Dakota County Groundwater Quality Research Summary, 1999-2024
October 2020

Introduction

Since 1999, the staff of Dakota County, Minnesota, have conducted some of the most thorough local research on private well water quality in the state. Soils and geology make much of Dakota County highly vulnerable to groundwater contamination. Public water suppliers provide their customers with water that meets health standards, but the county's groundwater poses health risks that water suppliers and private well owners must both address. The County has conducted the work described in this report to understand the issues and trends in its groundwater quality, inform private well owners of potential risks and remedies, and develop strategies to address contamination, where possible.

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Dakota County Groundwater Quality Research Summary, 1999-2024

- 1999-2003 Hastings Area Nitrate Study (HANS) Phase I, Minnesota Pollution Control Agency (MPCA) Clean Water Partnership grant ($75,000)
- 2003-2008 HANS Phase II, U.S. Environmental Protection Agency (EPA) 319 grant ($185,434); Vermillion River Watershed Joint Powers Organization (VRWJPO, $199,914 in-kind Surface Water Monitoring)
- 2008-2013 HANS Phase III, MPCA Clean Water Partnership grant ($172,700)
- 2013-2016 Nitrate Reduction Project, EPA 319 Grant ($215,307)
    - Related: 2011-2013 Minnesota Department of Agriculture (MDA)/University of Minnesota (UMN) Agricultural Water Quality Research, 2008 Clean Water, Land and Legacy Amendment grant (Legacy Amendment) ($71,684): nitrogen fertilizer research on irrigated, coarse-textured soils.
    - Related: 2013-2015 MDA/UMN Agricultural Water Quality Research, Legacy Amendment grant ($62,400): nitrogen fertilizer research on irrigated, coarse-textured soils.
    - Related: 2013-2015 MDA Township Testing, Legacy Amendment grant ($107,958): nitrate testing of private wells.
- 2016 VRWJPO/SWCD Irrigation Scheduling project, VRWJPO ($18,800)
- 2015-2017 Minnesota Department of Health (MDH)/Dakota County Wells and Increased Infant Sensitivity and Exposure (WIISE) study in Inver Grove Heights, Legacy Amendment grant ($24,000)
    - Related: 2018 Inver Grove Heights and Rosemount Public Meeting
- 2017-2018 Nitrate Time-Sequence Videos
- 2018 – Community-focused Sampling: Burnsville
- 2019 – Community-focused Sampling: Greenvale Township and Lakeville
- 1999-2019 Ambient Groundwater Quality Study (AGQS or Ambient Study), long-term, county-wide study of a representative set of private wells
- 2020 – Shallow Groundwater Nitrate Baseline Interpolation

- 2020-2024 – Community-focused Sampling in 2020: Apple Valley, Coates, Douglas Township, Eagan, Hampton (City), Hastings, Marshan Township, Miesville, New Trier, Northfield (in Dakota County), Randolph (City), Rosemount, and Vermillion (City)
- 2020 – Biosolid Application Sites

1999-2003 Hastings Area Nitrate Study (HANS), Phase I

Purpose: to determine the cause(s) and extent of nitrate contamination in the groundwater of the City of Hastings and the surrounding townships.

External Funding: $75,000, Minnesota Pollution Control Agency (MPCA) Clean Water Partnership grant

Partners with Dakota County: City of Hastings, Dakota County Soil and Water Conservation District (SWCD), Metropolitan Council, Minnesota Department of Agriculture (MDA), Minnesota Department of Health (MDH), Minnesota Department of Natural Resources (DNR), Minnesota Pollution Control Agency (MPCA), and United States Geological Survey (USGS).

Notable:

- National Groundwater Association "2003 Groundwater Protection Project of the Year."
- MDA followed Dakota County's lead and began monitoring for pesticide degradates, not just parent compounds, in 2002.

Conclusions:

- The City of Hastings and the surrounding area have a "nitrate problem" in the groundwater. The City of Hastings municipal supply meets drinking water guidelines, but drinking water quality in the City will continue to be a concern for the foreseeable future.
- The high correlation between nitrate and pesticides points to row-crop agriculture as the main source of groundwater contamination.
- The frequency of caffeine detections indicates widespread effects from domestic wastewater. (Note: subsequent studies were unable to duplicate these results.) Farmers in the Hastings area are following recommended Best Management Practices for both fertilizer and pesticide application, but the soil and geological conditions are working against them.
- The Vermillion River may be having an effect on drinking water quality within the Hastings city limits. The South Branch of the Vermillion River contributes nitrate to the main stem of the river, which then loses nitrate-bearing water in the buried bedrock valley just upstream of Hastings.
- Areas for future study include developing a better understanding of the Vermillion River/groundwater interactions, accurately characterizing the groundwater flow between the Vermillion River in the City of Hastings and the buried bedrock valley, and studying nitrate as an indicator for other forms of contamination in groundwater (such as agricultural chemicals or organic wastewater contaminants) in other parts of Dakota County.

Complete Report: Complete results are reported in the Hastings Area Nitrate Study Final Report (www.dakotacounty.us, search *HANS*).

Well Sampling Component:

Participant Recruitment: The goal was to sample 150 private drinking water wells in the Hastings area. To identify domestic wells for sampling, County staff searched the Dakota County Well and Water Management System (WELLMAN) and Parcel Query database for wells for which the County had construction and geologic data, such as depth, static water level, year constructed, aquifer, and construction details. County staff contacted well owners beforehand for permission to sample and sent participants letters with their results after the sample analysis was completed.

Sampling: In September 2000, 20 representatives of Dakota County and its HANS partners sampled 146 domestic wells (outdoor faucets), plus five City of Hastings municipal supply wells. While the representatives were sampling, they drew sketches estimating the locations and separations of wells, septic systems, and structures at each site where such features could be seen.

Parameters: All wells had samples, taken after the faucet had been run for 15 minutes, which were analyzed for nitrate; the nitrate results are discussed in detail below. In addition, 20 percent (29) of the 151 wells were selected for other analyses, including a time-series comparison of the number of minutes the faucet was run (5, 10, 15, and 20 minutes) before the sample was taken. Samples from this subset of wells were also analyzed for caffeine and pesticides (MDA List 1). The 29 wells were selected to be representative of the study area's aquifers, well depths, and geographic (horizontal) locations.

In August 2001, in order to analyze the groundwater for pesticides and pesticide metabolites at lower detection limits than in 2000 (0.05 μg/L compared to 0.5 μg/L) and to be able to compare the Hastings results with MPCA's similar study in Cottage Grove, Dakota County staff re-sampled 27 of the wells above, plus three additional wells. (The wells were re-sampled for nitrate at the same time; the 2001 results were not significantly different from the 2000 results; $t = -0.22$, $p = 0.8279$.) The USGS Organic Geochemistry Research Laboratory analyzed the samples for low levels of pesticides using GC/MS and pesticide breakdown products using HPLC/MS, with a detection limit of 0.05 μg/L.

Results:

Hastings Area Nitrate Study, September 2000 Sampling Event								
	Parameter (units)	**# of Samples**	**Samples w/ Detections**	**Drinking Water Guideline**	**Samples above Drinking Water Guideline**	**Mean (Average)**	**Median**	**Maximum**
Outside Sample	Nitrate (mg/L)	151[(1)(2)]	100 (66%)	10 mg/L	39 (26%)	6.31	3.70	40.00
	[(1)]146 Private drinking water wells and 5 City of Hastings PWS wells							
	Although most of the wells were sampled after the water had been run for 15 minutes, a representative subset was sampled after the water had been run for 5, 10, 15, and 20 minutes. There was no significant difference in nitrate results based on how long the water had been run before sampling.							

Hastings Area Nitrate Study, August 2001 Sampling Event								
	Parameter (units)	**# of Samples**	**Samples w/ Detections**	**Drinking Water Guideline (2020)**	**Samples above Drinking Water Guideline**	**Mean (Average)**	**Median**	**Maximum**
Outside Sample	Nitrate (mg/L)	30[(2)]	Reported as statistically not different from the September 2000 sampling event (t = -0.22, p = 0.8279)					
	Acetochlor ESA (µg/L) Acetochlor OXA (µg/L)	30[(2)]	8 (27%) 1 (3%)	300 µg/L 90 µg/L	None	Not Reported Not Reported	1.30 ND	4.04 0.21
	Alachlor (µg/L) Alachlor ESA (µg/L) Alachlor OXA (µg/L)	30[(2)]	1 (3%) 14 (47%) 6 (20%)	9 µg/L 50 µg/L 50 µg/L	None	0.35 Not Reported Not Reported	ND 1.74 ND	0.35 8.62 0.53

Hastings Area Nitrate Study, August 2001 Sampling Event								
	Atrazine (µg/L) Deethylatrazine (µg/L) Deisopropylatrazine (µg/L)	30[(2)]	10 (33%) 11 (37%) 5 (17%)	3 µg/L	None	Not Reported Not Reported Not Reported	0.08 0.09 ND	0.54 0.37 0.12
	Metolachlor (µg/L) Metolachlor ESA (µg/L) Metolachlor OXA (µg/L)	30[(2)]	1 (3%) 16 (53%) 13 (43%)	300 µg/L 800 µg/L 800 µg/L	None	Not Reported Not Reported Not Reported	ND 0.60 0.44	0.11 4.30 3.00
	Dimethenamid ESA (µg/L)	30[(2)]	1 (3%)	300 µg/L	None	Not Reported	ND	0.11
	[(2)]27 Private drinking water wells selected from 2000 sample set plus 3 additional, selected to be representative of the study area's aquifers, well depths, and geography.							

Hastings Area Nitrate Study, August 2001 Sampling Event (continued)		
Pesticide	**Year Pesticide Introduced**	**Median Nitrate Result (mg/L) in wells in which compound detected**
Acetochlor degradates	1994	8.3
Alachlor and degradates	1969	9.8
Atrazine and degradates	1956	14.0
Metolachlor and degradates	1976	10.3
Dimethenamid degradate	1993	14.0

2003-2008 Hastings Area Nitrate Study Phase II

Purpose: Implementation of the HANS Mitigation Plan – agricultural education and outreach, groundwater and surface water monitoring, and acquisition of natural areas along the Vermillion River.

External Funding: $185,434, EPA 319 grant (State Contract CFMS A79604/MPCA #5340); $199,914, VRWJPO Surface Water Monitoring (in-kind)

Partners with Dakota County: City of Hastings, Dakota County SWCD, MDA, MDH, MPCA, University of Minnesota Extension, (UMN Extension), and VRWJPO.

Notable:

- In 2009, following Dakota County's lead, MDA began sampling private drinking water wells for pesticides, not just monitoring wells.
- In 2009, MDA conducted a comparison of ELISA (immuno-assay) results vs. GS/MS for pesticides in drinking water wells. Dakota County did this before them, in 2006.

Conclusions:

- At that time, nitrate conditions in shallow wells were getting worse but deeper wells appeared stable. Nitrate levels and herbicide levels in private wells continue to be highly correlated to each other.
- 137 samples were from wells that were also sampled in 2000. Most (61 wells, 44.5 percent) had 2008 results that were within 1 mg/L of their 2000 results. 52 wells (38 percent) had increases of at least 1 mg/L; the average (mean) increase for these wells was 3.32 mg/L. 24 wells (17.5 percent) had decreases of at least 1 mg/L; the average decrease for these wells was 4.62 mg/L.
- With assistance from this grant, the County's Farmland and Natural Areas Program purchased the 40-acre Wilmar permanent conservation easement, including 2,774 feet of Vermillion River frontage. The property is classified as a "regionally significant" area in the Minnesota Department of Natural Resource's Biological Survey for Dakota County and identified as a targeted conservation corridor by the Metro Greenways Collaborative.

Well Sampling Component:

Participant Recruitment: County staff asked the households that had their wells sampled in 2000-2001 for permission to resample their wells. 137 households agreed and 3 replacements were added. In addition, the County, MDA, and the City of Hastings held a nitrate clinic at the Hastings City Hall.

Sampling: Staff from Dakota County and partner agencies collected the samples from the participants' outdoor faucets.

Parameters: Nitrate and herbicides.

Results:

Hastings Area Nitrate Study, Phase II, September 2008 Sampling Event								
	Parameter (units)	**# of Samples**	**Samples w/ Detections**	**Drinking Water Guideline**	**Samples above Drinking Water Guideline**	**Mean (Average)**	**Median**	**Maximum**
Outside Samples	Nitrate (mg/L)	140 Collected 177 Brought In [3]	213 (67%)	10 mg/L	104 (33%)	7.16	6.15	37.00
	Acetochlor ESA (µg/L) Acetochlor/Metolachlor ESA-2nd amide Acetochlor OXA (µg/L)	30 [4]	1 (3%) 13 (43%) 4 (13%)	300 µg/L 300 µg/L 90 µg/L	None	ND 0.02 0.01	ND ND ND	0.08 0.07 0.08
	Alachlor (µg/L) Alachlor ESA (µg/L) Alachlor ESA-2nd amide Alachlor OXA (µg/L)	30 [4]	1 (3%) 21 (70%) 5 (17%) 14 (47%)	9 µg/L 50 µg/L 50 µg/L 50 µg/L	None	ND 1.01 0.01 0.03	ND 0.84 ND 0.01	0.03 3.99 0.17 0.14
	Atrazine (µg/L) Deethylatrazine (µg/L) Deisopropylatrazine (µg/L) Didealkylatrazine (µg/L) Hydroxyatrazine (µg/L)	30 [4]	14 (47%) 15 (50%) 8 (27%) 17 (57%) 1 (3%)	3 µg/L	None	0.05 0.02 0.02 0.08 0.01	ND ND ND 0.03 ND	0.45 0.05 0.09 0.39 0.23
	Deethylcyanazine acid	30 [4]	19 (63%)	1.0 µg/L	3 (10%)	0.37	0.13	2.70

Hastings Area Nitrate Study, Phase II, September 2008 Sampling Event								
	Metolachlor (µg/L) Metolachlor ESA (µg/L) Metolachlor OXA (µg/L)	30 [4]	1 (3%) 18 (60%) 19 (63%)	300 µg/L 800 µg/L 800 µg/L	None	ND 0.57 0.26	ND 0.25 0.15	0.04 3.72 1.34
[3]Well owners also brought in 48 "-after R/O treatment" samples for comparison, so a total of 365 samples were analyzed for nitrate during the event. From the before-and-after R/O treatment comparisons, the median result before treatment (raw water) was 13.1 mg/L. The median result after treatment was 2.55 mg/L.								
[4] Same wells that were sampled in 2001.								

2008-2013 Hastings Area Nitrate Study Phase III

Purpose: Continued implementation of the HANS Mitigation Plan – agricultural education and outreach, groundwater and surface water monitoring, well sealing, and acquisition of natural areas along the Vermillion River.

External Funding: $172,700, MPCA Clean Water Partnership Continuation Grant

Partners with Dakota County: City of Hastings, Dakota County SWCD, MDA, MDH, MPCA, UMN Extension, VRWJPO.

Notable: The City of Hastings received a grant to help seal its original municipal well, and 20 private well owners within the city limits received well-sealing grants.

Well Sampling Component: This project did not have a private well water monitoring component separate from the Ambient Groundwater Quality Study (see below).

2013-2016 Nitrate Reduction Project

Purpose: Continued implementation of the HANS Mitigation Plan – agricultural education and outreach, groundwater and surface water monitoring, well sealing, and acquisition of natural areas along the Vermillion River.

External Funding: $215, 307, EPA 319 Grant

Partners with Dakota County: City of Hastings, Dakota County SWCD, MDA, MDH, MPCA, UMN Extension, VRWJPO.

Well Sampling Component: This project did not have a private well water monitoring component separate from the Ambient Study and MDA Township Testing programs (see below).

2011-2013 MDA/ University of Minnesota Agricultural Water Quality Research Project

Purpose: Provide a better understanding of nitrogen fertilizer management on a local level and the associated water quality impacts, to be accomplished through a unique partnership between Dakota County, the UMN Department of Soil, Water, and Climate, UMN Extension, and the MDA.

External Funding: $71,684, Legacy Amendment grant (State Contract #29933/Dakota County Contract #14179): "Validating N Recommendations and Water Quality Impacts under Irrigated Agriculture"

Partners with Dakota County: MDA, UMN, UMN Extension.

Conclusion: Revised recommended Best Management Practices (BMPs) for nitrogen fertilizer on irrigated corn on coarse-textured soils.

2013-2015 MDA/ University of Minnesota Agricultural Water Quality Research Project

Purpose: Evaluating agricultural technologies to improve nitrogen management to groundwater effects of nitrogen fertilizer application to corn in continuous corn or corn/soybean rotations.

External Funding: $62,400, Legacy Amendment grant (State Contract #44135/Dakota County Contract #25165): "Nitrogen Water Quality Work on Irrigated Sandy Soils Conducted in Dakota County, Minnesota" (Second 2 years of 4-year project)

Partners with Dakota County: MDA, UMN, UMN Extension.

Conclusion: Validated recommended BMPs for nitrogen fertilizer on irrigated corn on coarse-textured soils.

2013-2015 MDA Township Testing

Purpose: In 2013, to determine the number of private drinking water wells that exceed the nitrate guideline in at-risk townships and cities. In 2014, Dakota County added an assessment of the number of private drinking water wells that exceed the guidelines for manganese.

External Funding:

- 2013-2014: $65,348, Legacy Amendment (MDA Township Testing, State Contract #58238/Dakota County Contract #GR00449)
- 2014-2015: $42,610, Legacy Amendment (MDA Township Testing, State Contract #76767/Dakota County Contract #GR00438)

Partners with Dakota County: MDA

Notable: **National Association of Counties 2014 Achievement Award** "Creation of Drinking Water Profiles for At-Risk Communities."

Conclusions:

- In most of the townships tested, more than 5 percent of the wells tested – in some municipalities, more than half --exceeded the drinking water standard for nitrate.
- The 2014 project found many wells, especially in western Dakota County, that exceeded a drinking water guideline for manganese.
- The Community Drinking Water Profiles developed and completed by Dakota County allowed the County and MDA to determine if the samples were representative of the community's drinking water profile.

Well Sampling Component:

Participant Recruitment: Using a mailing list supplied by County staff, the commercial laboratory sent every household in the participating townships and cities a sample kit with instructions and a survey about their well and any water treatment system for their drinking water. 1,435 households participated.

Sampling: Participants returned the postage-paid kit, with their samples (outdoor faucet), to the laboratory. Well owners were notified by letter of their results after the sample analysis was completed.

Parameters: In 2013, the samples were analyzed for nitrate. In 2014, the samples were analyzed for nitrate and manganese. (Dakota County funded the manganese analysis.)

Results:

MDA/Dakota County Township Testing, 2013-14 Nitrate Results – All Wells[1] (uncensored results)								
Municipality	**# of Households (at the time)**	**# of Samples**	**Samples w/ Detections**	**Nitrate Drinking Water Guideline**	**Samples above Drinking Water Guideline**	**Mean (Average) (mg/L)**	**Median (mg/L)**	**Maximum (mg/L)**
Castle Rock Township	473	103	49 (48%)	10 mg/L	15 (15%)	4.06	0.00	59.80
Coates	55	11	11 (100%)	10 mg/L	6 (55%)	11.67	10.50	15.90
Douglas Township	250	68	41 (27%)	10 mg/L	24 (35%)	8.25	3.09	68.6
Empire Township	220	62	35 (56%)	10 mg/L	19 (31%)	5.79	1.72	30.2
Eureka Township	525	127	49 (39%)	10 mg/L	8 (6%)	2.56	0.00	27.40
Farmington	80	20	4 (20%)	10 mg/L	None	0.85	0.00	9.12
Greenvale Township	283	62	8 (13%)	10 mg/L	3 (5%)	0.99	0.00	20.90
Hampton Township & City	326	82	50 (61%)	10 mg/L	25 (30%)	5.90	2.28	28.90
Hastings	40	2[2]	2 (100%)	10 mg/L	1 (50%)[2]	11.64	11.64	18.3
Marshan Township	401	116	89 (77%)	10 mg/L	61 (53%)	10.33	11.10	32.70
Nininger Township	301	91	60 (66%)	10 mg/L	31 (34%)	7.47	4.79	29.80

MDA/Dakota County Township Testing, 2013-14 Nitrate Results – All Wells[1] (uncensored results)								
Randolph Township	231	56	23 (41%)	10 mg/L	6 (11%)	3.30	0.00	18.70
Ravenna Township	804	308	241 (78%)	10 mg/L	118 (38%)	7.27	7.07	22.80
Rosemount	528	172	109 (21%)	10 mg/L	12 (7%)	2.88	1.21	21.90
Sciota Township	121	30	12 (40%)	10 mg/L	4 (13%)	3.13	0.00	21.20
Vermillion Township	417	82	60 (73%)	10 mg/L	37 (45%)	8.12	8.94	27.10
Waterford Township	202	43	22 (51%)	10 mg/L	11 (26%)	5.55	0.25	33.20
Total	**5257**	**1435**	**865**	**10 mg/L**	**381 (27%)**	**5.69**	**2.26**	**68.60**

[1]MDA removed a number of wells from their reporting as being too susceptible to contamination. There may be discrepancies in the reported numbers; these do not change the overall conclusions.

[2]Too few samples to draw meaningful conclusions.

MDA/Dakota County Township Testing, 2014 Manganese Results – All Wells*								
Municipality	**# of Households (at the time)**	**# of Samples**	**Samples w/ Detections**	**Manganese Drinking Water Guidelines**	**Samples above Drinking Water Guideline**	**Mean (Average)**	**Median**	**Maximum**
Empire Township	220	59	31 (53%)	0.100 mg/L (infant < 1yr)	22 (37%)	0.099	0.009	0.463
				0.300 mg/L (All Others)	8 (14%)			
Eureka Township	525	123	83 (67%)	0.100 mg/L (infant < 1yr)	28 (23%)	0.077	0.032	0.572
				0.300 mg/L (All Others)	10 (8%)			
Farmington	80	19	15 (79%)	0.100 mg/L (infant < 1yr)	5 (26%)	0.079	0.066	0.243
				0.300 mg/L (All Others)	None			
Greenvale Township	283	60	54 (90%)	0.100 mg/L (infant < 1yr)	34 (57%)	0.184	0.149	0.586
				0.300 mg/L (All Others)	16 (27%)			
Ravenna Township	804	297	87 (29%)	0.100 mg/L (infant < 1yr)	1 (0.3%)	0.010	0.000	0.105
				0.300 mg/L (All Others)	None			
Rosemount	528	164	91 (55%)	0.100 mg/L (infant < 1yr)	61 (37%)	0.147	0.008	1.040
				0.300 mg/L (All Others)	39 (24%)			

MDA/Dakota County Township Testing, 2014 Manganese Results – All Wells*								
Total	**2,440**	**722**	**361 (50%)**	**0.100 mg/L (infant < 1yr)**	**150 (21%)**	**0.076**	**0.002**	**1.040**
				0.300 mg/L (All Others)	**73 (10%)**			
*There may be small discrepancies in the well and detection counts with numbers reported elsewhere.								

2016 Dakota County/VRWJPO/SWCD/UMN Extension Irrigation Scheduling Project

Purpose: Use irrigation water management to educate irrigators about irrigation water management tools and to engage growers in being part of the solution in curbing groundwater contamination from N fertilizers.

External Funding: $18,800, VRWJPO

Partners with Dakota County: Dakota County SWCD, UMN Extension, VRWJPO.

Conclusions: There is a lack of technical support for irrigators in Dakota County. Surveys of participants show irrigators are hungry for more actionable data that can assist their decision-making process. This data communication can come from a field technician leaving a checkbook printout on the shop door, an email or txt msg, or a smart-phone application that provides the grower real time soil moisture info. What is important, is that services like this one are flexible enough to provide growers with information that they find valuable.

Project Description: This incentive program provided services to collect field-specific moisture and direct assistance to producers using the "Irrigation Scheduling Checkbook," a tool to assist in irrigation water management. The total annual cost to provide these services would normally be $600 per field. The program provided $400 per field, so the participating producers were responsible for the remaining $200 per field. If a producer wished to use technologies and services with higher costs than what the program provided, the producer could still participate in the program, but was responsible for the remaining costs. University of Minnesota Extension staff provided program participants information about field-measured soil moisture conditions and consultation on scheduling their next irrigation cycle.

Well Sampling Component: This project did not have a private well water monitoring component separate from the Ambient Study and MDA Township Testing programs (see below).

Participant Recruitment: Dakota County SWCD, VRWJPO, UMN Extension and Dakota County recruited participants through mailings and presentations. Fourteen growers participated with 28 fields (21 fields in the Vermillion River Watershed and seven in the Cannon River Watershed).

2015-2017 Wells and Increased Infant Sensitivity and Exposure (WIISE) Study

Purpose: Because Ambient Study results (see below) found elevated levels of manganese in northern areas of the County, MDH partnered with the County in a joint study of private wells in Inver Grove Heights.

External Funding: $24,000, Legacy Amendment grant (MDH)

Partners with Dakota County: MDH, City of Inver Grove Heights.

Conclusions: Private wells in Inver Grove Heights have a serious risk of being contaminated with naturally occurring manganese. The risk of arsenic is fairly low, but wells should be tested at least once. The risk of nitrate contamination is low.

Water softeners had a dramatic effect on manganese reduction. Sixty-one percent of samples were softened, 38 percent were not softened, and 2 percent were unknown. In unsoftened samples, the outside spigot and inside tap concentrations are not very different. In contrast, all of the softened samples had manganese that was greatly reduced in the inside tap sample. All softened samples were below both health-based guidance values. Water softening showed the same level of manganese reduction effectiveness across the entire range of outside spigot sample levels.

Complete Report: Complete results are reported in *Wells and Increased Infant Sensitivity and Exposure (Scher and Demuth, 2017)* (www.dakotacounty.us, search *WIISE*).

Well Sampling Component:

Participant Recruitment: County staff completed an inventory of the 1,463 Inver Grove Heights households that use private wells as their primary water supply, including the age, depth, and aquifer of the wells, where known. Of these, County staff randomly selected 800 households who were then mailed an introductory letter and fact sheet that explained the project and invited those interested to respond. No

study incentives were offered to participants beyond the free water testing. The letter informed potential participants that the study results are considered public data. A total of 274 well owners responded to the initial mailing by the deadline (response rate=34 percent) and all 274 households were included in the study.

Outdoor spigot water sampling: In fall 2015, County staff collected a well water sample of unfiltered, untreated water from an outside spigot at each of the participating homes.

Survey: An adult member of the household responsible for well water quality was asked to complete an online survey about any water treatment devices in the home, the primary source of drinking water, and risk perceptions and concerns about well water quality.

Inside tap sampling: In late spring 2016, County staff asked households that had a manganese result above 100 µg/L in their outdoor faucet sample to participate in free follow-up sampling of manganese from an inside drinking water tap. County staff mailed water sample bottles and instructions, along with information about four dates and times available for sample drop-off. The purpose of the inside tap sampling was to assess the effectiveness of commonly-used water treatment devices to reduce manganese. Participants also submitted a water hardness test strip and a paper Water Test Form during sample drop-off on which they recorded the sample location (e.g., kitchen tap; refrigerator water dispenser) and any treatment devices the water had been through.

Parameters: Arsenic, chloride, fluoride, iron, lead, manganese, nitrate, sulfate, and coliform bacteria.

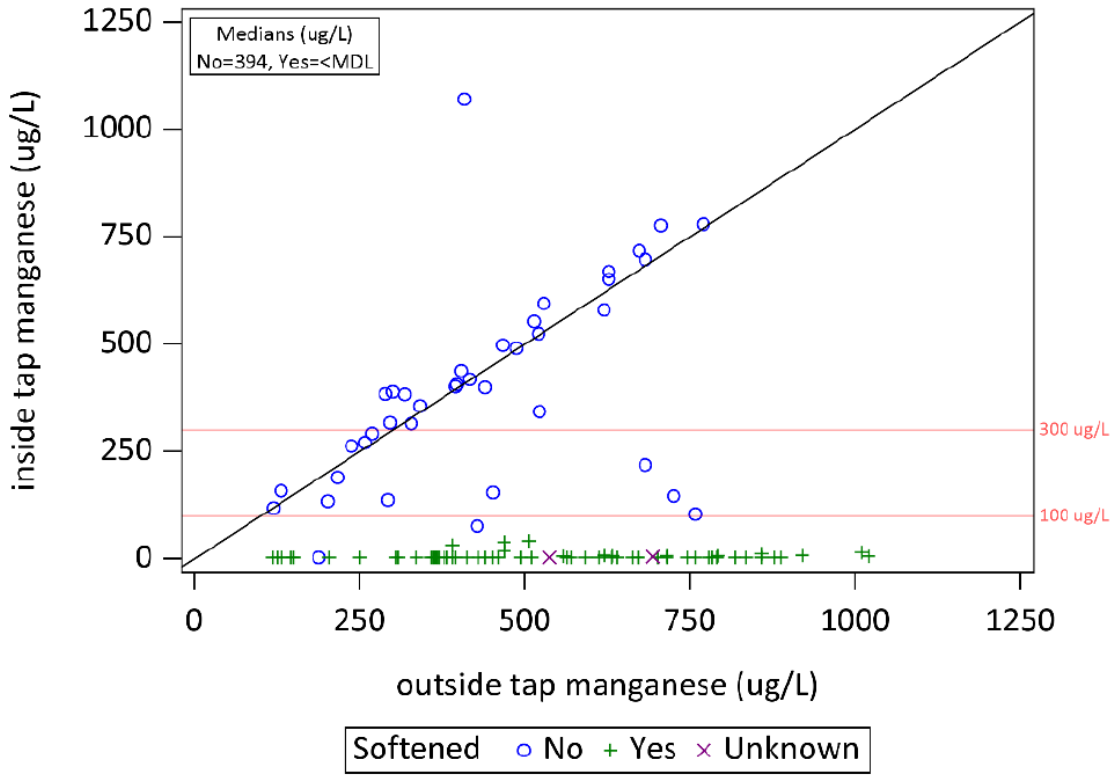
Results:

Wells and Increased Infant Sensitivity and Exposure (WIISE) Study, 2015-2016 Sampling								
	Parameter (units)	**# of Samples**	**Samples w/ Detections**	**Drinking Water Guideline**	**Samples above Drinking Water Guideline**	**Mean (Average)**	**Median (middle)**	**Max**
Outside Sample	Arsenic (µg/L)	274	155 (57%)	10 µg /L No amount is safe	3 (1%)	1.9	0.8	13.3
	Chloride (mg/L)	274	274 (100%)	250 mg/L (SMCL for taste and smell)	1 (0.3%)	26.6	15.6	288.0
	Coliform bacteria	270	67 (25%)	Bacteria not present	67 (25%)	NA	NA	NA

Wells and Increased Infant Sensitivity and Exposure (WIISE) Study, 2015-2016 Sampling								
	Parameter (units)	**# of Samples**	**Samples w/ Detections**	**Drinking Water Guideline**	**Samples above Drinking Water Guideline**	**Mean (Average)**	**Median (middle)**	**Max**
	Fluoride (mg/L) 0.7 mg/L minimum is recommended for good dental health.	274	216 (79%)	2.0 mg/L (SMCL to prevent fluorosis)	None	0.12	0.15	0.27
	Iron (mg/L)	274	245 (89%)	0.3 mg/L (SMCL to prevent staining)	172 (63%)	1.37	0.88	12.0
	Lead (µg/L)	273	144 (53%)	15 µg /L No amount is safe	5 (2%)	1.7	0.6	111.1
	Manganese (mg/L)	274	220 (80%)	0.100 mg/L (infant < 1 yr)	194 (71%)	0.357	0.344	1.790
				0.300 mg/L (All Others)	153 (56%)			
	Nitrate (mg/L)	274	88 (32%)	10 mg/L	None	0.61	0.00	6.1
	Sulfate (mg/L)	262	262 (100%)	500 mg/L	None	26.6	25.8	75.2
Inside Sample	Arsenic (µg/L)	53	16 (30%)	10 µg /L No amount is safe	None	0.64	0.00	9.58
	Lead (µg/L)	30	5 (17%) More detailed Information in table below	15 µg /L No amount is safe	None	0.15	0.00	1.73
	Manganese (mg/L)	114	48 (42%)	0.100 mg/L (Infant < 1 yr)	38 (33%)	0.214	0.00	4.19
				0.300 mg/L (All Others)	27 (25%)			
	Nitrate (mg/L)	32	4 (13%)	10 mg/L	None	0.09	0.00	1.14

The collection of both outside spigot and inside tap samples in the WIISE study allowed for evaluation of manganese treatment device effectiveness. Out of the 194 households with an outside spigot manganese result above 100 µg/L, 100 households participated in sampling for manganese from an inside tap, with a total of 114 samples.

As shown below, water softeners had a dramatic effect on manganese reduction. The majority of unsoftened samples fall along the diagonal line of unity, meaning that the outside spigot and inside tap concentrations are not very different. In contrast, all of the softened samples are along the bottom of the plot, showing that manganese has been greatly reduced in the inside tap sample. **All softened samples were below both health-based guidance values, shown at 100 µg/L and 300 µg/L as horizontal lines.** Water softening showed the same level of manganese reduction effectiveness across the entire range of outside spigot sample levels.



WIISE Study

Manganese concentration by softener test strip result (inside tap)

Softener test strip result (Hardness in mg/L)	Percent of samples in hardness category	Manganese mean (µg/L)	Manganese median (µg/L)
0	28%	4.1	<MDL
50	30%	5.2	<MDL
120	7%	14.7	<MDL
250	24%	391.1	399.0
425	10%	491.8	241.0

Lead results for households with lead >15 µg/L in outside spigot samples

Household	Sample Description	Lead Result (µg/L)
A	Outside Faucet	111.1
A	1st draw kitchen faucet	3.04
A	Purge at kitchen faucet	0.5
A	Fridge filter (carbon)	< 0.5
B	Outside Faucet	21.4
B	1st draw kitchen faucet	< 0.5
B	Purge at kitchen faucet	< 0.5
B	Fridge filter (carbon)	< 0.5
C	Outside Faucet	31.4
C	1st draw kitchen faucet	1.13
C	Purge at kitchen faucet	< 0.5
D	Outside Faucet	15.9
D	1st draw kitchen faucet	< 0.5
D	Purge at kitchen faucet	< 0.5
D	RO	< 0.5
E	Outside Faucet	25.4
E	1st draw kitchen faucet	0.6
E	Purge at kitchen faucet	< 0.5
E	Carbon filter with ion exchange	< 0.5

2018 Inver Grove Heights and Rosemount Public Meeting

Purpose: To inform residents about the results of the WIISE Study, the County held a public meeting for private well owners from Inver Grove Heights and Rosemount on the evening of May 16, 2018. Staff also provided practical tips for maintaining water wells and offered several well water tests.

Partners with Dakota County: MDH, City of Inver Grove Heights.

Conclusions: As found in the original WIISE Study, private wells in Inver Grove Heights have a serious risk of being contaminated with naturally occurring manganese, as do private wells in Rosemount. The risk of arsenic is fairly low, but wells should be tested at least once. The risk of nitrate contamination is low. The results also confirmed that water softeners and reverse osmosis systems are effective at reducing manganese.

Well Sampling Component:

Participant Recruitment: By postcard, the County invited all residents of Inver Grove Heights and Rosemount who rely on private wells to participate. Well owners were offered a free test for manganese. Well owners could choose to pay for additional analyses for arsenic, nitrate, lead, chloride, fluoride or a manganese test from a different faucet in the home.

Sampling: Residents were asked to bring a water sample from their primary drinking water faucet, which could be taken from either the kitchen faucet, a reverse osmosis system spigot, a refrigerator water dispenser usually equipped with a carbon filter, or a pitcher-type filter (carbon). Not all untreated samples have a corresponding treated sample and vice versa.

Parameters: Arsenic, chloride, fluoride, lead, manganese, and nitrate.

Results:

Wells and Increased Infant Sensitivity and Exposure (WIISE) Study, 2018 Inver Grove Heights and Rosemount Public Meeting								
	Parameter (units)	**# of Samples**	**Samples w/ Detections**	**Drinking Water Guideline**	**Samples above Drinking Water Guideline**	**Mean (Average)**	**Median (middle)**	**Max**
Untreated Samples	Arsenic (µg/L)	46	11 (24%)	10 µg /L No amount is safe	None	0.64	0.00	5.04
	Chloride (mg/L)	10	6 (60%)	250 mg/L (SMCL for taste and smell)	None	12.60	4.15	40.20
	Fluoride (mg/L) 0.7 mg/L minimum is recommended for good dental health.	18	18 (100%)	2.0 mg/L (SMCL to prevent fluorosis)	None	0.13	0.12	0.25
	Lead (µg/L)	48	18 (38%)	15 µg /L No amount is safe	None	0.63	0.00	6.45
	Manganese (mg/L)	95	66 (67%)	0.100 mg/L (infant < 1yr)	54 (57%)	0.208	0.154	0.963
				0.300 mg/L (All Others)	30 (32%)			
	Nitrate (mg/L)	45	25 (56%)	10 mg/L	None	1.36	0.26	8.94
Treated Samples	Arsenic (µg/L)	75	21 (28%)	10 µg /L No amount is safe	None	0.67	0.00	6.42
	Chloride (mg/L)	7	7 (100%)	250 mg/L (SMCL for taste and	None	16.89	7.70	43.80
	Fluoride (mg/L) 0.7 mg/L minimum is recommended for good dental health.	30	25 (83%)	2.0 mg/L (SMCL to prevent fluorosis)	None	0.10	0.11	0.20

Wells and Increased Infant Sensitivity and Exposure (WIISE) Study, 2018 Inver Grove Heights and Rosemount Public Meeting								
	Parameter (units)	**# of Samples**	**Samples w/ Detections**	**Drinking Water Guideline**	**Samples above Drinking Water Guideline**	**Mean (Average)**	**Median (middle)**	**Max**
	Lead (µg/L)	56	9 (16%)	15 µg /L No amount is safe	1 (2%)	0.99	0.00	38.70
	Manganese (mg/L)	136	38 (28%)	0.100 mg/L (Infant < 1 yr)	23 (17%)	0.061	0.000	0.827
				0.300 mg/L (All Others)	15 (11%)			
	Nitrate (mg/L)	46	17 (37%)	10 mg/L	None	0.62	0.00	4.75

2017-2018 Nitrate Time-Sequence Videos

Purpose: To visualize nitrate trends in private wells on a County-wide basis, using all available nitrate results from 1991 to 2016.

Conclusions: Nitrate concentrations in shallow wells in eastern Dakota County are rising. Nitrate concentrations in deeper wells are beginning to rise above the drinking water guideline.

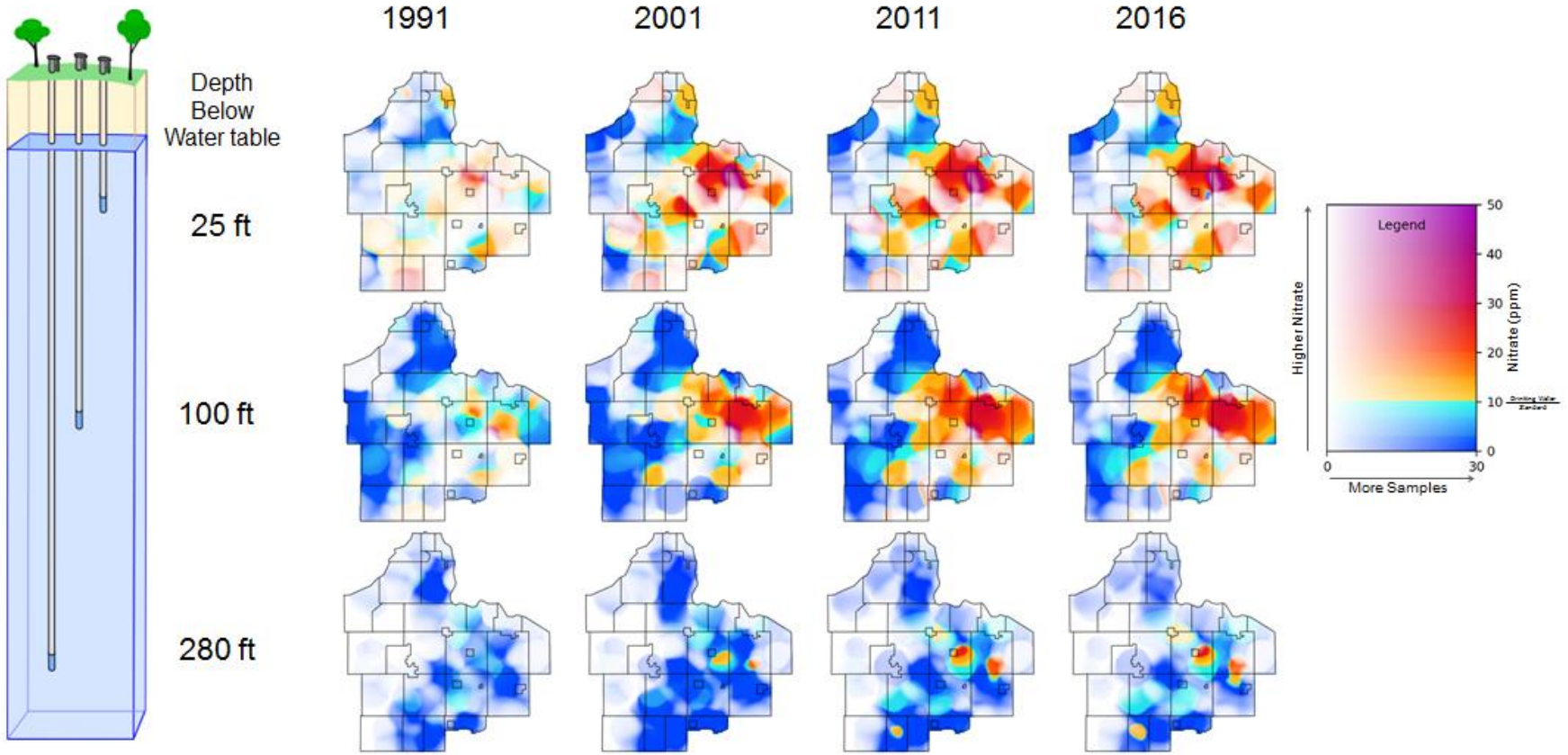
Project Description:

As shown in the figure below, County staff (Bill Olsen) assembled a data set of 10,700 untreated nitrate samples from wells (mostly private wells), of which more than 8,000 were from wells with known depths, and interpolated the results at different depth intervals for separate years, from 1991 to 2016. This large data set shows the changes in nitrate contamination over time throughout the County. The figure shows nitrate concentrations for selected years over time (left to right) and depths (top to bottom) throughout the County. (Contact County staff for a video version of the results from 1991-2016.)

These interpolated results are for wells that were constructed after the State Well Code (Minnesota Rules Chapter 4725) first went into effect in 1974 and for which the Minnesota Well Index has construction records. However, about 40 percent of the estimated 8,000 households in the County that use private wells have drinking water wells that predate the Well Code and are therefore shallower and more vulnerable to contamination than the wells modeled here.

Parameter: Nitrate

Results:


1991
2001
2011
2016
Depth
Below
Water table
25 ft
100 ft
280 ft
Legend
Higher Nitrate
Nitrate (ppm)
50
40
30
20
10
0
0
30
More Samples

2018 – Community-Focused Sampling: Burnsville

Purpose: Baseline water quality sampling of private wells, public health outreach

Partners with Dakota County: City of Burnsville

Conclusions: Private wells in Burnsville have a serious risk of being contaminated with naturally occurring arsenic or manganese. The risk of nitrate contamination is low.

Well Sampling Component:

Participant Recruitment: County staff invited all 200 households in Burnsville that use private wells to participate. Sixty-six households participated.

Sampling: The County provided participants with sample bottles to collect a water sample from both an outside untreated spigot and an inside primary drinking water tap.

Parameters: All outside samples were tested for chloride, manganese, arsenic, nitrate, and sulfate. If the outside sample result exceeded 3 mg/L for nitrate, 0.5 µg /L for arsenic or 0.100 mg/L for manganese, then the sample from the inside tap was tested for that chemical parameter. In addition, most (65) inside tap samples were analyzed for lead and copper.

Results:

Burnsville Study, 2018 Sampling								
	Parameter (units)	**# of Samples**	**Samples w/ Detections**	**Drinking Water Guideline**	**Samples above Drinking Water Guideline**	**Mean (Average)**	**Median (middle)**	**Max**
Outside Sample	Arsenic (µg/L)	66	34 (52%)	10 µg /L No amount is safe	None	1.67	0.85	9.67
	Chloride (mg/L)	66	58 (88%)	NA	NA	55.3	34.4	451.0
	Manganese (mg/L)	66	48 (73%)	0.100 mg/L infant < 1yr)	27 (41%)	0.137	.069	0.754
				0.300 mg/L (All Others)	13 (20%)			

Burnsville Study, 2018 Sampling								
	Parameter (units)	**# of Samples**	**Samples w/ Detections**	**Drinking Water Guideline**	**Samples above Drinking Water Guideline**	**Mean (Average)**	**Median (middle)**	**Max**
	Nitrate (mg/L)	66	27 (41%)	10 mg/L	None	0.56	0.05	5.59
	Sulfate (mg/L)	66	64 (97%)	500 mg/L	None	27.2	22.2	96.4
	Hardness (mg/L)	64	NA	NA	NA	370	425	425
Inside Sample	Arsenic (µg/L)	35	18 (51%)	10 µg /L No amount is safe	None	2.03	1.0	7.48
	Copper (mg/L)	65	30 (46%)	1.3 mg/L	None	0.014	<0.005	0.113
	Lead (µg/L)	65	5 (8%)	15 µg /L No amount is safe	None	0.6	0.5	2.13
	Manganese (mg/L)	23	10 (43%)	0.100 mg/L (Infant < 1 yr)	5 (22%)	0.117	0.007	0.793
				0.300 mg/L (All Others)	3 (13%)			
	Nitrate (mg/L)	6	5 (83%)	10 mg/L	None	2.56	2.68	5.37
	Hardness (mg/L)	64	NA	NA	NA	173	50	425

2019 – Community Focused Sampling: Greenvale Township

Purpose: Baseline water quality sampling of private wells, public health outreach

Conclusions: Private wells in Greenvale Township have a serious risk of being contaminated with naturally occurring manganese. There is a risk of nitrate or arsenic contamination, but the risk is fairly low.

Complete Report: Complete results are reported in the Greenvale Township Well Study Report (www.dakotacounty.us, search *Greenvale Private Well*).

Well Sampling Component:

Participant Recruitment: The County mailed sample bottles to all 278 households that use private wells in Greenvale Township. Eighty-nine households (32 percent) participated.

Sampling: Residents were asked to collect a water sample from both an outside untreated spigot and an inside primary drinking water tap.

Parameters: All outside samples were tested for manganese, arsenic, nitrate, and chloride. If the outside sample result exceeded 3.0 milligrams per liter (mg/L) for nitrate, 0.05 micrograms per liter (µg/L) for arsenic, or 0.090 mg/L for manganese, then the sample collected from the inside tap was tested for that chemical parameter. In addition, all inside tap samples were analyzed for lead. A hardness test strip was provided as part of the sampling kit for well owners to test and report when submitting samples. Wells were not tested for coliform bacteria.

Results:

Greenvale Township Study, 2019								
	Parameter (units)	**# of Samples**	**Samples w/ Detections**	**Drinking Water Guideline**	**Samples above Drinking Water Guideline**	**Mean (Average)**	**Min**	**Max**
Outside Sample	Arsenic (µg/L)	89	59 (66%)	10 µg /L No amount is safe	3 (3%)	2.90	< 0.5	50.1
	Chloride (mg/L)	89	49 (55%)	NA	NA	11.66	< 3	110
	Manganese* (mg/L)	89	83 (93%)	0.100 mg/L (infant < 1yr)	56 (63%)	0.226	>0.005	1.020
				0.300 mg/L (All Others)	24 (27%)			
	Nitrate (mg/L)	89	20 (22%)	10 mg/L	4 (4%)	1.14	< 0.05	22
	Hardness (mg/L)	89	NA	NA	NA	389.7	0	425
Inside Sample	Arsenic (µg/L)	59	31 (53%)	10 µg /L No amount is safe	1 (2%)	1.84	< 0.5	16.70
	Lead (µg/L)	87	8 (9%)	15 µg /L No amount is safe	None	0.68	< 0.5	5.42
	Manganese (mg/L)	57	16 (28%)	0.100 mg/L (Infant < 1 yr)	12 (21%)	0.09	< 0.005	0.770

Greenvale Township Study, 2019								
	Parameter (units)	**# of Samples**	**Samples w/ Detections**	**Drinking Water Guideline**	**Samples above Drinking Water Guideline**	**Mean (Average)**	**Min**	**Max**
				0.300 mg/L (All Others)	4 (7%)			
	Nitrate (mg/L)	8	8 (100%)	10 mg/L	4 (50%)	10.03	1.10	21
	Hardness (mg/L)	83	NA	NA	NA	137	0	425

2019 – Community Focused Sampling: Lakeville

Purpose: Baseline water quality sampling of private wells, public health outreach

Partners with Dakota County: City of Lakeville

Conclusions: Private wells in Lakeville have a serious risk of being contaminated with naturally occurring manganese. There is a risk of nitrate or arsenic contamination, but the risk is fairly low.

Complete Report: Complete results are reported in the Lakeville Private Well Study Report (www.dakotacounty.us, search *Lakeville Private Well*).

Well Sampling Component:

Participant Recruitment: The County mailed sample bottles to all 320 households in Lakeville that use private wells. One hundred households (31 percent) participated.

Sampling: Residents were asked to collect a water sample from both an outside untreated spigot and an inside primary drinking water tap.

Parameters: All outside samples were tested for manganese, arsenic, nitrate, and chloride. If the outside sample result exceeded 3.0 milligrams per liter (mg/L) for nitrate, 0.05 micrograms per liter (µg/L) for arsenic, or 0.090 mg/L for manganese, then the sample collected from the inside tap was tested for that chemical parameter. In addition, all inside tap samples were analyzed for lead. A hardness test strip was provided to well owners to test and report when submitting samples. Wells were not tested for coliform bacteria.

Results:

Lakeville Study, 2019								
	Parameter (units)	**# of well samples**	**# and % of detections**	**Drinking Water Guideline**	**# and % of Samples above Drinking Water**	**Mean (Average)**	**Min**	**Max**
Outside Sample	Arsenic (µg/L)	100	70 (70%)	10 µg/L No amount is safe	3 (3%)	2.36	< 0.05	12.30
	Chloride (mg/L)	100	51 (51%)	NA	NA	23	< 3.0	225
	Manganese (mg/L)	100	89 (89%)	0.100 mg/L (Infant < 1yr)	51 (51%)	0.127	< 0.005	0.539
				0.300 mg/L (All Others)	10 (10%)			
	Nitrate (mg/L)	100	17 (17%)	10 mg/L	2 (2%)	0.52	< 0.05	16.20
	Hardness (mg/L)	95	NA	NA	NA	377	50	425
Inside Sample	Arsenic (µg/L)	69	46 (67%)	10 µg/L No amount is safe	2 (3%)	2.10	< 0.05	19.40
	Lead (µg/L)	100	7 (7%)	15 µg/L No amount is safe	None	0.60	< 0.5	5.2
	Manganese (mg/L)	58	9 (16%)	0.100 mg/L (Infant < 1 yr)	3 (5%)	0.024	< 0.005	0.383
				0.300 mg/L (All Others)	2 (3%)			
	Nitrate (mg/L)	3	3 (100%)	10 mg/L	None	4.24	0.34	7.32
	Hardness (mg/L)	94	NA	NA	NA	107	50	425

1999-2019 Ambient Groundwater Quality Study

Purpose: The County conducted the Ambient Study from 1999 to 2019 to establish a baseline of water quality conditions in private drinking water wells and determine if specific contaminants of health and environmental concern are present and increasing or decreasing over time in different land use settings and different aquifers.

Partners with Dakota County: MDA, MDH, USGS, VRWJPO

Notable: One of the largest known datasets for triazine and chloroacetamide herbicides and their degradates in private wells with multiple years of data from the same wells. A significant dataset for nitrate and other anthropogenic compounds in private wells in Minnesota.

Conclusions: Described below and in the 1999-2019 Ambient Study Report.

Complete Report: Complete results are reported in the 1999-2019 Ambient Study Report (www.dakotacounty.us, search *ambient groundwater report*).

Well Sampling Component:

Participant Recruitment: County staff selected the Ambient Study wells to be representative of the private drinking water wells in the County, with a preference for wells with construction records. The County obtained permission from the well owners to sample their wells. A letter was sent to each well owner after each sampling event to explain the results.

Sampling: An independent sampling contractor or County staff person collected the samples from an untreated water spigot on the well owner's residence (outdoor) or a water hydrant in the yard or barn. The wells were purged, and meters or probes were used to determine field parameters: temperature, specific conductivity, pH, oxidation/reduction potential, and dissolved oxygen. Water samples were collected after the well parameters stabilized. Samples were not filtered. Replicates and blanks were collected per laboratory requirements. Both were analyzed for the same parameters to evaluate the variability in sample collection and the analytical method.

Parameters: Field stabilization parameters, nitrate, crop herbicides and their breakdown products, chloride, manganese, arsenic, common wastewater effluent compounds, volatile organic compounds (VOCs), pharmaceuticals, and per- and polyfluoroalkyl substances (PFAS).

- 2001 – The United States Geological Survey (USGS) lab provided a list of triazines and chloroacetamide herbicides commonly applied to corn and soybean crops, including the breakdown products of those herbicides. This list became the routine list of herbicides tested.
- 2003 – Analyzed samples from fifteen wells for tritium (an isotope of hydrogen) and helium in an effort to estimate the age of the groundwater. Results are reported in the 1999-2003 Ambient Study Report (www.dakotacounty.us, search *ambient groundwater report*).

- 2005 – Sampled 25 municipal water wells for nitrate, nitrite and the routine herbicide list. (MDA conducted its first reconnaissance sampling of public water supply wells for pesticides and pesticide breakdown products in 2010.)
- 2008 – Analyzed samples for Organic Wastewater Compounds (OWWC) and seven different perfluorochemicals (PFCs).The analysis for organic wastewater compounds included some herbicide parent compounds such as atrazine, alachlor, and metolachlor.
- 2009 – Tested samples for agricultural herbicides and their breakdown products for triazines and chloroacetamides. The County changed from annual to biennial sampling events.
- 2011 – Tested samples for an additional list of 51 herbicides in addition to the triazines and chloroacetamide list.
- 2013 – Sampled select wells for the routine list of herbicides and added chlorothalonil and three breakdown products. Analyzed the select wells for a list of pharmaceuticals, mainly antibiotics and antibiotic breakdown products.
- 2017 – Tested 9 study wells with known cyanazine breakdowns exceedances over the drinking water guideline and an additional 135 nearby wells for triazine herbicides and their breakdown products.
- 2018 – Tested study wells for gross alpha, cyanide and barium. Wells (not completed in the Jordan aquifer) were tested for 17 Per- and Polyfluoroalkyl Substances (PFAS).
- 2019—Tested study wells for radium 226 & 228; Jordan aquifer (Cjdn) wells were tested for 32 PFAS; 36 study wells tested for 135 pesticides at Weck Laboratories, Inc., including two treated water samples collected from refrigerator carbon water filters. MDA collected samples from 27 study wells that were analyzed by Weck for the same 135 pesticides. In addition, MDA collected samples from 72 wells previously sampled in the 2017 Dakota County sample event that exceeded 0.5 µg/L for total cyanazine, 27 in-home water treatment devices; MDH collected samples from 13 municipal wells—all samples were analyzed for the list of 135 pesticides by Weck.

Anthropogenic Compounds

Nitrate

The 77 Ambient Study wells have been systematically sampled for nitrate since 1999, with some wells sampled every sample event (16 times) and others only a few events (two to five times). The average number of samples per well is 10.

Nitrate findings from 1999 to 2019:

- Nitrate results ranged from non-detect (less than 0.2 mg/L or < 0.2 mg/L) to 30.6 mg/L.

- Nitrate was detected above the MRL at least once in 83 percent of the wells.
- 31 percent of wells have exceeded the drinking water guideline of 10 mg/L at least once.
- 23 percent of wells have average (mean) nitrate that exceeded 10 mg/L.
- 21 percent of wells have median nitrate that exceeded 10 mg/L.
- From 1999 to 2019, the percentage of wells exceeding the drinking water guideline increased from seven percent to 23 percent.

Nitrate Category	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2011	2013	2018	2019
< 0.25 mg/L	53%	53%	53%	51%	50%	48%	47%	46%	47%	48%	48%	50%	51%	45%	48%
0.25 to < 5.0 mg/L	13%	19%	16%	15%	12%	17%	21%	19%	19%	17%	15%	13%	12%	16%	13%
5.0 to < 10 mg/L	27%	21%	21%	20%	24%	18%	15%	15%	13%	18%	18%	13%	15%	15%	16%
>= 10 mg/L	7%	7%	9%	15%	14%	17%	18%	21%	21%	17%	19%	24%	22%	24%	23%

- There are more wells with an upward trend for nitrate than a downward trend. In the 77 study wells:
  - 17 percent of wells have a statistically significant upward trend.
  - 4 percent of wells have a statistically significant downward trend.
  - 79 percent of wells have stable nitrate levels; 14 percent of wells are stable above 10.

Pesticides

The pesticides that the Dakota County long-term Ambient Study (1999-2019) has focused on are corn and soybean herbicides because 1) they are the pesticides most commonly detected in the MDA state-wide monitoring program and 2) cyanazine degradates above the drinking water guideline have been very persistent in Dakota County groundwater. (The County has sampled for other pesticides in cooperation with the U.S.G.S. National Water Quality Laboratory; many of these pesticides and pesticide breakdown products have been detected, but at levels far below their respective drinking water guidelines.)

From 2001 through 2019, the County had 77 private wells, selected to be representative of drinking water conditions county-wide, sampled and analyzed for pesticides repeatedly. Most of the laboratory analysis for herbicides and herbicide breakdown products was conducted by the U.S.G.S. Organic Geochemistry Research Laboratory. (Details in the 2020 Ambient Study report.) A total of 67 wells have been tested at least

five times for triazine herbicides, which include atrazine and cyanazine, and their breakdown products -- sufficient sampling for statistically valid trend analysis. A total of 65 wells have been tested at least five times for acetanilide herbicides, which include alachlor, acetochlor, and metolachlor, and their breakdown products.

- Of the 77 wells sampled for the presence of pesticides, 51 different pesticides or pesticide breakdown products were detected out of the 72 analytes.
- The herbicides associated with corn and soybean production are the most heavily used in the County and were detected most frequently and at the highest concentrations in water samples, particularly where row crop agriculture is the dominant land use.
- Herbicides compounds were detected in 57 of the 77 wells sampled (73 percent).
- The total concentration of cyanazine and its breakdown products exceeded drinking water guideline of 1.0 µg/L in 22 percent of the sampled wells.
- The number of herbicide compounds, the frequency of occurrence and concentrations of herbicides detected is correlated with nitrate levels and the percent of row crop agriculture adjacent to sampled wells.
- The most commonly detected herbicide compound was alachlor ESA (73 percent) followed by metolachlor ESA (66 percent).
- As many as 25 different pesticide compounds were detected in a single well.
- Based on the frequency of detection, the most commonly detected herbicides were:
    - alachlor and alachlor breakdown products (73 percent of wells);
    - metolachlor and metolachlor breakdown products (65 percent of wells);
    - atrazine and atrazine breakdown products (64 percent of wells);
    - cyanazine breakdown products (64 percent of wells);
    - acetochlor breakdown products (56 percent of wells).
- Of the 16 most frequently detected herbicide compounds in the study, atrazine, introduced in 1957, is the only parent compound.

Ambient Groundwater Quality Study, 1999-2019 Herbicide Compounds – Highest Detections				
Compound	**Year of Highest Detection**	**Highest Detection (µg/L)**	**Drinking Water Guideline (µg/L)**	**Highest Detection as a percentage of the Guideline**
Chloroacetamides				
Alachlor ESA	2002	6.14	50.00	12.3%
Alachlor OXA	2005	1.45	50.00	2.9%
Metolachlor ESA	2006	7.87	800.00	1.0%
Metolachlor OXA	2006	3.11	800.00	0.4%
Alachlor ESA 2nd amide	2006	0.15	50.00	0.3%
Acetochlor/Metolachlor ESA 2nd amide	2003	0.33	800.00	0.04%
Triazines				
Deethylcyanazine acid (DCAC)	2004	5.0	1.00	500%
Cyanazine acid (CAC)	2004	1.3	1.00	130%
Cyanazine amide (CAM)	2005	0.43	1.00	43%
Didealkylatrazine (DDA)	2013	1.1	3.00	36.7%
Deethylhydroxyatrazine (DEHA)	2011	0.65	3.00	21.7%
Atrazine	2006	0.6	3.00	20.0%
Deethylatrazine (DEA)	2013	0.53	3.00	17.7%

Breakdown products of cyanazine are found in 64 percent of the Ambient Study wells. In 22 percent of study wells, total cyanazine exceeded the drinking water guideline established at 1.0 µg/L.

Dakota County Total Cyanazine Detections by Municipality as of 2020 (Dakota County Ambient Study and MDA/MDH testing)							
Municipality (Households on Private Wells, estimated)	**Community Wells Maximum Total Cyanazine**	**# of Private wells sampled for cyanazine**	**# of Private wells w/ cyanazine detections**	**% of Private wells w/ cyanazine detections**	**Private Wells w/ cyanazine exceedances (% is of wells sampled)**	**Private Wells median total cyanazine**	**Private Wells maximum total cyanazine**
Communities where cyanazine degradates have been detected in well water.							
Apple Valley (55)	0.05	1	0	0	0	0.000	0.000
Burnsville (247)	0.00	1	0	0	0	0.000	0.000
Castle Rock Twp (488)		25	15	60%	2 (8%)	0.000	1.614
Coates (54)		7	7	100%	2 (29%)	0.296	5.077
Douglas Twp (266)		2	2	100%	0	0.315	0.610
Eagan (126)	0.00	*No Private Wells Sampled*					
Empire Twp (223)	0.00	7	6	86%	0	0.000	0.880
Eureka Twp (526)		10	3	30%	1 (10%)	0.000	1.607
Farmington (101)	0.86	*No Private Wells Sampled*					
Greenvale Twp (281)		2	0	0	0	0.000	0.000
Hampton (11)	0.06	*No Private Wells Sampled*					
Hampton Twp (324)		8	5	63%	1 (13%)	0.060	2.490
Hastings (135)	0.70	4	3	75%	0	0.175	0.490
Inver Grove Heights (1540)	0.00	6	1	17%	0	0.000	0.740
Lakeville (381)	0.00	3	1	33%	0	0.000	0.060
Lilydale (0)		*No Private Wells Sampled*					
Marshan Twp (419)		59	42	82%	16 (27%)	0.459	18.744

Dakota County Total Cyanazine Detections by Municipality as of 2020 (Dakota County Ambient Study and MDA/MDH testing)							
Municipality (Households on Private Wells, estimated)	**Community Wells Maximum Total Cyanazine**	**# of Private wells sampled for cyanazine**	**# of Private wells w/ cyanazine detections**	**% of Private wells w/ cyanazine detections**	**Private Wells w/ cyanazine exceedances (% is of wells sampled)**	**Private Wells median total cyanazine**	**Private Wells maximum total cyanazine**
Communities where cyanazine degradates have been detected in well water.							
Mendota (1)		*No Private Wells Sampled*					
Mendota Heights (44)		*No Private Wells Sampled*					
Miesville (54)		*No Private Wells Sampled*					
New Trier (33)	0.00	*No Private Wells Sampled*					
Nininger Twp (314)		43	30	70%	9 (21%)	0.761	5.519
Northfield (14 in Dakota County)		*No Private Wells Sampled*					
Randolph (65)	0.00	*No Private Wells Sampled*					
Randolph Twp (280)		5	2	40%	0	0.000	0.290
Ravenna Twp (820)		2	2	100%	0	0.060	0.390
Rosemount (539)	0.08	14	9	64%	1 (7%)	0.000	1.069
Sciota Twp (157)		4	3	75%	0	0.000	0.190
South St. Paul (4)	0.00	*No Private Wells Sampled*					
Sunfish Lake (187)		3	0	0	0	0.000	0.000
Vermillion (13)	0.03	1	1	100%	0	0.697	0.697
Vermillion Twp (431)		27	17	63%	7 (26%)	0.764	3.480
Waterford Twp (213)		4	2	50%	0	0.000	0.053
West St. Paul (30)		*No Private Wells Sampled*					

Chloride

Chloride results from 1999–2019 chloride study find that:

- Results range from non-detect (less than 0.3 mg/L or < 0.3 mg/L) to 292.0 mg/L.
- All but two wells have had chloride above the MRL when sampled.
- One well exceeded the SMCL of 250 mg/L at least once.
- Five wells exceeded half the SMCL of 125 mg/L.
- Most of the highest chloride results (more than 50 mg/L) are near major highways.

Chloride Detection Frequency by Year and Concentration Category

Chloride Category	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2011	2013	2018	2019
< 3 mg/L	53%	53%	44%	29%	17%	28%	40%	25%	41%	34%	28%	32%	25%	19%	23%
3 to < 10 mg/L	7%	10%	18%	32%	48%	28%	22%	35%	14%	14%	20%	18%	20%	18%	16%
10 to < 20 mg/L	27%	28%	28%	24%	24%	26%	22%	22%	27%	27%	25%	27%	27%	33%	25%
>= 20 mg/L	13%	10%	10%	15%	12%	18%	17%	18%	19%	25%	28%	23%	27%	30%	36%

Naturally Occurring Parameters

Manganese

74 wells in the Ambient Study were tested for manganese in the sampling events that occurred between 2005 and 2013.

- Twenty-five (34 percent) of the wells exceeded the infant drinking water guideline of 0.100 mg/L at least one time and 19 percent of those wells exceeded the general drinking water guideline of 0.300 mg/L at least once.

Arsenic

In 2018, all 62 sampled Ambient Study wells were tested for arsenic. The highest result in the study was 9.9 µg/L. Arsenic was detected above the MRL (0.5 µg/L) in 24 of 77 wells (31 percent). None exceeded the drinking guideline of 10 µg/; however, MDH does not consider any level of arsenic to be safe.

Arsenic in drinking water wells is highly variable spatially. As of 2020, Dakota County does not have sufficient arsenic results to define "high arsenic" versus "low arsenic" areas. As with manganese, the County's community-focused well sampling program will produce county-wide information about the prevalence of arsenic in private drinking water wells.

Contaminants of Emerging Concern

PFAS

In 2008, Perfluorobutyrate (PFBA) was detected in 25 of 64 study wells that were sampled by the Minnesota Valley Testing Laboratory (MVTL) and analyzed by the MDH Laboratory for a list of seven PFAS chemicals. The 25 results are reported by the laboratory as estimated, which means that they were detected below the MRL of 300 ng/L (nanograms per liter equivalent for parts per trillion) and above the method detection level of 50 ng/L. The PFBA results ranged from 50 ng/L to 500 ng/L, all below the 2008 drinking water guideline of 7000 ng/L.

In 2018, 46 study wells, excluding the deeper wells in the Cjdn Aquifer, were analyzed for 21 per- and polyfluoroalkyl substances (PFAS), with lower detection levels than were available during the 2008 sampling event. In 2019, 17 wells were tested for 32 PFAS: 16 wells were in the Cjdn and one in the Unconsolidated Sediment aquifer (Ucs), well AGQS-20. AGQS-20 was previously tested in the 2018. It had the most PFAS compounds detected, seven. This well was resampled and tested in 2019, the average results from the two sample events is reported in the table and this well had the same 7 PFAS detected.

Fifty-four of the study wells were tested in both 2008 and 2018–2019. Twenty wells had PFBA detected in both sample events, and 23 had PFBA detected in the 2018–2019 and not in the 2008 sample event. The same well, AGQS-55, had the highest PFBA level in both sample events: 500 ng/L in 2008 and 280 ng/L in 2018.

A total of eight different PFAS chemicals were detected, with PFBA as the most frequently detected compound, found in 79 percent of the tested wells. MDH has established drinking water guidelines for five of the eight PFAS chemicals detected, and none of the well results exceeded the guidelines.

2018-2019 PFAS Detections (ng/L) from 64 Ambient Study Wells.

PFAS Compounds	PFBA	PFPeA	PFOA	PFHxS	PFHxA	PFOS	PFBS	PFHpA
% Detects	79%	34%	24%	19%	10%	8%	2%	2%
# of Detects	49	21	15	12	6	5	1	1
Minimum	<1	<1	<1	<1	<1	<1	<1	<1
Maximum	280	8	6	12	6	5	4	3
Average	67.1	4.0	3.5	3.9	3.2	3.7	4.3	3.1
Median	48.0	3.7	3.5	3.2	2.5	3.5	4.3	3.1
Drinking Water Guideline	7000	N/A	35	47	N/A	15	2000	N/A

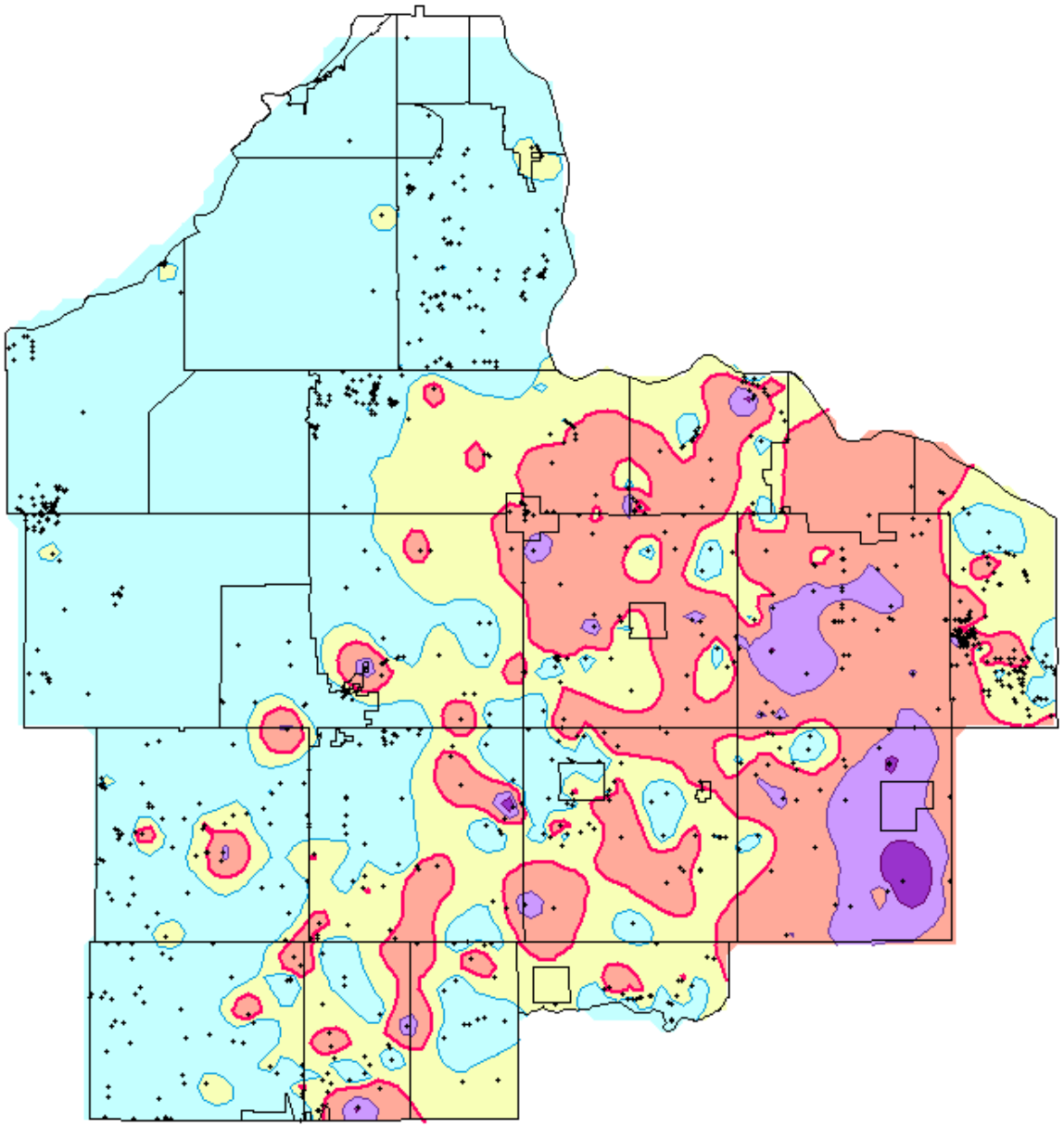
2020 – Shallow Groundwater Nitrate Baseline Interpolation

Purpose: Establish baseline of shallow groundwater nitrate concentrations for prioritizing activities and evaluating future changes related to the proposed Agricultural Chemical Reduction Effort (ACRE).

Conclusion: Based on 2013-2019 data, average nitrate concentrations 0-20 feet below the water table are currently as high as 30 mg/L.

Project Description: Dakota County staff (Bill Olsen) compiled and interpolated nitrate results from 897 samples collected from private wells with static water levels of 0 to 20 feet below the water table from 2013 through 2019.

Results:



Legend

Average nitrate concentrations in shallow groundwater

30mg/L
20mg/L
10mg/L
5 mg/L
0 mg/L

2020-2024 – Community-Focused Private Well Sampling

Purpose: The draft 2020 Dakota County Groundwater Plan, Strategy 1A3, states that private well owners will be given the opportunity for free outdoor and indoor water testing for pollutants once every five years. This serves two purposes (1) provides well owners opportunity to understand health concerns related to their drinking water; and (2) provides the county groundwater aquifer data.

Partners with Dakota County: Cities and townships in Dakota County

Well Sampling Component:

Participant Recruitment: The contract laboratory will send each well owner in the identified communities a sample kit, instructions, and a comprehensive survey about water treatment devices in the home. The sample kit will include two sample bottles, one for sample collection at the primary drinking water faucet and one from an outside untreated spigot. (The County will provide the mailing list to the laboratory.)

Based on the estimated number of private wells and previous sampling conducted, the draft five-year sampling schedule by city/township is outlined below, but may change year-to-year depending upon immediate needs. Cities/townships were prioritized by (1) last year comprehensive sampling was conducted (e.g., availability and age of data); (2) public health risk due to presence of contaminants such as nitrate or manganese; and (3) possible impact on near term policy decision making.

2020-2024 Community-Focused Private Well Sampling Estimated Sampling Schedule		
Year	**City/Township**	**Estimated # of Private Wells**
2020	**Eagan**	126
	Apple Valley	55
	Randolph	65
	Northfield (in Dakota County)	14
	Miesville	54
	New Trier	33
	Hampton	11
	Vermillion	13
	Coates	54
	Marshan Twp	419

2020-2024 Community-Focused Private Well Sampling Estimated Sampling Schedule		
Year	**City/Township**	**Estimated # of Private Wells**
	Hastings	135
	Douglas Twp	266
	Rosemount	539
	2020 Total Wells	**1,784**
2021	**Mendota**	1
	Mendota Heights	44
	South St. Paul	4
	West St. Paul	30
	Sunfish Lake	187
	Nininger Twp	314
	Hampton Twp	324
	Waterford Twp	213
	Vermillion Twp	431
	Empire Twp	223
	2021 Total Wells	**1,771**
2022	**Ravenna Twp**	823
	Castle Rock Twp	485
	Sciota Twp	155
	Randolph Twp	282
	2022 Total Wells	**1,745**
2023	**Eureka Twp**	526
	Farmington	101
	Burnsville	247
	Greenvale Twp	281
	Lakeville	381
	2023 Total Wells	**1,536**
2024	**Inver Grove Heights**	1540

2020-2024 Community-Focused Private Well Sampling Estimated Sampling Schedule		
Year	**City/Township**	**Estimated # of Private Wells**
	Lilydale	0
	2024 Total Wells	**1,540**
TOTAL		**8,376**

Sampling: Residents will be asked to collect a water sample from both an outside untreated spigot and an inside primary drinking water tap.

Parameters: Outside samples will be analyzed for arsenic, chloride, manganese, and nitrate. The Lab would only analyze the indoor sample for nitrate if > 3 mg/L, arsenic if > MDL, and manganese if equal to or greater than 90 µg /L in the outside sample. All inside samples will be analyzed for lead.

2020 -- Biosolid Application Sites

Purpose: Screening for pollution from biosolid applications in downgradient private wells.

Well Sampling Component:

Participant Recruitment: County staff will select approximately 30 wells downgradient from biosolid application sites for the screening effort. Infiltration areas and flow paths to wells will be modelled to help identify wells with a greater likelihood of being impacted by percolation from applied biosolids.

Parameters: Samples will be tested for manganese, arsenic, nitrate, chloride, sulfate, PFAS compounds, wastewater compounds, and the additional heavy metals cadmium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc. Since the county does not have information on the background levels of the heavy metals in groundwater, once the county has the sampling results, it will collect background samples for the heavy metals from ten additional wells not downgradient from biosolid application sites.

Abbreviations and Acronyms

ACRE	Agricultural Chemical Reduction Effort
AGQS	Ambient Groundwater Quality Study, or Ambient Study
BMP	Best Management Practice
Cjdn	(Cambrian) Jordan Aquifer
County	Dakota County, Minnesota
DNR	Minnesota Department of Natural Resources
ELF	Dakota County Environmental Legacy Fund
EPA	Environmental Protection Agency
HANS	Hastings Area Nitrate Study
Legacy Amendment	2008 Clean Water, Land and Legacy Amendment to the Minnesota Constitution
MCL	Maximum Contaminant Level
µg/L	Micrograms per liter, equivalent to parts per billion
mg/L	Milligrams per liter, equivalent to parts per million
MDA	Minnesota Department of Agriculture
MDH	Minnesota Department of Health
MPCA	Minnesota Pollution Control Agency
N	Nitrogen (or pounds of active nitrogen available in fertilizer)
NFMP	Nitrogen Fertilizer Management Plan
Opdc	(Ordovician) Prairie du Chien Aquifer
pCi/L	Picocuries per liter
PFCs	Perfluorochemicals
PFAS	Per- and Polyfluoroalkyl Substances
PMP	Pesticide Management Plan
RO	Reverse osmosis system
SMCL	Secondary Maximum Contaminant Level
SWCD	Dakota County Soil and Water Conservation District
Ucs	Unconsolidated sediments aquifer
UMN	University of Minnesota

USEPA	United States Environmental Protection Agency
USGS	U.S. Geological Survey
VRWJPO	Vermillion River Watershed Joint Powers Organization
WHPP	Wellhead Protection Plan
WIISE	Wells and Increased Infant Sensitivity and Exposure