St. Louis River Watershed (SLRW)

Groundwater Restoration and Protection Strategies Report

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St. Louis River Watershed Groundwater Restoration and Protection Strategies Report

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Contributors

The following agencies dedicated staff time and resources toward the development of the St. Louis 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)

Photo Credit: The photo on the front page is in the St. Louis River Watershed, courtesy of the MPCA.

Summary

Groundwater is an important resource in the St. Louis River Watershed (SLRW) One Watershed One Plan (1W1P) planning effort[1]. The SLRW relies more heavily on surface water use than groundwater use. Groundwater use increased by approximately 500 million gallons between 1988 to 2018. In 2018, approximately 92 percent of permitted groundwater withdrawn was for public water supply use, with the cities of Hibbing, Mountain Iron, Virginia and Cloquet being the largest water users. Both groundwater and surface water supply drinking water within the watershed. The second largest groundwater use was for power generation. It is important to ensure adequate supplies of high-quality groundwater remain available for the region's residents, businesses, and natural resources.

Approximately 44 percent of consumers (both private wells and public water systems) in the SLRW depend on buried sand and gravel aquifers of glacial origins for drinking water, not including surface water sources. These aquifers are covered by fine-grained sediment deposited by glaciers during the most recent ice age. Thirty-four percent of consumers draw from crystalline bedrock, where groundwater is found locally in faults and fractures. To a lesser extent, 18 percent, of drinking water users draw from surficial sand and gravel water table aquifers of glacial origin.

Groundwater has a greater risk to contamination in areas of high pollution sensitivity[2]. Overall, most of the watershed is rated "very low" to "moderate", reflecting the dense tills covering most of the land surface. However, areas with sand and gravel deposits from glacial outwash, sandy glacial lake deposits and fractured near-surface bedrock have a higher pollution sensitivity. 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.

Contamination, both naturally occurring and from human activity, is present in parts of the watershed groundwater, specifically:

- **Nitrate** – less than one percent of the 7,470 tested drinking water wells had levels at or above the Safe Drinking Water Act (SDWA) standard of 10 mg/L.
- There are no MDA ambient monitoring wells in the watershed.
- MPCA has five ambient monitoring wells with all samples for nitrate well below the SDWA standard.
- **Arsenic** – nearly three percent of the 1,731 tested wells had levels exceeding the SDWA of 10 µg/L. 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.
- **Pesticides** – there are no MDA ambient monitoring well within the watershed.

[1] For this report, the boundary of the St. Louis River One Watershed One Plan Planning area is composed of the St. Louis River watershed, the Cloquet River watershed, and the southern portion of the Lake Superior – South watershed terminating just north of Duluth.

[2] 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.

- **Contaminated sites –** MPCA identified 975 active tank sites that could leak chemicals into the environment and 46 leak sites that may cause localized groundwater pollution if not properly managed. The risk to groundwater is greatest in areas of high pollution sensitivity.
- Ten closed landfills with known groundwater contamination plumes are found within the watershed.

These contaminants can affect both private wells and public water systems when levels exceed drinking water standards. Nearly 76 percent of the people living in the watershed get their drinking water from a community public water supply system. Wellhead Protection Plans have been developed for 15 of the 21 community public water suppliers in the SLRW and identify land use protections strategies for the approximately 53,000 acres in Drinking Water Supply Management Areas (DWSMAs).

Permitted groundwater is primarily sourced from buried sand and gravel aquifers, along with bedrock aquifers in the watershed. There are 19 active groundwater-level monitoring wells in the SLRW and of those wells, five had enough measurements to calculate a statistical trend. One well had an upward trend, two wells had downward trends and two wells had no trend in water levels

Activities on the land surface can affect groundwater levels by reducing infiltration (groundwater recharge) especially in the southern portion of the watershed; these activities include changes in vegetation, increased areas of impervious surface, and changing surface water or stormwater flow.

The SLRW 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:

- One hundred-nine designated trout streams.
- There are 170 lakes in the SLRW with a with a 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.
- Forty-nine distinct native plant communities connected to groundwater. In addition, 35 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.

To address risks both from groundwater overuse and from the introduction of pollutants, this report outlines a broad range of strategies that can be implemented, as well as 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 is 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. **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 watershed. Representatives from BWSR, MDA, MDH, DNR, and MPCA 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.[3]

[3] 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 (https://bwsr.state.mn.us/sites/default/files/2019-09/1W1P_guidebook.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 80 major watersheds[4]. 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).

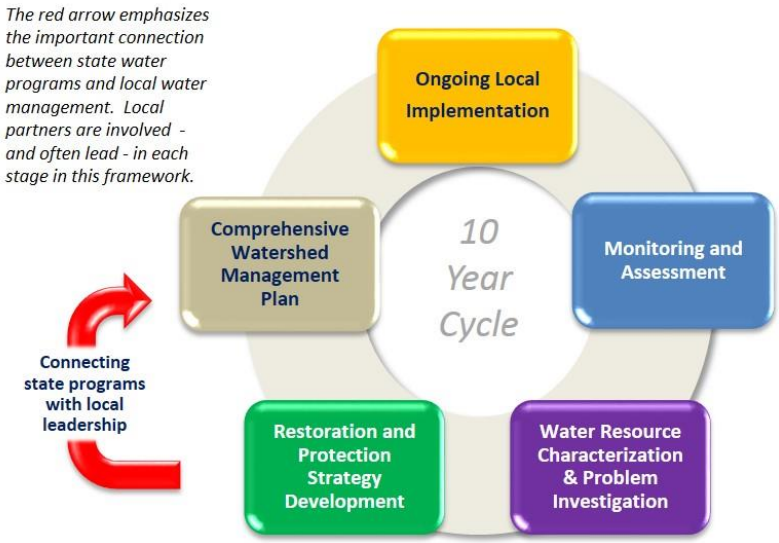


Figure 1: Watershed Approach Framework

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

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

recognizing protection based activities to maintain the health of high quality surface waters. GRAPS is largely protection-based—identifying actions to maintain groundwater quality and quantity. However, if contaminants exist or overuse is suspected, the strategies and actions identified to address the issue can result in restoration as well as protection. 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 type).

The report is divided into the following parts:

1. Watershed Overview: This section provides a brief overview of the watershed.
2. 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. 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

St. Louis River Watershed Overview

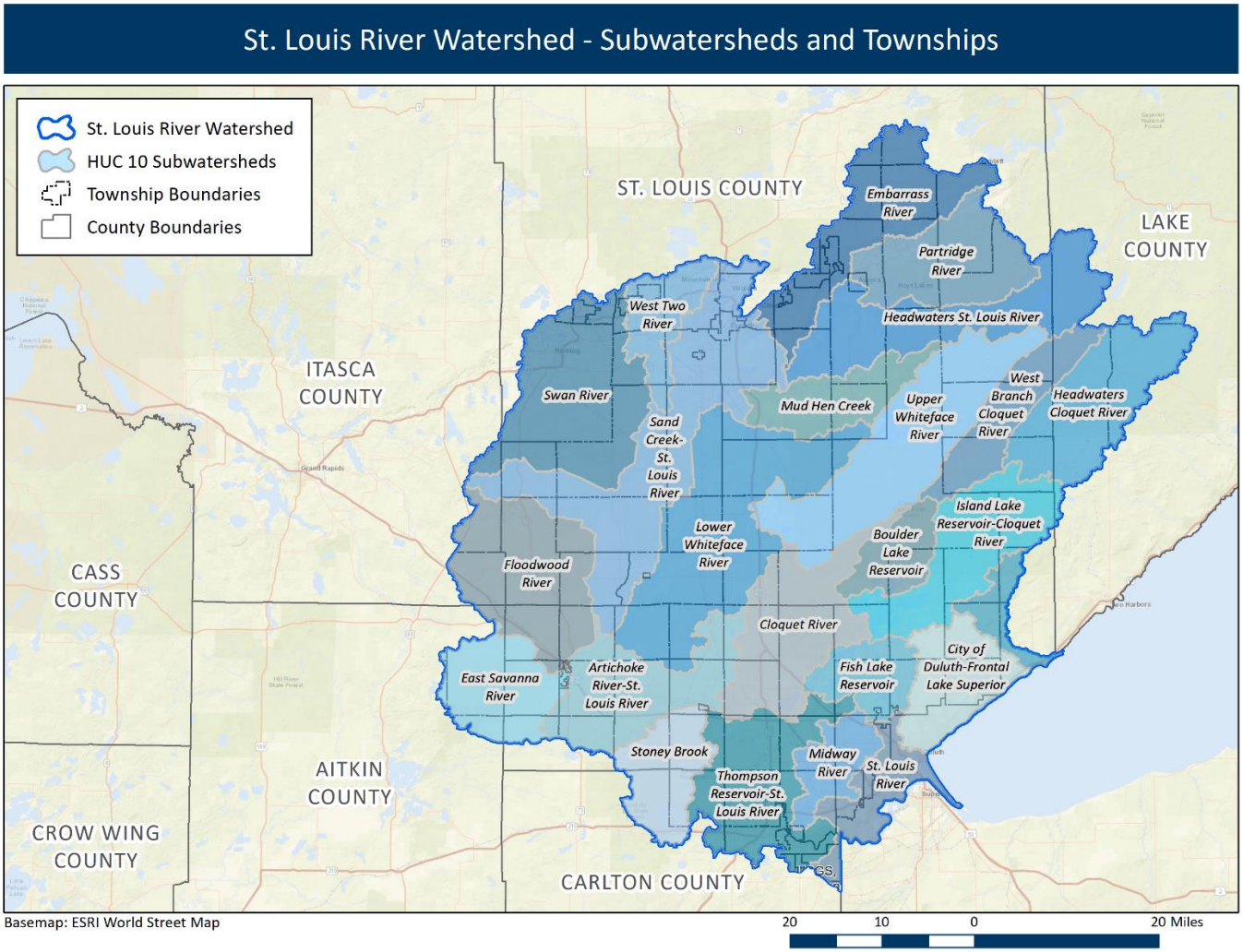
This report provides a brief overview of land use, geology, hydrogeology, pollution sensitivity, wellhead protection planning and drinking water, and water use and groundwater withdrawals affecting the St. Louis River Watershed (SLRW) 1W1P planning boundary groundwater quality and quantity. You can find more detailed information about the SLRW and groundwater through the following resources:

Restoration and Protection Plans

- MPCA watershed reports (www.pca.state.mn.us/water/watersheds/st-louis-river)

The St. Louis River Watershed 1W1P planning boundary is a large, geographically diverse and culturally rich watershed in northeastern Minnesota. The planning boundary touches five counties, one Tribal Reservation and three major watershed (Figure 2: St. Louis River Watershed - is comprised of twenty-three subwatersheds (HUC-10). The SLRW touches three major watersheds, the St. Louis River, Cloquet River, and the southern portion of Lake Superior – South watershed, terminating north of Duluth.). The SLRW population growth was nearly flat from the 2000 to 2010 census. Duluth and Hibbing are two of the largest communities in the watershed.

Of the roughly 207,125 people living in the watershed, approximately 157,880 (76 percent) utilize community public water and the remaining 24 percent obtain their drinking water from private wells.



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Land Use

The SLRW covers over 3000 square miles and is a water rich environment including over 500 lakes and 2000 miles of streams. The watershed is located in the Northern Lakes and Forest ecoregion dominated by wetlands and forests. Wetlands comprise the largest land cover in the watershed at over 40 percent, followed by forests at more than 35 percent (Figure 3).

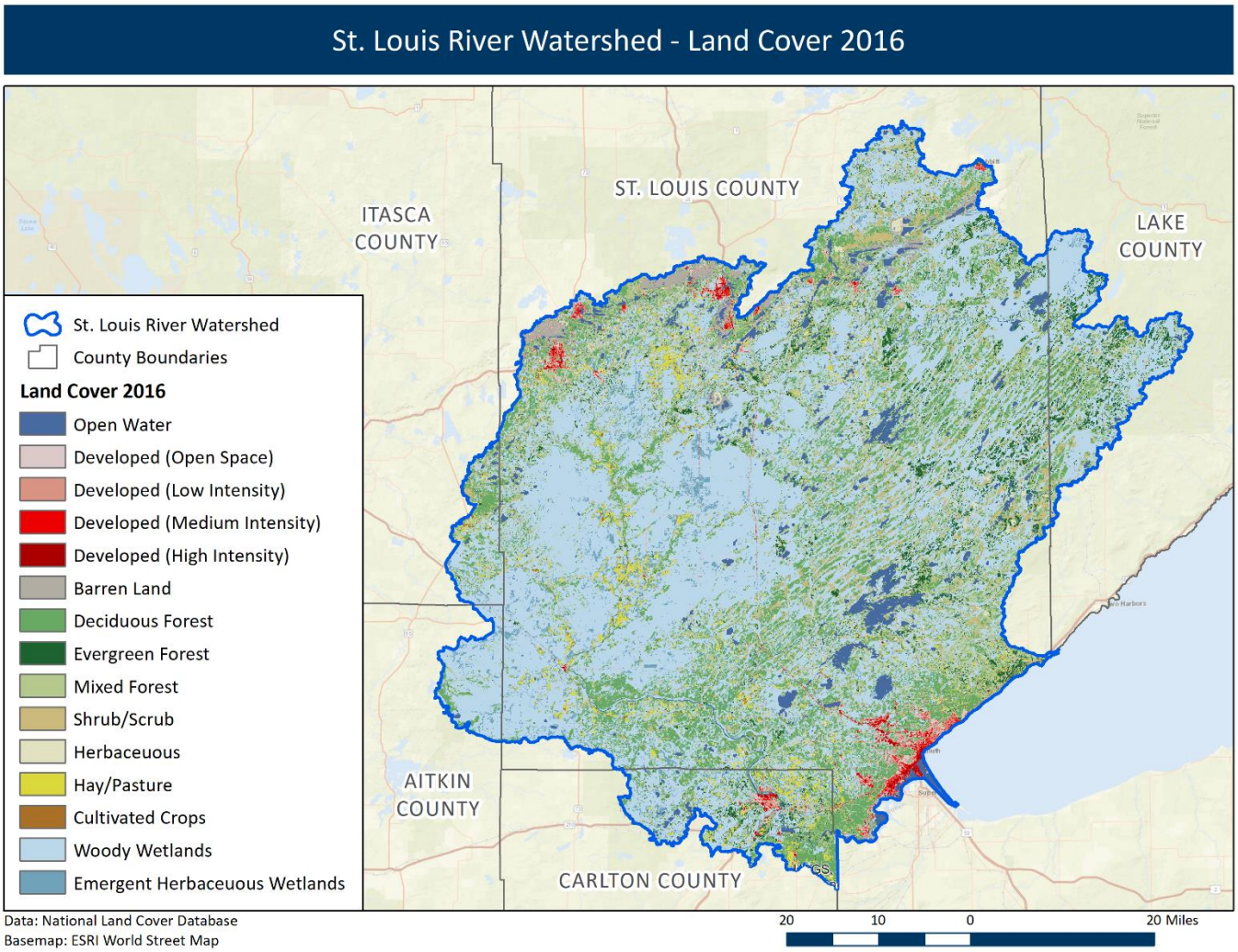

Figure 3: St. Louis River Watershed - Land Cover. Wetlands account for over 40 percent of land cover in the watershed.

Geology and Hydrogeology

Groundwater sources within the SLRW vary depending on the underlying geology. The geology in this watershed is the result of igneous, sedimentary, and glacial processes that took place in the region over billions of years.

The northern border of the watershed encompasses the Mesabi Iron Range. This area is known for its iron-rich sedimentary bedrock, formed 1.9 to 1.85 billion years ago from the chemical precipitation of iron oxides in shallow seawater. The range has been mined extensively for iron ore since the 1890s, and the landscape is dotted with abandoned open-pit mines that have since been filled by precipitation and groundwater.

South of the Iron Range, in the western part of the watershed, the bedrock consists of slightly younger fine-grained sedimentary rocks—shale, siltstone, and greywacke. Closer to the North Shore in the eastern part of the watershed, the bedrock is part of the Midcontinent Rift System, a geologic feature that formed 1.1 billion years ago as continental crust began to spread apart along what is now Lake Superior. The rifting produced gabbro,

anorthosite, and granite (intrusive igneous rocks formed by magma cooling underground) as well as basalt and rhyolite (rocks formed by volcanoes erupting on the land surface).

Water in these bedrock aquifers is mainly found in faults and fractures, since the rocks themselves tend to lack interconnected pore spaces. More information on the bedrock geology of this region is available from the Minnesota Geological Survey (MGS) (https://cse.umn.edu/mgs/precambrian-geology).

Overlying the bedrock is sediment from the advance and retreat of glaciers during the last ice age. Much of the land surface is covered in glacial till (unsorted sediment deposited directly by glacial ice). The high proportions of clay and silt in till deposits tend to impede the infiltration of water. Throughout the watershed there are also areas of sand and gravel sediments, which allow water to pass through more quickly.

There are several major types of aquifers in the watershed:

- Buried sand and gravel aquifers of glacial origin. Approximately 44% of all drinking water wells draw from these aquifers.
- Crystalline bedrock, where groundwater is found locally in faults and fractures. About 34% of wells draw from these aquifers.
- Surficial sand and gravel water table aquifers of glacial origin. About 18% of drinking water wells use these aquifers.
- Other drinking water sources: The largest city in the SLRW, Duluth, serves almost 87,000 people and draws its water from Lake Superior. There are also several other smaller towns within the watershed, mainly on the Iron Range, that draw surface water from mining pits and lakes.

Of the counties in this watershed, only Carlton County has a completed County Geologic Atlas (CGA). The CGAs for Aitkin, St. Louis, and Lake Counties are currently in progress. As a result, the areas outside Carlton County have fewer wells with aquifer interpretations in the County Well Index (CWI) database.

Figure 4: St. Louis River Watershed – Primary Aquifers by Section. Buried sand and gravel aquifers are the primary drinking water source for the watershed (not including surface water sources). Fractured bedrock aquifers are the next most common aquifer type, followed by surficial sand and gravel aquifers. depicts a generalized map of aquifers in the watershed.

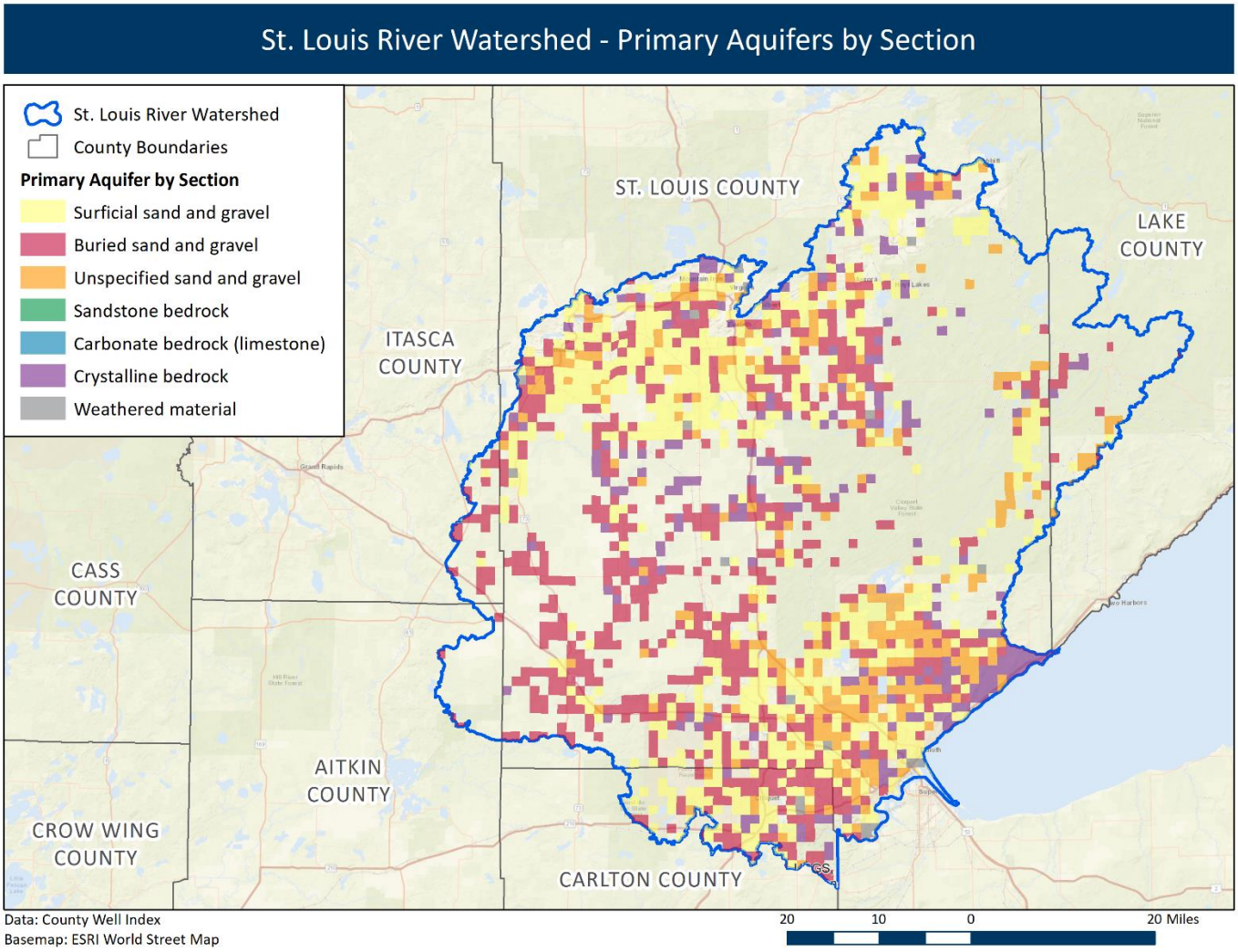

Figure 4: St. Louis River Watershed – Primary Aquifers by Section. Buried sand and gravel aquifers are the primary drinking water source for the watershed (not including surface water sources). Fractured bedrock aquifers are the next most common aquifer type, followed by surficial sand and gravel aquifers.

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 5: St. Louis River Watershed - Pollution Sensitivity of Near Surface Materials 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 near-surface pollution sensitivity rating is variable throughout the watershed. Overall, most of the watershed is rated “very

low" to "moderate", reflecting the dense tills covering most of the land surface. In some areas, particularly in a band running parallel to the north shore of Lake Superior, the land surface has a higher pollution sensitivity due to sand and gravel deposits from glacial outwash. Elsewhere in the watershed, there are patches of high vulnerability that originate from sandy glacial lake deposits. There are some areas of the watershed where bedrock occurs at or near the land surface. The pollution sensitivity of near-surface bedrock can vary, but where there are voids and fractures in the rock, transmission of contaminants can occur very quickly. More information on this dataset is available on the DNR website Minnesota Hydrogeology Atlas (MHA) (http://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 7 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. Figure 7 shows that the groundwater pollution sensitivity rating varies throughout the watershed. In general, areas of "high" pollution sensitivity correspond to areas where there are many wells in shallow glacial aquifers. Note that where well data is sparse, this map can be highly influenced by individual wells; this is the case throughout much of the central portion 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 39 and Figure 40.

It is also important to understand how recharge travel time ratings (Figure 6 and Figure 8) 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 5); whereas, for deeper aquifers more commonly used for drinking water, a rating of 'moderate' reflects travel times of years to decades (Figure 8). 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.

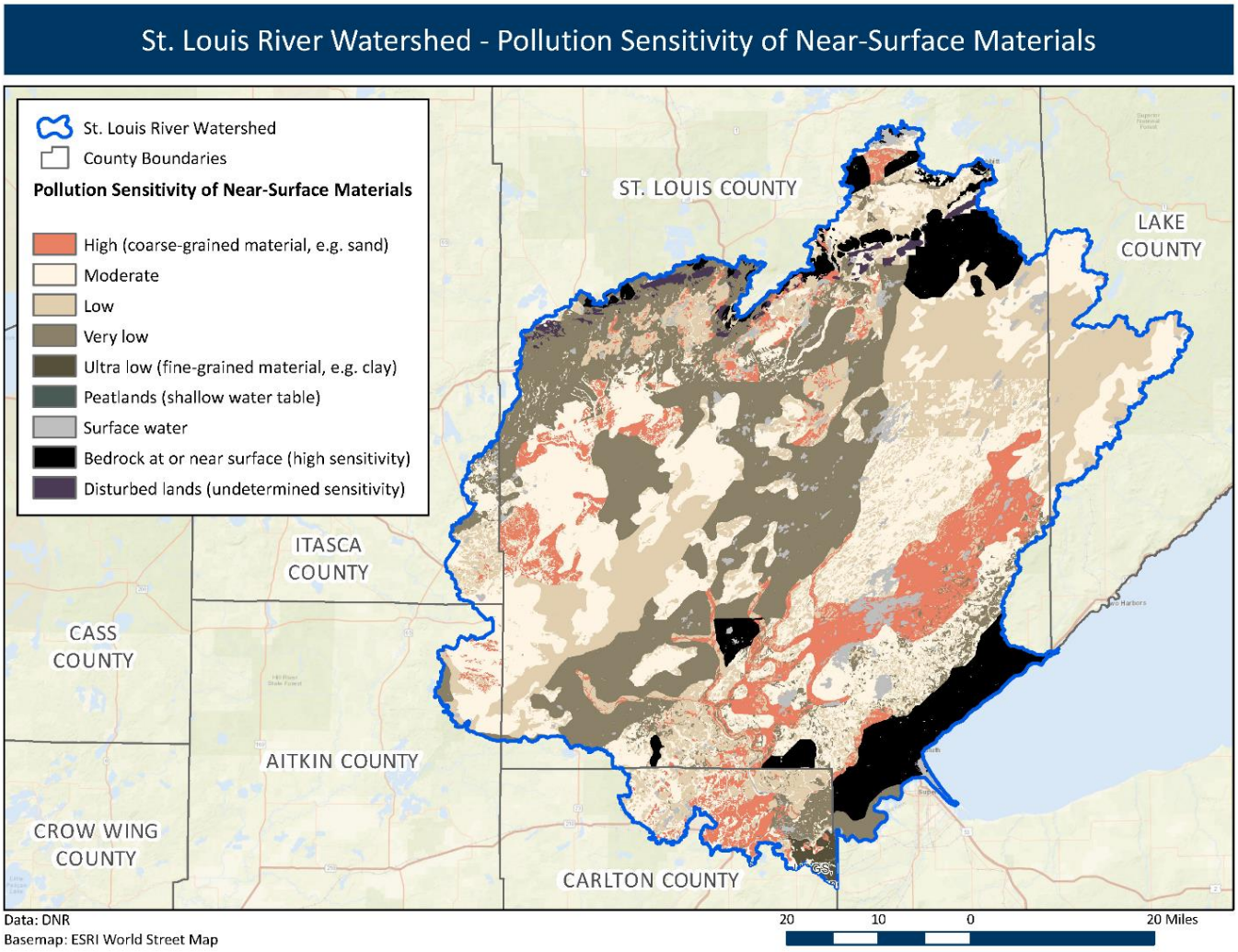

Figure 5: St. Louis River Watershed - Pollution Sensitivity of Near Surface Materials

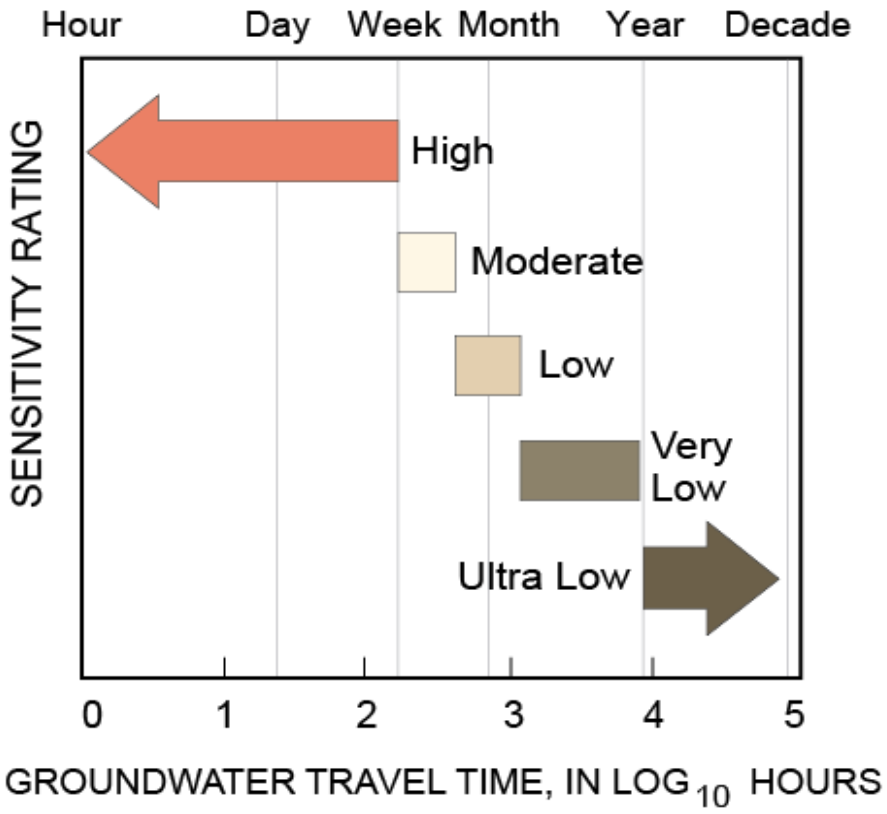

Figure 6: Recharge Travel Time for Near-Surface Materials

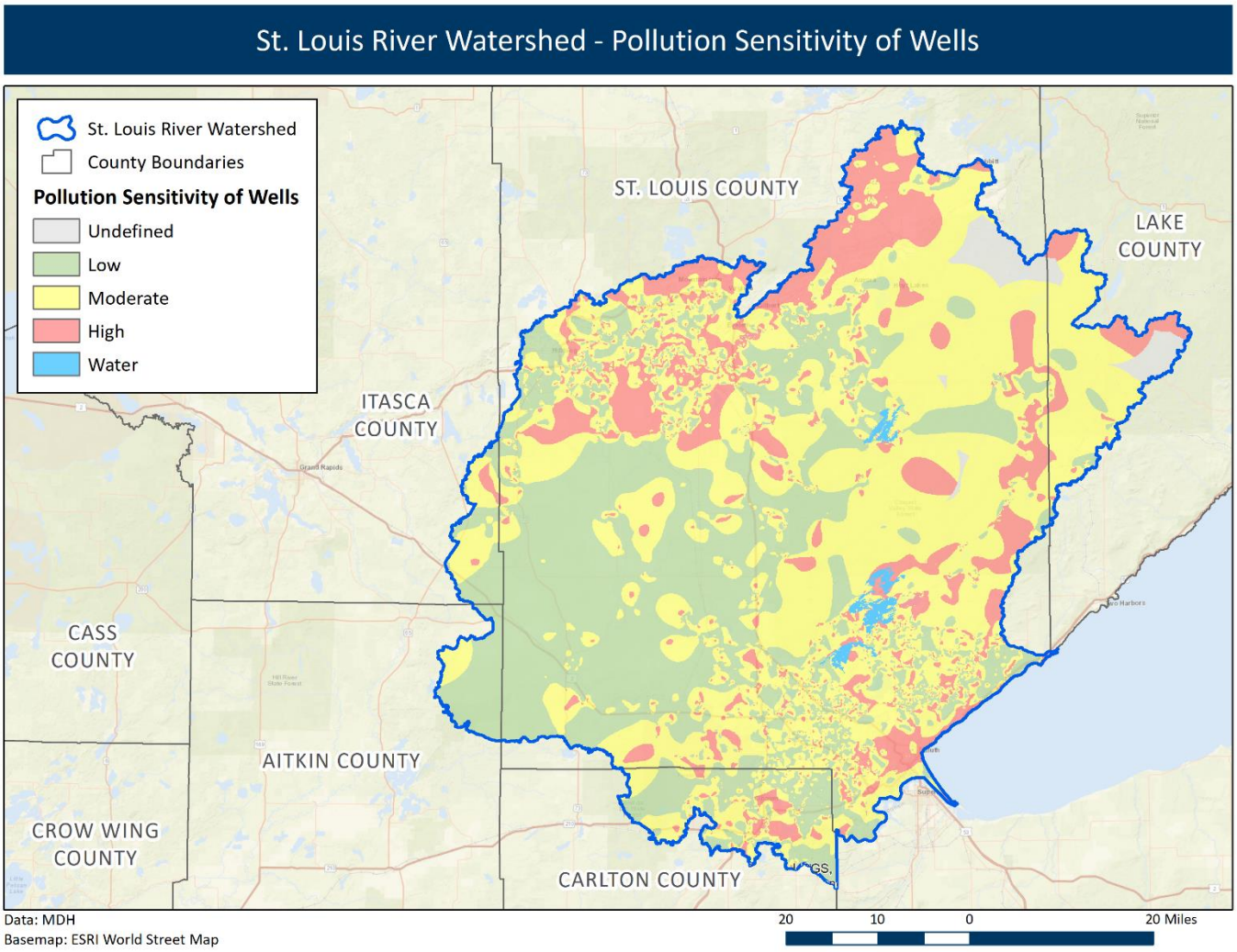

Figure 7: St. Louis River Watershed - Pollution Sensitivity of Wells.

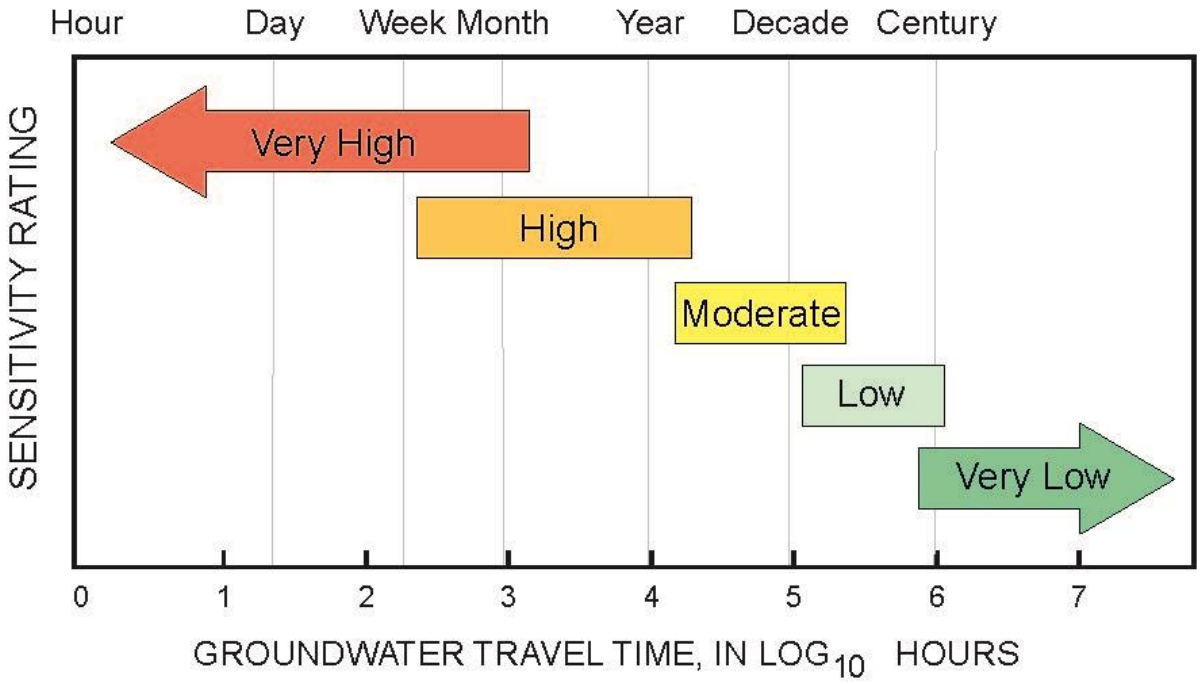

Figure 8: Recharge Travel Time for Buried Aquifers

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

Pollution Sensitivity Rating	Aquifer Recharge Time Period[5] 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

[5] 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 (WHP), 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 supplies[6], including municipal and nonmunicipal 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 manage the groundwater below. Learn more about MDH Source Water Protection (www.health.state.mn.us/communities/environment/water/swp/index.htm).

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 easily contaminated by activities at the ground surface. Others are deeper or more protected by geologic materials; these tend to exhibit a low vulnerability to overlying land uses. The types of management activities required within WHPAs will vary based largely on the 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.

Fifteen of the 21 community public water systems, within the SLRW are engaged in the wellhead protection planning process or are implementing their plans. Of the 15 systems with approved plans, the vulnerability varies across the watershed from low to very high, including four systems with a surface water contribution area or conjunctive delineation, which includes both surface water runoff and groundwater. Thirteen of the approved wellhead protection plans exhibit high or very high vulnerability in all or part of their DWSMA and is considered vulnerable to contamination from the land surface, with all others exhibiting moderate or low vulnerability. Figure 9 shows the status of wellhead protection planning for the public water supply systems in the watershed. Figure 10 shows the DWSMAs delineated at the time the report was compiled in the SLRW, covering over 53,000 acres. It is important to note that WHP areas do not follow watershed boundaries and are located in different watersheds in SLRW.

The City of Duluth draws its drinking water from Lake Superior, a surface water system, and is not reflected in the GRAPS report. To learn more review Duluth's Source Water Assessment (https://swareport.web.health.state.mn.us/SWA_Factsheet.html?pwsid=1690011#).

[6] Community public water supplies serve at least 25 persons or 15 service connections year-round. Community public water supplies include municipalities (cities), manufactured mobile home parks, etc. Currently there are almost 1,000 community water supplies in Minnesota.

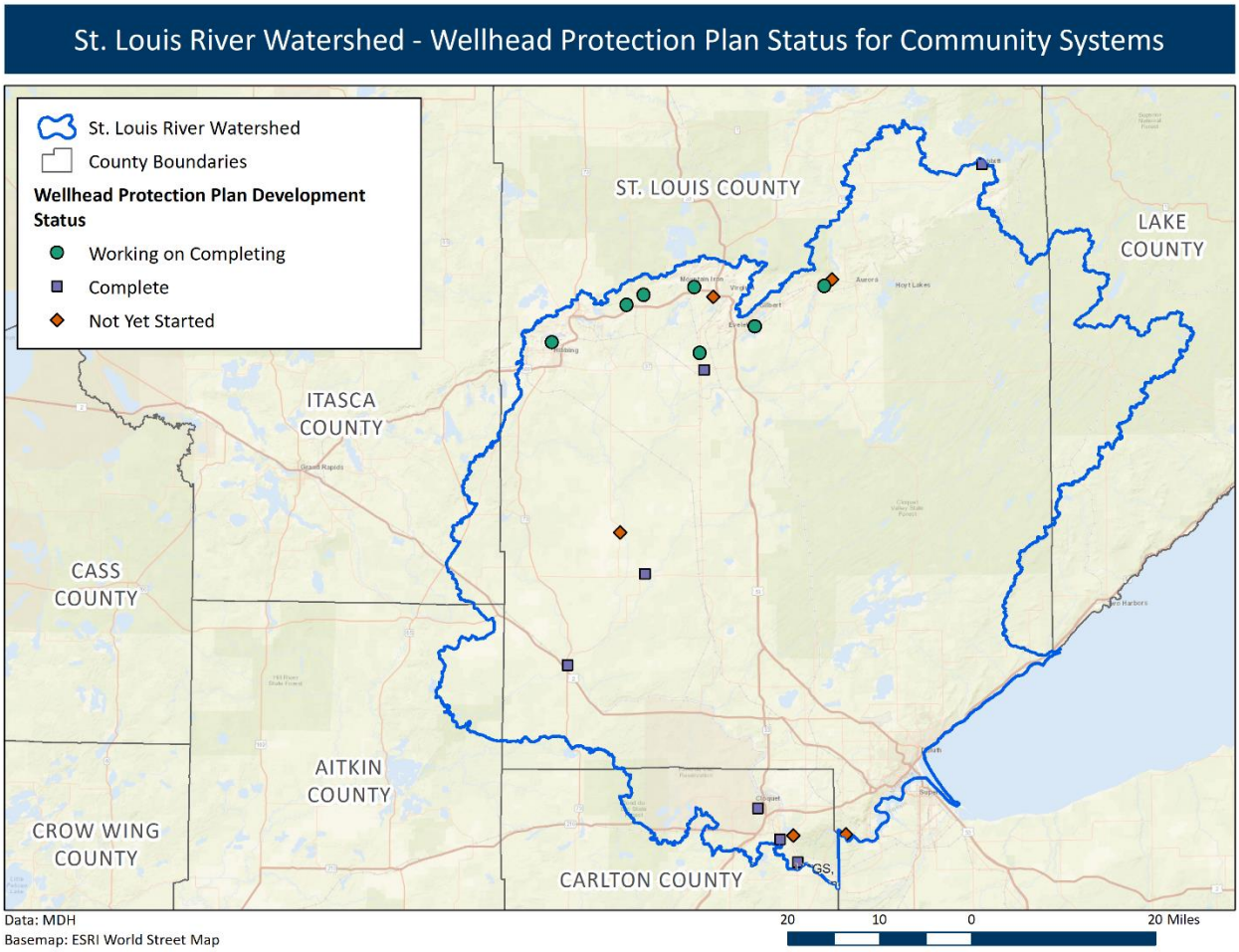

Figure 9: St. Louis River Watershed - Wellhead Protection Plan Development Status for Community Public Water Systems. Fifteen of the 21 community public water supply systems are engaged in the wellhead protection planning process or are implementing their plans. The City of Duluth is a surface water system and is not included in the GRAPS report.

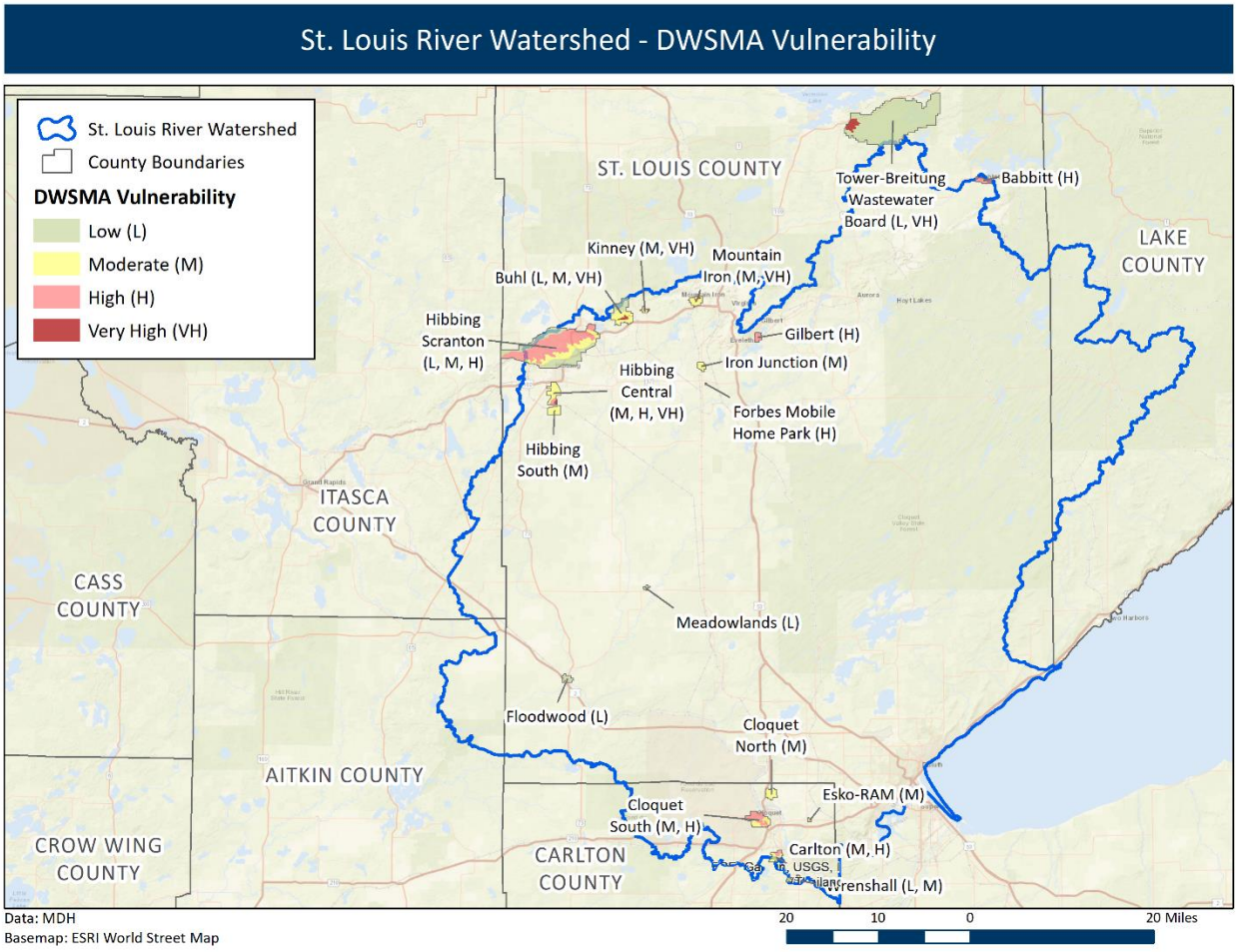

Figure 10: St. Louis River Watershed - Drinking Water Supply Management Areas. There are 15 approved Drinking Water Supply Areas (DWSMA) for community public water supply systems in the watershed. The City of Duluth is a surface water system and is not included in the GRAPS report.

Four WHPAs in the SLRW are considered a conjunctive delineation. A conjunctive WHPA delineation occurs when a strong connection exists between the groundwater capture zone for a well and either a surface water body or the land surface area intersected by that capture zone. In these instances, the WHPA merges the well capture zone (abbreviated GWCA for groundwater capture area) and the watershed area for the surface water body or land surface area which it intersects (abbreviated SWCA for surface water contribution area). The four public water systems with conjunctive delineations include Buhl, Hibbing (Scranton well field), Mountain Iron, and Tower-Breitung Waste Water Board.

The management of conjunctive WHPAs can present challenges because of their large size relative to more traditional WHPAs that are based solely on groundwater capture areas. In addition, management practices of potential contaminant sources can differ between the GWCA and SWCA. Within the GWCA, the focus will be on contaminants likely to soak into the ground whereas, in the SWCA, the focus will be on those contaminants most likely to runoff during rainfall or snowmelt events. It should be noted that conjunctive WHPAs do provide a means of achieving multiple benefits within a watershed.

Improvements in land use management in these areas stand to benefit both the aquifer used by the public water supplier and associated surface water bodies.

Private Wells

The SLRW has approximately 12,441 private wells with known locations ranging from 2 feet to 1,042 feet deep with an average depth of 131 feet that provide drinking water to residents. Over thirty-one percent (3,927 wells) of private wells are in a highly vulnerable setting. Private well users are not afforded the same water quality safeguards as people who get their water from public water systems. While public water systems make sure water is safe for the end-user, private well users are responsible for making sure their water is safe for everyone in the household to drink.

The Minnesota Well Code ensures that private wells are properly located and constructed. However, once the well is put into service, private well users are responsible for properly maintaining their well, testing it regularly, and treating the water when necessary.

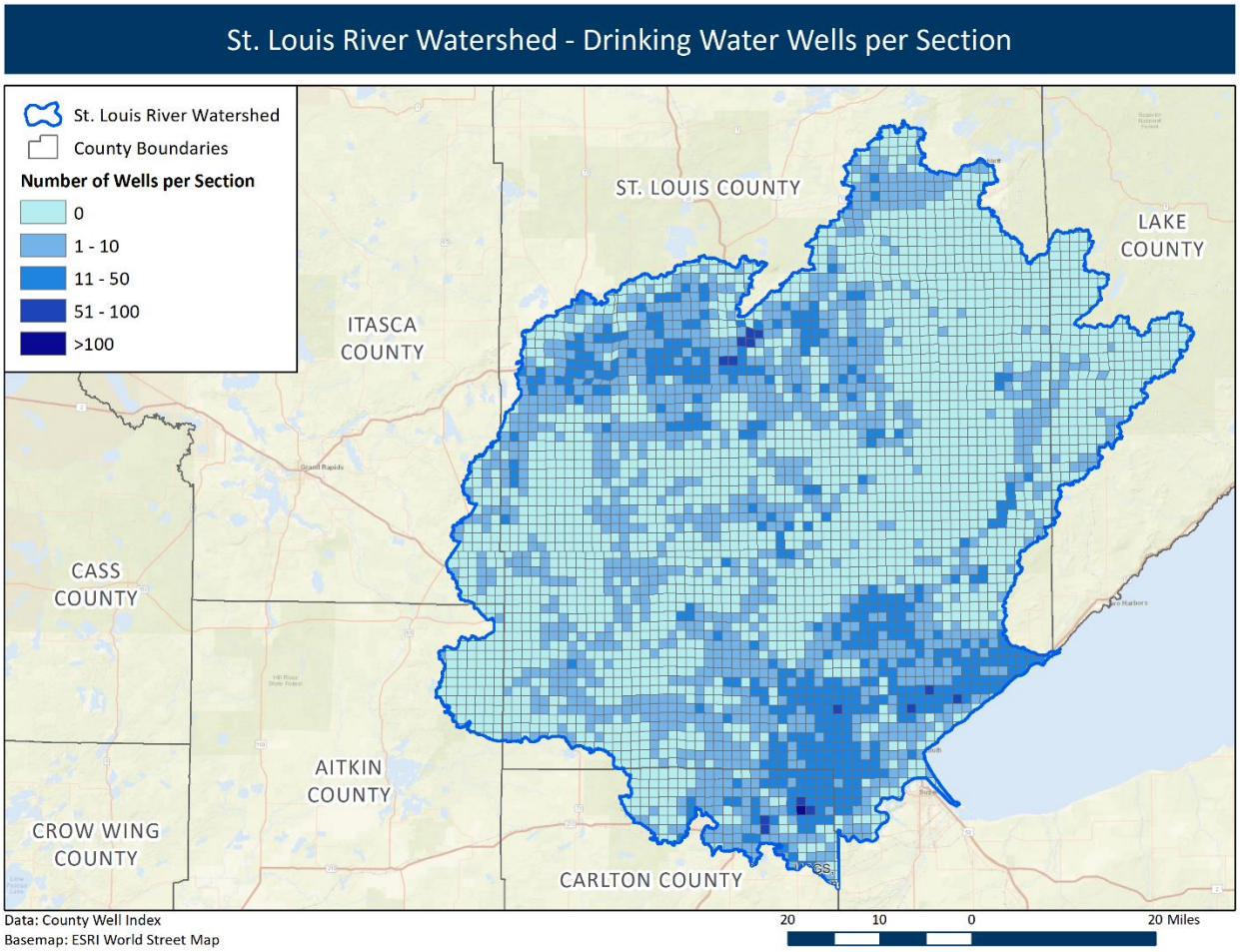

Figure 11: St. Louis River Watershed - Density of drinking water wells per section. There are 12,441 private wells identified.

Figure 11 illustrates well density and water use data in the SLRW. 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 is variable across the watershed. Only wells used for drinking water were included in this analysis.

Extreme Weather

Climate records show that across Minnesota there has been an increase in average rainfall, as well as heavy precipitation events. As storms become more frequent and intense, flooding will be an ongoing challenge for public water systems and private wells. Flood events can threaten the safety and availability of drinking water by washing pathogens (bacteria, viruses, and parasites) and chemical contamination into source aquifers or by overwhelming the capacity of treatment systems to clean the water. The full extent of floodwater contamination depends on land use and associated infrastructure in the affected area. Figure 12 displays drinking water wells and flood zone risk to contamination in the SLRW.

Extreme weather may also affect drought conditions by changing how and where precipitation falls. Increased rainfall over frozen ground and reduced snowpack from spring melt can decrease infiltration into groundwater when converted to runoff. The Groundwater Quantity Issues and Concerns section of the report assesses aquifer sustainability by evaluating long term monitoring well trends.

For more information on Climate and Health (www.health.state.mn.us/communities/environment/climate/) or visit the DNR's webpage Climate Change and Minnesota (www.dnr.state.mn.us/climate/climate_change_info/index.html).

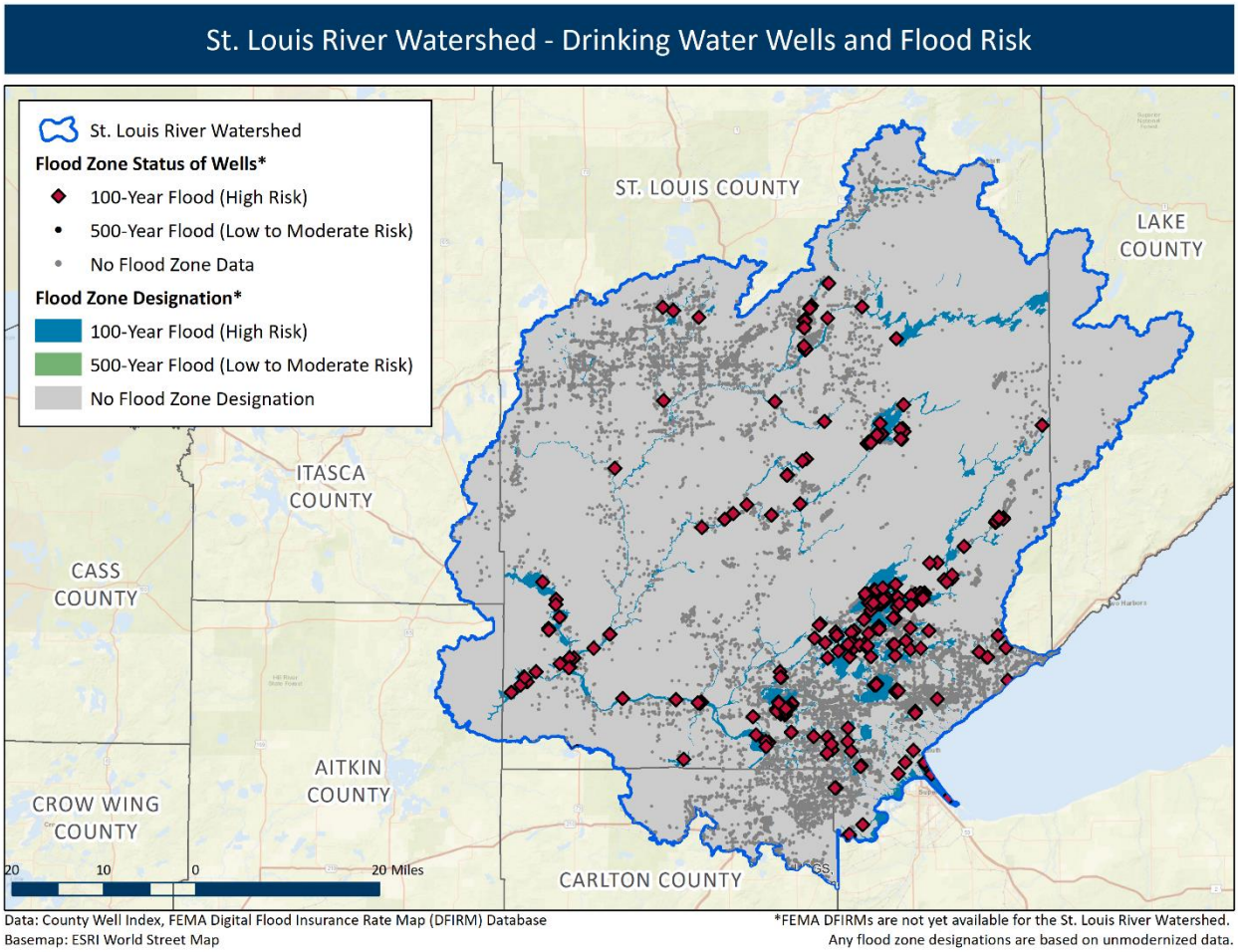

Figure 12: St. Louis River Watershed – Drinking water wells and flood zone risk to contamination.

Forest Land

Minnesota is home to over 17 million acres of forest land comprising 22 percent of the State's land area. In the SLRW, forest land and woody wetlands are the predominate land cover Figure 3. The State's Forest landscapes are a mix of private, tribal, and public lands. Private landowners manage 40 percent of forest land in MN and in the SLRW the State is the largest land manager of forest land.

Forests play an important role in keeping water clean. They act as natural water filters due to the large pore spaces in the soil that filter pollutants and recharge groundwater.

Forests are natural water filters and play an important role in keeping water clean. Forest soils contain large pore spaces that filter pollutants and recharge groundwater. Keeping forests on the landscape is one of the best ways to protect drinking water in the SLRW.

St. Louis River Watershed Groundwater Issues and Concerns

This section of the report describes the key groundwater quality and quantity issues for the SLRW. 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 SLRW 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 SLRW groundwater quality. Multiple state agencies monitor different types of groundwater wells and public water systems for contaminants. Nitrate and arsenic have been detected in wells sampled in the SLRW. 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 strive to meet Safe Drinking Water Act (SDWA)[7] requirements for the quality of water served to their customers. However, some public water systems may have water quality issues in their untreated source water that requires either blending or treatment to meet SDWA standards.

Nitrate

Nitrate-nitrogen (referred to as nitrate) is a compound that occurs naturally and has many human-made sources. When nitrate levels are above 3 milligrams per liter (mg/L)[8] 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. Most of the samples taken from wells within the watersheds did not exceed the SDWA standard for nitrate. This dataset includes newly constructed wells, private wells, and other drinking water supply wells. Sampling of newly constructed wells for nitrate began in 1974. Many older

[7] The Safe Drinking Water Act (SDWA) is the federal law that protects public drinking water supplies throughout the nation. Under the SDWA, EPA sets standards for drinking water quality; MDH is delegated to implement the program in MN to ensure drinking water safety.

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

wells, pre-well code, are not included in this dataset. Table 2 shows nitrate test results for samples taken from these wells.

Table 2: Summary of nitrate results in drinking water wells of the St. Louis River Watershed.

Depth Completed Range (feet)	Total samples (nitrate)	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	550	0	7.53	0.2	2.4	0
50 - 99	2,742	0	8	0.2	0.9	0
100 - 149	1,727	0	6.6	0.05	0.5	0
150 - 199	631	0	12.2	0.05	0.5	0.2
>= 200	1,820	0	50.6	0.14	1.5	0.1
Total	7,470	0	50.6	0.1	1.0	0

Where Is Nitrate in St. Louis River Watershed?

High levels of nitrate are present in areas where there are both human-caused sources of nitrate and high pollution sensitivity exist. The following images help identify where nitrate is detected and at what levels in the watershed:

- Figure 13 compares nitrate levels in wells in the SLRW. The absence of elevated nitrate concentrations throughout most of the watershed may be a function of low-impact land use near the wells or the presence of favorable geochemical conditions in the aquifers. Nitrate requires relatively oxidizing conditions to persist in groundwater, and the presence of locally reducing conditions can remove nitrate. The dataset used to create this figure is the same as that used in Table 2. These nitrate samples were taken from newly constructed wells, private wells, and other drinking water supply wells sampled by the Minnesota Department of Health (MDH).
- Figure 15 shows the five MPCA ambient monitoring well location sampled between 2010-2019 in the SLRW. Nitrate results were well below SDWA standards of 10 mg/L.

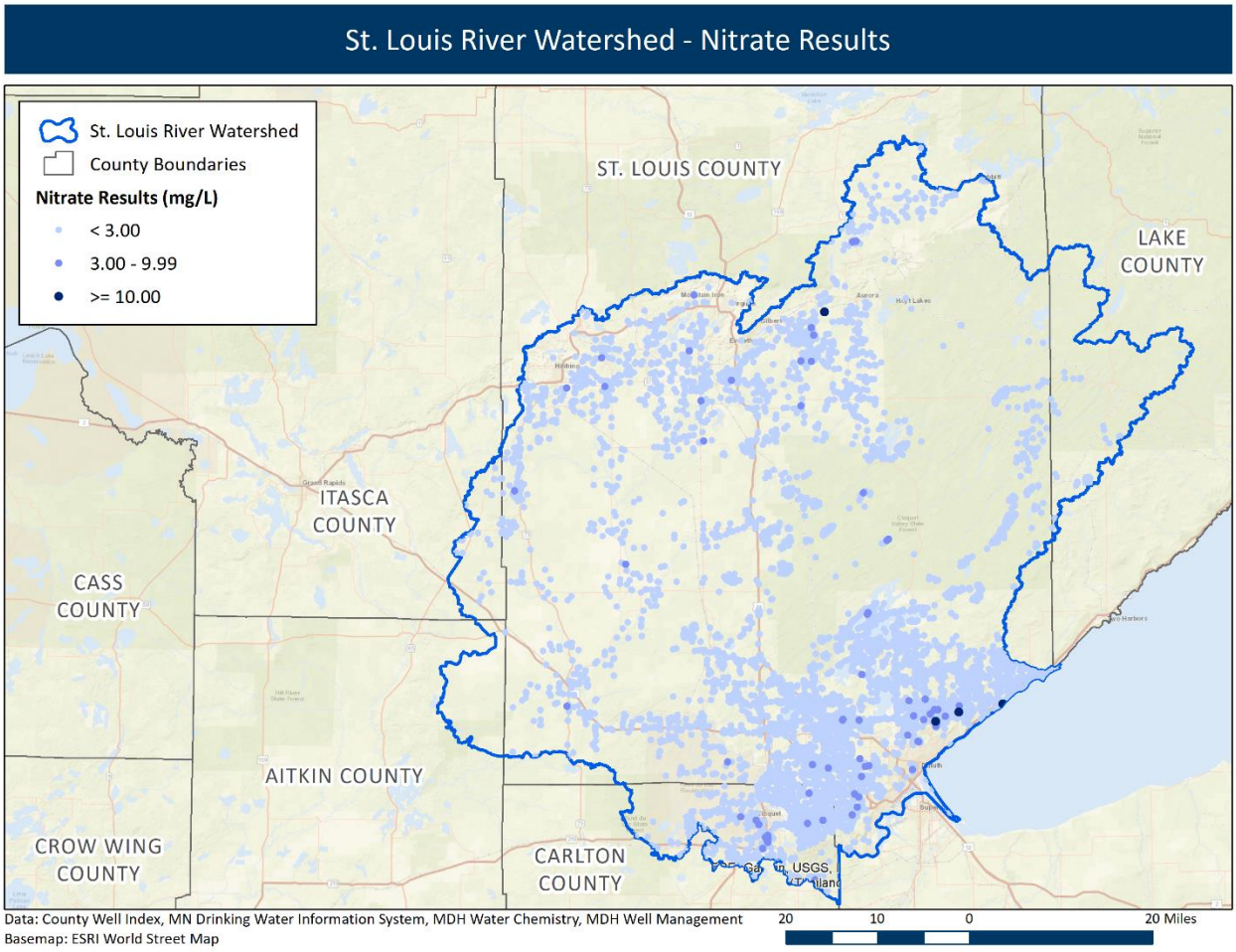

Figure 13: St. Louis River Watershed - Nitrate Results for Drinking Water Wells

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 3 provides a protection framework that identifies management priorities reflective of nitrate concentrations.

Table 3: 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

Nitrate Protection Framework	Nitrate Concentration	Implementation Emphasis
		▪ 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[9], 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 9 provides a more comprehensive list of specific actions counties and subwatersheds in the SLRW can take to restore and protect groundwater quality related to nitrate.

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

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

pesticides frequently used in row crop production and include acetochlor, alachlor, atrazine, metolachlor and metribuzin.

Where Are Pesticides in St. Louis River Watershed?

There are no MDA monitoring wells in the watershed.

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

Arsenic

Nearly three percent of the 1,731 arsenic samples taken from located wells in the SLRW have levels of arsenic higher than the SDWA standard of 10 micrograms per liter (µg/L)[10]. 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 4 outlines the number of well water samples tested for arsenic in the SLRW, using the dataset from the Minnesota Well Index (MWI) and well for newly constructed private wells. The table shows the percentage of samples with arsenic levels over the SDWA standard. It is important to remember that arsenic concentrations can be drastically different from nearly identical wells installed on adjoining properties.

Table 4: Summary of arsenic (As) concentrations in wells of the St. Louis 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	106	0.0005	24	1.15	15.1	3.8
50 - 99	554	0.0005	17.8	1.8	10.1	1.4
100 - 149	399	0.0005	46.8	1.9	11.5	2.0
150 - 199	143	0.0005	14.54	1.35	9.8	0.7

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

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 (%)
>= 200	529	0.0005	540.98	1,3	15.9	5.3
Total	1731	0.0005	540.98	1.6	12.5	2.8

Where Is Arsenic in the St. Louis River Watershed?

Figure 14 shows that arsenic is found in elevated concentrations throughout the watershed. The dataset used to create Figure 14 is the same information displayed in Table 4. Theses samples were taken from newly constructed domestic wells.

There are elevated levels of arsenic above the SDWA standard in wells completed in bedrock aquifers, including the Paleoproterozoic Virginia Thompson formation, Duluth Complex and undifferentiated Precambrian rock. There are some glacial wells with arsenic, but the majority of arsenic in the watershed are in bedrock wells. Typically, elevated arsenic in Minnesota groundwater is associated with glacial lobes originating from northwest Canada, but it also occurs in bedrock wells, although the source is not as well understood. In glacial aquifers, elevated arsenic is correlated with clay layers and reducing geochemical conditions that release arsenic into the groundwater. Well depths with elevated arsenic range from 42 to 505 feet in the SLRW. For wells with arsenic detected but below the SDWA standard, the wells were completed primarily in the Quaternary Buried Artesian aquifer, with around 40% in the bedrock aquifers.

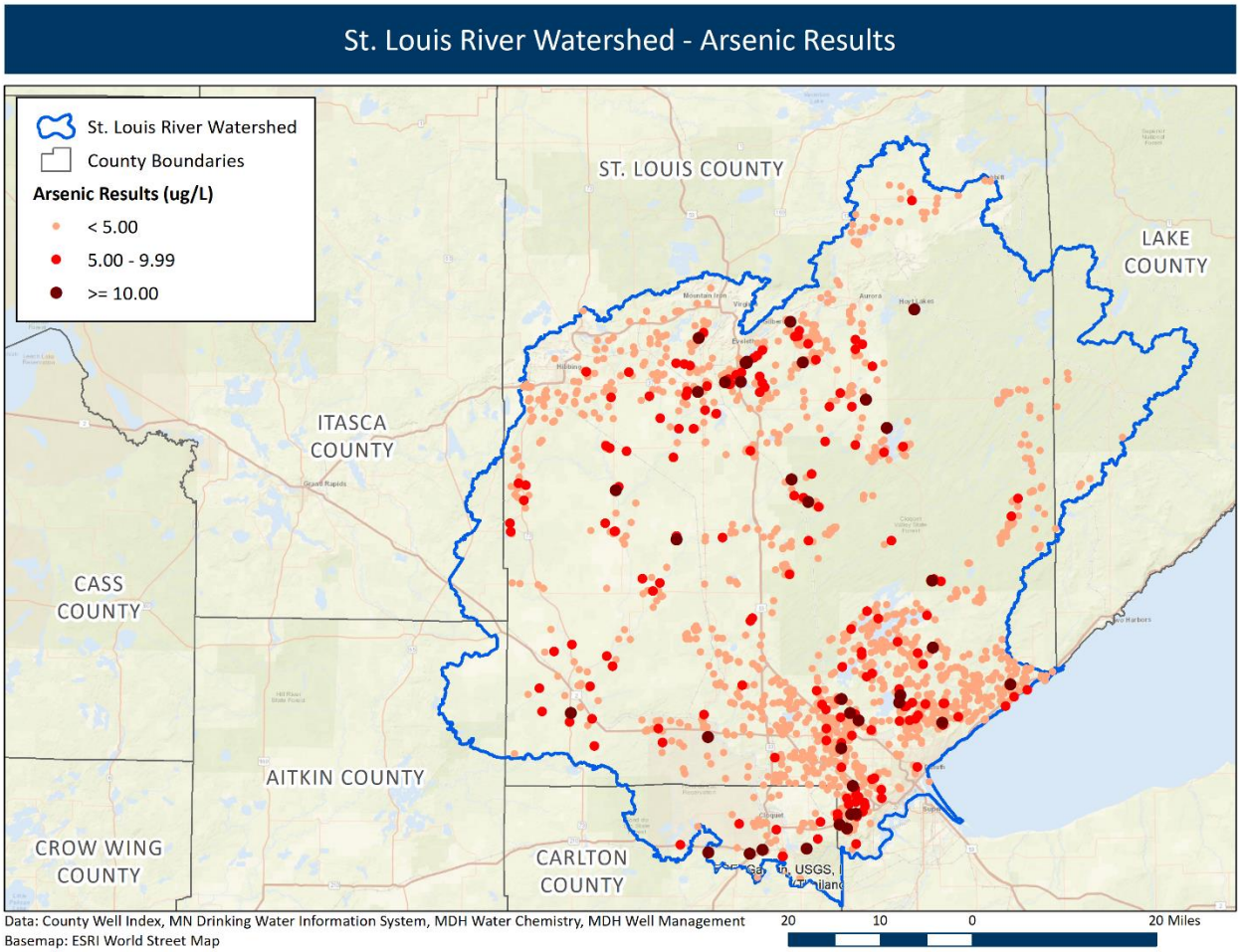

Figure 14: St. Louis River Watershed - Arsenic Results

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

Radioactive materials, also called radionuclides (Radium), are both naturally occurring and human-made. Drinking water that has radium exposes individuals to very low doses of radiation every day, increasing your risk of cancer if you drink water with radium in it every day for many years.

Concentrations of naturally occurring radium have not been detected in groundwater samples in the SLRW. The exact source of these compounds is not well understood. They may originate in the clay-rich glacial sediments or may be part of the original mineral composition of the Mt. Simon or fractured

Sioux Quartzite 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 St. Louis River Watershed?

Not enough is known about radium (or other radionuclide) distribution in the aquifers beneath the SLRW. The sparse results do not indicate a problem at this time.

How to Address Radionuclides in Groundwater

Human activity is unlikely to be the cause of radionuclides in 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 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. Water softeners and reverse osmosis are effective at removing radium from groundwater. Learn more at Radionuclides (Radium) in Drinking Water (https://www.health.state.mn.us/communities/environment/water/contaminants/radionuclides.html).

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. 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 is on shallow aquifers that underlie urban areas, due to the higher tendency of sensitivity to pollution, and are predominately located in sand and gravel and Prairie du Chien-Jordan aquifers.

From 2010-2019, five ambient network wells were sampled within the SLRW. Results indicate that the majority of detections were within the human health guidelines are set by either the United States Environmental Protection Agency (US EPA) or the MDH. Nitrate and chloride are of particular concern due to the health risks (nitrate) and ecological risks (chloride). Nitrate results were well below the MDH limit of 10 mg/L. Chloride can be damaging to plants and aquatic life but is categorized as a nuisance chemical in drinking water. This means there are no established health risk limits for it in drinking water but it can produce an unpleasant taste so, for it, the US EPA has set a secondary maximum contaminant level of 250 mg/L (US EPA, 2020). Results were in three of the five wells were below this level, while two wells showed consistent results above. While it is naturally found in groundwater, elevated levels can be caused by things like road salt and water softener salt.

MDH hosts information on a List of Contaminants in Water (www.health.state.mn.us/communities/environment/water/contaminants/index.html), as well as CECs (www.health.state.mn.us/communities/environment/risk/guidance/dwec/index.html).

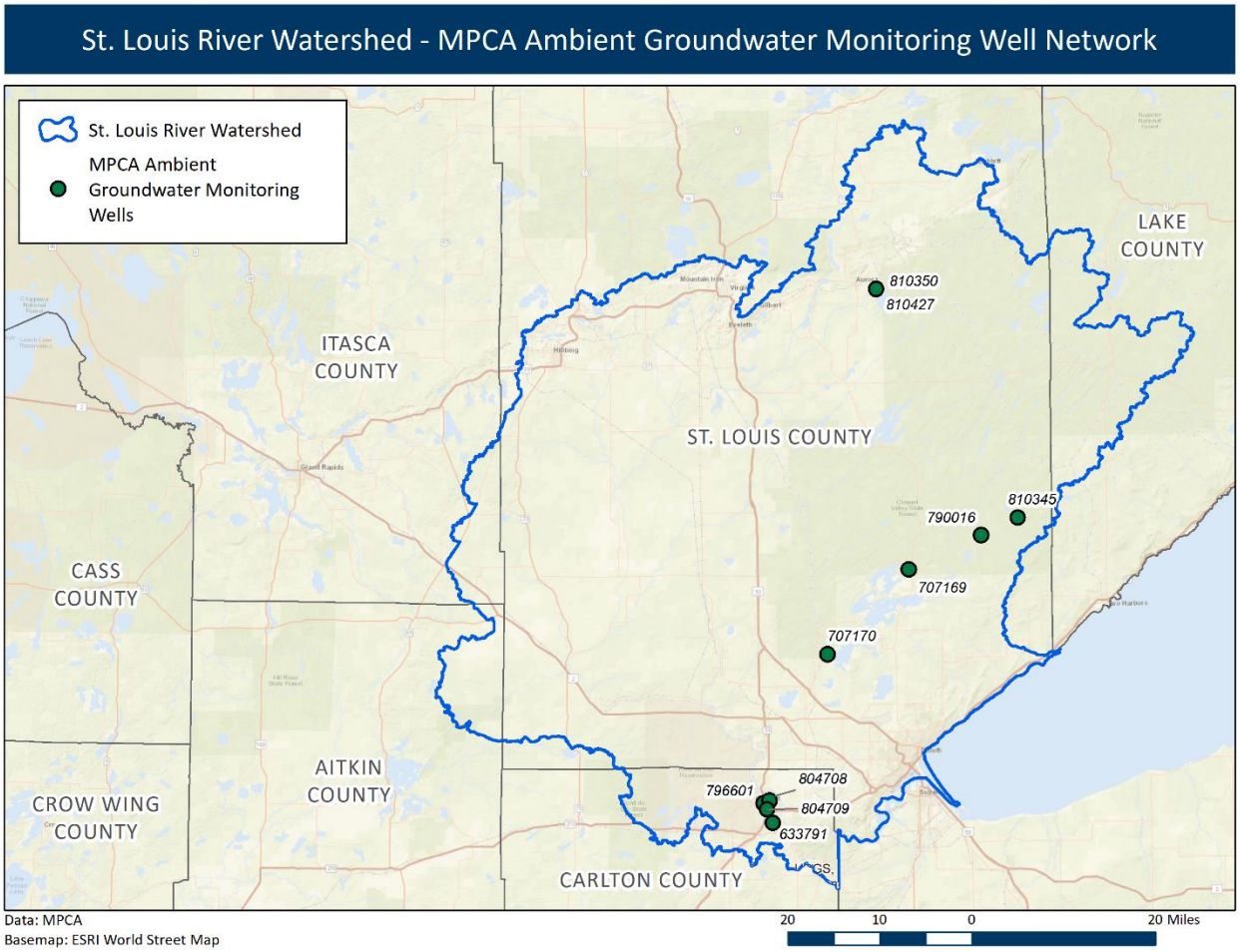

Figure 15: St. Louis Watershed – MPCA Ambient Groundwater Monitoring Wells

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 SLRW 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 (www.mda.state.mn.us/local-ordinances-regulating-livestock-minnesota).

MDA developed a new tool in collaboration with the National Weather Service called the Minnesota Runoff Risk Advisory Forecast (RRAF) system (www.mda.state.mn.us/protecting/cleanwaterfund/toolstechnology/runoffrisk). RRAF is designed to help farmers and commercial applicators determine the best time to apply manure to reduce the probability of off target movement of valuable nutrients and protect water resources.

Where Are Animal Feedlots in the St. Louis River Watershed?

The SLRW has 44 active feedlots. 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 administering the feedlot program locally, therefore they rely on the MPCA to execute within their jurisdiction.

Table 5 outlines the number of registered feedlots in the SLRW for each county. Figure 16: St. Louis River Watershed – Active Feedlots. There are 44 active feedlots within the watershed represents where active feedlot are found in the watershed.

Table 5: Number of registered feedlots and the delegated counties

Counties	Number of Registered Feedlots per County	Delegated County
Aitkin	0	No
Carlton	7	No
Itasca	0	No
Lake	0	No
St. Louis	37	No

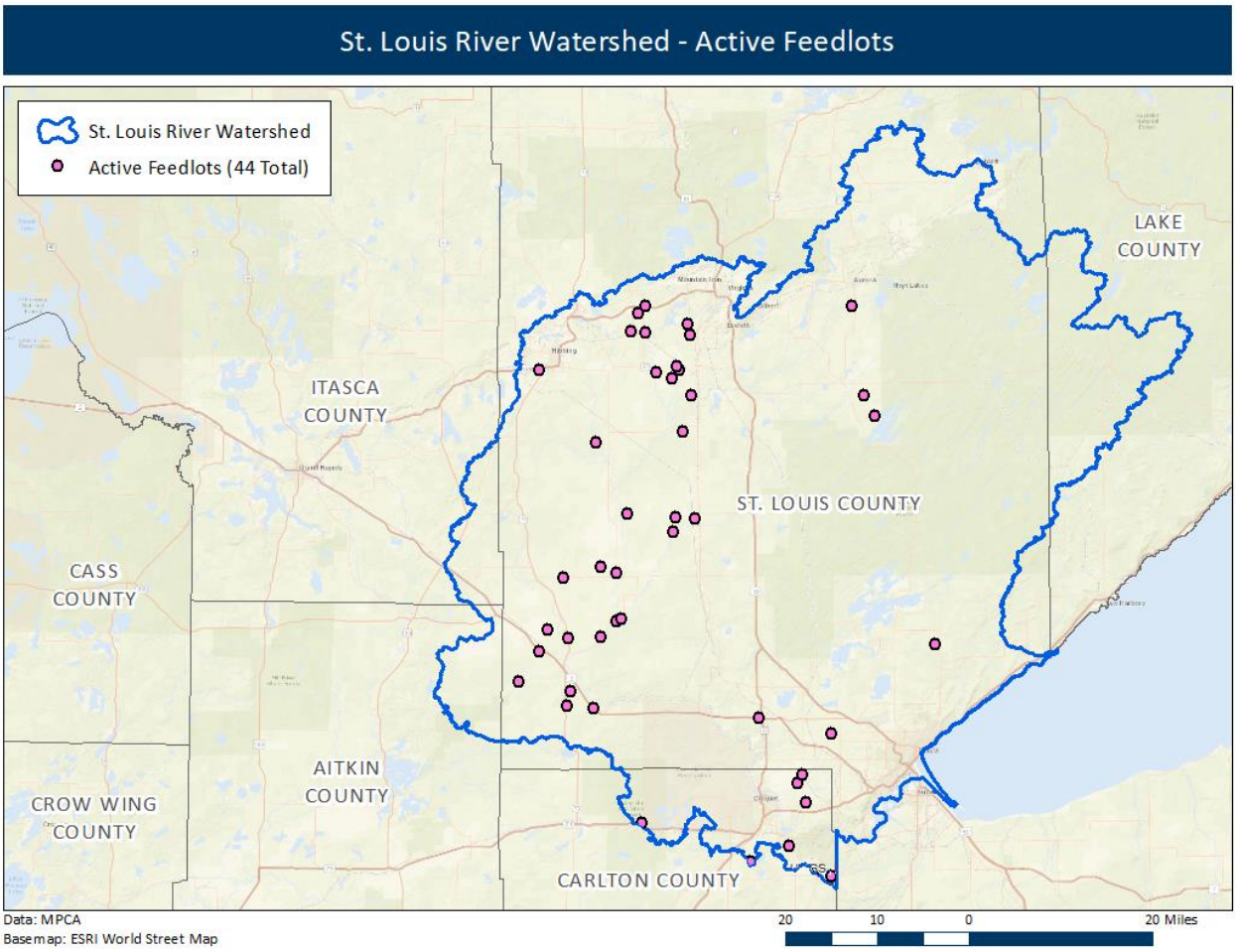

Figure 16: St. Louis River Watershed – Active Feedlots. There are 44 active feedlots within the watershed

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 9 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 3) represent only five percent of land cover within the SLRW. 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 St. Louis River Watershed?

SSTS are found in all five counties in the SLRW. 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 St. Louis River Watershed

County	Estimated number of failing SSTS per 1,000 acres
Aitkin	0 - 1
Carlton	2 - 3
Itasca	0 - 1
Lake	0 - 1
St. Louis	2 - 3

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 9 provides a more comprehensive list of specific actions the SLRW 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 975 active tank, 46 leak sites and 10 closed landfills in the SLRW. These types of contaminated sites (also referred to as point sources) have the potential to contaminate groundwater with a variety of chemicals.

Where Are Contaminated Sites in the St. Louis River Watershed?

Figure 17, maps active tank and leak sites compared to pollution sensitivity of near-surface materials in the SLRW. Figure 18 provides a map of the closed landfills in the SLRW. The following sites also provide maps to help identify contaminated sites.

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

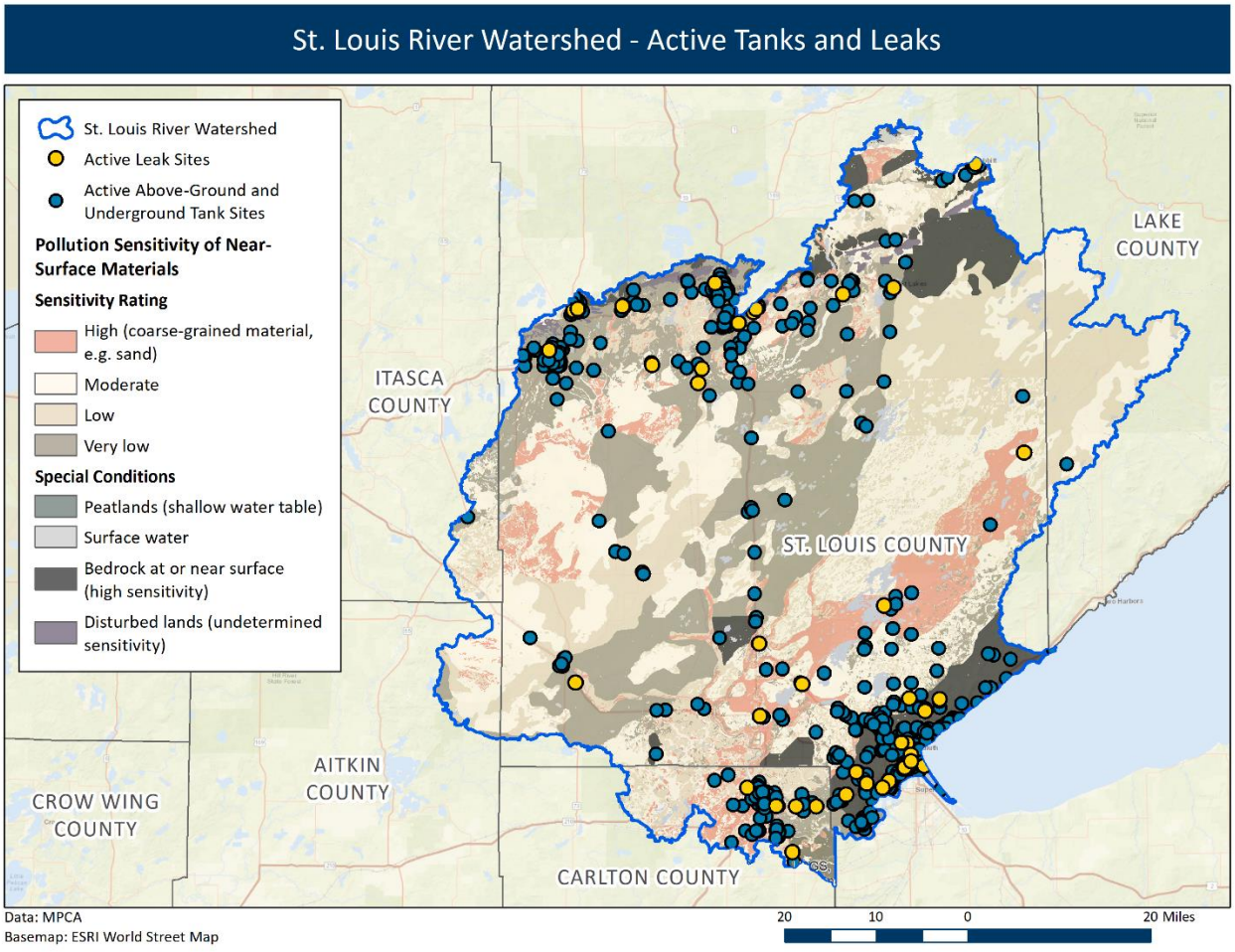

Figure 17: St. Louis River Watershed - MPCA Active Tank and Leak Sites and Pollution Sensitivity of Near-Surface Materials

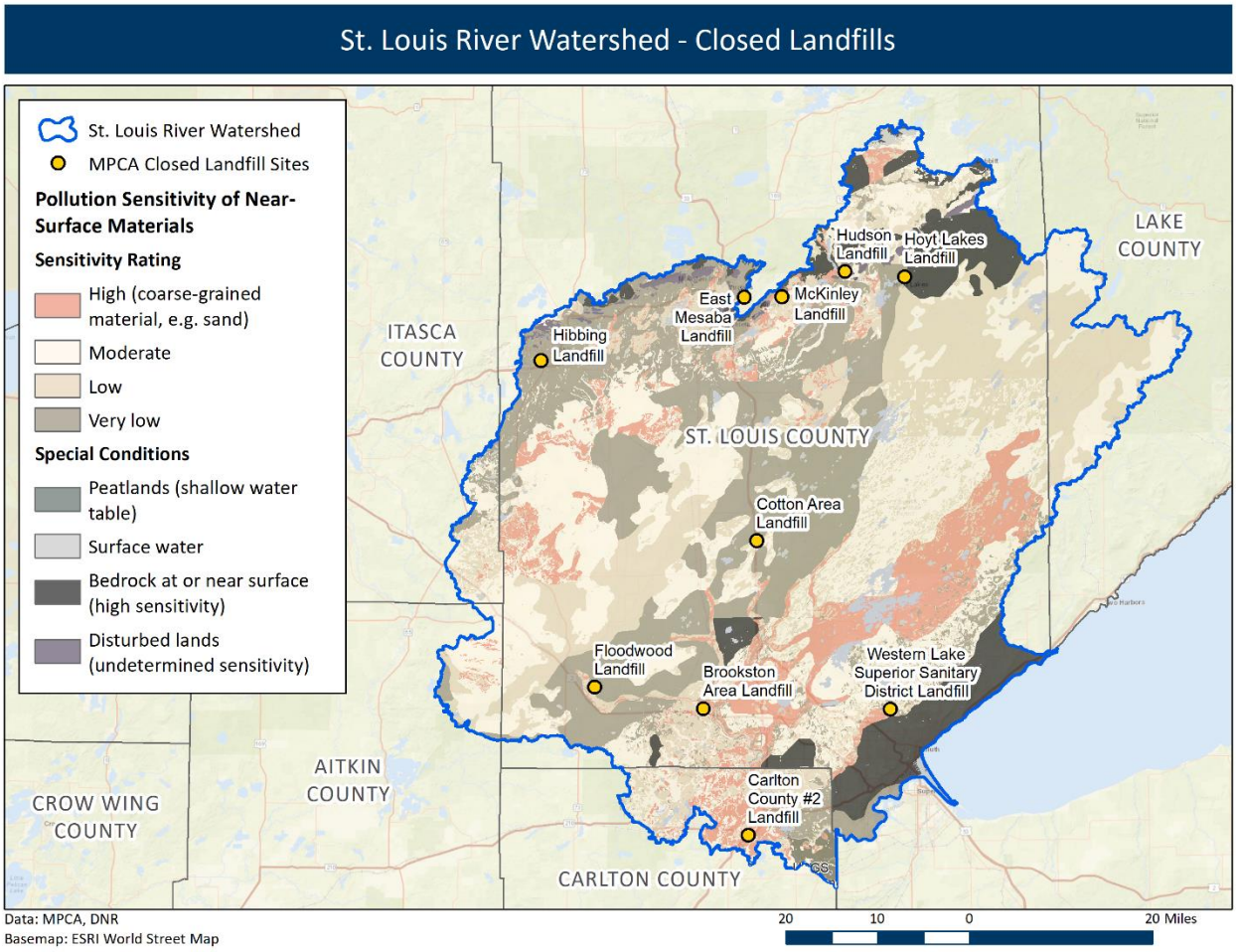

Figure 18: St. Louis River Watershed - MPCA Closed Landfill

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 9 provides a more comprehensive list of specific actions the SLRW 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. MS4s in Minnesota must satisfy the requirements of the MS4 general permit if they are located in an urbanized area and used by a population of 1,000 or more or owned by a municipality with a population of 10,000 or more, or a population of at least 5,000 and the system discharges to specially classified bodies of water. Entities with an MS4 permit require 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 9 provides a more comprehensive list of additional actions the SLRW 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 9 provides a more comprehensive list of specific actions the SLRW 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 (https://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

Depending on the year, the SLRW has 15 to 20 times more surface water use than groundwater use. This is largely due to mine dewatering on the iron range. Permitted groundwater use increased from approximately 1900 million gallons per year in 1988 to 2400 million gallons per year in 2018. Most groundwater is pumped from either the bedrock or buried sand and gravel aquifer. Most permitted groundwater use is for water supply. Because of major pumping to dewater mine pits, surface water use typically exceeds groundwater use by approximately 15 to 20 times, depending on the specific year.

Groundwater Use

A water-use appropriation permit is required from the DNR for groundwater users 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 which aquifers are being used and for what purpose. Permits require annual water-use reporting. This information is recorded using Minnesota Permitting and Reporting System (MPARS), which helps the DNR track the volume, source aquifer, and type of water use. The DNR has records of reported water use from 1988 to the present.

Figure 19 - Figure 21 show graphs of reported water use by calendar year from 1988 to 2018. A summary of reported 2018 water use by use category versus source aquifer is shown in Table 7. Figure 22 and Figure 23 show the distribution of permitted wells with reported 2018 water use, categorized by use category and aquifer type, respectively.

Annual groundwater use in the SLRW had a minimum of approximately 1900 million gallons per year in 1988 (Figure 22). Groundwater use increased to about 2400 million gallons per year in 2018.

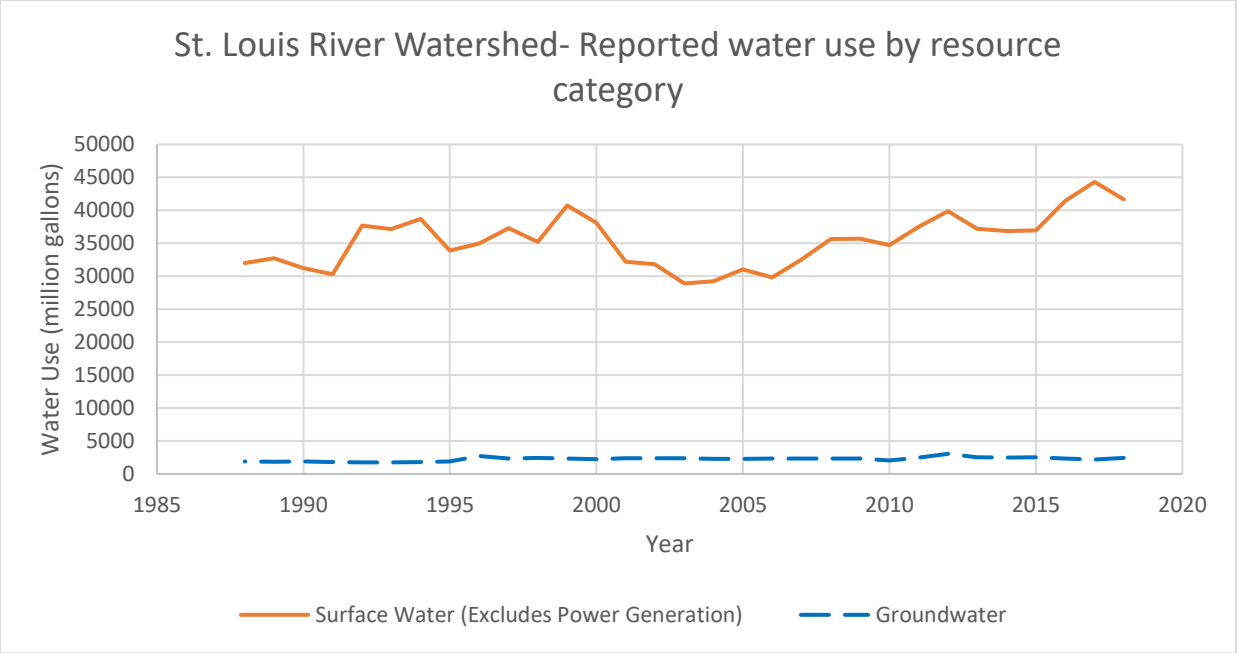

Figure 19: Reported water use from the DNR permit holders by resource category. Surface Water Use is much higher than groundwater use in this watershed. Duluth sources its drinking water from Lake Superior and there are many mines on the Mesabi Range that require significant volumes for dewatering.

Most permitted groundwater withdrawals are pumped from the buried sand and bedrock aquifers (Figure 20). Most permitted groundwater use is for water supply (Figure 22).

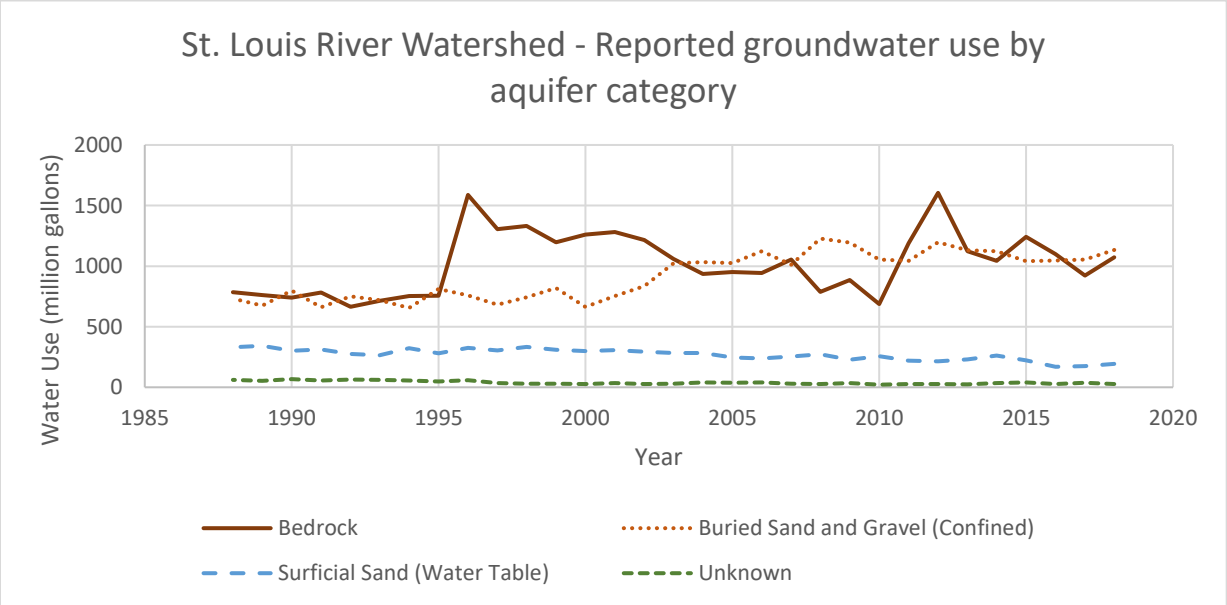

Figure 20: Reported groundwater use from DNR permit holders by aquifer category. Most permitted groundwater use is drawn from buried sand and bedrock aquifers.

In 2018, approximately 92 percent of permitted groundwater use was for water supply, approximately seven percent was used for power supply, and the remainder spread among other use categories (Table 7). Approximately 47 percent of permitted groundwater was sourced from the buried sand aquifer and 44 percent from bedrock aquifers.

Figure 21 shows the distribution of groundwater appropriation permits for 2018 by volume reported and use category. Figure 22 shows the same information by volume reported and aquifer category. The largest water users in the watershed are Minnesota Power and the cities of Hibbing, Mountain Iron, Virginia, and Cloquet.

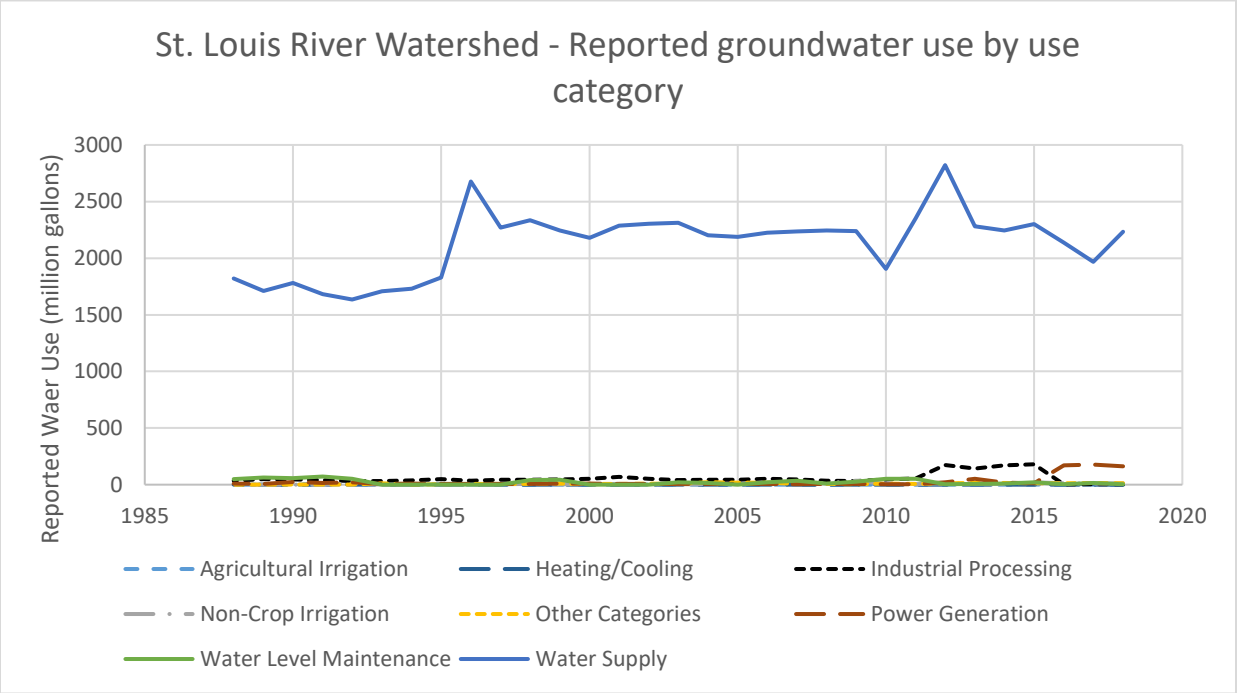

Figure 21: Reported groundwater use from DNR permit holders by use category. Most permitted groundwater withdrawals are used for water supply. Pumping for water supply rose from 1800 million gallons per year in 1998 to 2200 million gallons per year in 1988, with peaks in 1996 and 2012.

Table 7 [11]: Reported 2017 water use from DNR groundwater permit holders in million gallons per year.

Use Category	Surficial Sand Aquifer (Water Table)	Buried Sand and Gravel Aquifer (Confined)	Bedrock Aquifer	Unknown	Total (mgy)	Total (percent)
Agricultural Irrigation	—	—	—	—	—	—
Heating/Cooling	—	—	—	—	—	—
Industrial Processing	3.5	0.0	0.5	—	4.0	0.2
Non-Crop Irrigation	5.6	2.9	3.1	—	11.5	0.5
Other Categories	6.9	5.5	—	—	12.4	0.5
Power Generation	—	156.8	—	5.5	162.4	6.7
Water Level Maintenance	—	—	—	4.4	4.4	0.2
Water Supply	177.4	969.5	1068.1	17.0	2232.0	92.0
Total (mgy)	193.4	1134.7	1071.7	26.9	2426.7	—
Total (percent)	8.0	46.8	44.2	1.1	—	100 *

[11] Data from MPARS; mgy, million gallons per year; dash marks (-) indicate no use in those categories; * percentages may not equal 100 due to rounding.

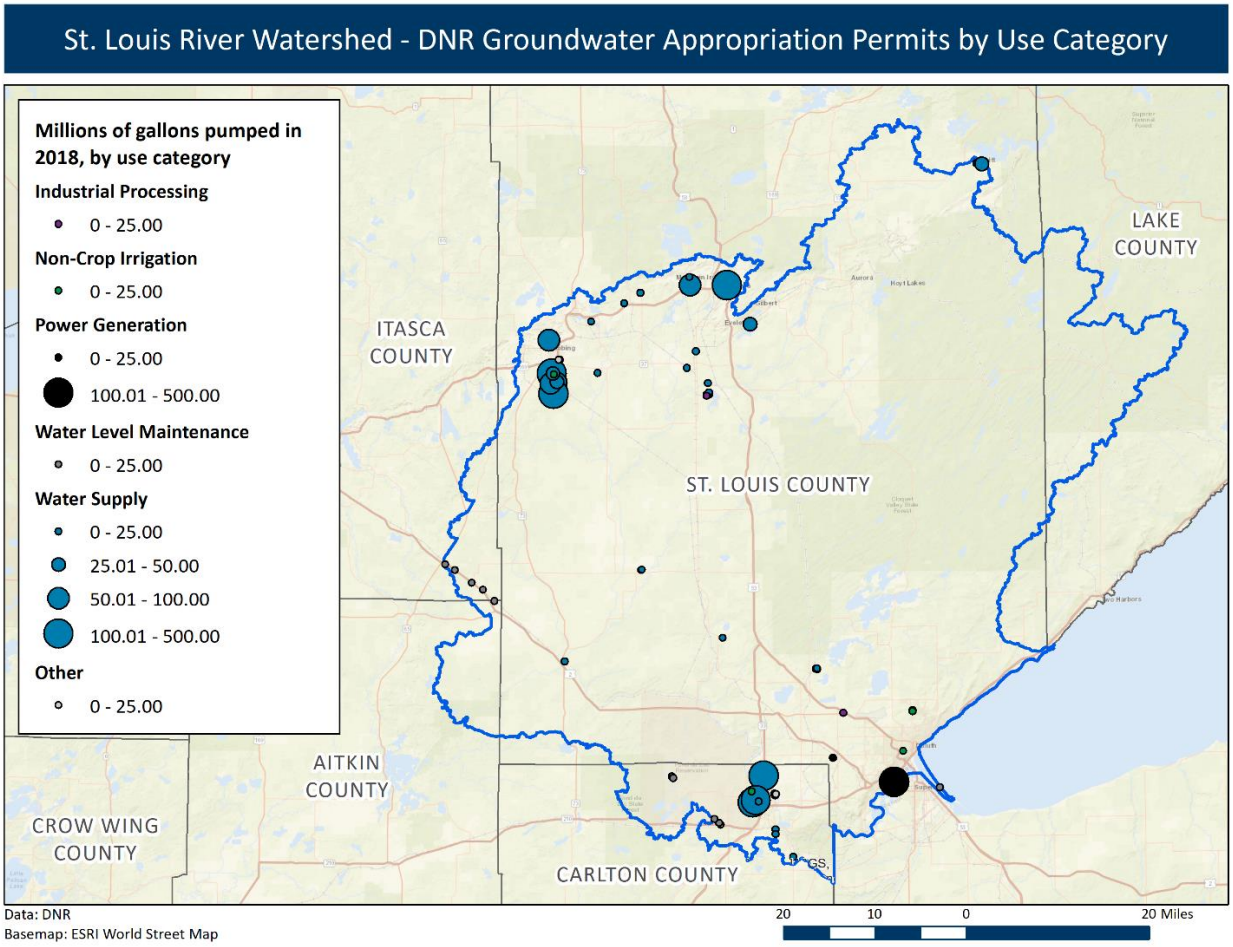

Figure 22: St. Louis River Watershed - Distribution of groundwater appropriation permits for 2018 by volume reported and use category. The largest water users in the watershed are Minnesota Power and the cities of Hibbing, Mountain Iron, Virginia, and Cloquet.

Groundwater Level Monitoring

The DNR maintains a statewide groundwater-level monitoring program for assessing groundwater resources, determining long-term trends, interpreting impacts of pumping and climate, planning for water conservation, evaluating water conflicts, and managing water resources.

There are 19 active groundwater-level monitoring wells in the planning area (Figure 24). Of these 19 wells, three wells in the watershed have been monitored since the 1950s.

Five wells had sufficient water-level data to calculate a long-term trend over the period 1990-2019 (Figure 25): two had downward trends, two had no trend, and one had an upward trend. The water level in both wells 69000 and 69055 in the northwest corner of the watershed are heavily influenced by changes in water levels in nearby mine pits. Thus, the overall trend for these two wells is not as meaningful as in other observation wells. Hydrographs from five wells are shown in Figures 28 through Figure 33.

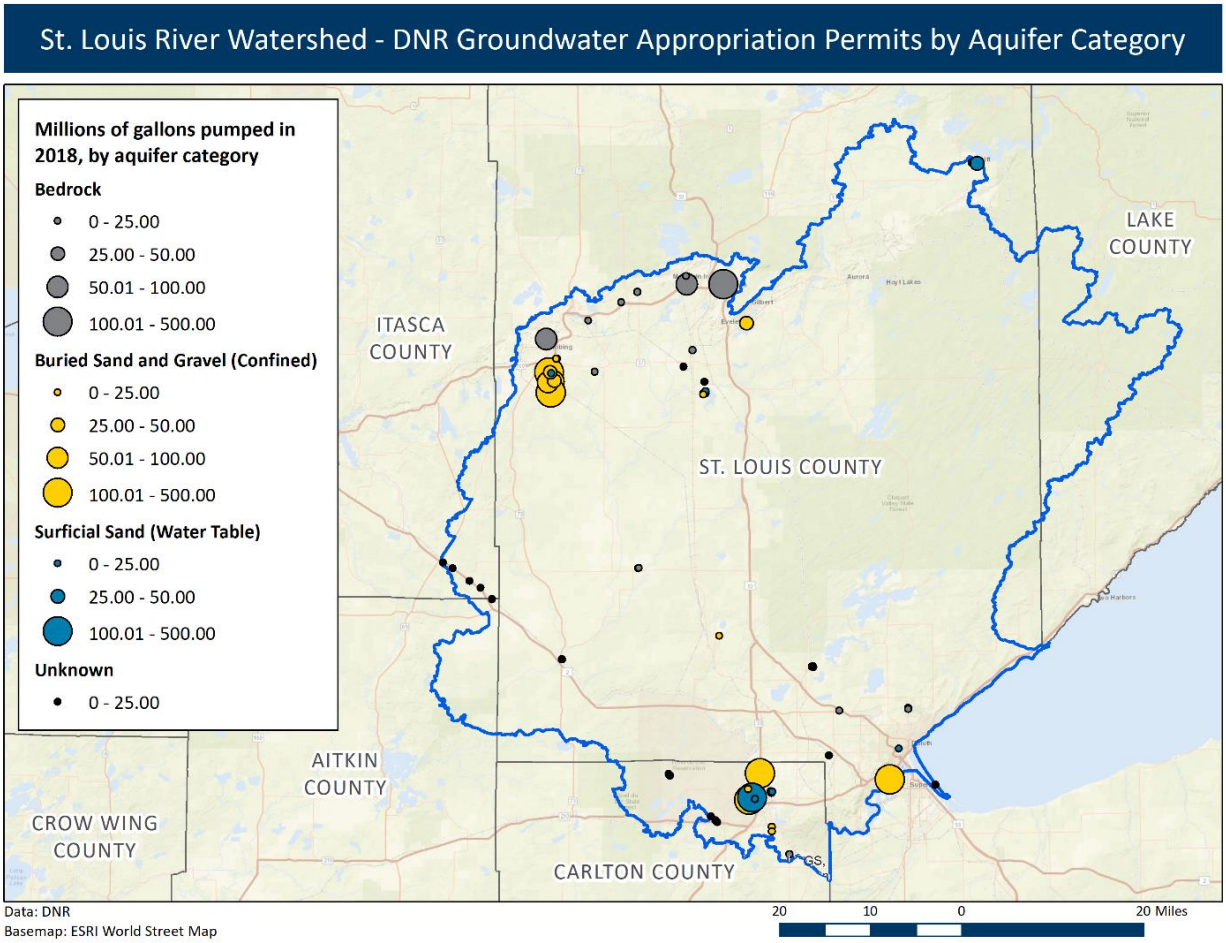

Figure 23: St. Louis River Watershed – Distribution of groundwater appropriation permits for 2018 by volume reported and aquifer category.

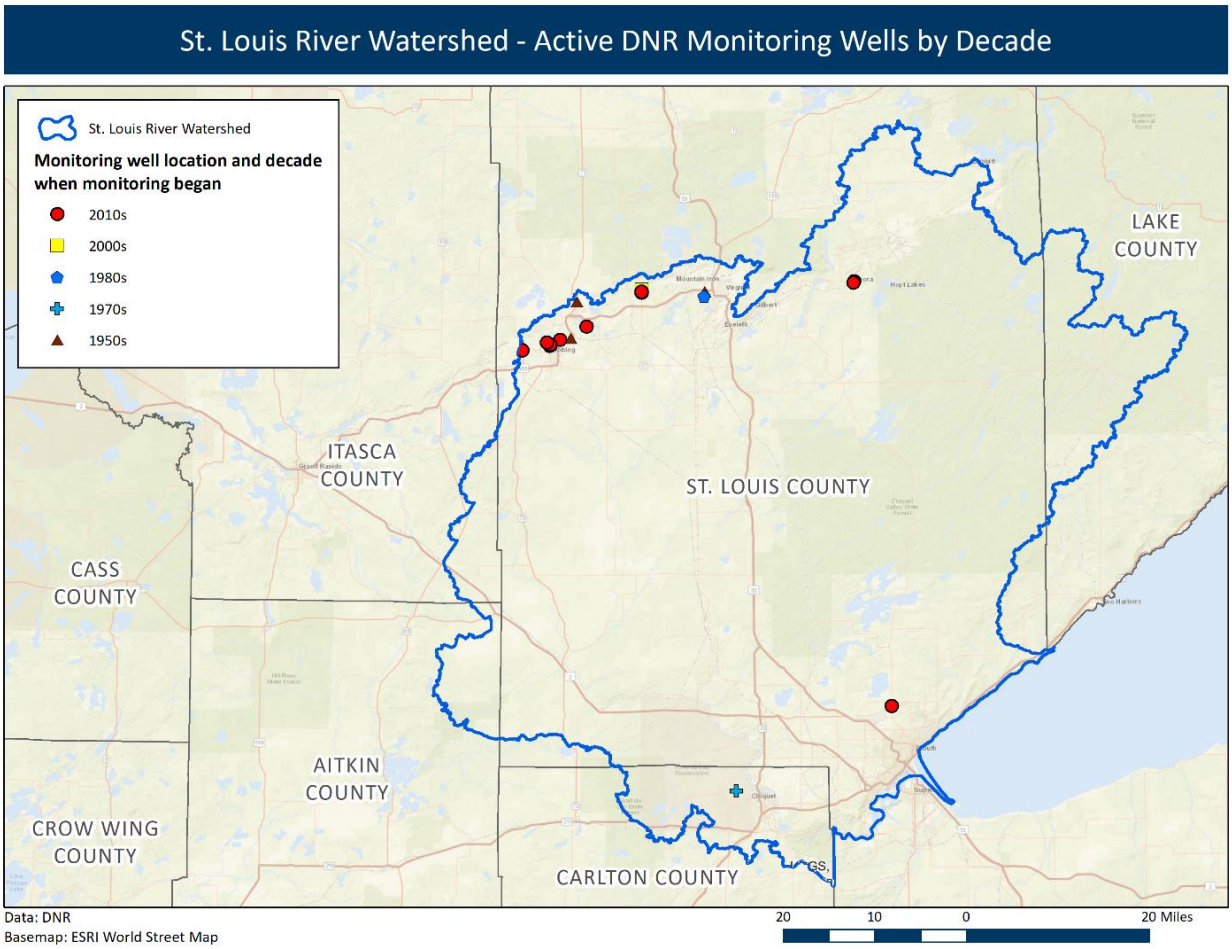

Figure 24: St. Louis River Watershed – Location of active groundwater-level monitoring wells in the St. Louis Watershed planning area by decade monitoring started. Three of the groundwater-level monitoring wells in the watershed have been monitored since the 1950s. One monitoring well was added in each of the following decades: 1970s, 1980s, and 2000s. Thirteen wells were added in the 2010s.

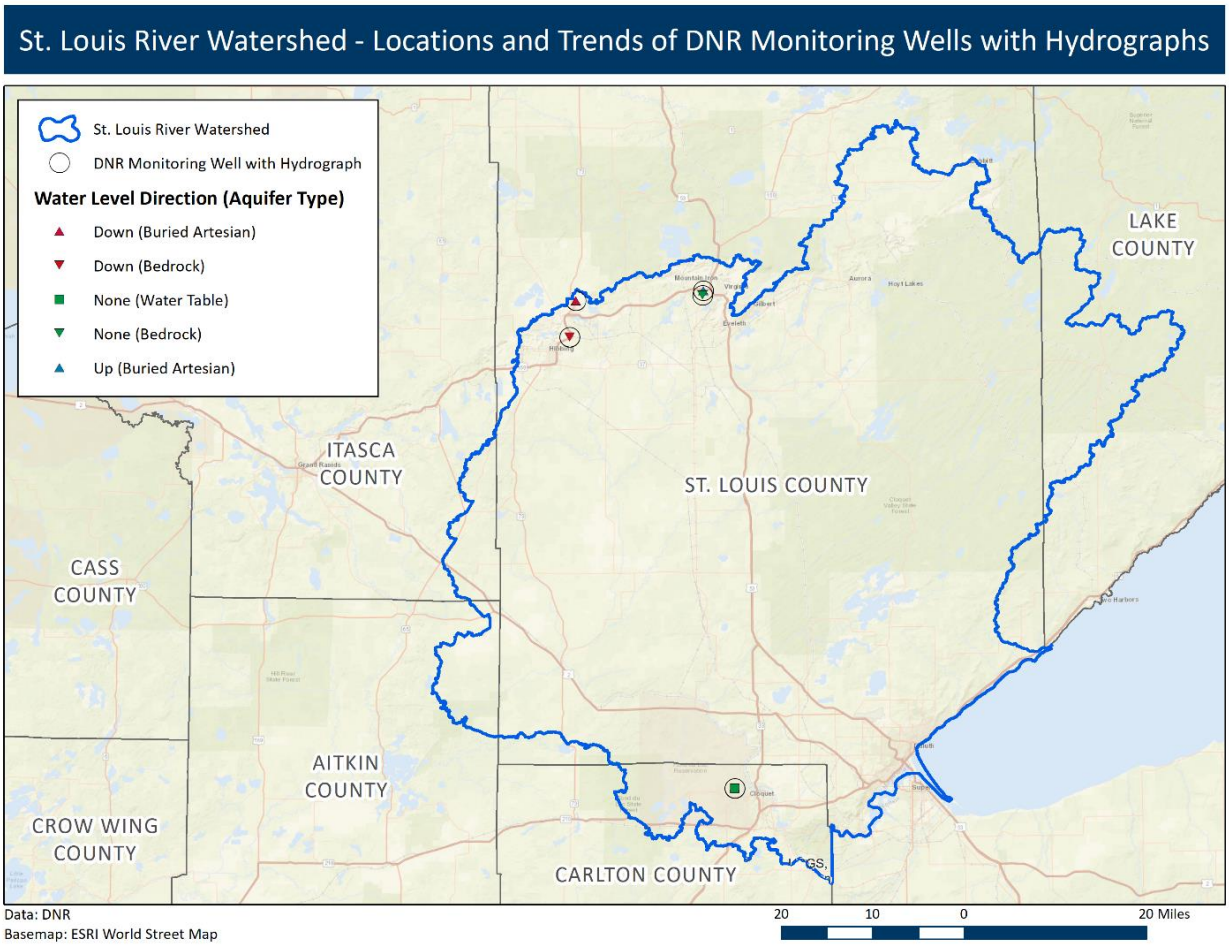

Figure 25: Location of active groundwater-level monitoring wells with enough data to calculate a statistical trend. Trends are calculated by the Mann-Kendall non-parametric statistical method. Location of wells with hydrographs are also shown. Five wells had sufficient water-level data to calculate a long-term trend over the period 1990-2019: two had downward trends, two had no trend, and one had an upward trend. The water level in both wells 69000 and 69055 in the northwest corner of the watershed are heavily influenced by changes in water levels in nearby mine pits. Thus, the overall trend for these two wells is not as meaningful as in other observation wells.

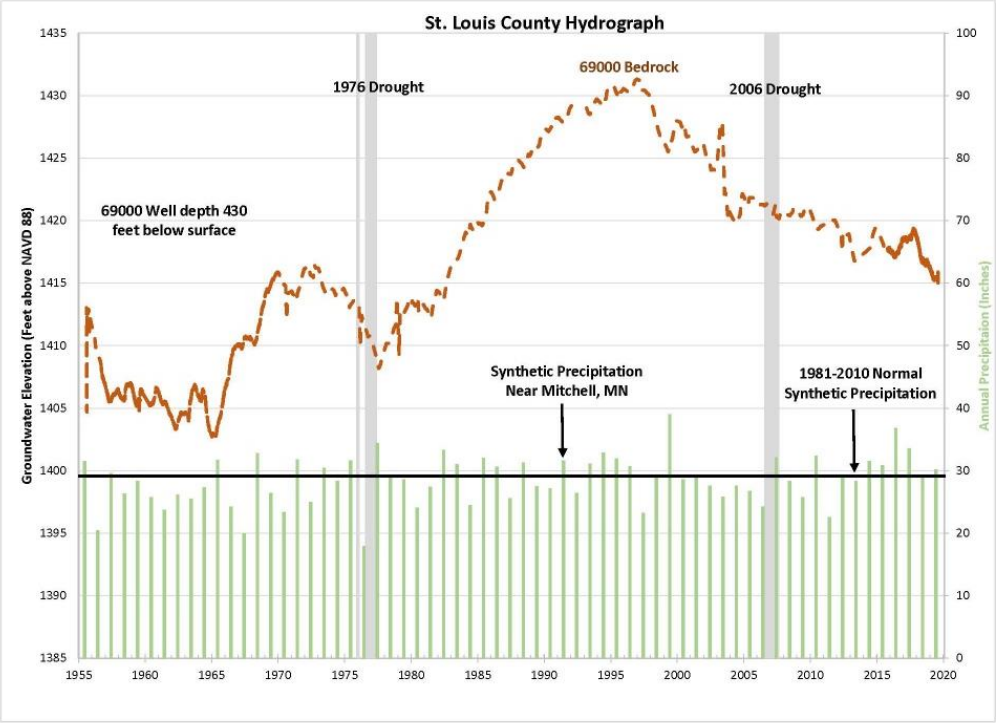

Figure 26: Hydrograph of well 69000 compared to precipitation. Water levels in this well are heavily influenced by water level changes in nearby mine pits. These trends are not due to variation in precipitation. The water level has a downward trend over the period 1990-2019.

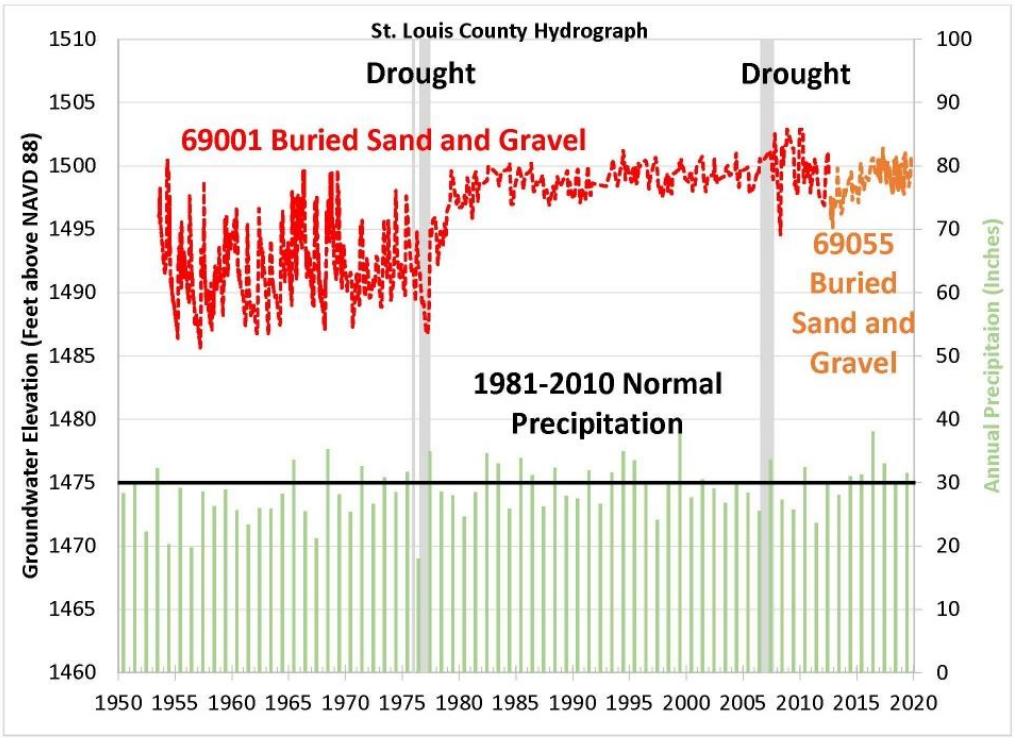

Figure 27: Hydrograph of well 69055 compared to precipitation. The water level has a long-term downward trend over the period 1990-2019 but was generally rising before that. The water level is heavily influenced by mining.

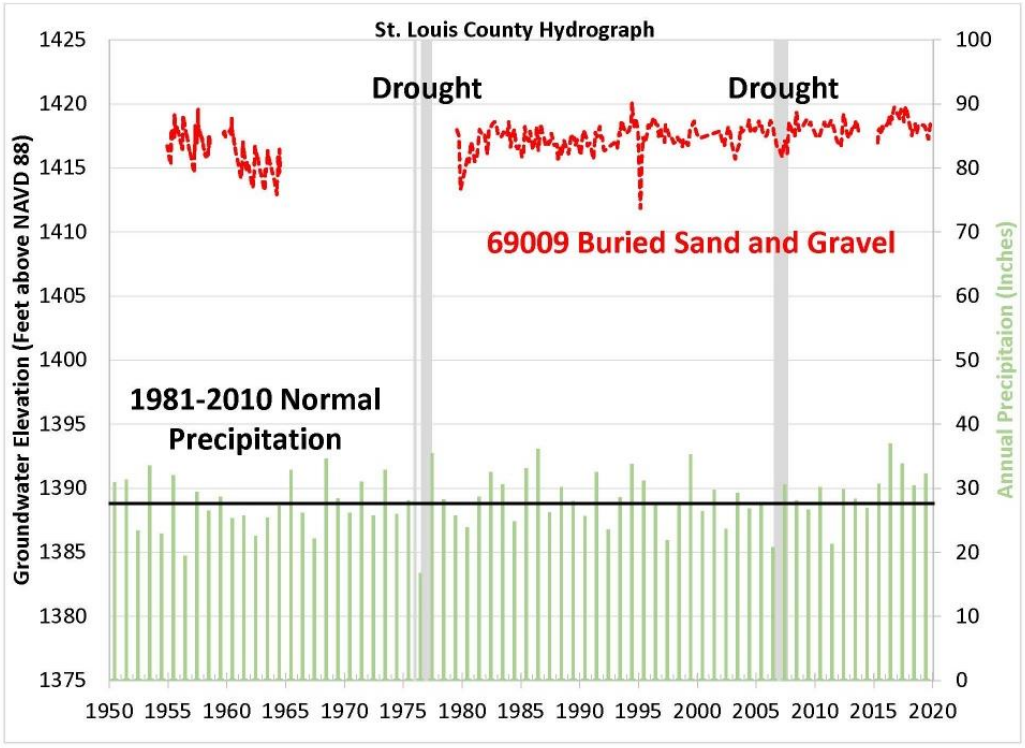

Figure 28: Hydrograph of well 69009 compared to precipitation. The water level has an upward trend over the period 1990-2019.

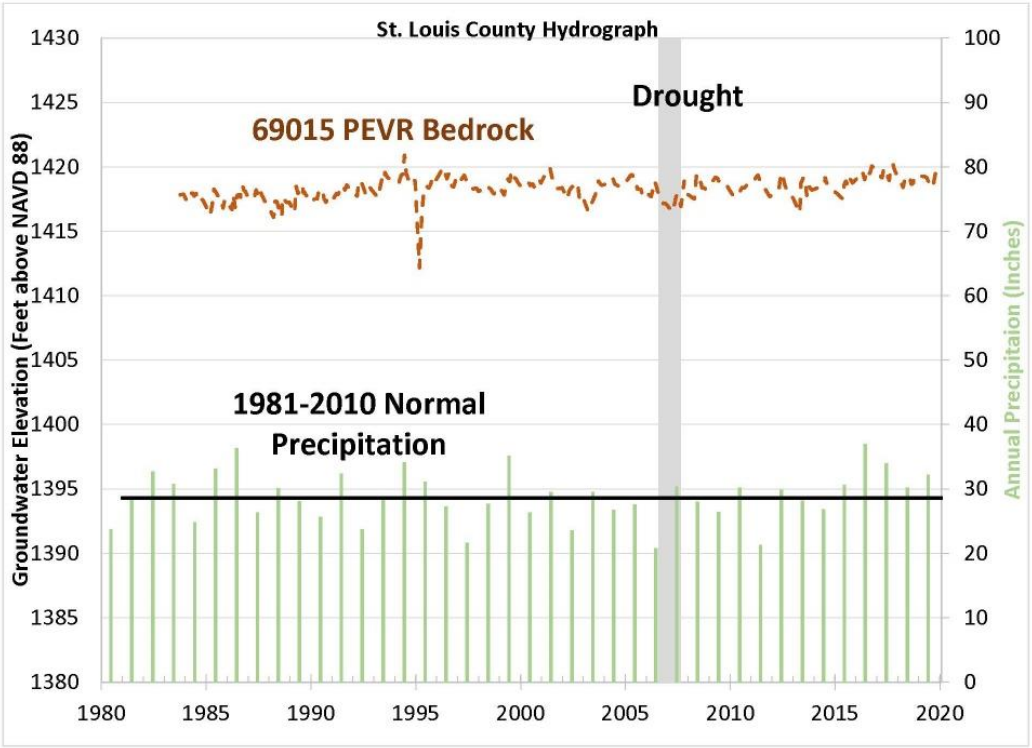

Figure 29: Hydrograph of well 69015 compared to precipitation. The water level has no trend over the period 1990-2019.

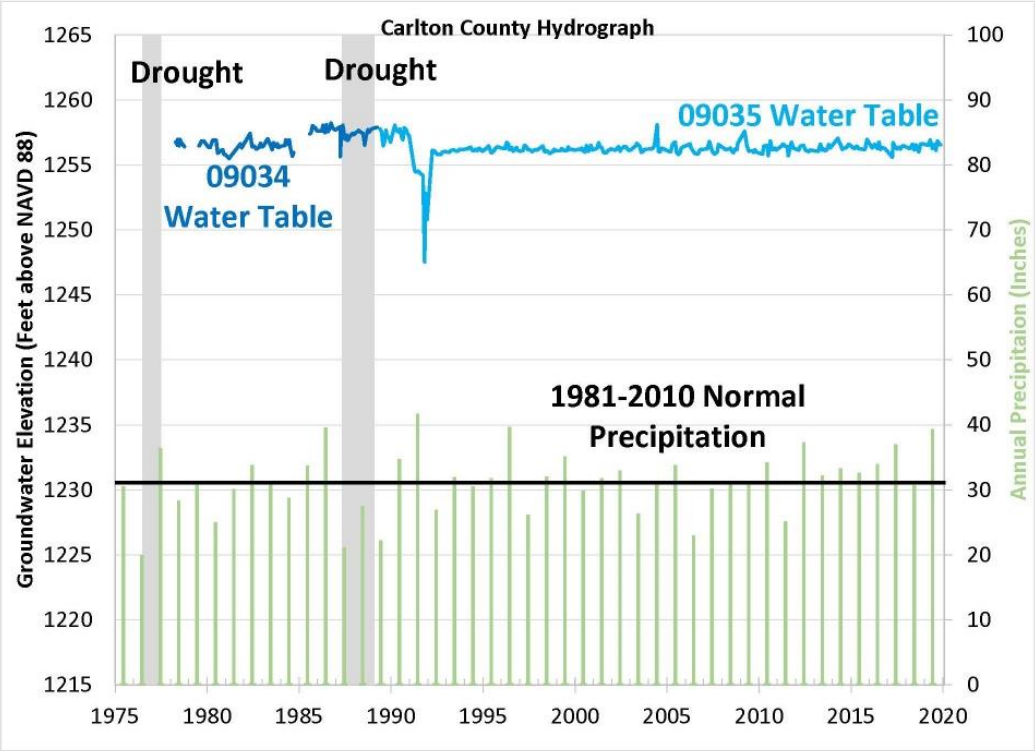

Figure 30: Hydrograph of well 09035 compared to precipitation. The water level has no trend over the period 1990-2019.

Groundwater Connected Natural Features at Risk

The SLRW planning area includes significant natural features, including surface waters that depend on groundwater to sustain them (Figure 31). 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. The following features occur within the SLRW:

- 109 designated trout streams
- Wetland complexes across the entire area
- Lakes that may be susceptible to changing aquifer levels
- Forty-nine distinct native plant communities connected to groundwater
- Thirty-five rare plant and animal species connected with groundwater that are listed as endangered, threatened or special concern, watch list, or 'Species in Greatest Conservation Need'
- Twenty-three colonial waterbird nesting areas

Rare Natural Features Connected with Groundwater in the St. Louis River Watershed

Rare natural features (

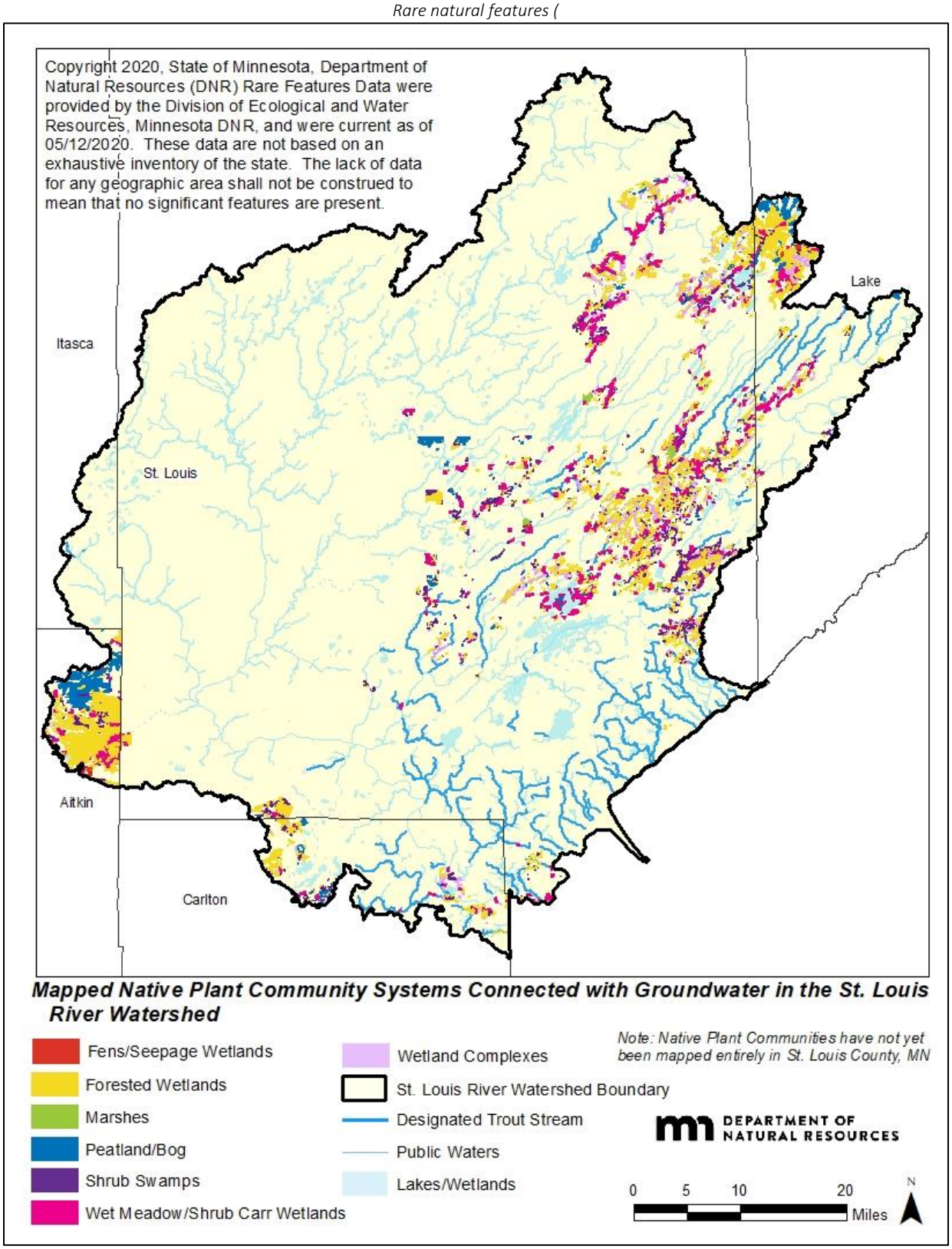

Figure 31Figure 31 through Figure 32) contribute to the health of the habitat and environment. Some even contribute directly to local economies in the form of recreation—including hunting/fishing, wildlife viewing, and camping. Rare natural features can include species of rare plants and animals as well as native plant communities (habitats). These resources are at risk if groundwater quantity or quality is disrupted.

There are 109 designated trout streams in the SLRW (Table 10). 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).

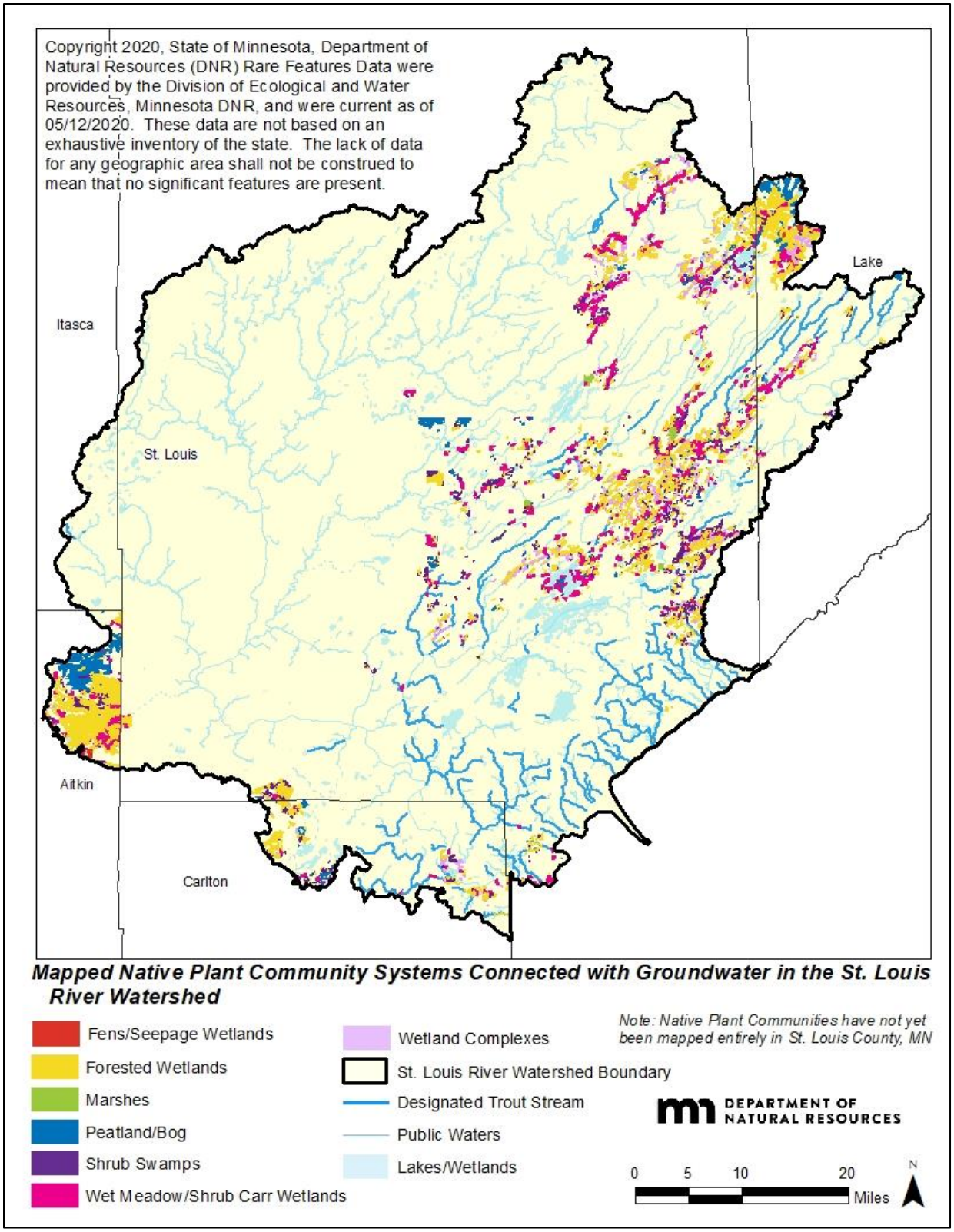

Figure 31: St. Louis River Watershed – Trout Streams, Public Waters, and Native Plant Community Systems Connected with Groundwater

There are 49 distinct native plant communities associated with or dependent on groundwater in the SLRW (Figure 31)

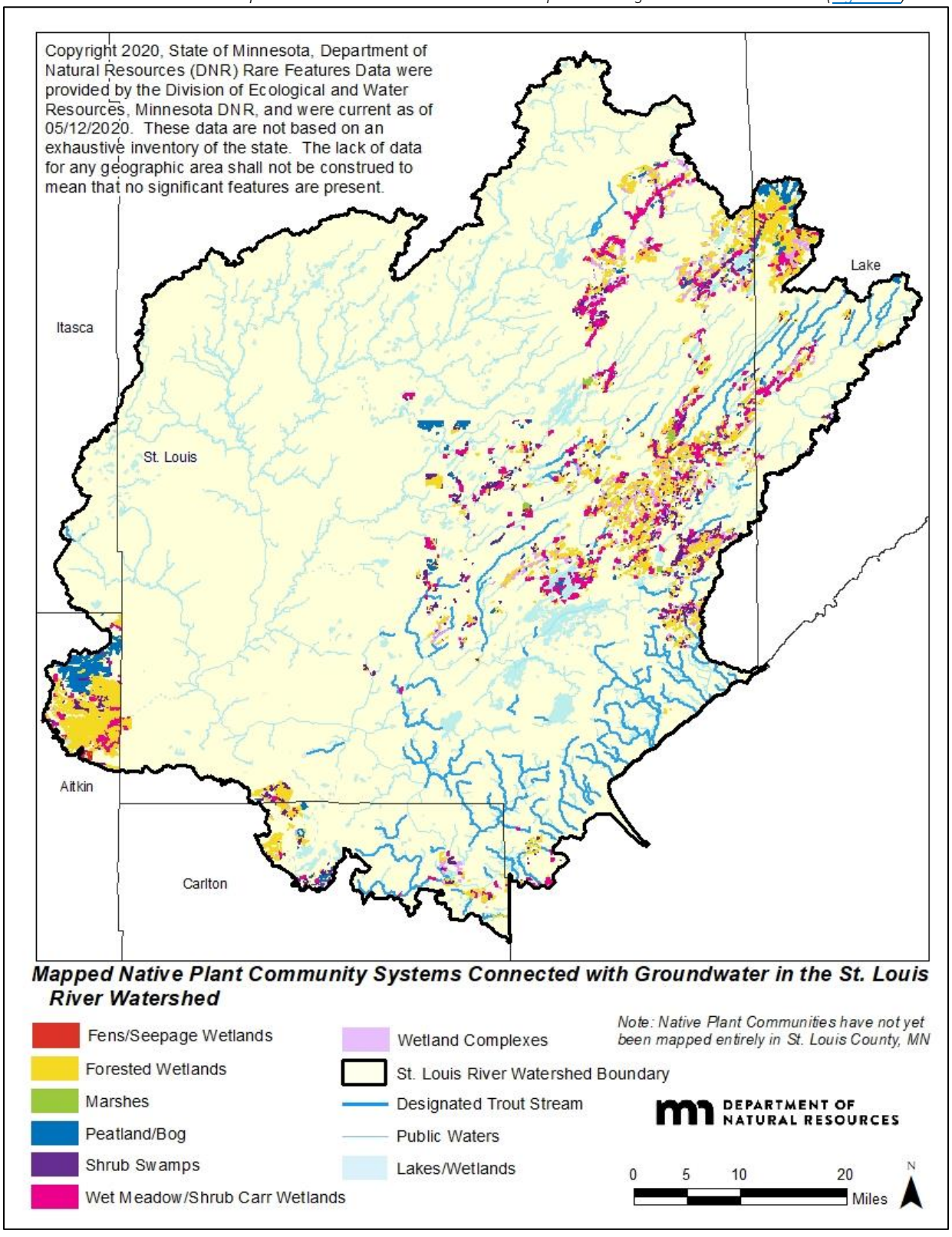

Figure 31. They range from forested communities such as floodplain forests, to open communities such as marshes and rich fens. Two of these native plant communities are considered critically imperiled or imperiled status, eight are considered vulnerable to extirpation status, and twenty are considered apparently secure or secure. To learn more about Conservation Status Ranks for Native Plant Community Types and Subtypes (http://files.dnr.state.mn.us/natural_resources/npc/s_ranks_npc_types_&_subtypes).

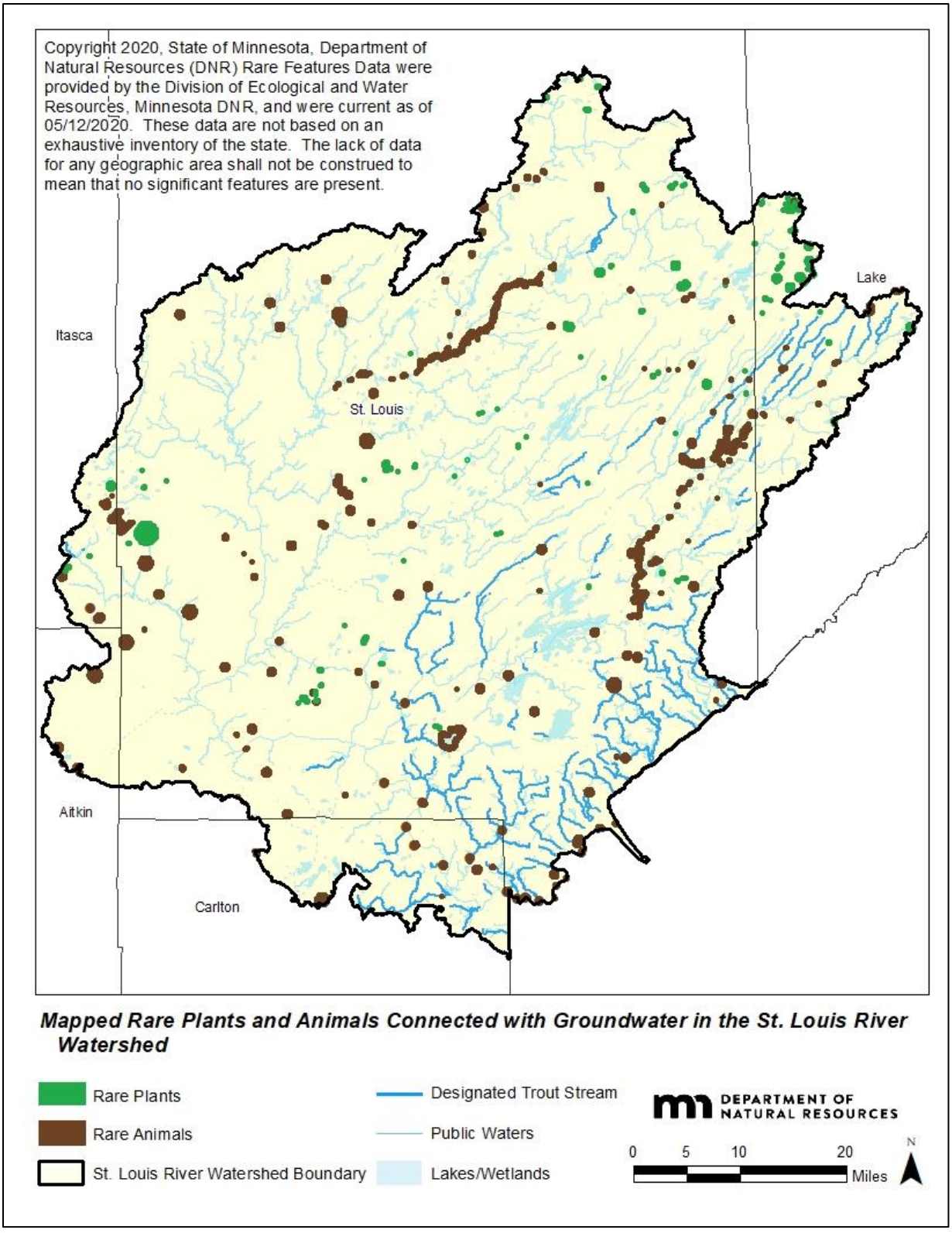

Figure 32: St. Louis River Watershed – Trout Streams, Public Waters, and Rare Plants and Animals Connected with Groundwater

There are 35 species of birds, fish, reptiles, amphibians, mussels and plants that are either endangered, threatened, special concern, watch list, or are a state listed “Species In Greatest Conservation Need”, that are dependent on habitats with groundwater or groundwater seepage areas in the SLRW (Figure 32). A detailed list of native plant communities and rare features is available in the Additional Resources section at the end of the report in Table 12 through Table 14.

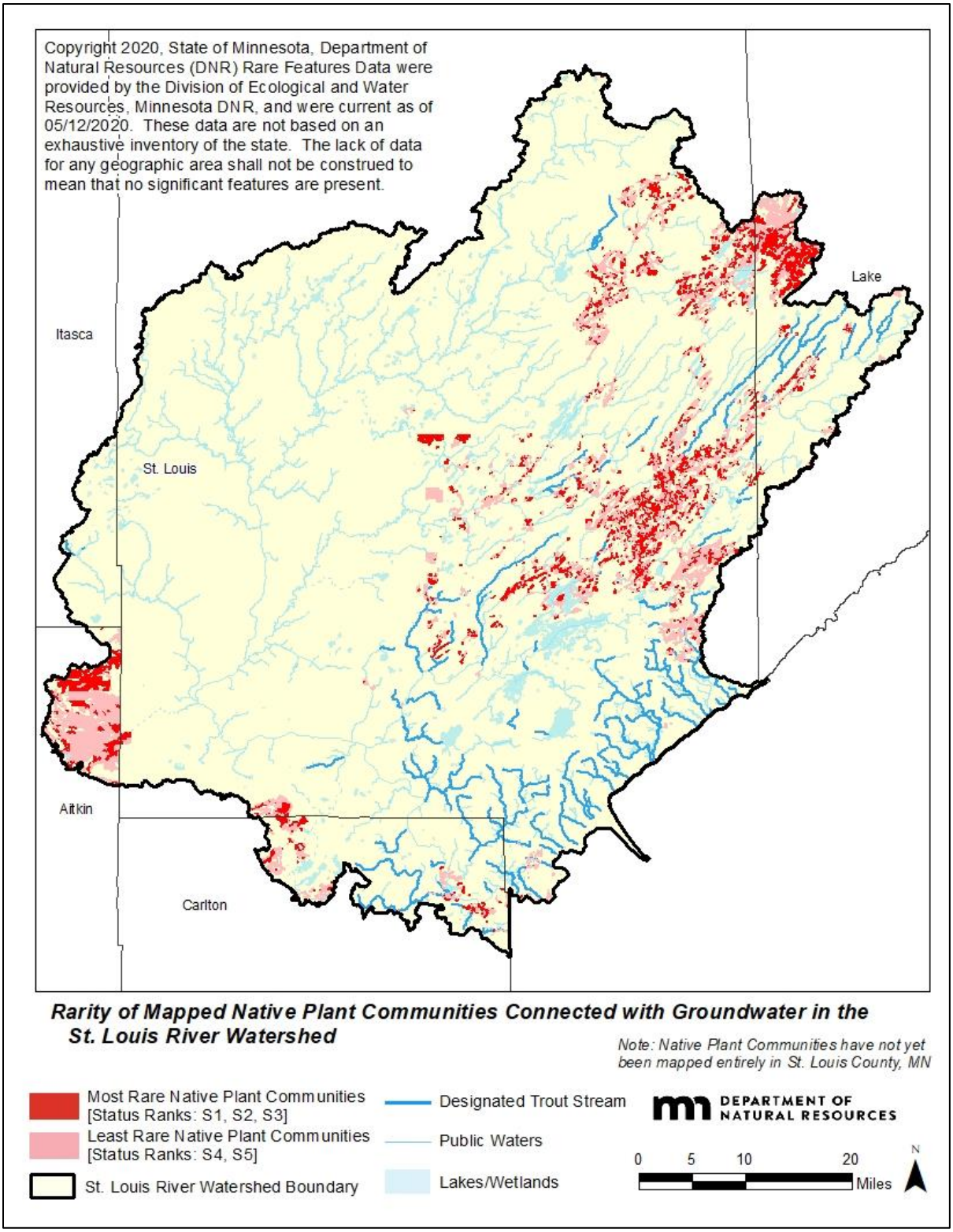

Figure 33: St. Louis River Watershed - Trout Streams, Public Waters, and Rarity of Native Plant Communities Connected with Groundwater. Native Plant Community S-ranks correspond to that community's rarity. S1=Critically Imperiled, S2= Imperiled, S3=Vulnerable to Extirpation, S4=apparently secure; uncommon but not rare, S5=Secure, common, widespread, and abundant.

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 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 34). There are 170 groundwater-flow dominated lakes in the SLRW. Large-scale groundwater pumping near a lake will likely have more impact to groundwater-flow dominated lakes than to surface water-flow dominated lakes.

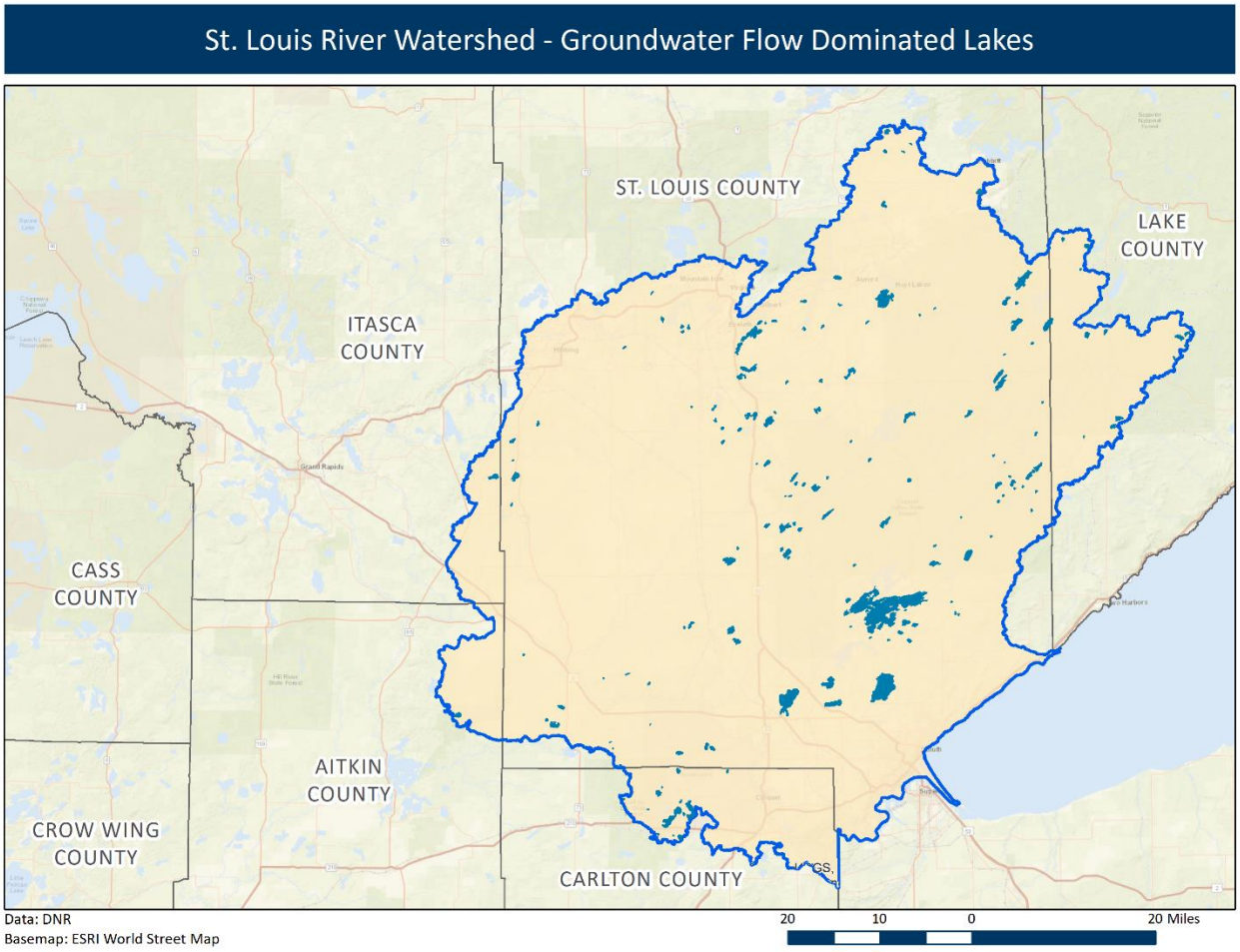

Figure 34: Groundwater-Flow Dominated Lakes in the St. Louis River Watershed. There are 170 groundwater-flow dominated lakes in the planning area.

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 9) provides a more comprehensive list of specific actions the SLRW can take to conserve water and promote recharge.

St. Louis 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 9) 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 9) 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 5). 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 9) 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 SLRW 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 9) 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 measurable 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 the St. Louis River Watershed

This section provides a table of strategies and actions local partners in the SLRW 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 35 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.

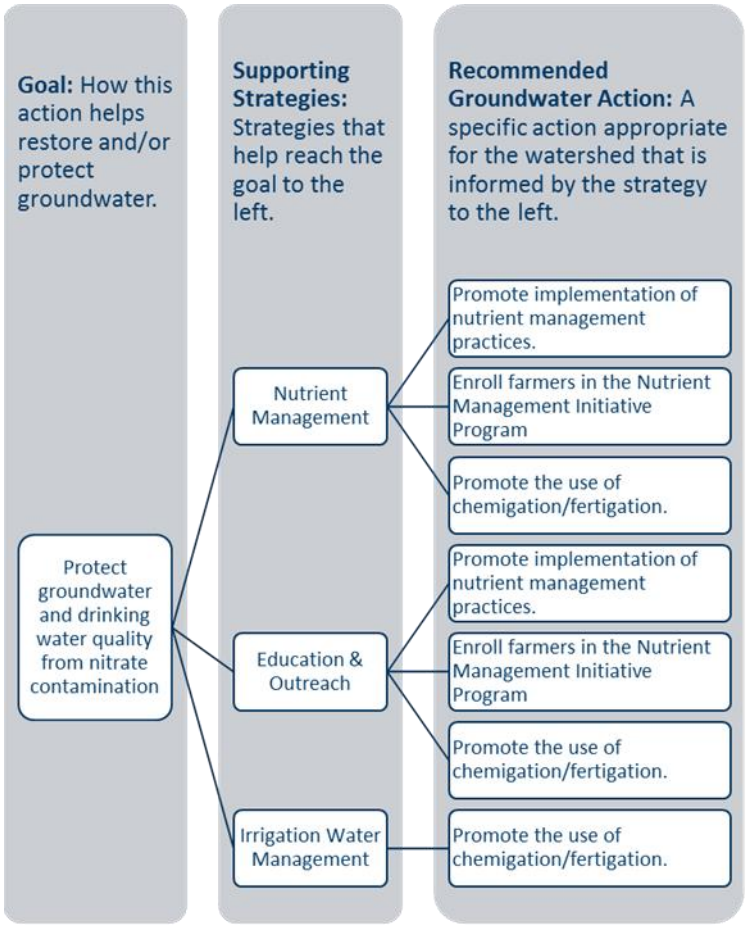

Figure 35: Visual representation of the relationship between goals, supporting strategies, and recommended groundwater action.

How to Use the Table of Actions and Strategies

The Table of Actions and Strategies (Table 9) 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 9 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 can 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-10s Involved**: This column denotes which HUC-10 subwatershed(s) within the SLRW to consider using the action described in the corresponding row. There are 19 HUC-10s within the watershed. Table 8 provides the name and the HUC-10 number assigned to each major watershed. Figure 2 is a map of the HUC-10s.
- **Agencies that can assist[12]:** 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.

[12] 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*)

- **Benefit:_____**[13]**:** 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 8: HUC 10 subwatersheds within the St. Louis River Watershed

HUC-10 Name	Reference Name in Implementation Table	HUC-10 Number
Artichoke River-St. Louis River	Artichoke	0401020113
Boulder Lake Reservoir	Boulder Lake	0401020203
City of Duluth-Frontal Lake Superior	Duluth	0401010204
Cloquet River	Cloquet	0401020206
East Savanna River	East Savanna	0401020111
Embarrass River	Embarrass	0401020103
Fish Lake Reservoir	Fish Lake	0401020205
Floodwood River	Floodwood	0401020110
Headwaters Cloquet River	Headwaters Cloquet	0401020201
Headwaters St. Louis River	Headwaters St. Louis	0401020102
Island Lake Reservoir-Cloquet River	Island Lake	0401020204
Lower Whiteface River	Lower Whiteface	0401020109
Midway River	Midway	0401020114
Mud Hen Creek	Mud Hen	0401020104
Partridge River	Partridge	0401020101
Sand Creek St. Louis River	Sand Creek	0401020107
St. Louis River	St. Louis	0401020116
Stoney Brook	Stoney Brook	0401020112
Swan River	Swan	0401020106
Thompson Reservoir-St. Louis River	Thompson	0401020115
Upper Whiteface River	Upper Whiteface	0401020108
West Branch Cloquet River	West Branch	0401020202
West Two River	West Two	0401020105

Summary of Key Findings and Issues

Below is a summary of key groundwater quality and quantity findings found in the SLRW. 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 the 7,470 tested drinking water wells sampled by MDH had levels at or above the SDWA standard of 10 mg/L.
- There are no MDA ambient monitoring wells in the watershed.
- MPCA has five ambient monitoring wells with all samples for nitrate well below the SDWA standard.

[13] 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*).

- **Arsenic** – nearly three percent of the 1,731 tested wells had levels exceeding the SDWA standard of 10 µg/L. 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.
- **Pesticides –** there are no MDA ambient monitoring wells in the watershed.
- **DWSMAs** cover over 53,000 acres in the watershed. Fifteen of the 21 community public water suppliers are engaged in the wellhead protection planning process or are implementing their plans. Of the 15 systems with approved plans, the vulnerability varies across the watershed from low to very high. Thirteen of the approved wellhead protection plans exhibit a high vulnerability in all or part of their DWSMA and is considered vulnerable to contamination from the land surface, with all others exhibiting moderate or low vulnerability.
  - Four of the PWS have conjunctive delineations (Buhl, Hibbing (Scranton well field), Mountain Iron, and Tower-Breitung Waste Water Board) and are influenced by contaminants that soak into the ground as well as those contaminants most likely to runoff during rainfall and snowmelt events.
- Approximately 76 percent of the people living in the watershed get their drinking water from a community public water supply system. It is important to note that the City of Duluth and a few smaller communities use surface water, not groundwater, for their drinking water supply.
- **Private wells** – there are 12,441 private drinking water wells with known locations ranging from 2 ft. to 1,042 ft. deep with an average depth of 131 ft. Over 31 percent (3,927 wells) of private wells are in a highly vulnerable setting.
- **Flood events** can threaten the safety and availability of drinking water by washing pathogens and chemical contamination into source aquifers. St. Louis County has the greatest number of wells at risk within the 100 year flood zone.
- **Animal feedlots – t**here are 44 active feedlots in the watershed with the greatest concentration in St. Louis County. There are no delegated counties in the SLRW, all relying on the MPCA to administer the feedlot rule.
- **Row crop agriculture** is not notable in the watershed. In areas with high pollution sensitivity, agricultural inputs can contaminate the underlying aquifer.
- **SSTS** are found throughout the watershed. Information reported by counties indicate Carlton and St. Louis County has the highest number of failing SSTS at two to three per 1,000 acres.
- **Contaminated sites –** there are 975 active tank sites that could leak chemicals into the environment and 46 leak sites that may cause localized groundwater pollution if not properly managed. The risk to groundwater is greatest in areas of high pollution sensitivity.
- Ten closed landfills with a known groundwater contamination plume are found within the watershed.

Key Groundwater Quantity Findings and Issues

- In 2018, approximately 85 percent of permitted water use was for water supply, approximately five percent was used for industrial processing, 4 percent for non-crop irrigation, and the remainder spread among other use categories. Approximately 47 percent of permitted groundwater was sourced from the buried sand aquifer and 41 percent from bedrock aquifers.
- Five DNR observation wells with enough water-level measurements to calculate a statistical trend. One well had an upward trend, two wells had a downward trend and two wells had no trend in water levels.
- SLRW has 109 designated trout streams.
- There are 170 lakes in the SLRW with a watershed to lake ratio of 10 or less and are considered groundwater-flow dominated lakes, susceptible to changing aquifer levels.

- Wetland complexes across the entire watershed are susceptible to changing aquifer levels.
- Forty-nine distinct native plant communities connected to groundwater. In addition, 35 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 9: Actions and Strategies to Restore and Protect Groundwater

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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 14)* *Drinking Water Wells Map (Figure 11)*						
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, including bedrock at or near surface, and/or where there are known groundwater contaminants. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *Arsenic Map (Figure 14)* *Drinking Water Wells Map (Figure 11)* *Nitrate Map (Figure 13)*						

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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: 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 14)*						
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 11)* *DWSMA Map (Figure 10)*						
Protect Groundwater and Drinking Water Quality: Well Inventory	Land Use Planning and Management	To understand water quality trends, establish a well inventory to record baseline data or changes in groundwater quality. An example of a successful model is the Southeast MN Domestic Well Network.	X	X	X	X	X	All	MDH Well MGMT	*N/A*						
Protect Groundwater and Drinking Water Quality: Closed Landfills	Contaminant Planning and Management	▪ Identify MPCA closed landfill locations and groundwater areas of concern in comprehensive land use plans, zoning maps and ordinances. Identifying the location will help assure drinking water and public		X			X	Artichoke Embarrass Fish Lake Lower Whiteface	MPCA CLP Land Manager	*Closed Landfill Map (Figure 18)*						

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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	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.						Partridge Sand Creek Swan Thompson West Two								
Protect Groundwater and Drinking Water Quality: Leaky Tanks	Contaminant 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		X			X	Artichoke Boulder Lake Cloquet Duluth	MPCA Tanks Program	Focus in areas with high pollution sensitivity, including bedrock at or near surface, and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5)*						

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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	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.						Embarrass Fish Lake Headwaters Cloquet Headwaters St. Louis Island Lake Lower Whiteface Midway Mud Hen Partridge Sand Creek St. Louis Swam West Two		*Pollution Sensitivity Wells (Figure 7)* *DWSMA Map (Figure 10)* *Tank & Leak Site Map (Figure 17)*						
Protect Groundwater and Drinking Water Quality: Feedlots	Contaminant Planning and Management	Prioritize feedlot inspections, regardless of size, in areas of greatest risk to pollution, to minimize the loss of nitrate and harmful bacteria.		X			X	Headwaters St. Louis Thompson	MPCA Feedlot Program	*Focus in areas with high pollution sensitivity*, including bedrock at or near surface, *and highly vulnerable DWSMAs.* *Pollution Sensitivity Map (Figure 5)*						X

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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*
										Pollution Sensitivity Wells (Figure 7) *DWSMA Map (Figure 10)* *Active Feedlots (Figure 16)*						
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. ▪ Evaluate local ordinances and revise to include manure timing guidelines to protect from nitrate loss. Follow the UMN Extension guidelines, including no summer application and fall application only after soil temperature is below 50 degrees.		X			X	Headwaters Thompson	MPCA Feedlot Program	Focus in areas with high pollutions sensitivity, including bedrock at or near surface, and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *DWSMA Map (Figure 10)* *Active Feedlot Map (Figure 16)*			X	X		X
Protect Groundwater and Drinking Water Quality: Manure Management	Education and Outreach Nutrient Management	Promote actions to prepare for field application of manure: ▪ Inspect equipment to ensure everything is functioning properly to avoid leaks or spills		X			X	Headwaters St. Louis Thompson	MPCA Feedlot Program	Focus in areas with high pollution sensitivity, including bedrock at or near surface, and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5)*			X	X		X

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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*
	Contaminant Planning and Management	▪ Get manure sampled and analyzed for nutrient availability ▪ Plan applications for each field ▪ Determine any setbacks needed in fields and mark locations of sensitive features to avoid ▪ Use the Minnesota Runoff Risk Advisory Forecast system tool to determine the best time to apply manure. ▪ Put together an emergency action plan that identifies leak and spill containment								*Pollution Sensitivity Wells (Figure 7)* *DWSMA Map (Figure 10)* *Active Feedlot Map (Figure 16)*						
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) ▪ Adopt and use of the UMN 'Best Management Practices for Nitrogen use in Minnesota ▪ Properly credit nitrogen sources (soil/manure tests, past crops, & mineralization)		X	X		X	Artichoke Cloquet Duluth Fish Lake Floodwood Midway Sand Creek Swan Thompson West Two	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, including bedrock at or near surface, and highly vulnerable DWMSAs. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *DWSMA Map (Figure 10)*						X

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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*
		▪ 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														
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	Artichoke Cloquet Duluth Fish Lake Floodwood Midway Sand Creek Swan Thompson West Two	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, including bedrock at or near surface, and highly vulnerable DWMSAs. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *DWSMA Map (Figure 10)*						X
Protect Groundwater and Drinking Water Quality: Nitrate	Nutrient 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.		X	X		X	Artichoke Cloquet Duluth	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, including bedrock at or near surface, and highly vulnerable DWMSAs.	X		X		X	X

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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*
	Education and Outreach Cropland Management	Cover Crops, Alternative Crops, Precision Ag / New Technologies, Nutrient Management Initiative, etc.)						Fish Lake Floodwood Midway Sand Creek Swan Thompson West Two		*Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *DWSMA Map (Figure 10)*						
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	Artichoke Cloquet Duluth Fish Lake Floodwood Midway Sand Creek Swan Thompson West Two	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, including bedrock at or near surface, irrigated row crops, and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *DWSMA Map (Figure 10)* *Drinking Water Wells Map (Figure 11)*	X		X	X	X	X
Protect Groundwater	Education and Outreach	Promote the benefits of farming using soil health principles that increase soil moisture		X	X		X	Artichoke	NRCS Field Office	Focus on areas with high pollution sensitivity, including bedrock at or			X	X	X	X

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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*
and Drinking Water Quality: Nitrate **Groundwater Sustainability: Water Conservation**	Nutrient Management Cropland Management	holding capacity, organic matter, and nutrient cycling.						Cloquet Duluth Fish Lake Floodwood Midway Sand Creek Swan Thompson West Two		near surface, and highly vulnerable DWMSAs. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *DWSMA Map (Figure 10)* *Nitrate in Wells Maps (Figure 13)*						
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	Artichoke Cloquet Duluth Fish Lake Floodwood Midway Sand Creek Swan Thompson West Two	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, including bedrock at or near surface, and highly vulnerable DWMSAs. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *DWSMA Map (Figure 10)* *Nitrate in Wells Maps (Figure 13)*						

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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	Artichoke Cloquet Duluth Fish Lake Floodwood Midway Sand Creek Swan Thompson West Two	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity and highly vulnerable DWMSAs. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *DWSMA Map (Figure 10)* *Nitrate in Wells Maps (Figure 13)*		X	X	X	X	X
Protect Groundwater and Drinking Water Quality: Nitrate **Protect Groundwater and Drinking Water Quality: Pesticides** **Groundwater Sustainability:**	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	Duluth Sand Creek Swan Thompson	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 5)* *Pollution Sensitivity Wells (Figure 7)* *DWSMA Map (Figure 10)*			X	X	X	X

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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 Conservation																
Protect Groundwater and Drinking Water Quality: Pesticides	Education and Outreach Integrated Pest Management	Promote the adoption and use of MDA's water quality BMPs for agricultural pesticides and insecticides.		X	X		X	Artichoke Cloquet Duluth Fish Lake Floodwood Midway Sand Creek Swan Thompson West Two	MDA Pesticide & Fertilizer Division	Focus in areas of pesticide detection in MDA's monitoring wells, along with areas of high pollution sensitivity, and highly vulnerable DWMSAs. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *DWSMA Map (Figure 10)*						X
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	Artichoke Cloquet Duluth Fish Lake Floodwood Midway Sand Creek	MDA Pesticide & Fertilizer Division	Focus in areas of pesticide detection in MDA's monitoring wells, along with areas of high pollution sensitivity and highly vulnerable DWMSAs. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *DWSMA Map (Figure 10)*						

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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*
								Swan Thompson West Two								
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, including bedrock at or near surface, 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 14)* *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *DWSMA Map (Figure 10)*						
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	X	X	X	X	X	All	MPCA SSTS Field Staff	Focus in areas with high pollution sensitivity, including bedrock at or near surface, highly vulnerable DWSMAs, and areas with a density of SSTS. You can use the Well Density						

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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*
		▪ Risks to human health and the environment ▪ Financial options to repair or replace failing or non-compliant system								Map as an imperfect surrogate for SSTS density. *Drinking Water Wells Map (Figure 14)* *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *DWSMA Map (Figure 10)*						
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	Focus in areas with high pollution sensitivity, including bedrock at or near surface, 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 14)* *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *DWSMA Map (Figure 10)*						
Protect Groundwater and Drinking Water Quality: Wellhead	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	Artichoke Embarrass Floodwood Midway	MDH SWP Unit	*Wellhead Protection Plan Development Status (Figure 9)* *DWSMA Map (Figure 10)*						

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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*
Protection (WHP)	Land Use Planning and Management							Lower Whiteface Sand Creek Swan Thompson West Two								
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	Artichoke Embarrass Floodwood Midway Lower Whiteface Sand Creek Swan Thompson West Two	MDH SWP Unit	*DWSMA Map (Figure 10)*						
Protect Groundwater and Drinking Water: Household	Education and Outreach	▪ Educate the public about the risks of improperly disposing of HHW and promote community-supported collection sites.	X	X	X	X	X	All	MPCA Hazardous Waste Program	Focus on areas with high pollution sensitivity, including bedrock at or near surface, and highly vulnerable DWMSAs						

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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*
Hazardous Waste (HHW)	Land Use Planning and Management	▪ 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.								*Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *DWSMA Map (Figure 10)*						
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	Focus on areas with high pollution sensitivity, including bedrock at or near surface, and highly vulnerable DWMSAs *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *DWSMA Map (Figure 10)*						
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/guidan	X	X	X	X	X	All	MDH CEC Program	Focus on areas with high pollution sensitivity, including bedrock at or near surface, and highly vulnerable DWMSAs *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)*						

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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*
		ce/dwec/outreachproj.html) for opportunities.								*DWSMA Map (Figure 10)*						
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, including bedrock at or near surface. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)*						
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	N/A						
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 features from future land use	X	X	X	X	X	All	MN Assoc. of Counties	Focus in areas with high pollution sensitivity, including bedrock at or near surface, highly vulnerable		X				

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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		impacts for their long-term sustainability and use.								DWSMAs and groundwater connected natural features *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *DWSMA Map (Figure 10)* *GWC Plants, Animals, Native Plant Communities Map (Figure 32)* *Mapped Native Plant Communities (Figure 33)*						
Protect Groundwater and Drinking Water Quality **Water Sustainability**	Land Use Planning and Management	Incorporate basic groundwater and drinking water information into local comprehensive plans and ordinances including: ▪ Local geology and aquifer information ▪ The sources of drinking water and the pollution sensitivity of public and private wells ▪ Maps of state approved WHP areas ▪ Groundwater dependent natural features ▪ Contaminant areas of concern ▪ Other local information needed to consider and protect groundwater	X	X	X	X	X	All	MDH SWP Unit	*Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *DWSMA Map (Figure 10)* *GWC Plants, Animals, Native Plant Communities Map (Figure 32)* *Mapped Native Plant Communities (Figure 33)* *Tank & Leak Site Map (Figure 24)*						

Goal	Supporting Strategy	Recommended Groundwater Actions	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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*
		and drinking water resources in local land use planning decisions														
Protect Groundwater and Drinking Water Quality	Land Use Planning and Management	Conduct a survey of property owners within the flood plain to identify unused/unsealed wells. Seal those wells identified to prevent contamination of the aquifer.	X	X	X	X	X	All	MDH Well MGMT	Prioritize areas of greatest risk to flooding: *Drinking Water Wells and Flood Risk (Figure 12)*						
Protect Groundwater and Drinking Water Quality	Land Use Planning and Management	Request flooded well test kits from MDH Well Management to distribute to private well owners after a flood event.	X	X	X	X	X	All	MDH Well MGMT	*Prioritize areas impacted by recent flooding that may be at risk to contamination:* *Drinking Water Wells and Flood Risk (Figure 12)*						
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, and RIM Reserve for wellhead protection.	X	X	X	X	X	All	BWSR	Prioritize areas of high pollution sensitivity, including bedrock at or near surface, and highly vulnerable DWSMAs. Target areas of high water use, known groundwater connected natural features. Examine areas where you can expand on existing easements and protected lands to increase protections. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)*	X	X	X	X	X	X

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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 10) *Monitoring Wells/Pumping (Figure 24)* *GWC Plants, Animals, Native Plant Communities Map (Figure 32)* *Mapped Native Plant Communities (Figure 33)* *RIM Easements Map (Figure 36)*						
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, including bedrock at or near surface, and highly vulnerable DWSMAs. *RIM Easements Map (Figure 36)* *GWC Plants, Animals, Native Plant Communities Map (Figure 32)* *Mapped Native Plant Communities (Figure 33)* *Pollution Sensitivity Map (Figure 5)* *DWSMA Map (Figure 10)*	X	X	X	X	X	X

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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: Stormwater Management **Water Sustainability: Recharge**	Land Use Planning and Management Education and Outreach	Manage stormwater runoff to minimize adverse impacts to groundwater. Refer to the Minnesota Stormwater Manual for infiltration guidance on project sites located in wellhead protection areas.		X			X	Artichoke Embarrass Floodwood Midway Lower Whiteface Sand Creek Swan Thompson West Two	MPCA MS4 Program	Prioritize MS4 communities, target highly sensitive areas and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5)* *DWSMA Map (Figure 10)*	X	X		X		X
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	N/A		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	Artichoke Embarrass Floodwood Midway Lower Whiteface	DNR Ecological & Water Resources	N/A		X				

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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*
								Sand Creek Swan Thompson West Two								
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. *GWC Plants, Animals, Native Plant Communities Map (Figure 32)* *Mapped Native Plant Communities (Figure 33)* Groundwater Dominated Lakes Map *(Figure 34)*	X	X	X	X	X	X
Protect Groundwater and Drinking Water Quality: Forestry	Land Use Planning and Management	Promote forest land long-term easements, and forest management on private lands, utilizing local, state, and federal technical and financial assistance options.	X	X	X	X	X	All	DNR Ecological & Water Resources	Prioritize private lands with high sensitivity, including bedrock at or near surface, as well as vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5*: St. Louis River Watershed - Pollution Sensitivity of Near Surface Materials*)* *DWSMA Map (Figure 10)*	X	X	X	X	X	X

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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: Forestry	Land Use Planning and Management	Promote forestland cover in vulnerable DWSMAs in local comprehensive plans and ordinances, and in comprehensive watershed management plans such as the County Local Water Plan, or 1W1P for drinking water protection.	X	X	X	X	X	All	DNR Ecological & Water Resources	Prioritize private lands with high sensitivity, including bedrock at or near surface, as well as vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5*: St. Louis River Watershed - Pollution Sensitivity of Near Surface Materials*)* *DWSMA Map (Figure 10)*Figure 10	X	X	X	X	X	X
Protect Groundwater and Drinking Water Quality: Forestry	Land Use Planning and Management	Inform landowners who own 20 acres or more of forested land cover that they are eligible to have private forest management plans prepared for their forested property.	X	X	X	X	X	All	DNR Ecological & Water Resources	Prioritize private lands with high sensitivity, including bedrock at or near surface, as well as vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5*: St. Louis River Watershed - Pollution Sensitivity of Near Surface Materials*)* *DWSMA Map (Figure 10)*Figure 10	X	X	X	X	X	X
Protect Groundwater and Drinking Water Quality: Forestry	Land Use Planning and Management	Assist private forest landowners to implement a DNR certified and registered private forest management plan.	X	X	X	X	X	All	DNR Ecological & Water Resources	Prioritize private lands with high sensitivity, including bedrock at or near surface, as well as vulnerable DWSMAs.	X	X	X	X	X	X

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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*
										Pollution Sensitivity Map (Figure 5: St. Louis River Watershed - Pollution Sensitivity of Near Surface Materials*)* *DWSMA Map (Figure 10)*Figure 10						
Protect Groundwater and Drinking Water Quality: Forestry	Land Use Planning and Management	Explore grant opportunities for protecting or establishing forested lands.	X	X	X	X	X	All	DNR Ecological & Water Resources	Prioritize private lands with high sensitivity, including bedrock at or near surface, as well as vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5*: St. Louis River Watershed - Pollution Sensitivity of Near Surface Materials*)* *DWSMA Map (Figure 10)*Figure 10	X	X	X	X	X	X
Protect Groundwater and Drinking Water Quality: Forestry	Education and Outreach	Promote education and awareness of the benefits of forests on groundwater and drinking water.	X	X	X	X	X	All	DNR Ecological & Water Resources	Prioritize private lands with high sensitivity, including bedrock at or near surface, as well as vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5*: St. Louis River Watershed - Pollution Sensitivity of Near Surface Materials*)*	X	X	X	X	X	X

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Itasca Co.	Target Lake Co.	Target St. Louis 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 10)*Figure 10						
Protect Groundwater and Drinking Water Quality: Forestry	Education and Outreach	Provide technical assistance for public and private landowners on tree and forest health and invasive species. ▪ Monitor forest health for invasive pests to minimize the spread	X	X	X	X	X	All	DNR Ecological & Water Resources	Prioritize private lands with high sensitivity, including bedrock at or near surface, as well as vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5*: St. Louis River Watershed - Pollution Sensitivity of Near Surface Materials*)* *DWSMA Map (Figure 10)*	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 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 land uses, such as row crop agriculture, will help protect groundwater quantity and quality.

Existing Programs and Resources

- BWSR **Conservation Reserve Program** (https://bwsr.state.mn.us/conservation-reserve-program): A voluntary program designed to help farmers restore and protect environmentally sensitive land.
- BWSR **Conservation Reserve Enhancement Program - CREP** (https://bwsr.state.mn.us/mn-crep-landowners): 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. Figure 36 shows where RIM easements are in the watershed.

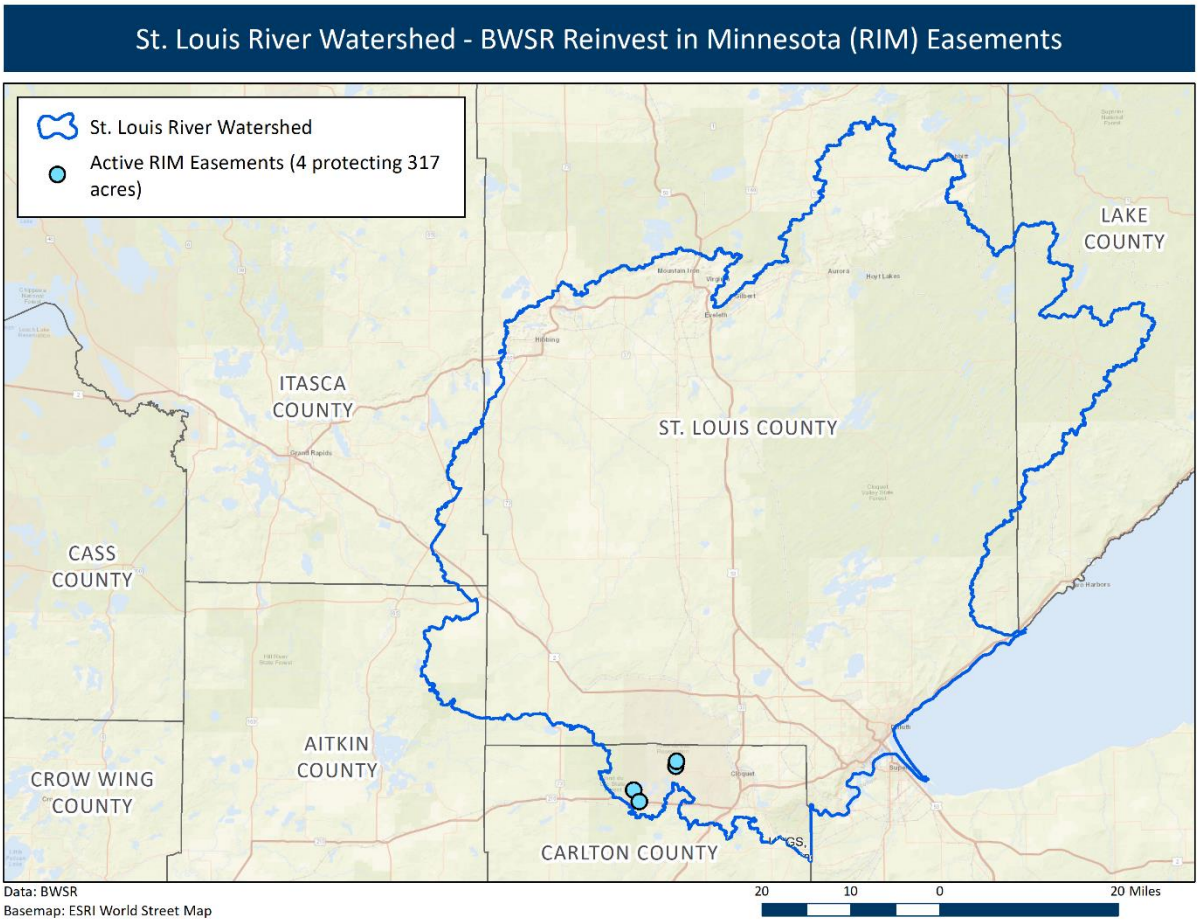

Figure 36: St. Louis River Watershed – BWSR RIM easements

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** (https://extension.umn.edu/animals-and-livestock#manure-management): Information about manure characteristics, application, and economics.
- 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** (https://www.mda.state.mn.us/protecting/cleanwaterfund/research/handbookupdate): 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** ()https://www.mda.state.mn.us/environment-sustainability/minnesota-agricultural-water-quality-certification-program A voluntary program for farmers to implement conservation practices to protect water quality.

Education and Outreach

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

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

Existing Programs and Resources

- Metropolitan Council **Water Conservation Toolbox** (https://metrocouncil.org/Wastewater-Water/Planning/Water-Supply-Planning/Guidance-Planning-Tools/Water-Conservation/Toolbox.aspx): Information about how residents and businesses, suppliers, learners, and communities can conserve water.
- Minnesota Rural Water Association **Source Water Protection Resources** (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** (http://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** (www.mda.state.mn.us/pesticide-fertilizer/pesticide-best-management-practices): A program that develops and implements statewide strategies for the increased use of IPM on private and state managed lands.
- MDA **Groundwater and Surface Water Protection from Agricultural Chemicals** (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** (https://www.mda.state.mn.us/irrigation-outreach-farm-nitrogen-management-central-minnesota): 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 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 **Fertilizer** (https://www.mda.state.mn.us/pesticide-fertilizer/fertilizers). 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/protecting/cleanwaterfund/onfarmprojects/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/township-testing-program): 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/pesticide-fertilizer/nitrogen-fertilizer-best-management-practices-agricultural-lands)): Provides nitrogen BMPs for various areas within Minnesota.
- MDA **Minnesota Nitrogen Fertilizer Management Plan** (www.mda.state.mn.us/pesticide-fertilizer/minnesota-nitrogen-fertilizer-management-plan): The state's blueprint for preventing or minimizing impacts of nitrogen fertilizer on groundwater.
- MDA Monitoring & Assessment for Agricultural Chemicals in the Environment (www.mda.state.mn.us/node/2696): Information about agricultural chemical monitoring and assessment programs and additional resources.
- UMN Extension **Nutrient Management** (https://extension.umn.edu/crop-production#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 **Nitrogen Application with Irrigation Water: Chemigation** (https://extension.umn.edu/irrigation/applying-nitrogen-irrigation-water-chemigation): Information about risks, benefits, and methods.
- MDA **The Agricultural BMP Handbook for Minnesota** (https://www.mda.state.mn.us/protecting/cleanwaterfund/research/handbookupdate): 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** (https://extension.umn.edu/animals-and-livestock#manure-management): Information about manure characteristics, application, and economics.

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** (https://septic.umn.edu/septic-system-owners): 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 37 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.

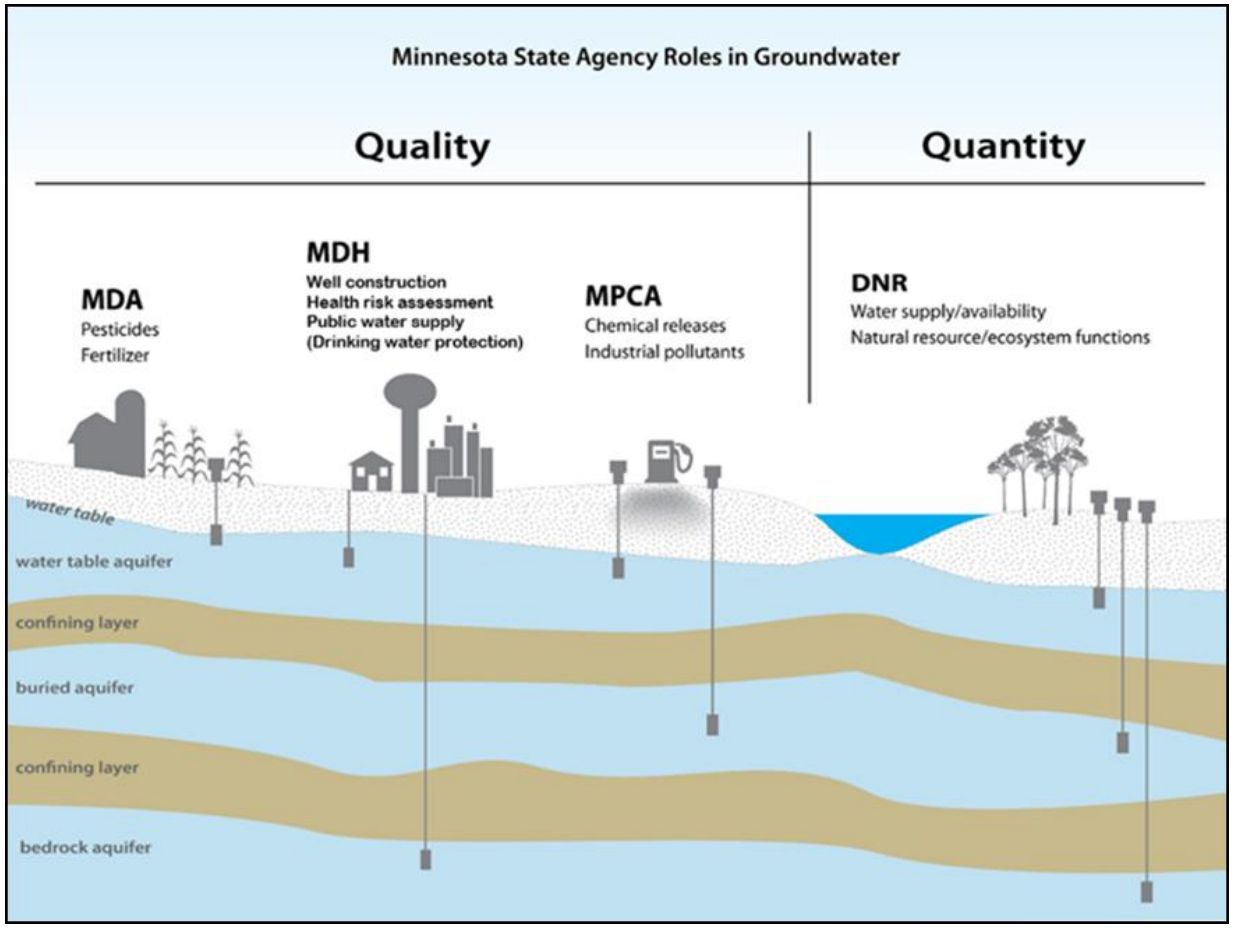

Figure 37: Minnesota State Agency Roles in Groundwater

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 38 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 difficult 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 38: 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 watershed. 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. ▪ Protecting Drinking Water Sources (www.health.state.mn.us/communities/environment/water/swp/about.htm) ▪ 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 (www.pca.state.mn.us/water/state-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/communities/environment/water/dwar.html)
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/communities/environment/water/swp/swa.html) ▪ Maps and Geospatial Data (www.health.state.mn.us/communities/environment/water/swp/maps/index.htm)
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

Type of Information	Where you can get more information
	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. ▪ Minnesota Well Index (MWI) (www.health.state.mn.us/communities/environment/water/mwi/index.html)
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. ▪ Protecting Drinking Water Sources (www.health.state.mn.us/communities/environment/water/swp/about.htm) ▪ 651-201-4700

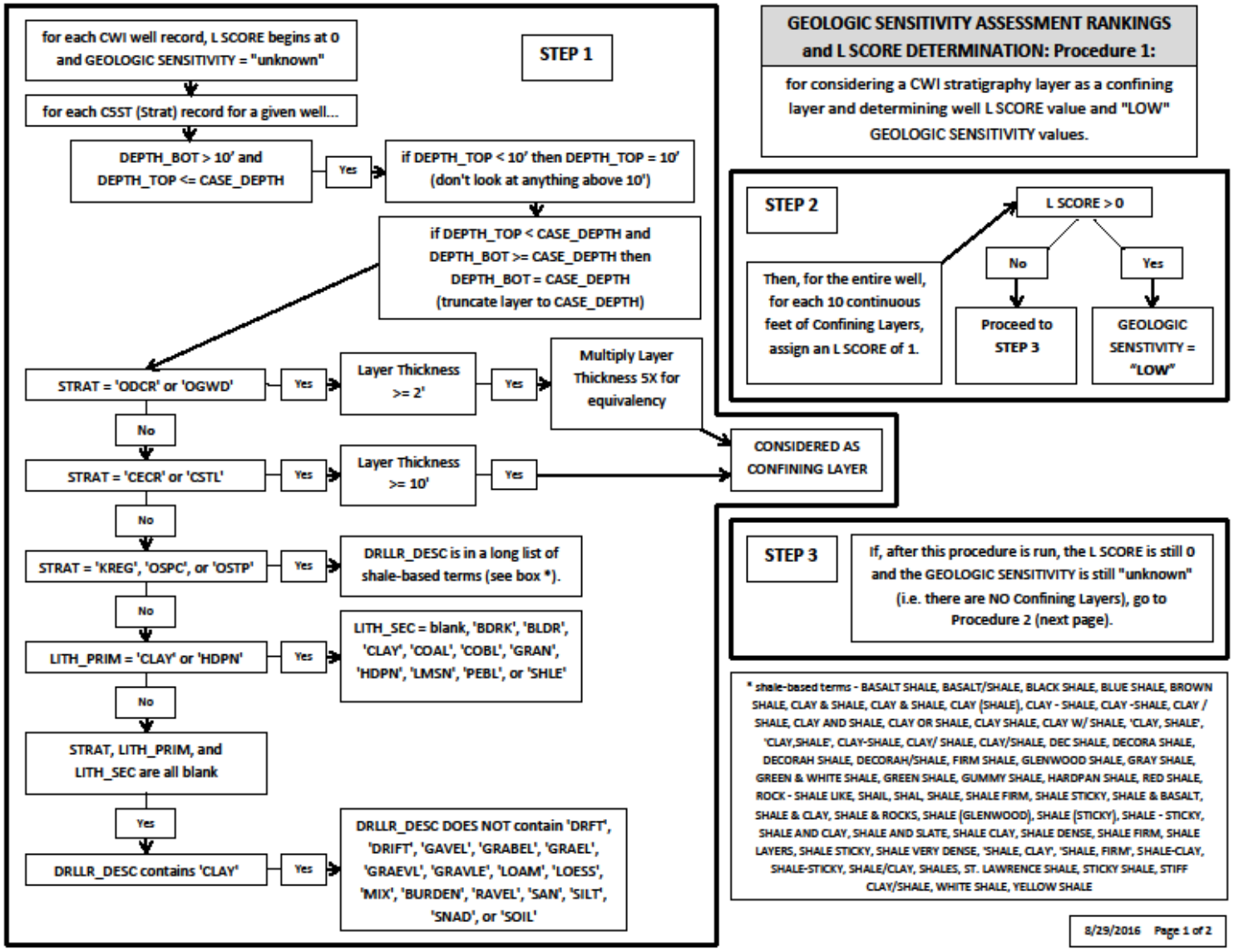

Figure 39: Sensitivity Assessment and Calculation for Pollution Sensitivity of Wells (Figure 9)

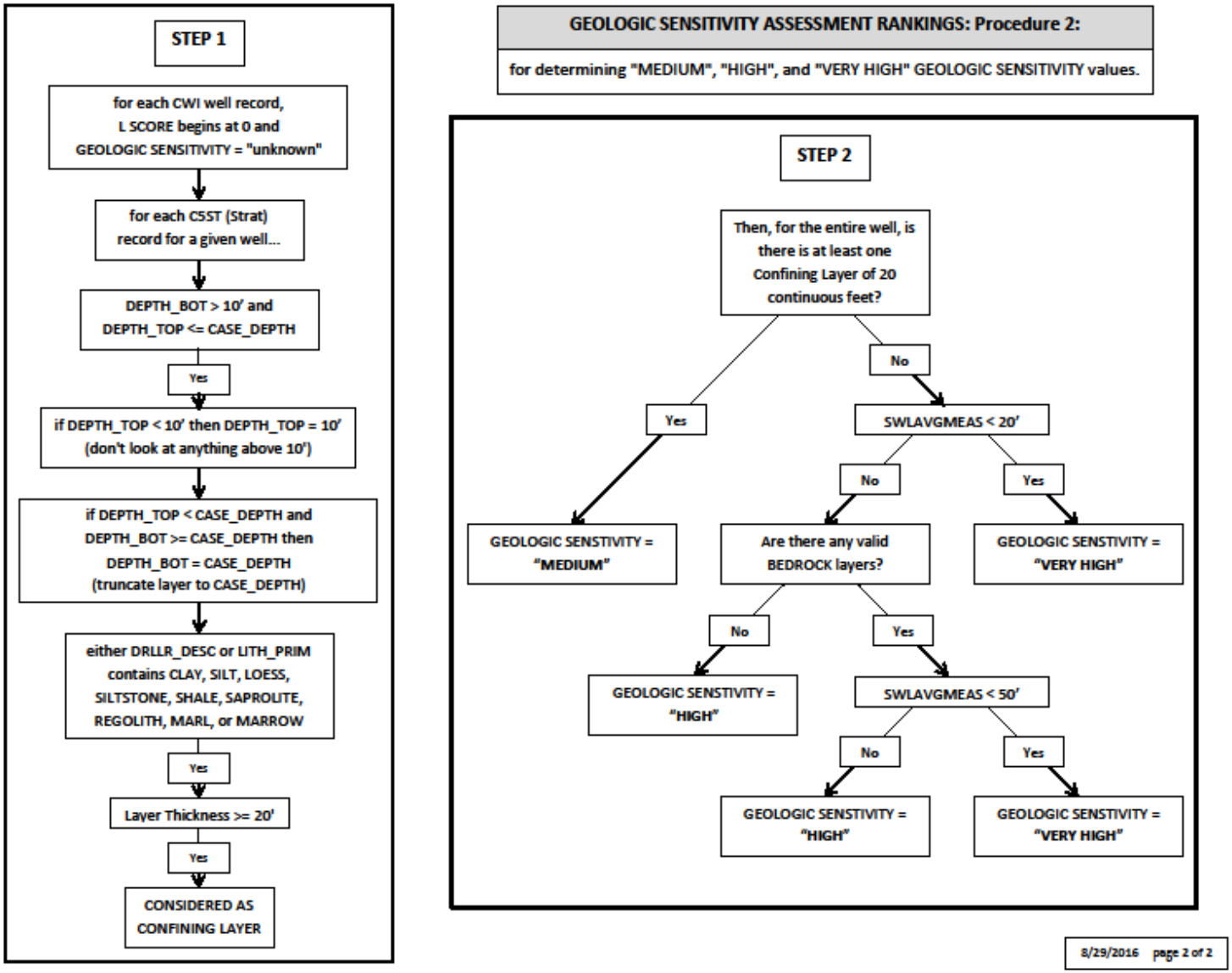

Figure 40: Sensitivity Assessment and Calculation for Pollution Sensitivity of Wells (Figure 9) continued

Table 10: Designation Trout Streams in the St. Louis River Watershed[14]

Trout Stream Name	Length in Miles
Amity Creek	10.0
Amity Creek, East Branch	7.8
Artichoke River	1.9
Beartrap Creek	7.6
Berry Creek	23.9
Big Sucker Creek	18.2
Buckingham Creek	6.6
Chalberg Creek	5.7
Chester Creek, East Branch	3.4
Chicken Creek	14.5
Cloudy Spring Creek	5.4
Coffee Creek	3.6
Coolidge Creek	5.4
Dutch Slough	5.2
Elm Creek	3.4
Floodwood River, West Branch	0.1
Fond du Lac Creek	6.2
French River	13.0
Gill Creek	1.3
Gimlet Creek	6.0
Hay Creek	8.5
Hellwig Creek	13.2
Humphrey Creek	3.7
Indian Creek	5.9
Johnson Creek	2.5

[14] Last Updated 11/06/2020

Keene Creek	8.1
Kingsbury Creek	6.4
Kinney Creek	3.8
Knowlton Creek	2.1
Lester River	20.1
Little Cloquet River	1.4
Little Mud Creek	3.7
Little Otter Creek	9.7
Little Sucker River	1.4
Maki Creek	3.7
Merritt Creek	2.6
Midway River	13.8
Miller Creek	9.4
Mission Creek	7.0
Mud Creek	4.6
Murphy Creek	14.7
Otter Creek	20.8
Pancake Creek	2.1
Pine River	10.6
Red River	4.1
Rocky Run	4.3
Ryan Creek	1.9
Sargent Creek	7.3
Schmidt Creek	0.6
Silver Creek	3.7
Slaughterhouse Creek	2.0
Spring Creek	3.1
Stewart Creek	3.1
Stewart River	2.2
Stoney Brook, Martin Branch	4.4
Sullivan Creek	6.4
Talmadge River	6.3
Tischer Creek	6.2

Trappers Creek	6.1
Us-kab-wan-ka River	19.7
West Rocky Run	7.9
Whiteface River, South Branch	4.7
Whyte Creek	5.5
Wyman Creek	8.2
Wyman Creek Braid	1.8
44 Unnamed Streams	93.2

Table 11: Rare Species Connected with Groundwater in the St. Louis River Watershed[15]

Scientific Name	Common Name	Species Class	Listing Status[16]	AQUATIC (Y OR N)	WETLAND (Y OR N)	GROUND-WATER DEPENDENT (Y OR N)	General Habitat Type
Rare Plant: Ahtiana aurenscens	Eastern candlewax lichen	Terrestrial plant	SPC	N	Y	Y	Conifer bark of *Thuja occidentalis* (northern white cedar), in swamps
Rare Plant: Carex exilis	Coastal Sedge	Terrestrial plant	SPC	N	Y	Y	Fens sustained by groundwater, with weakly acidic and nutrient-rich environs
Rare Plant: Ceratophyllum echinatum	Spiny Hornwort	Terrestrial plant	watchlist	Y	N	N	lakes and slow-moving streams
Rare Plant: Drosera anglica	English Sundew	Terrestrial plant	SPC	N	Y	Y	Rich open peatland fens sustained by groundwater, with weakly acidic and nutrient-rich environs
Rare Plant: Frullania selwyniana	Selwyn's Ear-leaf Liverwort	Terrestrial plant	SPC	N	Y	Y	only on the bark of Thuja occidentalis in dense cedar swamps, usually highly paludified

[15] Last Updated 11/06/2020

[16] 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[16]	AQUATIC (Y OR N)	WETLAND (Y OR N)	GROUND-WATER DEPENDENT (Y OR N)	General Habitat Type
Rare Plant: Juncus stygius var. americanus	Bog Rush	Terrestrial plant	SPC	N	Y	Y	Open peatlands, usually water tracks of norther fens
Rare Plant: Menegazzia terebrata	Port-hole Lichen	Terrestrial plant	SPC	N	N	Y	Trunks of Thuja occidentalis in forested peatlands, and cliff communities.
Rare Plant: Polemonium occidentale ssp. lacustre	Western Jacob's-ladder	Terrestrial plant	END	N	Y	Y	Forested conifer swamps, on hummocks of sphagnum moss
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: Ranunculus lapponicus	Lapland Buttercup	Terrestrial Plant	SPC	N	Y	Y	On sphagnum hummocks in rich forested or alder swamps, associated with Thuja occidentalis or Picea mariana
Rare Plant: *Rubus vermontanus*	Vermont bristle-berry	Terrestrial Plant	SPC	N	Y	Y	Mesic hardwood forests, partially wooded and woodland edges; shallow wetlands in oak and pine woodlands
Rare Plant: *Sticta fuliginosa*	Peppered moon lichen	Terrestrial Plant	SPC	N	Y	Y	Mature, moist forests and bogs, Betula alleghaniensis and Thuja occidentalis preferred substrates
Rare Plant: *Thelia hirtella*	Nipple Moss	Terrestrial Plant	SPC	N	N	N	On bark at the base or on the trunks of hardwoods, sometimes on decayed logs and stumps, rarely on soil or rock.
Rare Plant: *Tomentypnum falcifolium*	Curved-leaved golden moss	Terrestrial Plant	Watchlist	N	Y	Y	Forested and non-forested rich peatlands
Rare Plant: *Trichocolea tomentella*	A Species of Liverwort	Terrestrial Plant	THR	N	Y	Y	Found in rich conifer swamps such as with cedar, black spruce or in mixed lowland hardwood swamp where cedar can be dominant
Rare Plant: *Xyris montana*	Montane Yellow-eyed Grass	Terrestrial Plant	SPC	N	Y	Y	Sunny, acidic, peaty habitats with sphagnum; shores and mats of bog lakes and ponds, fens, water tracks
Rare Animals:	American bittern	Bird	Watch List; SGCN	N	Y	Sometimes	Marshes/ wetlands; emergent marsh

Scientific Name	Common Name	Species Class	Listing Status[16]	AQUATIC (Y OR N)	WETLAND (Y OR N)	GROUND-WATER DEPENDENT (Y OR N)	General Habitat Type
Botaurus lentiginosus							
Rare Animals: *Coturnicops noveboracensis*	Yellow rail	Bird	SPC; SGCN	N	Y	Sometimes	Dependent on open rich fens, wet meadow, and wet prairie; requires very narrow range of water depth (~2-10 cm)
Rare Animals: *Glyptemys insculpta*	Wood Turtle	Turtle	THR	Yes	N	Possibly	Aquatic in small fast-moving waters with sand or gravel shores and adjacent deciduous and coniferous forests
Rare Animals: *Hemidactylium scutatum*	Four-toed salamander	Amphibian	SPC; SGCN	Y	Y	Possibly	Nest sites include shrub swamps and conifer swamps near hardwood forests; sites often include 0.5meter water depth and sphagnum moss
Rare Animals: Hydroptila novicola	A Caddisfly	Insect	Watchlist	Y (larvae)	N	Possibly	Larval stages aquatic in fast-moving, cold, clear streams where they feed on epiphytic algae that grows on the surfaces of stream rocks
Rare Animals: *Lasmigona compressa*	Creek Heelsplitter	Mussel	SPC	Y	N	Y	Creeks, small rivers, and the upstream portions of large rivers. Its preferred substrates are sand, fine gravel, and mud
Rare Animals: *Limnephilus secludens*	A Caddisfly	Insect	END	(larvae)	N	Y	Larval stages aquatic in fast-moving, cold, clear streams in vegetated riparian corridors
Rare Animals: *Notropis anogenus*	Pugnose shiner	Fish	THR; SGCN	Y	N	Y	Glacial lakes and streams with good water clarity and an abundance of submerged vegetation; prefers clear glacial lakes and streams with dense vegetation
Rare Animals: Ophiogomphus anomalus	Extra-striped Snaketail	Insect	SPC	Y (larvae)	N	Y	Larvae prefer clear, swift-flowing rivers. Adults patrol rivers and forage in adjacent wetlands, lowland forests, and mature upland forests with closed canopy and low understory
Rare Animals: Oxyethira itascae	A Caddisfly	Insect	SPC	Y (larvae)	N	Y	Larvae of Oxyethira have been found in both lakes and streams. Adults seem to prefer meandering silt-bottomed streams.
Rare Animals: *Phalacrocorax auritus*	Double-crested Cormorant	Bird	Watchlist	Y	N	N	Lakes; nests in trees near water or on ground on islands

Scientific Name	Common Name	Species Class	Listing Status[16]	AQUATIC (Y OR N)	WETLAND (Y OR N)	GROUND-WATER DEPENDENT (Y OR N)	General Habitat Type
Rare Animals: *Somatochlora brevicincta*	Quebec Emerald	Insect	SPC	Y	Y	Y	Breed in 'flarks', in mossy patterned poor fens; larvae living along water-filled game trails in poor fens, within open acid peatland systems
Rare Animals: *Somatochlora forcipata*	Forcipate Emerald	Insect	SPC	Y (larvae)	Y	Y	Small forested or open streams and spring fen channels
Rare Animals: *Somatochlora forcipata*	Forcipate Emerald	Insect	SPC; SGCN	Y (larvae)	Y	Y	Spring fen channels; alkaline water conditions

Tables 12-13[17] show the documented wetland native plant communities connected to groundwater in the St. Louis River Watershed.

Table 12: St. Louis 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		
OPn91a	Shrub Rich Fen (Water Track)	S4 - Apparently Secure; Uncommon but not Rare
OPn91b	Graminoid Rich Fen (Water Track)	Subtypes are either S2-imperiled or S3-vulnerable
OPn91b1	Graminoid Rich Fen (Water Track), Featureless Water Track Subtype	S3 - Vulnerable to Extirpation

[17] Updated 11/06/2020

Table 13: St. Louis 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
Acid Peatlands		
APn91a	Low Shrub Poor Fen	S5 - Secure
APn91b	Graminoid Poor Fen (Basin)	S3 - Vulnerable to Extirpation
APn91c1	Graminoid Poor Fen (Water Track), Featureless Water Track Subtype	S4 - Apparently Secure; Uncommon but not Rare
APn91c2	Graminoid Poor Fen (Water Track), Flark Subtype	S3 - Vulnerable to Extirpation
Forested Rich Peatland		
FPn62a	Rich Black Spruce Swamp (Basin)	S3 - Vulnerable to Extirpation
FPn63a	White Cedar Swamp (Northeastern)	S4 - Apparently Secure; Uncommon but not Rare
FPn63b	White Cedar Swamp (Northcentral)	S3 - Vulnerable to Extirpation
FPn73a	Alder - (Maple - Loosestrife) Swamp	S5 - Secure
FPn81a	Northern Rich Tamarack Swamp (Water Track)	S4 - Apparently Secure; Uncommon but not Rare
FPn82a	Rich Tamarack - (Alder) Swamp	S5 - Secure
Marsh		
MRn83a	Cattail - Sedge Marsh (Northern)	S2 - Imperiled
MRn93a	Bulrush Marsh (Northern)	S3 - Vulnerable to Extirpation
Open Rich Peatland		
OPn81a	Bog birch - Alder Shore Fen	S5 - Secure
OPn81b	Leatherleaf - Sweet Gale Shore Fen	S5 - Secure
OPn92a	Graminoid Rich Fen (Basin)	S4 - Apparently Secure; Uncommon but not Rare
OPn92b	Graminoid Rich Fen (Basin)	S4 - Apparently Secure; Uncommon but not Rare
Forested Wetland		
WFn53a	Northern Wet Cedar Forest	Between S3-vulnerable and S4-apparently secure
WFn53b	Lowland White Cedar Forest (Northern)	S3 - Vulnerable to Extirpation
WFn55a	Black Ash - Aspen - Balsam Poplar Swamp (Northeastern)	S4 - Apparently Secure; Uncommon but not Rare
WFn55c	Black Ash - Mountain Maple Swamp (Northern)	S4 - Apparently Secure; Uncommon but not Rare
WFn64a	Northern Very Wet Ash Swamp	S4 - Apparently Secure; Uncommon but not Rare
WFn64b	Black Ash - Yellow Birch - Red Maple - Alder Swamp (East central)	S4 - Apparently Secure; Uncommon but not Rare
WFn64c	Black Ash - Alder Swamp (Northern)	S4 - Apparently Secure; Uncommon but not Rare
WFn74	Northern Wet Alder Swamp	S4 - Apparently Secure; Uncommon but not Rare

Table 14: St. Louis River Watershed documented wetland native plant communities dependent on groundwater associated with water tables that are high for some part of the growing season

Native Plant Community Code	Native Plant Community Name	Conservation Status Rank
Floodplain Forest		
FFn57a	Black Ash - Silver Maple Terrace Forest	S3 - Vulnerable to Extirpation
Wet Meadow/Shrub Carr Wetlands		
WMn82a	Willow - Dogwood Shrub Swamp	S5 - Secure, Common, Widespread, and Abundant
WMn82b	Sedge Meadow	S4 or S5 - Subtype S-Ranks are either S4 or S5
Wm82b1	Sedge Meadow, Bluejoint Subtype	S5 - Secure, Common, Widespread, and Abundant
WMn82b3	Sedge Meadow, Beaked Sedge Subtype	S4 - Apparently Secure; Uncommon but not Rare

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