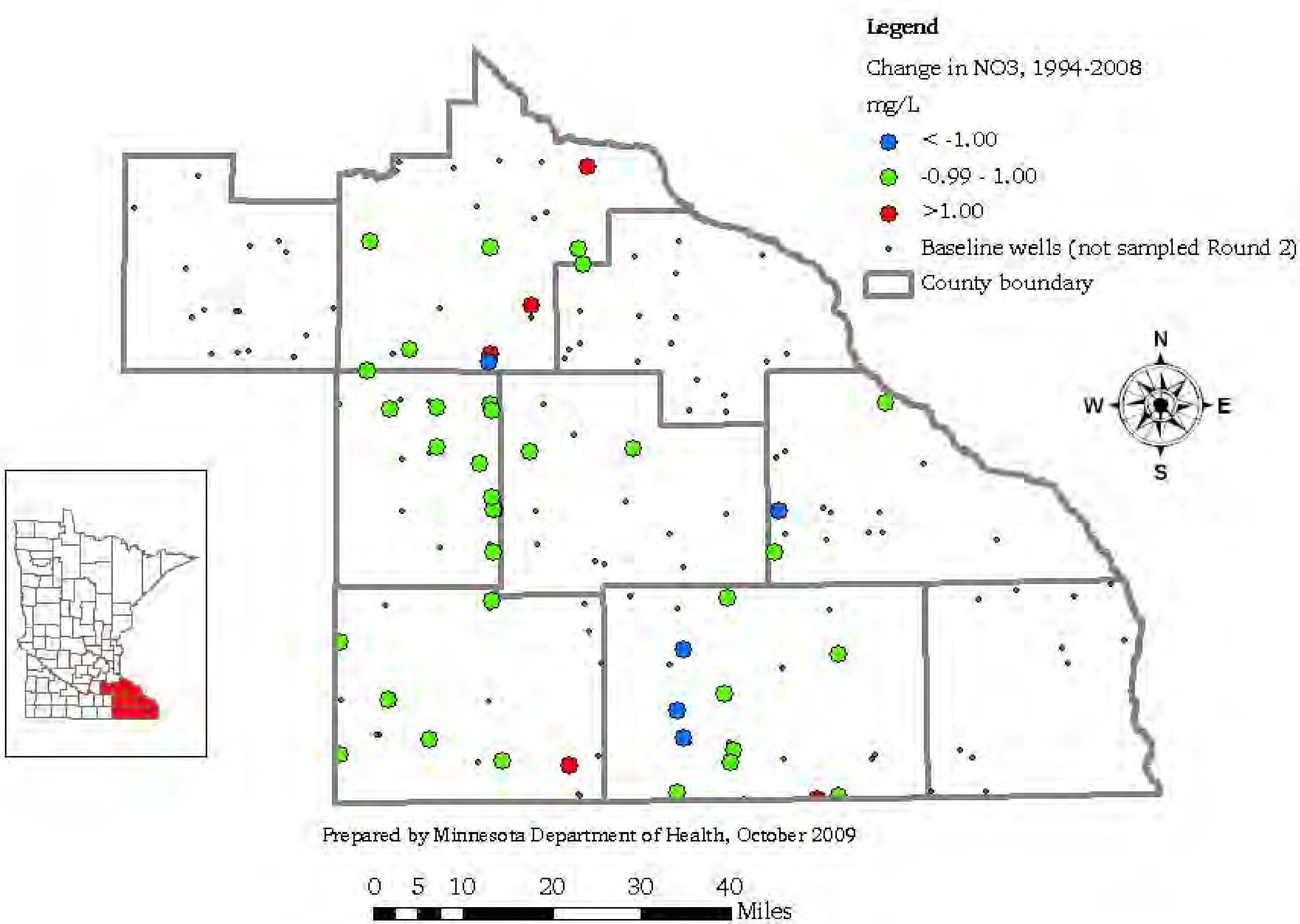
Southeast Minnesota Nitrate Monitoring Network
Figure 13: Baseline Wells Nitrate Concentration, Round 2, August 2008



Prepared by Minnesota Department of Health, October 2009

Southeast Minnesota Nitrate Monitoring Network
Figure 14: Change in Nitrate Concentration, 1994-2008



Prepared by Minnesota Department of Health, October 2009

Table 1: Field Definitions for Project Shapefile (regional_675_buffer_master.shp)

Field Name	Field Definition
IDENTIFIER	County name followed by the two-character buffer number
CTY_CODE	Unique two-character county code number
POINT_NO	Two-character buffer number
RELATEID	Ten-character (four leading zeroes) unique identifier for each well
INFO	Confidence of aquifer assignment **0** = LOW confidence (neither well casing depth nor geologic information available) **1** = MEDIUM confidence (well depth estimated from owner, aquifer assignment made on basis of comparison to nearby wells with known completion) **2** = HIGH confidence (well casing depth and geologic information available)
AQUIFER	CWI aquifer assignment for each well (see Table 4 for aquifer codes)
MATRIX	Matrix of the open-hole interval **S** = solution-weathered bedrock **F** = fractured bedrock **C** = clastic bedrock **B** = both solution-weathered and clastic bedrock **Q** = clastic unconsolidated material **L** = low permeability material
PROTECTION	Indicates presence/absence of an overlying layer that provides geologic protection from direct recharge to the aquifer **Yes** = geologic protection from at least 10 feet of overlying clay or shale (as per Department of Natural Resources, 1991) **Yes** = geologic protection from conventionally-accepted regional bedrock confining unit (e.g., OGWD, ODCR, etc.) **No** = Else
WELLCODE	Indicates whether well conforms to Minnesota Water Well Construction Code **Yes** = records verify that well casing is grouted into place (or cable-tool drilling) **No** = grouted of casing cannot be verified
RECHARGE2GW	Indicates whether surface drainage is toward the well casing **Yes** = drainage toward well casing **No** = drainage not toward well casing
NO3_R0	Nitrate concentration, mg/L, collected prior to monitoring schedule
NO3_R1	Nitrate concentration, mg/L, collected Round 1 (February 2008)
NO3_R2	Nitrate concentration, mg/L, collected Round 2 (August 2008)
NO3_R3	Nitrate concentration, mg/L, collected Round 3 (February 2009)
NO3_R4	Nitrate concentration, mg/L, collected Round 4 (August 2009)

Table 2: Archived Changes to Well Network Since Monitoring Began

		Unique number of sampled well			
County	***Buffer***	***Round 1****	***Round 2****	***Round 3****	***Comment***
Dodge					No changes
Fillmore					No changes
Goodhue	25035	***268816***	***268816***	Unknown	WNC reports that owner may have sampled a different well for Round 3
Houston					No changes
Mower	50001	268851	***756377***	***756377***	
Olmsted	55004	715375	***558811***	***558811***	715375 in wrong grid node; 558811 selected beginning round 2
Olmsted	55011	Unknown	***55W0000165***	***55W0000165***	Original well not in county; 55W0000165 selected beginning round 2
Olmsted	55048	Unknown	***268949***	***268949***	Original well in wrong grid node; 268949 selected beginning round 2
Olmsted	55069	268888	***757026***	***757026***	Homeowner replaced original well after Round 1
Rice					No changes
Wabasha					No data received
Winona					No changes

*Unique number of network well is indicated in ***bold italics***.

Table 3: Field Definitions for Potential Nitrate Source Inventory

Field Name	**Field Definition**
RELATEID	Ten-character (four-leading zeroes) unique identifier for each well
PCSI_TYPE	Three-letter code describing type of potential contaminant source. Codes for nitrate-related sources are in the "Potential Nitrate Source Inventory Form" (CD accompanying this report)
DISTANCE	Distance in feet from the well to the potential contaminant source
BEARING	Compass direction (north = 0) from the well to the potential contaminant source

Table 4: County Well Index Aquifer Code Definitions

Aquifer Code	Count	CWI Aquifer Designation
CFIG	9	Franconia-Ironton-Galesville
CFRN	27	Franconia
CGSL	1	Galesville
CIGE	1	Ironton-Galesville-Eau Claire
CIGL	10	Ironton-Galesville
CJDN	68	Jordan
CJFR	2	Jordan-Franconia
CJIG	1	Jordan-Galesville
CJSL	1	Jordan-St. Lawrence
CSLF	5	St. Lawrence-Franconia
CSTL	3	St. Lawrence
DCLP	7	Lower Cedar Valley-Pinicon Ridge
DCLS	1	Lower Cedar Valley-Spillville
DCVA	2	Cedar Valley Group
DCVL	4	Lower Cedar Valley
DCVU	8	Upper Cedar Valley
DSOM	4	Cedar Valley-Maquoketa
DSPL	18	Wapsipinicon-Spillville
MTPL	1	Multiple aquifer well
ODCR	2	Decorah
ODGL	2	Dubuque-Galena
ODUB	1	Dubuque
OGAL	30	Galena
OGCM	3	Galena-Cummingsville
OGDC	2	Galena-Decorah
OGSV	1	Galena-Stewartville
OMAQ	3	Maquoketa
OMQD	5	Maquoketa-Dubuque
OMQG	3	Maquoketa-Galena
OPCJ	29	Prairie du Chien-Jordan
OPDC	105	Prairie du Chien
OPGW	2	Platteville-Glenwood
OPNR	1	Shakopee-New Richmond
OPOD	11	Oneota
OPSH	13	Shakopee
OPVL	1	Platteville
OSPC	6	St. Peter-Prairie du Chien
OSTP	32	St. Peter
QBAA	17	Quaternary buried artesian aquifer
QUUU	15	Quaternary undifferentiated
QWTA	15	Quaternary water table aquifer
	203	Blank cell indicates unable to designate

Table 5: Average [NO3] by Major Aquifer, mg/L

Aquifer	Round 1 February 2008	Round 2 August 2008	Round 3 February 2009
Quaternary	2.5	3.0	2.7
DSPL	3.5	3.1	2.8
OGAL	4.4	4.2	2.9
OSTP	2.1	2.2	1.8
OPDC	5.2	4.1	4.6
OPCJ	6.5	6.5	7.5
CJDN	4.0	3.5	3.6
CFRN	0.5	0.5	0.5
Total # sampled	523 *(77% of 675)*	511 *(76% of 675)*	490 *(73% of 675)*