Lower St. Croix River Watershed (LSCRW)

Groundwater Restoration and Protection Strategies Report

June 2018

GRAPS Report #5

MINNESOTA

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Contributors

The following agencies dedicated staff time and resources toward the development of the Lower St. Croix River Watershed 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)
- Metropolitan Council (Met Council)

Photo Credit: The photo on the front page is in Scandia, MN in the Lower St. Croix River Watershed and is courtesy of the Washington Conservation District.

Summary

Groundwater is an important resource in the Lower St. Croix River One Watershed One Plan (1W1P) planning boundary. Groundwater accounts for over 97 percent of the reported non-power plant cooling water use. More than 80 percent of groundwater withdrawn is for public water supply use. In addition, groundwater accounts for 100 percent of the region's drinking water. It is important to make sure that adequate supplies of high quality groundwater remain available for the region's residents, businesses, and natural resources.

Drinking water predominantly comes from bedrock aquifers in the watershed with shallower wells drawing from glacial sediments. The bedrock aquifers are deeper and tend to be more geologically protected than the shallower aquifers, except for the karst region in the southern part of the watershed in Washington County. Areas with karst conditions have rapid recharge of surface water and increase the risk of surface contaminants polluting groundwater.

Groundwater has a greater risk to contamination in areas of high pollution sensitivity[1]. A large band of 'high' pollution sensitivity extends through the middle part of the watershed through Anoka, Isanti, and Chisago counties, along with much of Washington County considered sensitive. Understanding pollution sensitivity is a key consideration to prevent groundwater pollution. Many land-use activities (including row crop agriculture, stormwater, septic systems, and tanks/landfills) within the watershed could contaminate groundwater if pollutants are not carefully managed, especially in areas of high pollution sensitivity and karst geology.

Contamination, both naturally occurring and from human activity, is present in parts of the Lower St. Croix River watershed (LSCRW) groundwater, specifically:

- **Contaminated sites** – Over one quarter of all registered tanks are leaking chemicals into the environment and have the potential to cause localized groundwater pollution.
  - Three closed landfills with known groundwater contamination plumes are within the watershed.
  - Historic contamination of Perfluorinated Chemicals (PFCs) and Volatile Organic Compound (VOCs) are found in Washington County.
- **Radionuclides** - Elevated concentrations of naturally occurring radioactive radium occur within the bedrock Mt. Simon aquifer and related geologic units.
- **Arsenic** – 20 percent of tested wells have elevated arsenic with approximately four percent exceeding the safe drinking water act (SDWA) standard of 10 micrograms per liter (µg/L).
- **Nitrate** – less than one percent of tested drinking water wells had levels at or above the SDWA standard of 10 milligrams per liter (mg/L). Although, approximately 16 percent of samples from shallow wells (less than 50 feet deep) exceeded the SDWA standard.
  - MDA monitoring wells (shallow non-drinking water wells in agricultural areas) in Chisago County recorded the highest nitrate result at 9.21 mg/L.
  - MDA Township Testing Program (TTP) in Washington County confirmed nitrate is a significant issue in the southern part of the watershed. This is where row crop production combined with vulnerable geology has resulted in more than ten percent of the samples collected exceeding the SDWA standard.

[1] Areas of high pollution sensitivity allow the rapid downward movement of water into surficial sands (water table) aquifers, increasing the risk for groundwater contamination from surface pollutants.

    - More than 28 percent of the 300 wells tested in Cottage Grove Township exceeded the SDWA standard.
    - More than 13 percent of the 226 wells tested in Denmark Township exceeded the SDWA standard.
    - The areas with elevated nitrate correspond with the areas of high pollution sensitivity and karst geology.
  - **Pesticides** were detected in all three MDA monitoring wells, but not at concentrations above human-health based drinking water standards or reference values.

The contaminants listed above can affect public water systems when levels exceed drinking water standards. Some of the public water systems have water quality issues in their untreated source water that requires either blending or treating the water to meet SDWA standards. About 53 percent of the people living in the watershed get their drinking water from a public water supply system. Wellhead Protection Plans have been developed for most of the public water suppliers in the LSCRW and identify land use protections strategies for the approximately 63,900 acres in Drinking Water Supply Management Areas (DWSMAs).

Groundwater is generally available from bedrock aquifers. In areas near large high capacity wells, where groundwater is used heavily, levels vary seasonally. An analysis of groundwater levels in wells with at least 20 years of measurement identified that most water levels follow precipitation trends, but slightly delayed. The overall trend in groundwater levels has been down, but the trend correlates with rainfall. Water levels and precipitation have both been rising since 2013.

The LSCRW includes significant natural features, including surface waters that depend on groundwater to sustain them. If groundwater quantity or quality is degraded, these resources are at risk. The following features occur within the watershed:

- Groundwater seeps and springs associated with the St. Croix River are especially important for the 20 designated trout streams.
- Sixty-seven of the 533 lakes in the watershed have a watershed to lake ratio of 10 or less and are considered groundwater dependent lakes.
- Wetland complexes across the entire watershed.
- Twenty-six kinds of native plant communities and 40 state-listed endangered, threatened, or special concern plant and animal species connected to groundwater.

To address risks both from groundwater overuse and from the introduction of pollutants, this report outlines a broad range of strategies and specific actions that individuals, local government, and other partners can take. The nine categories of strategies highlighted below were selected to address the key risks to groundwater and drinking water within the 1W1P planning area. Areas of higher pollution sensitivity are often an appropriate place to prioritize pollution prevention activities.

1. **Education and Outreach:** Educate landowners, private well users, and others about how their actions affect groundwater and how they can conserve, restore, and protect groundwater.
2. **Subsurface Sewage Treatment Systems (SSTS) Management:** Monitor, maintain, and/or upgrade SSTS to ensure proper operation and treatment.
3. **Irrigation Water Management:** Control the volume, frequency, and application rate of irrigation water to sustain groundwater.
4. **Land Use Planning and Management:** Use city or county government planning and regulations along with land management goals that implement best management practices (BMPs), conserve water, and educate stakeholders to protect groundwater levels, quality, and contributions to groundwater dependent features.

5. **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.
6. **Conservation Easements:** Maintain and expand the amount of land protected from being converted to high intensity uses, such as row crop agriculture.
7. **Cropland Management:** Encourage the implementation of voluntary practices to manage resource concerns while minimizing environmental loss.
8. **Nutrient Management:** Assure that application of crop fertilizer or manure follows guidelines for the right source, right rate, right time, and right place.
9. **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.

This GRAPS report was designed to help prioritize and target local efforts to restore and protect groundwater resources in the LSCRW. Representatives from BWSR, MDA, MDH, DNR, MPCA, and the Metropolitan Council compiled existing state and regional data and developed maps to establish a baseline understanding of groundwater conditions and associated resource management concerns for the 1W1P planning boundary. The team highlighted strategies and supporting actions that can be applied at a county or watershed-level to help restore and protect groundwater. To target local implementation, actions listed in this report are paired with those counties and subwatersheds (HUC-10) where risks have been identified. This report should be used in conjunction with the WRAPS report, which focuses on surface water issues and needs, to ensure that both groundwater and surface water are effectively addressed during the 1W1P planning process.[2]

[2] It is important to note that groundwater science lacks the predictive tools available for surface water analysis and as such cannot provide quantifiable strategies commonly found in WRAPS. BWSR recognizes this challenge and has provided guidance in the Setting Measurable Goals document (www.bwsr.state.mn.us/planning/1W1P/Setting_Measurable_Goals.pdf) to meet the 1W1P measurability requirement.

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Introduction

What Is the GRAPS Report?

The State of Minnesota adopted a watershed approach to address the state's 81 major watersheds[3]. 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).

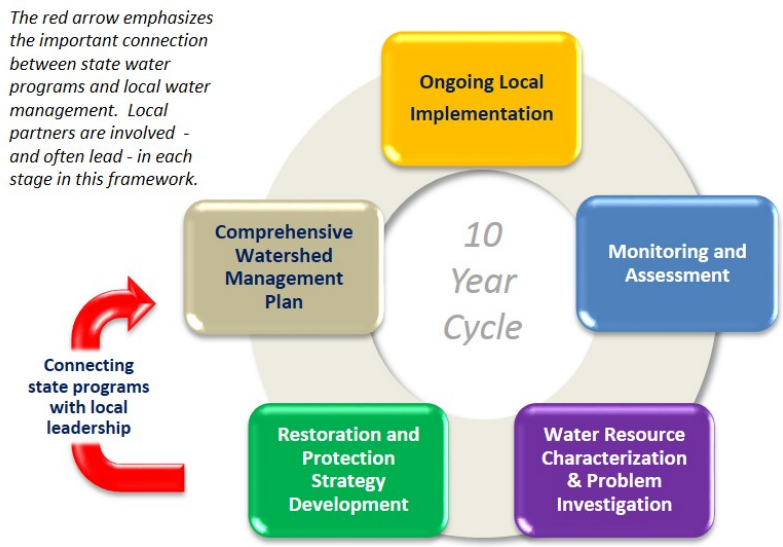

Figure 1: Watershed Approach Framework

Groundwater Restoration and Protection Strategies (GRAPS) reports are designed to help prioritize and target local efforts to restore and protect groundwater resources in the One Watershed One Plan (1W1P) planning process. 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 groundwater.

GRAPS reports are meant to be used in conjunction with Watershed Restoration and Protection Strategies (WRAPS) reports in the development of 1W1P plans. WRAPS inform how to restore and protect surface water, and GRAPS inform how to restore and protect groundwater in the same geographic area. WRAPS is initiated through an intensive monitoring effort to determine if a surface water body is meeting its designated use. WRAPS identify actions and the rate of adoption needed to restore water quality, as well as recognizing protection based activities to maintain the health of high quality surface waters. GRAPS is largely protection-based—identifying actions to maintain groundwater

[3] 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).

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. In most cases, it is very difficult determine the rate of BMP adoption needed to restore groundwater; therefore, quantification is not part of GRAPS.

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 the different needs and information partners and agencies may seek. This report is not necessarily designed to be read cover to cover. Rather, you can flip to the parts that are most relevant to the issues facing your community. If you are accessing this document electronically, you can click on hyperlinks throughout the report to jump to related information and/or access webpages (all hyperlinks are in blue font).

The report is divided into the following parts:

1. **Lower St. Croix River Watershed Overview**: This section provides a brief overview of the watershed.
2. **Lower St. Croix River Watershed 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. **Lower St. Croix River Watershed 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**

Lower St. Croix River Watershed Overview

This section 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 Lower St. Croix River Watershed (LSCRW) groundwater quality and quantity. You can find more detailed information about the LSCRW and groundwater through the following resources:

Groundwater Plans

- Washington County Groundwater Plan (www.co.washington.mn.us/DocumentCenter/View/794)
- DNR North & East Metro Groundwater Management Area (www.dnr.state.mn.us/gwmp/area-ne.html)

Completed WRAPS (WRAPS reports were completed at a smaller subwatershed scale)

- MPCA Sunrise River Watershed WRAPS (www.pca.state.mn.us/water/tmdl/sunrise-watershed-multiple-impairments-tmdl-project)
- MPCA Goose Creek Watershed WRAPS (www.pca.state.mn.us/water/tmdl/goose-creek-watershed-restoration-and-protection-project-tmdl-project)
- MPCA Valley Branch Watershed WRAPS (www.pca.state.mn.us/water/tmdl/valley-branch-watershed-district-watershed-restoration-and-protection-strategy-project)

Completed TMDLs and Implementation Plans

- MPCA Lake St. Croix - Excess Nutrients TMDL (www.pca.state.mn.us/water/tmdl/lake-st-croix-excess-nutrients-tmdl-project)
- MPCA Carnelian-Marine St. Croix WD Lakes - Excess Nutrients TMDL (www.pca.state.mn.us/water/tmdl/carnelian-marine-st-croix-wd-lakes-excess-nutrients-tmdl-project)
- MPCA Chisago Lakes TMDL - Nutrient/Eutrophication Biological Indicators (www.pca.state.mn.us/water/tmdl/chisago-lakes-tmdl-nutrienteutrophication-biological-indicators-tmdl-project)
- MPCA Comfort Lake-Forest Lake Watershed District Impaired lakes - Excess Nutrients TMDL (www.pca.state.mn.us/water/tmdl/comfort-lake-forest-lake-watershed-district-impaired-lakes-excess-nutrients-tmdl-project)
- MPCA Martin and Typo Lakes - Excess Nutrients TMDL (www.pca.state.mn.us/water/tmdl/martin-and-typo-lakes-excess-nutrients-tmdl-project)
- MPCA Browns Creek Lack of Cold Water Assemblage and Impaired Biota TMDL (www.pca.state.mn.us/water/tmdl/browns-creek-lack-cold-water-assemblage-and-impaired-biota-tmdl-project)

Monitoring and Assessment Plans

- MPCA Lake St. Croix Total Phosphorus Loading Study (www.pca.state.mn.us/sites/default/files/wq-iw6-04i.pdf)
- MPCA Nutrient Reduction Strategy (www.pca.state.mn.us/sites/default/files/wq-s1-80.pdf)

The LSCRW watershed (0703005) encompasses 585,735 acres in east central Minnesota within the St. Croix River Basin. It begins downstream of the confluence of the St. Croix and Snake rivers near Pine City, and runs parallel to the St. Croix River to the Mississippi River near Prescott, Wisconsin. The watershed includes portions of Pine, Chisago, Isanti, Anoka, and Washington counties (Figure 2). Its close proximity to expanding suburban landscapes has led to an increase in population of nearly 14

percent between 2000 and 2010. Anoka and Washington County fall within Metropolitan Council jurisdiction, resulting in greater access to information on land use, population, natural resources, and water resource planning. Metropolitan Council data and information is accessible in the Additional Resources section found in the appendices.

Of the roughly 158,704 people living in the watershed, approximately 83,939 (53 percent) use community public water. The remaining 47 percent get their drinking water from private wells.

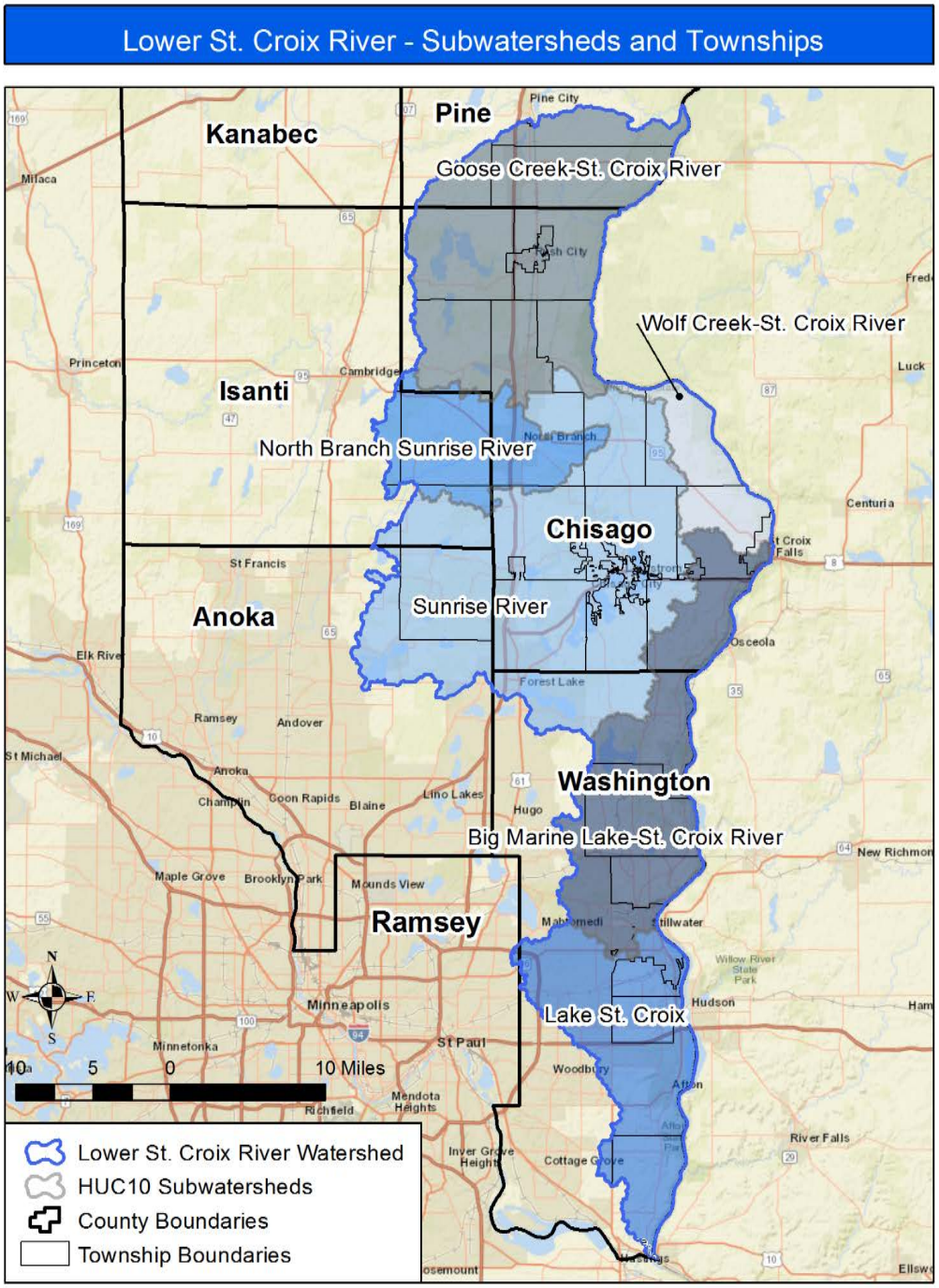

Figure 2: Lower St. Croix River Watershed – Six Subwatersheds (HUC-10): Goose Creek-St. Croix River, North Branch Sunrise River, Wolf Creek-St. Croix River, Sunrise River, Big Marine Lake–St. Croix River, Lake St. Croix.

Land Use

The LSCRW is comprised of rolling, woodland bluff land, and small wooded valleys, with agriculture and urban development above the bluff land. Before western settlement, hardwood forests and mixed savannah with large white pine stands in the far northern portion of the watershed dominated the landscape. In the mid 1800's the area experienced a logging boom that cleared the land for agricultural production. The conversion in land use is still evident, with agricultural production as the largest land cover type, followed by forested land (Figure 3 and Figure 4).

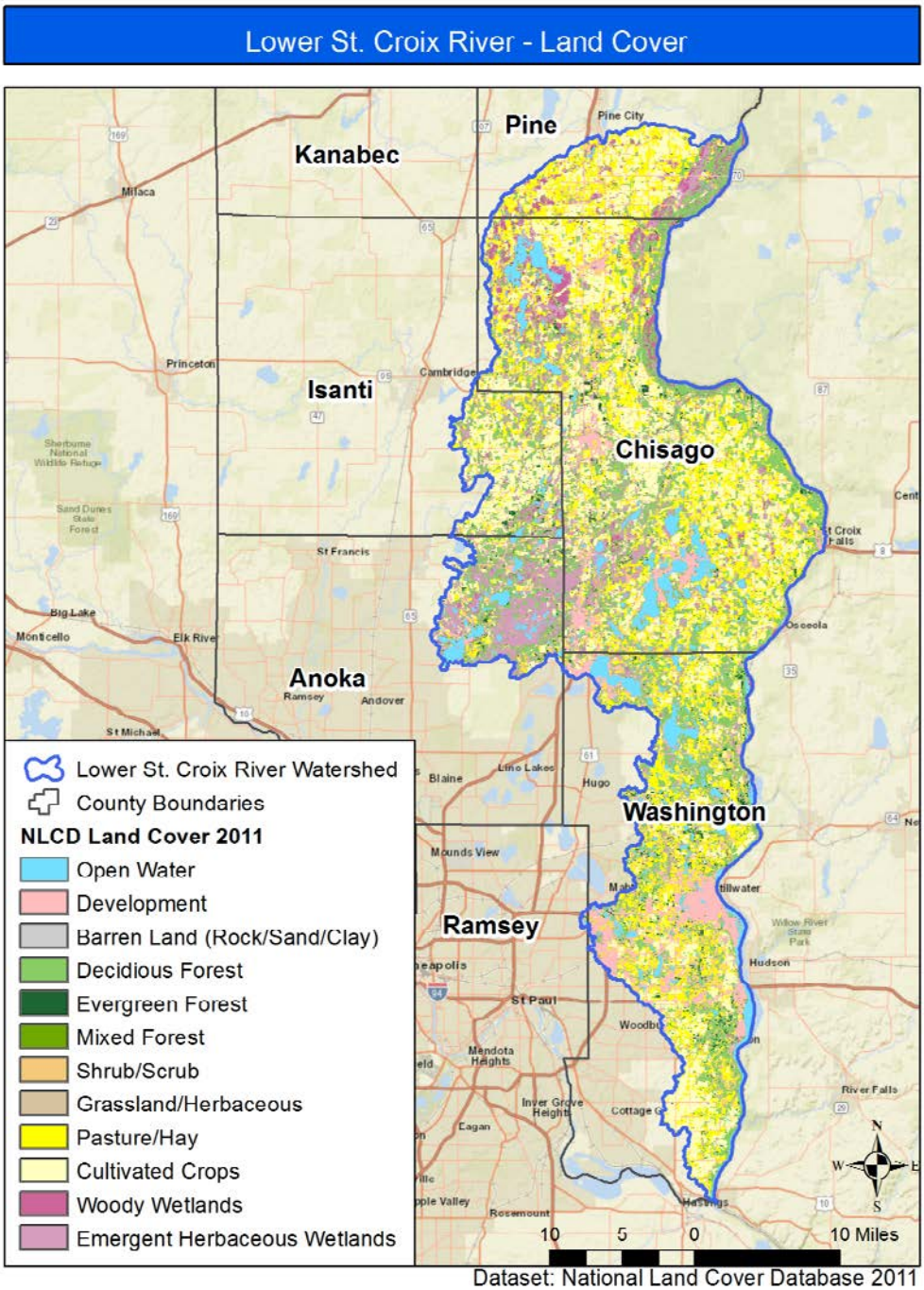

Figure 3: Lower St. Croix River Watershed - Land Cover

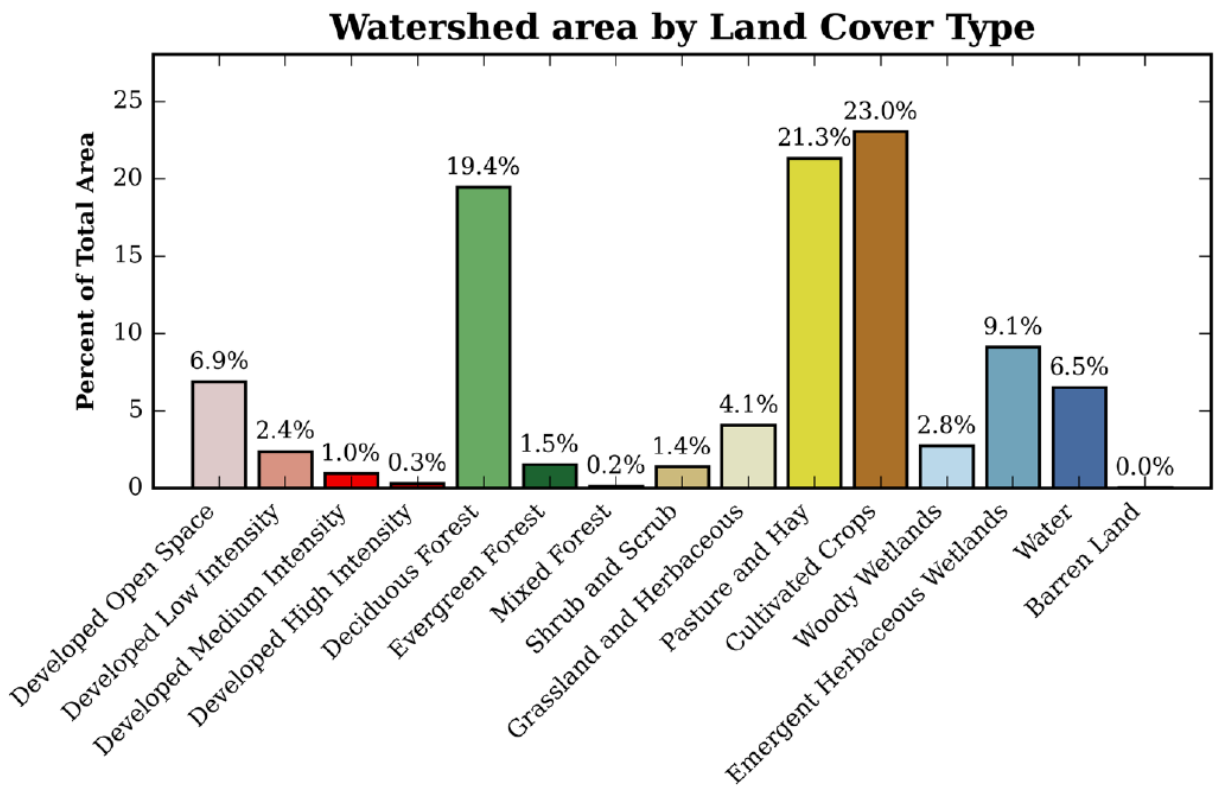

Figure 4: A summary of land cover type in the Lower St. Croix River Watershed

Geology and Hydrogeology

Groundwater sources within the LSCRW vary according to the underlying geology. The geology in the LSCRW is the result of complex processes, which occurred from igneous, metamorphic, sedimentary and glacial action that took place in the region over several geologic time periods. Figure 5 depicts a generalized map of aquifers in the watershed. Figure 6 is a simplified geologic cross-section of the LSCRW.

There are three major types of bedrock aquifers in the watershed (Figure 5):

- Basalt (volcanic rocks) in the northernmost part of the watershed.
- Sandstone (Jordan Sandstone, Tunnel City Group/Wonewoc Sandstone, and Mt. Simon Sandstone aquifers) that are present through the middle section of the watershed as well as through the St. Croix River Valley.
- Sandstone/carbonate mix aquifers (Prairie du Chien Dolomite, St. Peter Sandstone, and Platteville Limestone) prevalent in the southern half of the LSCRW.

Glacial deposits in the watershed consist mainly of undifferentiated red and gray drift (predominantly till) and corresponding outwash derived from them. These outwash units form aquifers locally.

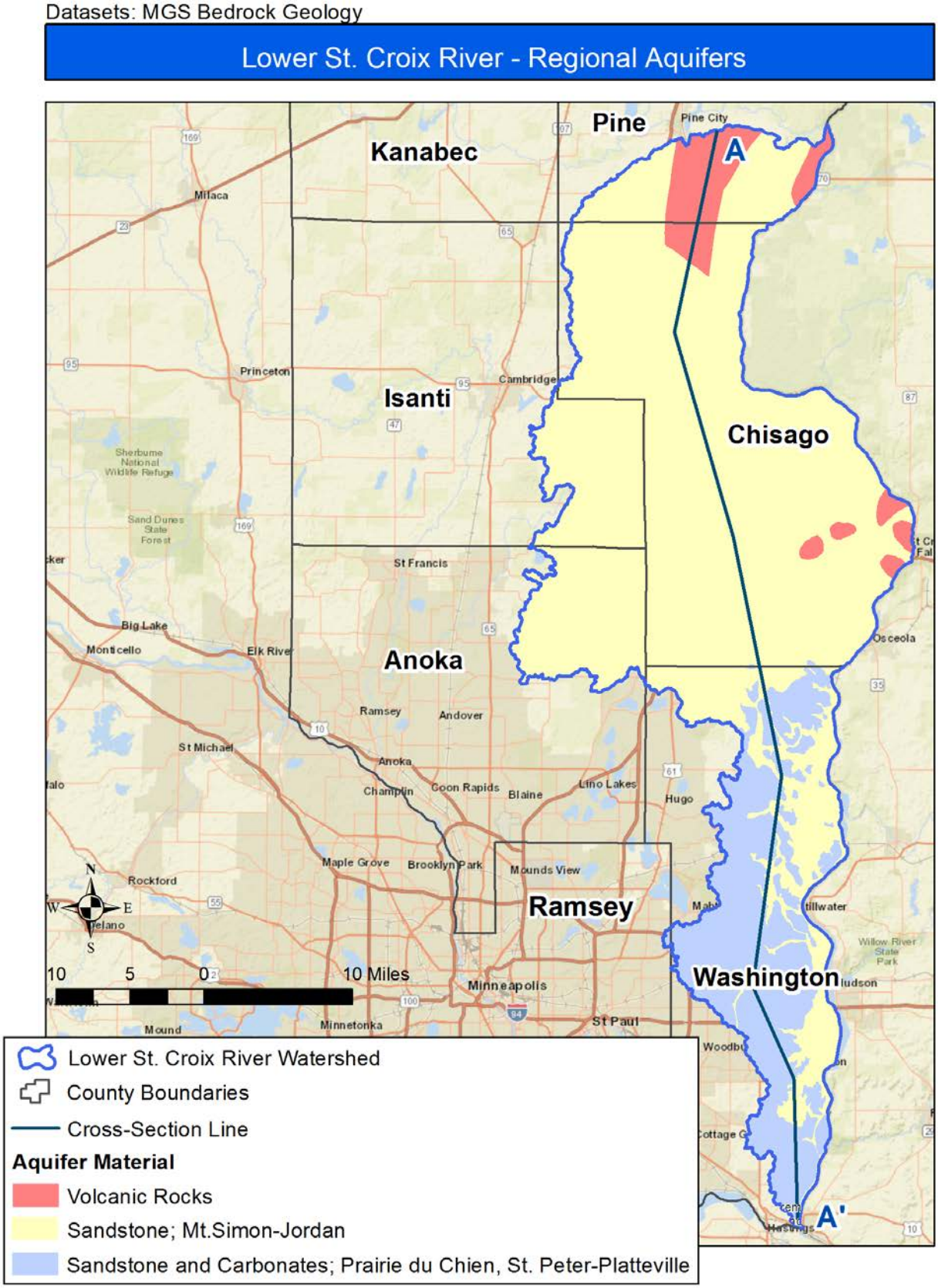

Figure 5: Lower St. Croix River Watershed - Regional Aquifers: Volcanic Rocks, Sandstone, and Sandstone/Carbonates.

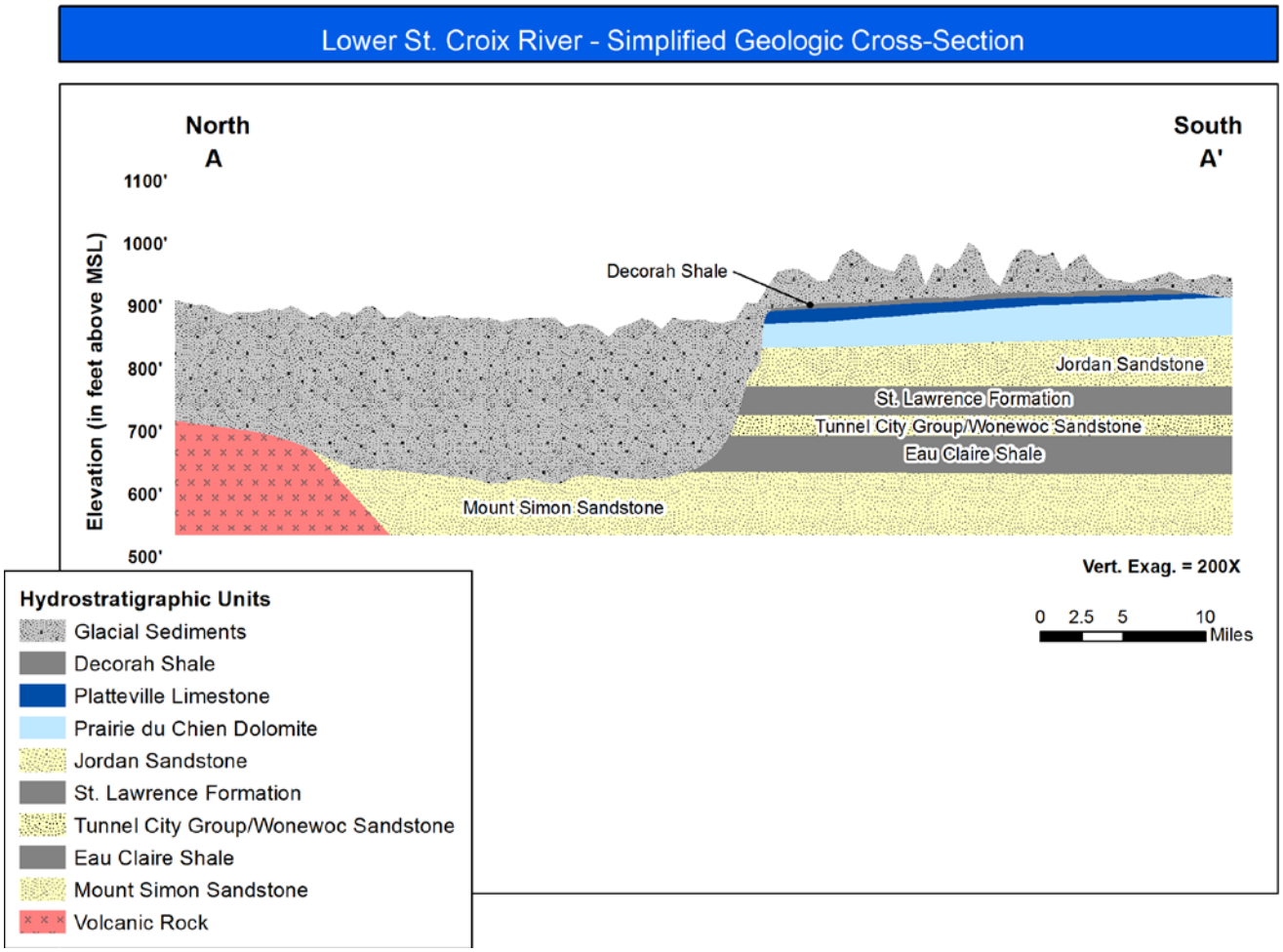

Figure 6: Lower St. Croix River Watershed - Simplified Geologic Cross-Section

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.

It is important to understand the target aquifer when assessing pollution sensitivity. Certain aquifers may be deeper and more geologically protected than water table aquifers, or surficial sand aquifers, in a given area. Figure 7 depicts the pollution sensitivity of near-surface materials dataset developed by the DNR. This dataset only takes into account the top ten feet of soil and geologic material when assigning a sensitivity rating. This figure shows that the watershed has a mix of pollution sensitivity ratings based on surficial materials. The southern part of the watershed in Washington County has a higher pollution sensitivity rating due to the presence of karst.

Karst conditions include features such as sinkholes, caves, sinking streams, and springs. Dissolution of water-soluble carbonate rocks (such as limestone and dolostone) create these features. Dissolution starts an erosive process and creates conduits for rapid groundwater flow within the rock mass. Areas with karst conditions are more likely to have rapid exchange between surface water and groundwater. This rapid exchange increases the risk of surface contaminants polluting groundwater (Adams, Barry, Green, et. al, 2016). A band of 'high' pollution sensitivity reaches through portions of Chisago, Isanti, and

Anoka counties in the middle of the watershed. More information on this dataset can be found on the DNR website Minnesota Hydrogeology Atlas (MHA) (www.dnr.state.mn.us/waters/programs/gw_section/mapping/platesum/mha_ps-ns.html).

The pollution sensitivity of deeper aquifer materials depicted in Figure 9 was created by calculating the sensitivity at individual wells in the watershed and then interpolating between them to create a smooth layer. The wells used to make this figure vary in depth but overall provide a picture of the geologic sensitivity of aquifers below the water table. This method was employed due to the absence of an available statewide dataset depicting pollution sensitivity, or vulnerability, of aquifers. This figure shows that most of the watershed has a 'low' pollution sensitivity rating. The southern part of the watershed in Washington county has a mix of 'moderate' and 'high' pollution sensitivity ratings. Similar to Figure 7, a small band that reaches through portions of Chisago, Isanti, and Anoka counties also displays pockets of more 'moderate' and 'high' pollution sensitivity areas than in the rest of the watershed. More information on the geologic sensitivity calculations used to make this figure is included in the references section of this report as Figure 40 and Figure 41.

It is also important to understand how recharge travel time ratings (Figure 7 and Figure 9) for surficial water table aquifers differ from those used for deeper aquifers (Table 1). 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 (Figure 10). This difference stems from the fact that infiltrating water and contaminants reach surficial materials more quickly than deeper 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.

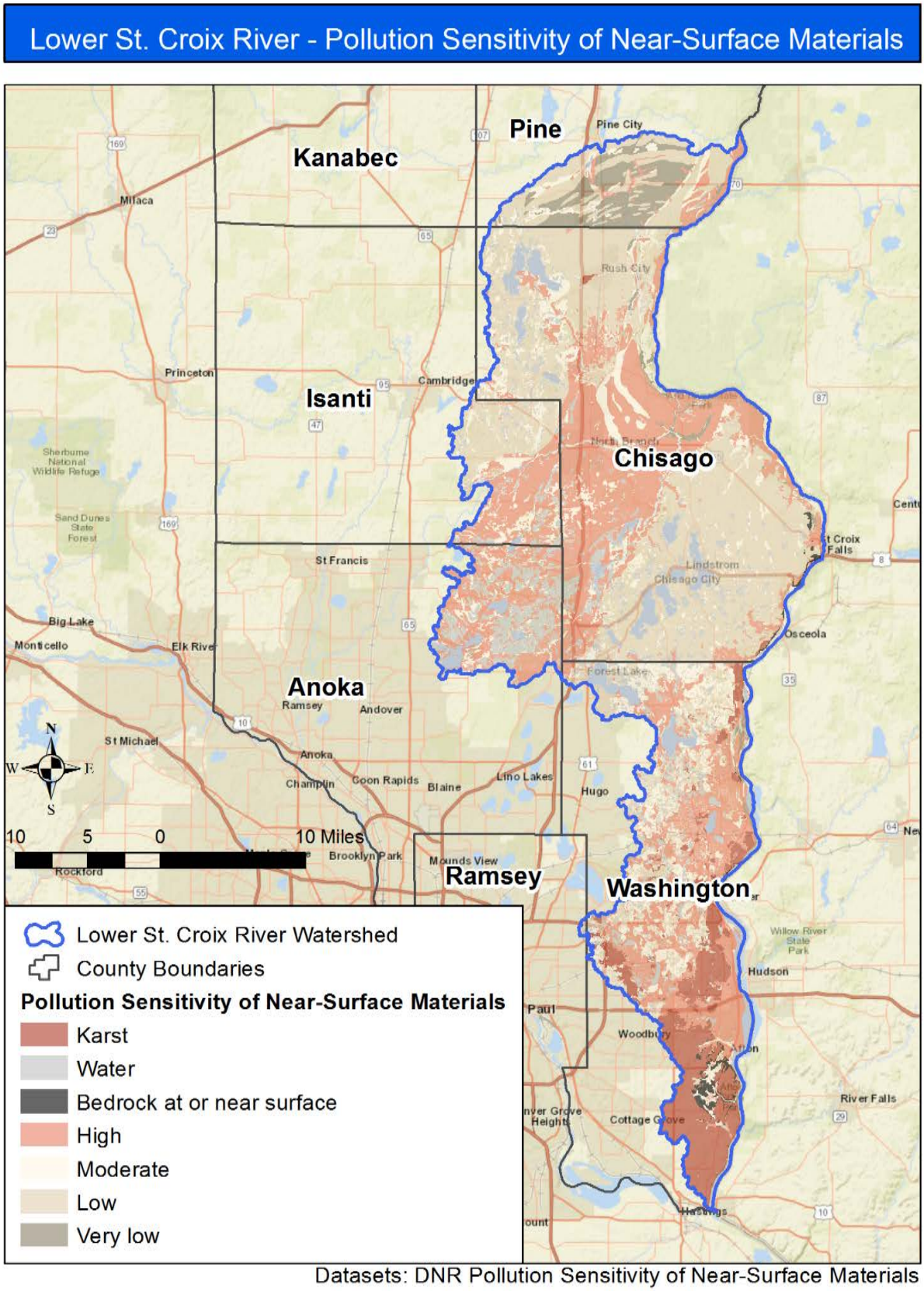

Figure 7: Lower St. Croix River Watershed - Pollution Sensitivity of Near Surface Materials

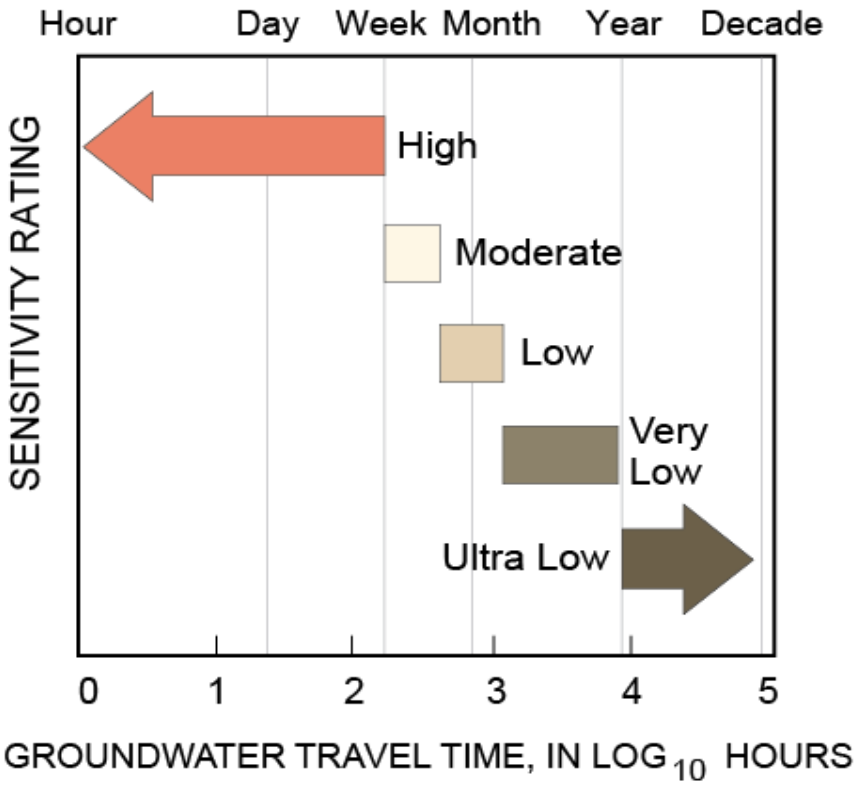

Figure 8: Recharge Travel Time for Near-Surface Materials

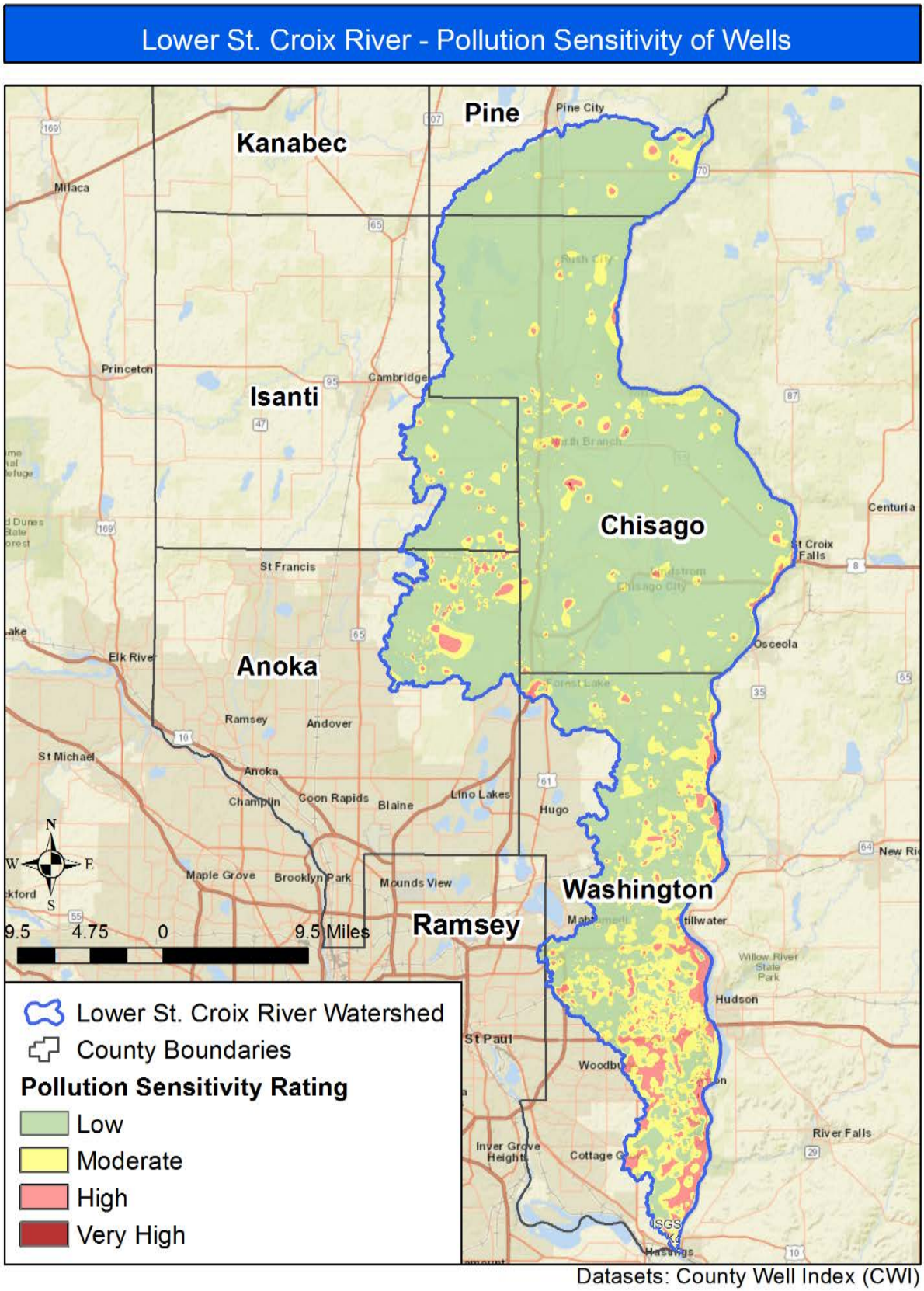

Figure 9: Lower St. Croix River Watershed - Pollution Sensitivity of Wells

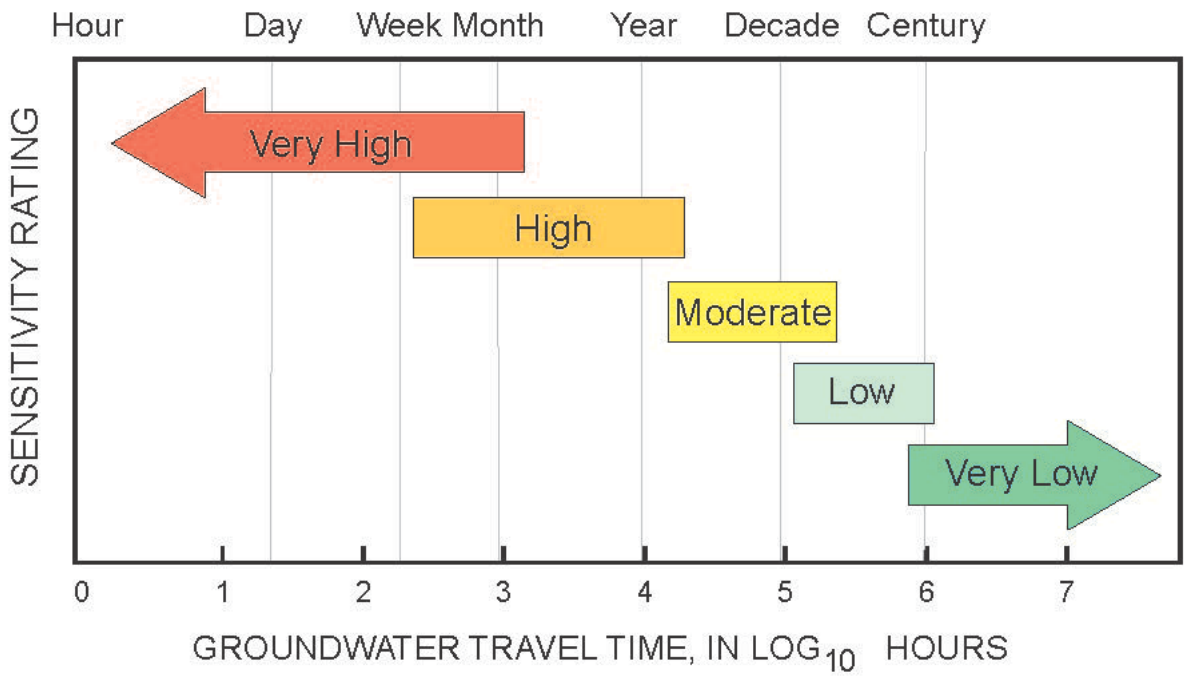

Figure 10: Recharge Travel Time for Buried Aquifers

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

Pollution Sensitivity Rating	Aquifer Recharge Time Period[4] for Surficial Aquifers	Aquifer Recharge Time Period for Buried Aquifers
High	Hours to a week	Days to months
Moderate	A week to weeks	Years up to one or two decades
Low	Weeks to a year	Several decades to a century

[4] 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.

Wellhead Protection Planning and Drinking Water Supply Management Areas

Wellhead protection planning is the process 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 vulnerability and are appropriate for safeguarding drinking water supplies. Community public water suppliers, including municipal and non-municipal systems, 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 in order to more easily manage the groundwater below. Learn more about the MDH Source Water Protection Program at Source Water Protection (www.health.state.mn.us/divs/eh/water/swp/).

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 used (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 activities at the ground surface can easily contaminate the aquifers and wells. Others are deeper or more protected by geologic materials; these tend to exhibit a low vulnerability to overlying land uses. The types of management activities required within WHPAs will vary based largely on these vulnerability assessments. Highly vulnerable WHPAs require a greater level of management to prevent potential contaminants at the ground surface from entering the aquifer. Whereas for WHPAs with low vulnerability the primary focus is on sealing unused/unsealed wells, since this is the primary pathway for contaminants to reach the aquifer.

Twenty-six of the 41 community public water supply systems within the LSCRW are in the wellhead protection planning process or are implementing their plans. Of the 29 systems with approved plans, the vulnerability varies across the watershed from very low to very high. Many of the non-vulnerable systems are located in Chisago County, whereas the systems in Washington County exhibit a greater risk to pollution with moderate to very high vulnerabilities. Figure 11 shows the status of wellhead protection planning for the public water supplies in the watershed. Figure 12 shows the DWSMAs delineated at the time the report was compiled in the LSCRW. Table 9 provides additional detail on public water suppliers in the LSCRW, including their WHP planning status, DWSMA vulnerability, and the size of DWSMA in acres. It is important to note that WHP areas do not follow watershed boundaries therefore; several DWSMAs are located in two watersheds. Table 9 identifies the partial DWSMAs.

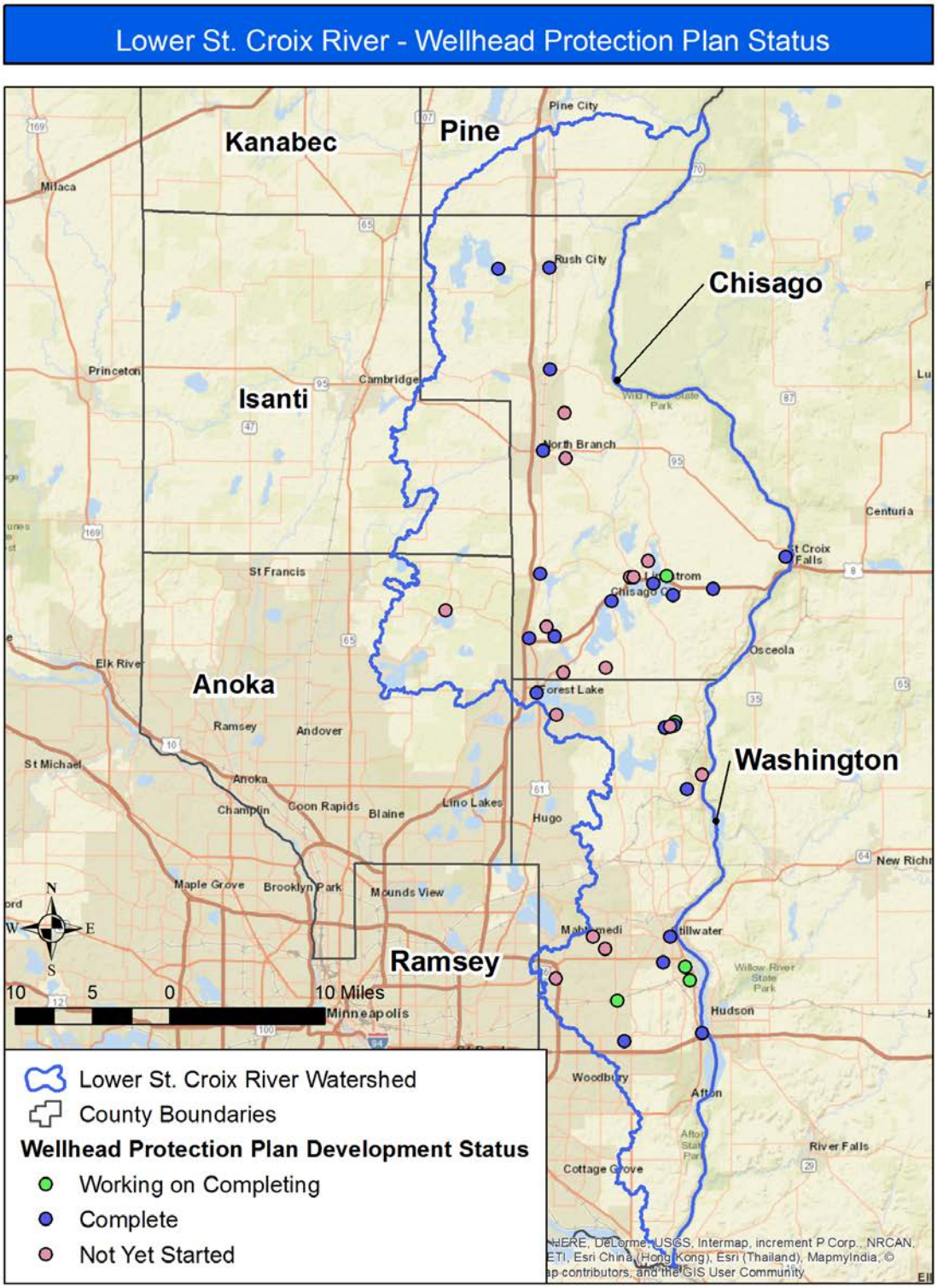

Figure 11: Lower St. Croix River Watershed - Wellhead Protection Plan Development Status for Community Public Water Supply Systems. ***Twenty-six*** *of the 41 public water supply systems are in the wellhead protection planning process or are implementing their plans.*

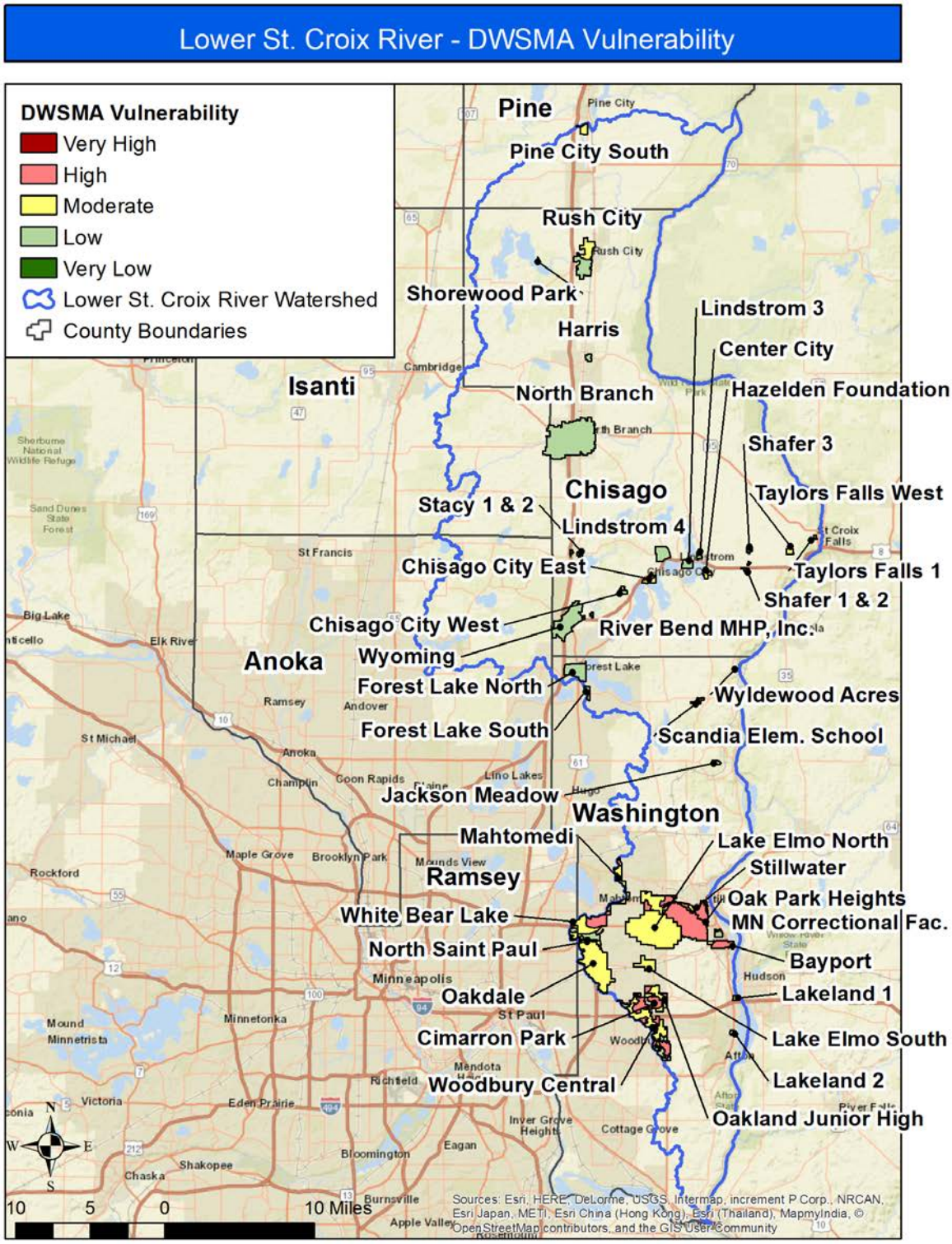

Figure 12: Lower St. Croix River Watershed - Drinking Water Supply Management Areas. There are 29 approved Drinking Water Supply Areas (DWSMA) for community public water supply systems in the watershed.

Groundwater Use

The largest water user in the LSCRW uses St. Croix River water for cooling at a power plant. Power plant cooling uses about 120 billion gallons per year, or 97 percent of the reported water use in the LSCRW. Power plant cooling is mostly non-consumptive and greatly skews the water use statistics, so power plant cooling has been removed from the water use statistics for the remainder of this report.

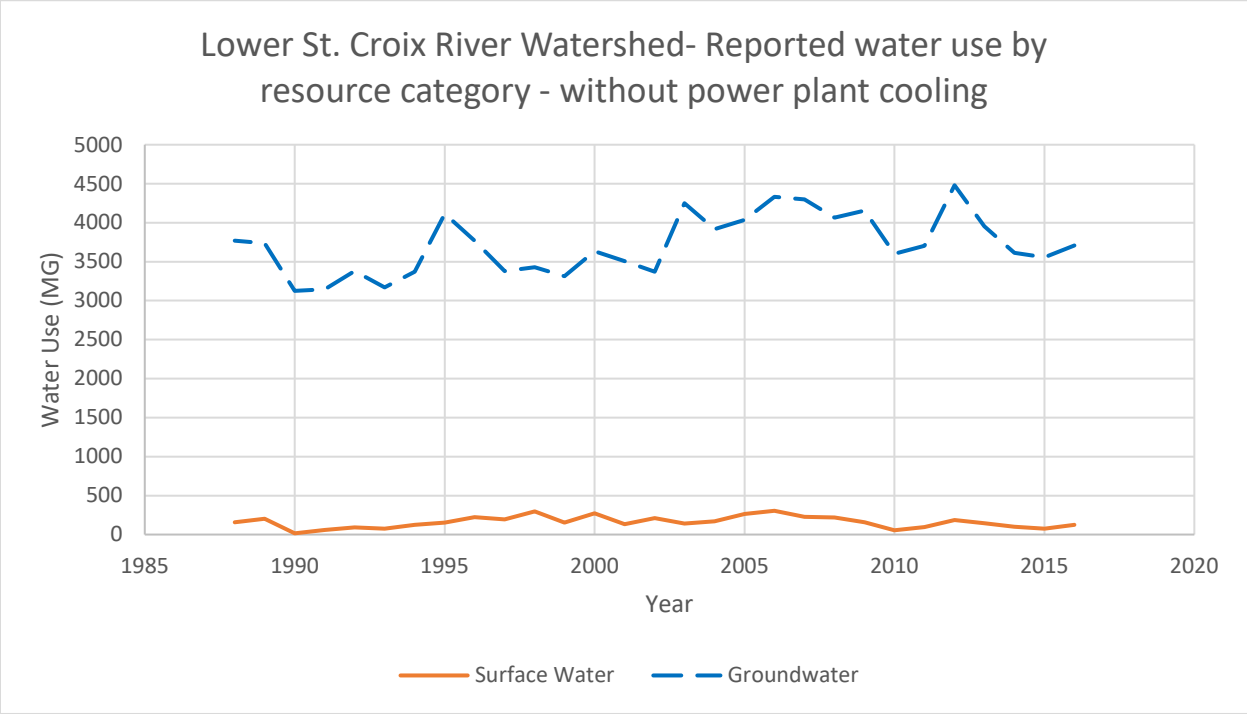

Figure 13: Reported Water Use by Resource Category, not including power plant cooling. Groundwater accounts for about 97 percent of the total reported water use in the Lower St. Croix Watershed, when power plant cooling is excluded from the total.

Groundwater accounts for 97 percent of the non-power-plant-cooling reported water use (Figure 13). Groundwater use totals about 3,700 gallons per year (Figure 15). More than 80 percent of groundwater withdrawn in the watershed is used for public water supply.

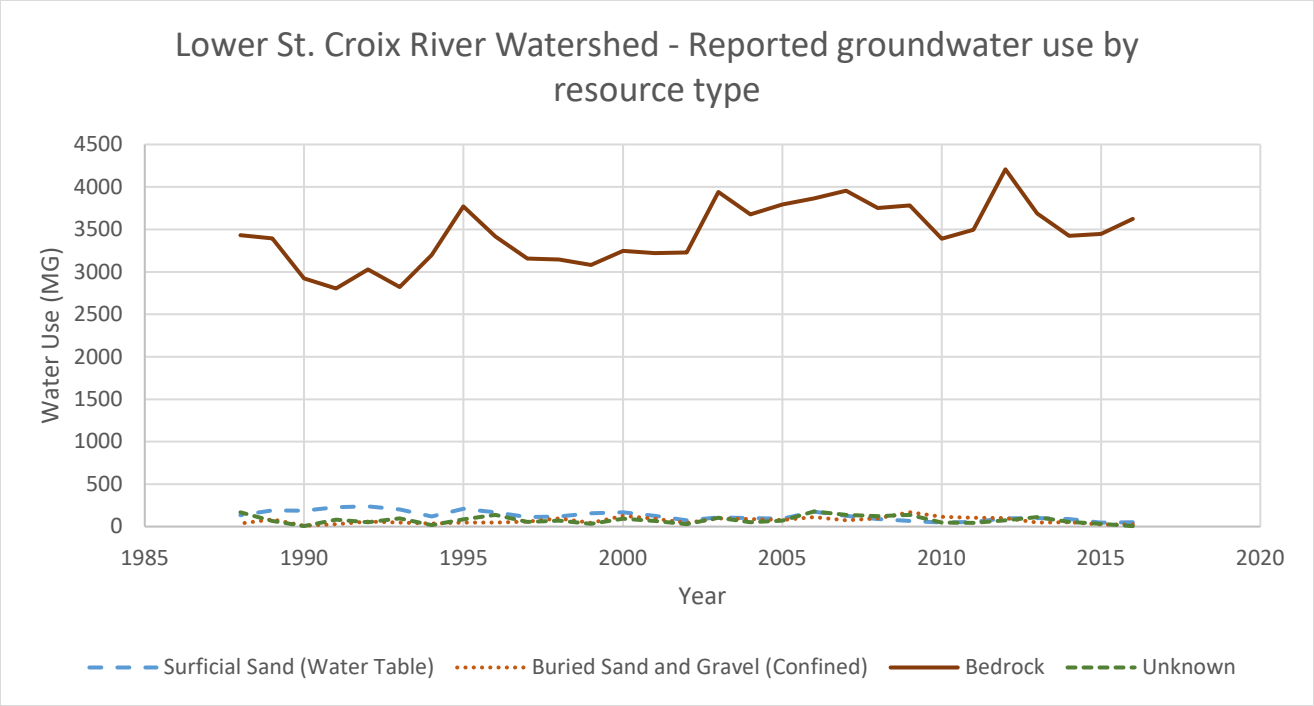

Figure 14: Reported groundwater use by aquifer type. More than 90 percent of groundwater used in the Lower St. Croix Watershed is taken from bedrock aquifers and water use from bedrock aquifers is growing. Surficial Sand (Water Table) and Buried Sand and Gravel (Confined) aquifers account for a small percentage of groundwater use.

Groundwater is sourced from three aquifer types (Figure 14): historically, more than 90 percent is pumped from bedrock aquifers, and the percent of water taken from bedrock sources has increased from 1990 to today. Surficial sand (water table) and buried sand and gravel (confined) aquifers only account for a small percentage of water use. Water use has risen from about 3,000 million gallons in 1990 to about 3,500 million gallons in 2016.

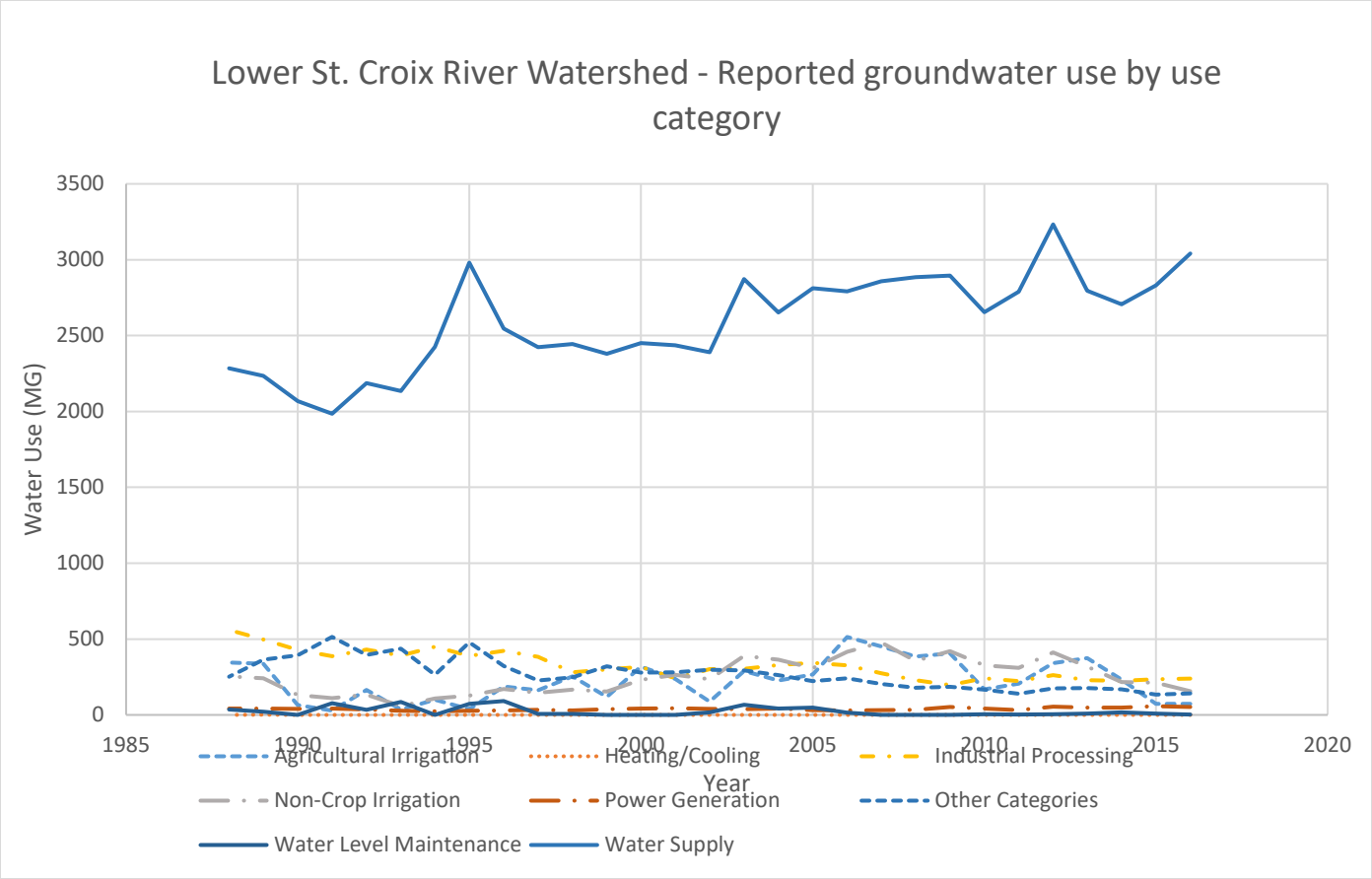

Figure 15: Water Use by Use Category. More than 80 percent of permitted groundwater withdrawals are used for municipal water supply. Pumping for water supply has risen from about 2000 million gallons per year in 1990 to about 3000 million gallons per year in 2016. Other uses have remained stable. Thus the most growth in water use is from increased demand for water supply.

Groundwater Withdrawals

A water-use appropriation permit from the DNR is required for all water appropriators (surface or groundwater) withdrawing more than 10,000 gallons of water per day or 1 million gallons per year. This provides the DNR with the ability to assess and regulate which aquifers are being used and for what purpose. One condition of the appropriation permit is to report actual water use; the DNR has records of reported water use from 1988 to the present.

Table 2 [5] provides data from the Minnesota DNR Permitting and Reporting System (MPARS).

[5] MGY means million gallons per year; dash marks (-) indicate no use in those categories; percentages may not total to 100 due to rounding.

Table 2: Reported 2016 water use from DNR groundwater permit holders

Aquifer	Water Supply	Agricultural Irrigation	Industrial Processing	Non-Crop Irrigation	Power Generation	Other	Total (MGY)	Total (percent)
Surficial Sand (Water Table)	-	2	33	-	-	15	50	1.35
Buried Sand and Gravel (Confined)	18	2	-	2	-	4	26	0.70
Bedrock	3023	64	206	154	52	125	3624	97.81
Unknown	-	5	-	-	-	-	5	0.14
Total (MGY)	3041	73	239	156	52	144	3705	100.00
Total (percent)	82.14	1.92	6.46	4.27	1.40	3.81	100.00	--

Most groundwater is used for water supply. Industrial processing is the second largest water user, followed by non-crop irrigation. Other uses account for less than ten percent of reported water use.

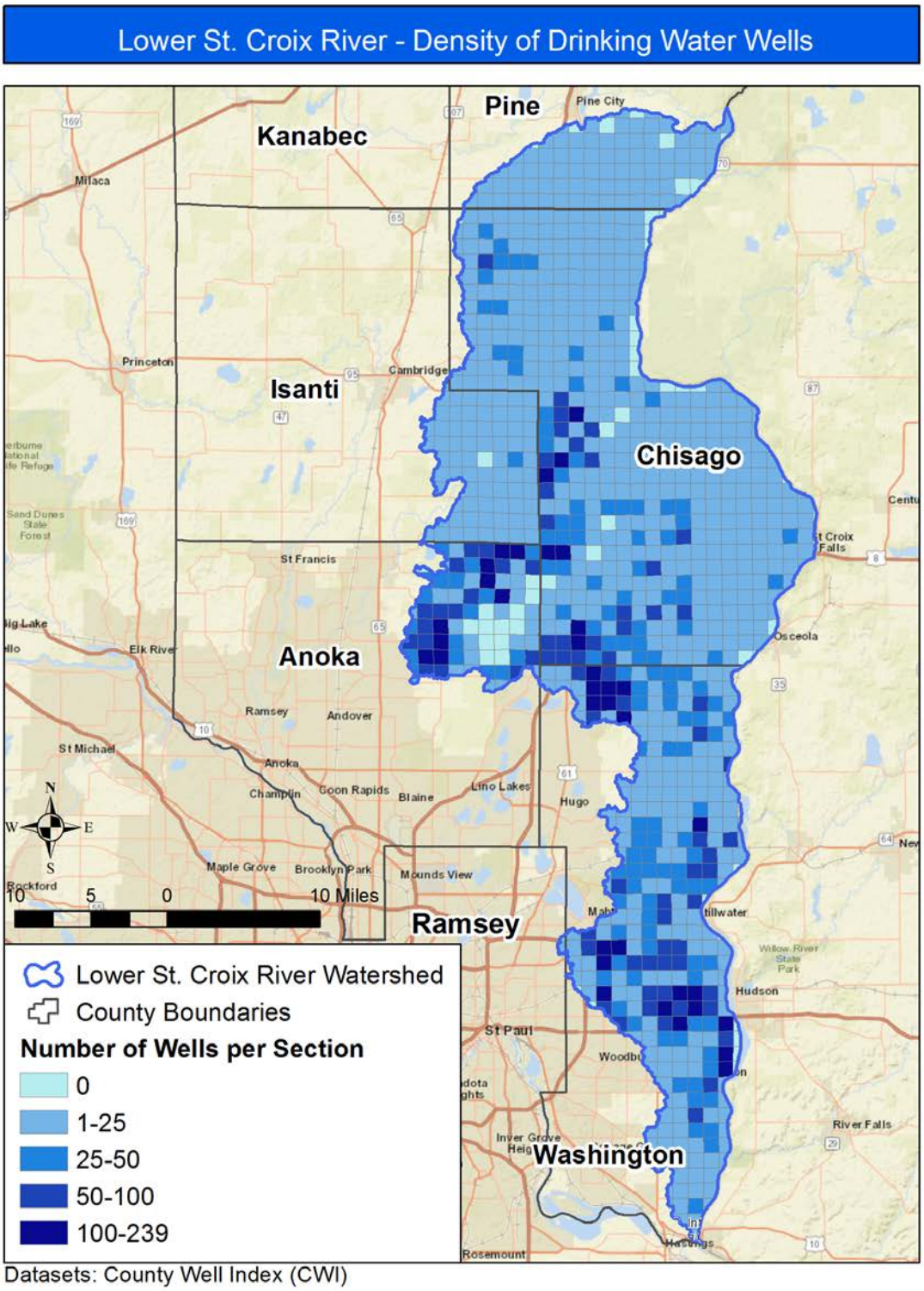

Figure 16: Lower St. Croix River Watershed – Density of Drinking Water Wells per Section.

Figure 16 illustrates well density in the LSCRW watershed. This figure contains a grid that depicts the number of wells in each six-by-six mile section of the watershed. Deeper colors correspond to a higher concentration of wells. Well density varies across the watershed. Only wells used for drinking water were included in this analysis.

Lower St. Croix River Watershed Groundwater Issues and Concerns

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

Groundwater Quality Issues and Concerns

Both naturally occurring and human-made contaminants affect the LSCRW groundwater quality. Multiple state agencies monitor different types of groundwater wells and public water systems for contaminants. Nitrate, pesticides, arsenic, radium, perfluorochemicals (PFCs), and volatile organic compounds (VOCs) have been detected in wells sampled in the LSCRW. This section provides context and data about these contaminants and their occurrence in the watershed. It also provides information about the following land uses: feedlots, row crop production, subsurface sewage treatment systems, contaminated sites (leaky tank sites and closed landfills), and household hazardous waste in the watershed that may affect groundwater quality.

All public water systems in the watersheds are required to meet Safe Drinking Water Act (SDWA) requirements for the quality of water served to their customers. Some public water systems have water quality issues in their untreated source water that requires either blending or treatment to meet SDWA standards.

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)[6] in groundwater, human activity is the likely cause (State of Minnesota Workgroup). 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 found in groundwater used for drinking water. The SDWA standard for nitrate in drinking water is 10 mg/L. Less than one percent of the 12,249 samples taken from wells within the watershed had levels of nitrate at or above the SDWA standard. This dataset includes newly constructed wells, private wells, and other drinking water supply wells sampled by MDH. Sampling of newly constructed wells for nitrate began in 1974. Many wells built prior to the well code are not included in this dataset. Table 3 shows nitrate test results for samples taken from these wells.

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

Table 3: Summary of Nitrate-N results in drinking water wells of the Lower St. Croix River Watershed.

Depth Completed Range (feet)	Total samples (n)	Minimum concentration (mg/L)	Maximum concentration (mg/L)	Median concentration (mg/L)	Samples at or above 3 mg/L (%)	Samples at or above 10 mg/L (%)
< 50	64	0	33.2	0.7	29.7	15.6
50 - 99	3143	0	12.2	0.6	5.9	0.1
100 - 149	2807	0	9.8	0.5	5.1	0
150 - 199	2478	0	53.77	0.5	5.0	0.1
>= 200	3757	0	9.91	0.7	11.5	0
Total	12249	0	57.77	0.5	7.4	0.1

The table does not display all information used to calculate the 'total' columns, with the exception of the total samples.

Where Is Nitrate in Lower St. Croix River Watershed?

High 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 the 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 LSCRW 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 3. These nitrate samples were taken from newly constructed wells, private wells, and other drinking water supply wells sampled by MDH.
- Figure 18 shows the Township Testing Program (TTP) schedule and the townships in which at least 10 percent of the wells tested had nitrate concentrations above the SDWA standard. MDA identified townships where groundwater is vulnerable and row crop agriculture is present as the focus of the testing program. In Cottage Grove Township, more than twenty-eight percent of the 300 wells sampled were over the SDWA standard for nitrate. In Denmark Township, more than thirteen percent of the 226 wells sampled were over the SDWA standard for nitrate. The completed townships (Cottage Grove and Denmark) are located in Washington County. Townships in Chisago County are scheduled to be sampled in 2018. Learn more about the TTP at Township (Nitrate) Testing Program (www.mda.state.mn.us/townshiptesting).
- Figure 19 shows the nitrate concentrations recorded at each MDA ambient monitoring well location in the LSCRW in 2016. The sampling data collected from Chisago County, records the highest nitrate result at 9.21 mg/L.
- Figure 22 shows the MPCA Ambient Monitoring Well locations and through their sampling activities nitrate (inorganic nitrogen) was detected in 99.2 percent of all samples. More information is reported in the Ambient Groundwater Monitoring section of the report.

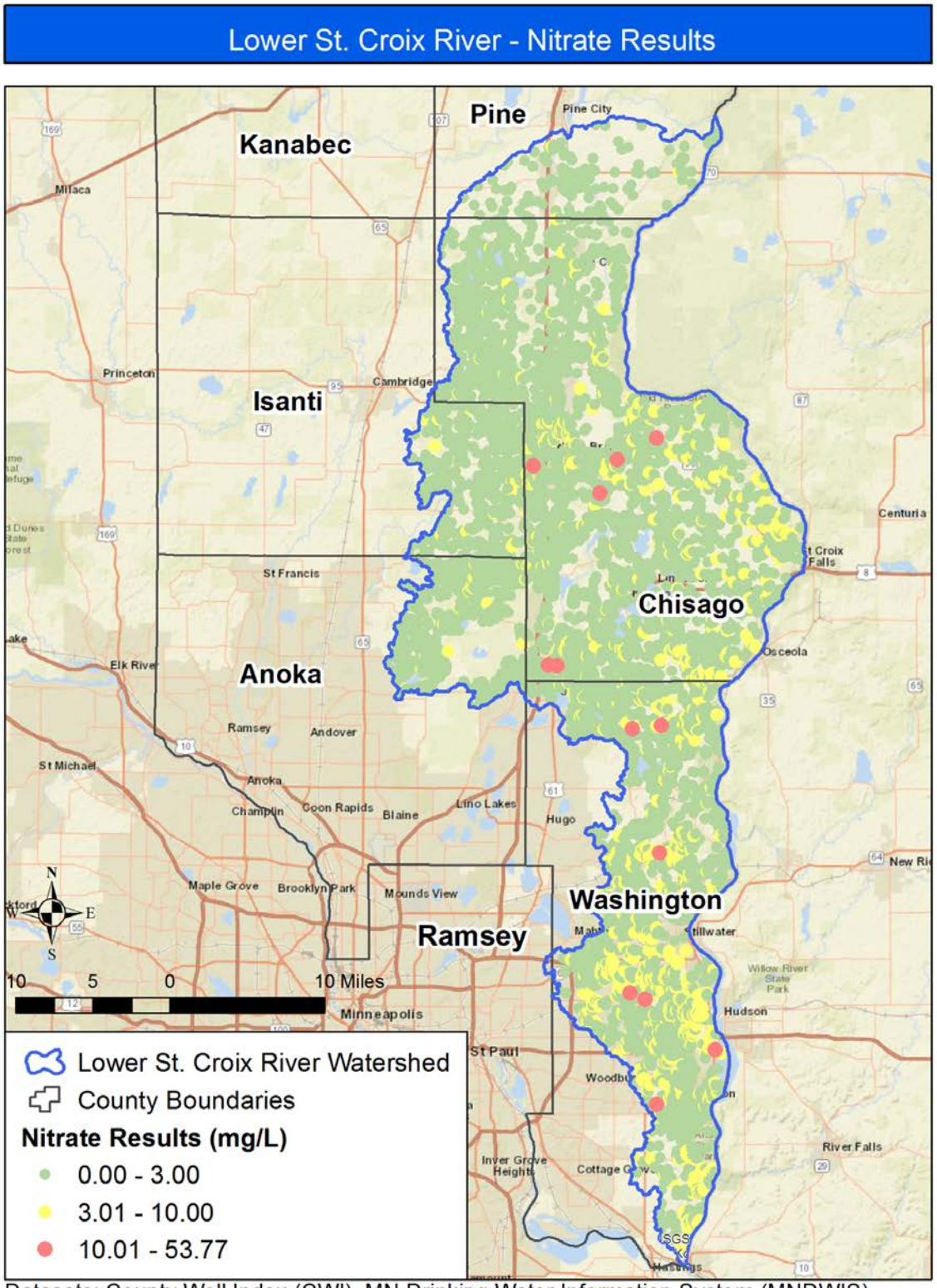

Figure 17: Lower St. Croix River Watershed - Nitrate Results and Pollution Sensitivity of Wells

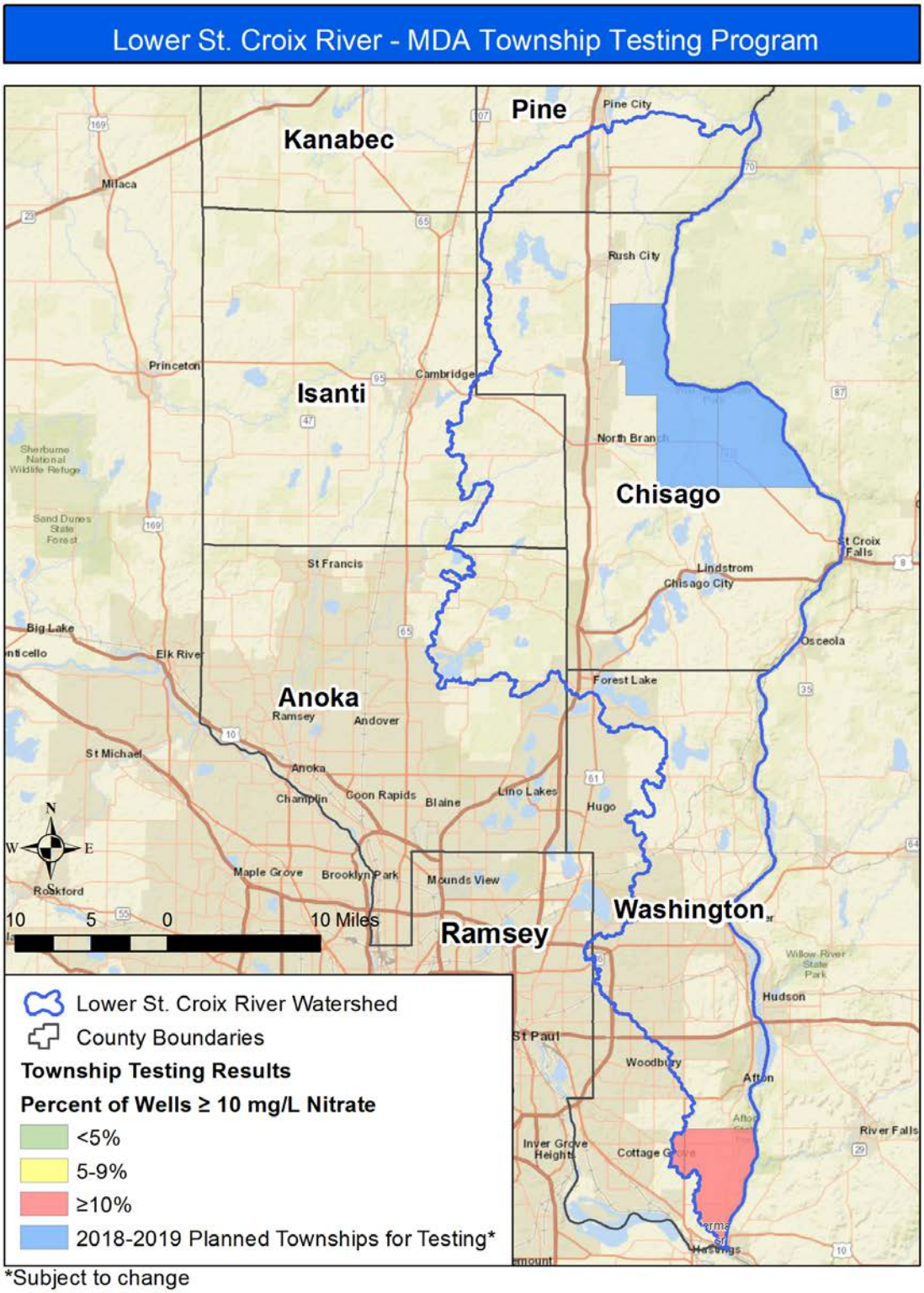

Figure 18: Lower St. Croix River Watershed - MDA Township Testing Program. Five hundred and twenty-six wells were sampled in Cottage Grove and Denmark Township in 2014.

Figure 19: Lower St. Croix River Watershed - MDA Monitoring Wells and Nitrate Results.

How to Address Nitrate in Groundwater

The Minnesota Groundwater Protection Act established a prevention goal that groundwater be maintained in its natural condition, free from any degradation caused by human activity. When degradation exists, it is important to understand the reflected level of management required based on the nitrate concentration. Table 4 provides a protection framework that identifies management priorities reflective of nitrate concentrations.

Table 4: Nitrate protection framework and associated land use management goals. Implementation activities should build as you move from one classification to the next.

Nitrate Protection Framework	Nitrate Concentration	Implementation Emphasis
Protection – Maintain	0 – 4.9 mg/L	Proactive and preventive: ▪ Maintain existing land cover by discouraging or preventing land conversion. ▪ Contaminant source management on existing land uses (Agricultural BMPs, SSTS management, easements, forest management plans).
Protection – Threatened	5.0 – 9.9 mg/L	Contaminant source reduction or elimination: ▪ Shifting land uses away from those that may leach excess nitrogen (Alternative Management Tools[7], upgrade failing SSTS, easements)
Restoration – Treatment	10.0 mg/L and above	Active intervention required by public water supplies to avoid drinking water consumption (new sources; treatment) while still aiming for long term contaminant source mitigation through reduction and elimination .

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

[7] MN Dept. of Agriculture developed Alternative Management Tools to protect groundwater quality from nitrate contamination. For more information, visit MDA Alternative Management Tools (http://www.mda.state.mn.us/chemicals/fertilizers/nutrient-mgmt/nitrogenplan/nitrogenmgmt/amts/amtools.aspx)

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 (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 Lower St. Croix River Watershed?

MDA uses three monitoring wells in the LSCRW to monitor for common detection pesticides. The monitoring wells are in these regions due to the sensitive geology and row crop agriculture, which increases the potential for pesticides or pesticide degradants to get into groundwater. Figure 20 shows the number of common detection pesticides recorded at each monitoring location in the LSCRW in 2016. A range of one to two common detection pesticides were detected in the samples from the monitoring wells. No detections exceeded any human health-based drinking water standards or reference values. MDA's monitoring wells only provide information about pesticides at their 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 watersheds.

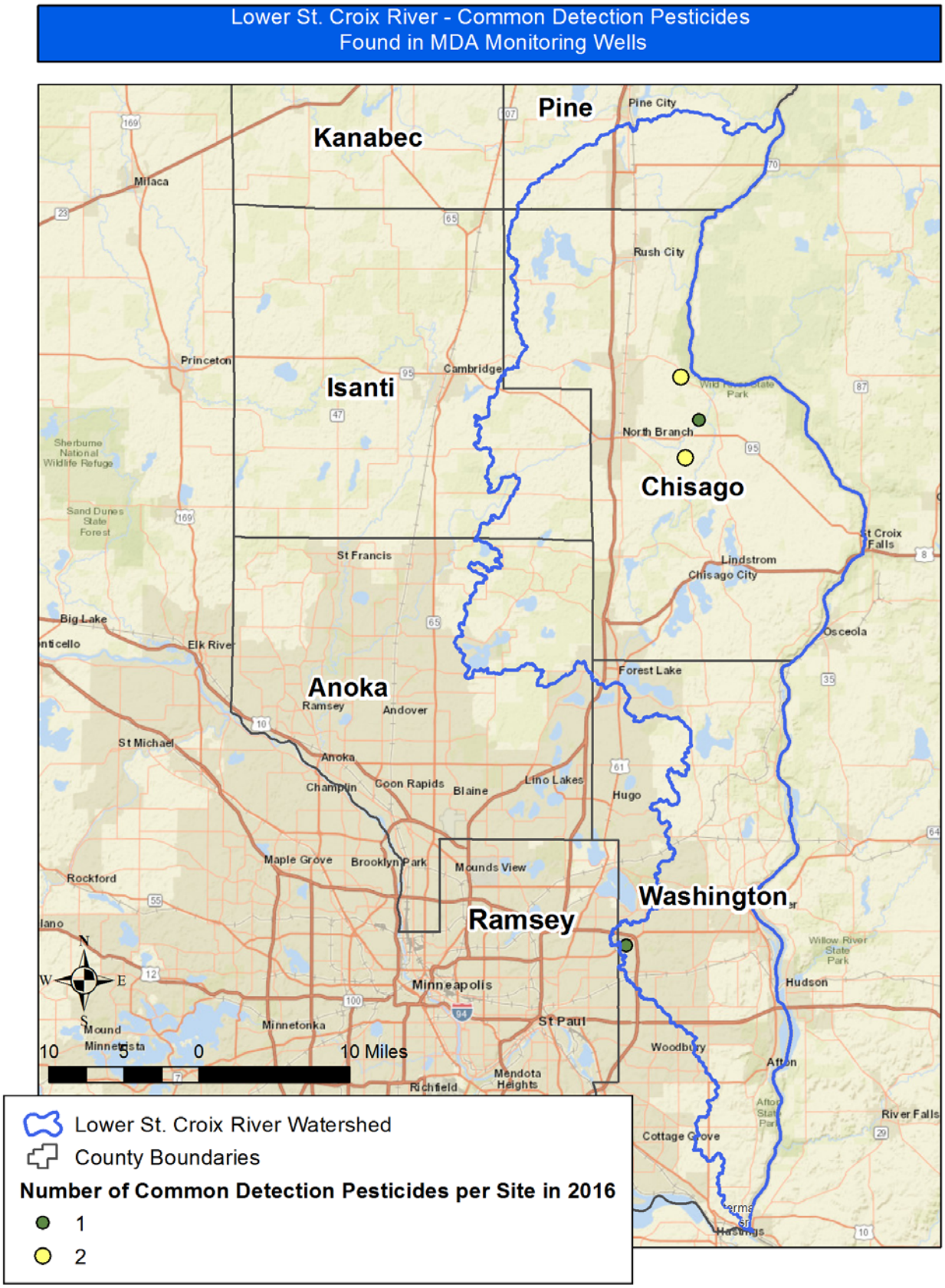

Figure 20: Lower St. Croix River Watershed - Common Detection Pesticides Found in MDA Monitoring Wells

How to Address Pesticides in Groundwater

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

- Providing educational opportunities about pesticide and insecticide BMPs for both agricultural lands and residential/commercial lawns (turf).
- Increasing 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 LSCRW can take to restore and protect groundwater quality related to pesticides.

Arsenic

Approximately four percent of the 887 arsenic samples taken from wells in the LSCRW have levels of arsenic higher than the SDWA standard of 10 micrograms per liter (µg/L)[8]. 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 (chronic exposure) is associated with diabetes and increased risk of cancers of the bladder, lungs, liver and other organs. The SDWA standard for arsenic in drinking water is 10 µg/L; however, drinking water with arsenic at levels lower than the SDWA 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 5 outlines the number of well water samples tested for arsenic in the LSCRW by MDH and shows the percentage of samples with arsenic levels over the SDWA standard. This dataset includes newly constructed wells (installed after 2008), 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 5: Summary of arsenic (As) concentrations in wells of the Lower St. Croix River Watershed.

Depth Completed Range (feet)	Total samples (n)	Minimum concentration (µg/L)	Maximum concentration (µg/L)	Median concentration (µg/L)	Samples at or above 5 µg/L (%)	Samples at or above 10 µg/L (%)
< 50	3	1	5.78	3.65	33.3	0
50 - 99	201	0.0005	24.4	3.56	19.4	8.5
100 - 149	173	0.0005	24.43	1	14.5	4.6
150 - 199	150	0.0005	41.38	1	15.3	5.3
>= 200	360	0.0005	40.6	1	4.2	1.7
Total	887	0.0005	41.38	1	20	4.4

Where Is Arsenic in the Lower St. Croix River Watershed?

Figure 21 shows that arsenic is found throughout the watershed. The dataset used to create Figure 21 is the same information displayed in Table 5. These samples were taken from newly constructed wells, domestic wells, and other drinking water supply wells sampled by MDH.

Arsenic is most prevalent in 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

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

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).

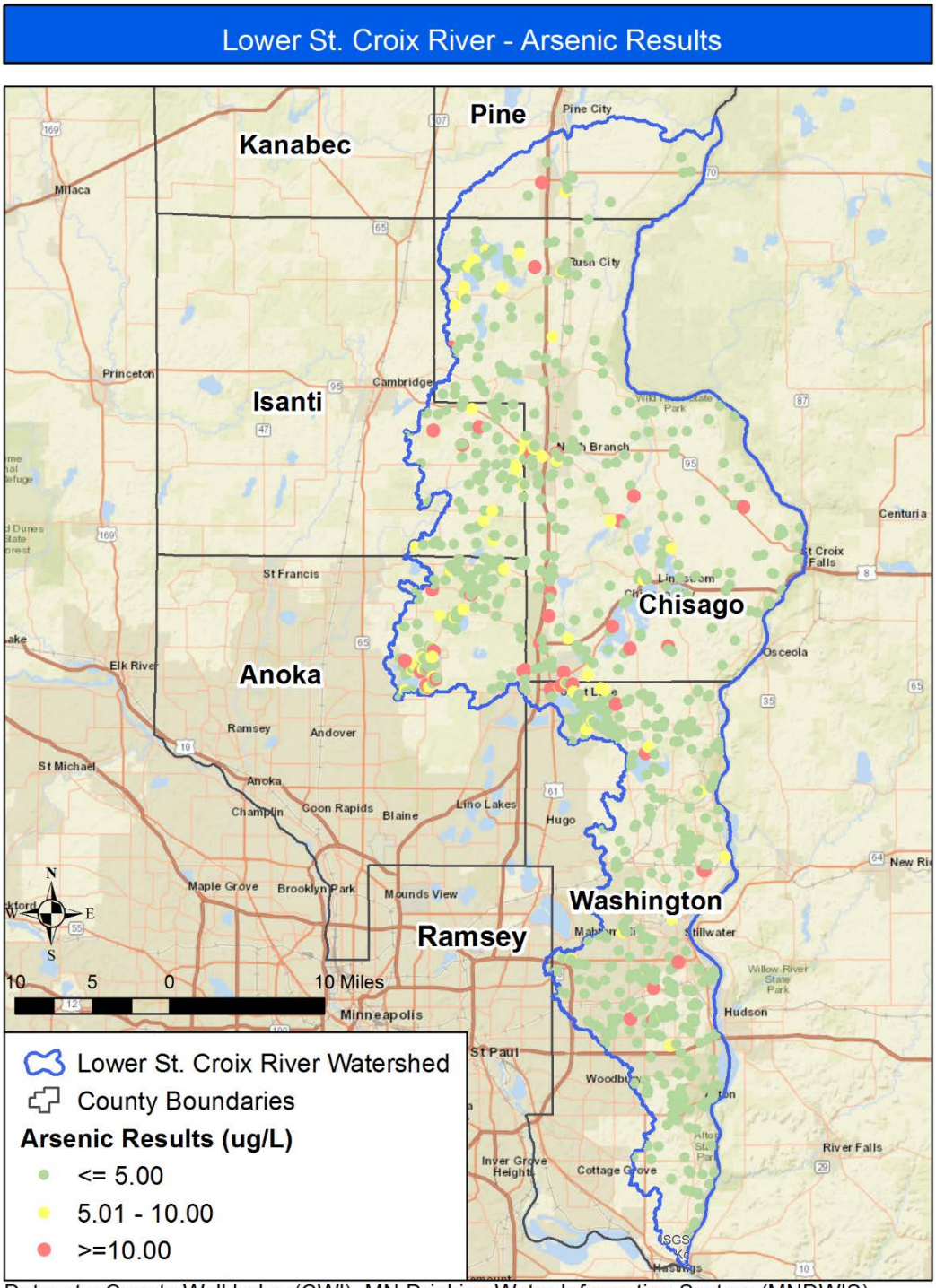

Figure 21: Lower St. Croix River Watershed - Arsenic Results

How to Address Arsenic in Groundwater

Unlike nitrate and pesticides, human activity rarely causes arsenic in Minnesota groundwater, except for local releases of insecticides or wood preservatives into the environment. Therefore, few actions can reduce the amount of arsenic in groundwater. Implementation efforts should focus on making private well users aware of the health risks associated with arsenic, encouraging them to test their water for arsenic, and providing them with treatment options to keep their drinking water safe when arsenic is present.

Radionuclides

Concentrations of naturally occurring radioactive radium have been detected in some groundwater samples in the LSCRW. In certain areas of the LSCRW, the levels at which these chemicals are found cause them to be considered drinking water contaminants. The exact source of these compounds is not well understood. They may originate in the clay-rich glacial or may be part of the original mineral composition of the Mt. Simon or related geologic units. What is known is that their presence in the groundwater is related to reducing geochemical conditions and the very slow rate of groundwater flow in theses bedrock layers.

Where are Radionuclides in the Lower St. Croix River Watershed?

Elevated concentrations of naturally-occurring radioactive radium occur all within the bedrock Mt. Simon aquifer or related geologic units in the LSCRW.

How to Address Radionuclides in Groundwater

Human activity is unlikely to be the cause of radionuclides in the LSCRW groundwater. Therefore, actions cannot reduce the amount of radionuclides present in groundwater. Implementation efforts should focus on awareness that radionuclides may be found in groundwater. The factors that contribute to the presence of radionuclides in the LSCRW groundwater are not well understood at this point. If private well users are concerned about radionuclides in their well, they can pay to have their water tested through an accredited laboratory. Learn more at Radionuclides (Radium) in Drinking Water (www.health.state.mn.us/divs/eh/water/contaminants/radionuclides.html).

Perfluorochemicals

Perfluorochemicals (PFCs), also referred to as Perfluoroalkyl Substances (PFAS), are a family of human-made chemicals that have been used for decades to make products that resist heat, oil, stains, grease and water. PFCs are extremely stable and do not breakdown in the environment. Common uses include nonstick cookware, stain-resistant carpets and fabrics, coatings on some food packaging, components of fire-fighting foam, and many industrial applications. PFCs are released into the environment through spills and disposal.

Where are PFCs in the Lower St. Croix River Watershed?

MDH and MPCA have investigated a number of sites across the state where PFCs were released to the environment. The greatest PFC contamination in the LSCRW is concentrated in the Oakdale, Lake Elmo, and West Lakeland areas. The contamination is traced back to PFC disposal in the former Washington County Landfill during the 1960s to 1970s and the 3M Oakdale disposal site, a Superfund site on EPA's National Priority List, used during the late 1940s to 1950s. The MPCA interactive map allows users to insert an address to determine if the location is near a sampling site. Both MDH and MPCA have extensive information related to PFC contamination and are available at the following:

- MPCA interactive map (mpca.maps.arcgis.com/apps/View/index.html?appid=ff4e56d9b6184ddaa297d1161784a884)
- MPCA PFCs in the envrionment (www.pca.state.mn.us/waste/perfluorochemicals-pfcs)
- MDH PFCs Emerging Contaminants (www.health.state.mn.us/divs/eh/hazardous/topics/pfcs/index.html)

The Ambient Groundwater Monitoring section of the reports provides results of the PFC monitoring activities conducted in the watershed.

How to Address PFCs in Groundwater

PFCs are in people and animals all over the world. They are found in some food products and the environment. Completely stopping exposure to PFCs is unlikely. However, if you live near sources of drinking water contaminated with PFCs consider the following actions:

- Apply a treatment system (reverse osmosis or activated carbon filter) to reduce the levels of PFCs in drinking water. MDH Point of Use Treatment Devices for PFC Removal in Drinking Water (www.health.state.mn.us/divs/eh/hazardous/topics/pfcs/wateranalysis.html)
- Breastfeeding and pregnant women who plan to breastfeed, with a private well may want to consider using filtered tap or bottled water until a treatment system has been installed. All affected community public drinking water systems have put in place measures that protect drinking water at or below the MDH health-based guidance and is considered safe for breastfeeding and pregnant women. MDH What levels of PFCs are safe to drink (www.health.state.mn.us/divs/eh/hazardous/topics/pfcshealth.html) provides more detailed information.

Table 8 provides a more comprehensive list of specific actions the counties and subwatersheds in the LSCRW can take to protect public health from the exposure to PFCs.

Volatile Organic Compounds

Volatile Organic Compounds (VOCs) are carbon-containing compounds that evaporate easily from water into air at normal air temperatures. VOCs are contained in a wide variety of commercial, industrial, and residential products including fuel oils, gasoline, solvents, cleaners and degreasers, paints, links, dyes, refrigerants and pesticides. MDH studies suggest that three to six percent of pubic water supplies and about two to four percent of all water supplies in Minnesota contain detectable amounts of VOCs.

Where are VOCs in the Lower St. Croix River Watershed?

Most VOCs found in the environment result from human activity. When VOCs are spilled or improperly disposed of, a portion will evaporate, but some will soak into the ground. Rain, water, or snowmelt push VOCs deeper into the soil profile until it reaches the groundwater table where it can migrate to nearby wells and end up in drinking water. VOC contamination has been found in three areas in the LSCRW:

- Baytown/West Lakeland Townships - trichloroethylene (TCE), a degreasing agent for washing metal parts and a dry cleaning solvent, has been detected in groundwater.
- Lake Elmo/Oakdale – VOC contamination has been detected in groundwater monitoring wells and private wells from the Washington County Landfill.
- Lakeland/Lakeland Shores – solvents and petroleum products have contaminated groundwater and has been detected in a large number of private wells.

Additional information on the VOC contamination is highlighted in the Ambient Groundwater Monitoring and the Special Well and Boring Construction Areas sections of the report.

How to Address VOCs in Groundwater

Prevent VOC contamination by restricting use of toxic chemicals and by disposing of them properly. Regularly check underground fuel tanks for leaks and remove them when they are no longer secure. Immediately report spills and leaks to the MN Duty Officer (https://dps.mn.gov/divisions/bca/bca-divisions/administrative/Pages/minnesota-duty-officer-program.aspx). If contamination is confirmed in a private well, water treatment systems are available to remove or reduce VOCs. MDH VOCs in Private Drinking Water Wells (www.health.state.mn.us/divs/eh/hazardous/topics/vocs.pdf) can provide information on treating contaminated water.

Table 8 provides a more comprehensive list of specific actions the counties and subwatersheds in the LSCRW can take to protect public health from the exposure to VOCs.

Ambient Groundwater Monitoring

The MPCA's Ambient Groundwater Monitoring Program monitors trends in statewide groundwater quality by sampling for a comprehensive suite of over 100 chemicals, including nutrients, metals, anions and cations, and volatile organic compounds (VOCs). The Ambient Groundwater Network currently consists of approximately 270 sites that represent a mix of deep domestic wells and shallow monitoring wells in non-agricultural regions across the state. The primary focus areas are shallow aquifers that underlie urban areas, due to the higher tendency of vulnerability to pollution. The wells are sampled annually. In addition to the annual ambient groundwater samples, MPCA staff collect approximately 40 contaminants of emerging concern (CEC) samples that are analyzed for over 267 analytes, such as pharmaceuticals, personal care products, and fire retardants.

From 2004 to 2017, fifty-seven ambient network wells were sampled within the LSCRW. Wells with less than five years of data were not included, leaving 27 wells (47 percent) for data analysis. Most of the ambient network wells sampled in the LSCRW were located in residential areas with subsurface sewage treatment systems (SSTS) or belonged to private domestic well owners, while three of the wells were located within a sewered residential area and one is located in an undeveloped area.

Ambient groundwater results indicate that the majority of the detections were within the human health guidelines set by MDH or the EPA. There were some exceedances to theses limits, making the most important groundwater quality issues for the watershed inorganic nitrogen (nitrate and nitrite), manganese, chloride, iron, and TCE. The exceedance results:

- Detections of inorganic nitrogen occurred at 99.2 percent of all samples, only 8.5 percent of detections exceeded the Maximum Contaminant Level (MCL) of 10 mg/L, all within four monitoring wells and one nonpublic water supply well.
- Manganese was detected in 21.8 percent of samples. It has a Risk Assessment Advice (RAA) of 100 µg/L for infants and 300 µg/L for children and adults. There were eight instances (17.4 percent) when concentrations exceeded the RAA for infants, 4 of which exceeded the RAA for children and adults. Exceedances to the RAA were primarily identified in monitoring wells, with one instance in a nonpublic water supply well.
    - Manganese occurs naturally in rocks and soil across the state and is often found in ground and surface water. Your body needs some manganese to stay healthy, but too much can be harmful. Children and adults who drink water with high levels of manganese over a long period of time may have problems with memory, attention, and motor skills. Infants (babies under one year old) may develop learning and behavior problems if they drink water with too much manganese in it.
- Chloride occurs naturally in groundwater and therefore has been commonly detected in the watershed (97.5 percent), typically at concentration below the EPA Secondary MCL (SMCL) of 250 mg/L in drinking water to minimize taste issues. One monitoring well located in a residential

area that exceeded the SMCL two years in a row. Chloride has become an increasing concern due to salt being used as a deicing agent on roads. Elevated chloride concentrations can affect the taste of drinking water (Kroening & Ferrey, 2013).

- TCE was detected at one domestic well in the watershed at a concentration that exceeded the Health Risk Limit (HRL) of 0.4 µg/L for short-term, sub-chronic, and chronic exposure, as well as the 2 µg/L HRL for cancer. The well was located near the Baytown Township groundwater contamination site, which is the likely contamination source. It is important to note that the Ambient Groundwater Network collects samples to identify contamination present in the groundwater and is not always representative of the drinking water quality. This well has been sampled a total of 13 times from 2006 to 2017 with no other TCE detections.

The CEC samples were collected at 30 of the 57 wells from 2010 to 2017 and analyzed for 267 analytes. The most commonly detected CECs were Menthol (14 detections), β-Sitosterol (10 detections), HHCB (8 detections), 1,7-Dimethylxanthine (6 detections), 11-Ketotestosterone (6 detections), and 17α-estradiol (5 detections). There were no exceedances to applicable water quality guidelines.

PFCs were sampled at 31 of the 57 wells within the watershed from 2005 to 2017. PFC samples were tested for 13 contaminants, such as perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), perfluorobutanoic acid (PFBA). There was a detection frequency of 20.8 percent for all PFCs. Of these detections, there were exceedances to the health based values (HBV) for PFOS of 27 ng/L and PFOA of 35 ng/L. The exceedances were found at one domestic well with two exceedances to PFOS, and one exceedance of PFOA was found in a monitoring well in a sewered residential area. PFC contamination in this area is likely attributed to dump sites and the Washington County landfill, where industrial waste was disposed.

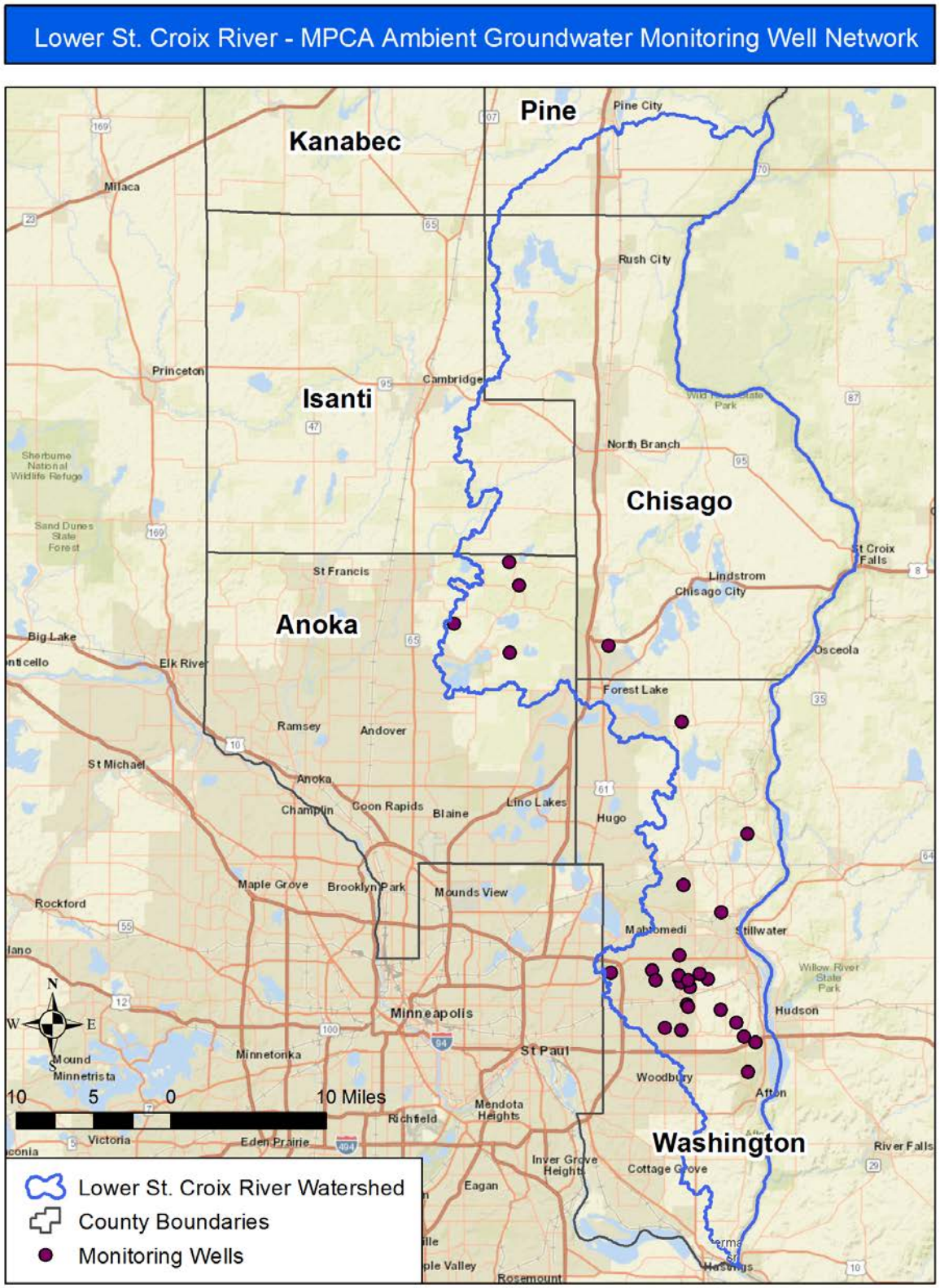

Figure 22: Lower St. Croix River Watershed - MPCA Ambient Groundwater Monitoring Well Network

Special Well and Boring Construction Areas

A Special Well and Boring Construction Area, also called a well advisory, is a mechanism that provides controls on the drilling or alteration of public and private water supply wells and monitors wells in areas of known groundwater contamination for risks to public health. The purposes of a Special Well and Boring Construction Areas is to inform the public of potential health risks in contaminated areas, ensure the construction of safe water supplies, and prevent the spread of contamination due to the improper drilling of wells and borings.

There are three Special Well and Boring Construction Areas in the LSCRW (Figure 23).

- Baytown/West Lakeland Township (www.health.state.mn.us/divs/eh/wells/swca/baytown.html) well advisory went into effect in 1988 after the discovery of VOC contaminants in several private wells in the area. An update in 2005 stated the primary contaminant now present in the groundwater is the VOC trichloroethylene (TCE), a degreasing agent for washing metal parts and a dry cleaning solvent. The site is listed as a state and federal Superfund site. TCE (www.health.state.mn.us/divs/eh/hazardous/topics/tce.html) is human carcinogen and has been linked to adverse immune system effects.
- Lake Elmo/Oakdale (www.health.state.mn.us/divs/eh/wells/swca/lakeelmo.html) well advisory was established in 1982 after the discovery of VOC contamination in on-site monitoring wells and off-site private wells from the Washington County Landfill. The well advisory area was expanded in 2007 after finding more extensive groundwater contamination by PFCs in Lake Elmo and Oakdale.
- Lakeland/Lakeland Shores (www.health.state.mn.us/divs/eh/wells/swca/lakeland.html) well advisory was issued in 1987 for the presence of a variety of VOCs found in 193 wells. The VOC compounds are solvents and petroleum products.

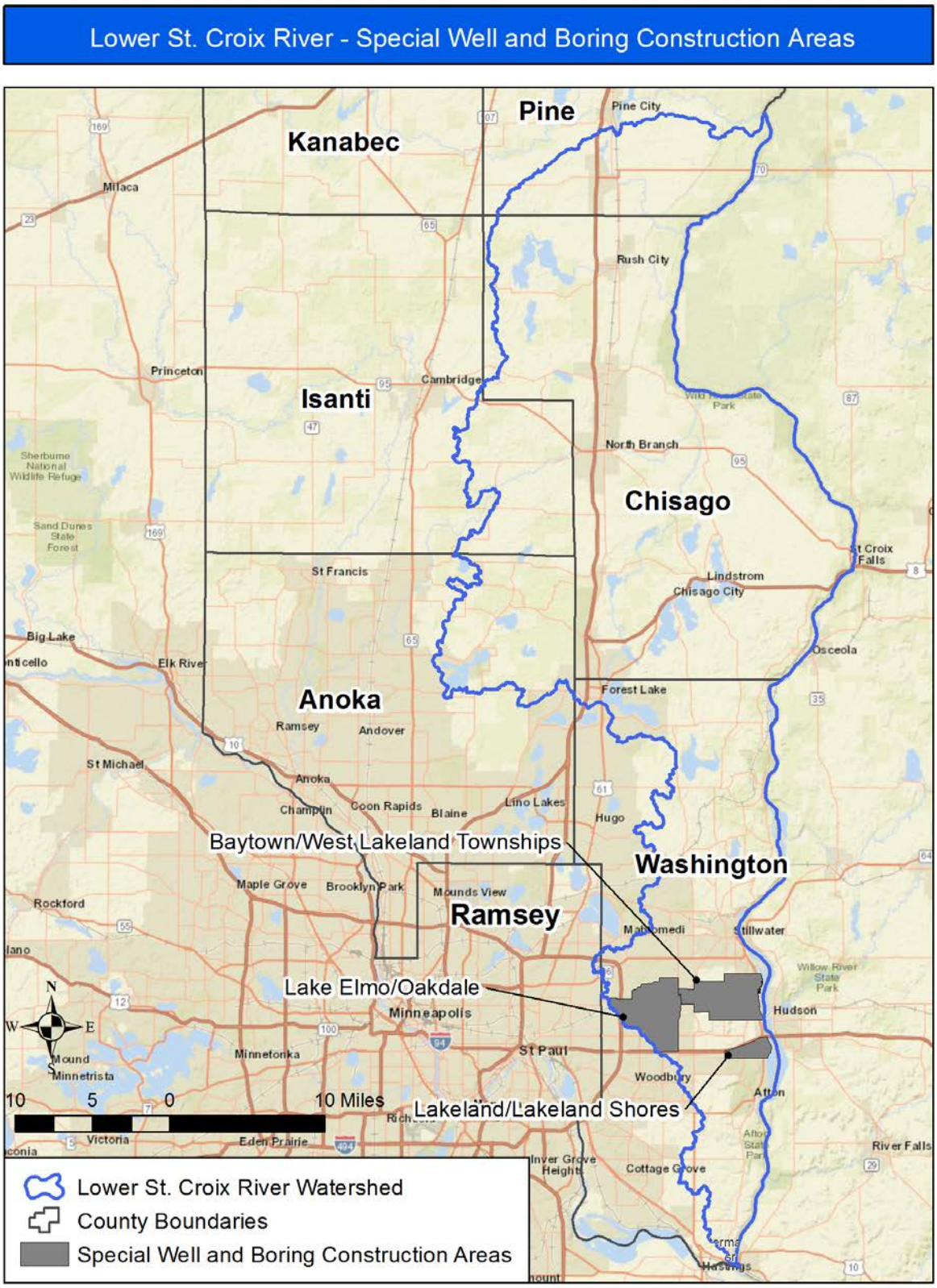

Figure 23: Lower St. Croix River Watershed – MDH Special Well and Boring Construction Areas

Potential Contaminant Sources

Some land use practices make it easier for contaminants to get into groundwater. Key land uses that are potential contaminant sources in the LSCRW are described below.

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 contaminate groundwater.

MDA hosts an interactive map that provides information on local ordinances regulating animal agriculture in Minnesota's counties. The information includes the most common areas of regulations, such as setbacks and separation distances, conditional use permits, feedlot size limitations, and minimum acreage requirements. For more information, visit the Local Ordinances Regulating Livestock - Web Mapping (http://www.mda.state.mn.us/animals/livestock/local-livestock-ordinances.aspx).

Where Are Animal Feedlots in Lower St. Croix River Watershed?

The LSCRW has 193 active feedlots. The animal agriculture industry in the watershed consists primarily of milk and beef cows, followed by hogs. 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. County feedlot programs have responsibility for implementing state feedlot regulations including: registration, permitting, inspections, education/assistance and complaint follow-up. There are no delegated counties within the LSCRW. The MPCA administers the feedlot program in the watershed.

Figure 24 contains a grid that depicts the number of active feedlots in each six by six-mile section of the watershed. Darker colors correspond to a higher concentration of active feedlots.

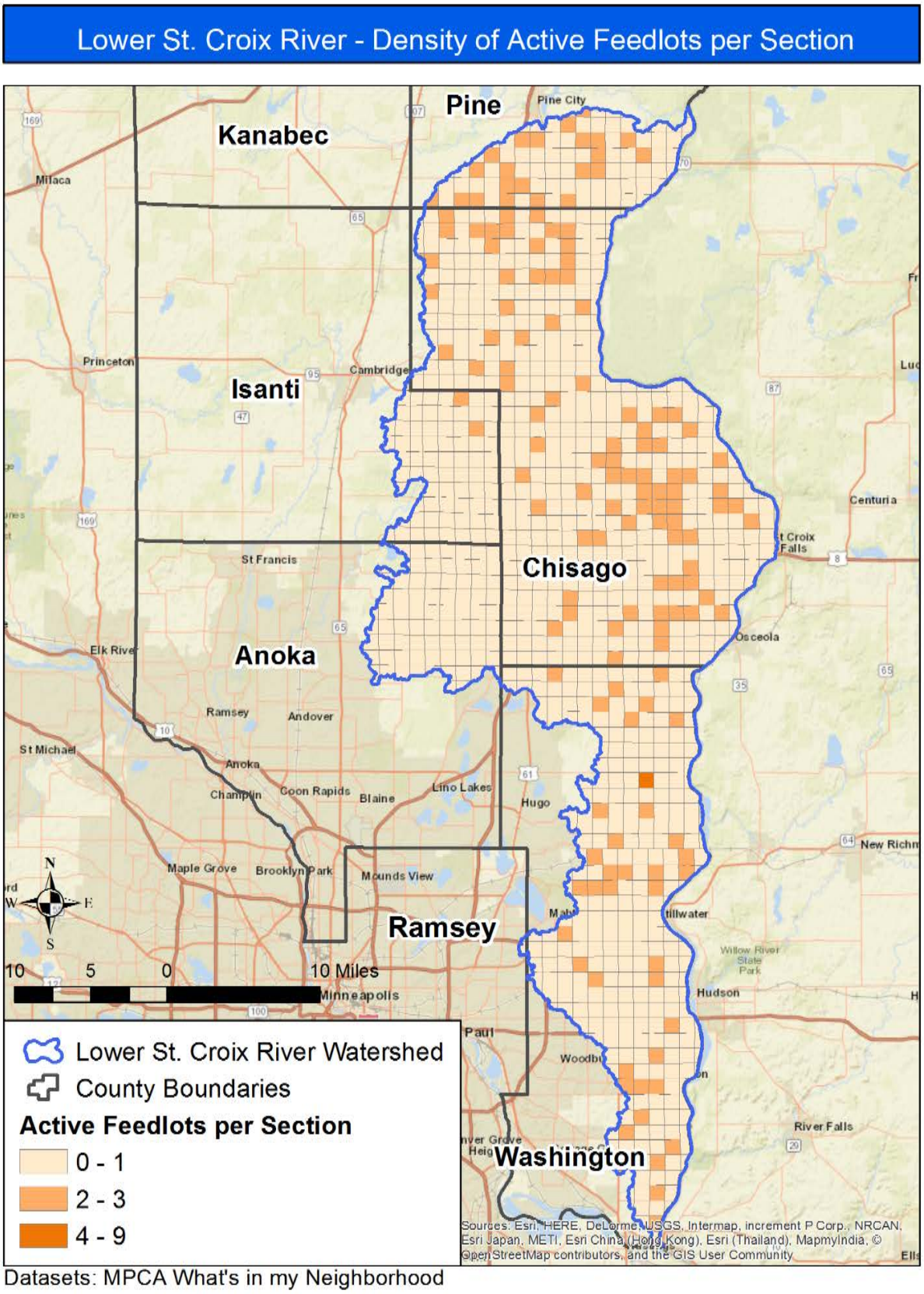

Figure 24: Lower St. Croix River Watershed - Active Feedlots

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. It is important to prioritize activities in the areas most sensitive to groundwater first. Table 8 provides a more comprehensive list of specific actions partners in can take to protect groundwater from nitrate and pathogen contamination.

Row Crop Agriculture

Row crop agriculture or cultivated crops (Figure 4) are the largest land cover at 23 percent. Impacts from row crop production to water resources include nitrogen loss in the form of nitrate to groundwater, which can move downward to aquifers or be laterally dispersed to lakes and rivers. Tile drainage is another pathway for nitrogen to reach surface water systems, however this is not a focus of the GRAPS report being the TMDL and WRAPS reports assess impacts. Agricultural chemicals, including pesticides, are another risk for groundwater contamination from row crop agriculture. Both nitrate and pesticides are addressed in the **Groundwater Quality Issues and Concerns** section of this report.

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. As more time passes, additional systems are likely to fail. Failing SSTS can pollute both surface and groundwater. A failing system is one that does not provide adequate separation between the bottom of the drain field and seasonally saturated soil. The wastewater in SSTS contains bacteria, viruses, parasites, nutrients, and some chemicals. SSTS infiltrate treated sewage into the ground, which ultimately travels to groundwater.

Where are SSTS in the Lower St. Croix River Watershed?

SSTS are found in all five counties in the LSCRW. Information reported by counties indicate a relatively small to high number of failing SSTS in the watershed (Table 6). State regulations require each county to adopt a local SSTS ordinance and that eminent health threats or failing systems be replaced and brought up to current standards. Even with a required ordinance, some counties still have identified gaps in their SSTS program, ranging from lack of records on treatment system age, type or function, known unsewered communities, and lack of a point of sale requirement triggering an inspection through a property sale.

Table 6: Reported number of failing SSTS in each county within the Lower St. Croix River Watershed

County	Estimated number of failing SSTS per 1,000 acres
Pine	0 - 1
Isanti	4 - 7.7
Chisago	4 - 7.7
Anoka	0 - 1
Washington	3 - 4

How to Protect Groundwater from SSTS Contamination

SSTS must be properly sited, designed, constructed and maintained to minimize the potential for disease transmission and groundwater contamination. Each county carries out permitting, inspections and operation of the SSTS program locally. Table 8 provides a more comprehensive list of specific actions the LSCRW can take 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 identified 347 active tank sites, 132 leak sites, and three closed landfills with 158 monitoring wells to monitor contaminate flow in the LSCRW. 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 Lower St. Croix River Watershed?

Figure 25 maps active tank and leak sites compared to pollution sensitivity of near-surface materials in the LSCRW. Figure 26 provides a map of the closed landfills in the LSCRW. 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** (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.

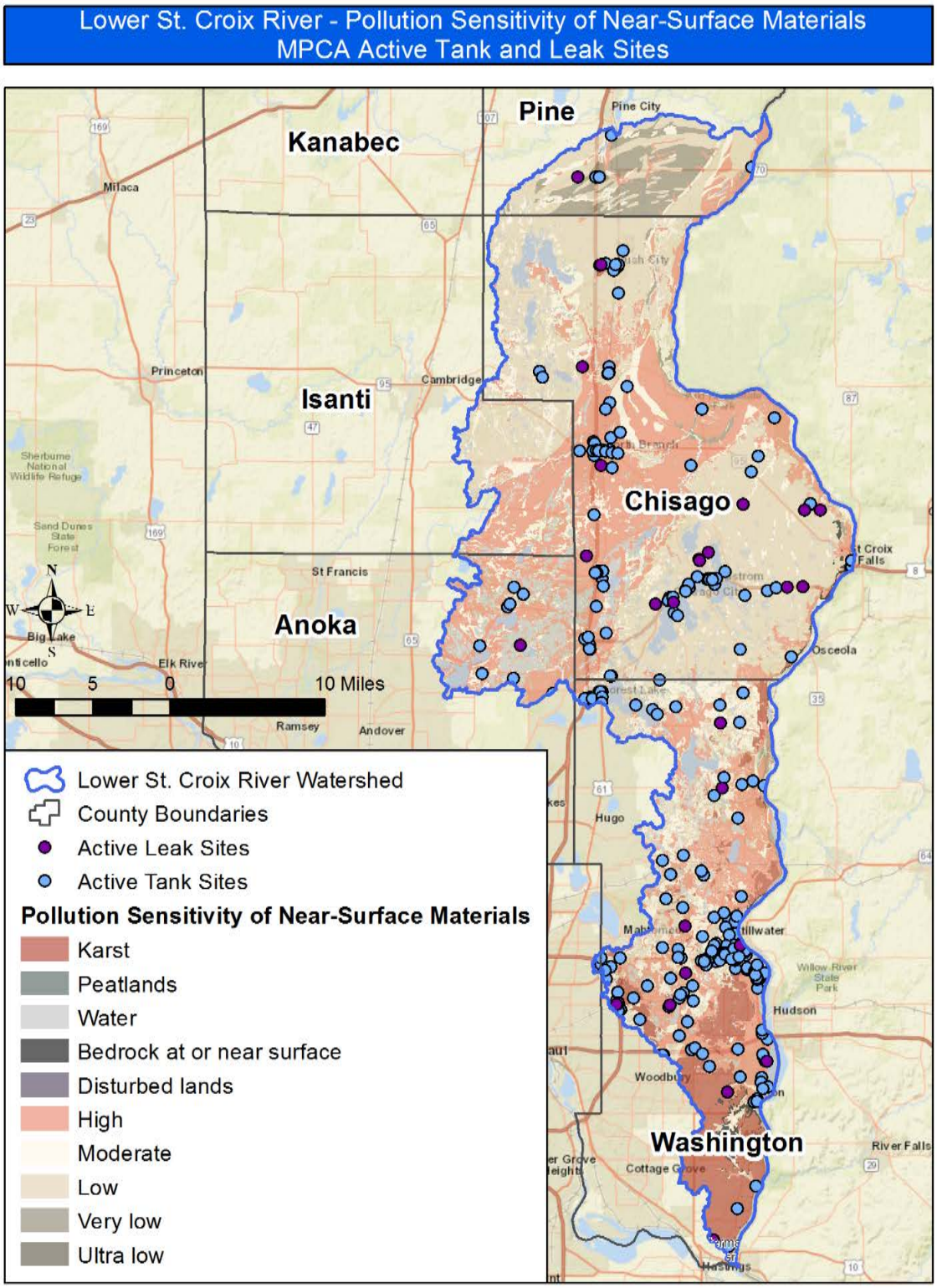

Figure 25: Lower St. Croix River Watershed - MPCA Active Tank and Leak Sites and Pollution Sensitivity of Near-Surface Materials

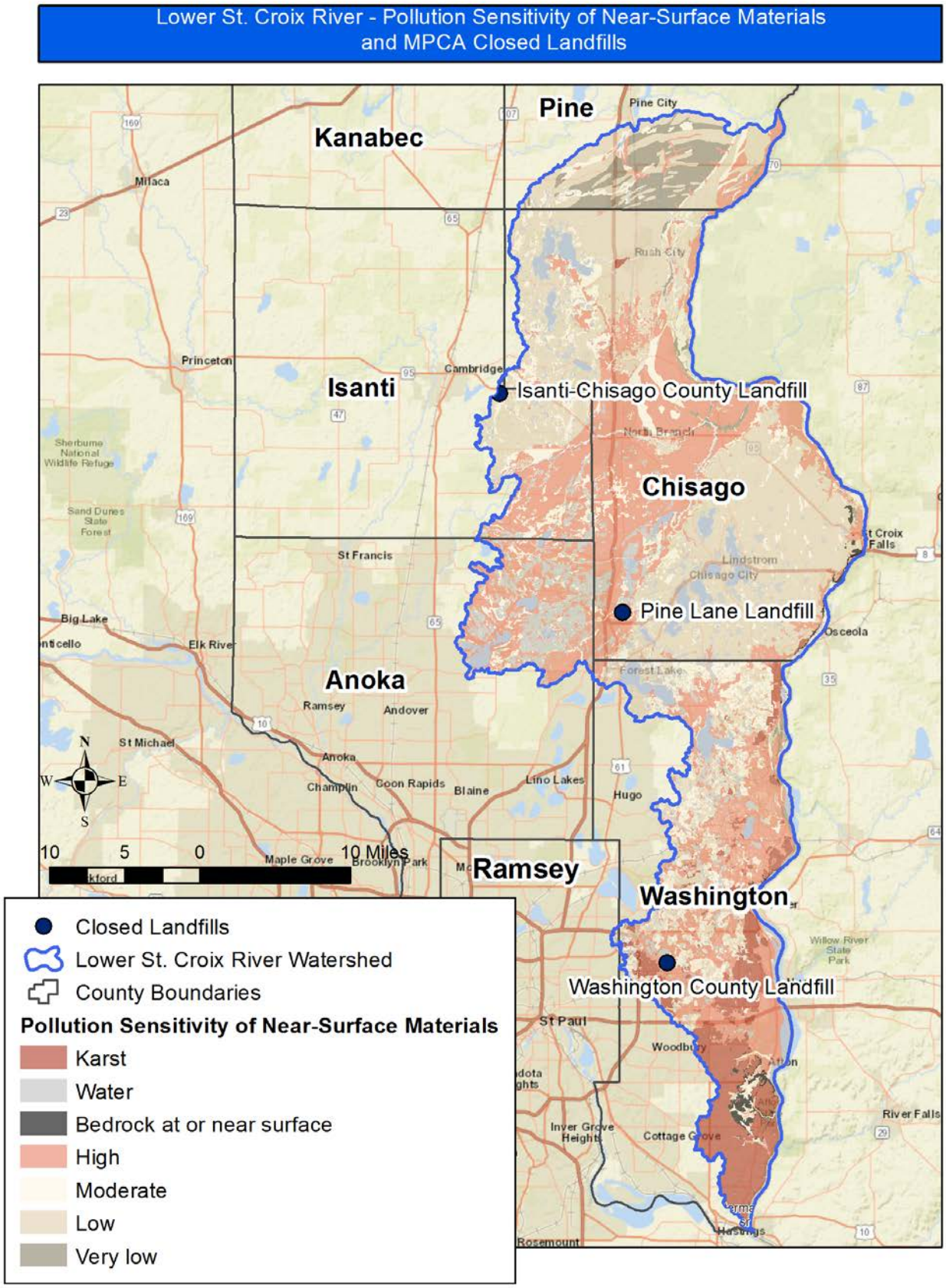

Figure 26: Lower St. Croix River Watershed - MPCA Closed Landfills

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 LSCRW 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 LSCRW has 18 cities, one township, one county, two non-traditional, and the Minnesota Department of Transportation that require an MS4 permit 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. Table 8 provides a more comprehensive list of additional actions the LSCRW can take to prevent stormwater infiltration from contaminating groundwater.

Household Hazardous Waste

Many household products you use to clean your home, maintain your yard, and control animals and insects contain hazardous materials. When these products are disposed of improperly, it may lead to groundwater contamination.

Minnesota's household hazardous waste (HHW) program is a partnership with the MPCA and the counties. Together, they provide education about HHW storage and disposal as well as maintain a network of regional, local and mobile facilities to collect HHW statewide. In addition, many counties offer temporary collection sites, including one-day events. The MPCA has a searchable database to find HHW collection sites for your county, Household Hazardous Waste Collection Sites (https://www.pca.state.mn.us/living-green/find-your-household-hazardous-waste-collection-site).

Similar to the partnership for HHW, MDA partners with counties to provide a means to safely dispose of unwanted and unusable pesticides through the Waste Pesticide Collection Program. Through this program, pesticide users in every county around the state have opportunities to dispose of unwanted agricultural pesticides through county HHW facilities, mobile collection events or by attending MDA schedule events. Participants can drop off up to 300 pounds free of charge. MDA manages a waste pesticide collection schedule to learn about partnerships and scheduled events, MDA Waste Pesticide Collection Schedule (www.mda.state.mn.us/chemicals/spills/wastepesticides/schedule.aspx).

How to Protect Groundwater from Household Hazardous Waste Contamination

Promote HHW and the pesticide collection program availability to residents and evaluate opportunities to expand services to increase participation. Table 8 provides a more comprehensive list of specific actions the LSCRW can take to assure consumer products do not contaminate groundwater.

Pharmaceuticals

The presence of pharmaceuticals in water is of increasing concern because they may cause harm to humans and aquatic life. Pharmaceuticals enter rivers, lakes and groundwater when human waste, animal waste or discarded medications move from stormwater systems, sewer systems or septic tanks into water. Wastewater and drinking water treatment may not completely remove pharmaceuticals. As a result, these chemicals can be found in drinking water sources.

How to Protect Groundwater from Pharmaceutical Contamination

Do not flush old or unwanted prescription or over the counter medications down the toilet or drain, and do not put them in the trash. There are more than 240 medication collection boxes located at law enforcement facilities and pharmacies in Minnesota. These collection sites do not charge for disposal. You can use the Earth 911 website to identify collection sites by zip code, *Locations that take medications (search.earth911.com/?what=Medications&where=MN)*. If a disposal site is not available, follow the MPCA guidance to minimize risk to the environment, *Medication Disposal Guidance (https://www.pca.state.mn.us/living-green/managing-unwanted-medications)*.

Groundwater Quantity Issues and Concerns

Most of the LSCRW is underlain by bedrock aquifers, so groundwater is generally available. In areas near large-capacity wells where groundwater is heavily pumped, groundwater levels generally vary seasonally. In portions of the county that are more rural and away from large water users, groundwater levels follow multiyear cycles that correlate with precipitation.

An analysis of groundwater levels in wells with at least 20 years of measurements identified that most water levels follow precipitation trends, but slightly delayed. The overall trend in groundwater levels has been down, but the trend correlates with rainfall. Water levels and precipitation have both been rising since 2013.

In a few select wells that are near pumping centers, significant drawdown occurs during the pumping season but generally recovers each year. Thirteen observation wells in the LSCRW were included in that assessment: 10 wells had a downward trend and three wells had no trend.

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.

To understand whether there is groundwater quantity concerns in the Lower St. Croix Watershed, water level monitoring data from local wells is essential. 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.

Groundwater Level Monitoring

The DNR maintains a statewide groundwater level monitoring program using observation wells for the purpose of assessing the status of groundwater resources. The network provides valuable information to determine long-term trends, interpreting impacts of pumping and climate, planning for water conservation, evaluating water use conflicts, and inform other water management decisions.

Data over a multiple decade period of record are needed when assessing whether groundwater levels have changed. The DNR observation wells have a large range of length of record. A few wells have water-level records extending back forty or more years. Additional observation wells were recently installed within the past year or two. The water level records from newer wells will be of great use in the future, but are not used in this report. The locations of DNR observation wells, their year of installation, and the location of well nests (where wells completed at different depths in different aquifers are located near each other) are shown in Figure 27.

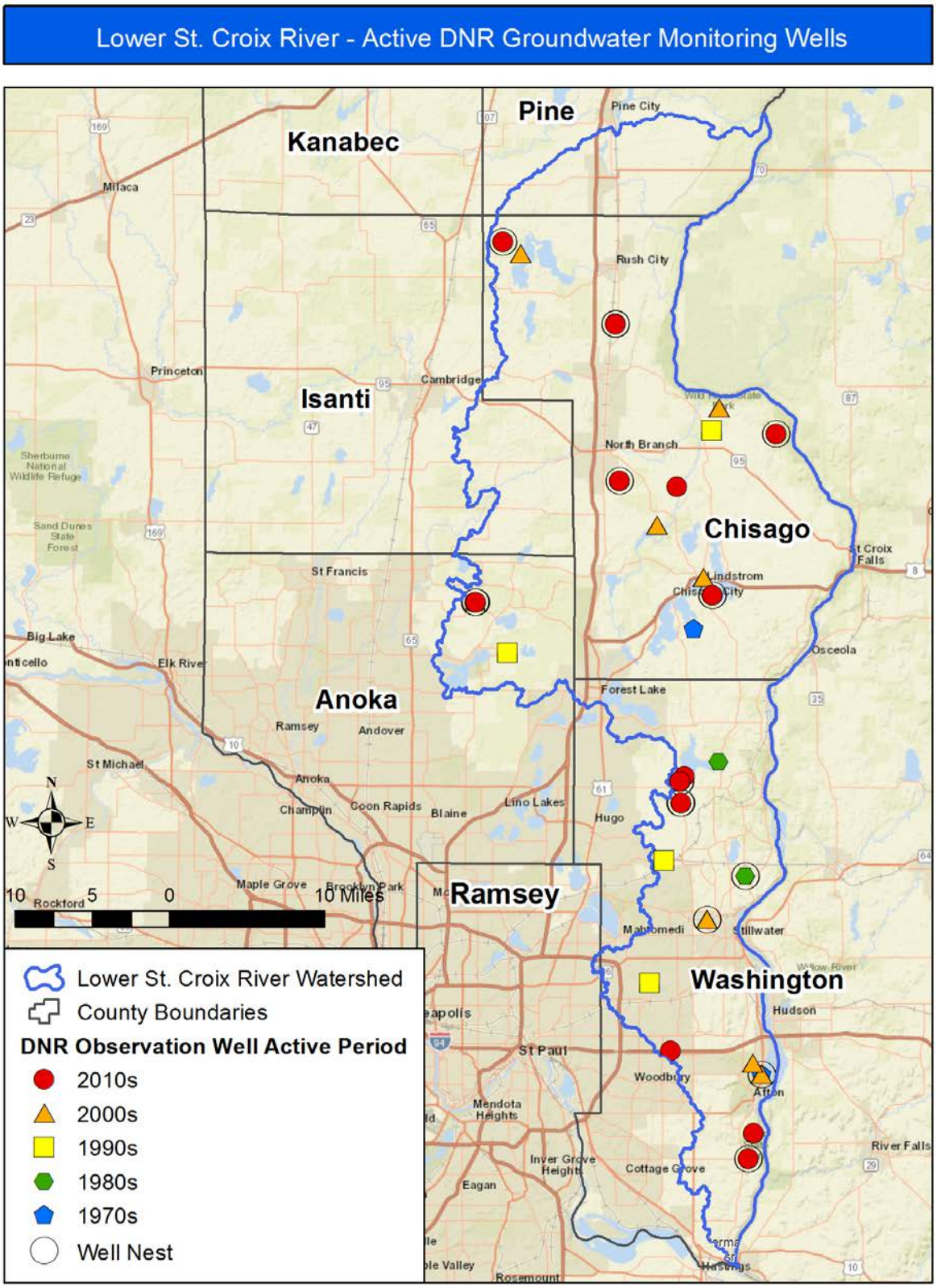

Figure 27: Lower St. Croix River Watershed - Location of Active DNR Groundwater Monitoring Wells

Thirteen observation wells with greater than 20 years of record were analyzed for water level trends by the Mann-Kendall non-parametric statistical method. The entire period of record was used for trend analysis at each well. Two wells are completed in the surficial sand (water table) aquifer, three wells are completed in the buried sand and gravel aquifer, and eight wells in bedrock aquifers.[9] The trends are calculated using one data point per year, the lowest annual water level reading. The trends are meant to show a general direction of water levels over time and are shown in Figure 28.

The Mann-Kendall method can indicate an upward trend, a downward trend or no trend. All calculated trends from observation wells in the LSCRW were either no trend or downward trend. A downward trend can result from changes in precipitation and groundwater recharge, increases in nearby pumping, or both. The location of wells with hydrographs showing water elevation over time shown in Figure 29. The hydrographs are Figure 30a through Figure 31d.

[9] Most statistical methods assume a normal data distribution. Because hydrologic data typically do not have a normal distribution, non-parametric statistics are required.

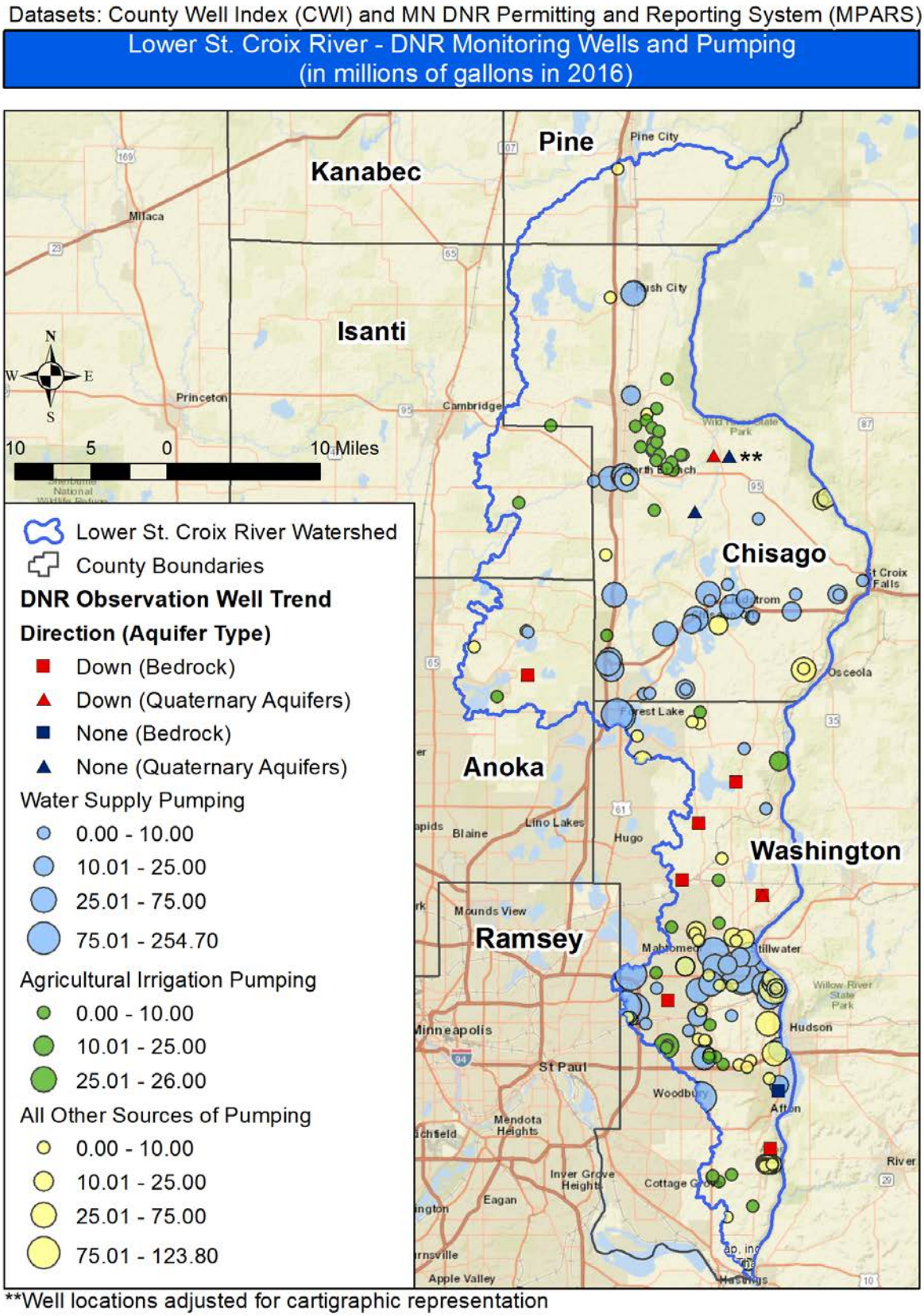

Figure 28: Lower St. Croix River Watershed – Location of Long-Term DNR Groundwater Level Monitoring Wells and Pumping.

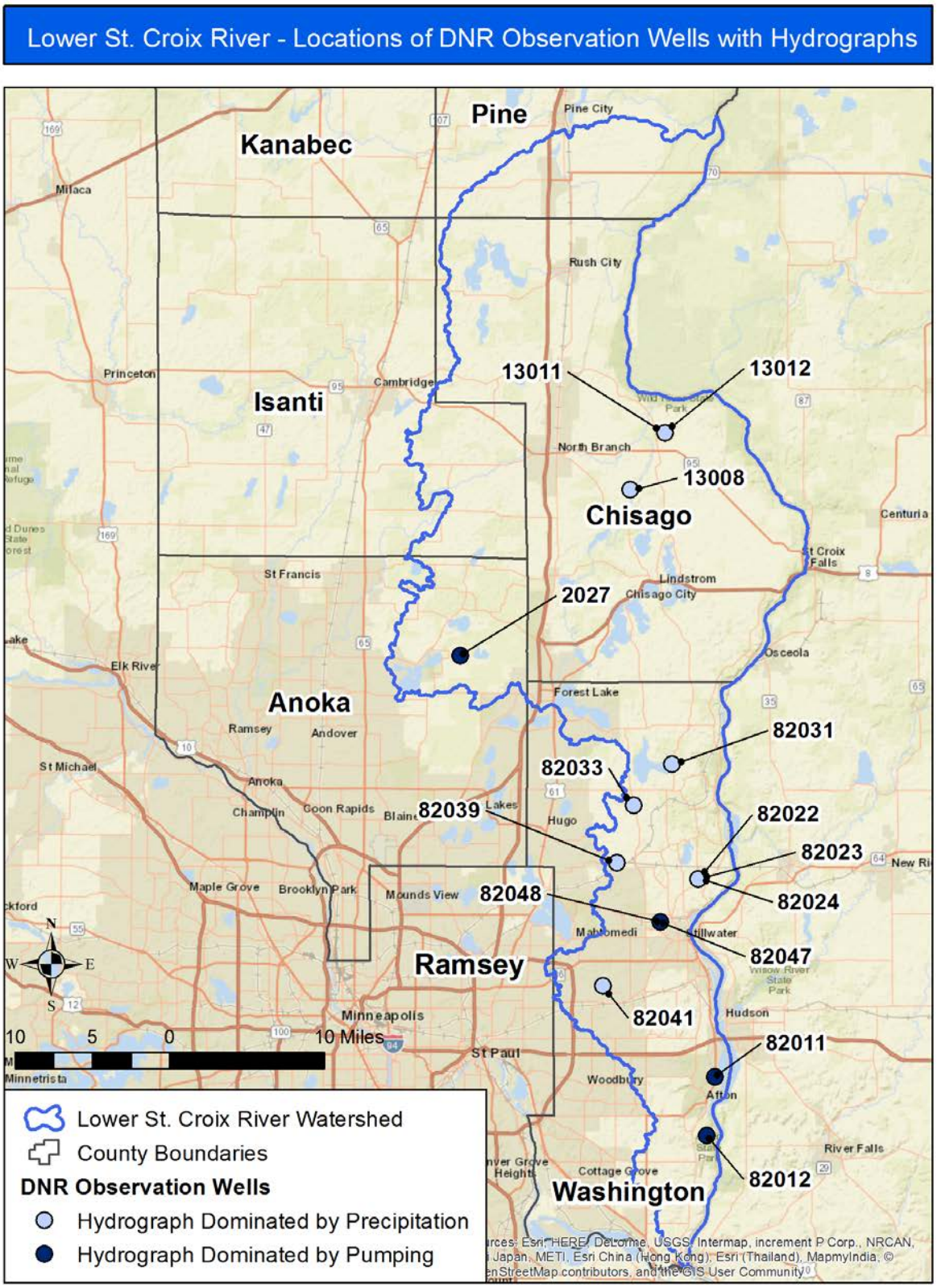

Figure 29: Lower St. Croix River Watershed – DNR Observation Wells with Hydrographs

Wells in the central part of the watershed that are not near cities or other pumping centers follow multiyear cycles that correlate with, but slightly lag, precipitation. The central part of the watershed is primarily an area of groundwater recharge. Groundwater flows from these upland recharge regions to the St. Croix River. This variability in water levels with time and precipitation can be seen in Figure 30 a-g.

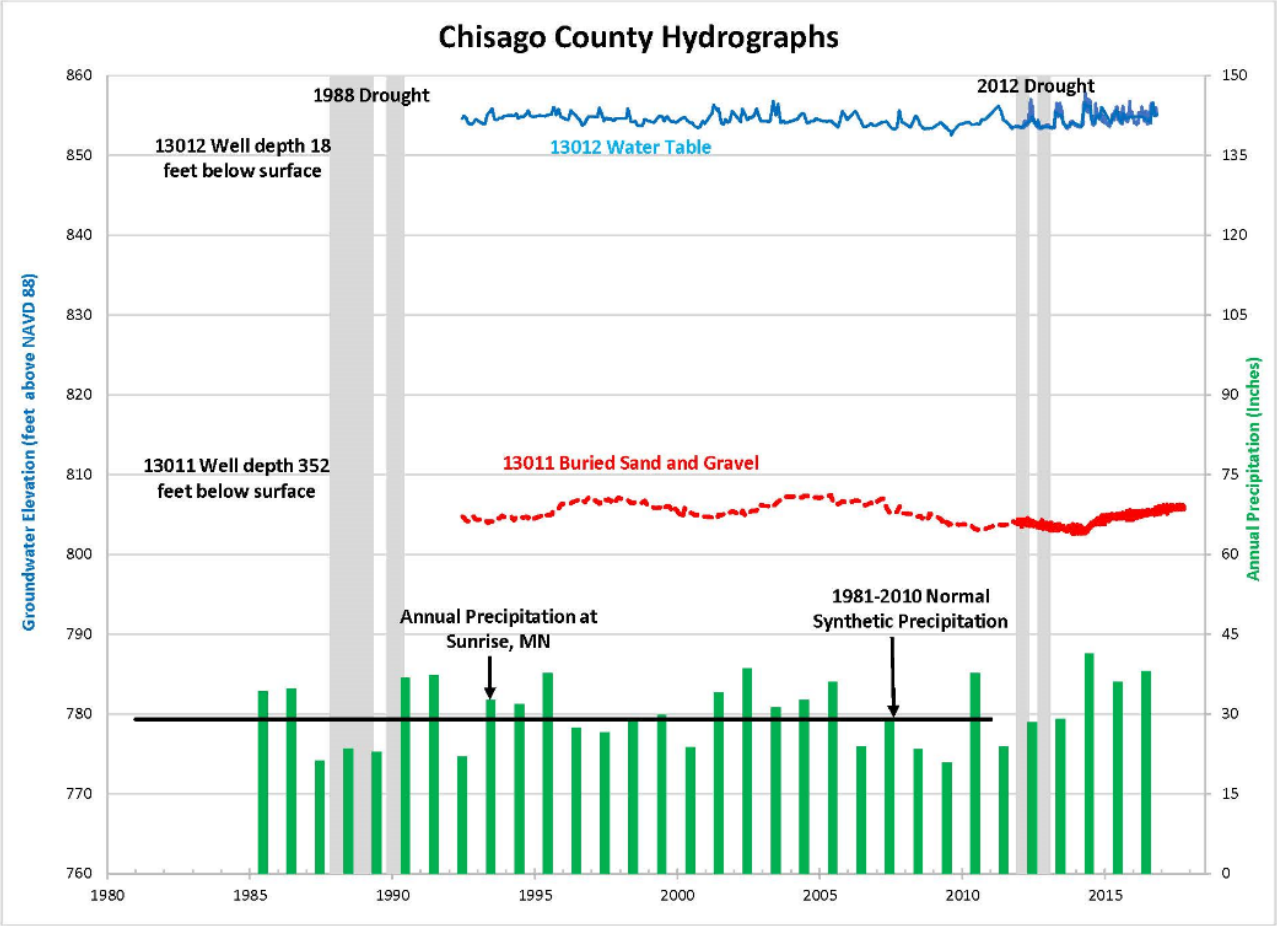

Figure 30a: Lower St. Croix River Watershed - Hydrographs from observation well next 13011 and 13012.

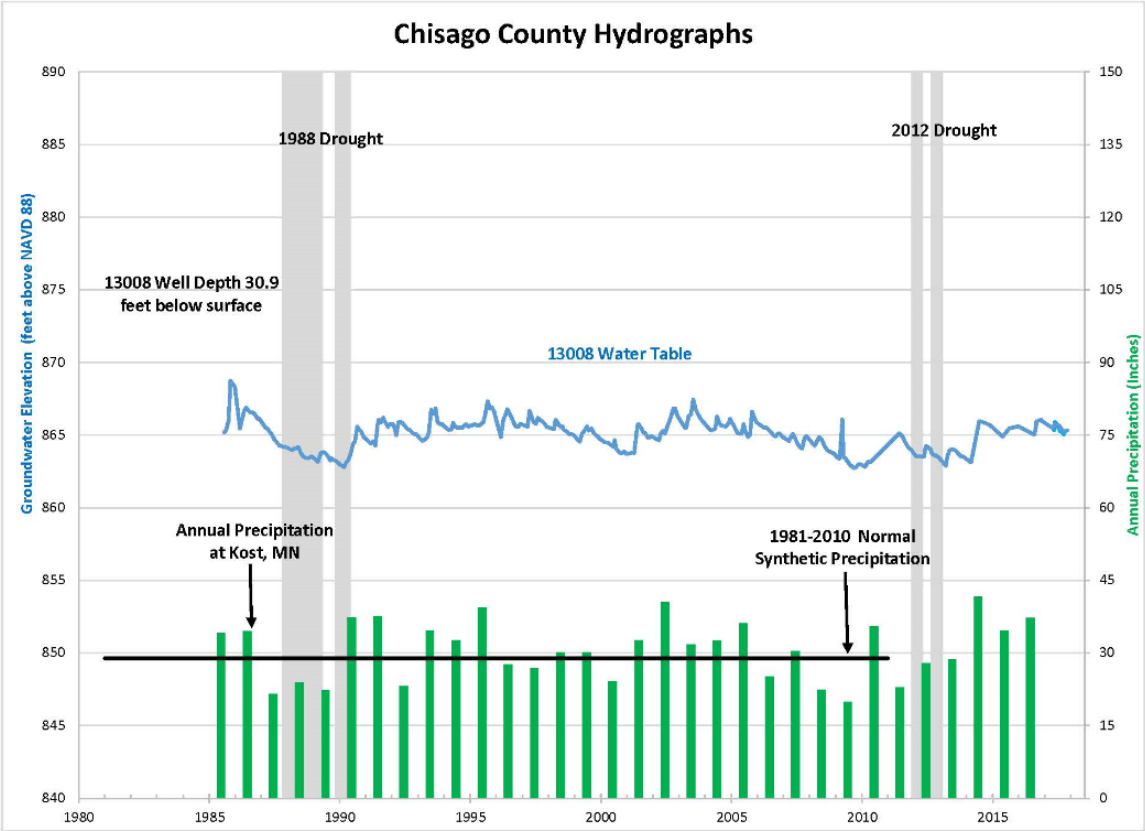

Figure 30b: Lower St. Croix River Watershed - Hydrographs from observation well 13008.

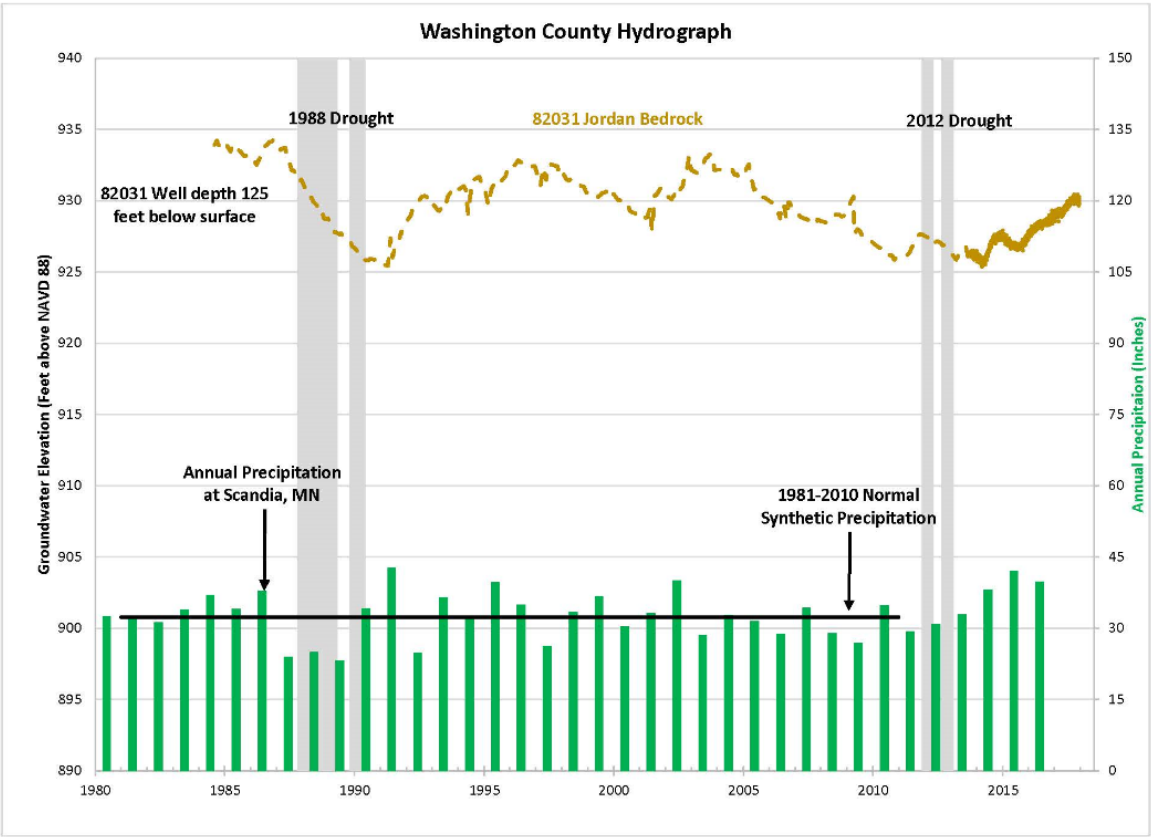

Figure 30c: Lower St. Croix River Watershed - Hydrographs from observation well 82031.

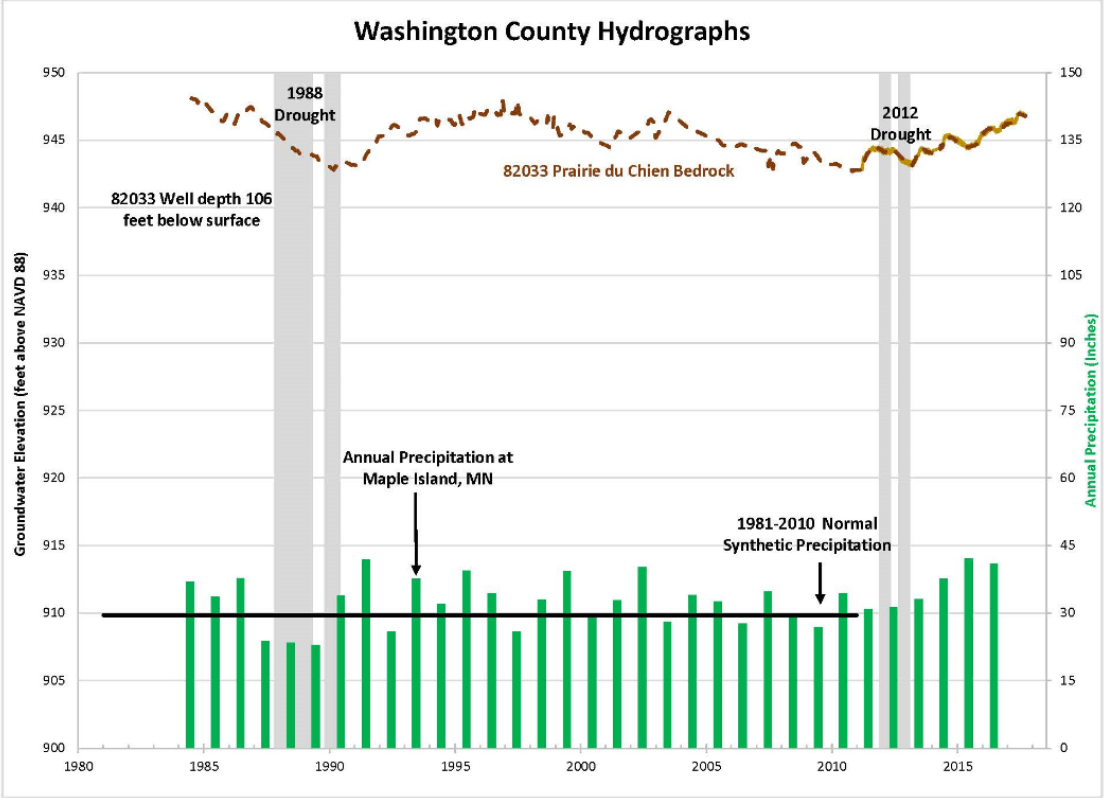

Figure 30d: Lower St. Croix River Watershed - Hydrograph from observation well 82033.

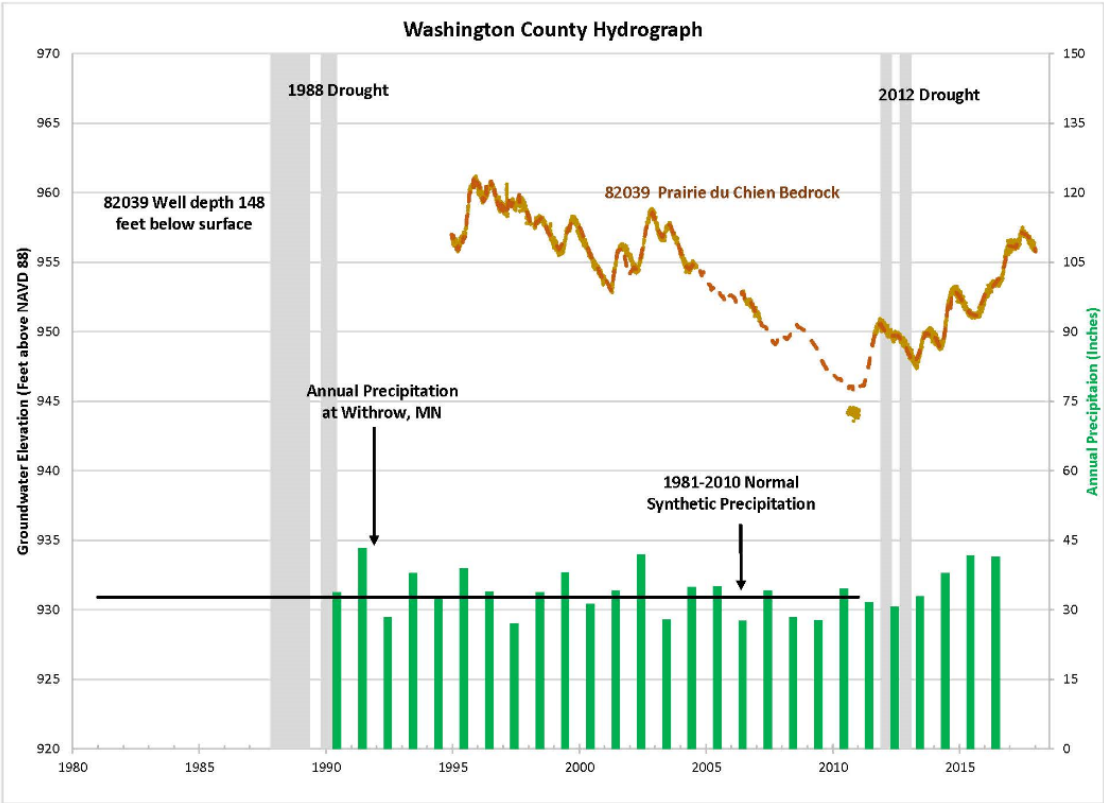

Figure 30e: Lower St. Croix River Watershed – Hydrograph from observation well 82039.

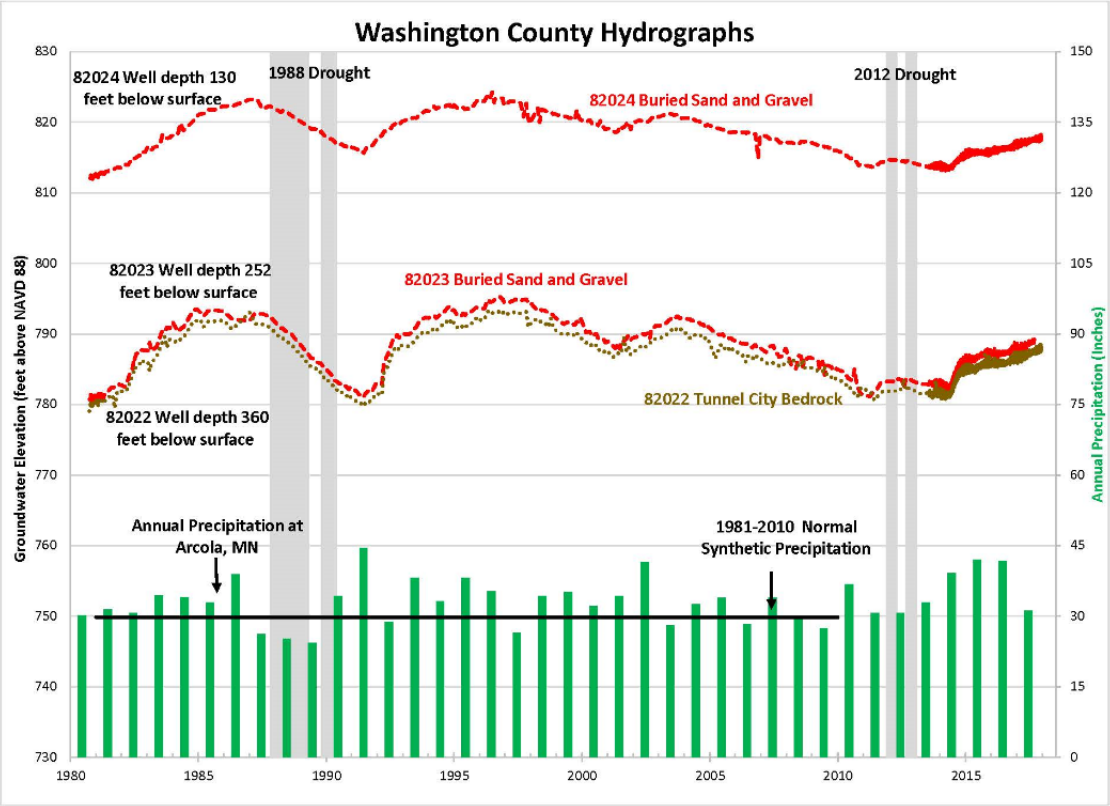

Figure 30f: Lower St. Croix River Watershed – Hydrographs from observation well nest 13022, 13023, and 13024. This well nest shows a groundwater recharge zone. Shallower aquifers have higher water levels than deeper aquifers indicating groundwater is moving downward here.

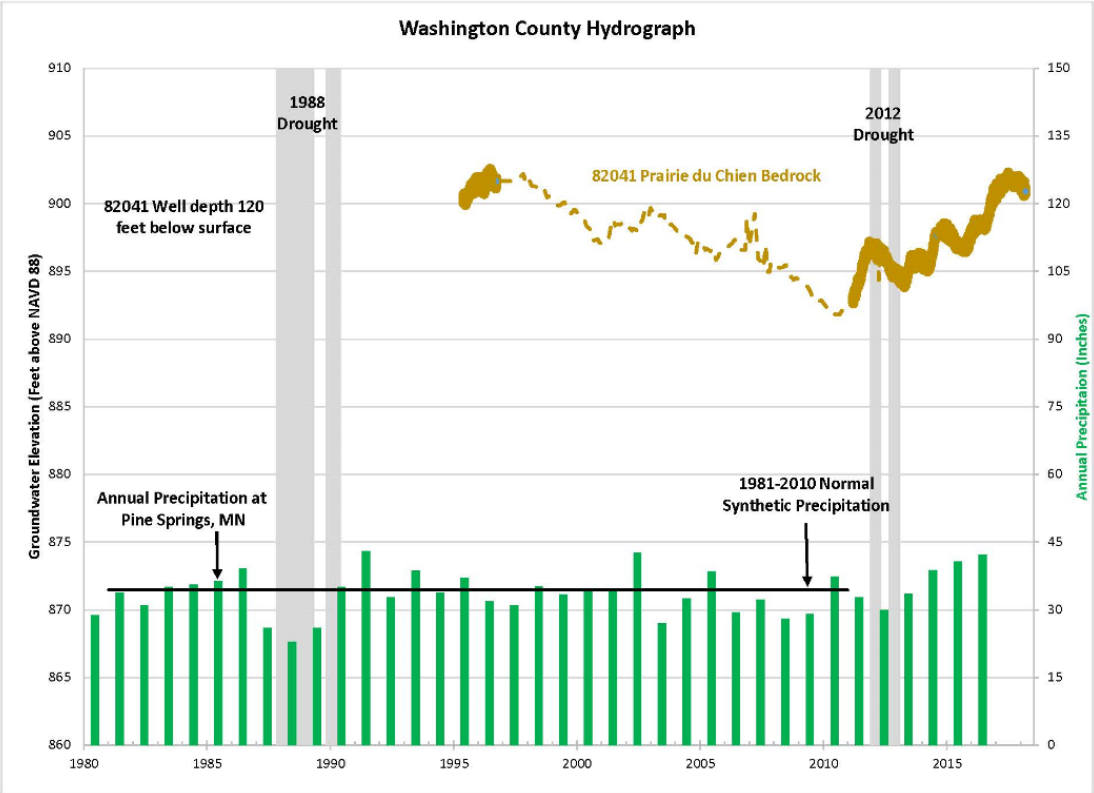

Figure 30g: Lower St. Croix River Watershed – Hydrograph from observation well 82041.

Figure 31 a-d show four hydrographs plotted against reported pumping. Water levels drop during the pumping season but recover in the off season. Figure 31 a-c show normal pumping patterns, where water use is higher in the summer. Figure 31 d shows water levels vs. pumping near Afton Alps ski area. Here most water use is during the winter months to make snow.

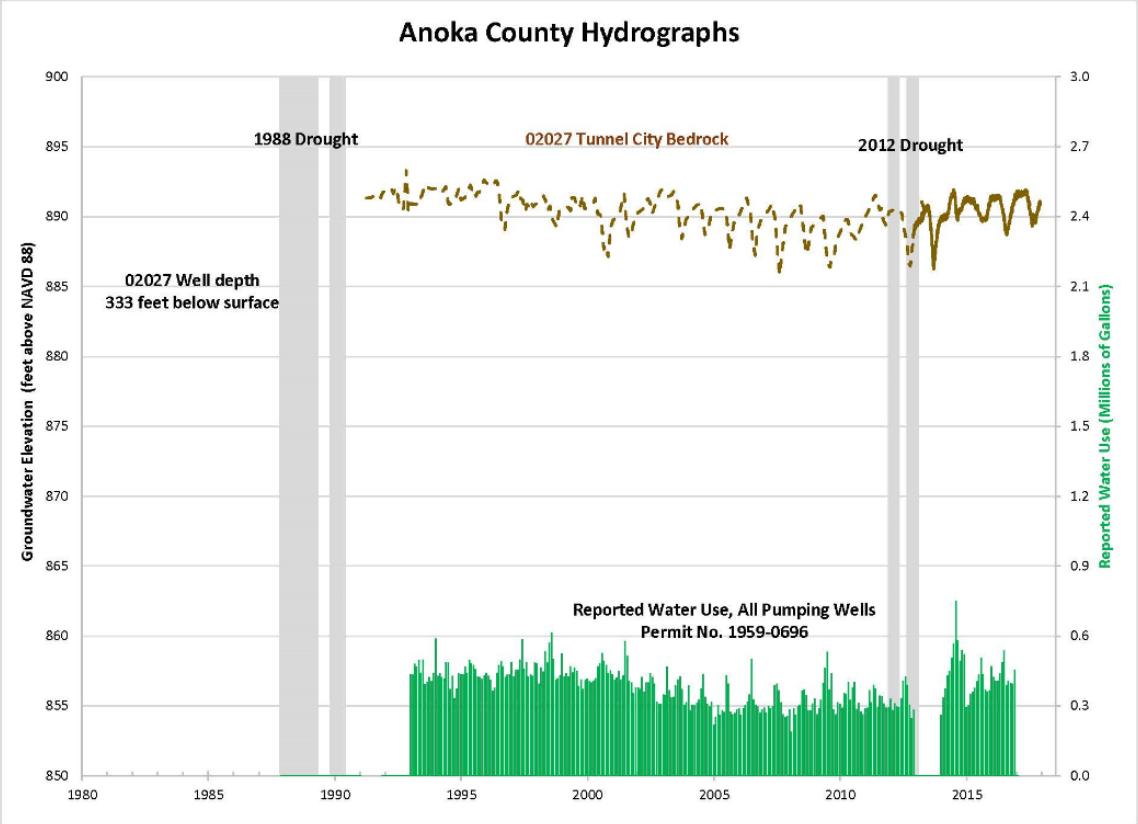

Figure 31a: Lower St. Croix River Watershed - Hydrographs from observation well 02027 compared with nearby large-volume pumping. The water level in this well is primarily affected by nearly large-volume pumping. The water level in this well varies annually with the pumping cycle. Hydrograph show the effects of summer pumping, with water levels lowest in the summer.

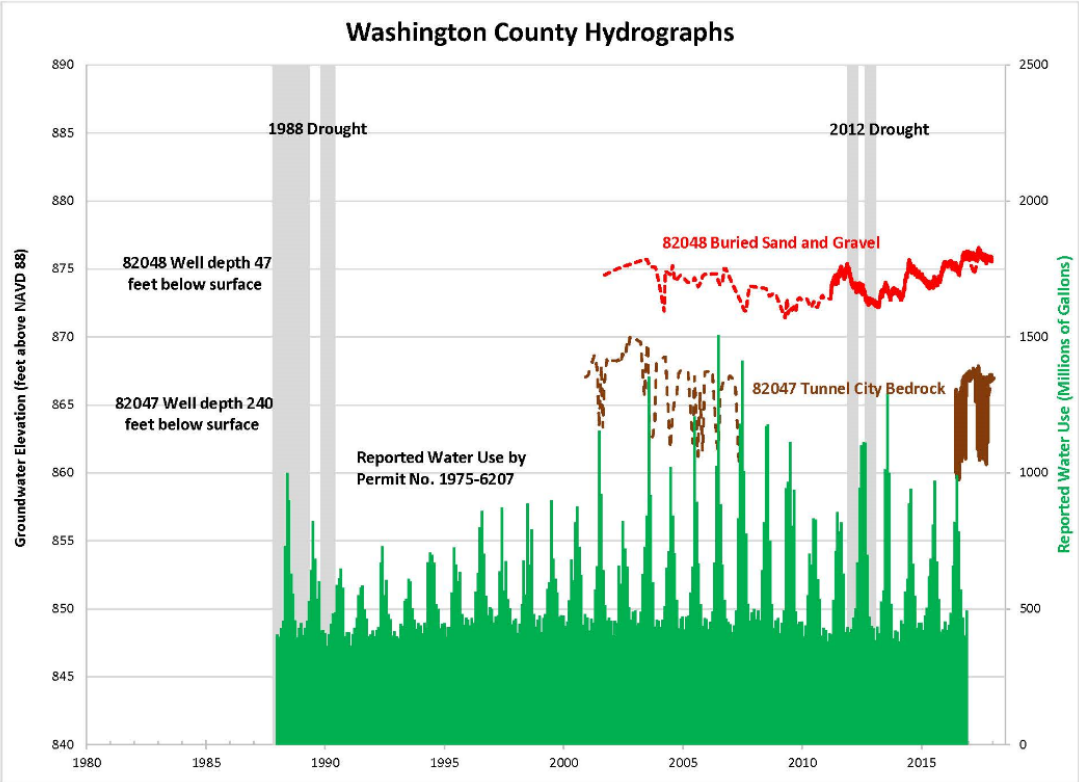

Figure 31b: Lower St. Croix River Watershed - Hydrograph from observation well nest 82047 and 82048 near Stillwater compared with nearby large-volume pumping. The water levels are primarily affected by nearly large-volume pumping. The water levels varies annually with the pumping cycle. Hydrograph show the effects of summer pumping, with water levels lowest in summer.

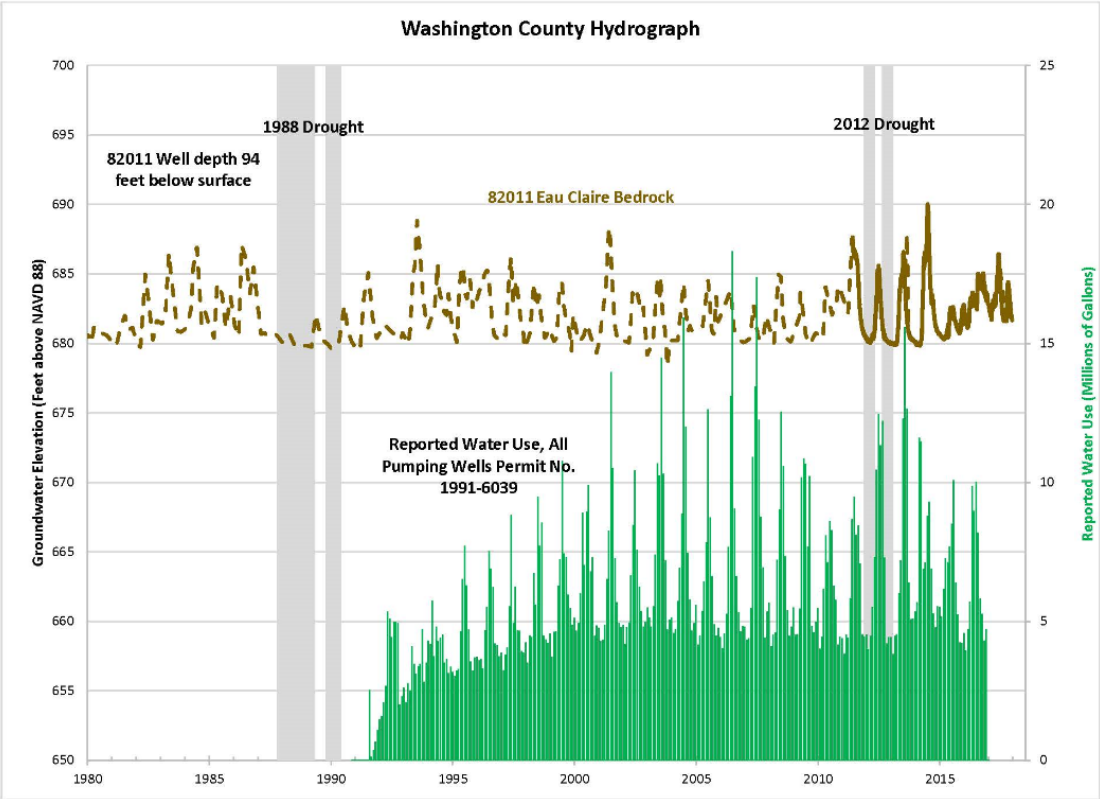

Figure 31c: Lower St. Croix River Watershed - Hydrograph from observation well 82011 compared with nearby large-volume pumping. The water level in this well is primarily affected by nearly large-volume pumping. The water level in this well varies annually with the pumping cycle. Hydrograph show the effects of summer pumping, with water levels lowest in the summer.

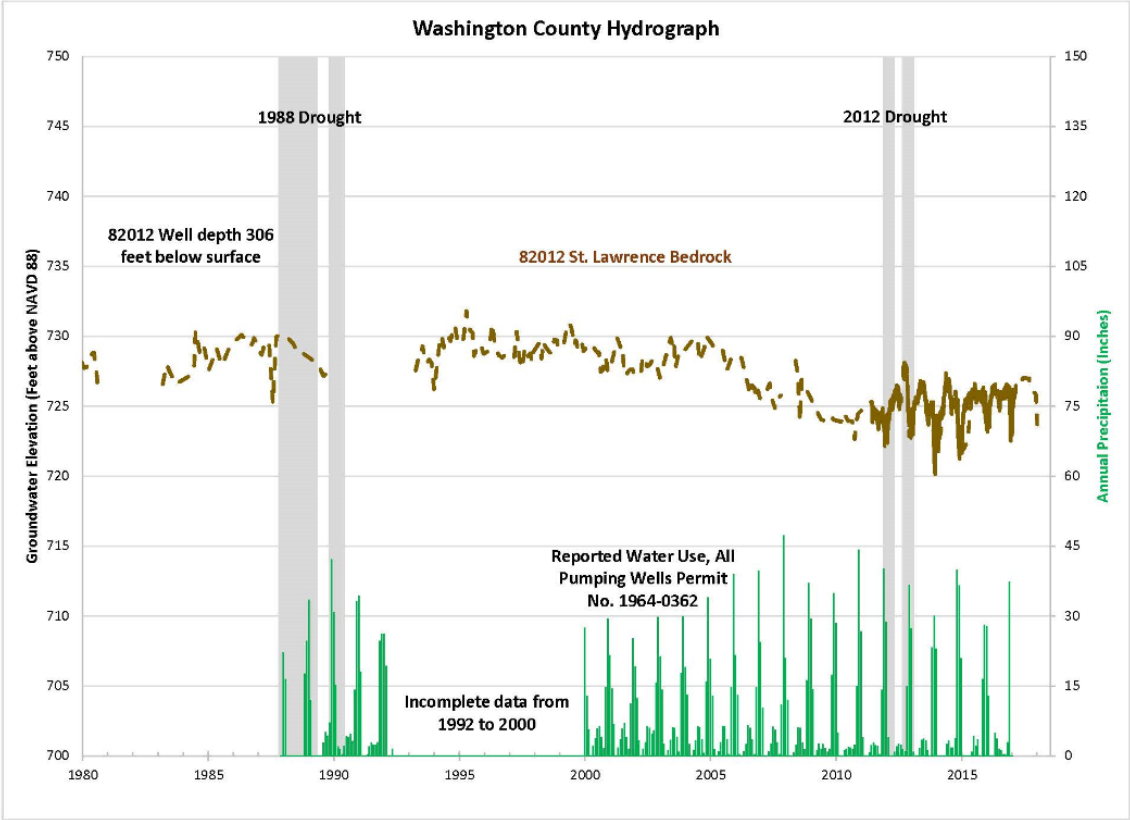

Figure 31d: Lower St. Croix River Watershed - Hydrograph from observation well 82012. The monitoring well is near Afton Alps Ski Area, where most water is used to make snow. Here the highest pumping and lowest water levels occur in the winter.

Data from observation wells measure how water levels in an aquifer change over time. In aquifers connected to the land surface water levels generally fluctuate with precipitation and groundwater recharge. Pumping of nearby wells completed in the same aquifer will also lower water levels in the observation wells. The effects of groundwater recharge versus pumping can be separated on a hydrograph by the nature of the water-level change. In confined aquifers, nearby pumping wells will cause cyclic water level drops of greater magnitude than the drops in water level solely attributable to changes in precipitation and recharge. Large-capacity pumping wells should not be placed in close proximity to existing domestic wells or to groundwater connected features.

North and East Metro Groundwater Management Area

The north and east metro region of the Twin Cities was identified during a statewide analysis of groundwater resources as an area seeing increasing demands for agriculture, industry and domestic needs, putting those underground water resources at risk of overuse and degradation. The area is growing in population and water use is increasing. In addition, this area is rich in surface waters that are connected to and affected by groundwater levels. In portions of the region, existing groundwater contamination further limits water availability to meet human needs. Communities, businesses, and agriculture in much of the region are entirely reliant on groundwater as a source of water supply. They are connected to one another through their use of the same aquifers and the cumulative effects of that use.

To better address these issues, the DNR has designated all of Washington and Ramsey Counties along with portions of Anoka and Hennepin, as the North and East Metro Groundwater Management Area (GWMA). This designation established in November 2015 allows a more comprehensive and focused

approach to ensuring that groundwater supplies remain adequate to meet human needs while protecting lakes, streams and wetlands.

The N & E Metro GWMA plan will guide the DNR's efforts to manage groundwater appropriations sustainably in this area over five years through 2020. The plan establishes sustainability goals to help appropriation permit holders plan for their future water use. The plan does not specify details of water management for any individual business or community, but rather sets the stage for managing appropriations more carefully and comprehensively in the years ahead.

The implementation plan for the N & E Metro GWMA can be retrieved on the DNR GWMA (www.dnr.state.mn.us/gwmp/area-ne.html). A summary of DNR implementation activities, as well as local actions carried out by LGUs in the N & E Metro GWMA is available in the appendix, as Figure 42 and Figure 43.

The Metropolitan Council completed a study, North & East Metro Analysis of Potential for Aquifer Recharge & Stormwater Reuse (https://metrocouncil.org/Wastewater-Water/Planning/Water-Supply-Planning/Studies-Projects-Workgroups-(1)/Completed-Studies-Projects/North-and-East-Metro-Analysis-of-Potential-for-A.aspx), evaluating the best locations for groundwater recharge. The metadata files were not complete at the time the report was compiled, however the report includes maps of this information to help guide recharge activities.

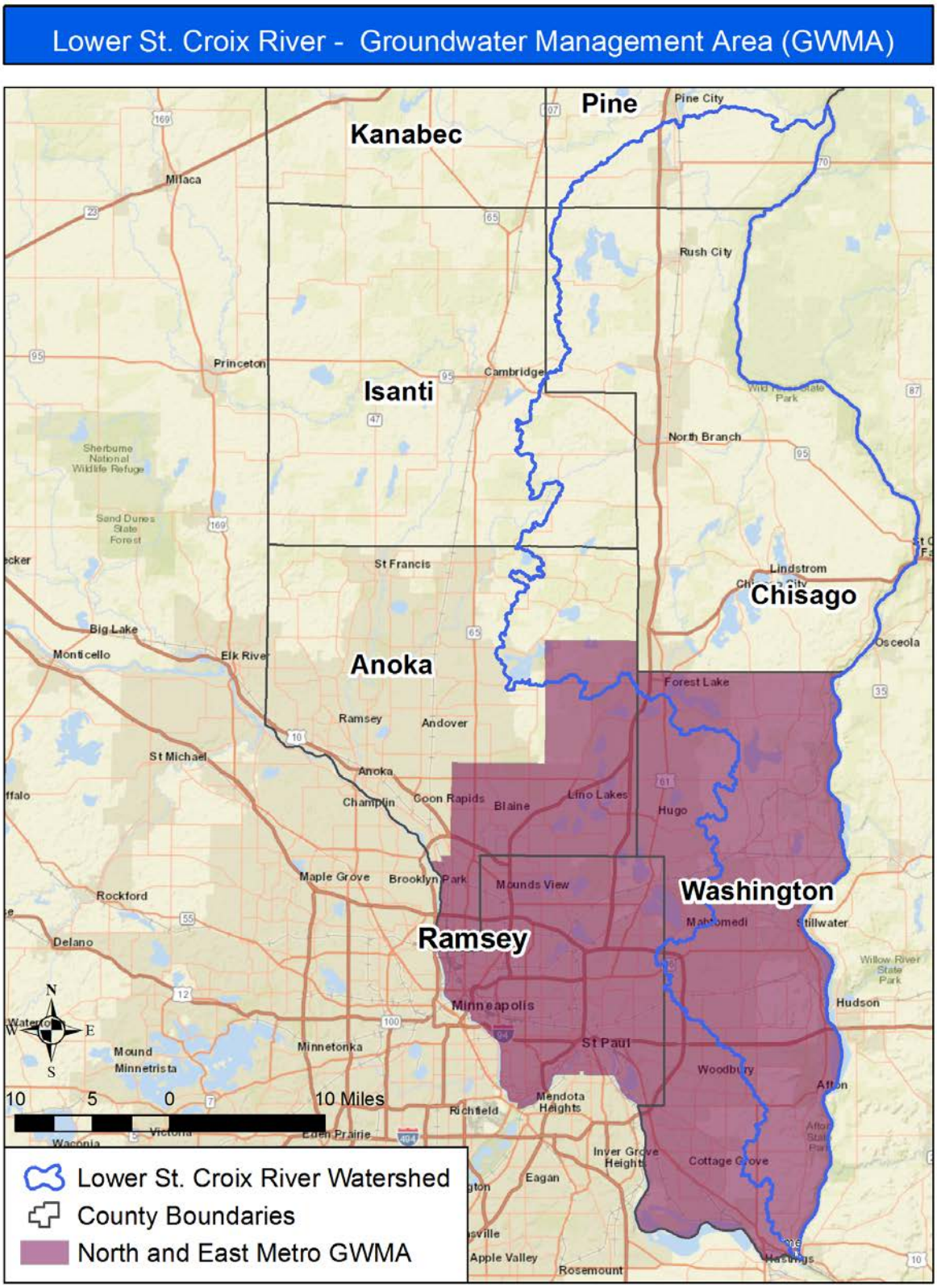

Figure 32: North & East Groundwater Management Area

Groundwater Connected Natural Features at Risk

The LSCRW boundary includes significant natural features, including surface waters that depend on groundwater to sustain them (Figure 35). Groundwater appropriations and land-use changes can impact the health of these natural resources. If groundwater quantity or quality is degraded, these resources are at risk. Groundwater seeps and streams associated with the St. Croix River are especially important resources in the watershed. The following features occur within the LSCRW:

- Twenty designated trout streams
- Wetland complexes across the entire area
- Lakes that may be susceptible to changing aquifer levels
- Twenty-six kinds of groundwater associated native plant communities
- Forty state-listed endangered, threatened, or special concern plant and animal species associated with groundwater

Rare Natural Features Connected with Groundwater in the LSCRW

Rare natural features (Figure 33 and Figure 34) contribute to the health of the habitat and environment. Some even contribute directly to local economies in the form of recreation—including hunting/fishing, wildlife viewing and camping. Rare natural features can include species of rare plants and animals as well as native plant communities (habitats). These resources are at risk if groundwater quantity or quality is disrupted.

There are twenty designated trout streams in the LSCRW, listed below. These streams are dependent on a constant supply of cold, oxygen-rich groundwater from springs or seeps. These streams are not only unique, but offer excellent recreation opportunities for fishing. Because surrounding land use changes and water appropriations can easily affect them, trout streams are waters designated by the DNR and protected from harm by law (Minnesota Rule 6264.0050).

- Brown's Creek (M-050-012)
- County Ditch 3 (M-050-034-001-001)
- Lawrence Creek (M-050-028)
- Old Mill Stream (M-050-019)
- Unnamed Stream (M-050-007-002-001)
- Unnamed Stream (M-050-017)
- Unnamed Stream (M-050-022.5)
- Unnamed Stream (M-050-024)
- Unnamed Stream (M-050-024.1)
- Unnamed Stream (M-050-026)
- Unnamed Stream (M-050-027)
- Valley Branch (M-050-007-002)
- Valley Creek (M-050-007)
- Valley Creek (M-050-007-B001)
- MAJ-070310105
- MAJ-070310570
- MAJ-070310571
- MAJ-070310575
- MAJ-070310687
- MAJ-070310691

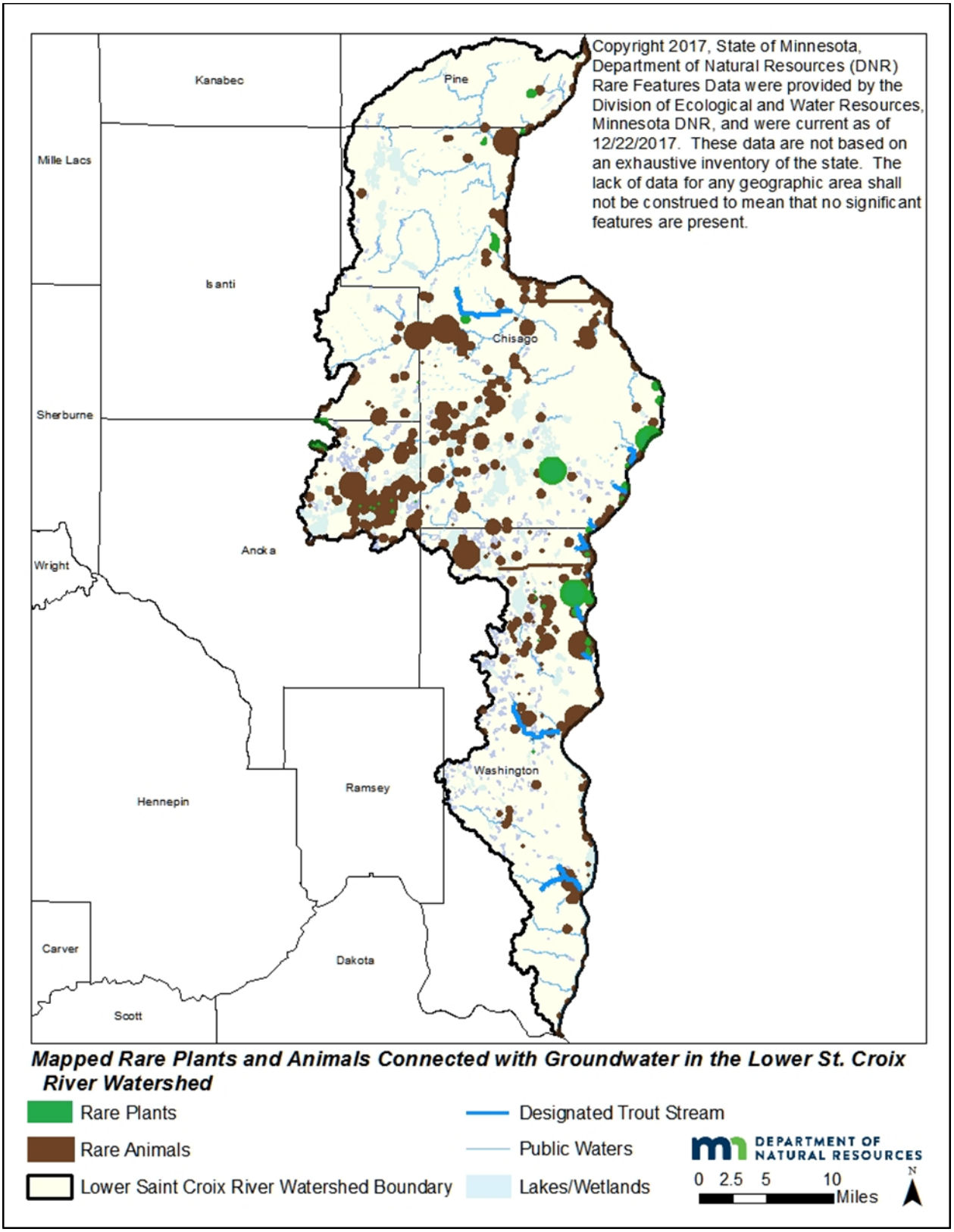

Figure 33: Lower St. Croix River Watershed - Rare Plants, Animals, and Native Plant Communities Connected with Groundwater

There are 26 kinds of native plant communities associated or dependent on groundwater in the LSCRW (Figure 34). They range from forested communities, such as tamarack swamps and floodplain forests, to open communities, such as seepage meadows, wet prairies, and rich fens. Six of these communities are

considered critically imperiled or imperiled and six are considered vulnerable status.[10] None of the 26 native plant communities associated or dependent on groundwater are considered apparently secure or secure. It is important to note that native plant communities have not yet been mapped in Pine County.

There are 40 species of birds, fish, amphibians, reptiles, mussels, insects, and plants that are either endangered, threatened, special concern that are dependent on habitats with groundwater or groundwater seepage areas in the LSCRW. A detailed list of native plant communities and rare features is available in the Additional Resources section at the end of the report (Table 13 and Table 14).

[10] The native plant community (NPC) types and subtypes recognized in Minnesota have been assigned conservation status ranks (S-ranks) that reflect the risk of elimination of the community from Minnesota. Learn more at Conservation Ranks for Native Plant Community Types and Subtypes (files.dnr.state.mn.us/natural_resources/npc/s_ranks_npc_types_&_subtypes.pdf).

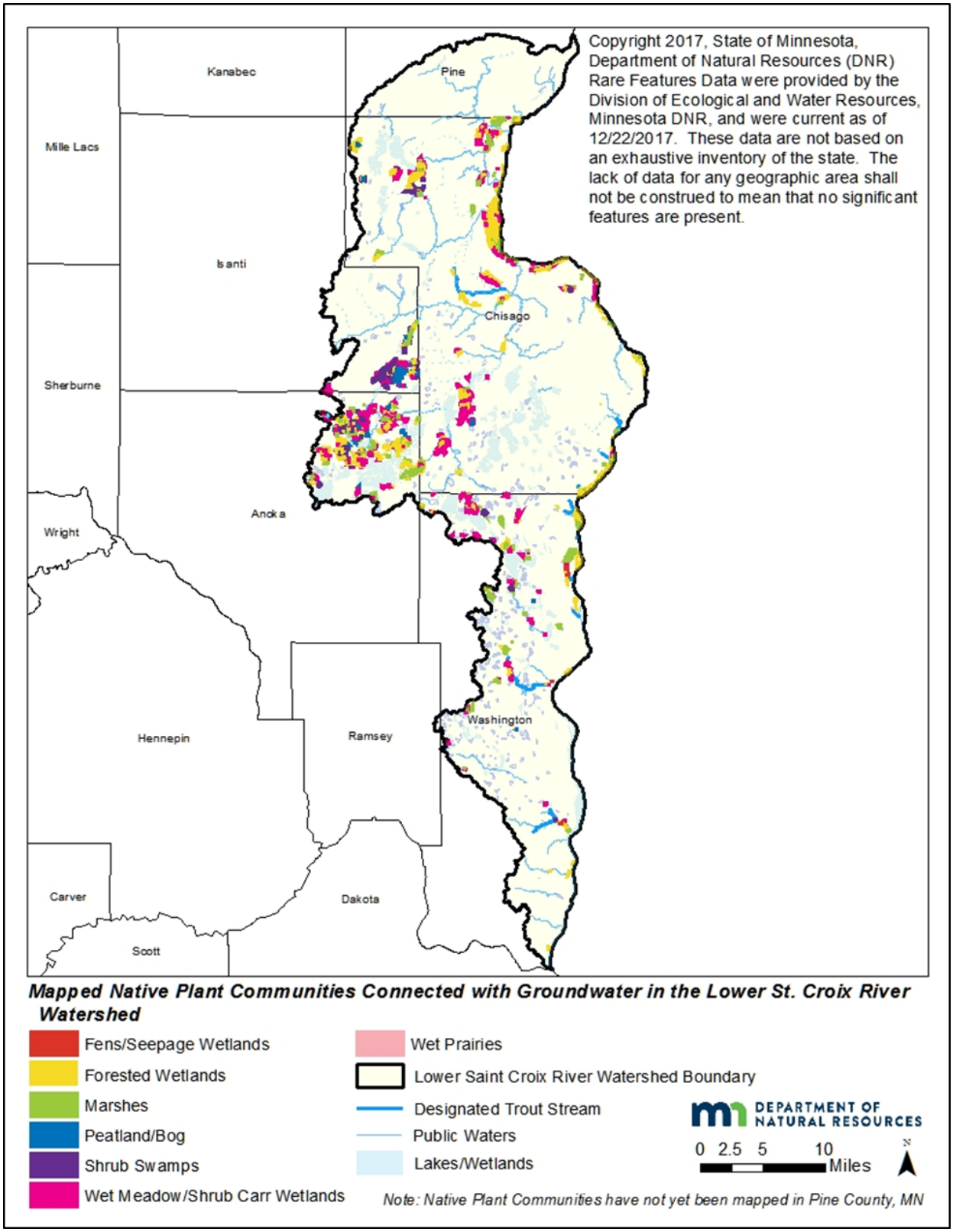

Figure 34: Lower St. Croix River Watershed - Native Plant Communities Connected with Groundwater

Groundwater connections to wildlife species are many and often complex. Wildlife groups as diverse as birds, bats, spiders, snakes, turtles, frogs, toads, fishes, and snails all contain species that require some form of surface water body to complete their life cycles and persist on the landscape. If groundwater

fluctuations or depletions affect a significant number of surface water features in this area, important wildlife habitats may be impacted or lost.

Groundwater Flow Dominated Lakes

All lakes are connected to groundwater, but the specific interaction between lake water and groundwater depends on the geology, topography, and volume of surface-water inflow and outflow associated with the lake. There are three basic lake types (Petersen and Solstad, 2007):

1. Lakes dominated by surface water inflow and outflow resulting from a large ratio of contributing surface watershed area to lake area.
2. Lakes dominated by groundwater inflow and outflow resulting from a smaller ratio of contributing surface watershed area to lake area (10 or less). This lake type is often landlocked with no surface outlet. Although for the purposes of this GRAPS report, the lake level versus outlet elevation has not been studied. Lakes have been put into this classification solely by watershed to lake area ratio.
3. Lakes intermediate between the first and second types. This applies to lakes that typically have a large watershed to lake area ratio, but during times of drought, the lake level will drop below the outlet level. Groundwater often becomes a significant part of the inflow to these lakes during extended dry periods.

Only the groundwater-dominant lakes as defined in type 2 above are shown in this report (Figure 35). Sixty-seven of the 533 lakes in the LSCRW have a watershed to lake area ratio of 10 or less and are considered groundwater-dependent lakes. Large-scale groundwater pumping near a lake will likely have more impact on groundwater-dominated lakes than on surface water dominant lakes.

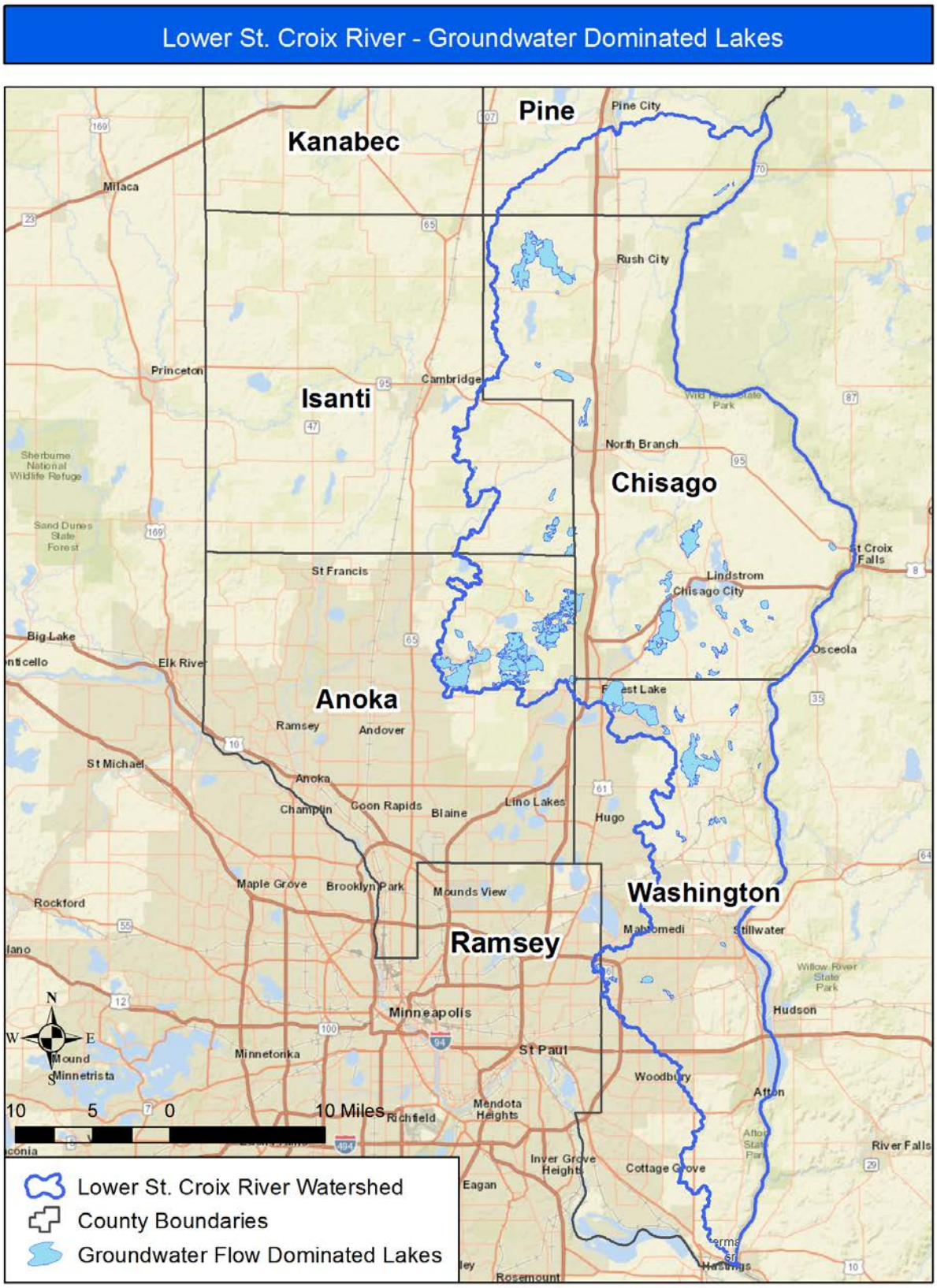

Figure 35: Lower St. Croix River Watershed - Groundwater Dominated Lakes

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 LSCRW can take to conserve water and promote recharge.

Lower St. Croix River Watershed 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) will 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. For example, a failing septic system has a greater potential to contaminate the aquifer in a highly sensitive setting with coarse textured material than an area with low sensitivity that has a protective clay 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, among others. 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 LSCRW 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 of remediating already-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 cost 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 Lower St. Croix River Watershed

This section provides a table of strategies and actions local partners in the LSCRW 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 key approaches to achieving the goal.
- **Recommended Groundwater Actions** are specific actions prescribed to a specific county or HUC-10 within the watershed that will help achieve the goal and pertains to the supporting strategy.

Figure 36 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.

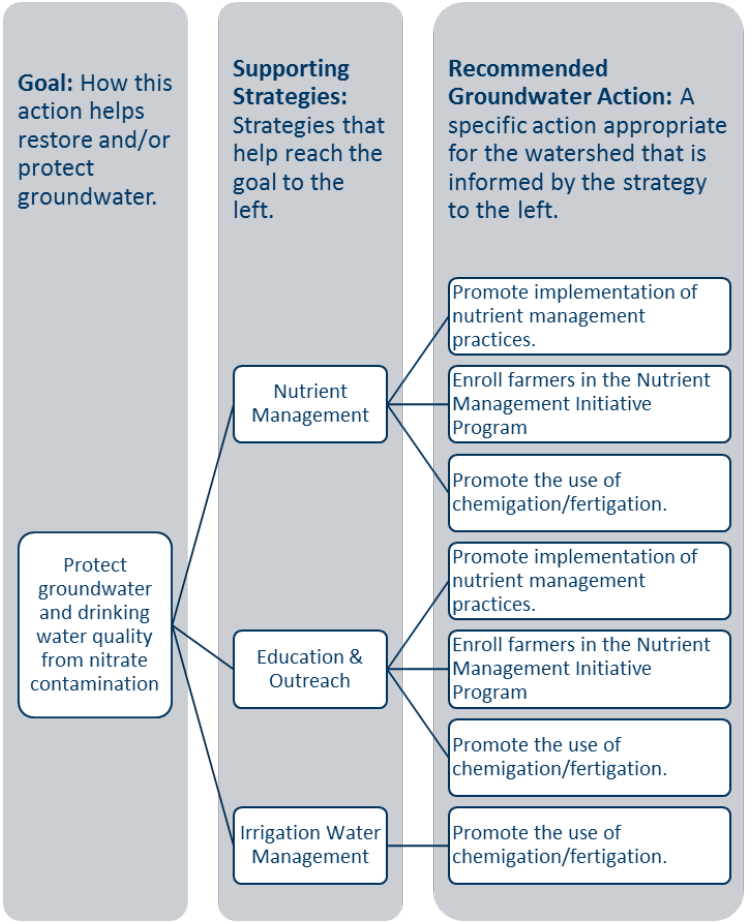

Figure 36: Visual representation of the relationship between goals, supporting strategies, and recommended groundwater action.

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 have been sorted alphabetically as much as possible. Each goal identifies the main objective—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 you 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's' denote 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 geographic 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 you work.
- **HUC-8s Involved**: This column denotes which HUC-8 major watershed(s) within the LSCRW to consider using the action described in the corresponding row. There are four HUC-8s within Missouri watersheds. Table 7 provides the name and the HUC-8 number assigned to each major watershed. Figure 2 is a map of the HUC-8s.
- **Agencies that can assist[11]:** This column lists agencies that may be able to assist with implementing the strategy through existing programs or providing more information or technical assistance.
- **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-8s. 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-8 to target. The maps are listed in *italicized font.* You can click on the *blue text* that says the figure number for the map to hyperlink directly to the map being referenced.
- **Benefit:_____ [12]:** This series of 'X' marks whether the corresponding action may have additional benefits. An 'X' denotes the action could create the described additional benefit.

Table 7: HUC 10 subwatersheds within the Lower St. Croix River Watershed

HUC-10 Name	Reference Name in Implementation Table	HUC-10 Number
Goose Creek - St. Croix River	Goose Creek	0703000502
North Branch Sunrise River	North Branch	0703000503
Sunrise River	Sunrise	0703000504
Wolf Creek – St. Croix River	Wolf Creek	0703000506
Big Marine Lake – St. Croix River	Big Marine	0703000509
Lake St. Croix	Lake St. Croix	0703000512

[11] 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*)

[12] Habitat=Improve/Protect Habitat, including pollinators; GWCF=Improve/Protect Groundwater Connected 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*).

Summary of Key Findings and Issues

Below is a summary of key groundwater quality and quantity findings found in the LSCRW. This summary can be used to help target groundwater actions during the 1W1P exercise.

Key Groundwater Quality Findings and Issues

- **Nitrate** – less than one percent of tested drinking water wells had levels at or above the SDWA standard of 10 mg/L, although shallow wells, less than 50 feet deep, had approximately 16 percent of samples exceed the SDWA standard.
  - MDA monitoring wells (shallow non-drinking water wells in agricultural areas) in Chisago County recorded the highest nitrate result at 9.21 mg/L.
  - MDA TTP in Washington County confirmed nitrate is a significant issue in the southern part of the watershed where row crop production combined with vulnerable geology has resulted in more than ten percent of the samples collected exceeded the SDWA standard.
    - Cottage Grove Township had more than 28 percent of the 300 wells tested exceed the SDWA standard and Denmark Township have more than 13 percent of the 226 wells tested exceed the SDWA standard. The areas with elevated nitrate correspond with the areas of high pollution sensitivity and karst.
- **Arsenic** – 20 percent of tested wells have elevated arsenic with approximately 4 percent exceeding the SDWA standard of 10 µg/L.
- **Pesticides** were detected in all three MDA monitoring wells but not at concentrations above human-health based drinking water standards or reference values.
- **Radionuclides** - Elevated concentrations of naturally occurring radioactive radium occur all within the bedrock Mt. Simon aquifer or related geologic units.
- **DWSMAs** cover approximately 63,900 acres in the watershed. Eight of the 26 approved wellhead protection plans exhibit a high vulnerability in all or part of their DWSMA and are considered vulnerable to contamination from the land surface.
- **Animal feedlots –** There are 193 active feedlots in the watershed with the greatest concentration in Chisago County. The MPCA manages the feedlot program since there are no delegated counties.
- **Row crop agriculture** accounts for 23 percent of land cover in the watershed and is most prevalent in Chisago and southern Washington County.
- **SSTS** are found throughout the watershed. Information reported by counties indicate Isanti and Chisago counties have the highest number of failing SSTS at four to 7.7 per 1,000 acres, followed by Washington County at three to four per 1,000 acres, and Anoka and Pine with zero to one failing SSTS per 1,000 acres.
- **Contaminated sites –** Over one quarter of all registered tanks are leaking chemicals into the environment and have the potential to cause localized groundwater pollution.
  - Three closed landfills with known groundwater contamination plumes are found within the watershed.
  - Historic contamination of PFCs and VOCs are found in Washington Co. As a result, there are three Special Well and Boring Construction areas or well advisories in place to inform the public of potential health risks in contaminated areas, ensure the construction of safe water supplies, and prevent the spread of contamination.

Key Groundwater Quantity Findings and Issues

- The availability of groundwater is generally not an issue from bedrock aquifers. However, seasonal drawdown is recorded in areas near high capacity wells with heavy use.

- An analysis of groundwater levels in wells identified that most water levels follow precipitation trends, but slightly delayed. The overall trend in groundwater levels has been down, but the trend correlates with rainfall. Water levels and precipitation have both been rising since 2013.
- Groundwater seeps and springs associated with the St. Croix River are especially important for the 20 designated trout streams.
- Sixty-seven of the 533 lakes in the watershed have a watershed to lake ratio of 10 or less and are considered groundwater dependent lakes, susceptible to changing aquifer levels.
- Wetland complexes across the entire watershed are susceptible to changing aquifer levels.
- Twenty-six kinds of native plant communities and 40 state-listed endangered, threatened, or special concern plant and animal species connected to groundwater that are at risk to changing aquifer levels and degraded groundwater quality.

Table of Actions and Strategies to Restore and Protect Groundwater

Table 8: Actions and Strategies to Restore and Protect Groundwater

Goal	Supporting Strategy	Recommended Groundwater Actions	Target Pine Co.	Target Isanti Co.	Target Chisago Co.	Target Anoka Co.	Target Washington Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*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 to private well users to help answer health related questions and information on arsenic removal.	X	X	X	X	X	All	MDH Well MGMT	Prioritize areas with a high density of private wells and areas with evidence of high levels of arsenic in private wells. *Arsenic Map* (Figure 21) *Drinking Water Wells Map* (Figure 16)						
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 well users to have their water tested for: ▪ Coliform Bacteria (every year) ▪ Nitrate (every other year) ▪ Arsenic (at least once) ▪ Lead (at least once) ▪ Manganese (at least once)	X	X	X	X	X	All	MDH Well MGMT	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) *Pollution Sensitivity Wells* (Figure 9) *Arsenic Map* (Figure 21) *Drinking Water Wells Map* (Figure 16) *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	All	MDH Well MGMT	Prioritize areas with a high density of private wells *Drinking Water Wells Map* (Figure 16)						

Goal	Supporting Strategy	Recommended Groundwater Actions	Target Pine Co.	Target Isanti Co.	Target Chisago Co.	Target Anoka Co.	Target Washington Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*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 of unsealed, unused wells. ▪ Provide educational materials on well sealing.	X	X	X	X	X	All	MDH Well MGMT	Prioritize areas with a high density of private wells and DWSMAs. *Drinking Water Wells Map (Figure 16)* *DWSMA Map (Figure 12)*						
Protect Groundwater and Drinking Water Quality: Closed Landfills	Contaminant Planning and Management Land Use Planning and Management	▪ Identify MPCA closed landfill location and groundwater areas of concern in comprehensive land use plans, zoning maps and ordinances. Identifying the location 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 the area. Request to be notified regarding any changes in the migration or movement of contaminants. ▪ Educate residents about the proper disposal of HHW, pharmaceuticals and personal care products that can contaminant landfills.		X	X		X	North Branch Sunrise Lake St. Croix	MPCA CLP Land Manager	*Closed Landfill Map (Figure 26)*						

Goal	Supporting Strategy	Recommended Groundwater Actions	Target Pine Co.	Target Isanti Co.	Target Chisago Co.	Target Anoka Co.	Target Washington Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
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. ▪ 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.	X		X	X	X	All	MPCA Tanks Program	Focus in areas with high pollution sensitivity and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 7)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 12)* *Tank & Leak Site Map (Figure 26)*						
Protect Groundwater and Drinking Water Quality: Karst Sinkhole Treatment	Cropland Management	Treat karst sinkhole features to reduce the movement of contaminants into groundwater by installing a vegetative buffer around the sinkhole and managing nutrients and pesticides within the watershed that flows into the sinkhole.					X	Lake St. Croix	NRCS Field Office	Prioritize areas of karst geology in agricultural settings. *Pollution Sensitivity Map (Figure 7)*						
Protect Groundwater and Drinking Water Quality: Feedlots (non-delegated counties)	Contaminant Planning and Management	▪ Conduct an inventory of active feedlots to help guide MPCA feedlot inspectors. ▪ Request the MPCA feedlot inspectors prioritize feedlot inspections, regardless of size, in areas of greatest risk to pollution, to minimize the loss of nitrate and harmful bacteria.	X	X	X		X	All	MPCA Feedlot Program	*Focus in areas with high pollutions sensitivity and highly vulnerable DWSMAs.* *Pollution Sensitivity Map (Figure 7)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 12)* *Active Feedlot Map (Figure 24)*						X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Pine Co.	Target Isanti Co.	Target Chisago Co.	Target Anoka Co.	Target Washington Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Protect Groundwater and Drinking Water Quality: Manure Management	Education and Outreach Nutrient Management	▪ Assist feedlot owners, especially sites with 300 or fewer animal units, in the development of a manure management plan. ▪ Host field days that promote; emergency response training, manure crediting, calibration of equipment, and the manure testing process. ▪ Conduct an active campaign on manure setbacks, can provide free window sticker from MPCA. ▪ Provide manure sample kits to feedlot operators to send in for analysis. If needed can help subsidize the cost to operators.	X	X	X		X	All	MPCA Feedlot Program	Focus in areas with high pollutions sensitivity and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 7)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 12)*			X	X		X
Protect Groundwater and Drinking Water Quality: Pasture Management	Land Use Planning and Management	Promote pasture management techniques and rotational grazing.	X	X	X		X	All	NRCS Field Office	Focus in areas with high pollutions sensitivity and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 7)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 12)*						
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 of nitrogen stewardship (right source, right rate, right timing, and right place)	X	X	X	X	X	All	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, highly vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map (Figure 7)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 12)*						X

Goal	Supporting Strategy	Recommended Groundwater Actions	Target Pine Co.	Target Isanti Co.	Target Chisago Co.	Target Anoka Co.	Target Washington Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
		▪ Adopt and use of the UMN 'Best Management Practices for Nitrogen use in Minnesota ▪ 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								*Township Testing Map* (Figure 18)						
Protect Groundwater and Drinking Water Quality: Nitrate	Nutrient Management Education and Outreach	Increase the number of farmers enrolled in the Nutrient Management Initiative Program to evaluate alternative nutrient management practices.	X	X	X	X	X	All	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, highly vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map* (Figure 7) *Pollution Sensitivity Wells* (Figure 9) *DWSMA 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	All	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, highly vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map* (Figure 7) *Pollution Sensitivity Wells* (Figure 9)	X		X		X	X

Goal	Supporting Strategy	Recommended Groundwater Actions	Target Pine Co.	Target Isanti Co.	Target Chisago Co.	Target Anoka Co.	Target Washington Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
										DWSMA Map (Figure 12) *Township Testing Map (Figure 18)*						
Protect Groundwater and Drinking Water Quality: Nitrate	Nutrient Management Education and Outreach	Promote the adoption of cover crops for scavenging nutrients under row crops.	X	X	X	X	X	All	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, irrigated row crops, highly vulnerable DWSMAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map (Figure 7)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 12)* *Township Testing Map (Figure 18)* *Drinking Water Wells Map (Figure 16)*	X		X	X	X	X
Protect Groundwater and Drinking Water Quality: Nitrate	Education and Outreach Nutrient Management Irrigation Water Management	Promote the use of chemigation/fertigation to synchronize nitrogen application to crop demand.		X	X	X	X	Goose Creek North Branch Sunrise Big Marine Lake St. Croix	MDA Pesticide & Fertilizer Division	Focus on irrigators in areas with high pollution sensitivity, and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 7)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 12)* *Township Testing Map (Figure 18)* *Monitoring Wells/Pumping (Figure 28)*						X
Protect Groundwater and Drinking Water Quality: Nitrate	Education and Outreach Nutrient 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	Goose Creek North Branch	MDA Pesticide & Fertilizer Division	Focus on irrigators in areas with high pollution sensitivity, and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 7)*						X

Goal	Supporting Strategy	Recommended Groundwater Actions	Target Pine Co.	Target Isanti Co.	Target Chisago Co.	Target Anoka Co.	Target Washington Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
	Irrigation Water Management							Sunrise Big Marine Lake St. Croix		*Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 12)* *Township Testing Map (Figure 18)* *Monitoring Wells/Pumping (Figure 28)*						
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	All	NRCS Field Office	Focus on areas with high pollution sensitivity, highly vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map (Figure 7)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 12)* *Township Testing Map (Figure 18)* *Nitrate in Wells Maps (Figure 17)*			X	X	X	X
Protect Groundwater and Drinking Water Quality: Nitrate **Groundwater Sustainability:** Water Conservation	Education and Outreach Nutrient Management Cropland Management	Contact state and federal agency resource partners and coordinate opportunities for local field days, training and outreach for farmers, co-ops, and crop consultants. Focus on alternative nitrogen management practices, soil health, and second crops.	X	X	X	X	X	All	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, highly vulnerable DWMSAs, and vulnerable townships identified by MDA through their Township Testing program. *Pollution Sensitivity Map (Figure 7)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 12)* *Township Testing Map (Figure 18)* *Nitrate in Wells Maps (Figure 17)*						

Goal	Supporting Strategy	Recommended Groundwater Actions	Target Pine Co.	Target Isanti Co.	Target Chisago Co.	Target Anoka Co.	Target Washington Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
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	All	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, highly vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map (Figure 7)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 12)* *Township Testing Map (Figure 18)* *Nitrate in Wells Maps (Figure 17)* *Pesticides Map (Figure 20)*		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	Big Marine Lake St. Croix	UMN Lawns & Turfgrass MGMT Team	Focus in MS4 communities and residential developments with high pollution sensitivity, along with highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 7)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA 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	Education and Outreach	Promote the adoption and use of MDA's water quality BMPs for agricultural pesticides and insecticides.	X	X	X	X	X	All	MDA Pesticide &	Focus in areas of pesticide detection in MDA's monitoring wells, along with areas of high pollution sensitivity, vulnerable DWMSAs, and highly						X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Pine Co.	Target Isanti Co.	Target Chisago Co.	Target Anoka Co.	Target Washington Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Quality: Pesticides	Integrated Pest Management								Fertilizer Division	vulnerable townships identified by MDA through their Township Testing program. *Pollution Sensitivity Map (Figure 7)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 12)* *Township Testing Map (Figure 18)* *Pesticides Map (Figure 20)*						
Protect Groundwater and Drinking Water Quality: Pesticides	Education and Outreach	Promote to farmers and area businesses the Agricultural and Non-Agricultural Waste Pesticide Collection Program to dispose of unwanted and unusable pesticides.	X	X	X	X	X	All	MDA Pesticide & Fertilizer Division							
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. ▪ Evaluate existing SSTS ordinances and identify opportunities to enhance groundwater protection. Activities may include adding a Point of Sale requirement to trigger a SSTS inspection during real estate transactions. ▪ Improve SSTS records by obtaining information on treatment system; age, type and function to understand potential risks to groundwater.	X	X	X	X	X	All	MPCA SSTS Field Staff	Focus in areas with high pollution sensitivity, highly vulnerable DWSMAs, and areas with a density of SSTS. You can use the Well Density Map as an imperfect surrogate for SSTS density. *Drinking Water Wells Map (Figure 16)* *Pollution Sensitivity Map (Figure 7)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 12)*						
Protect Groundwater and	SSTS Management	Take advantage of increased funding for county SSTS programs by applying for:	X	X	X	X	X	All	MPCA SSTS Field Staff							

Goal	Supporting Strategy	Recommended Groundwater Actions	Target Pine Co.	Target Isanti Co.	Target Chisago Co.	Target Anoka Co.	Target Washington Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Drinking Water Quality: SSTS		▪ Advanced Inspector Grants, which pays for 75 percent of the cost to review an SSTS with design flows of 2,500 gallons/day or more. ▪ Low-income Fix-up Grants to address systems deemed an imminent threat or failing to protect groundwater. SSTS Financial Assistance (www.pca.state.mn.us/water/ssts-financial-assistance)														
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	All	MPCA SSTS Field Staff							
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	All	MPCA SSTS Field Staff							
Protect Groundwater and Drinking Water Quality: Wellhead Protection (WHP)	Education and Outreach Cropland Management	Serve on WHP planning teams to assist public water suppliers with planning and implementation activities to address land use planning concerns.	X	X	X	X	X	Goose Creek North Branch Sunrise	MDH SWP Unit	*Wellhead Protection Plan Development Status (Figure 11)* *DWSMA Map (Figure 12)*						

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Pine Co.	Target Isanti Co.	Target Chisago Co.	Target Anoka Co.	Target Washington Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
	Land Use Planning and Management							Big Marine Lake St. Croix								
Protect Groundwater and Drinking Water Quality: Wellhead Protection	Land Use Planning and Management	Integrate WHP plan strategies into local plans, such as the 1W1P and land use plans.	X	X	X	X	X	Goose Creek North Branch Sunrise Big Marine Lake St. Croix	MDH SWP Unit	*DWSMA Map (Figure 12)*						
Protect Groundwater and Drinking Water: Household Hazardous Waste (HHW)	Education and Outreach Land Use Planning and Management	▪ Educate the public about the risks of improperly disposing of HHW and promote community-supported collection sites. ▪ Make disposal of HHW easy for the public by expanding collection sites through mobile units by stopping in different communities throughout the summer for free drop off. ▪ Promote other recycling options of various products at area businesses throughout the year.	X	X	X	X	X	All	MPCA Hazardous Waste Program							
Protect Groundwater and Drinking Water: Pharmaceuticals	Education and Outreach	Keep unused/unwanted medications out of drinking water supplies by educating the public about available safe and secure drop box locations at law enforcement facilities and pharmacies.	X	X	X	X	X	All	MPCA Hazardous Waste Program							

Goal	Supporting Strategy	Recommended Groundwater Actions	Target Pine Co.	Target Isanti Co.	Target Chisago Co.	Target Anoka Co.	Target Washington Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Protect Groundwater and Drinking Water: Contaminants of Emerging Concern (CEC)	Education and Outreach	Enhance Minnesotans' understanding of CEC's by communicating the health impacts and exposure potential of emerging contaminants in drinking water. Outreach and Education Grants are available through the MDH CEC Initiative. See Outreach and Education Grants (www.health.state.mn.us/divs/eh/risk/guidance/dwec/outreachproj.html) for opportunities.	X	X	X	X	X	All	MDH CEC Program							
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	All	DNR Ecological & Water Resources	Focus in areas with high pollution sensitivity. *Pollution Sensitivity Map (Figure 7)* *Pollution Sensitivity Wells (Figure 9)*						
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 conservation. Dakota County's webpage Water Quality (https://www.co.dakota.mn.us/Environment/WaterQuality/WellsDrinkingWater/Pages/default.aspx) is a good example.	X	X	X	X	X	All	MDH Well MGMT & SWP Unit							
Protect Groundwater and Drinking Water Quality	Land Use Planning and Management	Develop ordinances, overlay districts, performance standards, etc. to further protect drinking water and groundwater connected	X	X	X	X	X	All	MN Assoc. of Counties	Focus in areas with high sensitivity, highly vulnerable DWSMAs and groundwater connected natural features		X				

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Pine Co.	Target Isanti Co.	Target Chisago Co.	Target Anoka Co.	Target Washington Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Water Sustainability		features from future land use impacts for their long-term sustainability and use.								*Pollution Sensitivity Map (Figure 7)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 12)* *GWC Plants, Animals, Native Plant Communities Map (Figure 33)* *Mapped Native Plant Communities (Figure 34)*						
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 ▪ Special Well and Boring Construction Areas ▪ Other local information needed to consider and protect groundwater and drinking water resources in local land use planning decisions	X	X	X	X	X	All	MDH SWP Unit							
Groundwater Sustainability: Water Conservation	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	X		MN Assoc. of Counties	Prioritize vulnerable DWSMAs and the North & East GWMA: *DWSMA Map (Figure 12)* *GWMA Map (Figure 32)*						

Goal	Supporting Strategy	Recommended Groundwater Actions	Target Pine Co.	Target Isanti Co.	Target Chisago Co.	Target Anoka Co.	Target Washington Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Protect Groundwater and Drinking Water Quality **Water Sustainability:** Recharge	Conservation Easements	Enroll private lands in land acquisition programs or conservation easements. Programs may include: Continuous CRP, RIM Reserve for wellhead protection, and CREP.	X	X	X	X	X	All	BWSR	Prioritize areas of high pollution sensitivity, and highly vulnerable DWSMAs. Target areas of high water use, known groundwater dependent natural features. Examine areas where you can expand on existing easements and protected lands to increase protections. *Pollution Sensitivity Map (Figure 7)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 12)* *Monitoring Wells/Pumping (Figure 28)* *GWMA Map (Figure 32)* *GWC Plants, Animals, Native Plant Communities Map (Figure 33)* *Mapped Native Plant Communities (Figure 34)* *RIM Easements Map (Figure 37)*	X	X	X	X	X	X
Protect Groundwater and Drinking Water Quality **Water Sustainability:** Recharge	Conservation Easements	Maintain and expand set-aside acres in sensitive areas, 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	All	FSA	Prioritize private lands with existing CRP contracts, along with state and federal easement, such as RIM and DNR and USFW habitat easements. Target areas of known groundwater dependent features, areas of high pollution sensitivity, and highly vulnerable DWSMAs. *RIM Easements Map (Figure 37)*	X	X	X	X	X	X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Pine Co.	Target Isanti Co.	Target Chisago Co.	Target Anoka Co.	Target Washington Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
										GWC Plants, Animals, Native Plant Communities Map (Figure 33) *Mapped Native Plant Communities (Figure 34)* *Pollution Sensitivity Map (Figure 7)* *DWSMA Map (Figure 12)*						
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 and special requirements for karst geology.		X	X	X	X	North Branch Sunrise Big Marine Lake St. Croix	MPCA MS4 Program	Prioritize MS4 communities and target highly sensitive areas, karst geology and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 7)* *DWSMA 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		X	X	X	X	Goose Creek North Branch Sunrise Big Marine Lake St. Croix	MDA Pesticide & Fertilizer Division	Prioritize areas of high water use intensity by agricultural irrigators, highly sensitive areas, and highly vulnerable DWSMAs. *Monitoring Wells/Pumping (Figure 28)* *Pollution Sensitivity Map (Figure 7)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 12)*		X		X		X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Pine Co.	Target Isanti Co.	Target Chisago Co.	Target Anoka Co.	Target Washington Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
		▪ Test irrigation water and take credit for nitrate present as a fertilizer source														
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	All	DNR Ecological & Water Resources			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	Goose Creek North Branch Sunrise Big Marine Lake St. Croix	DNR Ecological & Water Resources			X				
Groundwater Sustainability: Water Conservation	Land Use Planning and Management Education and Outreach	Assist farmers with a water appropriation permit by developing a water resource plan that identifies water conservation measures that improve water use efficiencies and reduce water demand.		X	X	X	X	Goose Creek North Branch Sunrise Big Marine Lake St. Croix	DNR Ecological & Water Resources	Prioritize areas of high water use intensity by agricultural irrigators. *Monitoring Wells/Pumping (Figure 28)*		X				X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Pine Co.	Target Isanti Co.	Target Chisago Co.	Target Anoka Co.	Target Washington Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
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	X	X	X	X	All	DNR Ecological & Water Resources	Target areas near sensitive features and groundwater fed lakes, along with the N & E GWMA. *GWMA Map (Figure 32)* *GWC Plants, Animals, Native Plant Communities Map (Figure 33)* *Mapped Native Plant Communities (Figure 34)* Groundwater Dominated Lakes Map *(Figure 35)*	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** (www.mda.state.mn.us/protecting/conservation/programs/ccrp.aspx): A voluntary program designed to help farmers restore and protect environmentally sensitive land.
- BWSR **Conservation Reserve Enhancement Program - CREP** (www.bwsr.state.mn.us/crep/index.html): This project is a federal, state and local partnership and will voluntarily retire environmentally sensitive land using the nationally-recognized Reinvest in Minnesota (RIM) Reserve program. Figure 37 shows where RIM easements are in the Missouri watersheds.

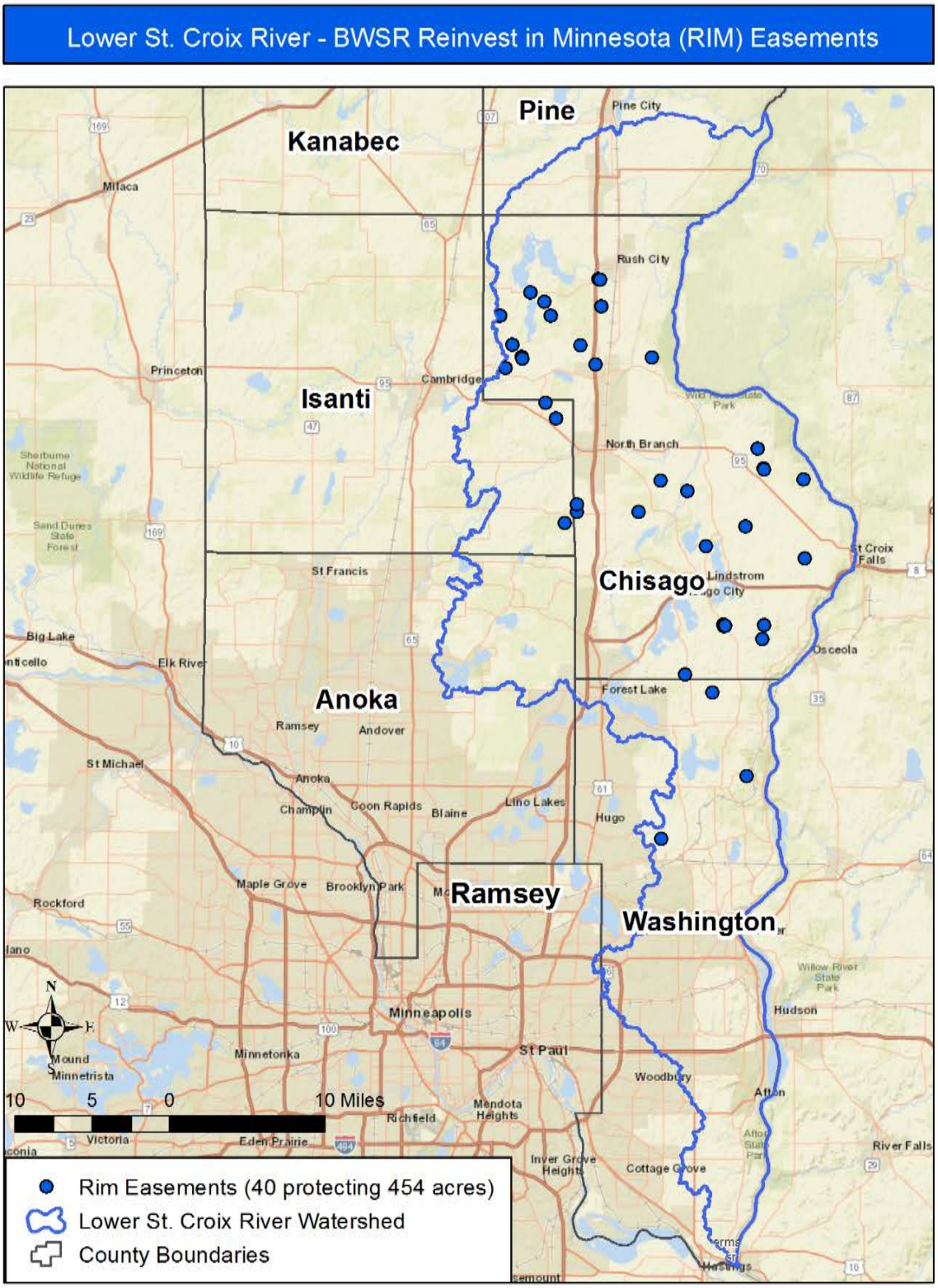

Figure 37: Lower St. Croix River Watershed – BWSR RIM easements

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** (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 **Manure Management** (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 information about contaminated sites and facilities all around Minnesota.
- UMN Extension **Manure Management in Minnesota** (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** (www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/technical/ecoscience/nutrient/?cid=nrcs142p2_023688): Basic manure management information.
- MDH **Contaminants of Emerging Concern** (www.health.state.mn.us/cec): A program that investigates and communicates the health and exposure potential of contaminants of emerging concern (CECs) 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** (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** (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** (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** (mccc.msu.edu/statesprovince/minnesota/): Provides resources to help with technical support and answer questions from a local perspective at no cost.
- MDA **Minnesota Agricultural Water Quality Certification Program** (www.mda.state.mn.us/awqcp): A voluntary program for farmers to implement conservation practices to protect water quality.
- UMN Extension **Pasture Management** (www.extension.umn.edu/agriculture/horse/pasture/)
- MDA **Rotational Grazing** (mda.state.mn.us/protecting/conservation/practices/grazing.aspx)
- NRCS **Pasture and Range Management** (https://www.nrcs.usda.gov/wps/portal/nrcs/main/mn/technical/landuse/pasture/)

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** (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** (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** (www.health.state.mn.us/divs/eh/wells/index.html): Information about proper well construction, maintenance, testing, and sealing.

- MDH **Wellowner's Handbook** (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** (www.health.state.mn.us/divs/eh/wells/waterquality/arsenic.html): Information about arsenic in Minnesota.
- MDH **Water Treatment Units for Arsenic Reduction** (www.health.state.mn.us/divs/eh/wells/waterquality/arsenictreat.pdf)
- MDA **Waste Pesticide Collection Program** (https://www.mda.state.mn.us/chemicals/spills/wastepesticides.aspx): Information about the safe disposal of unwanted and unusable pesticides from farms and area businesses.
- MPCA **Managing Unwanted Medications** (https://www.pca.state.mn.us/living-green/managing-unwanted-medications)**:** Information about the safe disposal of unwanted or unused medications from households.

Integrated Pest Management

Integrated Pest Management (IPM) is a balanced approach to pest management which 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** (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** (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** (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** (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** (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)** (www.dnr.state.mn.us/mpars/index.html): DNR is the permitting authority for high capacity water use.
- DNR **Sustainability of Minnesota's Groundwaters** (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, as well as factsheets.
- DNR **Water Conservation** (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 **Stormwater and Wellhead Protection** (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** (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** (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** (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.
- MPCA **Household Hazardous Waste** (www.pca.state.mn.us/waste/household-hazardous-waste-managers-and-operators): Resources for HHW managers and operators, education resources, searchable by county HHW facilities.

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** (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** (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** (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** (www.mda.state.mn.us/nitrogenbmps): Provides nitrogen BMPs for various areas within Minnesota.
- MDA **Minnesota Nitrogen Fertilizer Management Plan** (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** (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** (www.mda.state.mn.us/chemicals/pesticides/maace.aspx): Information about agricultural chemical monitoring and assessment programs and additional resources.
- UMN Extension **Nutrient Management** (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 Use in Southeastern Minnesota** (www.extension.umn.edu/agriculture/nutrient-management/nitrogen/docs/08557-southeastMN.pdf): Information about best management practices for nitrogen application.
- UMN Extension **Best Management Practices for Nitrogen Use in South-Central Minnesota** (www.extension.umn.edu/agriculture/nutrient-management/nitrogen/docs/08554-southcentralMN.pdf): Information about best management practices for nitrogen application.

- UMN Extension **Nitrogen Application with Irrigation Water: Chemigation** (www.extension.umn.edu/agriculture/nutrient-management/nitrogen/nitrogen-application-with-irrigation-water-chemigation/): Information about risks, benefits, and methods.
- UMN Extension **Crop Calculators** (www.extension.umn.edu/agriculture/nutrient-management/crop-calculators/): Use crop calculators to help determine needed nutrients.
- UMN Extension **Nutrient/Lime Guidelines** (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** (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 (PDF)** (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** (www.nutrientstewardship.com/4rs): Information about the 4Rs of Nutrient Stewardship.
- MPCA **Manure Management** (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.
- UMN Extension **Manure Management in Minnesota** (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** (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** (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 38 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.

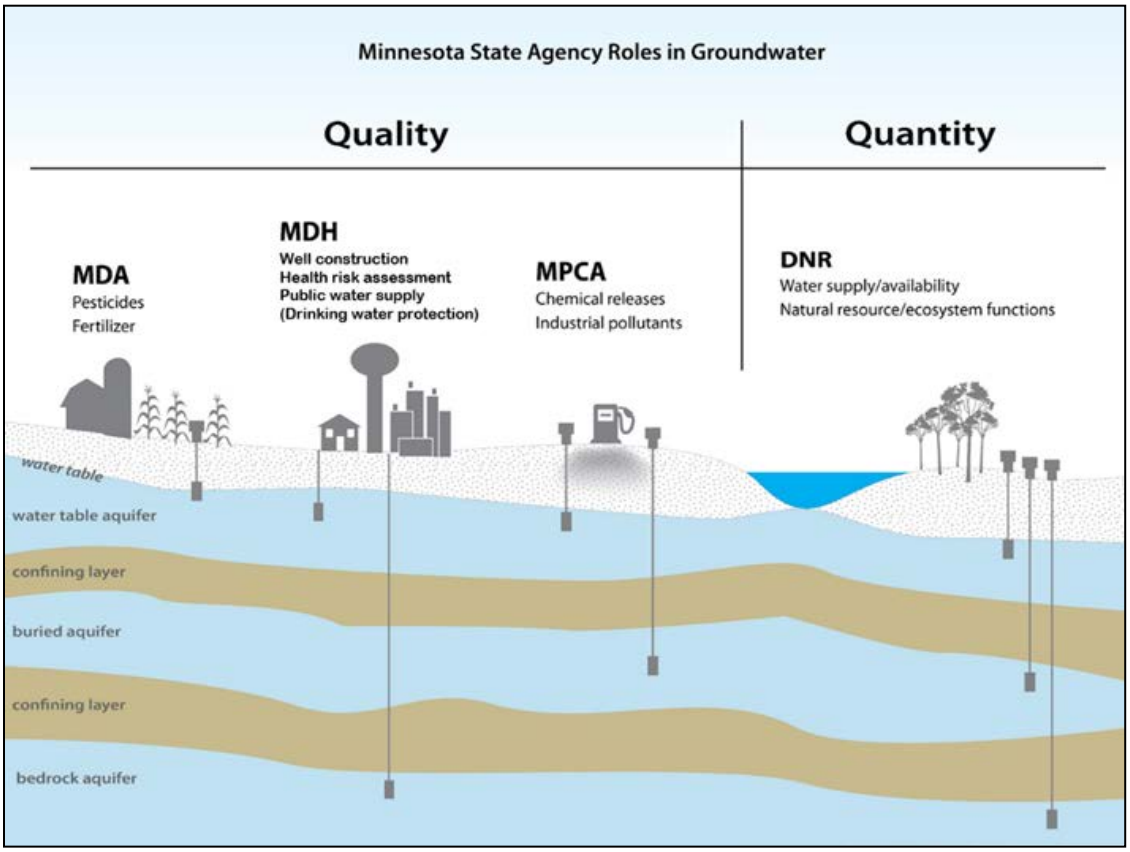

Figure 38: Minnesota State Agency Roles in Groundwater

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 39 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 39: 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
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
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 Public Water Supply System

A public water supply system that serves at least 25 persons or 15 service connections year-round, which includes municipalities (cities), manufactured mobile home parks, nursing homes, etc.

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.

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).

Dataset Sources

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- Multi-Resolution Land Characteristics Consortium (2011), *National Land Cover Database 2011* [electronic file], U.S. Geological Survey, Reston, Va. Available via USDA-NRCS Geospatial Data Gateway: 1-Where (http://datagateway.nrcs.usda.gov/GDGOrder.aspx/). [August 25, 2014].

Additional Resources

The following resources may be helpful for gathering data and learning more about groundwater in the Missouri watersheds. 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. ▪ Drinking Water Protection Annual Reports (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 (www.health.state.mn.us/divs/eh/water/swp/swa/) ▪ Maps and Geospatial Data (www.health.state.mn.us/divs/eh/water/swp/maps/index.htm)
Metropolitan Council Information	The Metropolitan Council information is limited to Anoka and Washington Counties only within the LSCRW. ▪ Forecasts for population, households, and employment for 2010, 2020, 2030, and 2040 (https://metrocouncil.org/Data-and-Maps/Publications-And-Resources/Files-and-reports/Thrive-MSP-2040-Forecasts-(January-2017).aspx) ▪ Water Supply Plan (https://metrocouncil.org/Wastewater-Water/Publications-And-Resources/WATER-SUPPLY-PLANNING/MASTER-WATER-SUPPLY-PLAN-2015/Master-Water-Supply-Plan-Appendix-1-Communitie.aspx) ▪ GIS Data (https://metrocouncil.org/Data-and-Maps/Maps/Map-Gallery.aspx) ▪ Watershed Data (https://eims.metc.state.mn.us/)

Type of Information	Where you can get more information
Point Source Pollution	Visit the following sites for more information on point source pollution: ▪ Nonpoint Source Pollution (oceanservice.noaa.gov/education/kits/pollution/03pointsource.html) ▪ Point Source Pollution (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) (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

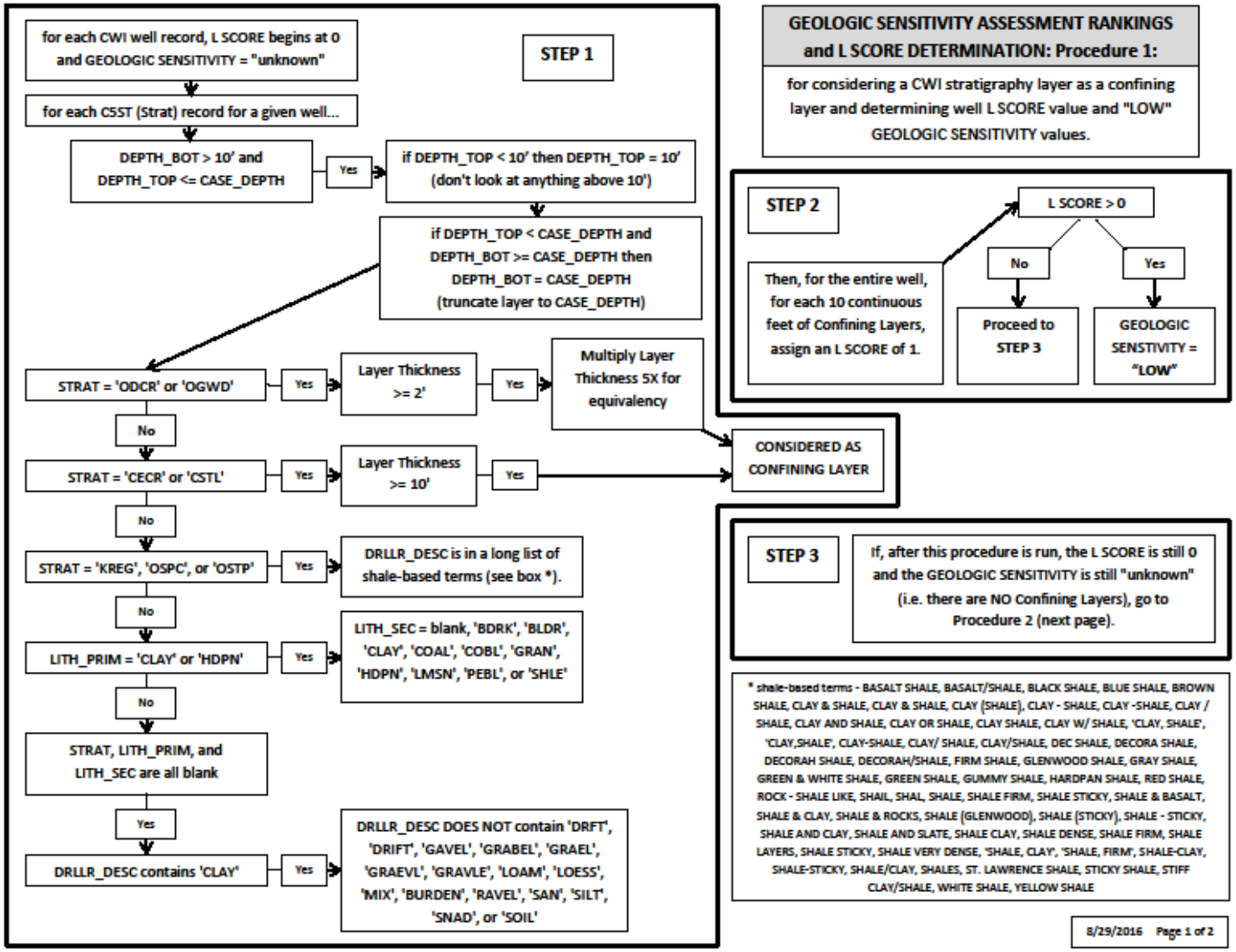

Figure 40: Sensitivity Assessment and Calculation for Pollution Sensitivity of Wells (Figure 9)

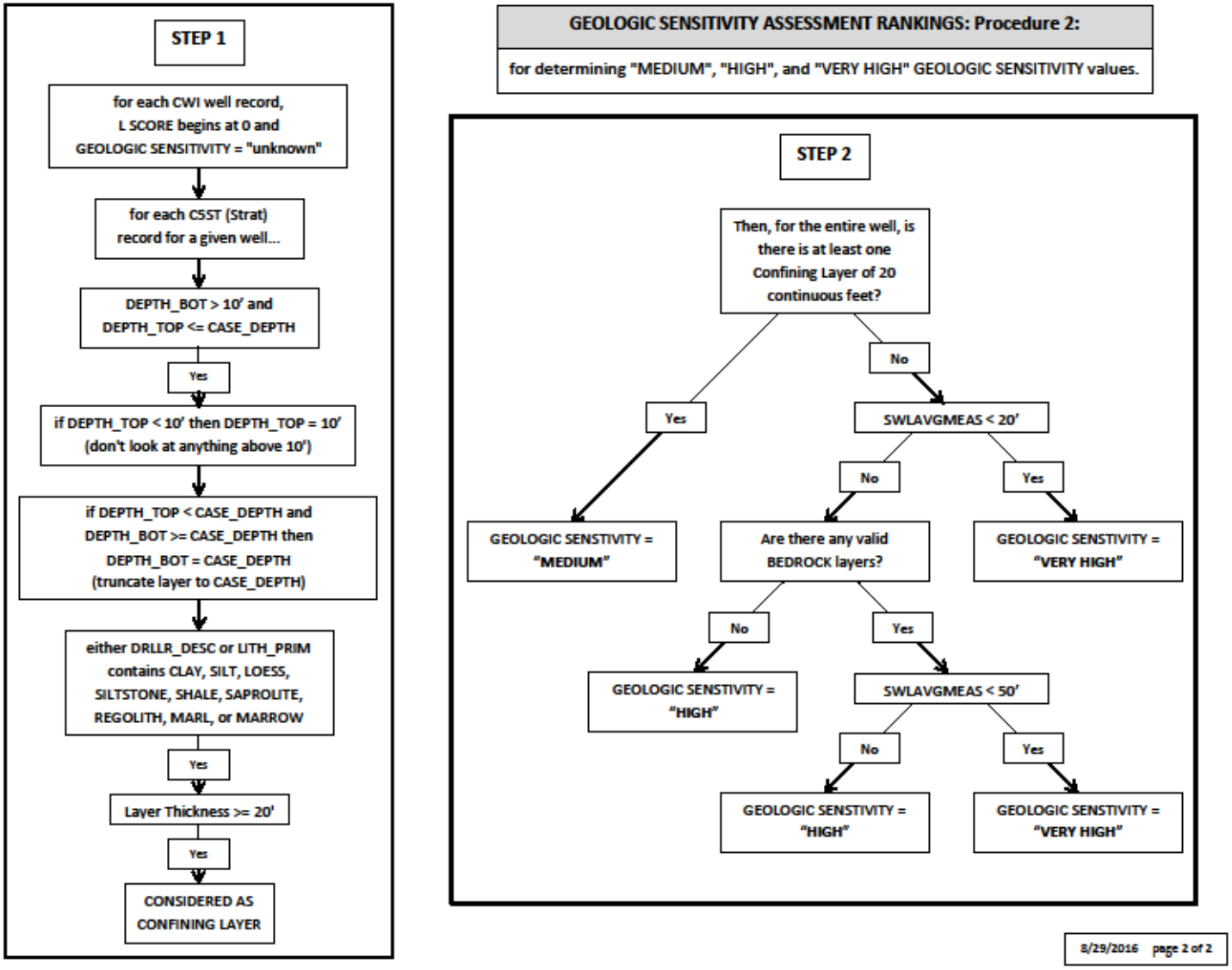

Figure 41: Sensitivity Assessment and Calculation for Pollution Sensitivity of Wells (Figure 9) continued

Figure 42: DNR Implementation Activities in the North & East Metro Groundwater Water Management Areas

DEPARTMENT OF NATURAL RESOURCES

North & East Metro Groundwater Management Area

DNR Implementation Activities Update: April 2018

Objective I. Groundwater use in the GWMA does not harm aquifers and ecosystems and does not negatively impact surface waters.

- DNR water monitoring and surveys unit is actively working on adding another weather station to provide real time data from the GWMA (Plan part I.1.a.iv.i.).
- Developed and using standard groundwater models and methods to predict impacts from groundwater appropriations (Plan part I.1.c.i.).
- Developed GIS model of wet prairie complexes (Plan part I.1.d.i.).
- Worked with USGS to model total annual volume withdrawn from White Bear Lake due to permitted groundwater appropriations (Plan part I.2.d.i.a.).
- DNR has worked with others to identify priority groundwater recharge areas throughout the GWMA (Plan part I.7.a.).
- Groundwater sensitivity maps have been developed for the GWMA (Plan part I.7.c.).

Objective II. Groundwater use in the GWMA is reasonable, efficient, and complies with water conservation requirements.

- DNR has worked with other entities and water users in the GWMA to report on water conservation practices being used in the GWMA (Plan part II.2.b.).
- DNR staff have updated the water conservation and efficiency web page to include information and additional website links about water conservation-related information (Plan part II.2.d.).
- DNR is working with other organizations to promote water storage, water re-use, and use of viable alternative water sources to conserve groundwater (Plan part II.3.).
- DNR continues to work with municipal/public water suppliers to include measurable water conservation goals within their water supply plans (Plan part II.4.a.).

Objective III. Groundwater use in the GWMA does not degrade water quality.

- DNR continues to evaluate new water appropriation permit applications for their potential to move known contaminants (Plan part III.2.a.).
- DNR continues to ensure that water supply plans take into account contaminant plume management (Plan part III.3.).

Objective IV. Groundwater use in the GWMA does not create unresolved well interferences or water use conflicts.

- DNR continues to improve information on aquifer characteristics in the GWMA to identify and reduce the interferences and conflicts prior to permit issuance (Plan part IV.3.).

Objective V. All groundwater users in the GWMA have the necessary permits to use groundwater.

- DNR continues to provide updated information to well drillers and consultants on existing laws and the water appropriation permit application process (Plan part V.1.c.).
- DNR staff are working to improve options for the public to report unpermitted water use through the DNR information center, website and other avenues (Plan part V.1.d.).

Figure 43: North & East Metro Management Area accomplishments by Advisory Team Organizations

North & East Metro Groundwater Management Area

Accomplishments within the GWMA by Advisory Team Organizations (2017)

City of Cottage Grove

- Installed two temporary water treatment plants to meet new health based values related to PFC's.
- Due to well impacts from the new PFC health based values, implemented an emergency watering ban in the summer of 2017 that reduced the City's total water pumping by 32%.
- In 2017 implemented a pilot program to supply smart irrigation controllers to residents at a reduced rate. This program was very successful and will be expanded in 2018 with additional funding from the South Washington Watershed District.
- Completed a water rate study, which included implemented a water conservation surcharge for high water users. These funds will be used to implement the City's water conservation program.
- Started a rain barrel rebate program in 2017.
- Drilled Well #12 to supplement water supply contaminated by PFCs.
- Drilled a monitoring well down stream of 3M Woodbury disposal site, through the Wellhead Protection Program. Results show increased levels of PFCs in the plum upstream of the City's main wellfield.

City of Hugo

- The City completed the start up of Beaver Ponds Water reuse system. The system is capable of pumping 100 gpm and will supply stormwater to irrigate the 5.5 acre Beaver Pond Park. The project reduces potable water use by approximately 3.8 MGY. (Construction Contract - $172,500)
- The City completed construction of phase 1 of the Water's Edge reuse system. The system is capable of pumping 375 gpm and will supply stormwater to irrigate the 30 acre Water's Edge townhome community. The project is estimated to reduce potable water use by approximately 16.9 MGY. (Construction Contract - $347,900)
- Street sweeping twice annually and additional sweeping as required
- General MS4 compliance items
- Approved preliminary plat and phase 1 final plat for 220-acre Adelaide Landing development that incorporates water reuse for all living units, parklands, open spaces, and boulevards.
- Installation of 2nd water re-use pump in Clearwater Cove neighborhood serving all irrigation needs for living units, park, etc.
- Replaced baseline smart controllers at Hanifl Soccer Fields ($9,200)
- Water rebate program – replacement of irrigation controllers, etc.
- City serves as LGU, and required installation in 2017 of numerous stormwater BMP's for water quality and quantity improvements concurrent with construction and development.
- Adoption of new water resources management plan
- Completion of Phase 2 design for Water Edge reuse system
- Completion of design for CSAH 8 reuse system
- Adoption of new water rates, including increased rates for high-end users and irrigation systems
- The City has completed a number of Wellhead Protection Implementation activities such as; updating the City's website with educational materials related to abandoned/unused wells, well management, WHP Planning, Proper disposal of hazardous materials, stormwater management, and turf management. Additionally, the City sent out educational brochures for residents to inform them on

Groundwater, Steps the City has taken to develop a wellhead protection plan, and information about why WHP Planning is important and how it protects groundwater sources.

Minnesota Department of Health

Source Water Protection:

- Wellhead Protection activities for Public Water Supply Systems continues to help preserve drinking water quality for the residents of Minnesota. In 2017 MDH worked with DNR staff to develop conservation activities to be included in Wellhead Protection plans to reinforce the message of efficient water use. Financial support through MDH Source Water Implementation grants are available biannually to Public Water Suppliers to fund activities within an MDH approved Wellhead Protection plan: MDH SWP Grants (www.health.state.mn.us/divs/eh/water/swp/grants/index.html).
- Additionally, MDH recently created a new surface water planner and hydrogeologist team that will be working on protecting surface water sources for drinking water use.

Water Re-use:

- A new report to the Minnesota Legislature lays out a path for safe and sustainable water reuse to become a bigger part of the state's overall water management picture in the near future. "Water reuse in Minnesota has been hampered by a lack of a clear approval process for projects, by a lack of information on reuse water quality and standards and by uncertainties about costs and risks to health and the environment," said Minnesota Health Commissioner Jan Malcolm. "The benefits, costs and risks of water reuse all need to be balanced. This report helps us clarify how to evaluate the resources and take the next steps to successfully advance water reuse in Minnesota." To view the full report, go to the MDH website at Advancing Safe and Sustainable Water Reuse in Minnesota (PDF).

Flooding threats to private well water users due to climate change:

- Climate change is an existential threat that will challenge public health for the foreseeable future. MDH scientist Dr. Brenda Hoppe and MN the Climate and Health Program are working to help ensure that MN communities are ready to respond to the effects of a changing climate. Dr. Hoppe will present results of a study (vulnerability assessment) of the likely impacts of future precipitation on risk for Minnesotans on private wells. Climate change vulnerability assessments can identify, quantify and map key factors that influence a population's exposure to climate hazards and the potential threats to health, homes, and well-being. By including future climate estimates, decision-makers can manipulate these factors to represent a range of scenarios, taking the long view to explore potential threats alongside opportunities to mitigate these threats through targeted climate adaptation strategies. Dr. Hoppe will describe important partnerships across MDH as well as other state agencies within this work and lessons learned from applying future climate estimates to public health investigations.

Ramsey Conservation District

- Approximately 4500 property parcels were review for compliance with the new state buffer law
- Wetland Conservation Act efforts
- 2 violation/incident responses
- 70 consults
- 14 TEP Reviews
- 263 site visits for storm water BMP's / water quality projects
- 136 concept plans for storm water BMPs/water quality projects
- 100 construction document designs for storm water BMPs/water quality projects
- 60 installations of storm water BMPs/water quality projects
- 928 construction inspections for sediment and erosion control

- 18 aquatic biovolume surveys conducted
- 1 storm water pond survey

Ramsey County

- TCAAP / Rice Creek Commons - collaborating with Rice Creek Watershed District, the City of Arden Hills, and Alatus, LLC to identify and develop potential water reuse systems for the redevelopment of the former Twin Cities Army Ammunition Plant
- Monitoring lake water quality on 30 Ramsey County lakes including sampling lakes for chloride impairment
- Monitoring lake water levels on 30 county lakes
- Public Works staff hosted and attended clinics for reducing winter salt application
- Inspection of 906 outfalls from the county's storm sewer system, 33 structural pollution control devices, and 30 ponds
- Hosted household hazardous waste collection events at 13 locations including one permanent collection facility and one waste oil / antifreeze collection facility
- Constructed 3 storm water BMP's (2 filtration basins and 1 pond)
- Performed maintenance on 19 county ponds/sediment basins & 15 pollution control & infiltration BMPs
- Field staff underwent annual training for spill prevention and illicit discharge detection
- Street sweeping on 1,870 total lane miles

Rice Creek Watershed District

- Stormwater Reuse for Irrigation Assessment Methodology

  Stormwater reuse for irrigation is gaining attention for its potential to reduce the amount of stormwater runoff entering rivers and other waterways while also reducing groundwater use. With funding from the Board of Water and Soil Resources (BWSR), RCWD developed an assessment methodology that is a step-by-step, repeatable planning process for identifying sites that would be suitable locations for reuse projects. Technical criteria are used to evaluate the feasibility of locations, and qualitative criteria are used to prioritize those technically feasible sites.
  The methodology has been used initially within the RCWD but was developed with the intention that it would be used by other watersheds and regional entities throughout the state. Qualitative criteria can be modified to meet different community goals. A workshop was held in March 2017 which provided technical training on how to use the reuse assessment.

- Stormwater Reuse for Irrigation Projects and Initiatives to Protect Groundwater and Surface Water
- Forest Lake High School Stormwater Reuse Partnership Project: Partnership with Forest Lake Area Schools and the City of Forest Lake to implement this innovative reuse project at the Forest Lake High School athletic fields.
- Water's Edge Stormwater Reuse Partnership Project: Partnership to fund construction and implementation of the City of Hugo's innovative reuse project that will reduce groundwater used for irrigation and protect downstream surface waters.
- Bald Eagle Lake TMDL Implementation: Collaboration with City of Hugo for project maintenance and monitoring of Bald Eagle Lake Stormwater Reuse/Phosphorus Reduction Project located at Oneka Ridge Golf Course in City of Hugo.
- Clear Lake Subwatershed Assessment Study – Developed this plan in partnership with the City of Forest Lake to identify high priority stormwater reuse and water quality management projects that would also reduce groundwater use in this urbanizing area.

- Southeast White Bear Lake Drainage Area Subwatershed Plan- Developed this study in collaboration with Washington Conservation District and the cities located within this drainage area to identify high priority stormwater reuse and water quality management projects.
- RCWD pursues partnerships with city partners to identify the most productive sites for reduction of groundwater use (for irrigation). RCWD has increased funding to it Urban Stormwater Cost-Share program to incentivize regional stormwater reuse projects by city and county partners.
- Other Water Quality and Reuse Projects & Programs Related to N&E Metro GWMA Objectives
- Oasis Pond Iron Enhanced Sand Filter Project: Collaboration with the City of Roseville to design and implement this iron enhanced sand filter project.
- Hanson Park Project: Project implementation and construction of this regional flood control and water quality improvement project to protect Long Lake and portions of the southwest region of the RCWD.
- Mirror Pond Project: Project implementation and construction of this regional flood control and water quality improvement project to protect Long Lake and portions of the southwest region of the RCWD.
- Middle Rice Creek Restoration: Project implementation and construction of this stream restoration BMPs in location of the former TCAAP in Arden Hills.
- Carp Management: Project implementation and construction of the Long Lake watershed carp management project.
- Implementation of the Anoka Chain of Lakes TMDL projects- RCWD continues to pursue competitive grant opportunities to implement water quality BMPs with local partners.
- Ongoing implementation of targeted Water Quality /TMDL implementation projects.
- Urban Stormwater Cost Share projects – Increased funding for cost-share with city/county partners to further incentivize regional stormwater reuse, flood control, and water quality projects.
- Water Quality Cost - Share: Provides technical and financial assistance to private landowners to implement water quality restoration and/or protection projects.
- RCWD 2017 Buffer Compliance Incentive Payment - The Board of Managers approved a special cost-share program to provide additional financial incentive to landowners complying with the State Buffer Law
- Water Quantity, Flood Control and Water Quality Permit Program – This regulatory program addresses stormwater quantity and quality from new developments and re- development projects along with the administration of the Wetland Conservation Act in 25 of the District's 28 cities & towns.
- Lake & Stream Management: Program includes monitoring, development of lake management plans, invasive species control, and support of volunteer Stream and Wetland Monitoring Program.
- Water Education and Outreach Program: Provides support for the Master Water Steward program, the RCWD City /County partnership meeting series, East Metro Water Resources Education Program (EMWREP), Blue Thumb, Metro Watershed Partners, and general outreach to cities and landowners; efforts include offering workshops that support water resource issues such as Winter Road Maintenance.

City of Shoreview

- Shoreview's existing odd/even water use restrictions were modified to include a mid-day (11:00 a.m. to 5:00 p.m.) ban.
- All of Shoreview's water use restrictions were made to apply equally to properties regardless of water source e.g. City water, private well, surface water appropriation.
- New private well drilling in Shoreview was prohibited. Residents are allowed to continue to operate functional private wells but no new wells within our public water service area are allowed.
- An efficiency study was completed in 2017 indicating that WaterSmart (launched in 2016) helped reduce water consumption by single-family customers by 1.1% equating to more than 3.2 million gallons.

- Shoreview's already aggressive street sweeping program was modified to result in every city street being swept a minimum of 5 times per calendar year.
- Shoreview received Met Council/Watershed grant funding to advance a significant storm water re-use project that will offset an estimated 6 million gallons per year. Construction in 2018.
- The City evaluated and compared effectiveness of two leak detection and notification methods; one via WaterSmart and the other using direct consumption reports from our meter reading software.
- The City continued to implement various programs and services e.g. illicit discharge detection, erosion control inspection, storm water BMP construction and maintenance, etc. in accordance with MS4 responsibilities.

USGS

- Presentation to the Minnesota Legislative Water Commission titled "Water-Level Changes in Lakes in the Northeast Metro: Why do they differ?" This presentation highlighted results from a recently completed study of lakes in the northeast Twin Cities Metropolitan Area that were published in a USGS Scientific-Investigations Report (https://pubs.er.usgs.gov/publication/sir20165139A).
- Presentation titled "Characterizing Groundwater and Surface-Water Exchanges in White Bear Lake, Minnesota, USA, Using Hydrologic, Geophysical, and Water-Quality Techniques" at the Geological Society of America 2017 Annual Meeting in Seattle, WA..
- Presentation titled "Simulation and Assessment of Groundwater Flow and Surface-Water Exchanges in Lakes of the Northeast Twin Cities Metropolitan Area, Minnesota, 2003 through 2013" at the Minnesota Water Resources Conference in St. Paul, MN
- Presentation presentation titled "Use of Continuous Seismic-Reflection Profiling and Ground-Penetrating-Radar Surveys to Characterize Lake-sediment Lithology" at the USGS/Bad River Tribe TESNAR Geophysical Workshop in Odanah, Wisconsin.
- The second chapter of a two-part report on Simulation and Assessment of Groundwater Flow and Groundwater and Surface-Water Exchanges in Lakes of the Northeast Twin Cities Metropolitan Area was published. The new chapter, Chapter B of Water levels and groundwater and surface-water exchanges in lakes of the northeast Twin Cities Metropolitan Area, Minnesota, 2002 through 2015, was written by Perry Jones with five MN WSC co-authors. The report has significant implications for water management within the State of Minnesota.
- Participated with Minnesota Department of Natural Resources, Metropolitan Council, Minnesota Department of Health, and Minnesota Department of Agriculture in a meeting updating progress on the northeast Twin Cities Metropolitan Area transient groundwater-flow model hosted by Matt Tonkin, SS Papadopolous & Associates.
- Participated with Minnesota Department of Natural Resources, Metropolitan Council, Minnesota Department of Health, and Minnesota Department of Agriculture in a meeting updating progress on the northeast Twin Cities Metropolitan Area transient groundwater-flow model hosted by Matt Tonkin, SS Papadopolous & Associates.
- Congressional Interactions: Perry Jones (MN WSC) received a letter from Congresswoman Betty McCollum (Fourth Congressional District, Minnesota), congratulating him on the USGS's Best Groundwater Report recognition for a 2016 report on the Northeast Metro Lakes project.
- Participated in a review of the Biological Monitoring Program at the Great Lakes National Program Office, USEPA Region 5.
- Met with Metropolitan Council Staff to represent results from the groundwater and surface-water exchange study of northeast Twin Cities Metropolitan Area lakes.
- Attended a meeting of the Minnesota Legislature's Clean Water Council in St. Paul. Stark provided a briefing on a study of groundwater and surface water interactions in the northeast portion of the Twin Cities Metropolitan Area.

- Briefed the Minnesota Legislative Water Commission regarding USGS studies focused on analysis of lake level changes and groundwater and surface-water exchanges in the northeast Twin Cities Metropolitan Area.
- Presented results from the study "Characterizing Groundwater and Surface-Water Interactions in Selected Northeast Twin Cities Lake" to Minnesota Legislative Water Commission.

Washington County

- Provided grants to homeowners sealing a total of 29 abandoned wells.
- Provided grants to homeowners to replace 5 septic systems and loans to replace 22 septic systems.
- Partnered with MNTAP to provide water use assessments to a hospital and a correction facility in Washington County.
- Partnered with MNTAP to provide an intern at DiaSorin in Stillwater that resulted in water savings of 3.7 million gallons/year.
- Provided water efficiency grants to two schools and three cities in Washington County – work included toilet and urinal replacement (saving 2.22 and 2.87 gallons of water per flush), sprinkler system upgrades, funding for rain barrels and 81 smart controllers (smart controllers saving a potential 3,240,000 gallons of water per year).
- Funded the Washington Conservation District to update the county Minnesota Land Cover Classification System that can be used by local units of government for mapping natural areas, pollinator habitat, and use in water management planning.
- Funded the East Metro Water Resources Education Program to bring groundwater and water resources education to 4th and 5th grade classrooms – over 300 students were taught about where their water comes from and about water conservation practices they can do at home.
- Funded the Washington Conservation District to inventory the animal holding facilities in the county (including horse stables holding more than 10 horses) as a first step to target outreach around water quality efforts.
- Provide well testing services for water quality including coliform bacteria and nitrates, and also providing services for testing VOCs and PFCs.

White Bear Lake Restoration Association

- The primary focus of WBLRA (White Bear Lake Restoration Association) as it relates to the above activities is to educate and disseminate science and factually based information to its members and the public in the N&E MGWA and beyond not only on the issues surrounding White Bear Lake and its low water levels, but also the science of ground water and surface water interaction. Continuing the Mission of White Bear Lake Restoration Association to preserve and protect White Bear Lake for future generations, and educate the public in issues regarding the vitality of White Bear Lake now and into the future.
- Provide up to date scientific resources and information regarding bullets 1-4 to over 1,000 WBLRA members from all over the country through website, interviews, and public forums.
- Testify in WBLRA et WBLHOA vs. DNR et White Bear Lake and White Bear Township court case on bullets 1-4. Part of a public court record and a summary of the WBLRA activities since its founding in 2012.
- Meet with representatives from MN State Legislative districts and cities surrounding WBL throughout 2017 to discuss bullets 1-4. Meet with Governor Dayton's Chief Water Advisor to discuss and clarify misleading information provided to Governor Dayton regarding bullets 2, 3, and 4.
- Testify in Senate and House Environmental Committee hearings regarding bullets 1-4
- Continue to assist H2O non-profit and Race to Reduce (R2R) the local arm of H20 in private fundraising for their water based curriculum in schools/cities surrounding White Bear Lake. Funding assisted R2R in developing curriculum to meet MN State Education and Environmental Education standards. Also

WBLRA was the initial connection between Sen. Chuck Wiger and R2R that led to MN State funding of the non-profit environmental education effort. 2017, Senator Wiger proposed renewing MN state funding for H20 in 2018 legislative session. WBLRA promoted and created that connection.

- Attend and participated in DNR and NEMGWA public events 2017.
- Coordinate a public event in White Bear Lake for WBLRA members and friends with USGS Scientist and 2012 & 2016 lead author of N&E MGWA studies Perry Jones, on the science and
- facts of ground and surface water supply and interactions, and its impact on White Bear Lake and the NEMGW area.
- Coordinate with City of Dellwood to include water conservation information and tips in biannual newsletter. Including links to Washington County water conservation resources, yard care and hearty native plant landscaping, and replacing appliances with Water Sense approved appliances (Ongoing for the past 5 years).
- Completed a fundraising campaign of $400,000.00 plus for an independent study of White Bear Lake by a nationally recognized water resource-based engineering and environmental consulting firm identifying lead causes and factors in the decline of White Bear Lake. Held public forum to disseminate this information and educate the public regarding the science surrounding N&E MGWA ground water and surface water issues.
- Speak at Forest Lake Rotary Club about items 1-4
- With legal partners and members, won a landmark court case against MN DNR and cities of White Bear Lake and White Bear Township regarding the proper management of groundwater and surface water and their interactions as related to White Bear Lake. This case provided an opportunity to educate people throughout the state about water resources, water science and bullets 1-4 through print, media and on-line interviews and coverage which continues to this day. Outreach numbers in the hundred of thousands plus.
- As private citizens, and without remuneration, the board members of WBLRA consistently communicate a message of water conservation, proactive and progressive water resource management, and the hope that cities, municipalities, legislators and governing bodies will join together, beyond their geographical boundaries and financial motivations, to provide this area with a long term sustainable and safe water supply by reducing our reliance on the unsustainable practice of draining our finite ground water resources.

City of Woodbury

Identify and embrace water conservation best practices 2017

- Promoted water conservation to individuals during the summer months through City newsletter and social media (ie. Smart irrigation month).
- Distributed 360 smart irrigation controllers to residents with irrigation systems. Estimated water efficiency improvement of up to 10.5 million annually.
- Provided $85,000 in cost share assistance (50%) to 22 commercial and association properties to implement irrigation efficiency upgrades. Water efficiency improvements are being monitored but are estimated to be in the several million annually.
- Updated irrigation system at City-owned golf course.
- Updated city code to require all irrigation systems have working, moisture-sensing technology and require all new controllers be WaterSense certified. Update includes an enforcement element and penalties.
- Implemented and completed $75,000 of irrigation system efficiency upgrades at 26 City owned and managed irrigation systems. Water efficiency improvement being monitored but are estimated to be in the several million annually.

Protect surface waters 2017

- Implementation where applicable of stormwater infiltration practices in new development. Protect surface waters
- 20 development projects reviewed and approved meeting city/state/watershed district stormwater treatment requirements
- Installation of 2 infiltration basins with roadway rehabilitation project
- Pond maintenance (dredging) of 18 ponds
- Sump installation with roadway rehab project
- Education
- Restoration of a five acre farmed wetland in collaboration with SWWD
- Developing lake management plans for all SWWD lakes in Woodbury in collaboration with SWWD
- 100% infiltration of water in the Central Draw in CD-P85 and CD-P86 (runoff from 65% of Woodbury's land area and upstream communities)
- Purchase of 23 acres of land adjacent to Battle Creek Lake for open space/stormwater/wetland preservation purposes

Table 9: Lower St. Croix River Watershed Public Water Supply System Information

HUC 10 Subwatershed	Public Water Supplier	Drinking Water Supply Management Area (DWSMA) Vulnerability	Size of DWSMA(s) in acres	Wellhead Protection Planning Status	Notes
Big Marine Lake-St. Croix River	Shafer (1)	Low	20.17	Complete	N/A
Big Marine Lake-St. Croix River	Shafer (2)	Very Low	74.57	Complete	Located in both Big Marine and Sunrise River subwatersheds
Big Marine Lake-St. Croix River	Shafer (3)	Very Low	52.84	Complete	Located in both Big Marine and Sunrise River subwatersheds
Big Marine Lake-St. Croix River	Taylors Falls (West)	Moderate	112.21	Complete	N/A
Big Marine Lake-St. Croix River	Taylors Falls	Moderate	23.72	Complete	N/A
Big Marine Lake-St. Croix River	Lake Elmo (North)	Moderate	4,318.97	Amending	Located in both Big Marine and Lake St. Croix subwatersheds.
Big Marine Lake-St. Croix River	Mahtomedi	Moderate and High	1,182.59	Complete	Majority of the DWSMA is in Twin Cities-Mississippi River watershed.
Big Marine Lake-St. Croix River	Oak Park Heights	Moderate and High	3,767.61	Complete	Located in both Big Marine and Lake St. Croix subwatersheds.
Big Marine Lake-St. Croix River	Stillwater	Moderate, High and Very High	5,792.12	Complete	Located in both Big Marine and Lake St. Croix subwatersheds.
Big Marine Lake-St. Croix River	Scandia Elementary School	Moderate	56.6	Complete	Located in both Big Marine and Sunrise River subwatersheds
Big Marine Lake-St. Croix River	Hilltop Water Company	N/A	N/A	Developing	N/A
Big Marine Lake-St. Croix River	Jackson Meadow	Low	81.95	Developing	N/A
Big Marine Lake-St. Croix River	Wyldewood Acres	Low	70.77	Developing	Located in both Big Marine and Sunrise River subwatersheds
Big Marine Lake-St. Croix River	Scandia Water Company	N/A	N/A	Not Yet Started	N/A

HUC 10 Subwatershed	Public Water Supplier	Drinking Water Supply Management Area (DWSMA) Vulnerability	Size of DWSMA(s) in acres	Wellhead Protection Planning Status	Notes
Big Marine Lake-St. Croix River	Oakhill Cottages	N/A	N/A	Not Yet Started	N/A
Big Marine Lake-St. Croix River	Marine Stugas Townhomes	N/A	N/A	Not Yet Started	N/A
Goose Creek-St. Croix River	Harris	Low	100.03	Complete	N/A
Goose Creek-St. Croix River	Rush City	Moderate and Low	1,365.05	Complete	N/A
Goose Creek-St. Croix River	Pine City (South)	Moderate	750.77	Complete	Majority of the DWSMA is in the Snake River Watershed.
Goose Creek-St. Croix River	Shorewood Park	Low	11.13	Developing	N/A
Lake St. Croix	North St. Paul	Moderate and Low	6,895.45	Amending	Part of the DWSMA is in Twin Cities-Mississippi River watershed.
Lake St. Croix	White Bear Lake	High and Moderate	9,157.51	Complete	Majority of the DWSMA is in Twin Cities-Mississippi River watershed.
Lake St. Croix	Bayport	High and Moderate	502.40	Complete	N/A
Lake St. Croix	MN Correctional Facility - Stillwater	Low	141.62	Complete	N/A
Lake St. Croix	Cimarron Park	High and Moderate	541.29	Complete	N/A
Lake St. Croix	Oakdale	Moderate	4,841.54	Complete	Part of the DWSMA is in Twin Cities-Mississippi River watershed.
Lake St. Croix	Woodbury	High, Moderate and Low	13,499	Complete	Majority of the DWSMA is in Twin Cities-Mississippi River watershed.
Lake St. Croix	Lake Elmo South	Moderate	553.96	Complete	N/A
Lake St. Croix	Lakeland Municipal Water (1)	Moderate	67.52	Complete	N/A
Lake St. Croix	Lakeland Municipal Water (2)	Low	69.25	Complete	N/A
Lake St. Croix	Oak-land Middle School	High and Moderate	795.91	Complete	N/A

HUC 10 Subwatershed	Public Water Supplier	Drinking Water Supply Management Area (DWSMA) Vulnerability	Size of DWSMA(s) in acres	Wellhead Protection Planning Status	Notes
Lake St. Croix	Cedar Terrace Mobile Home Park	N/A	N/A	Not Yet Started	N/A
Lake St. Croix	Indian Hills Development	N/A	N/A	Not Yet Started	N/A
Lake St. Croix	Bay Lake Reserve Development	N/A	N/A	Not Yet Started	N/A
North Branch Sunrise River	North Branch	Low	4,600.67	Complete	N/A
Sunrise River	Center City	Moderate	63.9	Complete	N/A
Sunrise River	Hazelden Foundation	Moderate	133.83	Complete	N/A
Sunrise River	Chisago City (West)	Moderate and Low	117.87	Complete	N/A
Sunrise River	Chisago City (East)	Moderate	220.97	Complete	N/A
Sunrise River	Lindstrom (3)	Low	518.28	Amending	N/A
Sunrise River	Lindstrom (4)	Low	257.37	Amending	N/A
Sunrise River	Stacy (1)	Very Low	51.07	Complete	N/A
Sunrise River	Stacy (2)	Very Low	34.2	Complete	N/A
Sunrise River	Wyoming	Low	1,746.81	Complete	N/A
Sunrise River	Forest Lake (North)	Low	840.85	Complete	N/A
Sunrise River	Forest Lake (South)	Low	432.07	Complete	Majority of the DWSMA is in Twin Cities-Mississippi River watershed.
Sunrise River	River Bend Mobile Home Park, Inc.	Low	35.21	Complete	N/A
Sunrise River	Linwood Terrace, Inc.	N/A	N/A	Not Yet Started	N/A
Sunrise River	Peaceful Valley Mobile Home Park	N/A	N/A	Not Yet Started	N/A
Sunrise River	Stonegate Co-op, Inc.	N/A	N/A	Not Yet Started	N/A
Sunrise River	Elms Estates, Inc.	N/A	N/A	Not Yet Started	N/A

HUC 10 Subwatershed	Public Water Supplier	Drinking Water Supply Management Area (DWSMA) Vulnerability	Size of DWSMA(s) in acres	Wellhead Protection Planning Status	Notes
Sunrise River	Blue Waters Mobile Home Park	N/A	N/A	Not Yet Started	N/A
Sunrise River	Birchwood Terrace	N/A	N/A	Not Yet Started	N/A
Sunrise River	Preserve at Birch Lake	N/A	N/A	Not Yet Started	N/A
Sunrise River	Liberty Ponds Development	N/A	N/A	Not Yet Started	N/A
Wolf Creek-St. Croix River	N/A	N/A	N/A	N/A	N/A

Table 10: Rare Species Connected with Groundwater in the Lower St. Croix River Watershed[13]

Scientific Name	Common Name	Species Class	Listing Status[14]	AQUATIC (Y OR N)	WETLAND (Y OR N)	GROUNDWATER DEPENDENT (Y OR N)	General Habitat Type
Rare Plant: *Berula erecta*	Stream parsnip	Terrestrial Plant	THR	N	y	Y	Calcareous fens; alkaline springs; usually occurs in active seepage areas
Rare Plant: *Floerkea proserpinacoides*	False mermaid	Terrestrial Plant	THR	N	Y	Y	Cold, spring-fed seeps dependent on groundwater input; along wooded hillsides and in narrow valleys; some populations extend from the seep into adjacent seepage swamps
Rare Plant: *Hydrocotyle americana*	American water-pennywort	Terrestrial Plant	SPC	N	Y	Y	Small, sensitive wetlands typically imbedded in upland forests along streams or rivers, and often dependent on local discharge of groundwater; wet margins of small, cold, groundwater streams that emerge from small ravines, and these streams may broaden into open meadows or sedgy seeps with shallow pools
Rare Plant: *Platanthera clavellata*	Club-spur orchid	Terrestrial Plant	SPC	N	Y	Y	Swamp forests; non-forested poor fens that often ring peatland lakes
Rare Plant: *Platanthera flava var. herbiola*	Tubercled rein-orchid	Terrestrial Plant	THR	N	Y	Y	Wet meadows or sunny swales in savannas; also occurs at the margins of shallow marshy lakes, especially where there is a turf of low-growing native grasses or sedges; with ground water is usually at, or near the surface
Rare Plant: *Poa paludigena*	Bog bluegrass	Terrestrial Plant	THR	N	Y	Y	Wetland habitats that are maintained by groundwater seeps; often at the base of a

[13] Last Updated 04/19/2018

[14] END =State Endangered; THR = State Threatened; SPC = State Special Concern; Watch list = Species the DNR is tracking because they are in suspected decline SGCN= Species of Greatest Conservation Need

Scientific Name	Common Name	Species Class	Listing Status[14]	AQUATIC (Y OR N)	WETLAND (Y OR N)	GROUNDWATER DEPENDENT (Y OR N)	General Habitat Type
							slope or sandstone escarpment where the groundwater seeps out, sometimes on moss or sphagnum hummocks
Rare Plant: *Polygala cruciata*	Cross-leaved milkwort	Terrestrial Plant	END	N	Y	Y	Wet, sandy shores of shallow lakes in the Anoka Sand Plain, and in sandy or peaty meadows or swales that may be in low depressions or at the margins of emergent wetlands; open and sunny with acidic soils and fluctuating water tables
Rare Plant: *Rubus stipulatus*	Big horseshoe lake dewberry	Terrestrial Plant	END	N	Y	Y	Wet meadow/carr
Rare Plant: *Xyris torta*	Twisted yellow-eyed grass	Terrestrial Plant	END	N	Y	Y	Wet, sandy shores of shallow lakes in the Anoka Sandplain and in sandy or peaty meadows or swales; open and sunny with acidic soils and fluctuating water tables
Rare Plant: *Aphanorrhegma serratum*	Lidded earth moss	Moss	SPC	N	Y	Y	Poorly drained soils that are subject to inundation such as stream and river banks and floodplains or other low areas, such as within old fields
Rare Plant: *Atrichum tenellum*	Little saw moss	Moss	SPC	N	Y	Y	Wet soils in open hardwood forests. It has also been reported in other parts of its range to occur in a range of disturbed, acidic, open habitats on moist, sandy humus and loams. These include stream sides, lake margins, ditch banks and open, rich graminoid-dominated peatlands
Rare Plant: *Cirriphyllum piliferum*	Hair-pointed feather moss	Moss	THR	N	Sometimes	Y	Variety of habitats: in forests on litter, bark, wood, and shale. Also reported growing in deciduous woods on road banks, creek, and rotten wood; along base of cliff on calcareous rock, talus debris, and Taxus bark; along small fast running creek on soil banks and tree roots; upland cedar with hemlock and fir, tamarack swamp

Scientific Name	Common Name	Species Class	Listing Status[14]	AQUATIC (Y OR N)	WETLAND (Y OR N)	GROUNDWATER DEPENDENT (Y OR N)	General Habitat Type
Rare Fungi: *Lactarius fuliginellus*	A species of fungus	Fungus	SPC	N	Y	Y?	Prefers hardwood habitats in areas that are near water or that are periodically inundated; Anoka Sandplain shallow wetlands, possibly with groundwater influence
Rare Animal: *Lasmigona compressa*	Creek heelsplitter	Mussel	SPC; SGCN	Y	N	Y	Creeks, small rivers, and the upstream portions of large rivers with sand, fine gravel, or mud substrates; found mostly in headwaters. Populations are susceptible to lower water table or decline ground water input that affect stream permanence
Rare Animal: *Pleurobema sintoxia*	Round pigtoe	Mussel	SPC; SGCN	Y	N	Y	Medium to large rivers with sand, gravel, or mud substrates; some populations are found in headwaters; these populations are susceptible to lower water table or decline ground water input that affect stream permanence
Rare Animal: *Actinonaias ligamentina*	Mucket	Mussel	THR; SGCN	Y	N	Y	Medium to large rivers with sand and gravel substrates; some populations are found in headwaters; these populations are susceptible to lower water table or decline ground water input that affect stream permanence
Rare Animal: *Alasmidonta marginata*	Elktoe	Mussel	THR; SGCN	Y	N	Y	Medium to large rivers with sand and gravel substrates; some populations are found in headwaters; these populations are susceptible to lower water table or decline ground water input that affect stream permanence
Rare Animal: *Elliptio dilatata*	Spike	Mussel	THR; SGCN	Y	N	Y	Small to large rivers; reservoirs and lakes; some populations occur in headwaters; these populations are susceptible to lower water table or decline ground water input that affect stream permanence

Scientific Name	Common Name	Species Class	Listing Status[14]	AQUATIC (Y OR N)	WETLAND (Y OR N)	GROUNDWATER DEPENDENT (Y OR N)	General Habitat Type
Rare Fish: *Etheostoma microperca*	Least darter	Fish	SPC; SGCN	Y	Sometimes	N?	Freshwater streams and lakes with excellent water clarity; prefer pools with dense aquatic vegetation; occupies areas of still water, possibly using wetlands which are permanently or seasonally connected to streams
Rare Fish: *Ichthyomyzon gagei*	Southern brook lamprey	Fish	SPC; SGCN	Y	N	N?	Very clear, streams with moderate to strong flows overs sand and gravel bottoms
Rare Fish: *Notropis anogenus*	Pugnose shiner	Fish	THR; SGCN	Y	N	N?	Glacial lakes and streams with good water clarity and an abundance of submerged vegetation; prefers clear glacial lakes and streams with dense vegetation
Rare Animal: *Acris blanchardi*	Blanchard's cricket frog	Amphibian	END	Y	Y	Possibly	Shallow wetlands, lakes, streams, or rivers with emergent vegetation and muddy shores; breeding sites often consist of wetland basins adjacent to rivers
Rare Animal: *Necturus maculosus*	Mudpuppy	Amphibian	SPC; SGCN	Y	Y	Unlikely	Freshwater lakes, rivers, streams, and ponds; if lakes and river levels are impacted by the loss of groundwater, this species would be impacted
Rare Animal: *Emydoidea blandingii*	Blanding's turtle	Reptile	THR; SGCN	Y	Y	Possibly	Wetland complexes, small streams, and adjacent uplands, typically, but not always mapped as sandy soils; if groundwater levels impact wetland and/or river levels, then this species is groundwater dependent
Rare Animal: *Apalone mutica*	Smooth softshell	Reptile	SPC; SGCN	Y	N	Unlikely	Large, unpolluted rivers with sandy substrates; associated with large rivers, if groundwater levels impact the river level then this species is groundwater dependent
Rare Animal: *Coluber constrictor*	North American racer	Reptile	SPC; SGCN	N	Y	Possibly	Forested hillsides, bluff prairies, grasslands, and open woods; may forage within or adjacent to wetlands; groundwater may be critical for overwintering

Scientific Name	Common Name	Species Class	Listing Status[14]	AQUATIC (Y OR N)	WETLAND (Y OR N)	GROUNDWATER DEPENDENT (Y OR N)	General Habitat Type
Rare Animal: *Crotalus horridus*	Timber rattlesnake	Reptile	THR; SGCN	N	Y	Possibly	Forested bluffs, south-facing rock outcrops, and bluff prairies; particularly in the Mississippi River valley; may forage within or adjacent to wetlands
Rare Animal: *Glyptemys insculpta*	Wood turtle	Reptile	THR; SGCN	Y	Y	Possibly	Forested riverine systems and well-drained soils; if groundwater levels impact the river level, then this species is groundwater dependent
Rare Animal: *Pituophis catenifer*	Gophersnake	Reptile	SPC; SGCN	N	Y	Possibly	Dry sand prairies or bluff prairies; may forage within or adjacent to wetlands
Rare Animal: *Plestiodon fasciatus*	Common five-lined skink	Reptile	SPC; SGCN	N	Y	Possibly	Granite outcrops in the MN River Valley; OR in exposed limestone and sandstone outcrops and bluff prairies in E MN; often occurs near wetlands, possibly due to greater foraging opportunities
Rare Animal: *Coturnicops noveboracensis*	Yellow rail	Bird	SPC; SGCN	N	Y	Y?	Dependent on open rich fens, wet meadow, and wet prairie; requires very narrow range of water depth (~2-10 cm)
Rare Animal: *Parkesia motacilla*	Louisiana waterthrush	Bird	SPC; SGCN	N	Y	Maybe	Mature, riparian forests; Needs relatively high-quality forest adjoining a) cold water stream, b) seepage areas associated with larger streams/rivers, or c) small channels associated with larger streams/rivers
Rare Animal: *Phalaropus tricolor*	Wilson's phalarope	Bird	THR; SGCN	N	Y	Maybe	Wet prairie or rich fen habitats, or grass or sedge-dominated wetlands; requires very shallow water associated with prairies, open rich peatlands, or other open habitats
Rare Animal: *Cicindela macra macra*	Sandy stream tiger beetle	Insect	SPC; SGCN	N	N	N?	Sandy shorelines above water table

Scientific Name	Common Name	Species Class	Listing Status[14]	AQUATIC (Y OR N)	WETLAND (Y OR N)	GROUNDWATER DEPENDENT (Y OR N)	General Habitat Type
Rare Animal: *Ironoquia punctatissima*	A caddisfly	Insect	THR	Y	?	Y	Larval stages aquatic. Undisturbed small streams in the southern part of the state
Rare Animal: *Limnephilus rossi*	A caddisfly	Insect	THR; SGCN	Y	?	?	Larval stages aquatic; sometimes placed in genus Asynarchus, small streams
Rare Animal: *Ochrotrichia spinosa*	A purse casmaker caddisfly	Insect	END	Y	?	?	Larval stages aquatic; small streams
Rare Animal: *Ophiogomphus susbehcha*	St. Croix snaketail	Insect	THR; SGCN	Y	Y	Y	Medium to large rivers that are clean and highly oxygenated - sandy/gravel substrate where the benthic nymphs live
Rare Animal: *Paradamoetas fontana*	A jumping spider	Insect	SPC; SGCN	N	Y	Probably	Occurs in bogs, marsh edges, mesic prairie, and upland prairie
Rare Animal: *Parapsyche apicalis*	A caddisfly	Insect	THR	N	?	Possibly	Larval stages aquatic; very small cold water streams with dense canopy cover

Tables 11-13[15] show the documented wetland native plant communities connected to groundwater in the Lower St. Croix River Watershed.

Table 11: Lower St. Croix River Watershed – Documented wetland native plant communities dependent on sustained groundwater discharge

Native Plant Community Code	Native Plant Community Name	Conservation Status Rank
Fens and Seepage Wetlands		
WMs83	Southern Seepage Meadow/Carr	S3 - Vulnerable to Extirpation
WMs83a	Seepage Meadow/Carr	S3 - Vulnerable to Extirpation
WMs83a1	Seepage Meadow/Carr, Tussock Sedge Subtype	S3 - Vulnerable to Extirpation

[15] Updated 12/22/2017

Table 12: Lower St. Croix River Watershed documented wetland native plant communities dependent on groundwater associated with consistently high water tables

Native Plant Community Code	Native Plant Community Name	Conservation Status Rank
Forested Wetlands		
WFn55b	Black Ash - Yellow Birch - Red Maple - Basswood Swamp (Eastcentral)	S3 - Vulnerable to Extirpation
WFn64	Northern Very Wet Ash Swamp	S4 - Apparently Secure; Uncommon but not Rare
WFn64b	Black Ash - Yellow Birch - Red Maple - Alder Swamp (Eastcentral)	S4 - Apparently Secure; Uncommon but not Rare
WFs57	Southern Wet Ash Swamp	SNR - State Not Ranked
WFs57a	Black Ash - (Red Maple) Seepage Swamp	S1S2 - Between Critically Imperiled and Imperiled
FPs63a	Tamarack Swamp (Southern)	S2S3 - Between Imperiled and Vulnerable to Extirpation
Shrub Swamps		
OPn81b	Leatherleaf - Sweet Gale Shore Fen	S5 - Secure, Common, Widespread, and Abundant
FPn73a	Alder - (Maple - Loosestrife) Swamp	S5 - Secure, Common, Widespread, and Abundant
Wet Meadows/Shrub Carr Wetlands		
OPn92	Northern Rich Fen (Basin)	S4 - Apparently Secure; Uncommon but not Rare
OPn92a	Graminoid Rich Fen (Basin)	S4 - Apparently Secure; Uncommon but not Rare
OPn92b	Graminoid - Sphagnum Rich Fen (Basin)	S4 - Apparently Secure; Uncommon but not Rare
Peatland/Bog		
APn91a	Low Shrub Poor Fen	S5 - Secure, Common, Widespread, and Abundant
Marshes		
MRn83	Northern Mixed Cattail Marsh	S2 - Imperiled
MRn93	Northern Bulrush-Spikerush Marsh	SNR - State Not Ranked
MRn93b	Spikerush - Bur Reed Marsh (Northern)	S2 - Imperiled

Table 13: Lower St. Croix River Watershed documented wetland native plant communities dependent on groundwater associated with water tables that are high for some portion of the growing season

Native Plant Community Code	**Native Plant Community Name**	**Conservation Status Rank**
Forested Wetlands		
FFn67a	Silver Maple - (Sensitive Fern) Floodplain Forest	S3 - Vulnerable to Extirpation
FFs59c	Elm - Ash - Basswood Terrace Forest	S2 - Imperiled
FFs68a	Silver Maple - (Virginia Creeper) Floodplain Forest	S3 - Vulnerable to Extirpation
Wet Meadow/Shrub Carr Wetlands		
WMn82	Northern Wet Meadow/Carr	SNR - State Not Ranked
WMn82a	Dogwood Shrub Swamp	S5 - Secure, Common, Widespread, and Abundant
WMn82b	Sedge Meadow	S4 or S5 - Subtype S-Ranks are either S4 or S5
WMn82b4	Sedge Meadow, Lake Sedge Subtype	S5 - Secure, Common, Widespread, and Abundant
Wet Prairies		
WPs54b	Wet Prairie (Southern)	S2 - Imperiled

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