North Fork Crow River Watershed (07010204)
Groundwater Restoration and Protection Strategies Report

June 2017

MINNESOTA

North Fork Crow River Watershed (07010204) Groundwater Restoration and Protection Strategies Report (GRAPS)

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Contributors

The following agencies dedicated staff time and resources toward the development of the North Fork Crow River GRAPS report:

- Minnesota Board of Water and Soil Resources (BWSR)
- Minnesota Department of Agriculture (MDA)
- Minnesota Department of Health (MDH)
- Minnesota Department of Natural Resources (DNR)
- Minnesota Pollution Control Agency (MPCA)

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Executive Summary

The North Fork Crow River Watershed (NFCRW) (Hydrologic Unit Code [HUC] 07010204) spans over 949,107 acres in central Minnesota. Parts of Pope, Kandiyohi, Stearns, Meeker, Wright, Hennepin, Carver, and McLeod counties are in the watershed. Groundwater accounts for over 94 percent of the water appropriated and 100 percent of the drinking water in the NFCRW. The watershed is home to a variety of natural resources that rely on groundwater (groundwater dependent features). There are many land uses and activities in the NFCRW that impact the availability and quality of groundwater and drinking water resources. Five State of Minnesota agencies collaborated to develop a Groundwater Restoration and Protection Strategies (GRAPS) report for the NFCRW. This report is designed to help prioritize and target local efforts to restore and protect groundwater resources in the NFCRW.

Representatives from BWSR, MDA, MDH, DNR, and MPCA researched, compiled existing state data, and developed maps to establish a baseline understanding of groundwater conditions and associated resource management concerns for the NFCRW. The team developed strategies and supporting actions that can be applied at a county, subwatershed, or watershed level to help restore and protect groundwater.

Due to the differences in the geology and land use practices throughout the watershed, the types of groundwater issues and concerns vary. The NFCRW can be divided into three main regions based on geology and general land use practices:

- **The western region** is underlain by glacial sediments and crystalline rock. The majority of the groundwater is available from layers of glacial sand. The region has a low population density and has extensive irrigated row crop agriculture. A large portion of the region has high pollution sensitivity, meaning there is a higher risk for groundwater to be polluted by contaminants from the ground surface. Other parts of the region have low pollution sensitivity (the contamination risk is lower). This region of the watershed overlaps with the Bonanza Valley Groundwater Management Area, a region identified by the DNR as being at risk for groundwater overuse.
- **The central region** is underlain by glacial sediments and Cretaceous sandstone and shale. Most groundwater is derived from the glacial sands. In general, the population density in this region increases as you move from the west to the east. The region has some row crop agriculture and a few areas with high and medium pollution sensitivity, with the remainder having a low pollution sensitivity.
- **The eastern region** is underlain by glacial sediments and Paleozoic sandstone and shale; glacial sands and Paleozoic sandstones constitute the dominant aquifers. This region has the highest population density of the three regions, since it includes parts of the western suburbs of Minneapolis. There is little row crop production in this region. Most of the region has low pollution sensitivity with a few areas of medium or high pollution sensitivity.

Groundwater and drinking water quality concerns in the watershed include:

- Nitrate contamination in wells primarily located in areas with high pollution sensitivity.
- Arsenic has been detected in groundwater in a variety of locations throughout the watershed.
- Pesticides have been detected in groundwater in the western region of the watershed.

- Animal feedlots, stormwater infiltration practices, and subsurface sewage treatment systems (SSTS) are located throughout the watershed and can lead to groundwater contamination if improperly installed or maintained.
- Active and leaky tank sites (referred to as contaminated sites) are located throughout the watershed, with the most in the western and eastern regions.
- Closed landfills with known groundwater contamination plumes are scattered throughout the watershed, with the greatest concentration in the central region.

Groundwater quantity concerns in the watershed occur where groundwater withdrawals outpace groundwater recharge and where withdrawals can adversely affect groundwater dependent features. There is a record of declining water levels primarily in the western region. A variety of natural resources, such as fens and trout streams, depend on groundwater to sustain their characteristics. These groundwater dependent features can be negatively impacted by changes in groundwater quantity or quality.

While there are a variety of groundwater quantity and quality issues and concerns, this report identifies the following key strategies to address the issues and concerns:

- **Conservation Easements:** Maintain and expand the amount of land protected from being converted to high intensity uses, such as row crop agriculture.
- **Contaminant Planning and Management:** Use land use planning, ordinances, and collaboration with state regulatory agencies to protect groundwater and drinking water supplies from contaminant releases.
- **Cropland Management:** Encourage the implementation of voluntary practices to manage resource concerns while minimizing environmental loss.
- **Education and Outreach:** Educate landowners, private well users, and other stakeholders about how their actions affect groundwater and what they can do to conserve, restore, and protect groundwater.
- **Integrated Pest Management:** Implement a pest management approach that incorporates the many aspects of plant health care/crop protection in ways that mitigate harmful environmental impacts and protect human health.
- **Irrigation Water Management:** Control the volume, frequency, and application rate of irrigation water to sustain groundwater.
- **Land Use Planning and Management:** Use city or county government planning and regulations along with land management goals that implement best management practices (BMP), conserve water, and educate stakeholders to protect groundwater levels, quality, and contributions to groundwater dependent features.
- **Nutrient Management:** Assure that application of crop fertilizer or manure uses the right source, right rate, right time, and right place.
- **Subsurface Sewage Treatment System (SSTS) Management:** Monitor, maintain, and/or upgrade SSTS to assure proper operation and treatment.

The GRAPS report proposes specific actions individuals, local government, and partners can take within each of the nine key strategies. The report also identifies which counties and subwatersheds (HUC-10) should be prioritized for each action. The NFCRW GRAPS report should be used in conjunction with the **North Fork Crow Watershed Restoration and Protection Strategy Report** (https://www.pca.state.mn.us/sites/default/files/wq-ws4-06a.pdf) report to develop the local water management plan. The WRAPS report informs how to restore and protect surface water, and the GRAPS report informs how to restore and protect groundwater in the NFCRW.

Introduction

What Is the GRAPS Report?

The State of Minnesota adopted a watershed approach to address the state's 81 major watersheds.[1] Major watersheds are denoted by an 8-digit hydrologic unit code (HUC). This watershed approach incorporates water quality assessment, watershed analysis, civic engagement, planning, implementation, and measurement of results into a 10-year cycle that addresses both watershed restoration and protection (Figure 1).

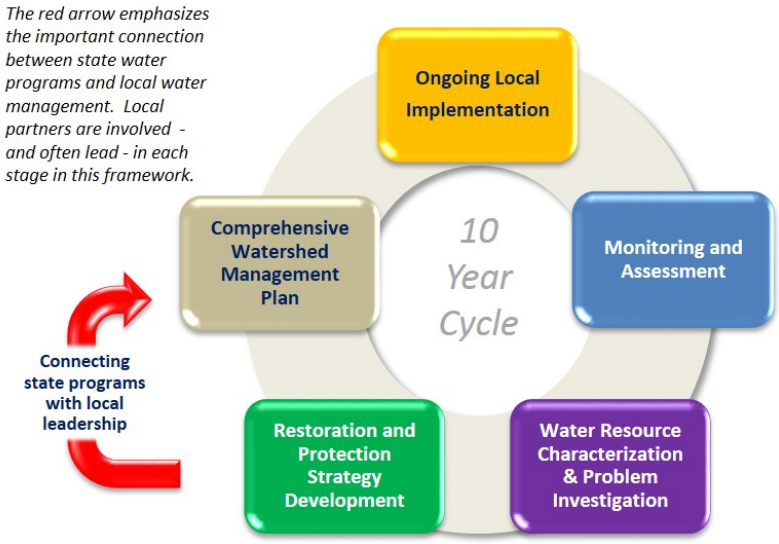

Figure 1: Watershed Approach Framework

Groundwater Restoration and Protection Strategies (GRAPS) reports are designed to help prioritize and target local efforts to restore and protect groundwater resources as part of local water planning. While groundwater is not broken into watersheds like surface water, several state agencies have worked together to compile information and strategies for groundwater below surface water watersheds. A GRAPS report uses existing state data and information about groundwater and land-use practices that affect groundwater in the watershed to identify key groundwater quality and quantity concerns. The report also suggests targeted strategies and actions to restore and protect the groundwater. GRAPS reports are meant to be used in conjunction with Watershed Restoration and Protection Strategies (WRAPS) reports in the development of local watershed management plans. WRAPS inform how to restore and protect surface water, and GRAPS inform how to restore and protect groundwater in the same geographical area.

[1] You can learn more about the Watershed Approach at Watershed approach to restoring and protecting water quality (https://www.pca.state.mn.us/water/watershed-approach-restoring-and-protecting-water-quality).

WRAPS focus on restoration, which is initiated through an intensive monitoring effort to determine if a surface water is meeting its designated use. WRAPS identify actions and the rate of adoption needed to restore water quality. GRAPS, on the other hand, is largely protection-based—identifying actions to maintain groundwater quality and quantity. However, if contaminants exist or overuse is suspected, the strategies and actions identified to address the issue can result in restoration as well as protection.

How to Use this Report

This report is a resource and tool for developing local water management plans. The report is divided into six parts to accommodate different needs and information partners and agencies may seek. This report is not necessarily designed to be read cover to cover. Rather, you should flip to the parts that sound most helpful. If you are accessing this document electronically, you can click on hyperlinks throughout the report to move to different parts of the report and/or access webpages (all hyperlinks are in blue font).

The report is divided into the following parts:

1. **NFCRW Overview**: This section provides a brief overview of the watershed and groundwater in the NFCRW.

2. **NFCRW Groundwater Issues and Concerns**: This section highlights the main groundwater quality and quantity concerns, where each concern is most prevalent within the watershed, and general ways to address the concern.

3. **NFCRW Strategies and Actions to Protect and Restore Groundwater**: This section provides tips for prioritizing and targeting restoration and protection strategies, makes suggestions about what strategies and actions would be most appropriate in which counties and subwatersheds, describes the suggested strategies, and provides information about existing programs and resources for each strategy.

4. **Making Sense of the Regulatory Environment:** This section provides an overview of the roles State agencies play in managing groundwater and drinking water.

5. **Appendices**

NFCRW Overview

This report provides a brief overview of land use, geology, hydrogeology, pollution sensitivity, wellhead protection planning and drinking water, and water use and groundwater withdrawals affecting the NFCRW's groundwater quality and quantity. You can find more detailed information about the NFCRW and groundwater through the following resources:

- MPCA **Groundwater Report for the North Fork Crow River Watershed** (https://www.pca.state.mn.us/sites/default/files/wq-ws1-08.pdf).
- MPCA **North Fork Crow River** (https://www.pca.state.mn.us/water/watersheds/north-fork-crow-river).
- MPCA **North Fork Crow Watershed Restoration and Protection Strategy Report** (https://www.pca.state.mn.us/sites/default/files/wq-ws4-06a.pdf).

The NFCRW spans 949,107 acres in central Minnesota. The headwaters for the North Fork Crow River are in Pope County at the outlet of Grove Lake. The river flows about 120 miles southeast from Grove Lake to the confluence with the South Fork Crow River in Rockford and on to the confluence with the Mississippi River near Dayton. The Middle Fork Crow River, which joins the North Fork near Manannah, is a major tributary to the North Fork Crow River. Parts of Pope, Kandiyohi, Stearns, Meeker, Wright, Hennepin, Carver, and McCleod counties are in this watershed. Major cities include Litchfield, St. Michael, Buffalo, Otsego, Dayton, and Rockford. Figure 2 provides a map of the NFCRW. Of the roughly 135,746 people living in the watershed, approximately 77,538 (57 percent) utilize community public water supply systems, and the remaining 43percent get their water from private wells.

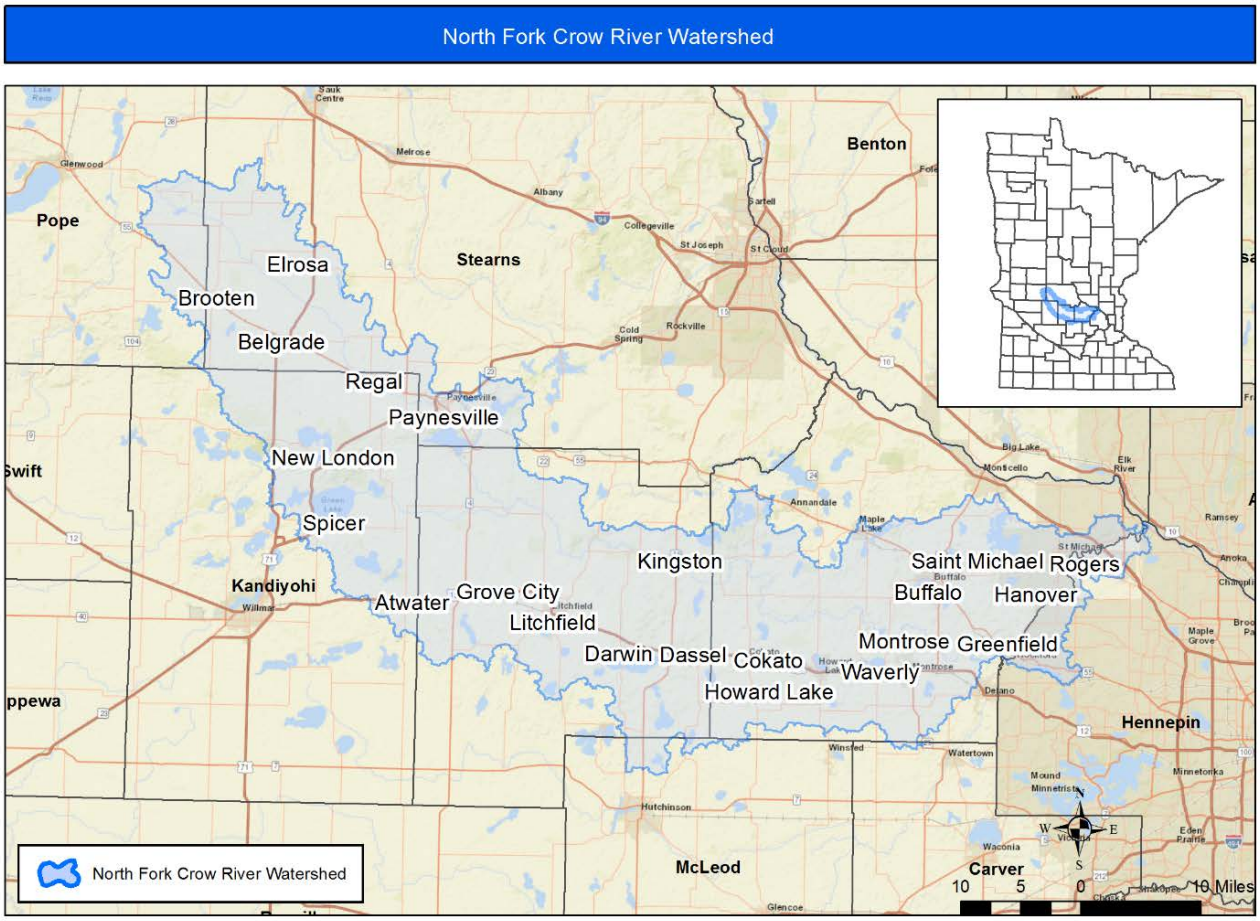

Figure 2: North Fork Crow River Watershed

Land Use

NFCRW is a large and diverse watershed that can be broken into three different regions based on the geology and general land use practices. Figure 4 provides a map of the three main regions within the NFCRW.

- **The western region** is underlain by glacial sediments and crystalline rock. The majority of the groundwater is available from layers of glacial sand. The region has a low population density and has extensive irrigated row crop agriculture. A large portion of the region has high pollution sensitivity, meaning there is a higher risk for groundwater to be polluted by contaminants from the ground surface. Other parts of the region have low pollution sensitivity (the contamination risk is lower). This region of the watershed overlaps with the Bonanza Valley Groundwater Management Area, a region identified by the DNR as being at risk for groundwater overuse.
- **The central region** is underlain by glacial sediments and Cretaceous sandstone and shale. Most groundwater is derived from the glacial sands. In general, the population density in this region increases as you move from the west to the east. The region has some row crop agriculture and

a few areas with high and medium pollution sensitivity, with the remainder having a low pollution sensitivity.

- **The eastern region** is underlain by glacial sediments and Paleozoic sandstone and shale; glacial sands and Paleozoic sandstones constitute the dominant aquifers. This region has the highest population density of the three regions, since it includes parts of the western suburbs of Minneapolis. There is little row crop production in this region. Most of the region has low pollution sensitivity with a few areas of medium or high pollution sensitivity.

Row crop production is the dominant land use across the watershed. Irrigated row crops are most common in the west and continually decline as you move eastward. Pasture and hay land can be found throughout much of the watershed to support the diverse animal agriculture industry. Suburban growth is present in the eastern edge of the watershed. Land cover statistics (USGS, 2017) indicate that about 16 percent of the NFCRW is covered by open water, wetlands, or herbaceous/shrub wetlands. Figure 3 shows the land cover of the NFCRW.

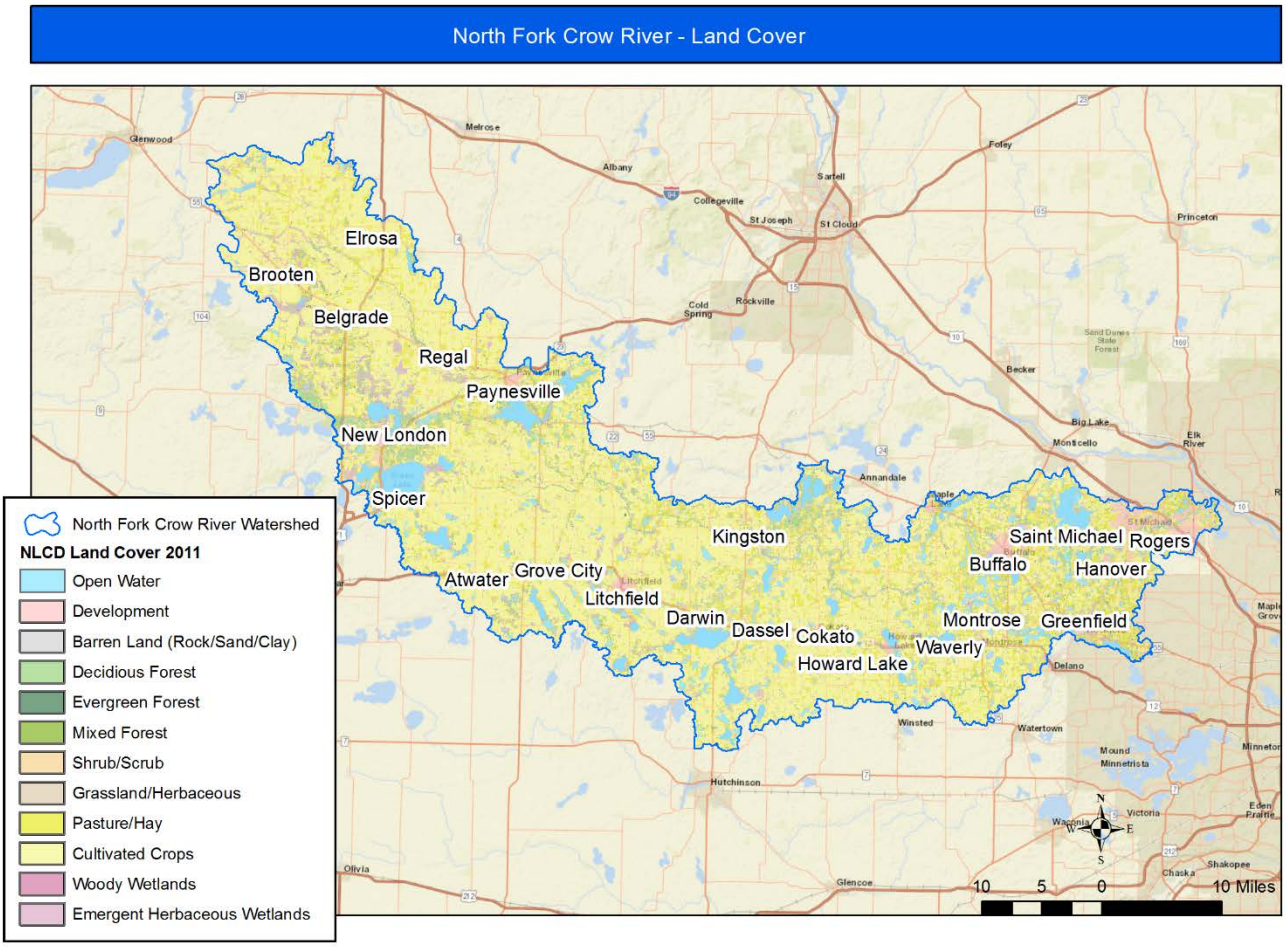

Figure 3: North Fork Crow River-Land Cover

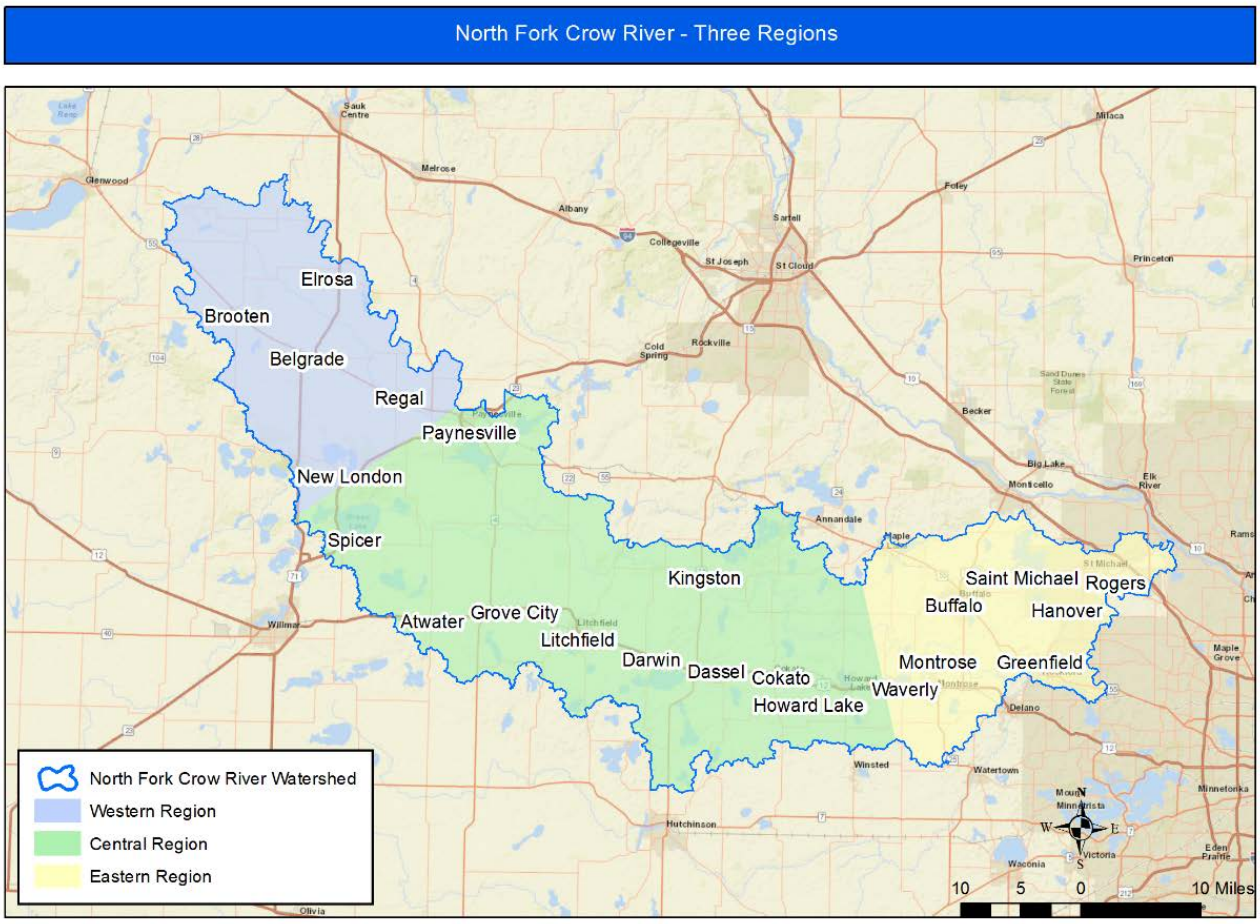

Figure 4: North Fork Crow River-Three Regions

Geology and Hydrogeology

The availability of groundwater within the watershed varies according to the underlying geology. Glacial sediments underlie the entire watershed. Most commonly, these sediments consist of clay-rich till. Local sand and gravel deposits can be productive aquifers when saturated; however, their occurrence and yield are unpredictable, limiting aquifer availability. Underlying the tills in the western region of the watershed is dense crystalline bedrock, which is generally unproductive except where fractured. Continuing eastward within the watershed, the glacial tills are underlain by patches of Cretaceous-age bedrock, which locally are sandy enough to form productive aquifers. The eastern region of the watershed has both glacial sand aquifers and Paleozoic-age bedrock aquifers. The latter are productive enough to supply a variety of high-demand uses. Figure 5 shows a generalized map of aquifers in the watershed. Figure 6 shows a geologic cross-section of the watershed.

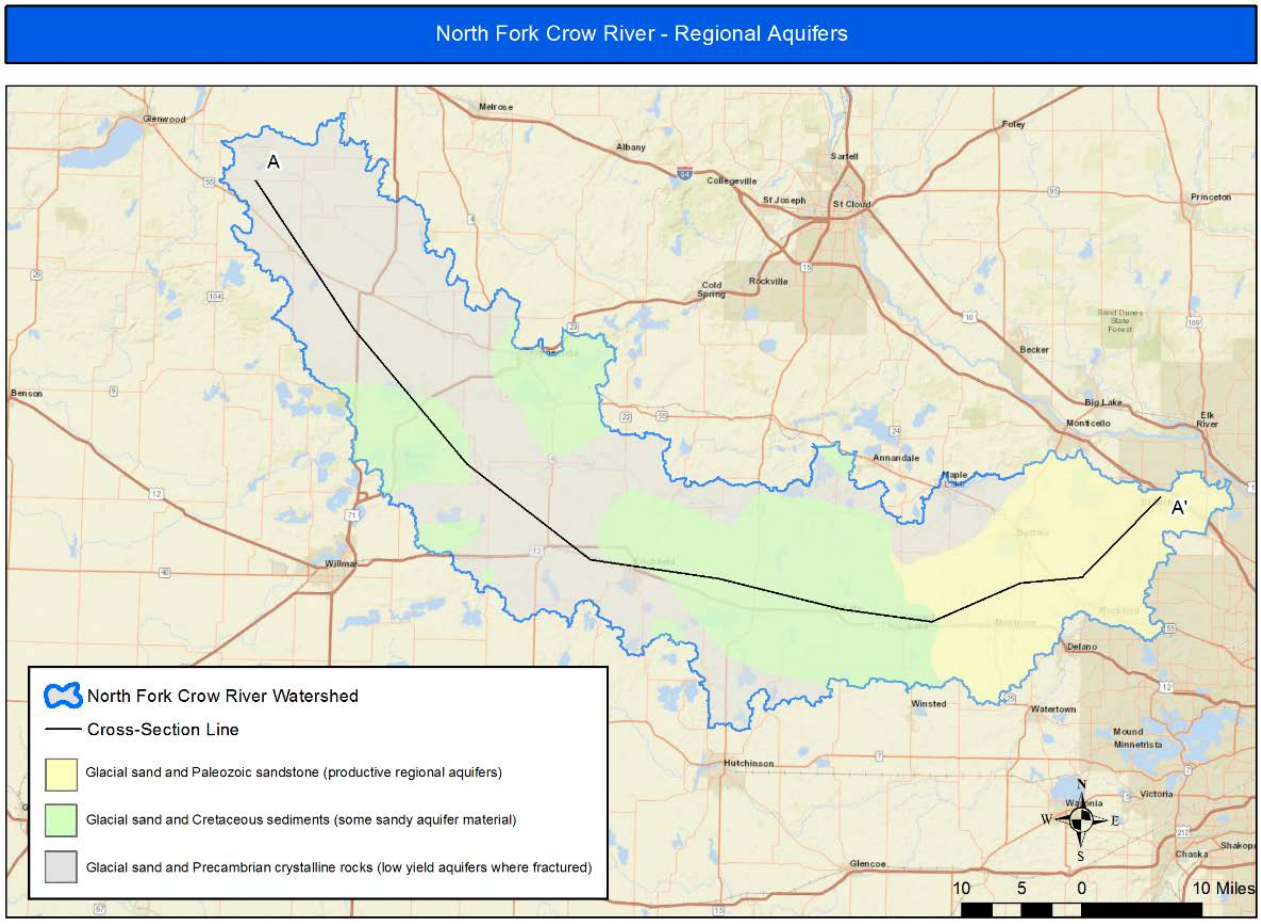

Figure 5: North Fork Crow River-Regional Aquifers

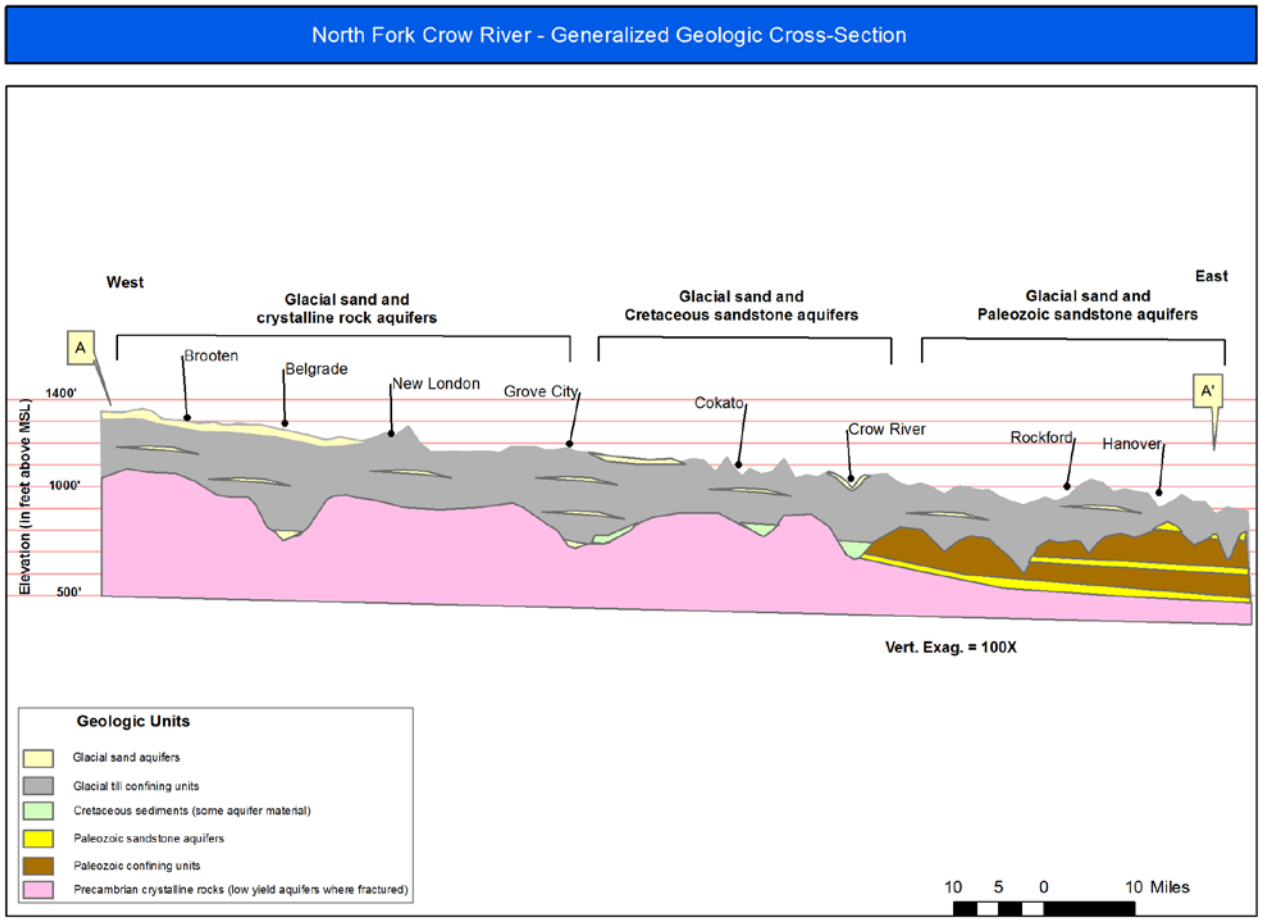

Figure 6: North Fork Crow River-Generalized Geologic Cross-Section

Pollution Sensitivity

Understanding pollution sensitivity is important for prioritizing and targeting implementation efforts. Pollution sensitivity (also known as aquifer vulnerability or geologic sensitivity) refers to the time it takes recharge and contaminants at the ground surface to reach the underlying aquifer. Statewide and regional efforts often focus on pollution sensitivity of near-surface materials, or the water table (Figure 7), while local assessments often focus on the sensitivity of aquifers used for drinking water supply (Figure 10). It is important to understand the target aquifer when assessing pollution sensitivity. A drinking water aquifer may be deeper and more geologically protected than the water table aquifer in a given area, or it may not. Figure 7 depicts the statewide GIS layer of Pollution Sensitivity of Near-Surface Materials, while the geologic sensitivity raster depicted in Figure 10 was created by calculating the geologic sensitivity at individual wells in the watershed, and then inferring between them to create a smooth layer. The wells used to make this figure vary in depth, but overall they provide a picture of geologic sensitivity of aquifers below the water table.

It is also important to understand how recharge travel time ratings for surficial water table aquifers (Figure 7 and Figure 8) differ from those used for deeper buried aquifers (Figure 10). These two types of

aquifers follow two different sets of recharge travel times that correspond to sensitivity ratings. For example, a pollution sensitivity rating of 'moderate' for surficial materials reflects vertical travel times on the order of weeks (Figure 8); whereas, for deeper aquifers more commonly used for drinking water, a rating of 'moderate' reflects travel times of years to decades (Table 1). This difference stems from the fact that surficial materials are reached more quickly by infiltrating water and contaminants than deeper buried aquifers. Deeper aquifers often have protective clay layers that make travel time significantly longer. As noted above, this distinction is important when determining the potential impact of various contaminants on surficial materials and drinking water aquifers.

Figure 7 and Figure 10 both show that the western region of the NFCRW has the largest area with high pollution sensitivity in both surficial materials and deeper aquifers. The central and eastern regions of the watershed have less concentrated areas with high or moderate pollution sensitivity of the surficial materials. Deeper aquifers in this region tend to have low pollution sensitivity, with patchy areas that are moderately sensitive. Table 1 provides an overview of the various recharge travel times for surficial and buried aquifers.

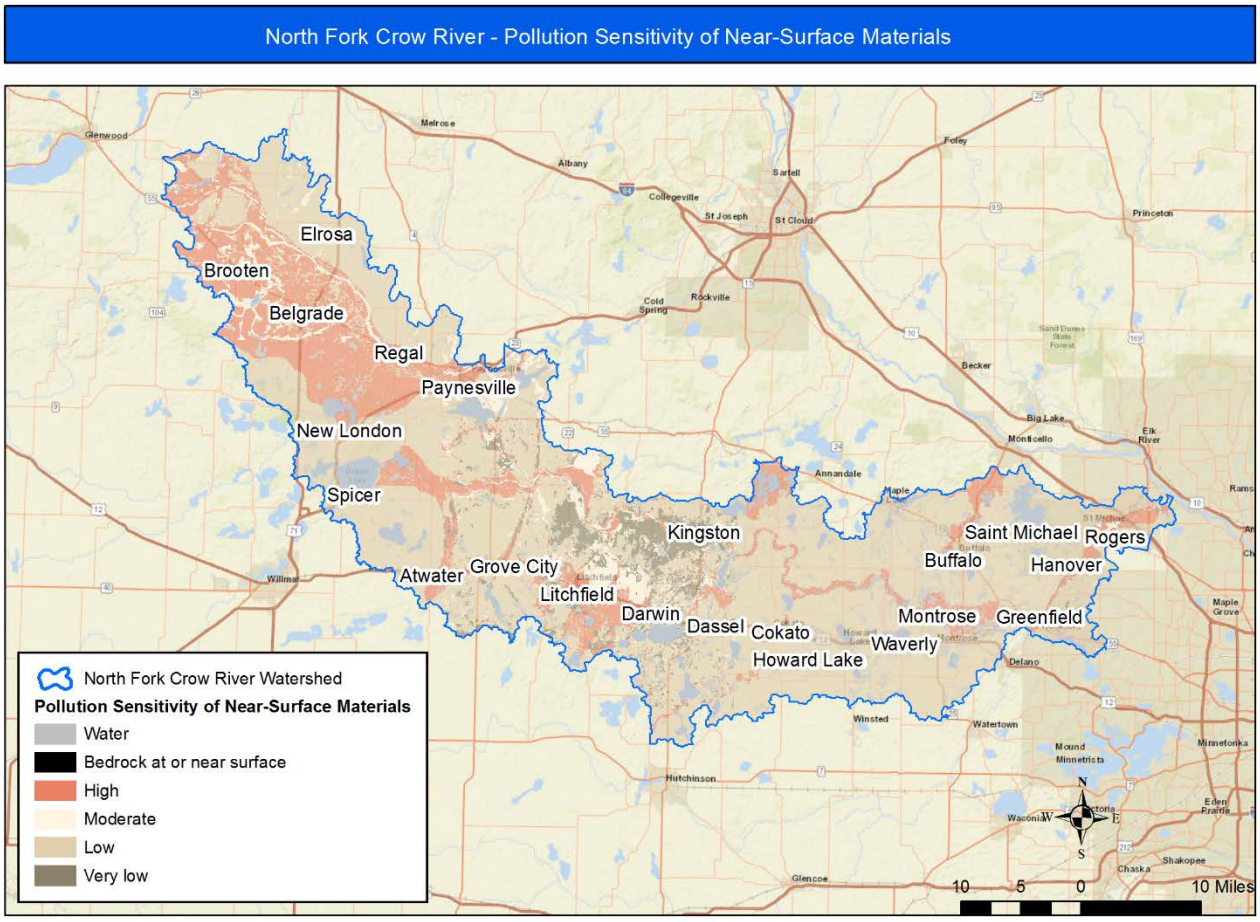

Figure 7: North Fork Crow River-Pollution Sensitivity of Near-Surface Materials

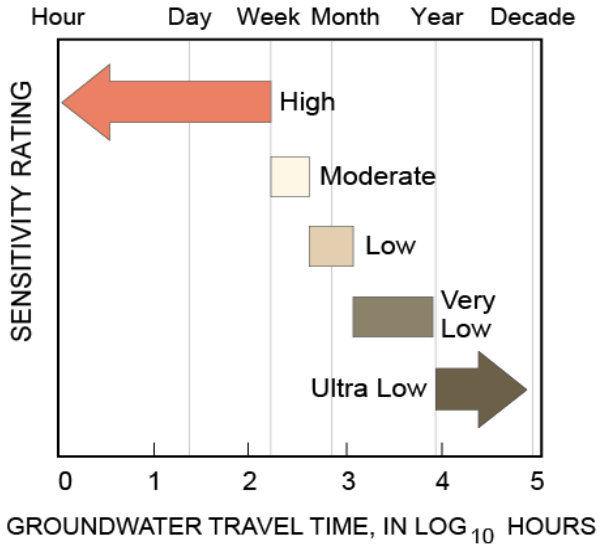

Figure 8: Recharge Travel Time for Near-Surface Materials

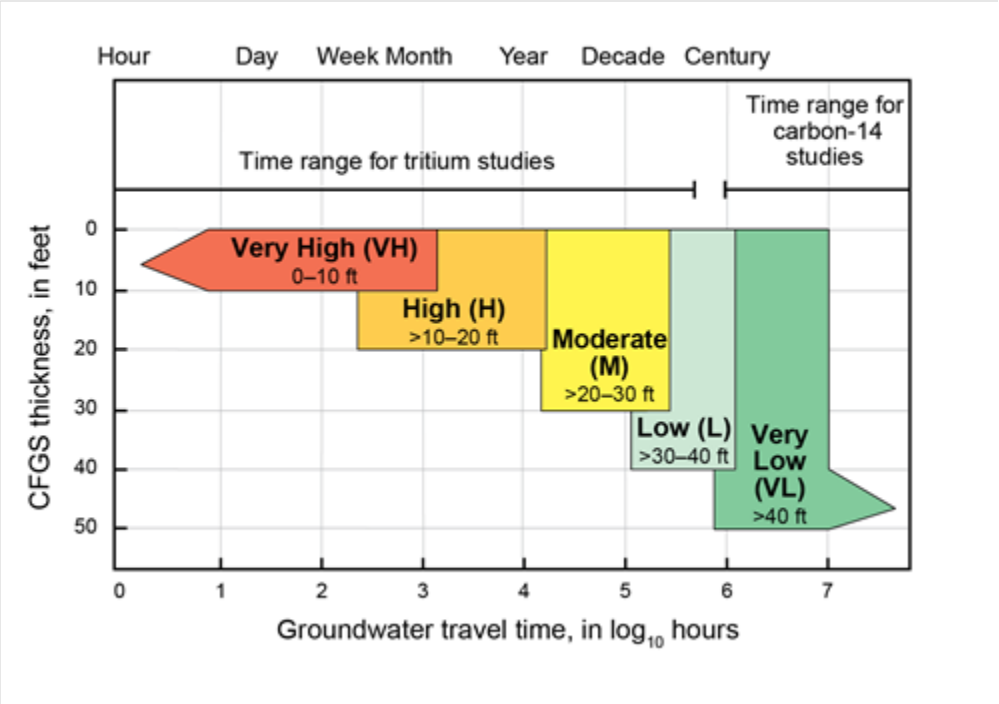

Figure 9: Recharge Travel Time based on Cumulative Fine-Grained Sediment (CFGS) for Buried Aquifers

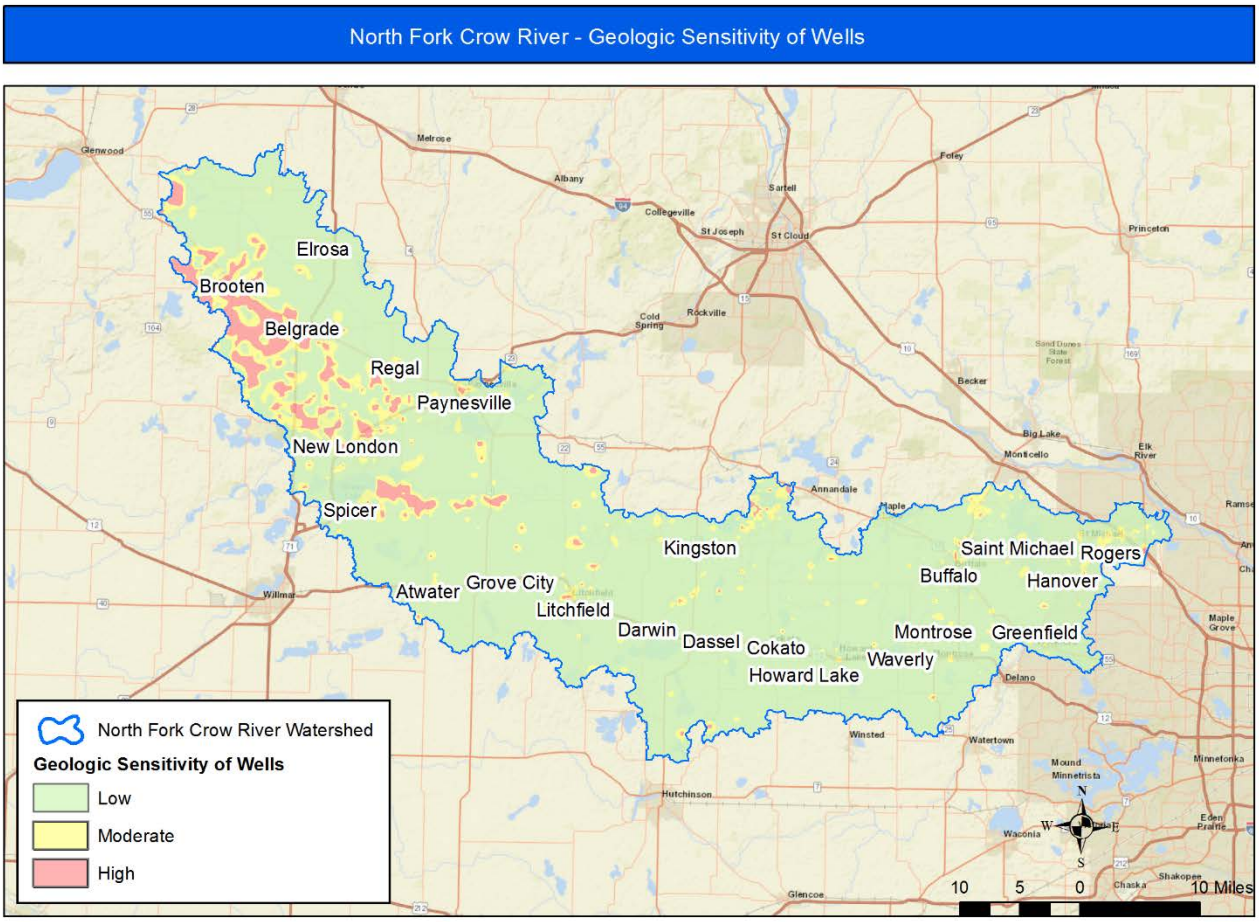

Figure 10: North Fork Crow River-Geologic Sensitivity of Wells

Table 1: Sensitivity rating and the associated recharge travel times for surficial and buried aquifers.

Pollution Sensitivity Rating	Aquifer Recharge Time Period[2] for Surficial Aquifers	Aquifer Recharge Time Period for Buried Aquifers	Description
High	hours to a week	days to months	Contaminants in high pollution sensitivity areas may reach the aquifers without significant dilution or degradation. As such, many types of land use must be managed to assure the aquifer does not get contaminated.
Moderate	a week to weeks	years up to one or two decades	Contaminants in moderate pollution sensitivity areas may be diminished by the time they reach the aquifers because of increased attenuation. As such, fewer land uses must be managed to assure the aquifer does not get contaminated.
Low	weeks to a year	several decades to a century	Contaminants in low pollution sensitivity areas may be very diminished by the time they reach the aquifers because of increased attenuation. As such, few land uses must be managed to assure the aquifer does not get contaminated.

Wellhead Protection Planning and Drinking Water Supply Management Areas

Wellhead protection planning is the program whereby public water systems examine land uses in the recharge area for their wells and develop strategies for land use management. The strategies are based on the geologic vulnerability and are appropriate for safeguarding drinking water supplies. Both community and nontransient noncommunity public water suppliers are required to prepare Wellhead Protection Plans. As part of this effort, the recharge area that contributes water to the public water supply well(s) is delineated based on physical and chemical characteristics of the aquifer being used. These areas, known as wellhead protection areas (WHPAs), provide an assessment of the aquifer vulnerability (sensitivity) of the public water supply wells. Once the WHPA is established, a Drinking Water Supply Management Area (DWSMA) is created to provide planning boundaries on the land surface for management of the resource. Learn more about the MDH Source Water Protection Program at Source Water Protection (http://www.health.state.mn.us/divs/eh/water/swp/).

[2] Aquifer recharge time periods refer to the time it takes aquifers to receive recharge from the land surface. Aquifer recharge rate informed by the Geologic Sensitivity Project Workgroup, 1991.

While the word ‘sensitivity’ is used to describe groundwater generally throughout the state, ‘vulnerability’ is the term used for wellhead protection planning to protect public sources of drinking water. While there are minor differences between how these words are developed (as described above), the words are essentially the same for the purposes of planning and management.

Aquifers and wells used for public water supplies vary widely. Some are very shallow and unprotected and can be easily contaminated by activities at the ground surface. Others are deeper or more protected by geologic materials; these tend to exhibit a low vulnerability to overlying land uses. Guided by the vulnerability of the public water systems’ wells and the aquifer they draw from, the scope and breadth of management activities within wellhead protection areas, and the associated drinking water supply management areas varies.

Fifteen of the 24 community public water systems within the NFCRW are in the wellhead protection planning process or are implementing their plans. The remaining nine systems will be brought into the wellhead protection planning process by 2020. Of the 13 systems with approved plans, seven are considered to be not vulnerable to contamination from the land surface with all others exhibiting moderate and high vulnerability. Figure 11 shows the state of wellhead protection planning for the community public water supplies in the watershed. Figure 12 shows the vulnerability of the DWSMAs that have been delineated to date in the NFCRW.

Figure 11: North Fork Crow River-Wellhead Protection Plan Development Status for Community Public Water Systems

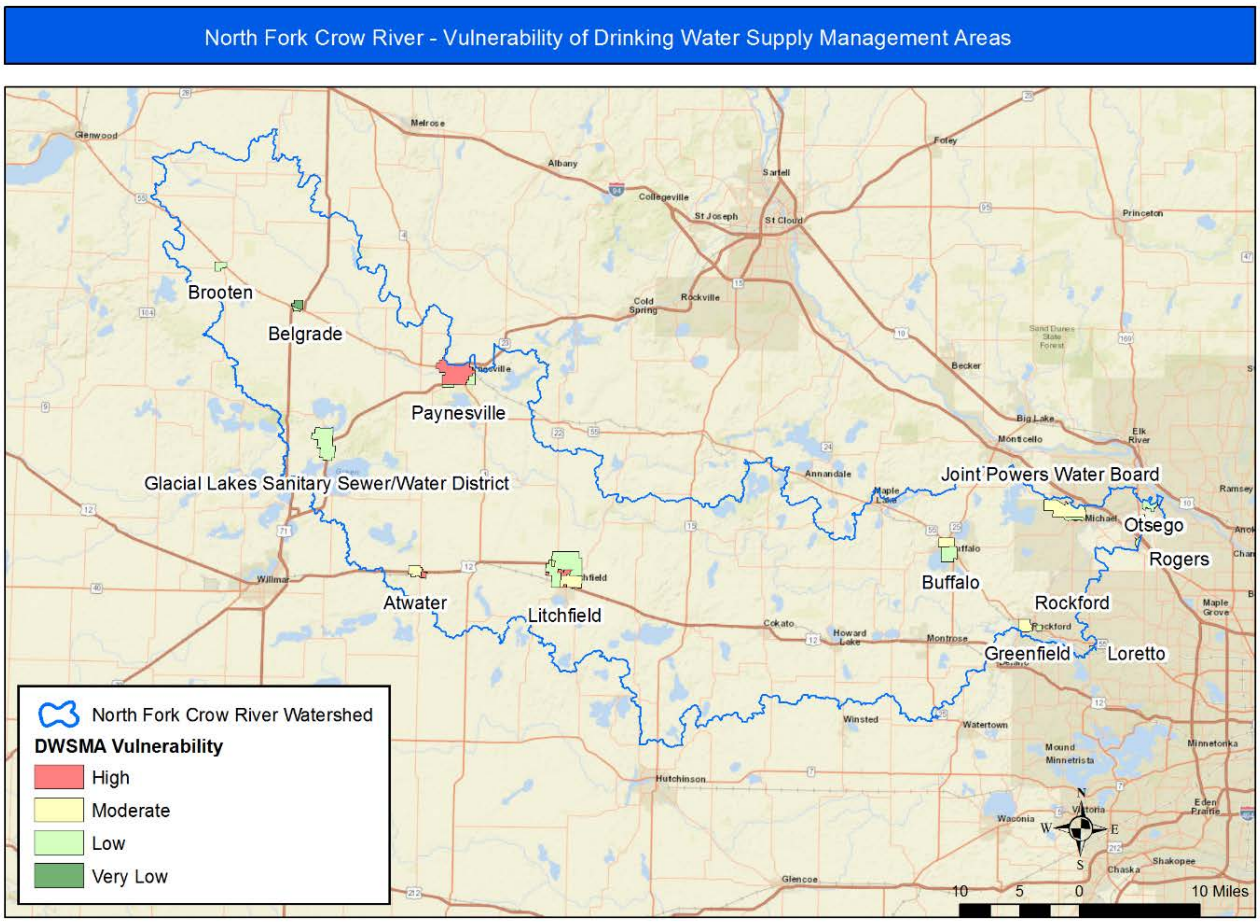

Figure 12: North Fork Crow River-Vulnerability of Drinking Water Supply Management Area

Water Use

Groundwater accounts for over 94 percent of the water appropriated in the NFCRW. Groundwater has been the primary source of water for the watershed for many years. As populations grow and land use practices evolve, there is a growing demand for water within the NFCRW. Figure 13 shows that permitted groundwater use has steadily increased in the NFCRW since 1988. There is very little surface water used in the NFCRW, and it has remained relatively constant since 1988. Due to the small volume, domestic wells do not typically require a water appropriation permit for use.

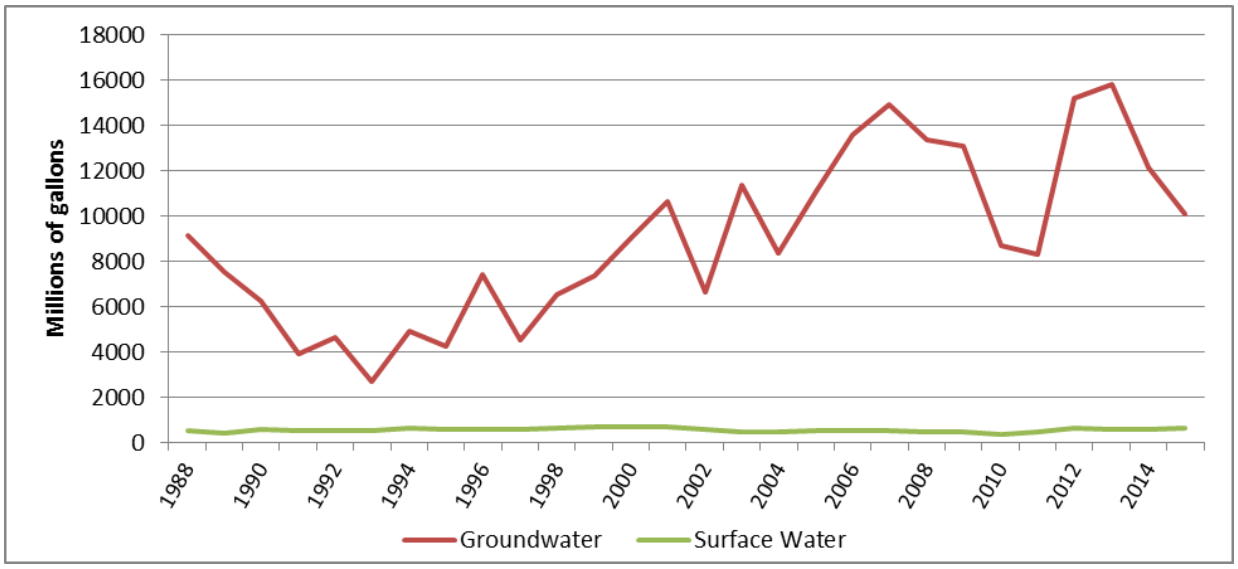

Figure 13: Groundwater vs. Surface Water Use

There are many types and uses of permitted wells in the NFCRW. Beyond drinking water supplies for public water systems, wells are used for irrigation, animal feeding, industrial and commercial purposes, controlling sites of groundwater contamination, and other specialized needs. Irrigation and public water supplies are the two largest uses of water in the NFCRW. The amount of water permitted for agricultural irrigation and public water supplies has steadily increased since 1988, as the trend line in Figure 14 notes. Domestic use does not require a water use permit; therefore, no data on use is available.

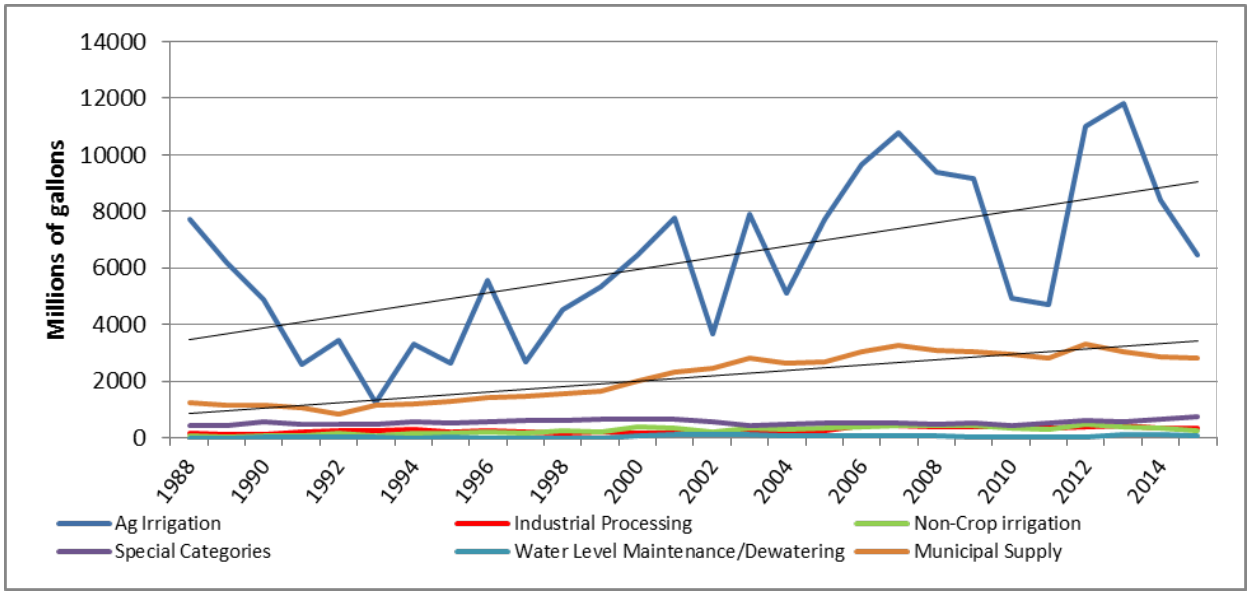

Figure 14: Water Use by Permit Type

Groundwater Withdrawals

Permitted groundwater withdrawals vary greatly throughout the NFCRW:

- The **western region** has the highest concentration of irrigation permits. This highly permitted region overlaps with the Bonanza Valley Groundwater Management Area, a region identified by the DNR as being at risk for groundwater overuse. Learn more about the Bonanza Valley Groundwater Management Area (GWMA) (http://www.dnr.state.mn.us/gwmp/area-bv.html).
- The **central region** contains water use permits issued largely for agricultural irrigation. The DNR cited a suspected area for groundwater overuse from agricultural irrigation just west of Litchfield. Further monitoring is required to understand if the water source is sustainable.
- The **eastern region** of the watershed contains a mix of groundwater use permits, with public water supplies forming the largest category.

Figure 15 provides a map of where irrigation, drinking water, and other types of wells are located in the NFCRW.

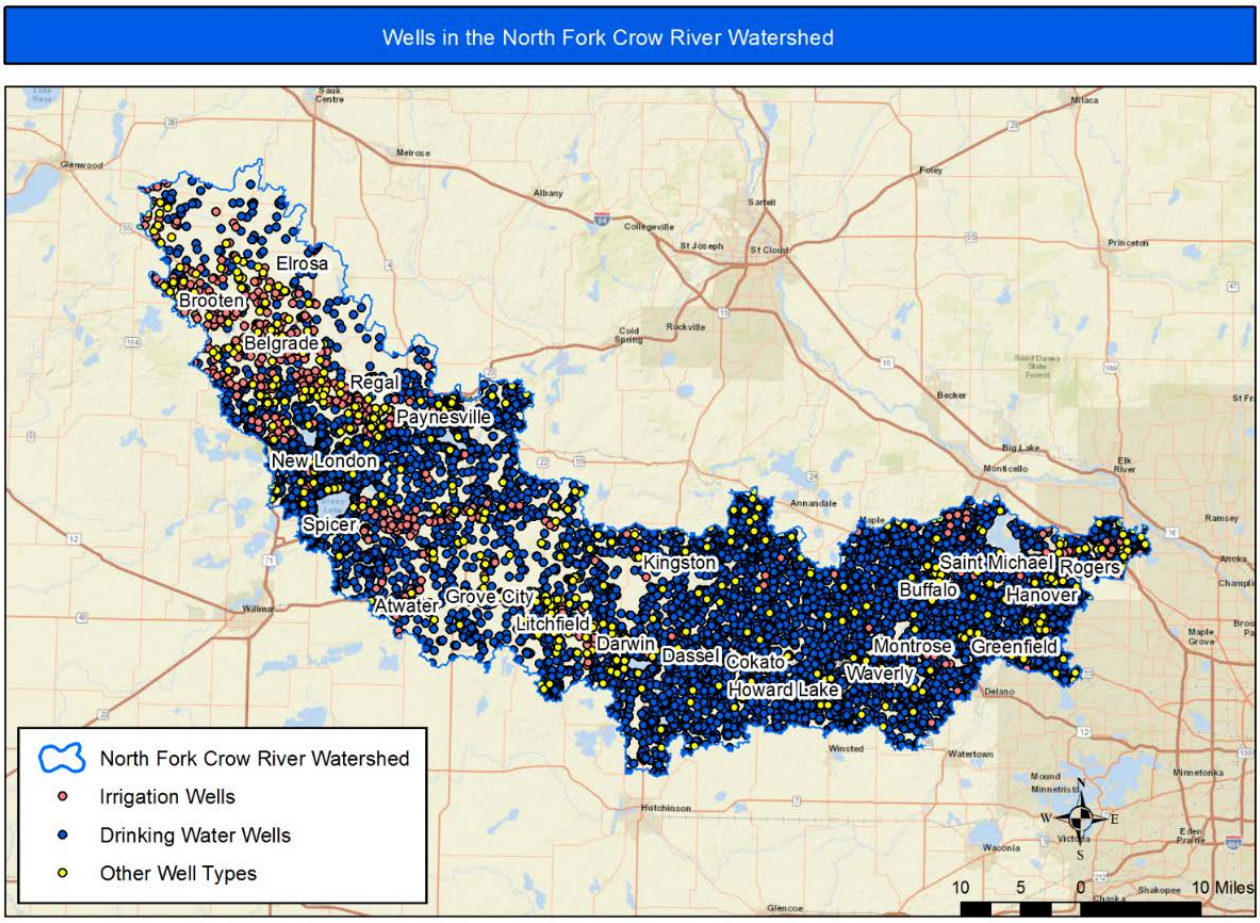

Figure 15: Wells in the North Fork Crow River Watershed

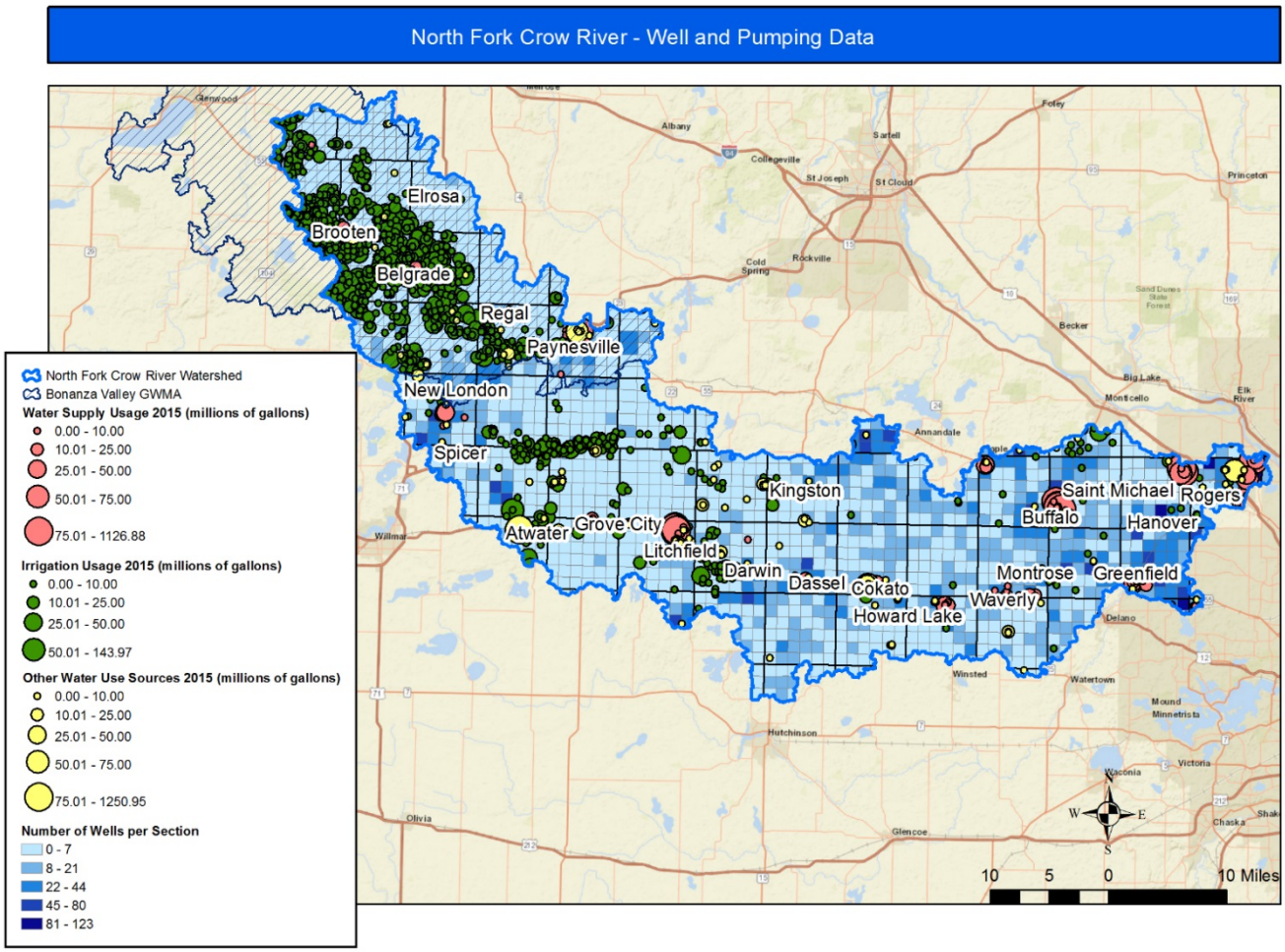

Figure 16: North Fork Crow-Well and Pumping Data

Figure 16 illustrates both well density and water use data in the NFCRW. This figure contains a grid that depicts the number of wells in each six miles by six miles section of the watershed. Deeper colors correspond to a higher concentration of wells. Well density is variable across the watershed. All well types were included in this analysis.

Circles represent water use data. The three colors of circles correspond to water use permits issued for public water supply, irrigation, and all remaining sources of water use. The size of the symbol indicates how many millions of gallons were reported as pumped in 2015.

NFCRW Groundwater Issues and Concerns

This section of the report describes the key groundwater quality and quantity issues for the NFCRW. The descriptions of each issue include an overview of the issue, where the issue is most prevalent, and references a few key approaches to address the issue. The NFCRW Strategies and Actions to Protect and Restore Groundwater provides a more detailed list of actions to address NFCRW groundwater issues and concerns.

Groundwater Quality Issues and Concerns

Naturally-occurring minerals and human-made contaminants affect NFCRW groundwater quality. Multiple state agencies monitor different types of groundwater wells and public water systems for contaminants. Nitrate, arsenic, and pesticides have been detected in wells sampled in the NFCRW. This section provides context and data about these contaminants and their occurrence in the watershed. It also provides information about SSTS, contaminated sites, and feedlots in the area that may affect groundwater quality.

All public water systems in the watershed meet Safe Drinking Water Act (SDWA) requirements for the quality of water served to their customers. However, some public water systems have water quality issues in their untreated source water that requires either blending or treatment to meet SDWA standards. Review of over five thousand water quality analyses taken from public wells in the watershed since 1993 shows that 58 public water wells (1 percent) exceed a drinking water standard in the untreated water. All but three of these were related to arsenic, a naturally occurring contaminant that is common in both public and private wells in the watershed. Of the other three exceedances, two were related to radium (a naturally-occurring contaminant found in deep bedrock aquifers) and a single exceedance of 1,2-dichloroethane (a human-made solvent).

Nitrate

Nitrate is a compound that occurs naturally and has many human-made sources. When nitrate levels are above 3 milligrams per liter (mg/L)[3] in groundwater, human activity is the likely cause (Mueller and Helsel, 1996). Human-induced sources of nitrate include animal manure, fertilizers used on agricultural crops, failing SSTS, fertilizers used at residences and commercially, and nitrous oxides from the combustion of coal and gas.

Nitrate is one of the most common contaminants of groundwater in Minnesota and is a public health concern where it is found in groundwater used for drinking water. The U.S. Environmental Protection Agency (EPA) standard for nitrate in drinking water is 10 mg/L. Approximately 0.2 percent of the 7,822

[3] One milligram per liter is the same as 1 part per million (ppm).

samples taken from wells within the watershed had levels of nitrate at or above the EPA standard. This dataset includes newly constructed wells, private wells, and other drinking water supply wells sampled by the Minnesota Department of Health (MDH). Sampling of newly constructed wells for nitrate began in 1974. Many older wells are not included in this dataset. Table 2 shows nitrate test results for samples taken from these wells.

Table 2: Summary of nitrate results in drinking water wells of the North Fork Crow River Watershed.

Depth Completed Range (feet)	Total samples (n)	Minimum Nitrate-N concentration (mg/L)	Maximum Nitrate-N concentration (mg/L)	Median Nitrate-N concentration (mg/L)	Nitrate-N samples at or above 3 mg/L (%)	Nitrate-N, samples at or above 10 mg/L (%)
< 50	143	0	23.24	0.1	5.6	2.8
50 - 99	2513	0	19.21	0.5	3.1	0.2
100 - 149	2590	0	34.00	0.5	1.0	0.1
150 - 199	1470	0	181.80	0.5	0.9	0.2
>= 200	1106	0	7.70	0.5	0.5	0.0
Total	7822	0	181.80	0.5	1.7	0.2

Where Is Nitrate in the NFCRW?

Nitrate is detected in groundwater throughout the NFCRW. Higher levels of nitrate are present in areas where there are both human-caused sources of nitrate and high pollution sensitivity, which is consistent with MDA findings in their Township Testing Program (TTP). The following images help identify where nitrate is detected, and at what levels, in the watershed:

- Figure 17 compares nitrate levels in wells in the NFCRW with the pollution sensitivity of the area. The map shows that there is a correlation between areas with high pollution sensitivity and nitrate detections above 3 mg/L. In other instances, the absence of elevated nitrate concentrations may be a function of low-impact land use near the well or the presence of favorable geochemical conditions in the aquifer. Nitrate requires relatively oxidizing conditions to persist in groundwater, and the presence of locally reducing conditions can remove nitrate. The dataset used to create this figure is the same as that used in Table 2.
- Figure 18 shows the TTP schedule and the percentage of nitrate detected in sampling conducted in the northwestern part of the watershed. MDA identified townships where groundwater is vulnerable and row crop agriculture is present as the focus of the testing program. Their results show that more than five percent of wells sampled to date in four townships had levels of nitrate over the EPA standard. Future sampling will include townships in the center of Meeker County and the northwestern and northeastern portions of Wright County. Learn more about the TTP at Township (Nitrate) Testing Program (http://www.mda.state.mn.us/townshiptesting).

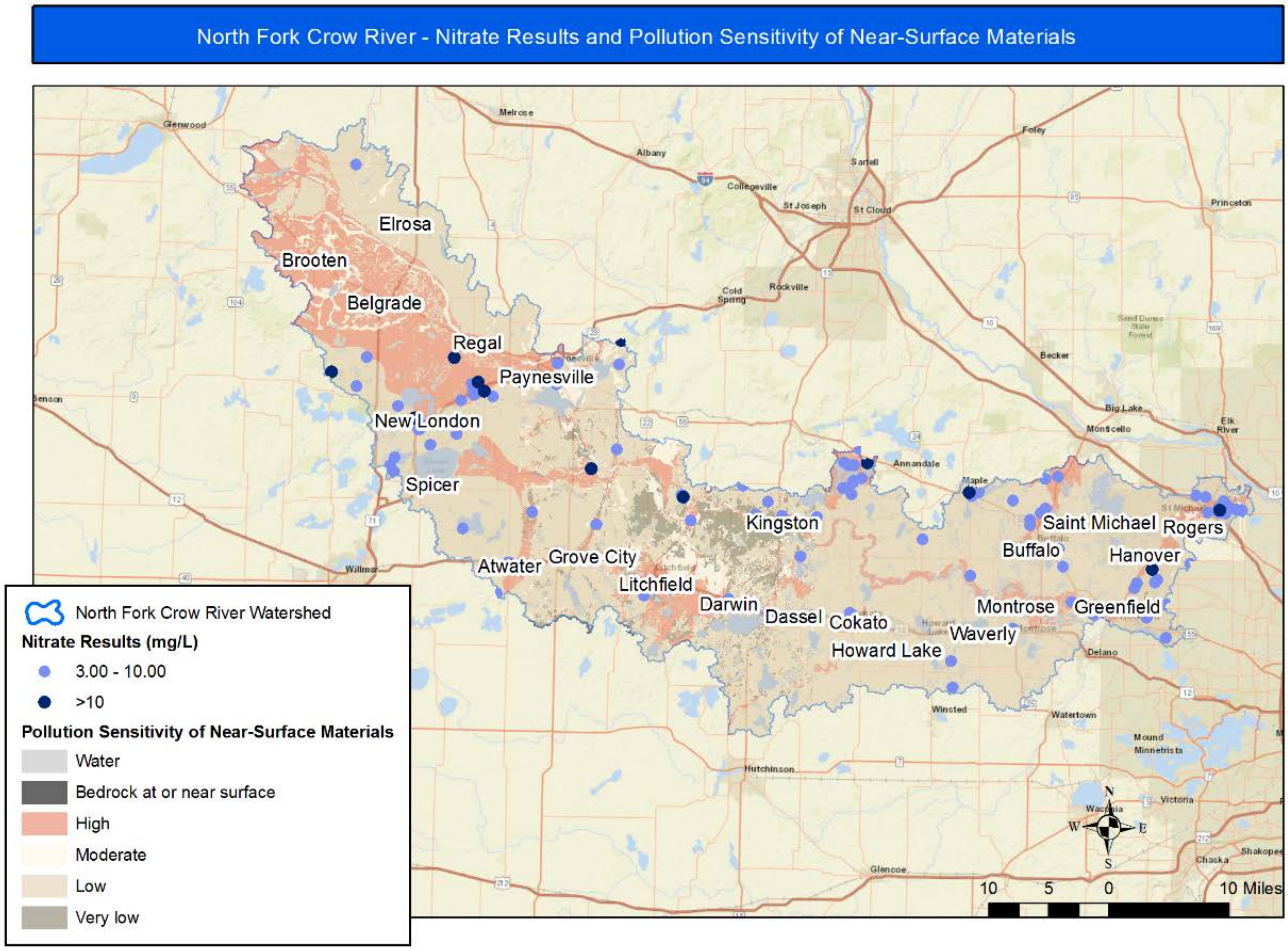

Figure 17: North Fork Crow River-Nitrate Results and Pollution Sensitivity of Near-Surface Materials

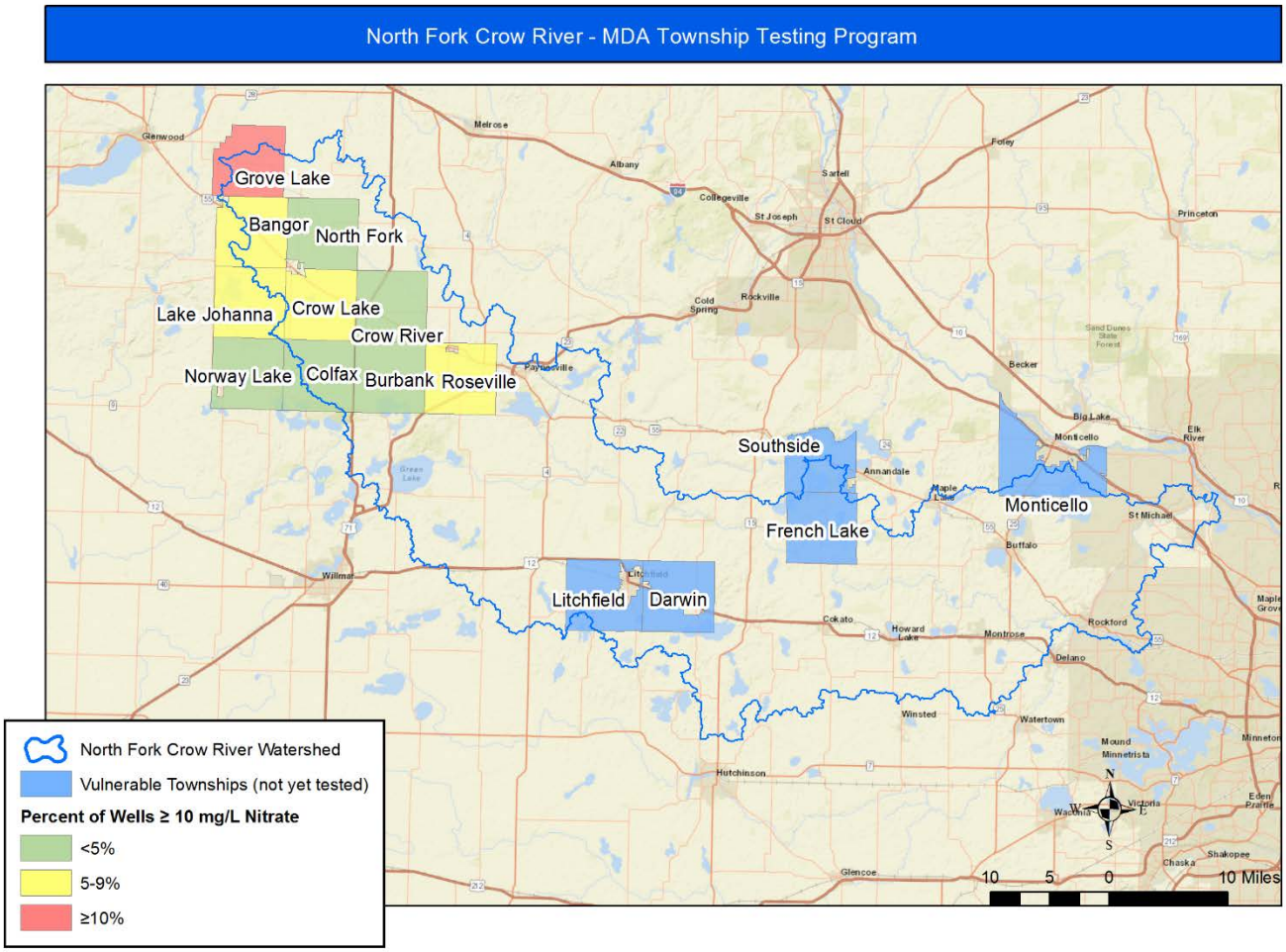

Figure 18: North Fork Crow River-MDA Township Testing Program

How to Address Nitrate in Groundwater

General approaches to reduce the amount of nitrate that may enter groundwater include:

- Provide educational opportunities on the 4R nutrient management concept (right source, right rate, right time, and right place)
- Employ nutrient BMPs and cropping
- Leverage the work of existing programs focused on nutrient management
- Develop incentives and provide technical assistance for adopting nutrient BMPs
- Provide educational opportunities about turf BMPs
- Assure SSTS are constructed properly and encourage regular maintenance of the systems
- Prioritie feedlot inspections and the proper application of manure in areas at greatest risk to contamination in delegated feedlot counties
- Employ land use controls that safeguard public health through regulations and ordinance development

- Implement conservation easements through programs such as the Conservation Reserve Program (CRP) and Reinvest in Minnesota (RIM) in vulnerable wellhead protection areas and areas with private wells.

Table 8 provides a more comprehensive list of specific actions counties and subwatersheds in the NFCRW can take to restore and protect groundwater quality related to nitrate.

Arsenic

Approximately 21 percent of the 1,086 arsenic samples taken from wells in the NFCRW have levels of arsenic higher than the drinking water standard of 10 micrograms per liter (µg/L)[4]. Arsenic occurs naturally in rocks and soil across Minnesota and can dissolve into groundwater. Consuming water with low levels of arsenic over a long time is associated with diabetes and increased risk of cancers of the bladder, lungs, liver, and other organs. Drinking water with arsenic at levels lower than the EPA standard over many years can still increase the risk of cancer. The EPA has set a goal of 0 µg/L for arsenic in drinking water because there is no safe level of arsenic in drinking water.

Since 2008, the State of Minnesota has required that water from new water supply wells be tested for arsenic. Table 3 outlines the number of well water samples tested for arsenic in the NFCRW by the Minnesota Department of Health, and shows the percentage of samples with arsenic levels over the EPA standard. This dataset includes newly constructed wells, domestic wells, and other drinking water supply wells. It is important to remember that arsenic concentrations can be drastically different from nearly identical wells installed on adjoining properties.

Table 3: Summary of arsenic (As) concentrations in wells of the North Fork Crow River Watershed.

Depth Completed Range (feet)	Total samples (n)	Minimum As concentration (µg/L)	Maximum As concentration (µg/L)	Median As concentration (µg/L)	As samples at or above 5 µg/L (%)	As samples at or above 10 µg/L (%)
< 50	41	0.0005	25.03	0.016	26.8	17.1
50 - 99	337	0.0005	105.4	4.4	45.7	28.8
100 - 149	325	0.0005	57.5	2.9	39.1	21.2
150 - 199	209	0.0005	54.8	1	24.9	13.9
>= 200	174	0.0005	47.12	1	28.7	14.9
Total	1086	0.0005	105.4	2.6	46.9	21.0

[4] One microgram per liter is the same as 1 part per billion (ppb).

Where Is Arsenic in the NFCRW?

Arsenic is most prevalent in the Quaternary Buried Artesian Aquifers (lenses of sand and gravel enclosed within clay-rich sediments). Elevated levels are likely related to local geochemical conditions that allow for mobilization of the metal. These geochemical conditions tend to be moderately reducing and are often associated with the contact between sand and gravel aquifers and adjacent clay-rich sediments (Erickson and Barnes, 2004 and 2005). Figure 19 shows that arsenic is found throughout the watershed. It is more prevalent in some areas than others. The dataset used to create Figure 18 is the same that is displayed in Table 3.

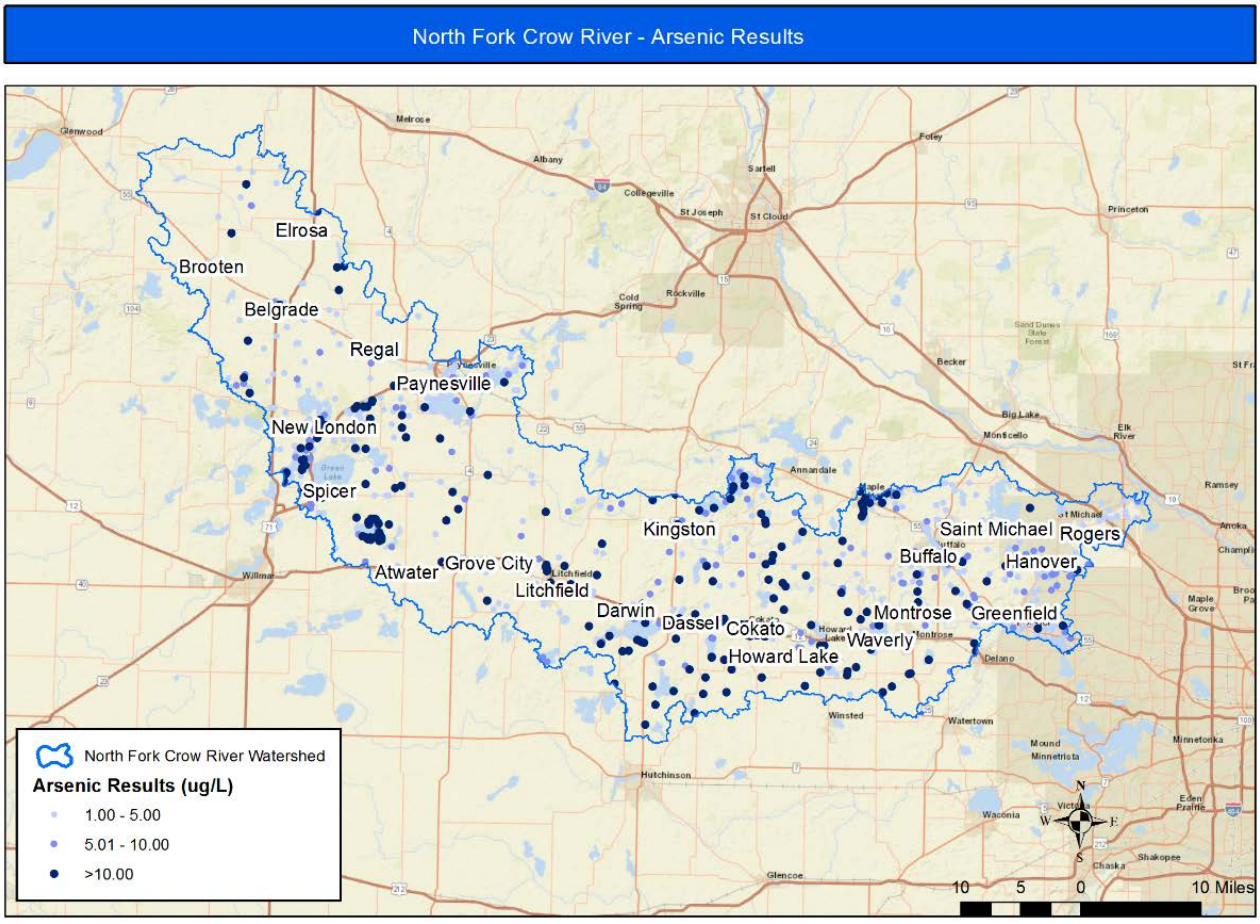

Figure 19: North Fork Crow River-Arsenic Results

How to Address Arsenic in Groundwater

Unlike nitrate and pesticides, human activity rarely causes arsenic in groundwater, except for local releases of insecticides or wood preservatives into the environment. Therefore, few actions can reduce the amount of arsenic present in groundwater. Implementation efforts should focus on making private

well users aware of the health risks, encouraging them to test their water for arsenic, and providing them with treatment options to keep their drinking water safe when arsenic is present.

Pesticides

A pesticide is any substance or mixture of substances intended for preventing, destroying, repelling, or lessening the damage of any pest and may be a chemical substance or a biological agent. Consuming water with different types of pesticides in it can cause a variety of health problems. MDA monitors for 'common detection pesticides' as a part of the MDA Pesticide Management Plan (http://www.mda.state.mn.us/protecting/waterprotection/pmp.aspx). Common detection pesticides are pesticides frequently used in row crop production and include acetochlor, alachlor, atrazine, metolachlor, and metribuzin.

Where Are Pesticides in the NFCRW?

MDA uses 11 monitoring wells in the western region of the NFCRW to monitor for common detection pesticides. The monitoring wells are in the western region because there are sandy soils and irrigated row crops increasing the potential for pesticides or pesticide degradates to get into groundwater. Figure 20 displays the number of common detection pesticides recorded at each monitoring location in the NFCRW in 2015. Anywhere from zero to five common detection pesticides were detected at the monitoring wells. No detections exceeded any human health-based drinking water standards or reference values. The MDA's 11 monitoring wells only give information about pesticides at those specific locations. Pesticide sampling of private wells is included as part of the TTP, which is currently underway and will provide more information on the presence of pesticides in other locations in the watershed.

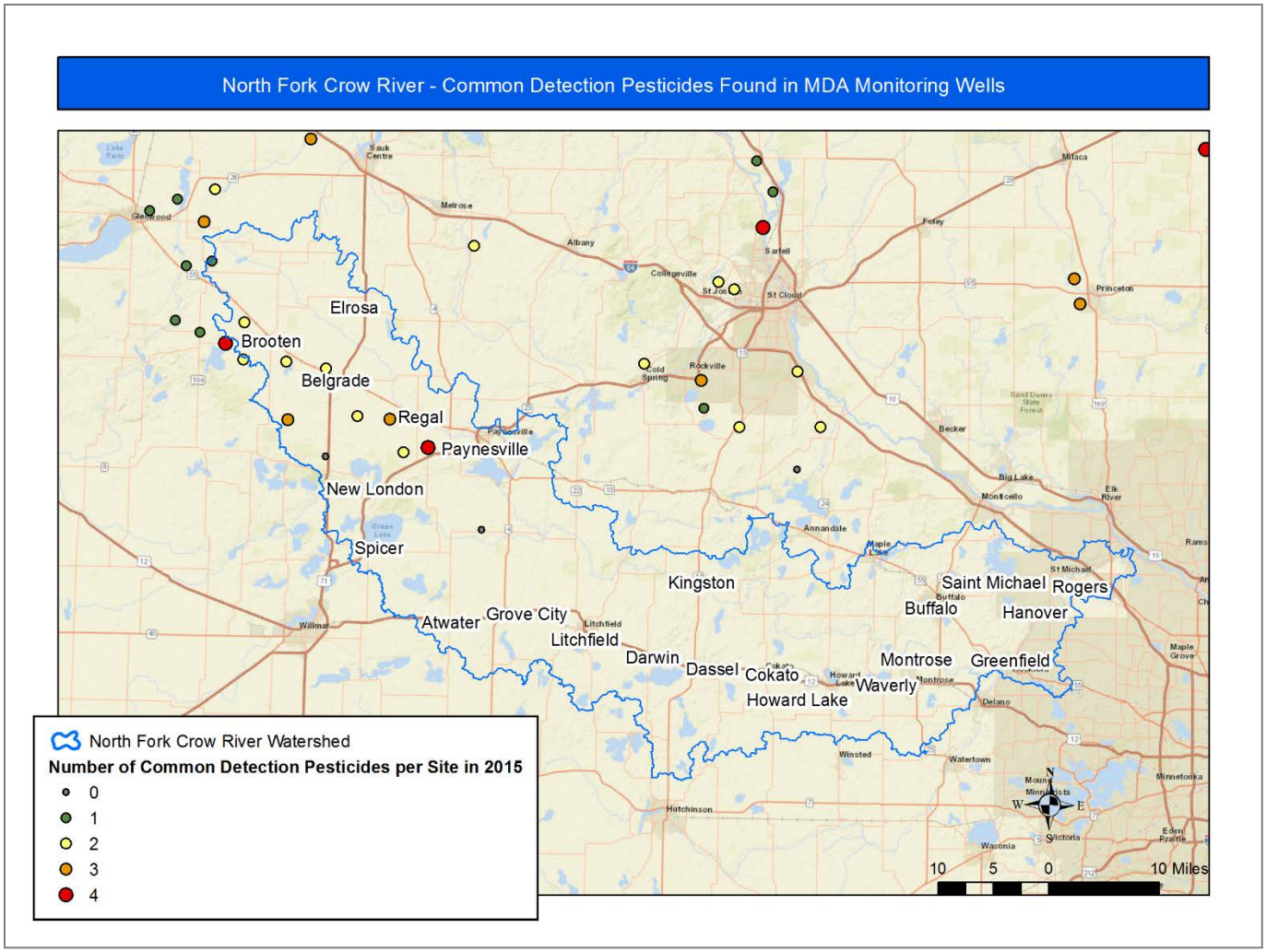

Figure 20: North Fork Crow River-Common Detection Pesticides Found in MDA Monitoring Wells

How to Address Pesticides in Groundwater

General approaches to reduce the amount of pesticides that may enter groundwater include:

- Provide educational opportunities about pesticide and insecticide BMPs for both agricultural lands and residential/commercial lawns (turf)
- Increase the adoption of water quality BMPs for pesticides and insecticides

Table 8 provides a more comprehensive list of specific actions the counties and subwatersheds in the NFCRW can take to restore and protect groundwater quality related to pesticides.

Animal Feedlots

MPCA regulates the land application and storage of manure generated from animal feedlots in accordance with Minnesota Rule Chapter 7020. The MPCA Feedlots Program (https://www.pca.state.mn.us/quick-links/feedlots) requires that the land application and storage of manure be conducted in a manner that prevents nitrate contamination to both groundwater and

surface water. Animal manure contains significant quantities of nitrogen and pathogens. Improper management of manure especially in places with high pollution sensitivity can lead to contamination of groundwater.

Where Are Animal Feedlots in the NFCRW?

The NFCRW has 1,339 feedlots. The watershed is a top livestock producing region for poultry, hogs, and dairy. Minnesota Rule 7020 allows the MPCA to transfer or 'delegate' regulatory authority and administration of certain parts of the feedlot program to a county. A delegated county regulates feedlots with less than 1,000 animal units; MPCA regulates anything above that threshold. Table 4 outlines the number of registered feedlots for the entire county and whether that county has been delegated the authority to administer the feedlot program locally.

Table 4: Number of registered feedlots and the delegated counties.

County	Number of Registered Feedlots per County	Delegated?
Pope	334	Yes
Stearns	1539	Yes
Kandiyohi	450	Yes
Meeker	315	Yes
Wright	285	Yes
Hennepin	43	No
McLeod	357	Yes
Carver	264	Yes

How to Protect Groundwater from Contamination

Manure management plans, feedlot inspections, permitting, technical assistance, and record keeping are all used to manage nitrogen impacts to water quality. Because of the large number of registered feedlots within the watershed, it is important to prioritize activities in the most groundwater sensitive areas first. Table 8 provides a more comprehensive list of specific actions partners in the NFCRW can do to protect groundwater from nitrate and pathogen contamination.

Failing Subsurface Sewage Treatment Systems (SSTS)

Of the approximately 450,000 SSTS (commonly called septic systems) across the state, slightly over 100,000 of them are estimated to be failing. Failing SSTS can pollute both surface and groundwater. A failing system is one that does not provide adequate separation between the bottom of the drainfield and seasonally saturated soil. The wastewater in SSTS contains bacteria, viruses, parasites, nutrients, and some chemicals. SSTS infiltrate treated sewage into the ground, ultimately traveling to groundwater.

Where Are SSTS in the NFCRW?

SSTS are found in every county in the NFCRW. There are no existing statewide data sets identifying where failing SSTS are located. However, State regulations require each county to adopt a local SSTS

ordinance and that imminent health threats or failing systems be replaced and brought up to current standards.

How to Protect Groundwater from SSTS Contamination

SSTS must be properly sited, designed, constructed, and maintained to minimize the potential for disease transmission and contamination of groundwater. Each county carries out permitting, inspections, and operation of the SSTS program locally. Table 8 provides a more comprehensive list of specific actions the NFCRW can do to assure SSTS do not contaminate groundwater. You can find more information about building and maintaining SSTS at Subsurface Sewage Treatment Systems (https://www.pca.state.mn.us/water/subsurface-sewage-treatment-systems).

Contaminated Sites

The MPCA identifies 961 active tank and leak sites and six closed landfills in the NFCRW. These types of contaminated sites, also referred to as point sources, have the potential to contaminate groundwater with a variety of chemicals.

Where Are Contaminated Sites in the NFCRW?

Figure 21 maps active tank or leak sites compared to pollution sensitivity of aquifers tapped by drinking water wells in the NFCRW. Figure 22 provides a map of the closed landfills in the NFCRW. The following sites also provide maps to help identify contaminated sites.

- **What's in My Neighborhood** (https://www.pca.state.mn.us/data/whats-my-neighborhood)**:** This app identifies potential contamination sites for water quality, feedlots, hazardous waste, investigation and clean up, air quality, and solid waste.
- **Landfill Cleanup Act Participants** (http://mpca.maps.arcgis.com/apps/Solutions/s2.html?appid=6470bb44bd83497993da5836333d1cb3): This site has an interactive map that shows closed landfills and the corresponding groundwater plumes and groundwater areas of concern.

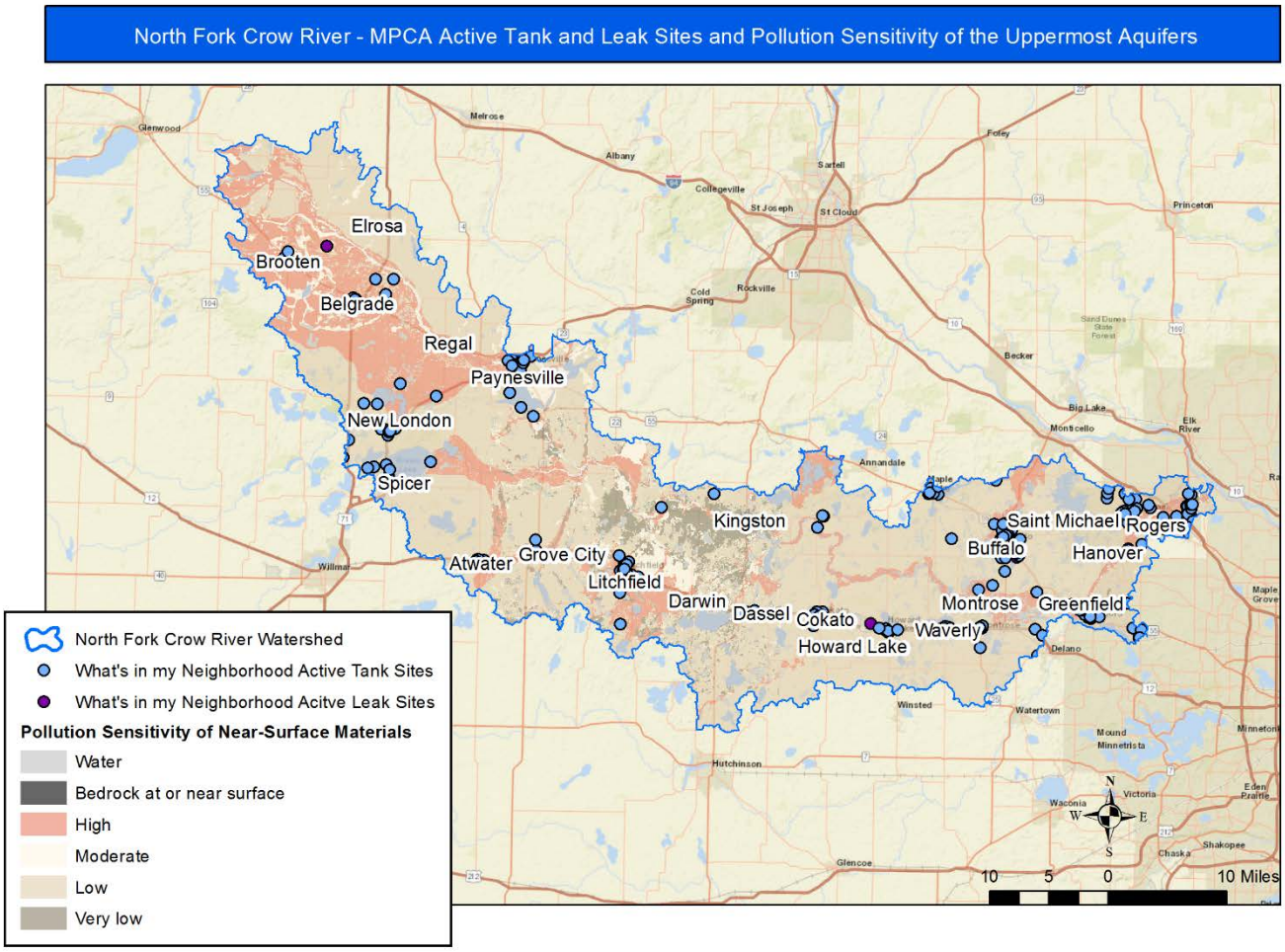

Figure 21: North Fork Crow River-MPCA Active Tank and Leak Sites and Pollution Sensitivity of the Uppermost Aquifers

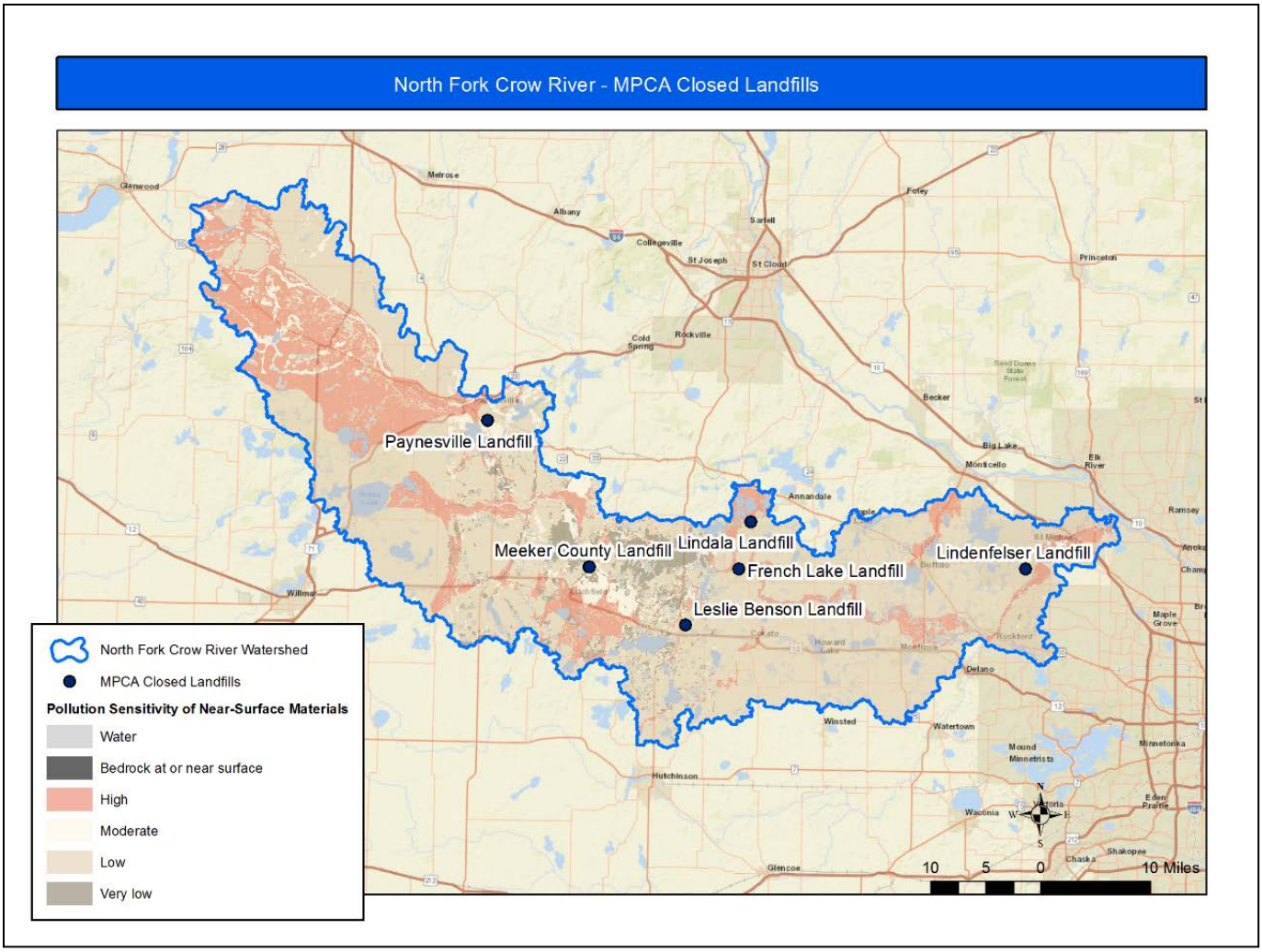

Figure 22: North Fork Crow River-MPCA Closed Landfills

How to Protect Groundwater from Contaminated Sites

Contaminated sites should be identified before making or changing any land use plans, zoning maps, and/or ordinances. Table 8 provides a more comprehensive list of specific actions the NFCRW can do to assure contamination sites do not further contaminate groundwater.

Stormwater

The MPCA Stormwater Program (https://www.pca.state.mn.us/water/stormwater) regulates the discharge of stormwater and snowmelt runoff from municipal separate storm sewer systems (MS4s), construction activities, and industrial facilities, mainly through the administration of the National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Program. The NFCRW has eleven cities, two counties, and the Minnesota Department of Transportation that have MS4 permits requiring the treatment and management of stormwater runoff.

The management of stormwater runoff is increasingly reliant on the infiltration of stormwater into the soil to control the volume of runoff. A number of stormwater practices concentrate runoff and force

infiltration into the soil where it can recharge groundwater aquifers. The impacts of these practices on groundwater quality have not been thoroughly evaluated.

How to Manage Potential Stormwater Infiltration Risk

Caution should be observed when infiltrating stormwater especially in areas with vulnerable drinking water sources. Use the MDH Stormwater Guidance for Sites in Drinking Water Supply Management Areas (https://stormwater.pca.state.mn.us/images/d/d3/Flow_Chart_-_MDH_Stormwater_Guidance_for_Sites_in_Drinking_Water_Supply_Management_Areas.pdf) to better understand when infiltration is appropriate in wellhead protection areas. This guidance has been incorporated as part of the updated stormwater permit and is available in Minnesota's Stormwater Manual (https://www.pca.state.mn.us/water/minnesotas-stormwater-manual). Table 8 provides a more comprehensive list of additional actions the NFCRW can take to prevent stormwater infiltration from contaminating groundwater.

Groundwater Quantity Issues and Concerns

Groundwater levels naturally have seasonal fluctuations and annual variability. Climate and weather typically drive minor variability. Human activities (primarily water withdrawals and land use change) have a much larger influence on water levels. Activities on land can affect groundwater levels by reducing infiltration (groundwater recharge); these activities include tiling, changes in vegetation, increased areas of impervious surface, and changing surface water or stormwater flow.

Depending on the location, hydrogeology, intensity of use, and other factors, water level changes may have little impact on the groundwater resource or other natural features. In other places, pumping wells or changing land use can significantly affect water levels. These changes result in well interference; less water available for withdrawal; less streamflow; and lower water levels in wetlands, fens, or lakes. Lower water levels in wetlands, fens, or lakes can impact aquatic and terrestrial communities. Even if other wells or natural features are not immediately impacted, a downward trend in groundwater levels can indicate an unsustainable use and should be addressed.

How to Address Groundwater Quantity Issues

Most groundwater quantity (sustainability) issues are the result of overuse of groundwater and/or reduction in recharge to the underlying aquifer. Therefore, the strategies to address water quantity issues are similar, regardless of the groundwater quantity issue. The two primary goals to assure water sustainability are:

- **Water conservation:** Reduce or limit the amount of groundwater used
- **Promote or protect recharge:** Find ways for water to infiltrate back into the ground

There are a variety of strategies to help meet water conservation and recharge goals. The type of strategy used depends on the primary factor affecting quantity in the area in question. Strategies include: conservation easements, cropland management, education and outreach, irrigation water management, and land use planning and management. Table 8 provides a more comprehensive list of specific actions the NFCRW can take to conserve water and promote recharge.

Decreasing Water Levels

In some areas, increasing pumping or pumping in excess of what is being recharged can result in a downward trend in water levels. Not only can declining water levels have an adverse impact on neighboring wells or natural resources, but it can also be indicative of use trends that are unsustainable. In addition, some wells recover seasonally to their static water level, but the water level during pumping is either significantly low or increasingly lower annually. This can also result in adverse impacts to natural resources, other wells, or indicate an unsustainable use. More information about groundwater sustainability can be found at Sustainability of Minnesota's Groundwaters (http://www.dnr.state.mn.us/waters/groundwater_section/sustainability/index.html).

Where Are Decreasing Water Levels in the NFCRW?

Observation wells are used to measure long-term trends in water levels. Declining water level trends were noted in 11 observation wells in the NFCRW (Figure 23). These wells were all in either water table or buried glacial drift aquifers. A number of wells also displayed significant drawdowns with recovery at the end of each water year. Of these wells, nine wells displayed increasing drawdowns during the pumping season in more recent years compared to historic levels. The majority of these wells are located within the western region of the watershed in the Buried Drift Aquifer.

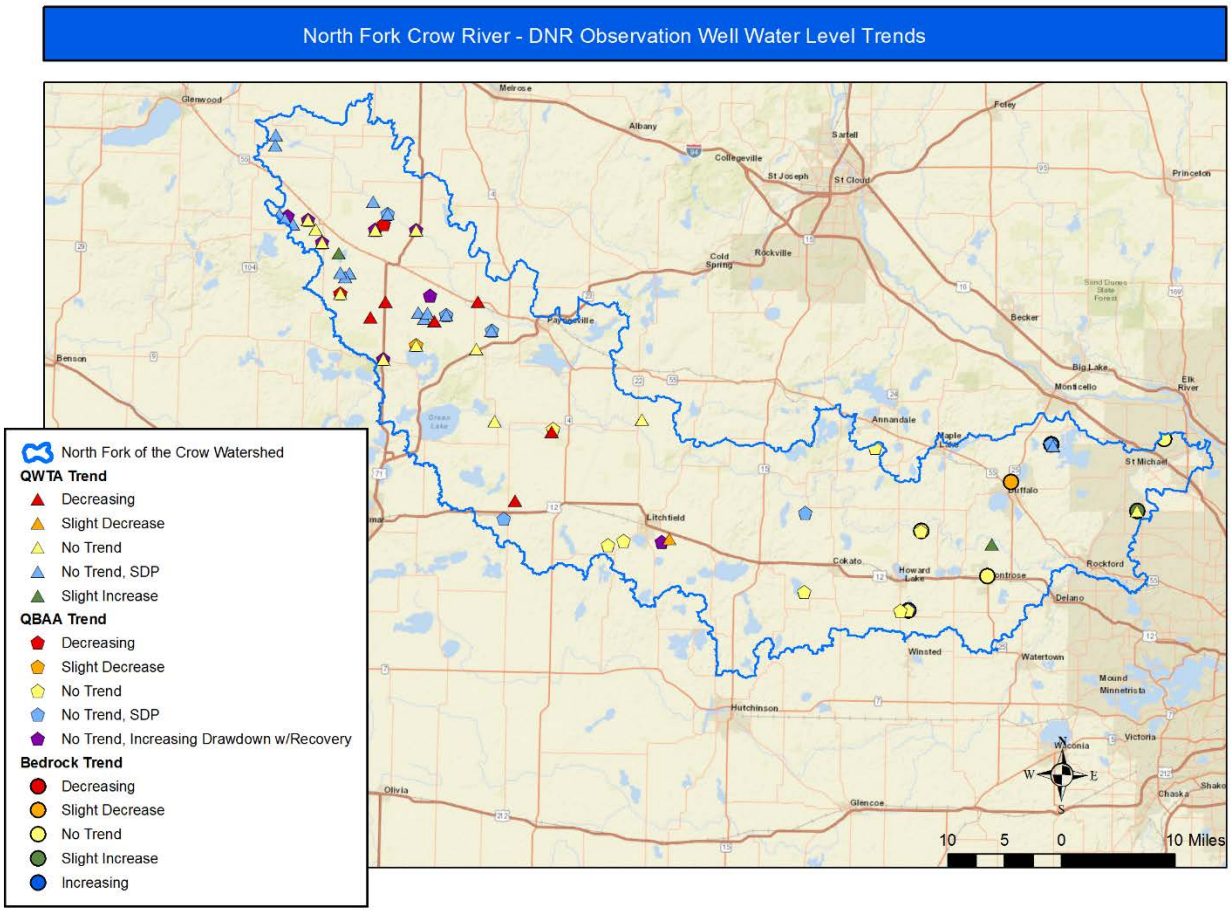

Figure 23: North Fork Crow River-Observation Well Water Level Trend Information

Groundwater Dependent Features at Risk

There are certain natural resources, such as fens and trout streams, that depend on groundwater to sustain their characteristics. These features can be very sensitive to changes in groundwater flow or water quality due to groundwater withdrawal or land use activities. Important groundwater dependent natural resources in the watershed include trout streams, calcareous fens, lakes, plants, and animals (Figure 24). The NFCRW contains a variety of precious natural resources that are dependent on groundwater. If groundwater quantity or quality is degraded, these resources are at risk.

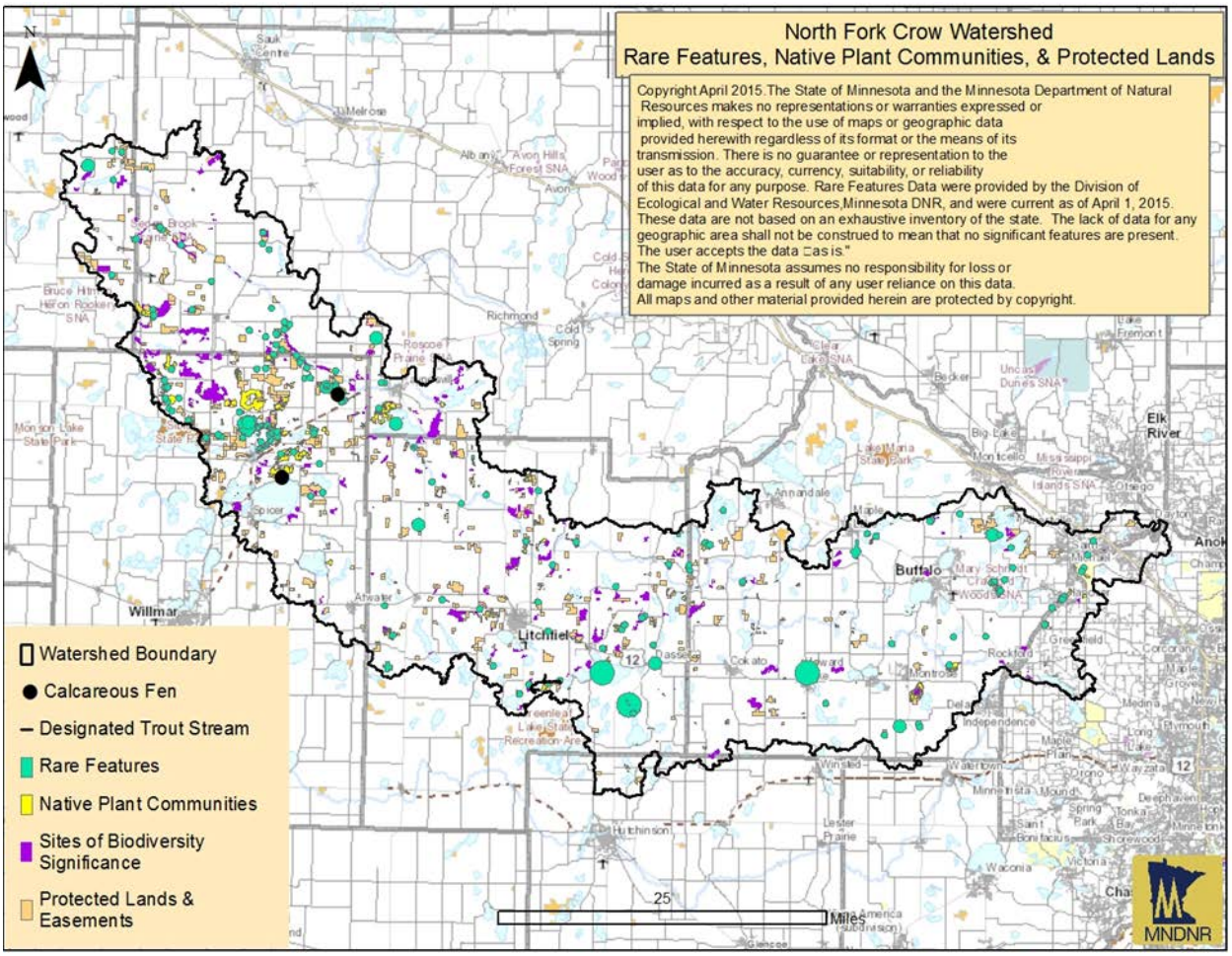

Figure 24: North Fork Crow River-Rare Features, Native Plant Communities, and Protected Lands

Trout Stream

Trout streams are waters designated by the DNR and protected by law (Minnesota Rule 6264.0050). Trout streams are particularly dependent on steady flow, stable cold-water temperatures, and sufficient oxygen levels. These conditions rely on a steady supply of groundwater from diffuse seepage or springs. Therefore, groundwater withdrawals can potentially have negative impacts on trout streams. There is one listed trout stream, Washington Creek, in the NFCRW (Figure 25).

There are not any known impacts to the trout stream from current groundwater withdrawals. However, there are a number of high capacity agricultural irrigation systems within 1.5 miles of the trout stream.

These withdrawals or additional appropriations in this area could have a negative impact on the trout stream.

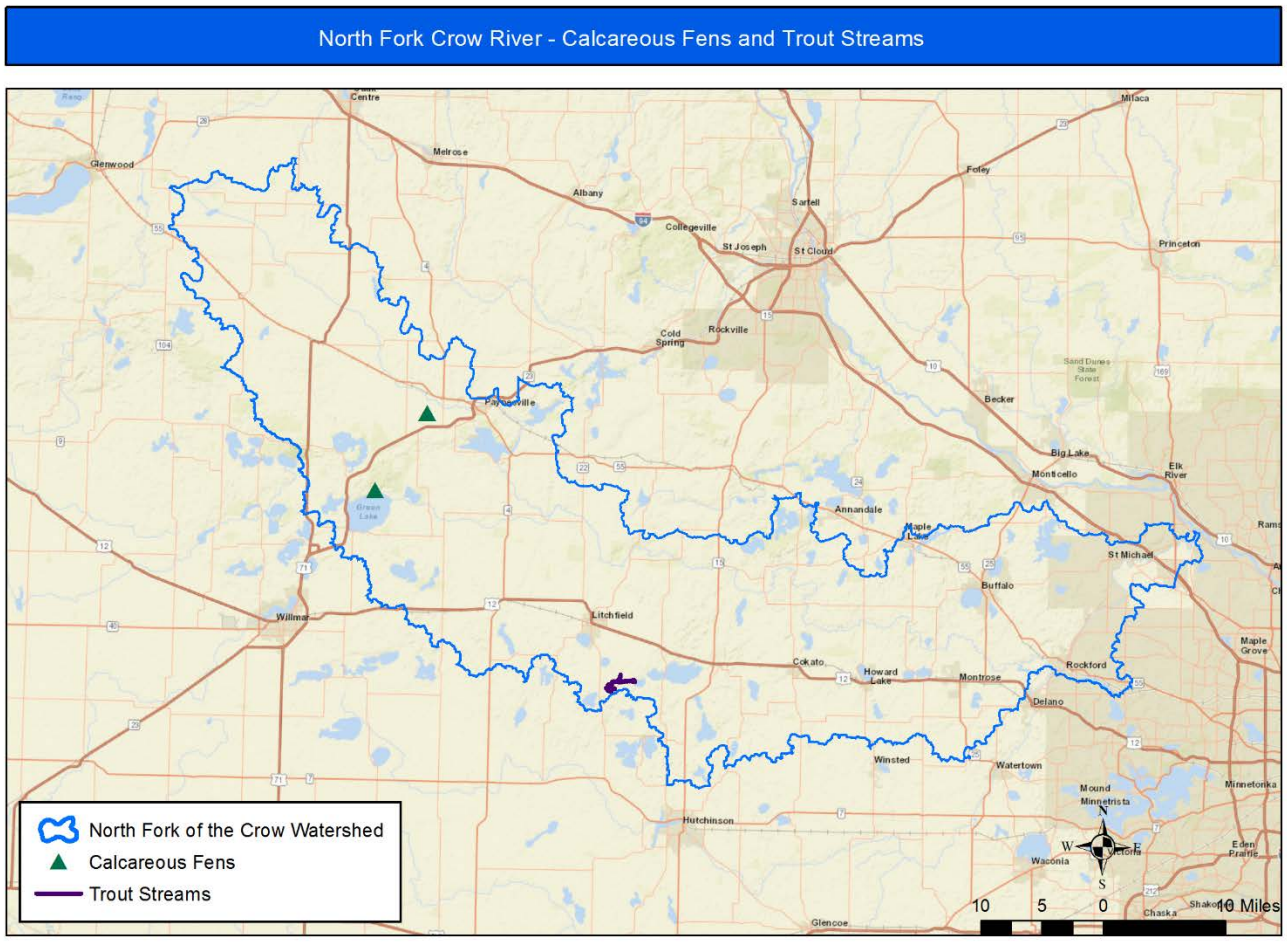

Figure 25: North Fork Crow River-Calcareous Fens and Trout Streams.

Calcareous Fens

Calcareous fens develop under very restricted conditions, where cool, mineral-rich groundwater keeps the soil surface continuously moist and allows peat to form. This combination provides habitat for species typical of rich fens and wet meadows and also for a distinctive group of rare wetland plants. Because they are so uncommon and provide habitat for numerous rare plant species, calcareous fens are given special protection in Minnesota (Minnesota Statute 103G.223).

There are three known calcareous fens in the NFCRW (Figure 25).

1. **The Regal Meadow Fen** located in northeast Kandiyohi County is a high quality fen located on land owned by the Nature Conservancy. The Regal Meadow Fen has several groundwater seeps and maintains a diverse population of calciphiles and other vegetation. This fen is near a number of agricultural irrigation systems. Water level monitoring is currently ongoing within both the shallow

water table aquifer and the buried artesian aquifer at this site in attempts to determine if nearby appropriations are having negative effects on hydraulic head and seep discharge at the fen. This fen could be impacted by additional appropriation proposed from within the water table or shallow buried aquifer.

2. **The New London 24 Calcareous Fen** is located north of Green Lake in Kandiyohi County. The fen is near the public water supply wells for the Green Lake Water Supply system (serving the New London/Spicer area) and a small number of agricultural irrigation systems. This fen is mostly surrounded by deciduous forest and rolling topography. As such, converting the land for agricultural uses would be difficult. Any land use conversion or nearby appropriation can have negative effects on the fen, and this area should be considered for protection.
3. **The Sucker Creek Fen** is located in Meeker County in the south central region of the watershed, immediately adjacent to Sucker Creek (the only designated trout stream in Meeker County). The presence of these two features in close proximity is indicative of high groundwater influence on surface waters in this area. While no negative impacts have yet been noted, there are a number of agricultural irrigation systems within three miles of this site. Additional appropriation in the immediate area may cause negative impact on the fen.

Groundwater Flow Dominated Lakes

As a part of the research completed for the County Geologic Atlas program elsewhere in the state, lake flow regimes have been divided into three categories:

1. those dominated by surface water flows
2. those dominated by groundwater flows
3. those that receive both surface and groundwater

Lakes with small catchments are often dominated by groundwater rather than surface water flows. Experience suggests that when the ratio of total upstream land area to acreage of the public water basin is small (e.g., 5:1 or 10:1), the lake has a high probability of being groundwater dominated.

Forty-five lakes were identified in the NFCRW as having ratios below 11:1. Of these, 29 were also identified as lakes of biological significance and/or lakes of phosphorous sensitivity (Table 5, Figure 26). Due to the potential impacts to these lakes from excessive groundwater use, the direct watersheds for these basins should be prioritized for protection in order to limit potential negative effects to water levels. There are an additional 16 lakes that met the watershed/lake acreage ratio requirements, but were not identified using either the phosphorous-sensitivity or biological significance datasets. These 16 lakes may be included in future strategies for protection areas. Additional information from lake hydrographs over time relative to the lake outlet could help confirm the source of lake flowage, as groundwater dominated lakes will likely have less variation during low precipitation periods.

Table 5: Potentially Groundwater Dominated Lakes

PWI #	Basin Name	County	Bio Signif	P-sensitivity	Basin Size (Ac)	UP_Acres	Ratio
34-0142-00	George	Kandiyohi		Highest	223.00	485.20	2.18
47-0142-00	Tower	Meeker		High	55.76	128.88	2.31
86-0178-00	Dog	Wright		Highest	165.56	410.38	2.48
86-0193-00	Mary	Wright	Moderate	Highest	182.00	490.25	2.69
47-0064-00	Erie	Meeker		Highest	185.00	594.02	3.21
47-0119-00	Mini-Belle	Meeker	High	Highest	593.00	1942.00	3.27
34-0141-00	Woodcock (West Woodcock)	Kandiyohi		High	171.00	579.00	3.39
27-0194-00	Schwappauff	Hennepin		Higher	93.27	364.71	3.91
86-0134-01	Upper Maple	Wright	High	Highest	725.00	2974.18	4.10
86-0046-00	Crawford	Wright		Highest	107.00	457.42	4.27
86-0053-02	Pulaski (Main Bay)	Wright		Highest	719.00	3151.58	4.38
86-0009-00	Martha	Wright		Highest	98.00	442.50	4.52
27-0171-00	Sylvan	Hennepin		High	110.00	498.44	4.53
86-0089-00	Tamarack	Wright		High	94.08	427.24	4.54
86-0063-00	Green Mountain	Wright		High	159.00	878.10	5.52
47-0026-00	Long	Meeker		Highest	162.00	981.00	6.06
47-0025-00	Little Swan	Meeker		High	52.31	328.10	6.27
34-0066-00	Long	Kandiyohi	Moderate	Highest	356.00	2513.00	7.06
86-0020-00	Wilhelm (William)	Wright		High	95.00	685.58	7.22
47-0138-00	Youngstrom	Meeker	Outstanding	Higher	166.00	1237.30	7.45
86-0289-00	East Lake Sylvia	Wright	Moderate	Highest	669.00	5054.00	7.55
47-0149-00	Unnamed	Meeker	Moderate		79.71	606.22	7.61
47-0102-00	Round	Meeker		Higher	273.20	2237.95	8.19
47-0198-00	Peterson	Meeker		High	140.91	1182.73	8.39
86-0288-00	John	Wright		Highest	395.00	3456.29	8.75
86-0279-00	West Lake Sylvia	Wright	High	Highest	891.00	8010.50	8.99
47-0046-00	Washington	Meeker	Moderate	Highest	2420.00	22594.29	9.34
86-0031-00	Pelican	Wright	Outstanding	Higher	2335.00	23014.01	9.86
47-0002-00	Francis	Meeker	High	Highest	1049.00	11126.87	10.61

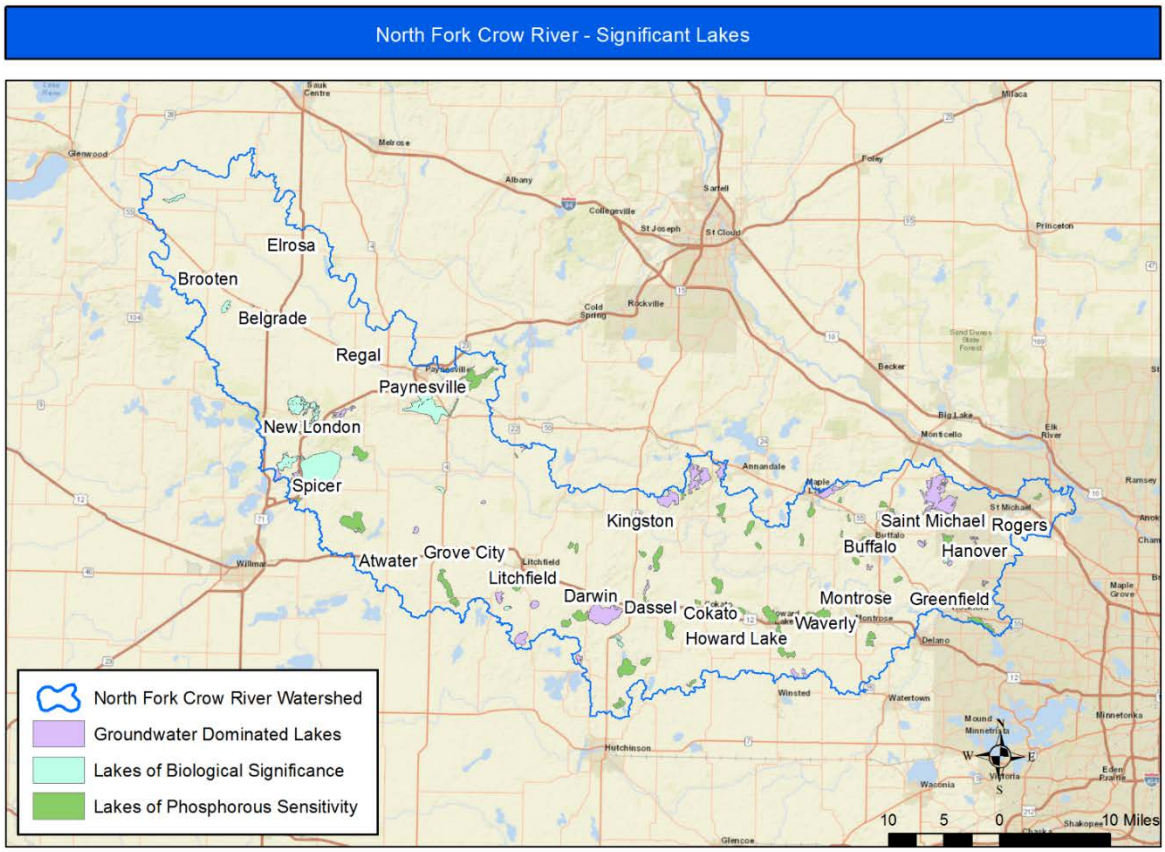

Figure 26: North Fork Crow River-Significant Lakes

Groundwater Sensitive Vegetation and Species

Table 6 shows that there are a number of critically imperiled (S1) or imperiled (S2) native plant communities closely associated with or influenced by groundwater in the watershed. All five S1 plant communities within the NFCRW are associated with or influenced by groundwater, while six of the S2 communities have the similar connections with groundwater. As referenced, groundwater plays a vital role in the sustainability of these rare plant communities. While Figure 24 shows where these features are in general, it does not show which are S1 or S2. Local investigation is necessary to determine which plant communities are present. Groundwater protection activities should be focused where these plant communities are found. More information regarding Biodiversity Significance ranking can be found at MBS Site Biodiversity Significance Ranks (http://www.dnr.state.mn.us/eco/mcbs/biodiversity_guidelines.html).

Table 6: Native Plant Communities Associated or Influenced by Groundwater with assigned conservation status ranks (S-ranks) that reflect the risk of elimination of the community from Minnesota. S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable to elimination.

Native Pland Communites in the North Fork Crow River Watershed				
Native Plant Community Code	**Native Plant Community Name**	***Conservation Status Rank**	**Closely Associated to Groundwater**	**Influence by Groundwater**
MRp83a	Cattail - Sedge Marsh (Prairie)	S1		Yes
MRp83b	Cattail Marsh (Prairie)	S1		Yes
OPp93c	Calcareous Fen (Southeastern)	S1	Yes	
WPs54a	Wet Seepage Prairie (Southern)	S1	Yes	
WFs57a	Black Ash - (Red Maple) Seepage Swamp	S1S2		Yes
FFs59c	Elm - Ash - Basswood Terrace Forest	S2		Yes
MHs39c	Sugar Maple Forest (Big Woods) Type	S2	No	
MHs39c	Sugar Maple Forest (Big Woods)	S2	No	
MRn83a	Cattail - Sedge Marsh (Northern)	S2		Yes
MRn83b	Cattail Marsh (Northern)	S2		Yes
OPp93b	Calcareous Fen (Southwestern)	S2	Yes	
UPs13b	Dry Sand - Gravel Prairie (Southern)	S2	No	
UPs13d	Dry Hill Prairie (Southern)	S2	No	
UPs23a	Mesic Prairie (Southern)	S2	No	
WPs54b	Wet Prairie (Southern)	S2		Yes
FPs63a	Tamarack Swamp (Southern) Type	S2S3		Yes
FDs37b	Pin Oak - Bur Oak Woodland	S3	No	
FFs59a	Silver Maple - Green Ash - Cottonwood Terrace Forest	S3	No	
FFs68a	Silver Maple - (Virginia Creeper) Floodplain Forest Type	S3	No	
MHs38b	Basswood - Bur Oak - (Green Ash) Forest	S3	No	
MHs38c	Red Oak - Sugar Maple - Basswood - (Bitternut Hickory) Forest	S3	No	
MHs39	Southern Mesic Maple-Basswood Forest	S3	No	
MHs39a	Sugar Maple - Basswood - (Bitternut Hickory) Forest	S3	No	
MHs49a	Elm - Basswood - Black Ash - (Hackberry) Forest	S3	No	
OPp91	Prairie Rich Fen Class	S3	Yes	
OPp91a	Rich Fen (Mineral Soil)	S3	Yes	
OPp91c	Rich Fen (Prairie Seepage)	S3	Yes	
WMp73a	Prairie Meadow/Carr	S3		Yes
WMs83a	Seepage Meadow/Carr	S3	Yes	
WMs83a1	Seepage Meadow/Carr, Tussock Sedge Subtype	S3	Yes	
OPn92a	Graminoid Rich Fen (Basin)	S4	Yes	
OPn92b	Graminoid - Sphagnum Rich Fen (Basin)	S4	Yes	
WFs55a	Lowland Aspen Forest	S4		Yes
WMn82b2	Sedge Meadow; Tussock Sedge Subtype	S4		Yes
WMn82b	Sedge Meadow	S4 OR S5		Yes
OPn81a	Bog birch - Alder Shore Fen	S5	Yes	
WMn82a	Willow - Dogwood Shrub Swamp	S5		Yes
WMn82b4	Sedge Meadow; Lake Sedge Subtype	S5		Yes
APn91	Northern Poor Fen Class	SNR	Yes	
OPn92	Northern Rich Fen (Basin)	SNR	Yes	
OPp93	Prairie Extremely Rich Fen Class	SNR	Yes	
WMs83	Southern Seepage Meadow/Carr Class	SNR	Yes	

NFCRW Strategies and Actions to Restore and Protect Groundwater

This section provides tips for prioritizing and targeting restoration and protection strategies and makes suggestions about what strategies and actions would be most appropriate within different areas of the watershed. Information on the geological, ecological, and sociological conditions for each county and subwatershed (HUC-10) informs which strategies and actions would be effective for each HUC-10 and county.

Tips for Prioritizing and Targeting Strategies and Actions

Determine Your Goal

You may decide to address an issue because of known instances or threats in an area, or maybe you are working in a geographic area because of jurisdiction or some other factors. The Actions and Strategies Table (Table 8) well help you focus on the goal, for instance, reducing nitrate in groundwater. Then you will need to decide, using the table, if you would like to focus on conservation easements, outreach and education, nutrient management, or some other strategy.

Match the Right Action with the Right Location

The Actions and Strategies Table (Table 8) will help you determine where the actions would be most effective. For instance, an activity that reduces nitrate in groundwater may be more valuable in sensitive areas or vulnerable wellhead protection areas. Or, if you are focused on a limited geography, the table will help you determine what actions are applicable to that area. Considering the sensitivity combined with the presence of drinking water wells and vulnerable wellhead protection areas can help further focus efforts. In another example, factors such as the presence of groundwater dependent features and a concentration of large appropriation wells can help determine where efforts to promote conservation and recharge would be most effective.

Know the Pollution Sensitivity

Groundwater quality is impacted by both point and non-point source pollution. These potential contaminant sources need to be managed according to the pollution sensitivity of the aquifer (Figure 7). Examining the sensitivity of the aquifer as it relates to contamination risk helps determine the level of management necessary to protect groundwater quality.

Table 1 illustrates common land uses that may need to be managed under the three sensitivity thresholds. For example, a failing septic system has a greater potential to contaminate the aquifer in a highly sensitive setting with coarse textured soils than an area with low sensitivity that has a protective soil layer that retards the movement of water into the aquifer.

Consider Multiple Benefits

Oftentimes, the restoration and protection strategies identified for both groundwater and drinking water positively influence other ecosystem services, such as surface waters, habitat, and pollinators.

Managing water as 'one water', rather than parceling it out to reflect the different aspects of water as it moves through the hydrologic cycle, allows for better planning and allocation of resources. The far right columns of the Actions and Strategies Table (Table 8) identifies the multiple benefits that could result from implementing the action.

Leverage Other Programs and Practices

Utilize existing Federal and State programs that are already working in the NFCRW to conserve land, prevent erosion, and protect or improve surface water quality. Many of the practices that are being implemented have a benefit for groundwater. You can further target some of these efforts based on the information provided in this report to maximize the benefits by protecting groundwater. Table 8 includes a column that identifies which agencies can assist with a specific action; the listed agencies typically have some type of program in place that you can leverage. The Descriptions of Supporting Strategies section of this report lists existing programs and resources for each of the suggested strategies.

Emphasize Protection

There is often a bias in groundwater management towards strategies that emphasize protection because of the cost and difficulty in remediating contaminated resources. In contrast to surface water bodies, groundwater:

- is difficult to access;
- cannot be observed, sampled, or measured easily;
- travels slowly, often along complex pathways and through aquifer media that can absorb and store contaminants over long time periods; and
- is very difficult and expensive to treat if contaminated.

Timeframes associated with groundwater cleanup activities are often measured in decades and costs millions of dollars. Groundwater management strategies that emphasize prevention and protection are critical.

Although the tide is changing within water resources management in Minnesota, many funding streams and priorities are focused on restoration activities that can show measureable outcomes. Even though it is difficult to demonstrate 'improvements' from protection strategies, it is important to stress the need to take a balanced approach and protect groundwater resources.

Strategies and Actions for NFCRW

This section provides a table of strategies and actions local partners in the NFCRW can take to restore and protect groundwater resources. Many of the proposed actions require the participation of a willing landowner to execute. Other actions reflect opportunities to manage land use through local controls. Many of the proposed strategies and actions align with strategies to protect surface waters.

Each action aligns with one or more supporting strategies and goals.

- **Goals** identify how an action helps restore and/or protect groundwater.
- **Supporting Strategies** are general key approaches to achieving the goal.

- **Recommended Groundwater Action** is a specific action prescribed for a specific county or HUC-10 within the watershed that will help achieve the goal and pertains to the general strategy.

Figure 27 provides a visual representation of the relationship between goals, supporting strategies, and recommended groundwater actions. Note that each goal is supported by many supporting strategies, and each supporting strategy may have a variety of recommended groundwater actions.

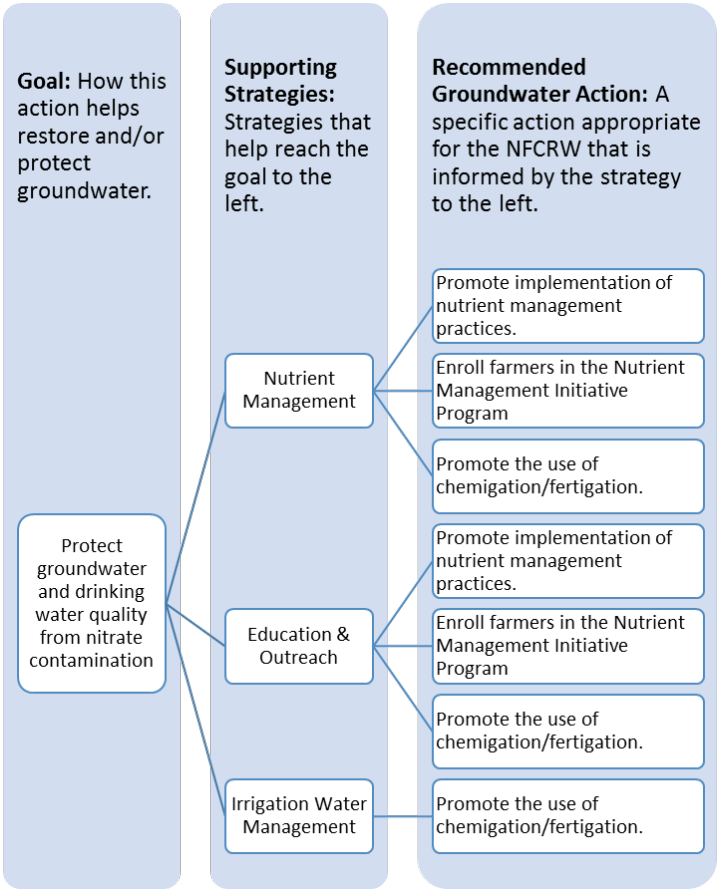

Figure 27: Visual representation of the relationship between goals, supporting strategies, and recommended groundwater action.

How to Use the Table of Actions and Strategies

The Table of Actions and Strategies (Table 8) is designed so that you can find actions and strategies related to whatever your priorities may be when it comes to restoring and protecting groundwater. There are a variety of columns to facilitate the following:

- finding actions for specific geographic areas (counties or HUC-10s);
- finding actions or strategies that would help achieve a specific goal;
- learning the additional benefits of implementing a specific action; and
- tips for determining where to target a specific action if you cannot implement the action in the entire recommended area.

The following list defines what each of the columns in Table 8 represent:

- **Goal:** How the action in this row helps restore and/or protect groundwater. The goals are sorted alphabetically as much as possible. Each goal identifies the main goal—such as whether it protects groundwater quality or sustains the amount of water available—and includes a keyword to explain how the goal is achieved. For example, a goal that is listed as 'Protect Groundwater and Drinking Water Quality: Closed Landfills' can be interpreted as: Protect groundwater and drinking water quality from landfill contamination.
- **Supporting Strategies**: Identifies and links you to general strategies that help accomplish the goal for the action in this row. Each strategy is hyperlinked to a section of the report that provides more information about the strategy and connects you with existing tools and programs that may assist you in implementing this strategy or implementing actions related to this strategy.
- **Recommended Groundwater Action**: A specific action the NFCRW can take to help achieve the goal to the left in the row and is informed by the strategy to the left in the same row.
- **Target _____ Co.:** The 'X' denotes which counties should consider using the action described in the corresponding row. An 'X' denotes the action would be most beneficial for that county. The addition of the counties helps to further prioritize and target where recommended groundwater actions should be implemented, narrowing the focus from a larger subwatershed to a specific geographical area. For example, many of the subwatersheds identify the need to work with irrigators; by adding the additional filter of counties, you are able to eliminate specific counties that do not have irrigators, targeting where implementation should occur. It also works as a quick reference to identify groundwater actions specific to the county in which your work.
- **HUC-10s Involved**: This column denotes which HUC-10 subwatershed(s) within the NFCRW should consider using the action described in the corresponding row. There are seven HUC-10s within the NFCRW. Table 7 provides the name and HUC-10 number assigned to each subwatershed. Figure 28 is a map of the HUC-10s.
- **Agencies that can assist:** This column lists agencies that may be able to assist with implementing the strategy through existing programs or providing more information or technical assistance. The following acronyms are used to conserve space: **BWSR**=Board of Soil and Water Resources; **FSA**=Farm Service Agency; **MDA**=Minnesota Department of Agriculture; **MDH**=Minnesota Department of Health; **MPCA**=Minnesota Pollution Control Agency; **NRCS**=Natural Resources Conservation Service; **UMN**=University of Minnesota Extension (*not a comprehensive list of agencies/partners*)
- **Tips for Targeting & Helpful Maps:** This column helps identify the areas that should be targeted for the specific action if it is not feasible to implement the action in all the recommended counties or HUC-10s. The column also includes links to maps within the GRAPS report that may be helpful in identifying which specific areas within a county or HUC-10 to target. The maps are listed in *italicized font.* You can click on the *blue font* that says the figure number for the map to hyperlink directly to the map being referenced.
- **Benefit:_____:** This series of 'X's marks whether the corresponding action may have additional benefits. An 'X' denotes the action could create the described additional benefit. The following keywords are used to conserve space: **Habitat**=Improve/Protect Habitat, including pollinators; **GWDF**=Improve/Protect Groundwater Dependent Features; **Soil Health**=Improve/Protect Soil Health; **Erosion**=Control Erosion; **Carbon**=Carbon Sequestration; **Nutrient Runoff**=Control Nutrient Runoff, including pesticides (*The multiple benefits achieved are dependent on the placement and type of BMPs implemented; seed mixes planted; and other site conditions*).

Table 7: HUC-10 subwatersheds within the North Fork Crow River Watershed

HUC-10 Name	Reference Name in Implementation Table	HUC-10 Number
Big Swan Lake	Big Swan	0701020405
Crow River	Crow	0701020407
Jewetts Creek	Jewetts	0701020403
Lake Koronis	Koronis	0701020401
Middle Fork Crow River	Middle Fork	0701020402
North Fork Crow River	North Fork	0701020406
Washington Creek	Washgtn	0701020404

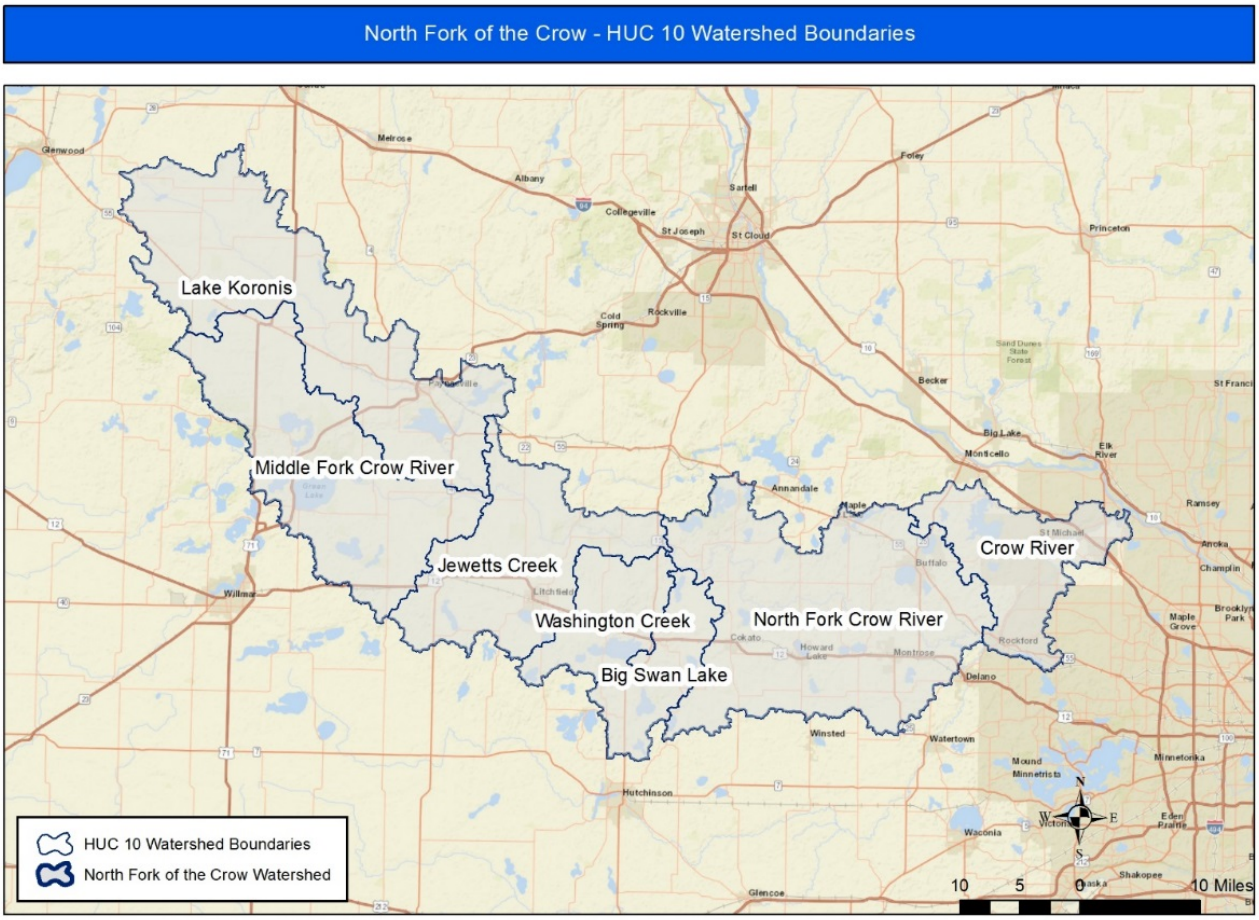

Figure 28: North Fork Crow River-HUC 10 Watershed Boundaries

Table of Actions and Strategies to Restore and Protect Groundwater

Table 8: Table of Actions and Strategies to Restore and Protect Groundwater

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target **Stearns** Co.	Target **Pope** Co.	Target **Kandiyohi** Co.	Target **Meeker** Co.	Target **Wright** Co.	Target **Hennepin** Co.	Target **Carver** Co.	Target **McLeod** Co.	HUC-10s Involved	Agencies that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: **Habitat***	*Benefit: **GWDF***	*Benefit: **Soil Health***	*Benefit: **Erosion***	*Benefit: **Carbon***	*Ben: **Nutrient Runoff***
Protect Private Well Users: Arsenic	Education and Outreach	▪ Educate well users about the health risks of elevated arsenic levels in drinking water. ▪ Promote testing of private wells through education or cost share. ▪ Provide information from MDH about arsenic in Minnesota's well water and information on arsenic removal to private well users to help answer health related questions.	X	X	X	X	X	X	X	X	All	MDH	Prioritize areas with a high density of private wells and areas with evidence of high levels of arsenic in private wells. *Arsenic Map (Figure 19)* *Well Density Map (Figure 15)*						
Protect Private Well Users: Well Testing	Education and Outreach	Make information available to private well users about local drinking water quality and well testing. Host a well testing clinic or provide resources to private well users to have their water tested.	X	X	X	X	X	X	X	X	All	MDA MDH	Prioritize areas with a high density of private wells, high pollution sensitivity, and/or where there are known groundwater contaminants. *Pollution Sensitivity Map (Figure 7)* *Arsenic Map (Figure 19)* *Well Density Map (Figure 15)* *Nitrate Map (Figure 17)*						
Protect Private Well Users: Manage Wells **Protect Groundwater and Drinking Water Quality:** Manage Wells	Education and Outreach	Promote proper management of wells through MDH tools, such as the 'Well Owners Handbook' in landowner outreach efforts.	X	X	X	X	X	X	X	X	All	MDH	Prioritize areas with a high density of private wells *Well Density Map (Figure 15)*						

Goal	Supporting Strategy	Recommended Groundwater Actions	Target **Stearns** Co.	Target **Pope** Co.	Target **Kandiyohi** Co.	Target **Meeker** Co.	Target **Wright** Co.	Target **Hennepin** Co.	Target **Carver** Co.	Target **McLeod** Co.	HUC-10s Involved	Agencies that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWDF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Protect Groundwater and Drinking Water Quality: Well Sealing	Education and Outreach	▪ Provide cost share to well owners for sealing unsealed, unused wells. ▪ Provide educational materials on well sealing.	X	X	X	X	X	X	X	X	All	MDH BWSR	Prioritize areas with a high density of private wells and WHP areas. *Well Density Map (Figure 15)* *Wellhead Protection Map (Figure 11)*						
Protect Groundwater and Drinking Water Quality: Closed Landfills	Contaminant Planning and Management Land Use Planning and Management	▪ Identify MPCA closed landfill locations and groundwater areas of concern in comprehensive land use plans, zoning maps and ordinances. Identifying these locations will help assure drinking water and public health implications are considered when evaluating future growth or development near these sites. ▪ Consult and review the MPCA Closed Landfill Program to make sure any proposed changes in zoning districts or new land use planning proposals are not in conflict with the State Closed Landfill Plan. ▪ Contact the MPCA Closed Landfill Program for current information and any concerns or changes to the groundwater area of concern when considering land use changes or developments near these areas. Request to be notified regarding any changes in the migration or movement of contaminants.	X			X	X				Crow Koronis Jewetts North Fork	MPCA	*Closed Landfill Map (Figure 22)*						
Protect Groundwater and Drinking Water Quality: Leaky Tanks	Contaminant Planning and Management Land Use Planning and Management	▪ Identify leaky and active tank sites in your area in comprehensive land use plans, zoning maps and ordinances. Identifying these locations will help assure drinking water and public health implications are considered when evaluating future growth or development near these sites.	X	X	X	X	X	X	X	X	All	MPCA	Focus in areas with high pollution sensitivity and vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 7)* *DWSMA Vulnerability Map (Figure 12)* *Contaminated Sites Map (Figure 21)*						

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target **Stearns** Co.	Target **Pope** Co.	Target **Kandiyohi** Co.	Target **Meeker** Co.	Target **Wright** Co.	Target **Hennepin** Co.	Target **Carver** Co.	Target **McLeod** Co.	HUC-10s Involved	Agencies that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWDF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
		▪ Contact the MPCA Tank Compliance and Assistance Program for current information and any concerns or changes to the groundwater area of concern when considering land use changes or developments near these areas. Request to be notified regarding any changes in the migration or movement of contaminants.																	
Protect Groundwater and Drinking Water Quality: Feedlots	Contaminant Planning and Management	Prioritize feedlot inspections, including both the Concentrated Animal Feeding Operation (CAFO) and the land application of manure, in areas of greatest risk to pollution.	X	X	X	X	X	X		X	All	MPCA MDH	Focus in areas with high pollutions sensitivity and vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 7)* *DWSMA Vulnerability Map (Figure 12)*						X
Protect Groundwater and Drinking Water Quality: Nitrate	Nutrient Management Education and Outreach	Promote implementation of nutrient management practices to improve farm profitability and reduce nitrogen loss. Practices include: ▪ Improve nitrogen efficiency by practicing the 4 R's (right source, right rate, right timing, and right place) ▪ Adopt and use of the UMN 'Best Management Practices for Nitrogen in Coarse Textured Soils'. ▪ Properly credit nitrogen sources (soil/manure tests, past crops, & mineralization) ▪ Implement comprehensive nutrient management plans to improve nitrogen crediting, equipment calibration, and record keeping ▪ Spoon feed nitrogen to sync with plant growth through side dressing and split fertilizer application	X	X	X	X	X	X		X	All	MDA NRCS UMN	Focus on areas with high pollution sensitivity, vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map (Figure 7)* *DWSMA Vulnerability Map (Figure 12)* *Township Testing Map (Figure 18)*						X

Goal	Supporting Strategy	Recommended Groundwater Actions	Target **Stearns** Co.	Target **Pope** Co.	Target **Kandiyohi** Co.	Target **Meeker** Co.	Target **Wright** Co.	Target **Hennepin** Co.	Target **Carver** Co.	Target **McLeod** Co.	HUC-10s Involved	Agencies that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: **Habitat***	*Benefit: **GWDF***	*Benefit: **Soil Health***	*Benefit: **Erosion***	*Benefit: **Carbon***	*Ben: **Nutrient Runoff***
Protect Groundwater and Drinking Water Quality: Nitrate	Nutrient Management Education and Outreach	Increase the number of farmers enrolled in the Nutrient Management Initiative Program.	X	X	X	X	X	X		X	All	MDA	Focus on areas with high pollution sensitivity, vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map (Figure 7)* *DWSMA Vulnerability Map (Figure 12)* *Township Testing Map (Figure 18)*						X
Protect Groundwater and Drinking Water Quality: Nitrate	Nutrient Management Education and Outreach Cropland Management	Identify programs and opportunities for growers to test and implement new nitrogen practices, innovative technology or cropping systems that protect groundwater quality that prevent or reduce nitrogen loss. (E.g. Cover Crops, Alternative Crops, Precision Ag / New Technologies, Nutrient Management Initiative, etc.)	X	X	X	X	X	X		X	All	MDA UMN NRCS Co-ops	Focus on areas with high pollution sensitivity, vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map (Figure 7)* *DWSMA Vulnerability Map (Figure 12)* *Township Testing Map (Figure 18)*	X		X		X	X
Protect Groundwater and Drinking Water Quality: Nitrate	Nutrient Management Education and Outreach	Promote the adoption of cover crops for scavenging nutrients under irrigated row crops.	X	X	X	X	X	X			Koronis Middle Fork Jewetts Washgtn North Fork Crow	MDA NRCS UMN	Focus on irrigators in areas with high pollution sensitivity and vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 7)* *DWSMA Vulnerability Map (Figure 12)* *Township Testing Map (Figure 18)* *Well & Pumping Map (Figure 16)*	X		X	X	X	X
Protect Groundwater and Drinking Water Quality: Nitrate	Education and Outreach Nutrient Management	Promote the use of chemigation/fertigation to synchronize nitrogen application to crop demand.	X	X	X	X	X	X			Koronis Middle Fork Jewetts Washgtn North Fork	MDA	Focus on irrigators in areas with high pollution sensitivity and vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 7)* *DWSMA Vulnerability Map (Figure 12)*						X

Goal	Supporting Strategy	Recommended Groundwater Actions	Target **Stearns** Co.	Target **Pope** Co.	Target **Kandiyohi** Co.	Target **Meeker** Co.	Target **Wright** Co.	Target **Hennepin** Co.	Target **Carver** Co.	Target **McLeod** Co.	HUC-10s Involved	Agencies that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWDF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
	Irrigation Water Management										Crow		*Township Testing Map (Figure 18)* *Well & Pumping Map (Figure 16)*						
Protect Groundwater and Drinking Water Quality: Nitrate	Education and Outreach Nutrient Management Irrigation Water Management	Host an irrigation water-testing clinic to determine nitrate concentrations in raw water to calculate the irrigation water nitrogen crediting formula.	X	X	X	X	X	X			Koronis Middle Fork Jewetts Washgtn North Fork Crow	MDA	Focus on irrigators in areas with high pollution sensitivity and vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 7)* *DWSMA Vulnerability Map (Figure 12)* *Township Testing Map (Figure 18)* *Well & Pumping Map (Figure 16)*						X
Protect Groundwater and Drinking Water Quality: Nitrate **Groundwater Sustainability:** Water Conservation	Education and Outreach Nutrient Management Cropland Management	Promote the benefits of farming using soil health principles that increase soil moisture holding capacity, organic matter, and nutrient cycling.	X	X	X	X	X	X		X	All	MDA NRCS UMN	Focus on areas with high pollution sensitivity, vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map (Figure 7)* *DWSMA Vulnerability Map (Figure 12)* *Township Testing Map (Figure 18)* *Nitrate in Wells Map (Figure 17)*			X	X	X	X
Protect Groundwater and Drinking Water Quality: Nitrate **Groundwater Sustainability:** Water Conservation	Education and Outreach Nutrient Management Irrigation Water Management	Contact state and federal agency resource partners and coordinate opportunities for local field days, training and outreach for farmers, coops, and crop consultants. Focus on irrigation management, alternative nitrogen management practices, soil health, and second crops.	X	X	X	X	X	X		X	All	UMN MDA NRCS	Focus on areas with high pollution sensitivity, vulnerable DWMSAs, and vulnerable townships identified by MDA through their Township Testing program. *Pollution Sensitivity Map (Figure 7)* *DWSMA Vulnerability Map (Figure 12)* *Township Testing Map (Figure 18)* *Nitrate in Wells Maps (Figure 17)*						

Goal	Supporting Strategy	Recommended Groundwater Actions	Target **Stearns** Co.	Target **Pope** Co.	Target **Kandiyohi** Co.	Target **Meeker** Co.	Target **Wright** Co.	Target **Hennepin** Co.	Target **Carver** Co.	Target **McLeod** Co.	HUC-10s Involved	Agencies that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWDF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
	Cropland Management																		
Protect Groundwater and Drinking Water Quality: Nitrate **Protect Groundwater and Drinking Water Quality:** Pesticides	Education and Outreach Cropland Management Integrated Pest Management	Promote the benefits of crop diversity and rotation, which include high yields for each crop in the rotation, pest and weed control, and enhanced soil fertility.	X	X	X	X	X	X		X	All	MDA NRCS	Focus on areas with high pollution sensitivity, vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map (Figure 7)* *DWSMA Vulnerability Map (Figure 12)* *Township Testing Map (Figure 18)* *Nitrate in Wells Maps (Figure 17)*		X	X	X	X	X
Protect Groundwater and Drinking Water Quality: Nitrate **Protect Groundwater and Drinking Water Quality:** Pesticides **Groundwater Sustainability:** Water Conservation	Education and Outreach Irrigation Water Management	Provide information on best practices for turf management to the public. Include information on fertilizer application, crediting for grass clippings, lawn watering and herbicide and pesticide application.	X	X	X	X	X	X		X	All	MPCA UMN	Focus in MS4 communities and residential developments with high pollution sensitivity, along with vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 7)* *DWSMA Vulnerability Map (Figure 12)* *Township Testing Map (Figure 18)* *Nitrate in Wells Maps (Figure 17)* *Pesticides Map (Figure 20)*			X	X	X	X
Protect Groundwater and Drinking Water Quality: Pesticides	Education and Outreach	Promote the adoption and use of MDA's water quality BMPs for agricultural pesticides and insecticides.	X	X	X	X	X	X		X	All	MDA NRCS	Focus in areas of pesticide detection in MDA's monitoring wells, along with areas of high pollution sensitivity, vulnerable DWMSAs, and vulnerable						X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target **Stearns** Co.	Target **Pope** Co.	Target **Kandiyohi** Co.	Target **Meeker** Co.	Target **Wright** Co.	Target **Hennepin** Co.	Target **Carver** Co.	Target **McLeod** Co.	HUC-10s Involved	Agencies that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWDF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
	Integrated Pest Management												townships identified by MDA through their Township Testing program. *Pollution Sensitivity Map (Figure 7)* *DWSMA Vulnerability Map (Figure 12)* *Township Testing Map (Figure 18)* *Pesticides Map (Figure 20)*						
Protect Groundwater and Drinking Water Quality: SSTS	SSTS Management	Enforce state and locally adopted SSTS ordinances for the protection of groundwater and drinking water sources.	X	X	X	X	X	X		X	All	MPCA BWSR UMN	Focus in areas with high pollution sensitivity, vulnerable DWSMAs, and areas with a density of SSTS. You can use the Well Density Map as an imperfect surrogate for SSTS density. *Well Density Map (Figure 15)* *Pollution Sensitivity Map (Figure 7)* *DWSMA Vulnerability Map (Figure 12)*						
Protect Groundwater and Drinking Water Quality: SSTS	Education and Outreach SSTS Management	Educate citizens about SSTS including: ▪ The basic principles of how a septic system works ▪ How to operate the system efficiently and effectively ▪ Risks to human health and the environment ▪ Financial options to repair or replace failing or non-compliant system	X	X	X	X	X	X	X	X	All	MPCA UMN							
Protect Groundwater and Drinking Water Quality: SSTS	Education and Outreach SSTS Management	Host local SSTS training and workshops for area contractors and citizens regarding SSTS technology, compliance, and maintenance.	X	X	X	X	X	X	X	X	All	MPCA UMN							

Goal	Supporting Strategy	Recommended Groundwater Actions	Target **Stearns** Co.	Target **Pope** Co.	Target **Kandiyohi** Co.	Target **Meeker** Co.	Target **Wright** Co.	Target **Hennepin** Co.	Target **Carver** Co.	Target **McLeod** Co.	HUC-10s Involved	Agencies that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWDF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Protect Groundwater and Drinking Water Quality: Wellhead Protection	Education and Outreach Cropland Management Land Use Planning and Management	Serve on wellhead protection planning teams to assist public water suppliers with planning and implementation activities to address land use planning concerns.	X	X	X	X	X	X	X	X	All	MDH	*Wellhead Protection Map (Figure 11)*						
Protect Groundwater and Drinking Water Quality: Wellhead Protection	Land Use Planning and Management	Integrate wellhead protection (WHP) plan strategies into local plans, such as the County Water Plan and land use plans.	X	X	X	X	X	X	X	X	All	MDH	*Wellhead Protection Map (Figure 11)*						
Protect Groundwater and Drinking Water	Education and Outreach	Educate the public and decision makers about the hydrologic connectivity of groundwater and surface water and how this influences the vulnerability of drinking water resources.	X	X	X	X	X	X	X	X	All	DNR MDH MPCA	Focus in areas with high pollution sensitivity. *Pollution Sensitivity Map (Figure 7)*						
Protect Groundwater and Drinking Water **Water Sustainability**	Land Use Planning and Management	Use setbacks, performance standards, conditional use permits, zoning districts, etc. that protect groundwater, drinking water and reduce conflicts between users (i.e. agriculture and urban uses).	X	X	X	X	X	X	X	X	All	MN Assocc. of Counties, MDH, DNR			X				
Protect Groundwater and Drinking Water Quality **Water Sustainability**	Education and Outreach	Develop a 'drinking water protection' page on the SWCD or county website or other communication tools that can be used to share information with citizens on what they can do to protect both public and private sources of drinking water. Include information about the connection between surface and groundwater, well sealing and water	X	X	X	X	X	X	X	X	All	MDH DNR MPCA MDA BWSR							

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target **Stearns** Co.	Target **Pope** Co.	Target **Kandiyohi** Co.	Target **Meeker** Co.	Target **Wright** Co.	Target **Hennepin** Co.	Target **Carver** Co.	Target **McLeod** Co.	HUC-10s Involved	Agencies that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWDF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
		conservation. Dakota County's webpage Water Quality (https://www.co.dakota.mn.us/Environment/WaterQuality/WellsDrinkingWater/Pages/default.aspx) is a good example.																	
Protect Groundwater and Drinking Water Quality **Water Sustainability**	Land Use Planning and Management	Develop ordinances, overlay districts, performance standards, etc. to further protect drinking water and groundwater dependent features from future land use impacts for their long-term sustainability and use.	X	X	X	X	X	X	X	X	All	DNR, BWSR, NRCS, MN Association of Counties	Focus in areas with high sensitivity, vulnerable DWSMAs and groundwater dependent natural features *Pollution Sensitivity Map (Figure 7)* *DWSMA Vulnerability Map (Figure 12)* *GWDF Map (Figure 24)*		X				
Protect Groundwater and Drinking Water Quality **Water Sustainability**	Land Use Planning and Management	Incorporate basic groundwater and drinking water information into local comprehensive plans and ordinances including: ▪ Local geology and aquifer information ▪ The sources of drinking water and the pollution sensitivity of public and private wells ▪ Maps of state approved WHP areas ▪ Groundwater dependent natural features ▪ Contaminant areas of concern ▪ Other local information needed to consider and protect groundwater and drinking water resources in local land use planning decisions	X	X	X	X	X	X	X	X	All	MDH DNR MPCA MDA MGS							
Protect Groundwater and Drinking Water Quality **Water Sustainability**	Land Use Planning and Management	Plan for future population growth by reflecting drinking water quality and quantity issues in land use plans. Use planning tools such as setbacks, performance standards, conditional use permits, zoning districts, etc. that protect aquifer health and yield.					X	X			Crow Big Swan North Fork	DNR, MDH, MN Assoc. of Counties							

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target **Stearns** Co.	Target **Pope** Co.	Target **Kandiyohi** Co.	Target **Meeker** Co.	Target **Wright** Co.	Target **Hennepin** Co.	Target **Carver** Co.	Target **McLeod** Co.	HUC-10s Involved	Agencies that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWDF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Protect Groundwater and Drinking Water Quality **Water Sustainability**	Land Use Planning and Management	Work with local officials to update land use plans and controls that identify long-term drinking water and sanitary service issues and needs in rapidly developing rural and urban areas that protect public health.					X				Crow North Fork	MPCA							
Protect Groundwater and Drinking Water Quality **Water Sustainability:** Recharge	Conservation Easements	Enroll private lands in land acquisition programs or conservation easements.	X	X	X	X	X	X		X	All	BWSR FSA NRCS	Prioritize areas of high pollution sensitivity and highly vulnerable WHP areas. Target areas of high water use intensity, known groundwater dependent natural features or downward trending water levels. Examine areas where you can expand on existing easements and protected lands to increase protections. *Pollution Sensitivity Map (Figure 7)* *Wellhead Protection Map (Figure 11)* *Well & Pumping Map (Figure 16)* *GWDF Map (Figure 24)* *Water Level Trends Map (Figure 23)* *RIM Easements Map (Figure 29)*	X	X	X	X	X	X
Protect Groundwater and Drinking Water Quality: Wellhead Protection **Water Sustainability:** Recharge	Conservation Easements	Enroll private lands into Continuous CRP and RIM Reserve for wellhead protection.	X								Koronis	BWSR FSA	Target vulnerable wellhead protection areas. *Wellhead Protection Map (Figure 11)*	X	X	X	X	X	X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target **Stearns** Co.	Target **Pope** Co.	Target **Kandiyohi** Co.	Target **Meeker** Co.	Target **Wright** Co.	Target **Hennepin** Co.	Target **Carver** Co.	Target **McLeod** Co.	HUC-10s Involved	Agencies that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: **Habitat***	*Benefit: **GWDF***	*Benefit: **Soil Health***	*Benefit: **Erosion***	*Benefit: **Carbon***	*Ben: **Nutrient Runoff***
Protect Groundwater and Drinking Water Quality **Water Sustainability:** Recharge	Conservation Easements	Maintain and expand set-aside acres, including areas in publicly supported conservation programs like CRP, from being converted to high intensity uses, such as corn and soybeans.	X	X	X	X	X	X	X	X	All	BWSR FSA NRCS	Prioritize private lands with existing CRP contracts, along with state and federal easement, such as RIM and DNR and USFW habitat easements. *RIM Easements Map (Figure 29)* *GWDF Map (Figure 24)*	X	X	X	X	X	X
Protect Groundwater and Drinking Water Quality: Stormwater Management **Water Sustainability:** Recharge	Land Use Planning and Management Education and Outreach	Manage stormwater runoff to minimize adverse impacts to groundwater. Refer to the Minnesota Stormwater Manual for infiltration guidance on project sites located in wellhead protection areas.	X	X	X	X	X	X	X	X	All	MDH MPCA	Prioritize MS4 communities, highly sensitive areas of the watershed and target vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 7)* *DWSMA Vulnerability Map (Figure 12)*	X	X		X		X
Protect Groundwater and Drinking Water Quality: Nitrate **Groundwater Sustainability:** Water Conservation	Education and Outreach Irrigation Water Management	Promote and encourage the adoption of irrigation water management BMPs that increase water conservation and decrease conditions for nitrogen loss to the root zone by utilizing: ▪ Irrigation water scheduling to control the volume, frequency, and application of irrigation water ▪ Conversion to low flow pressure irrigation nozzles ▪ Proper timing of irrigation through the use of online tools that identify local climate, growing degree days (GDD) and evapotranspiration (ET) conditions ▪ Test irrigation water and take credit for nitrate present as a fertilizer source	X	X	X	X	X	X			Koronis Middle Fork Jewetts Washgtn North Fork Crow	MDA, Central MN Ag Weather Network, UMNMN Climatology Working Group	Prioritize areas of high water use intensity by agricultural irrigators, highly sensitive areas and vulnerable DWSMAs. *Well & Pumping Map (Figure 16)* *Pollution Sensitivity Map (Figure 7)* *DWSMA Vulnerability Map (Figure 12)*		X		X		X

Goal	Supporting Strategy	Recommended Groundwater Actions	Target **Stearns** Co.	Target **Pope** Co.	Target **Kandiyohi** Co.	Target **Meeker** Co.	Target **Wright** Co.	Target **Hennepin** Co.	Target **Carver** Co.	Target **McLeod** Co.	HUC-10s Involved	Agencies that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: **Habitat***	*Benefit: **GWDF***	*Benefit: **Soil Health***	*Benefit: **Erosion***	*Benefit: **Carbon***	*Ben: **Nutrient Runoff***
Groundwater Sustainability: Water Conservation	Education and Outreach	Provide education on water conservation practices that can be adopted in people's homes and businesses. Use the Met Council's Water Conservation Toolbox.	X	X	X	X	X	X	X	X	All	MDH DNR Met Counc.			X				
Groundwater Sustainability: Water Conservation	Land Use Planning and Management	Assist communities serving over 1,000 people with water conservation measures outlined in their DNR municipal water supply plans.	X	X	X	X	X	X	X	X	All	DNR			X				
Groundwater Sustainability: Water Conservation	Land Use Planning and Management Education and Outreach	Assist farmers applying for a water appropriation permit by developing a water conservation plan that identifies water conservation measures that improve water use efficiencies and reduce water demand.	X	X	X	X	X	X			Koronis Middle Fork Jewetts Washgtn North Fork Crow	DNR	Prioritize areas of high water use intensity by agricultural irrigators. *Well & Pumping Map (Figure 16)*		X				X
Groundwater Sustainability: Water Conservation	Land Use Planning and Management Education and Outreach	Assist farmers by updating existing water conservation plans for appropriation permit holders to reflect management goals of the DNR's Bonanza Valley Groundwater Management Areas.	X	X	X						Koronis Middle Fork	DNR	Prioritize areas of high water use intensity by agricultural irrigators. *Well & Pumping Map (Figure 16)*		X				X
Groundwater Sustainability: Water Conservation **Groundwater Sustainability:** Recharge	Land Use Planning and Management	Use existing DWSMA, sensitive resource assessment information, and groundwater use intensity information to determine municipal drinking water supplies that are at risk in regards to sustainability, and prioritize BMP implementation for conservation and recharge.	X	X	X	X					Koronis Middle Fork Jewetts Washgtn	DNR BWSR NRCS FSA	*Well & Pumping Map (Figure 16)* *DWSMA Vulnerability Map (Figure 12)* *Pollution Sensitivity Map (Figure 7)*	X	X	X	X	X	X
Groundwater Sustainability: Recharge	Land Use Planning and Management	Evaluate areas with increased density of high capacity wells (irrigation wells) and groundwater use combined with observation well data indicating aquifer water level declines or increasing drawdown with	X	X	X	X					Koronis Middle Fork Washgtn	DNR BWSR NRCS FSA	Prioritize areas with high density of high capacity wells and increasing drawdown. *Well & Pumping Map (Figure 16)*	X	X	X	X	X	X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target **Stearns** Co.	Target **Pope** Co.	Target **Kandiyohi** Co.	Target **Meeker** Co.	Target **Wright** Co.	Target **Hennepin** Co.	Target **Carver** Co.	Target **McLeod** Co.	HUC-10s Involved	Agencies that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWDF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
		recovery, to prioritize parcels for recharge BMPs to offset use.											*Water Level Trends Map (Figure 23)*						
Water Sustainability: Recharge	Land Use Planning and Management	Limit ditching and channelization that pulls water through the landscape.	X	X	X	X	X	X	X	X	All	DNR	Target areas of high water use intensity, known groundwater dependent natural features or downward trending water levels *Well & Pumping Map (Figure 16)* *GWDF Map (Figure 24)* *Water Level Trends Map (Figure 23)*		X				
Water Sustainability: Recharge **Water Sustainability:** Rare or Declining Habitats	Land Use Planning and Management	Promote and increase the adoption of recharge BMPs including wetland construction/restoration, perennial establishment, riparian buffers, and conservation easements.			X						Middle Fork	DNR NRCW BWSR	Prioritize in the Alexandria End Moraine area and near sensitive features and groundwater fed lakes *GWDF Map (Figure 24)*	X	X	X	X	X	
Water Sustainability: Recharge **Water Sustainability:** Rare or Declining Habitats	Land Use Planning and Management	Accelerate wetland conservation and restoration to maintain water recharge levels needed to support groundwater dependent features.	X	X	X	X					Koronis Middle Fork Washgtn.	DNR BWSR NRCS	Prioritize areas of high water use intensity. *Well & Pumping Map (Figure 16)*	X	X		X		X
Water Sustainability: Recharge	Land Use Planning and Management Conservation Easements	Enroll natural areas/grasslands into land acquisition or conservation easements on private lands that promote infiltration/recharge.	X	X	X	X					Koronis Middle Fork Wasghtn	DNR BWSR FSA NRCS	Prioritize areas of high water use intensity. *Well & Pumping Map (Figure 16)*	X	X	X	X	X	X

Descriptions of Supporting Strategies

Conservation Easements

Conservation easements are a legal agreement between a landowner and a land trust or government agency that permanently limits uses of the land in order to protect its conservation values. Easements allow landowners to continue to own and use their land. They can also sell it or pass it on to heirs. Maintaining and expanding set-aside acres, including areas in publicly supported conservation programs (like CRP) from being converted to high intensity uses, such as row crop agriculture, will help protect groundwater quantity and quality.

Existing Programs and Resources

- MDA **Conservation Reserve Program** (http://www.mda.state.mn.us/protecting/conservation/programs/ccrp.aspx): A voluntary program designed to help farmers restore and protect environmentally sensitive land.
- BWSR **Reinvest in Minnesota (RIM) Wetlands Conservation Easements** (http:/www.bwsr.state.mn.us/easements/wetlands/): A program that restores wetlands and grasslands through permanent conservation easements on privately owned lands. Figure 29 shows where RIM easements are in the NFCRW.

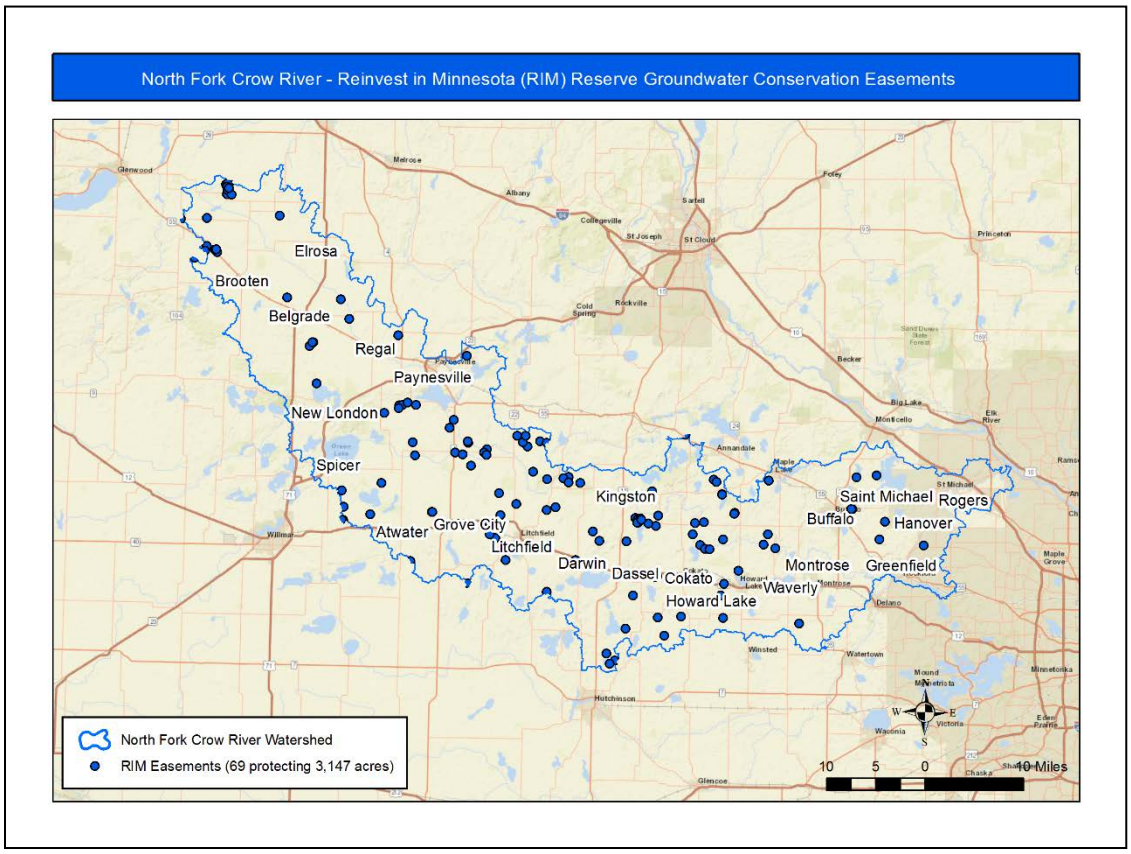

Figure 29: RIM easements applied in the North Fork Crow River Watershed.

Contaminant Planning and Management

Protect groundwater and drinking water supplies from contaminant releases in the environment through land use planning, ordinances, and collaboration with state regulatory agencies.

Existing Programs and Resources

- MDA **What's in My Neighborhood? Agricultural Interactive Mapping** (http://www.mda.state.mn.us/chemicals/spills/incidentresponse/neighborhood.aspx): A tool that tracks and maps spills of agricultural chemicals and sites contaminated with agricultural chemicals.
- MPCA **Land Application** (https://www.pca.state.mn.us/quick-links/feedlot-nutrient-and-manure-management): Resources such as fact sheets, guidelines, computer tools, and forms for feedlot nutrient and manure management.
- MPCA **Tank Compliance and Assistance Program--**Storage Tanks (https://www.pca.state.mn.us/waste/storage-tanks): A program that provides information and assistance to tank owners and others regarding technical standards required of all regulated underground storage tanks and aboveground storage tank systems.
- MPCA **Closed Landfill Program** (https://www.pca.state.mn.us/waste/closed-landfill-program): A voluntary program to properly close, monitor, and maintain Minnesota's closed municipal sanitary landfills.
- MPCA **Feedlots** (https://www.pca.state.mn.us/quick-links/feedlot-program): Information about feedlot rules, permits, and management.
- MPCA **What's in My Neighborhood** (https://www.pca.state.mn.us/data/whats-my-neighborhood)**:** An online tool for searching out information about contaminated sites and facilities all around Minnesota.
- UMN Extension **Manure Management in Minnesota** (http:/www.extension.umn.edu/agriculture/manure-management-and-air-quality/manure-management-basics/manure-management-in-minnesota/): Information about manure characteristics, application, and economics.
- USDA & NRCS **Manure Management in Minnesota** (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/technical/ecoscience/nutrient/?cid=nrcs142p2_023688): Basic manure management information.
- MDH **Contaminants of Emerging Concern** (http://www.health.state.mn.us/cec): A program that investigates and communicates the health and exposure potential of contaminants of emerging concern in drinking water.

Cropland Management

Voluntary practices to manage resource concerns while minimizing environmental loss. Practices may include conservation tillage, cover crops, soil health, and other agricultural BMPs.

Existing Programs and Resources

- MDA **The Agricultural BMP Handbook for Minnesota** (http://www.eorinc.com/documents/AG-BMPHandbookforMN_09_2012.pdf): A literature review of empirical research on the effectiveness of 30 conservation practices.
- NRCS **Conservation Stewardship Program** (http://www.nrcs.usda.gov/wps/portal/nrcs/main/mn/programs/financial/csp/): A voluntary

conservation program that encourages producers to address resource concerns in a comprehensive manner.

- NRCS **Environmental Quality Incentives Program** (https://www.nrcs.usda.gov/wps/portal/nrcs/main/mn/programs/financial/eqip/): A program that provides financial and technical assistance to agricultural producers so they can implement structural and management conservation practices that optimize environmental benefits on working agricultural land.
- NRCS **Cover Crops** (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/technical/?cid=nrcs142p2_023671): Provides information, fact sheets, and tools about cover crops.
- NRCS **Soil Health** (https://www.nrcs.usda.gov/wps/portal/nrcs/main/mn/soils/health/): Provides information about the basics and benefits of soil health.
- **Midwest Cover Crop Council** (http://mccc.msu.edu/statesprovince/minnesota/): Provides resources to help with technical support and answer questions from a local perspective for no cost.
- MDA **Minnesota Agricultural Water Quality Certification Program** (http://www.mda.state.mn.us/awqcp): A voluntary program for farmers to implement conservation practices to protect water quality.

Education and Outreach

Educate landowners, private well users, and other stakeholders about how their actions impact groundwater quality and quantity. Provide information about potential health risks related to groundwater quality. Identify actions individuals, households, and partner agencies can take to sustain groundwater and protect or improve drinking water quality. Some ideas include managing household hazardous waste, maintaining household septic systems, and household water conservation measures.

For educational materials and programs related to a specific topic, go to the strategy about that topic. For example, go to 'nutrient management' to learn more about potential education opportunities regarding reducing nitrogen use. The list below provides some additional tools that may be helpful.

Existing Programs and Resources

- Metropolitan Council **Water Conservation Toolbox** (https://metrocouncil.org/Wastewater-Water/Planning/Water-Supply-Planning/Guidance-Planning-Tools/Water-Conservation/Toolbox.aspx): Information about how residents and businesses, suppliers, learners, and communities can conserve water.
- Minnesota Rural Water Association **Source Water Protection Resources** (http://www.mrwa.com/sourcewater.html): Resources to help public water suppliers develop plans to use local community resources to protect drinking water quality.
- MPCA **Waste** (https://www.pca.state.mn.us/waste): Information about managing waste, recycling, composting, and preventing waste and pollution.
- MPCA **Manual for Turfgrass Maintenance with Reduced Environmental Impacts** (https://www.pca.state.mn.us/sites/default/files/p-tr1-04.pdf): Practical advice for those who manage turfgrass (golf courses and athletic fields excluded).
- MDH **Wells Laws and Rules** (http://www.health.state.mn.us/divs/eh/wells/rules/index.html): Minnesota State Well Code (MR 4725.0050 – 4725.7605).

- MDH **Wells and Borings—Well Management Program** (http://www.health.state.mn.us/divs/eh/wells/index.html): Information about proper well construction, maintenance, testing, and sealing.
- MDH **Wellowner's Handbook** (http://www.health.state.mn.us/divs/eh/wells/construction/handbook.pdf): A consumer's guide to water wells in Minnesota.
- MDH **Arsenic in Minnesota's Well Water** (http://www.health.state.mn.us/divs/eh/wells/waterquality/arsenic.html): Information about arsenic in Minnesota.

Integrated Pest Management

Integrated Pest Management (IPM) is a balanced approach to pest management that incorporates the many aspects of plant health care/crop protection in ways that mitigate harmful environmental impacts and protect human health. Some of the IPM program activities include generating and distributing IPM information for growers, producers, land managers, schools, and the general public. Information should help them make alternative choices in their pest management decisions.

Existing Programs and Resources

- MDA **Integrated Pest Management Program** (https://www.mda.state.mn.us/plants/pestmanagement/ipm.aspx): A program that develops and implements statewide strategies for the increased use of IPM on private and state managed lands.
- MDA **Water Quality BMPs for Agricultural Pesticides** (http://www.mda.state.mn.us/protecting/bmps/herbicidebmps.aspx): Information to address pesticide use and water resource protection.

Irrigation Water Management

The process of determining and controlling the volume, frequency, and application rate of irrigation water in a planned, efficient manner (NRCS Codes 442 & 449).

Existing Programs and Resources

- MDA **Irrigation Management** (http://www.mda.state.mn.us/protecting/conservation/practices/irrigation.aspx): Provides information about irrigation management, similar practices, guidance from NRCS, and links to additional resources.
- DNR **Minnesota Water Use Data** (http://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/wateruse.html)**:** Data gathered from permit holders who report the volume of water used each year.

Land Use Planning and Management

This broad strategy encompasses many different concepts including regulations, ordinances, BMP implementation, conservation measures, and education to protect groundwater levels, quality, and contributions to groundwater dependent features.

Land use planning focuses on the application of city or county government planning and regulations to restore and protect groundwater and groundwater levels. Local planning and regulations can help restrict land uses in groundwater sensitive areas, areas of high aquifer sensitivity, or regions of limited water supply to prevent conflict.

Land management implements voluntary practices that manage resource concerns while minimizing environmental loss. This may include the efficient use of groundwater through conservation measures and use of emerging technology to increase water conservation at the field or local level.

Existing Programs and Resources

- **Association of Minnesota Counties** (http://www.mncounties.org/): A voluntary, non-partisan statewide organization that helps provide effective county governance to Minnesotans. The Association works closely with the legislative and administrative branches of government in seeing that legislation and policies favorable to counties are enacted.
- DNR **Water Supply Plans** (http://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/eandc_plan.html)**:** Provides information about Minnesota public water supply plans.
- DNR **MPARS (MNDNR Permitting and Reporting System)** (http://www.dnr.state.mn.us/mpars/index.html): DNR is the permitting authority for high capacity water use.
- DNR **Groundwater Management Program** (http://www.dnr.state.mn.us/gwmp/index.html): A strategic plan to ensure that use of groundwater is sustainable and does not harm ecosystems, water quality, or the ability of future generations to meet their needs.
- DNR **Sustainability of Minnesota's Groundwaters** (http://www.dnr.state.mn.us/waters/groundwater_section/sustainability/index.html): Resources to help promote the sustainable use of groundwater, including a statement of issues and needs and factsheets.
- DNR **Water Conservation** (http://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/conservation.html): Provides tips and tools for promoting water conservation at home, public water supply systems, and other environments.
- **League of Minnesota Cities** (https://www.lmc.org/): Promotes excellence in local government through effective advocacy, expert analysis, and trusted guidance for all Minnesota cities.
- MPCA **Condition Groundwater Monitoring** (https://www.pca.state.mn.us/water/condition-groundwater-monitoring). MPCA and other government agencies are monitoring ground water to determine impacts from human-related chemicals such nitrate, volatile organic compounds and chloride.
- MPCA **Groundwater Report for the North Fork Crow River Watershed** (https://www.pca.state.mn.us/sites/default/files/wq-ws1-08.pdf): An overview of the physiography, land use, geology, and hydrogeology of the watershed.
- MPCA **Stormwater and Wellhead Protection** (http://stormwater.pca.state.mn.us/index.php/Stormwater_and_wellhead_protection): Guidance and recommendations for determining the appropriateness of infiltrating stormwater in a Drinking Water Supply Management Area.
- MPCA **Minnesota Stormwater Manual** (http:/stormwater.pca.state.mn.us/index.php/Main_Page): A manual to help the everyday user better manage stormwater.

- MPCA **Enhancing Stormwater Management in Minnesota** (https://www.pca.state.mn.us/water/enhancing-stormwater-management-minnesota): Information about standards and tools for minimal impact designs for stormwater management.
- MPCA **Stormwater** (https://www.pca.state.mn.us/water/stormwater): MPCA regulates the discharge of stormwater and snowmelt runoff from municipal separate storm sewer systems, construction activities, and industrial facilities.
- MDH **Source Water Protection** (http://www.health.state.mn.us/divs/eh/water/swp/): MDH works with communities to protect the source(s) of their drinking water.
- DNR and Minnesota Geological Survey **County Geologic Atlas Program** (http://www.dnr.state.mn.us/waters/groundwater_section/mapping/index.html): Provides additional information on the groundwater resources and hydrogeology of the watershed through maps and reports of geology, groundwater, pollution sensitivity, and special studies.

Nutrient Management

This strategy addresses both nutrient and manure management.

Nutrient management concepts are centered on applying crop fertilizer or manure using the right source, right rate, right time, and right place (NRCS Codes 327, 340, 345, 393, 590, 656).

Manure management targets the collection, transportation, storage, processing, and disposal of animal manure.

Existing Programs and Resources

- MDA **Nutrient Management** (http://www.mda.state.mn.us/chemicals/fertilizers/nutrient-mgmt.aspx). MDA is the lead state agency for all aspects of pesticide and fertilizer environmental and regulatory functions. This page provides information on nutrient management programs, reports, publications, factsheets, and related external sources.
- MDA **Nutrient Management Initiative Program in Minnesota** (http://www.mda.state.mn.us/nmi): The program assists farmers and crop advisers in evaluating alternative nutrient management practices for their fields.
- MDA **Township Testing Program** (http://www.mda.state.mn.us/townshiptesting): The program tests private wells for nitrate and pesticides in areas of the state with the greatest potential for nitrate and pesticide contamination.
- MDA **Nitrogen Fertilizer Best Management Practices** (http://www.mda.state.mn.us/nitrogenbmps): Provides nitrogen BMPs for various areas within Minnesota.
- MDA **Minnesota Nitrogen Fertilizer Management Plan** (http://www.mda.state.mn.us/chemicals/fertilizers/nutrient-mgmt/nitrogenplan.aspx): The state's blueprint for preventing or minimizing impacts of nitrogen fertilizer on groundwater.
- MDA **Ag Chemicals & Fertilizers** (http://www.mda.state.mn.us/chemicals.aspx): Promotes proper use, handling, and safety of agriculture chemicals and fertilizers.
- MDA **Monitoring & Assessment for Agricultural Chemicals in the Environment** (http://www.mda.state.mn.us/chemicals/pesticides/maace.aspx): Information about agricultural chemical monitoring and assessment programs and additional resources.
- UMN Extension **Nutrient Management** (http://www.extension.umn.edu/agriculture/nutrient-management/): The page focuses on helping farmers and agriculture professionals optimize crop production using appropriate nutrient inputs while minimizing effects on the environment.

- UMN Extension **Best Management Practices for Nitrogen on Coarse Textured Soils** (http://www.extension.umn.edu/agriculture/nutrient-management/nitrogen/docs/08556-coarsesoilsMN.pdf): Information about best management practices for nitrogen application.
- UMN Extension **Nitrogen Application with Irrigation Water: Chemigation** (http://www.extension.umn.edu/agriculture/nutrient-management/nitrogen/nitrogen-application-with-irrigation-water-chemigation/): Information about risks, benefits, and methods.
- UMN Extension **Crop Calculators** (http://www.extension.umn.edu/agriculture/nutrient-management/crop-calculators/): Use crop calculators to help determine needed nutrients.
- UMN Extension **Nutrient/Lime Guidelines** (http://www.extension.umn.edu/agriculture/nutrient-management/nutrient-lime-guidelines/): Guidelines for corn, fruit crops, vegetables crops, lawns, turf, gardens, soybeans, sugar beets, wheat, and more.
- NRCS **Nutrient Management Planning** (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/technical/ecoscience/nutrient/?cid=nrcs142p2_023693): Information about nutrient management policy and tools for developing nutrient management plans.
- MDA **The Agricultural BMP Handbook for Minnesota** (http://www.eorinc.com/documents/AG-BMPHandbookforMN_09_2012.pdf): A literature review of empirical research on the effectiveness of 30 conservation practices.
- Nutrient Stewardship **What are the 4Rs** (http://www.nutrientstewardship.com/4rs): Information about the 4Rs of Nutrient Stewardship.
- MPCA **Land Application** (https://www.pca.state.mn.us/quick-links/land-application): Resources such as fact sheets, guidelines, computer tools, and forms for feedlot nutrient and manure management.
- UMN Extension **Manure Management in Minnesota** (http:/www.extension.umn.edu/agriculture/manure-management-and-air-quality/manure-management-basics/manure-management-in-minnesota/): Information about manure characteristics, application, and economics.
- USDA & NRCS **Manure Management in Minnesota** (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/technical/ecoscience/nutrient/?cid=nrcs142p2_023688): Basic manure management information.

SSTS Management

Monitoring, maintenance, and/or upgrading of individual septic treatment systems to maintain proper operation and treatment of septage by the system. In some areas, the intensity of use may require upgrading to a sanitary sewer to eliminate risks to the environment.

Existing Programs and Resources

- MPCA **Subsurface Sewage Treatment Systems** (https://www.pca.state.mn.us/water/subsurface-sewage-treatment-systems). This program protects public health and the environment through adequate dispersal and treatment of domestic sewage from dwellings or other establishments generating volumes less than 10,000 gallons per day.
- UMN Extension **Septic System Owner's Guide** (http://www.extension.umn.edu/environment/housing-technology/moisture-management/septic-system-owner-guide/): Provides information about the basic principles of how a septic systems works and how to operate and maintain the system.

Making Sense of the Regulatory Environment

State agencies and programs play a variety of roles in restoring and protecting groundwater. Understanding the groundwater-related authorities and resources available at the state level and leveraging strengths of local water resource professionals are key to implementing effective groundwater protection strategies. Figure 30 provides a very basic introduction into the roles Minnesota state agencies have for groundwater.

- MDA works with groundwater that is or could be affected by pesticides and/or fertilizers.
- MDH focuses on proper well construction, assessing health risks related to groundwater, and protecting drinking water supplies.
- MPCA works with groundwater that is or could be affected by chemical releases and/or industrial pollutants.
- DNR focuses on assuring the availability of groundwater and protecting groundwater dependent features.

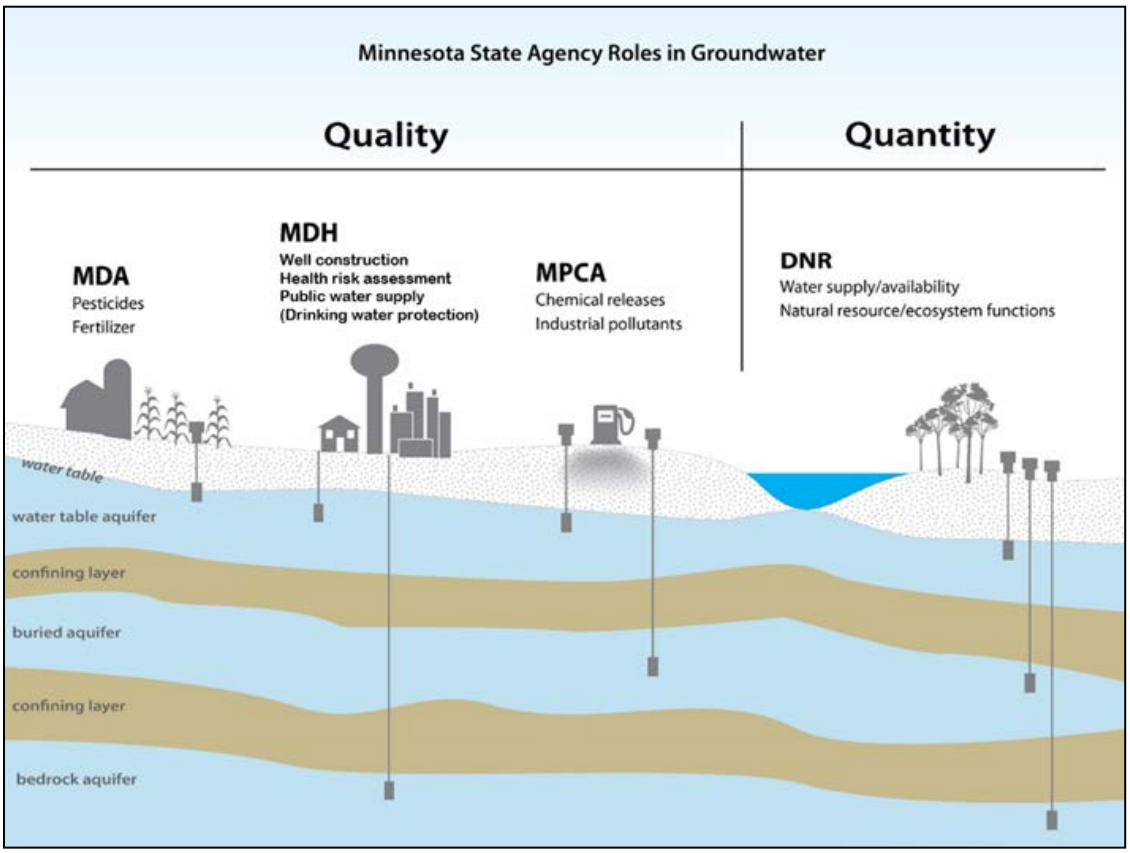

Figure 30: Minnesota State Agency Roles in Groundwater

Each of the state agencies listed above has a variety of programs to help meet their role in groundwater restoration and protection. Programs each of the agencies manage are referenced in the Descriptions of Supporting Strategies Section. Programs are listed under the restoration or protection strategy they mostly closely correspond to.

Figure 31 provides a more detailed overview of the different roles agencies play within Minnesota's Water Management Framework. Principal water resource management agencies are DNR, MPCA, MDA, BWSR, and MDH. These agencies are responsible for state or federal programs, including:

- the Clean Water Act for MPCA,
- the Safe Drinking Water Act for MDH, and
- Appropriation Permitting for the DNR.

The strength of these programs is that they provide technical assistance and regulatory oversight (including enforcement) to safeguard public health, natural resources, ecological needs, and the environment. These programs are generally effective at managing most types of point sources of contamination in the state and at managing quantity issues at the local and regional level. In addition, these programs often set standards for performance that can be used to drive action.

Two weaknesses of state or federal programs are that they (with few exceptions) are ineffective against non-point sources of contamination and lack authority relative to managing general land use practices. Non-point source management is a vexing issue for water resource managers at all levels. With few regulatory options available, the most common approaches involve the use of financial incentives, technical assistance, and education and communication about sound land and water stewardship. Seldom are representatives from state agencies able to spend the necessary time in the local community to build trust among landowners. As a result, these approaches benefit greatly from the perspectives and relationships that local water resource professionals can forge by working locally.

	Ongoing Implementation	Monitoring and Assessment	Watershed Characterization & Problem Investigation	Restoration and Protection Strategy Development	Comprehensive Watershed Management Plan
BWSR	Funding and technical assistance for locally implemented watershed restoration and protection projects	Monitor progress of local implementation goals	Conservation targeting tools (e.g.,, Environmental Benefits Index) BMP guidance (e.g., drainage water management)	Participate on interagency watershed teams developing WRAPS (with all agencies)	Comprehensive Watershed Management Planning (One Watershed, One Plan) Local water and watershed plans
MNDNR	Appropriations and Public Waters Permitting Shoreland and floodplain management Technical assistance for projects	Stream flow Fish and plants (lakes) Mercury in fish tissue Aquifer levels (with Met Council)	Stream hydrology and geomorphology (support MPCA) Small scale watershed modeling and groundwater level modeling County Geologic Atlas	Advise on conservation actions based on holistic view of watershed health (hydrology, geomorphology, connectivity, biology, water quality)	Input on local conservation actions informed by statewide plans for prairies, forests, etc. Water supply planning and groundwater management areas (with Met Council)
MDH	Funding for source water protection, contaminants of emerging concern Well sealing cost share	Source water and finished drinking water Bacteria monitoring on Lake Superior beaches	Guidance for contaminants of emerging concern Data analysis and modeling to support WHPA delineation and vulnerability assessments for public water supplies	Source water protection planning (identification of problems, issues, and opportunities) Well construction management	Guidance for infiltration in DWSMAs Source water protection planning (local measures and strategies)
PFA	Loans and grants for water infrastructure projects based on priorities set by MDH and PCA				
MPCA	NPDES permit programs, SSTS compliance Grants for Clean Water Partnership, Great Lakes Restoration, stormwater and wastewater treatment (PFA)	Water chemistry (surface and groundwater) Fish and macroinvertebrates (streams) Surface water assessment grants	Stressor Identification for biological impairments Watershed Modeling (8-HUC) TMDLs Civic engagement	Stakeholder agreement on broad watershed restoration and protection strategies (WRAPS) WRAPS report – includes implementation table TMDLs to EPA	Provide WRAPS for incorporation into local plans Input on management strategies informed by statewide nutrient plan
MDA	Ag BMP loans MN Agricultural Water Quality Certification Program Implement Pesticide and Nitrogen Fertilizer Management Plans	Pesticides in surface and groundwater Nitrate in groundwater	Research/evaluation on ag sources, practices and solutions Technical assistance on ag sources and practices, BMP demonstration/evaluation sites Stressor ID for pesticides	Ag practices and management options, nitrogen fertilizer and pesticide use Participate on interagency teams developing WRAPS Vegetative cover	Input on management strategies informed by pesticide and nitrogen fertilizer management plans
Metropolitan Council	Technical assistance and demonstration projects	Lake, stream, river monitoring: flow, chemistry, biology Effluent monitoring (WWTPs) Impervious surface and land cover assessments	Modeling and trend assessments (surface water) Pollutant load calculations Groundwater mapping and characterization	Participate in WRAPS and local water planning teams Master water supply plan Groundwater management areas (with DNR)	Participate in review of local water and watershed plans (metro area); local water supply plans; and comprehensive land use plans (metro area)

Figure 31: Roles agencies play within the Minnesota Water Management Framework

Appendices

List of Acronyms

BMP	Best Management Practices
BWSR	Board of Soil and Water Resources
CAFO	Concentrated Animal Feeding Operation
CRP	Conservation Reserve Program
DWSMA	Drinking Water Supply Management Area
EPA	United States Environmental Protection Agency
GRAPS	Groundwater Restoration and Protection Strategies
HUC	Hydrologic Unit Code
IPM	Integrated Pest Management
MCL	Maximum Contaminant Level
MDA	Minnesota Department of Agriculture
MDH	Minnesota Department of Health
DNR	Minnesota Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer Systems
MWI	Minnesota Well Index
NRCS	United States Department of Agriculture Natural Resources Conservation Service
NFCRW	North Fork Crow River Watershed
NLCD	National Land Cover Database
NPDES	National Pollutant Discharge Elimination System
PFA	Public Facilities Authority
QBAA	Quaternary Buried Artesian Aquifer

QWTA	Quaternary Water Table Aquifer
RIM	Reinvest in Minnesota Program
SDS	State Disposal System Program
SSTS	Subsurface Sewage Treatment System
SDWA	Safe Drinking Water Act
SWCD	Soil and Water Conservation District
TTP	MDA Township Testing Program
UMN	University of Minnesota Extension
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WIMN	What's in My Neighborhood
WHP	Wellhead Protection
WHPAS	Wellhead Protection Areas
WRAPS	Watershed Restoration and Protection Strategy

Glossary of Key Terms

Aquifer
An aquifer is an underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials (gravel, sand, or silt) from which groundwater can be extracted using a water well.

Aquifer Vulnerability
Defined as the ease with which recharge and contaminants from the ground surface can be transmitted into the subsurface aquifer. MDH uses the terminology 'vulnerability'; whereas the MNDNR references 'sensitivity'. Both terms cite the risk to groundwater degradation.

Community Water System
A public water system that serves where people live. The system has at least 15 service connections or living units used by year-round residents, or regularly serves at least 25 year-round residents.

Drinking Water Supply Management Area (DWSMA)
The surface and subsurface area surrounding a public water supply well, including the wellhead protection area that must be managed by the entity identified in a wellhead protection plan. The boundaries of the DWSMA are roads, public land survey and fractions thereof, property lines, political boundaries, etc. (See MN WHP Rules 4720.5100, Subp. 13.)

Groundwater recharge
The process through which water moves downward from surface water to groundwater. Groundwater recharge is the main way water enters an aquifer.

Hydrologic Unit Code (HUC)
HUCs are assigned by the USGS for each watershed. HUCs are organized in a nested hierarchy by size. For example, the St. Croix River Basin is assigned a HUC-4 of 0703 and the Sunrise River Watershed is assigned a HUC-8 of 07030005.

Maximum Contaminant Level (MCL)
The highest level of a contaminant that EPA allows in drinking water. MCLs ensure that drinking water does not pose either a short-term or long-term health risk. EPA sets MCLs at levels that are economically and technologically feasible.

Noncommunity Water System
A public water system that is not a community water supply and that serves a transient population.

Nontransient Noncommunity System
A public water system that serves at least 25 of the same people over 6 months of the year (such as schools, offices, factories, and childcare facilities).

Protection
This term is used to characterize actions taken in watersheds to maintain conditions and beneficial uses of waters not known to be impaired.

Pollution Sensitivity
The ease with which recharge and contaminants from the ground surface can be transmitted into the subsurface.

Public Water System
A water system with 15 or more service connections or regularly serves at least 25 people for 60 or more days a year. A system that serves water 60 or mores day a year is considered to 'regularly serve' water. Public water systems can be publicly or privately owned. Public water systems are subdivided into two categories: community and noncommunity water systems. This division is based on the type of consumer served and the frequency the consumer uses the water.

Restoration
This term is used to characterize actions taken in watersheds to improve conditions to eventually meet water quality standards and achieve beneficial uses of impaired waters.

Source (or Pollutant Source)
Actions, places, or entities that deliver/discharge pollutants (e.g., sediment, phosphorus, nitrogen, pathogens).

Source Water Protection
Protecting sources of water used for drinking, such as streams, rivers, lakes, or underground aquifers.

Transient Noncommunity System

A public water system that serves at least 25 people at least 60 days of the year but does not serve the same 25 people over 6 months of the year (places such as restaurants, campgrounds, hotels, and churches).

Water Budget
An accounting of all the water that flows into and out of a particular area. This area can be a watershed, wetland, lake, or any other point of interest.

Water Table
The boundary between the water filled rock and sediment of an aquifer and the dry rock and sediment above it. The depth to the water table is highly variable. It can range from zero when it is at land surface, such as at a lake or wetland, to hundreds or even thousands of feet deep. In Minnesota, the water table is generally close to the land surface, typically within a few tens of feet in much of the state.

Wellhead Protection (WHP)
A method of preventing well contamination by effectively managing potential contaminant sources in all or a portion of a well's recharge area. This recharge area is known as the wellhead protection area.

Wellhead Protection Area (WHPA)
The surface and subsurface area surrounding a well or well field that supplies a public water system, through which contaminants are likely to move toward and reach the well or well field. This definition is the same for the federal Safe Drinking Water Act (40 Code of Federal Regulations, Section 1428) and the Minnesota Groundwater Protection Act (Minnesota Statute 103I).

Additional Resources

The following resources may be helpful for gathering data and learning more about groundwater in the NFCRW. The resources are listed alphabetically by the topic they address.

Type of Information	Where you can get more information
Aquifer Vulnerability	For information on aquifer vulnerability ratings DWSMA, please contact MDH or the public water supplier in question. ▪ health.drinkingwater@state.mn.us ▪ 651-201-4700
Groundwater Quality Data	Find water-related monitoring data on Minnesota streams, lakes, wells, Superfund Program, closed landfills, other remediation sites, open landfills, data from MDA, MPCA, and USGS. ▪ Environmental Quality Information System (EQuIS) (https://www.pca.state.mn.us/quick-links/environmental-quality-information-system-equis) ▪ Environmental data (https://www.pca.state.mn.us/environmental-data) ▪ Groundwater (https://www.pca.state.mn.us/water/groundwater)
Drinking Water Annual Reports	MDH has issued a report regarding the state of drinking water in Minnesota each year since 1995. These reports provide test results, an overview on the role of the Department's drinking water program in monitoring and protecting drinking water, and an examination emerging issues.

Type of Information	Where you can get more information
	▪ Drinking Water Protection Annual Reports (http://www.health.state.mn.us/divs/eh/water/com/dwar/)
DWSMA maps and Shapefiles	PDF maps and shape files of the DWSMAs can be downloaded from the MDH website. ▪ Source Water Assessments (http://www.health.state.mn.us/divs/eh/water/swp/swa/) ▪ Maps and Geospatial Data (http://www.health.state.mn.us/divs/eh/water/swp/maps/index.htm)
Point Source Pollution	Visit the following sites for more information on point source pollution: ▪ Nonpoint Source Pollution (http://oceanservice.noaa.gov/education/kits/pollution/03pointsource.html) ▪ Point Source Pollution (http://www.mncenter.org/point-source-pollution.html) ▪ Water Permits and Forms (https://www.pca.state.mn.us/water/water-permits-and-forms)
Well Construction and Use Data	Most of the construction and use data pertaining to wells in the state is housed in the Minnesota Well Index (MWI), an online database. All of the key data in the MWI is also available in spatial datasets, designed for use in geographic information systems (GIS). The Minnesota Geological Survey and MDH work together to maintain and update the data in the Index. MWI provides basic information, such as location, depth, geology, construction and static water level, for many wells and borings drilled in Minnesota. It by no means contains information for all the wells and borings and the absence of information about a well on a property does not mean there is no well on that property. ▪ Welcome to the Minnesota Well Index (MWI) (http://www.health.state.mn.us/divs/eh/cwi/)
Wellhead Protection Plans	These plans can be obtained directly from the communities or from MDH with permission from the communities. Water chemistry data collected from these systems can be provided by request to MDH. ▪ health.drinkingwater@state.mn.us ▪ 651-201-4700

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