Watershed

April 2024

Root River Watershed Restoration and Protection Strategy Report Update 2024

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Acronyms

1W1P	One Watershed, One Plan
ACPF	Agricultural Conservation Planning Framework
AU	animal unit
BMP	Best management practice
BWSR	Board of Water and Soil Resources
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
CWMP	Comprehensive Watershed Management Plan
DNR	Minnesota Department of Natural Resources
DO	Dissolved oxygen
DWSMA	Drinking Water Supply Management Area
hDEM	hydrologically modified digital elevation model
HSPF	Hydrologic Simulation Program-Fortran
HSPF-SAM	Hydrologic Simulation Program-Fortran Scenario Application Manager
HUC	Hydrologic unit code
IBI	Index of Biological Integrity
IWM	Intensive watershed monitoring
lb	pound
lbs/ac	pounds per acre
LGU	Local Government Unit
LTBM	Long Term Biological Monitoring
mg/L	milligrams per liter
MDA	Minnesota Department of Agriculture
MDH	Minnesota Department of Health
MGS	Minnesota Geological Survey
MGWA	Minnesota Groundwater Association
mL	milliliter
MPCA	Minnesota Pollution Control Agency
NO3-N	Nitrate nitrogen

N	Nitrogen
NPDES	National Pollutant Discharge Elimination System
NRS	Nutrient Reduction Strategy
PTMApp	Prioritize Target Measure Application
RRW	Root River Watershed
RRFSP	Root River Field to Stream Partnership
SID	Stressor Identification
SPI	Stream Power Index
SSTS	Subsurface sewage treatment systems
STUBE	Secchi tube (transparency)
SWCD	Soil and Water Conservation District
TN	Total Nitrogen
TMDL	total maximum daily load
TP	Total phosphorus
TSS	total suspended solids
WASCOB	water and sediment control basin
WBIF	watershed based implementation funding
WID	water body identification number
WLA	wasteload allocation
WHAF	Watershed Health Assessment Framework
WRAPS	Watershed Restoration and Protection Strategy
WWTP	Wastewater Treatment Plant

Minnesota's Watershed Approach

Figure 1. Minnesota's watershed approach.

The State of Minnesota developed a watershed approach to focus holistically on each watershed's condition as the scientific basis of permitting, planning, implementation, and measurement of results. This process looks strategically at the drainage area as a whole instead of focusing on lakes and stream sections one at a time, thus increasing effectiveness and efficiency.

Every 10 years, each of Minnesota's 80 major watersheds are evaluated through monitoring/data collection and assessed against water quality standards to show trends in water quality and the impact of permitting requirements, as well as any restoration, or protection actions. A watershed restoration and protection strategies (WRAPS) report is then updated to provide technical information to support the implementation of restoration and protection projects by local partners through their One Watershed, One Plan (1W1P) comprehensive local water plan. The Minnesota Pollution Control Agency's (MPCA's) watershed work is tailored to meet local conditions and needs, based on factors such as watershed size, landscape diversity, and geographic complexity.

To identify and address threats to water quality in each watershed, WRAPS reports address both strategies for restoration for impaired waters, and strategies for protection for waters that are not impaired. Waters not meeting state standards are listed as impaired and total maximum daily load (TMDL) studies are developed for them. The TMDLs are incorporated into the WRAPS reports.

Key aspects of the MPCA's watershed work are to develop and utilize watershed-scale computer models, perform biological stressor identification (SID), conduct problem investigation monitoring, and use other tools to identify strategies for addressing point and nonpoint source pollution that will cumulatively achieve water quality targets. Point source pollution comes from sources such as wastewater treatment plants (WWTP) or industrial facilities; nonpoint source pollution is the result of runoff or containments not being absorbed in the soil. For nonpoint source pollution, the WRAPS report informs local planning efforts, but ultimately the local partners decide what work will be included in their local plans.

Minn. Stat. § 114D, also known as the Clean Water Legacy Act (CWLA), sets out the policy framework for the Watershed Approach, including requiring the development and updating of WRAPS for all watersheds of the state. The Clean Water, Land and Legacy Amendment, approved by Minnesota voters in 2008, directs dollars from an increase in sales tax to a Clean Water Fund, which is overseen by the Clean Water Council. The Clean Water Fund provides resources to implement the CWLA to achieve and maintain water quality standards in Minnesota through activities such as monitoring, watershed characterization and scientific study, planning, research, and on-the-ground restoration and protection activities.

Executive summary

The State of Minnesota has adopted a Watershed Approach for managing water quality for each of the 80 major watersheds in the state. Every 10 years, each major watershed undergoes intensive watershed monitoring (IWM) and assessment and has the opportunity for a WRAPS updating project. The first WRAPS IWM cycle in the Root River Watershed (RRW) began in 2008, with the initial WRAPS document report approved in 2016.

The Root River WRAPS Update Report 2024 is an update of the 2016 Root River WRAPS Report. This WRAPS Update Report summarizes water quality findings from Cycle 2 IWM, SID, water quality research projects and studies. The goals of this updated WRAPS report are to:

1. Highlight differences in watershed conditions from Cycle 1 to Cycle 2;
2. Identify updated resources and tools for watershed stakeholders as they plan and implement best management practices (BMPs);
3. Identify pollutant sources at a smaller scale and at select local priority subwatersheds; and
4. Provide updated recommendations for prioritizing and targeting implementation throughout the watershed.

Overall, water quality conditions have not changed significantly in the RRW since Cycle 1. A majority of monitoring sites continue to support aquatic life uses (MPCA 2021). Assessment of Cycle 2 data determined 26 new impairments for 21 streams consisting of 9 macroinvertebrate, 4 fish, 2 TSS, 10 nitrate and 1 *E. coli* listings to the 2022 impaired waters list. These new impairments are not necessarily an indication of degradation, but rather, a result of a larger data set obtained to conduct an assessment. Total suspended solids (TSS), nitrate (NO3-N) and *E. coli* continue to be prominent stressors to aquatic life and recreation, and contribute to exceedances of water quality standards. Altered hydrology has been found to be a driver of water quality issues and requires special consideration for effective implementation. Improvements in IBI scores on five stream reaches resulted in de-listings for four macroinvertebrate impairments and one fish impairment. Some of these waters are or have been the focus of local implementation outreach efforts.

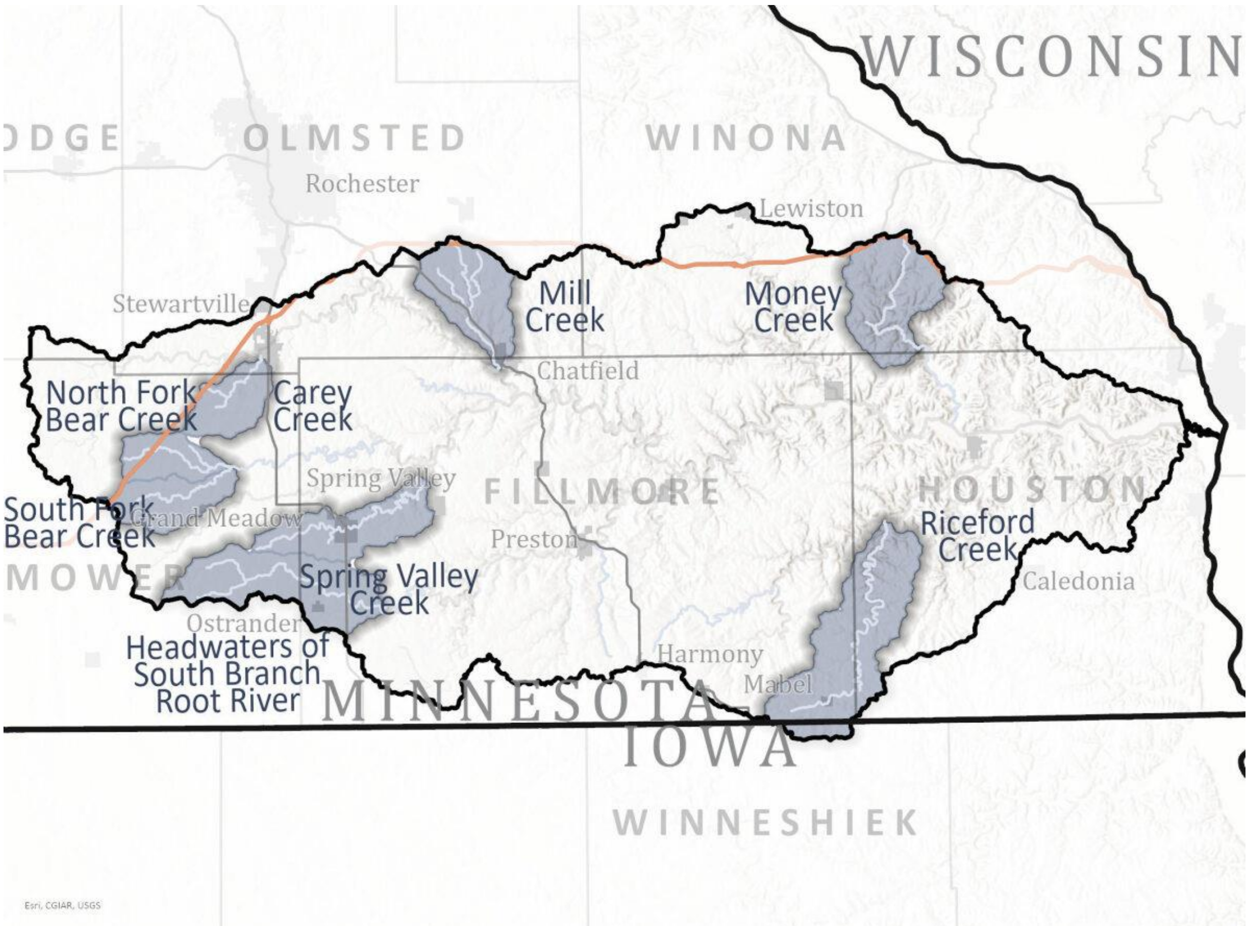
Some highlights of the Root River WRAPS Update Report 2024 are the new tools and studies (see Section 7.1) developed since the 2016 WRAPS report. These new tools and information will heavily influence the effectiveness and efficiency of future implementation. With a more focused and informed implementation approach, water quality benefits may be realized in the next watershed approach cycle (2028). The reader will also note that this WRAPS Update Report does not cover the entire hydrologic unit code (HUC)-8 RRW. Rather, select HUC-12 subwatersheds are the focus. These eight HUC-12 subwatersheds lie within 2024-2025 priority HUC-10 subwatersheds for the Root River Planning Work Group implementing the Root River Comprehensive Watershed Management Plan (CWMP).

Because many aspects of the watershed remain unchanged since the 2016 WRAPS Report, several sections of this report are condensed. Please refer to the 2016 WRAPS Report for more details on the RRW background and description.

1. Watershed background and description

The RRW is 26th largest watershed in the state of Minnesota. It drains 1,670 square miles and spans six counties in southeastern Minnesota (Figure 2). Many headwaters of the watershed, including the Root River, begin as drainage ditches in Mower County. These headwaters flow through intensely farmed areas, woodlands and rolling terrain emptying into the Mississippi River 81 miles later.

Figure 2. Root River Watershed and priority subwatersheds.



One of the most notable features of the RRW is its unique karst geology. Three distinct geomorphic regions comprise the watershed generally from west to east: till covered karst, near surface karst and bluffland karst. While karst offers stunning landscapes like sinkholes, springs and caves, it also very directly connects surface water with groundwater. This connection enables pollutants on the land's surface to easily reach groundwater aquifers used for drinking water sources. The RRW has many areas vulnerable to groundwater contamination. Pollution of groundwater used as drinking water is the longest standing water quality issue in the RRW. Local governments have worked for decades to reduce pollution of groundwater, particularly by nitrate, in the RRW. As such, much of the substance of this WRAPS Update and the RRW 1W1P is focused on priorities and strategies for reducing nitrate loading to groundwater. Further, the Minnesota Department of Health (MDH) is currently developing a Groundwater Restoration and Protection Strategy (GRAPS) report (expected in 2027), which will be a companion document to the WRAPS Update Report.

Given the emphasis on reducing nitrate loading to groundwater, several studies and tools have been developed to better understand the groundwater and surface water interaction. Refer to the following to learn more about these resources:

- Minnesota Department of Agriculture (MDA) Groundwater Lag time study
- DNR Groundwater Atlas Program
- DNR Minnesota Groundwater Tracing Database
- DNR Karst Features Inventory
- MN Ground Water Association (white paper on drain tile)
- MN Geological Survey Geologic Controls Report

There are 1,198 stream segments described by water body identification numbers (WIDs) in the RRW totaling 3,675 miles of streams. Twenty-three percent are coldwater (Class 2A) designated streams that may support trout populations and 77% are designated warmwater (Class 2B). The MPCA and DNR regularly propose changes to designated uses of Class 2 waters. These changes reflect whether some streams are classified as coldwater or warmwater. Currently, 27 streams in the RRW are being requested for future designated use changes by DNR. All are warmwater use streams being proposed for coldwater use and a trout designation. For more information about 2021-2022 use classifications, see: https://www.pca.state.mn.us/water/2021-amendments-water-quality-standards-use-classification-2.

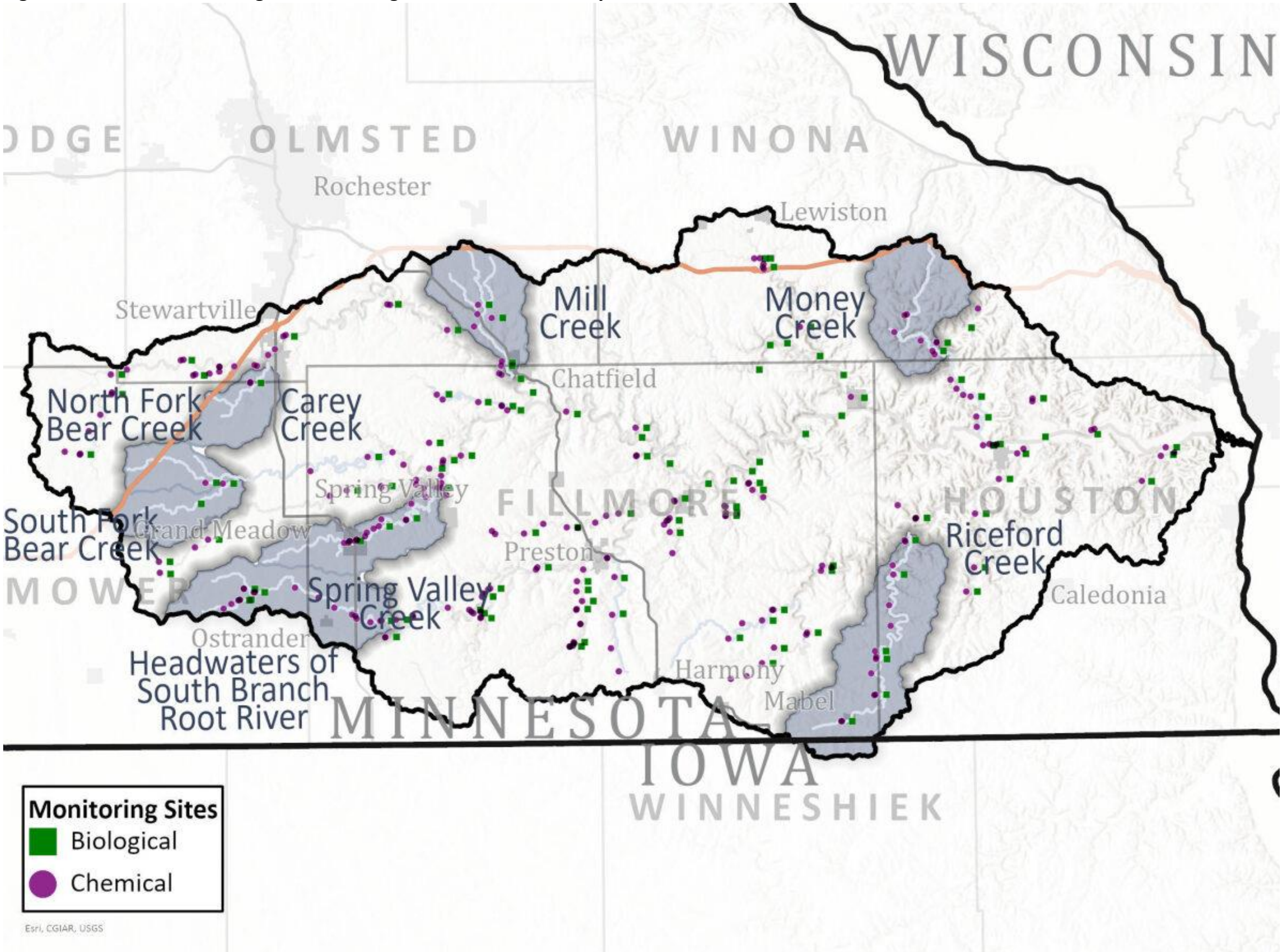
The dominant land use in the RRW remains to be agriculture. Since 2011, there has been a 32% increase in the acres of corn and soybeans harvested throughout Mower, Fillmore, Winona and Houston counties (CDL 2023). This is likely due to the transition of pastureland and conservation reserve program (CRP) lands to row crop. How land is used in the RRW is closely tied to its geology. The western portion of the watershed has thick glacial till and poorly drained soils. Because of this, there is a heavier presence of agricultural drain tile in this area. The most eastern portion of the watershed has steep bluffs and large acres of forestland. Lesser agricultural uses exist, represented by pasturelands and smaller tracts of row crop fields.

More detailed land use and RRW background information is described in the Cycle 1 WRAPS Report: https://www.pca.state.mn.us/sites/default/files/wq-ws4-18a.pdf

2. Watershed conditions

Assessing the condition of the RRW's water quality was repeated in 2020 following two years (2018-2019) of IWM. This second assessment of water chemistry and aquatic life data allowed MPCA to evaluate recent data and review Cycle 1 data and decisions. In addition to IWM sites, several long-term monitoring sites were established in the RRW and provide continuous water chemistry and aquatic life data (Figure 3).

Figure 3. Chemical and biological monitoring sites in the RRW for Cycle 2.



2.1 Cycle 2 Condition Summaries

Streams

While there are water quality impairments of aquatic life and aquatic recreation throughout the RRW, this watershed continues to support high quality streams. Fish and macroinvertebrates data collected in 2018 and 2019 found the aquatic life communities generally scored higher than the community scores in 2008. Water chemistry showed little change from the previous assessment in 2010. Dissolved oxygen (DO) and phosphorus are considered non-issues while TSS, *E. coli* and nitrate continued to exceed water quality standards. New impairments discussed in the subsequent text refer to added listings to the 2022 impaired waters list. Streams that changed use support status (impaired, de-listed, corrected) are discussed in this section.

Assessment decisions for RRW Cycle 2 monitoring data were made in 2020. There were 110 WIDs assessed for aquatic life and 18 WIDs assessed for both aquatic life and aquatic recreation. Of the 18 WIDs assessed for aquatic recreation, 17 were determined to be not supporting due to *E. coli*. The remaining WID did not have sufficient information to complete an assessment. Out of the 128 WIDs assessed for aquatic life, 21 were found to be supporting, 37 were found to be not supporting, 2 had limited support, and 68 WIDs were either inconclusive or had insufficient information to assess. Highlights of the Cycle 2 assessment can be found in MPCA's Monitoring Assessment and Trends Update Report.

Not all WIDs assessed as not meeting designated uses resulted in a new impairment designation. Many WIDs assessed in Cycle 2 were confirmed in their impairment status as they were also assessed as impaired during Cycle 1. Cycle 2 assessment of water quality data determined 26 new impairments for 21 streams (Figure 4, Table 1). These new impairments are included on the 2022 impaired waters list and consist of 9 macroinvertebrates, 4 fish, 2 TSS, 10 nitrate and 1 *E. coli* listing. Most of these new impairments were not listed because of a change in water quality condition, but rather, since enough water quality data was obtained in Cycle 2 to conduct an assessment.

Figure 4. Cycle 2 impairments in the RRW. The majority of these impairments were documented as more and new data came available (not because of recent degradation).

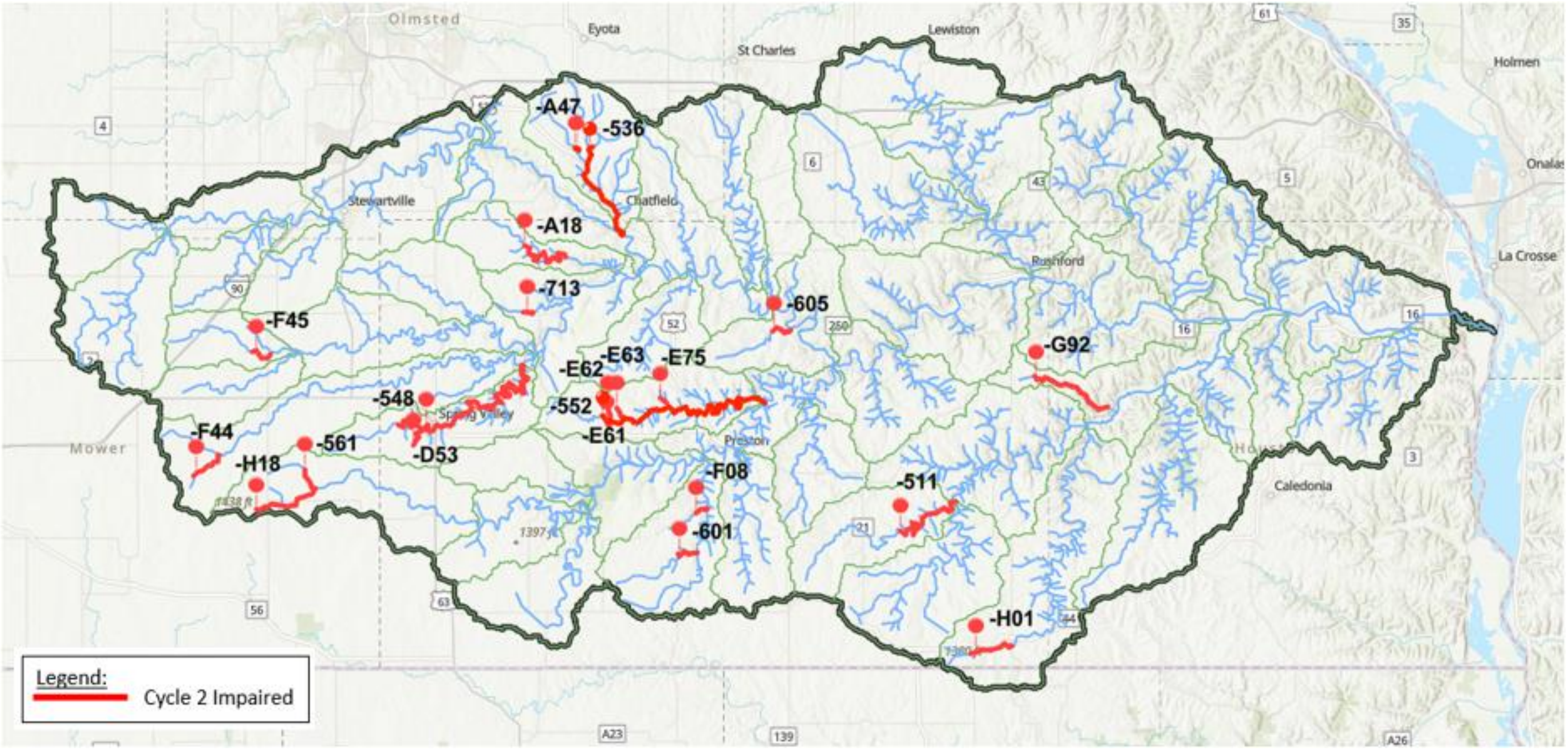


Table 1. New impairments in the RRW for Cycle 2.

Water body name	WID 07040008-XXX	Use class	Year listed	Affected use	Impaired Water Listing	Pollutant/Stressor
Mill Creek	-536	2Ag	2020	Aquatic Life	Macroinvertebrate Fish	Nitrate TSS Habitat Flow alteration
			2022	Drinking water	Nitrate	Nitrate
Unnamed Creek (Mill Creek Tributary)	-A47	2Ag	2022	Drinking water	Nitrate	Nitrate
Spring Valley Creek	-548	2Ag	2022	Drinking water	Nitrate	Nitrate
				Aquatic life	TSS	TSS
South Fork Root River	-511	2Ag	2022	Aquatic recreation	*E. coli*	*E. coli*
Riceford Creek	-H01	2Bg	2020	Aquatic life	Macroinvertebrate	NO3-N TSS Habitat Flow alteration
Crystal Creek	-601	2Ag	2022	Drinking water	Nitrate	Nitrate
Unnamed Creek (Bloody Run)	-F08	2Ag	2022	Drinking water	Nitrate	Nitrate
			2020	AQL	Fish Macroinvertebrate	Undetermined
Unnamed Creek (Spring Valley Creek Tributary)	-D53	2Ag	2022	Drinking water	Nitrate	Nitrate
Unnamed Creek (trib to Watson)	-E75	2Ag	2022	Drinking water	Nitrate	Nitrate
Unnamed Creek (trib to Watson)	-E61	2Ag	2022	Drinking water	Nitrate	Nitrate
Unnamed Creek (trib to Watson)	-E62	2Ag	2022	Drinking water	Nitrate	Nitrate
Unnamed Creek (trib to Watson)	-E63	2Ag	2022	Drinking water	Nitrate	Nitrate
North Fork Bear Creek	-F45	2Bg*	2020	AQL	Macroinvertebrates	Undetermined
Unnamed Creek	-605	2Bg	2022	AQL	Fish	Undetermined

Water body name	WID 07040008-XXX	Use class	Year listed	Affected use	Impaired Water Listing	Pollutant/Stressor
(Wadden Valley Creek)			2012		Macroinvertebrates	
Judicial Ditch 1	-561	2Bg	2020	AQL	Macroinvertebrates	Undetermined
County Ditch 8	-F44	2Bg*	2020	AQL	Macroinvertebrates	Undetermined
Jordan Creek	-713	2Bg	2020	AQL	Macroinvertebrates	Undetermined
Upper Bear (Lost Creek)	-A18	2Ag	2022	AQL	TSS	TSS
					Macroinvertebrate Fish	Nitrate Habitat TSS Flow alteration
South Branch Root River	-H18	2Bg*	2022	AQL	Macroinvertebrate	Nitrate DO Habitat Flow alteration
Bridge Creek	-G92	2Ag	2022	AQL	Macroinvertebrate	Habitat Flow alteration
Root River	-520	2Bg	2022	AQL	TSS	TSS TMDL approved in 2017
Root River, Middle Branch	-528	2Bg	2022	AQL	TSS	TSS TMDL approved in 2017
South Branch Root River	-550	2Ag	2022	AQL	TSS	TSS TMDL approved in 2017
Watson Creek	-552	2Ag	2022	AQL	TSS	TSS TMDL approved in 2017

*Use designation changing to 2Bm.

Ninety-seven impairments across 58 stream segments first listed during Cycle 1 were confirmed in Cycle 2 (Appendix A). These impairments include 51 for aquatic life, 21 for aquatic recreation, 19 for aquatic consumption (mercury) and 6 for drinking water (nitrate). Sixty-nine of these impairments have approved TMDLs calculated for pollution reduction. The remaining impairments have not been addressed by TMDLs and need additional information before being able to do so. This additional information is necessary to determine a linkage between a pollutant, or nonpollutant stressors, and the impairments.

Several WIDs listed as impaired in Cycle 1 have been recategorized in Cycle 2 (Figure 5, Table 2). Recategorizations that can occur are:

- **4C recategorization:** Cycle 2 data confirmed a nonpollutant was causing an impairment;
- **Delisting:** Cycle 2 data confirmed water quality standards are now being met;
- **Correction:** Cycle 2 data did not support the assessment decision of Cycle 1.

Figure 5. Delistings and corrections from Cycle 2 RRW assessment.

Table 2. RRW WIDs recategorized in Cycle 2.

Water body name	AUID	Use class	Year listed	Impaired Water Listing	Recategorization
Riceford Creek	-519	2Bg	2012	Macroinvertebrates	Correction
South Branch Root River	-550	2Ag	2012	Macroinvertebrates	Correction
South Branch Root River	-586*	2Bg	2004	Turbidity	Correction
Judicial Ditch 1	-561	2Bg	2006	Turbidity	Correction
South Branch Root River	-556	2Ag	2012	Macroinvertebrates	Delisting
Silver Creek	-640	2Ag	2012	Fish	Delisting
Middle Branch Root River	-506	2Bg	2012	Macroinvertebrates	Delisting
Middle Branch Root River	-528	2Bg	2012	Macroinvertebrates	Delisting
Pine Creek	-526	2Ag	2012	Macroinvertebrates	Delisting
Corey Creek	-631	2Ag	2012	Fish	4C (nonpollutant)

* This WID has been retired and now is captured by child WIDs: -H18 and –H19.

A positive confirmation of IWM Cycle 2 is that 21 WIDs in the RRW continue to meet aquatic life standards. Many WIDs meet both fish and macroinvertebrate standards (Figure 6, Table 3). While these waters are currently meeting aquatic life standards, active management is needed to protect them from future degradation.

Figure 6. WIDs meeting AQL standards in the RRW.

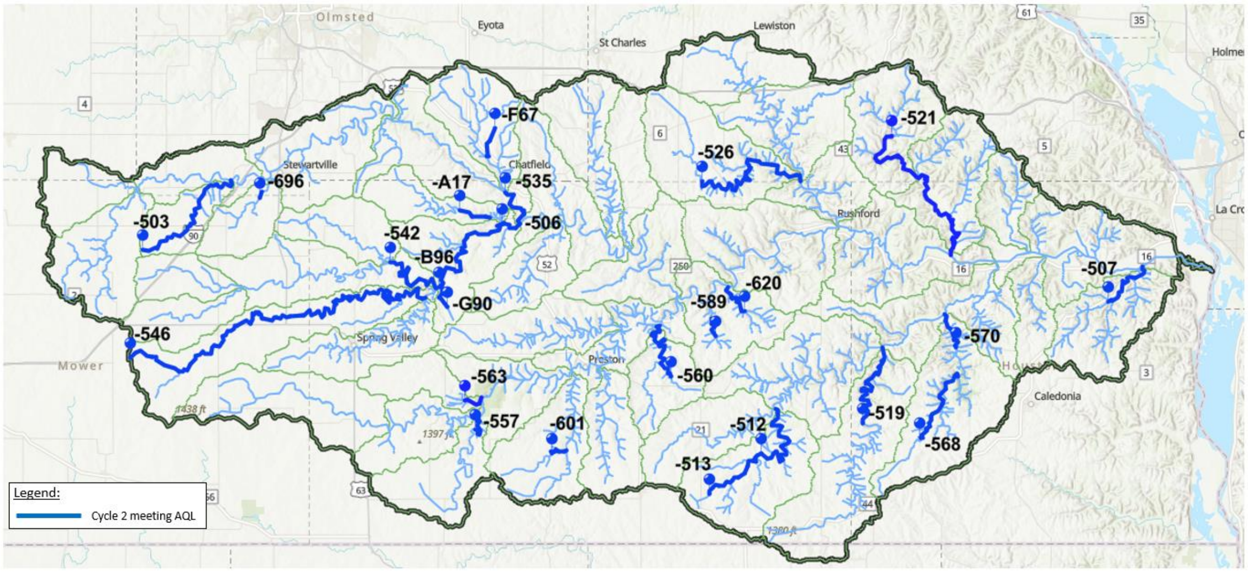


Table 3. RRW WIDs meeting fish and/or macroinvertebrate standards in Cycle 2.

Water body name	AUID	Use class	Meeting Fish standards?	Meeting Macroinvertebrate standards?
Robinson Creek	07040008-503	2Bg	X	X
Root River, Middle Branch	07040008-506	2Bg	X	X
Root River, Middle Branch	07040008-B96	2Bg	X	X
Thompson Creek	07040008-507	2Ag	X	X
Wisel Creek	07040008-512	2Ag	X	X
Wisel Creek	07040008-513	2Bg	X	X
Riceford Creek	07040008-519	2Bg	X	X
Pine Creek	07040008-526	2Ag	X	X
Root River, North Branch	07040008-535	2Bg	X	X
Bear Creek	07040008-542	2Bg	X	X
Deer Creek	07040008-546	2Bg	X	X
Canfield Creek	07040008-557	2Ag		X
Duschee Creek	07040008-560	2Ag	X	X
Beaver Creek West	07040008-568	2Ag	X	X
Beaver Creek	07040008-570	2Ag	X	X
Gribben Creek	07040008-589	2Ag		X
Crystal Creek	07040008-601	2Ag	X	X
Diamond Creek	07040008-620	2Ag	X	X
Carey Creek	07040008-696	2Bg		X
Bear Creek (Lost Creek)	07040008-A17	2Bg	X	X
Unnamed creek	07040008-F67	2Bg		X
Curtis Creek*	07040008-G90	2Ag	X	X
Money Creek	07040008-521	2Bg	X	X
Forestville Creek	07040008-563	2Ag	X	X

*Child WID of 07040008-541 re-designated from 2Bg to 2Ag.

Water quality and biological data indicate that nine stream segments are supporting designated uses but are very near the threshold for impairment (Figure 7, Table 4). These waters are vulnerable to future impairment and warrant special management to prevent future impairment. Additional discussion of these waters can be found in Section 7.

Figure 7. Waters close to the impairment threshold in the RRW.

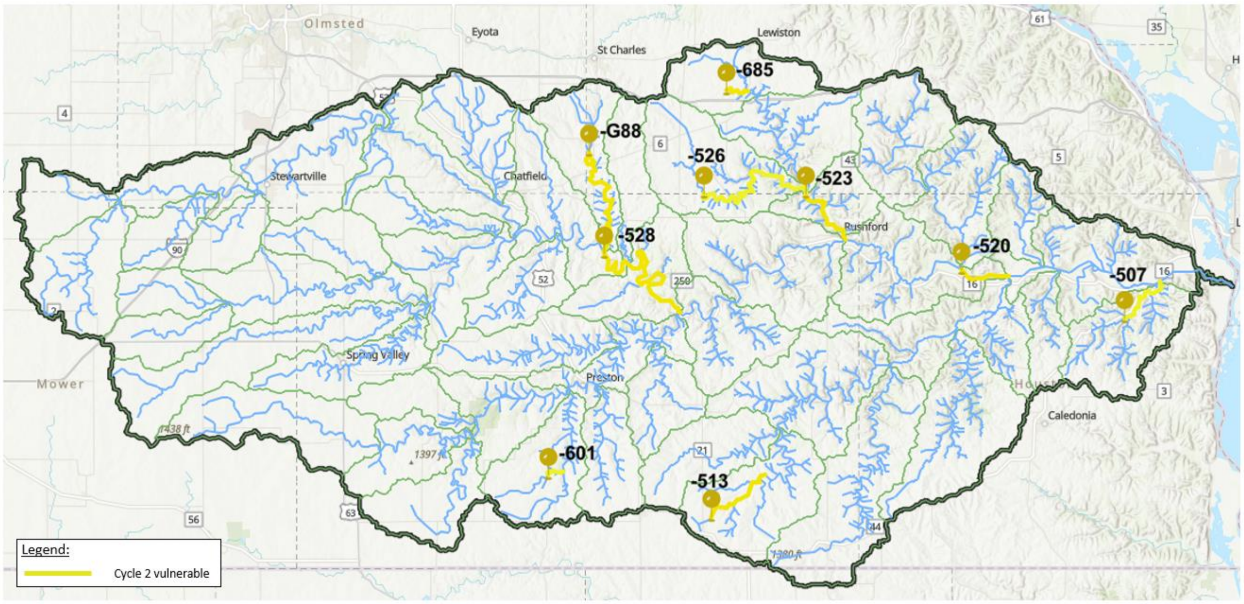


Table 4. Waters not currently impaired but vulnerable to future impairment.

Water body	WID	Water quality concern
Middle Branch Root River	07040008-528	Water transparency and TSS
Trout Run Creek	04070008-G88	Water transparency and TSS
Rush Creek	07040008-523	Water transparency and TSS
Root River	07040008-520	Water transparency and TSS
Wisel Creek	07040008-513	Macroinvertebrates
Thompson Creek	07040008-507	Water transparency and TSS
Crystal Creek	07040008-601	Fish and macroinvertebrates
Pine Creek	07040008-526	Macroinvertebrates and nitrate

Aquatic life stressors

Cycle 2 SID studied and diagnosed negative impacts to aquatic biology in select subwatersheds. Rather than covering the entire HUC-8 of the RRW, Cycle 2 SID focused on 13 streams (Figure 8, Table 5). The most common stressor in the RRW is habitat loss due to bedded sediment. Watershed hydrology was also investigated to confidently conclude that flow alteration is a stressor. Examples of flow alteration include channelization of streams and agricultural drain tile which in turn impact peak flows, sediment transport and available water in the stream channel. Flow alteration is either a direct or indirect contributor to all documented aquatic life stressors in the RRW.

Figure 8. Subwatersheds and streams studied in 2020 – 2021 for Cycle 2 SID in the RRW (MPCA 2022).

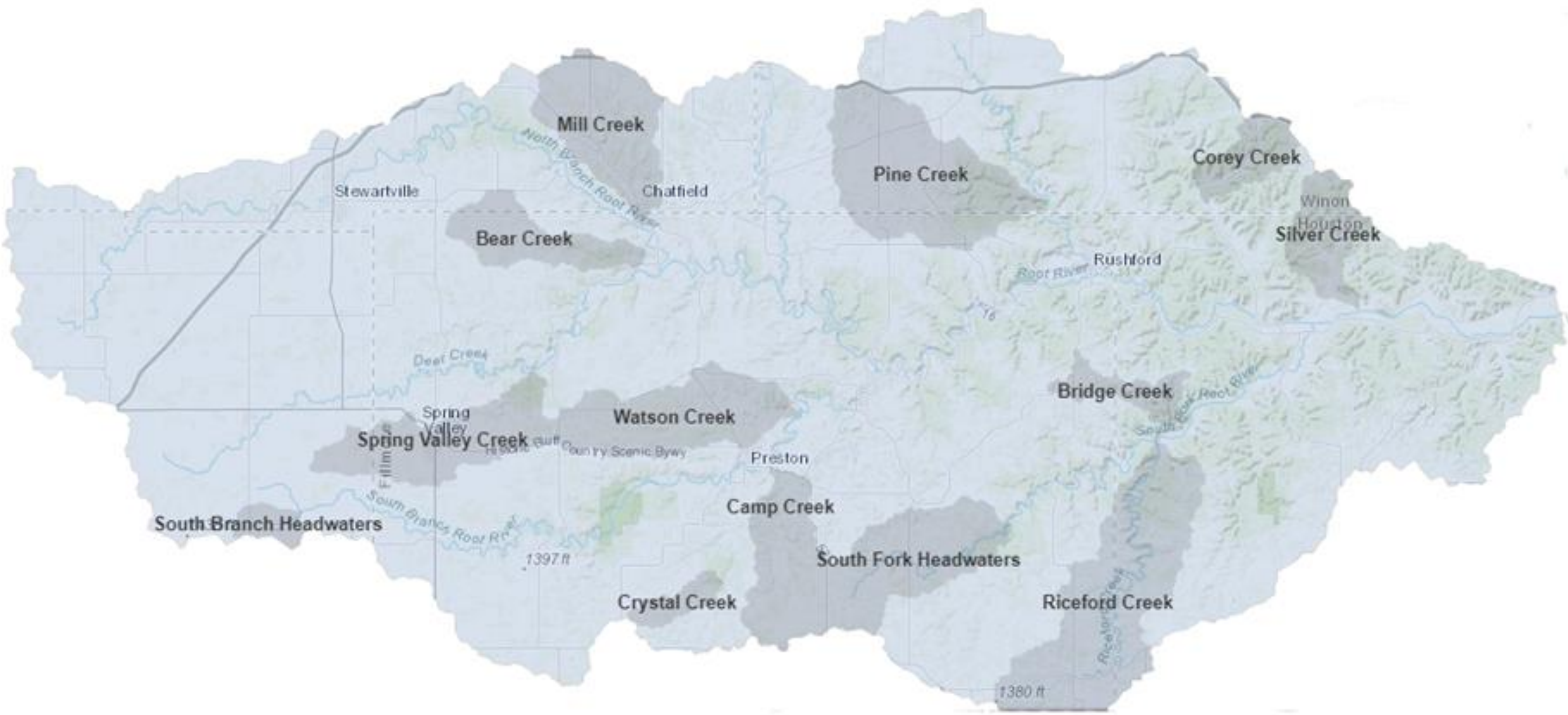


Table 5. Stressors to aquatic biology in select waters of the RRW from MPCA 2022. Highlighted streams are a focus of this report.

			STRESSORS						
Stream Name	**AUID**	**Aquatic Life Impairment**	**Temperature**	**Nitrate**	**TSS**	**DO/Eutro**	**Habitat**	**Connectivity**	**Flow Alteration**
New impairments/streams studied since previous SID									
Riceford Creek	07040008-H01	Macros	---	●	●	---	●	---	●
Upper Bear Creek	07040008-A18	Fish and Macros	---	●	●	---	●	o	●
Mill Creek	07040008-536	Fish and Macros	---	●	●	---	●	---	●
South Branch Headwaters	07040008-H18	Macros	---	●	o	●	●	---	●
Crystal Creek	07040008-601	*Not impaired*	---	o	o	---	o	---	o
Previously studied impairments also covered in 2022 SID									
Camp Creek	07040008-559	Fish and Macros	●	●	●	---	●	---	●
Riceford Creek	07040008-518	Macros	---	●	●	---	●	---	●
Corey Creek	07040008-631	Fish	●	---	---	---	●	●	●
Spring Valley Creek	07040008-548	Fish and Macros	●	●	●	o	●	---	●
Upper Bear Creek	07040008-540	Fish and Macros	---	●	●	---	●	o	●
Silver Creek	07040008-640	Fish and Macros	---	---	o	---	●	---	●
Bridge Creek	07040008-G92	Macros	---	---	o	---	●	---	●
Watson Creek	07040008-552	Fish and Macros	●	●	●	---	●	---	●
South Fork	07040008-573	Macros	o	●	●	●	●	---	●
Pine Creek	07040008-526	Macros *(delisting)*	---	o	o	o	o	---	o

KEY: ● = stressor; o = inconclusive/potential stressor; --- = not an identified stressor; gray shading = change in stressor status

* Highlighted waters indicate a focus in this WRAPS Update Report.

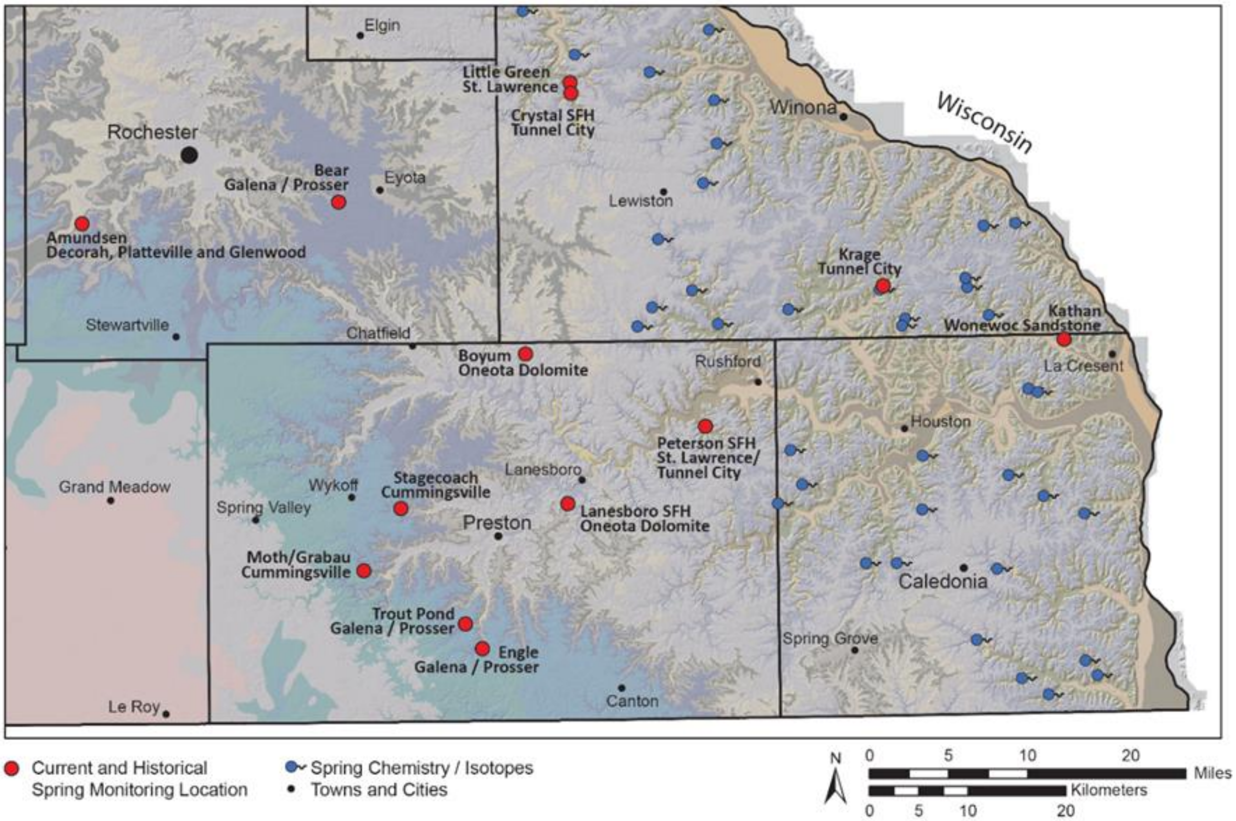
Springs and Groundwater

Because groundwater and surface water are so interconnected in the RRW, understanding the quality of groundwater and how it moves is very important (BALMM 2020). As previously noted, contamination of groundwater used as drinking water is of utmost importance in the RRW. Along with efforts of local governments and landowners to reduce pollution of groundwater, particularly by nitrate, government entities in the RRW have worked together to study the interaction of surface water and groundwater/drinking water in this region. State agencies, local government and private entities currently manage various groundwater projects within the RRW to better understand contamination severity of groundwater aquifers, age of groundwater, and groundwater availability. Findings from these projects allow for more efficient and effective implementation of reduction practices and goal setting. The following recent groundwater projects have expanded our knowledge of the water beneath the watershed's surface:

Sentinel Springs monitoring

The MPCA, DNR, MDA, MGS, Olmsted County, and Fillmore Soil and Water Conservation District (SWCD) collaboratively monitor a spring network in southeast Minnesota. Many of the springs are located in the RRW and have been measured for spring level, temperature, nitrate concentration and flow since 2016. Continuous monitoring of spring flow and nitrate as well as routine water chemistry sample collection sheds light on how aquifers respond to recharge and land use practices. Continuous or "time series" nitrate data is more informative than grab samples in that it captures delivery dynamics and lag times, thus helping resource managers better understand how nitrate moves from the land surface to groundwater. This is extremely important information for southeastern Minnesota because of karst geology and the known contamination of groundwater from nitrate and other pollutants. The Sentinel Spring monitoring locations are: Crystal Spring, Lanesboro Fish Hatchery, Stagecoach Spring (recently replaced with Peterson Fish Hatchery), Engle Spring and Bear Spring (Figure 9). Springs shown in blue in Houston and Winona counties have a full suite of chemistry associated with them collected as part County Geologic Atlas sampling. The hydrostratigraphy of the monitored springs varies, which means the spring water being monitored typically varies in age, chemistry and response to recharge (Faulkner and Trost 2022).

Figure 9. Current and historical spring monitoring locations in southeastern Minnesota; provided by John Barry, DNR.



Since 2012, continuous data has been collected by a Nitratax sonde at the Lanesboro Fish Hatchery spring, while several other spring locations were added in subsequent years (see Appendix C). Average nitrate concentrations from these long-term monitoring locations are summarized in Table 6 below.

Table 6. Average NO3-N concentrations from Sentinel Spring monitoring locations in SE Minnesota through 2022.

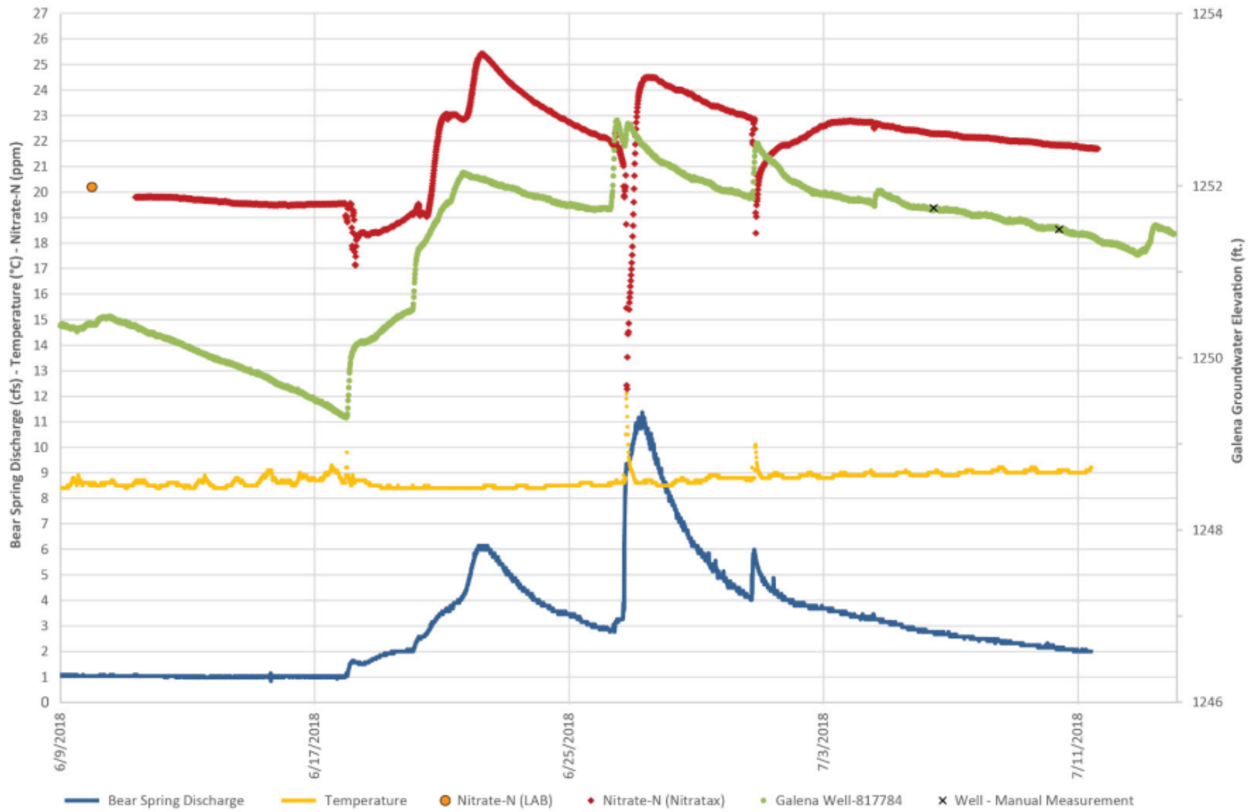
Spring name	Monitoring time frame	Minimum NO3-N (mg/L)	Maximum N03-N (mg/L)	Average N03-N (mg/L)	Receiving surface water
Crystal Springs Fish Hatchery	2016 – 2022	3.4	4.94	4.28	South Branch Whitewater
Lanesboro Fish Hatchery	2012-2022*	5.86	7.27	7.07	Duschee Creek
Stagecoach Spring	2018 – 2021	3.3	15.9	12.16	Watson Creek
Engle Spring	2017 – 2022	1.11	19.47	9.35	Willow Creek
Bear Spring**	2018 – 2022	0.94	33.96	17.23	Bear Creek

*Nitratax not deployed 2019-2021.

**Bear Spring located in the Zumbro River Watershed.

Continuous nitrate monitoring enables a greater understanding of how geology and precipitation influence nitrate concentrations of springs. Downward pulses in nitrate concentrations are coincident with precipitation events and indicate rapid connectivity between springs and their recharge areas. Spikes of increased nitrate concentrations are likely due to influx of nitrate from nutrient leaching in the soil and epikarst (the upper most layer beneath the land surface). A focused look at Bear Spring data overlayed with stream flow emphasizes this phenomenon (Figure 10). Figure 11 and Figure 12 display continuous nitrate concentrations from two Sentinel Spring locations (Engle Spring and Bear Spring).

Figure 10. 2018 Bear Spring discharge, temperature, and NO3-N concentrations (Barry et al 2018).



Gaps in data are due to equipment malfunction. See Section 4 for additional discussion on nitrate sources. For additional description of Sentinel Spring monitoring locations and monitoring data, see Appendix C.

Figure 11. Continuous NO3-N concentrations for Engle Spring (2017-2022).

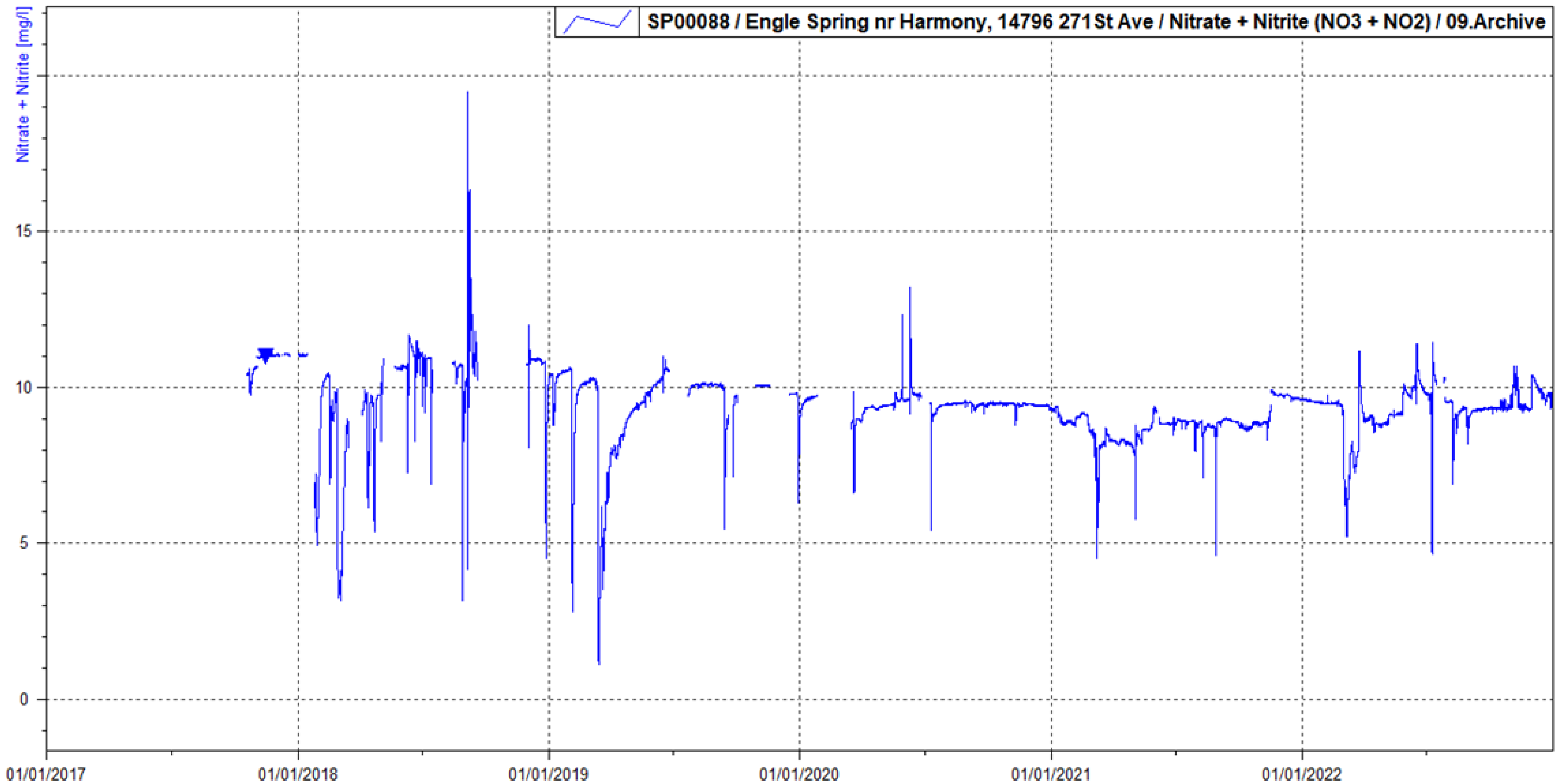
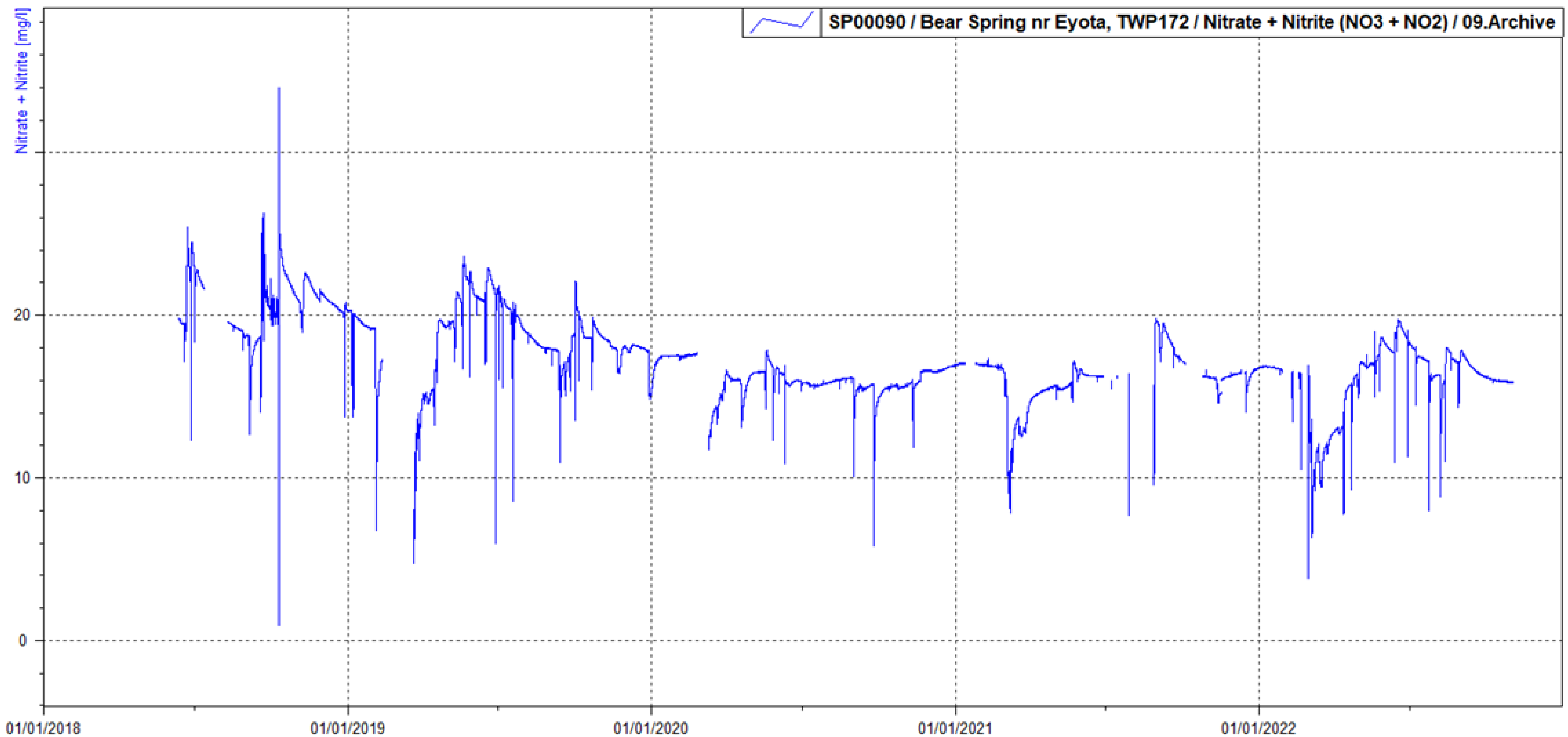


Figure 12. Continuous NO3-N concentrations from Bear Spring (2018-2022).



Root River Field to Stream Partnership

The Root River Field to Stream Partnership (RRFSP) is a multi-organizational effort to evaluate agricultural practices and water quality at multiple scales and landscape settings. The strategic selection of these study watersheds allows the findings to be applied to similar areas across southeastern Minnesota. The following four projects have been conducted by the RRFSP.

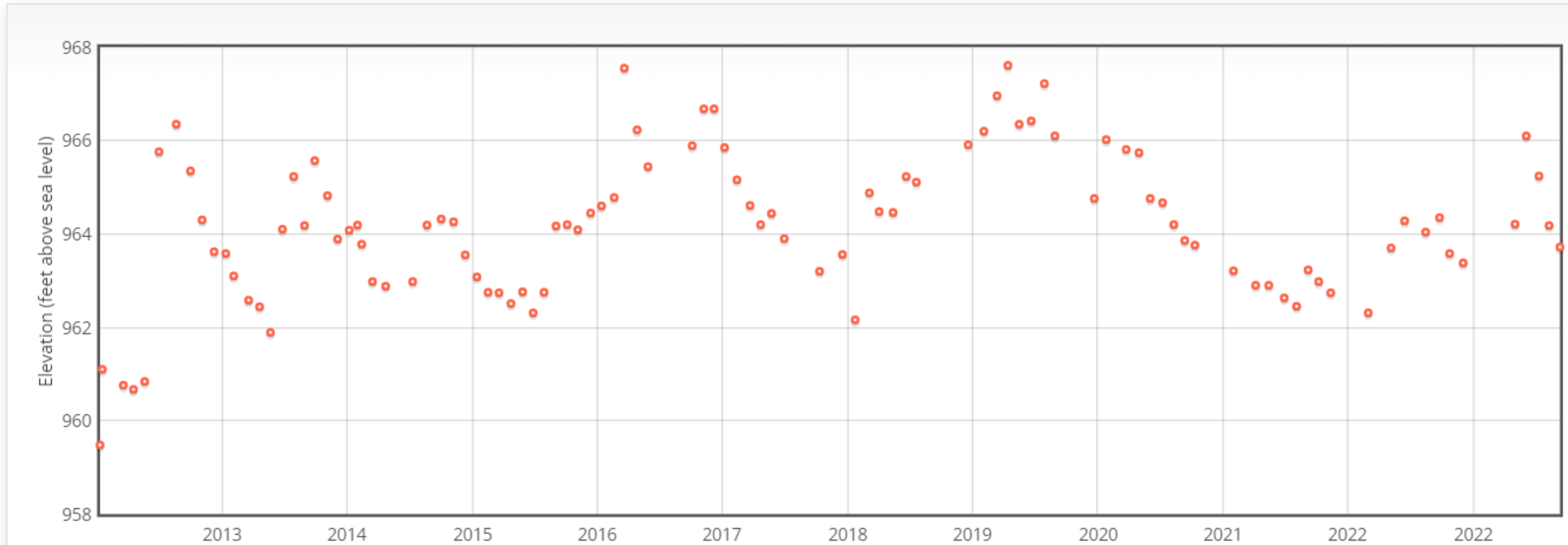
- **Groundwater Age Dating Study (Faulkner and Trost 2022):** This study was a partnership between RRFSP, University of Minnesota, Minnesota Geological Society (MGS) and United States Geological Service (USGS). Groundwater samples from 11 sites on Trout Brook in Dakota County (in Zumbro River Watershed), Crystal Creek in Fillmore County, and Bridge Creek and Hwy 76 in Houston County were collected (October 2020 through May 2021) and analyzed for various tracers to determine the age of groundwater. Sample sites varied between four wells, four springs, and three piezometers. Preliminary results include:
    - Groundwater samples suggested a mean age of at least 30 years.
    - Three of four springs had a complex mixture of both modern (after 1953) and premodern (before 1953) water.
    - The shallowest spring site sampled suggests groundwater residence time of about a decade.
    - Residence times for deeper springs and wells had residence times of around three to four decades.
    - These results were consistent with an independent method using a pesticide degradate as an age tracer in groundwater emanating from 13 springs across a 5-county area in southeast Minnesota.
- **2012-2019 Pesticide Monitoring Project (MDA 2021):** This monitoring project measured pesticide load and duration of pesticide present during storm runoff events in the three RRFSP watersheds. The top three pesticides detected were acetochlor, atrazine and metolachlor. Findings from this study are:
    - Pesticides were detected in all three RRFSP watersheds; 99% were herbicides;
    - 4% of pesticide concentrations were above aquatic life WQ reference values;
    - Measured total pesticide loads represent 1% of surveyed pesticide applications;
    - 89% of the pesticide loss occurred in May through July.
- **Real time data for Field to Stream:** https://mda.onerain.com/. This recently released website allows users to view real time monitoring conditions across the state. Data from edge-of-field surface runoff flumes and sub-surface drain tile sites are currently accessible. The site also displays current conditions measured at select groundwater, spring, and stream stations associated with the RRFSP. Other available data includes precipitation, stage, flow, runoff, wind speed, air temperature, water temperature, soil temperature at various depths, and continuous nitrate and turbidity.
- **Nested well monitoring.** In partnership with DNR's Cooperative Groundwater Monitoring Program, two groundwater monitoring wells were installed in the Crystal Creek Watershed in Spring of 2023. One well will evaluate groundwater from the Galena aquifer, the other from the Prairie Du Chien

aquifer. Wells will allow the understanding of 1) Groundwater levels under various climatic conditions, 2) Evaluation of long-term nitrate concentration trends, 3) Long-term relationships between agricultural practices and Galena aquifer nitrate trends at multiple scales including edge-of- field, well, spring and stream monitoring.

DNR's Observation Well Network

The DNR collaborates with MDH to maintain three observation wells in the RRW. Wells #787432 and #787433 monitor the Prairie du Chien and Jordan aquifers, respectively, in Chatfield (Figure 13). Well #658967 monitors the Jordan aquifer in Rochester. These wells monitor static water levels of groundwater aquifers over time to assess groundwater resources, determine long term trends, interpret impacts of pumping and climate, inform planning for water conservation, and evaluate water conflicts.

Figure 13. Observed water levels of MDH well 787432 from November 2012 – July 2023; provided by DNR Cooperative Groundwater Monitoring webpage.



MDH's Groundwater Restoration and Protection Strategy

The MDH coordinates the Groundwater Restoration and Protection Strategies (GRAPS) program. Many state agencies work together to gather data and create GRAPS reports for each watershed in Minnesota. The RRW 1W1P was one of the pilot watersheds to go through the CWMP process. At the time the Root CWMP was developed, the GRAPS program at MDH was not established. Because of this, the Root 1W1P group requested groundwater data as part of their CWMP midpoint review. The GRAPS team put together a collection of groundwater maps and data for the Root 1W1P planning boundary (which also includes the Upper Iowa River Watershed and Mississippi River – Reno Watershed). This data included: MDA Township Testing Program results, MDA Fall Fertilizer Restrictions Map, Primary Aquifer Map, Arsenic Results Map, Nitrate Results Map, DWSMA Maps for Public Water Suppliers, Karst Features Map, Drinking Water Well Map, Land Cover Map, and a Near Surface Pollution Sensitivity Map. The timing of this WRAPS Update Report with the midpoint of the Root CWMP allowed these data to be incorporated (see Figure 42, Figure 43, Figure 44, Figure 45, and Figure 46 in Section 7). A GRAPS report will be created for the Root 1W1P planning boundary at the end of this first CWMP cycle (2027). See Section 7 for select GRAPS information.

Additional information about regional groundwater monitoring can be found using the following resources and by referencing Appendix B.

- MPCA's 2020 GW Monitoring Status Report
- Minnesota Springs Inventory
- MDA well testing and evaluation
- MDH Well Management Program
- MGS/DNR County Well Index

2.2 Fish Kills

Fish kills can happen on any stream regardless of impairment status. Natural environmental processes and human sources of pollutants such as toxics are two very different types of causes of fish kills in Minnesota. Fish kills have occurred periodically in southeast Minnesota, including in the RRW.

In recent years, sizeable fish kills near the Lewiston area have been reported on South Branch Whitewater River (2015), Garvin Brook (2019), Trout Valley Creek (2021) and Rush Creek (2022). The Rush Creek fish kill is the only event located in the RRW. The commonalities across these four fish kills included:

- The streams were all at generally low flow condition just prior to the fish kill;
- A strong rainstorm occurred in each contributing area, with enough intensity to mobilize pollutants from the watershed but without volume to dilute the pollutant concentrations in the trout streams;
- Investigations of all four cases determined that polluted runoff from the upstream drainages caused the fish kills.

These commonalities can be useful to resource managers in describing high risk conditions and locations for fish kills.

A desired future condition in the RRW is that no fish kills will occur. Working toward zero fish kills will serve to reduce the risk of fish kills. Section 7 and 8 describe specific tools and strategies that may be employed to reduce fish kill risk in the RRW and more generally in southeast Minnesota. MPCA is dedicated to assisting local and state partners in creating and using these resources.

Rush Creek 2022 Fish Kill

Rush Creek is a cold-water trout stream that begins just south of the city of Lewiston in Winona County. It flows in a southerly direction into Fillmore County and eventually joins the Root River at the city of Rushford. Rush Creek is highly valued by trout anglers.

On the evening of July 25, 2022, an angler fishing Rush Creek reported dead fish to the Minnesota Duty Officer (MDO) (Figure 14). Local staff from the DNR and MPCA began coordinating on a response that evening. The field response got underway the following morning, July 26th, and included staff from Winona County, the MDA, DNR, and MPCA.

Fisheries staff from the DNR estimated that over 2,500 fish were killed, including at least 1,900 brown trout. The responding agencies concluded that the fish kill likely happened after a significant runoff-producing local rainfall event (1.5-2 inches fell in a short period) that occurred on July 23rd. Several factors may have contributed to the runoff being lethal to fish including: recent upstream applications of manure, fungicides, and insecticides; warmer summer stream temperatures; and low-flow conditions in the creek prior to the rainfall, resulting in limited dilution of the contaminated runoff. Actions to help prevent future fish kills can be found in subsequent Section 8.

Figure 14. Rush Creek fish kill location and affected fish.

Photo credit: Star Tribune

2.3 Water quality trends

Collecting surface water and groundwater data for trend analyses has been a long-standing priority in the RRW. Trend analyses offer an opportunity to better understand the trajectory of pollutants of concern (TN, TSS and TP) and observe changes over time. This is important information for water resource managers as they prioritize conservation practices, landowner outreach, and citizen education.

The following narrative summarizes trends from surface water and groundwater through MPCA's Watershed Pollutant Load Monitoring Network (WPLMN) and Long-Term Biological Monitoring (LTBM) programs, as well as MDA's RRFSP and Drinking Water Supply Management Area (DWSMA) monitoring programs.

Surface water quality

The RRW has nine long term monitoring stations throughout the watershed: six watershed pollutant load monitoring network (WPLMN) sites and three long term biological monitoring (LTBM) sites (Figure 15, Table 7). Data from WPLMN stations is used to measure and compare pollutant load information and track water quality trends. WPLMN stations have a flow gage logging flow data every thirty minutes. This is paired with water chemistry samples that are collected by staff. Water chemistry samples are mostly collected during elevated flow conditions following a precipitation event, but also during normal or dry conditions. Once 10 years of data has been collected at WPLMN sites, trend analyses can be conducted.

Figure 15. Long term monitoring stations for WPLM (triangles) and LTBM (squares) in the RRW.

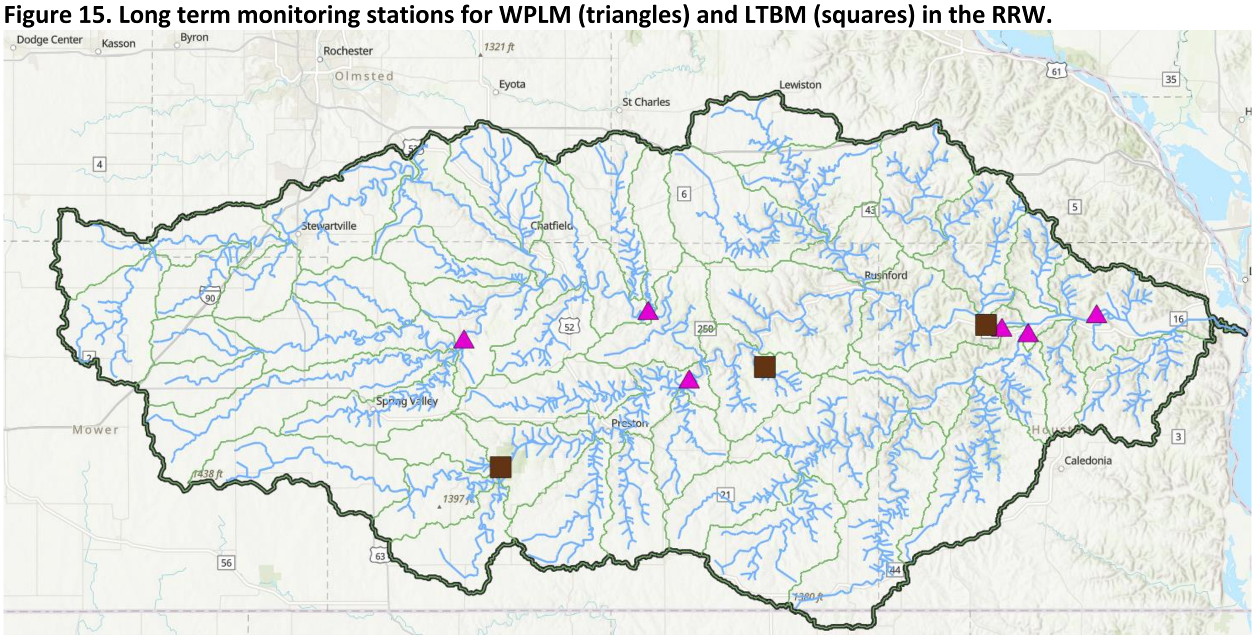


Table 7. RRW long term monitoring sites.

Site name	Station ID	Type of station	Approved period of record*
Middle Branch Root River	H43076001	WPLMN - subwatershed	9/11/2012 – 11/23/2021
Root River near Houston	E43017001	WPLMN - subwatershed	10/1/2012 – 9/25/2023
Root River near Mound Prairie	H43007002	WPLMN - HUC-8 outlet	10/9/2008 – 3/4/2022
Root River near Pilot Mound	E43054001	WPLMN - subwatershed	8/9/2002 – 9/25/2023
South Branch Root River at Lanesboro	H43049001	WPLMN - subwatershed	7/24/1998 – 11/1/2020
South Fork Root River near Houston	W43022002	WPLMN - subwatershed	3/2/2010 – 11/16/2010
Forestville Creek	08LM020	LTBM	2008 – 2022
Diamond Creek	04LM115	LTBM	2004 – 2021
Root River near Houston	08LM057	LTBM	2008 – 2021

* *There is a two-year delay between data collection and publication to allow for data analysis and review.*

The MPCA's latest trend analysis was developed in 2020 as part of the five-year update on Minnesota's Nutrient Reduction Strategy (NRS; MPCA 2020). At the writing of this report, of all the long-term monitoring stations, only station, "Root River near Mound Prairie," has the 10 years of data required to conduct an official trend analysis. Trends are established for flow corrected and nonflow corrected values. Flow corrected values describe whether a pollutant load is increasing or decreasing at any given flow. Nonflow corrected values are connected to particular flows and may be skewed towards higher flows (since that is the target for WPLMN sampling). For this report, only flow corrected trends will be discussed. Table 8 describes trends for nitrate, total phosphorus (TP) and total suspended solids (TSS). The flow corrected trend (trend at any given flow) for TP and TSS is generally decreasing from previous years; no changes in nitrate.

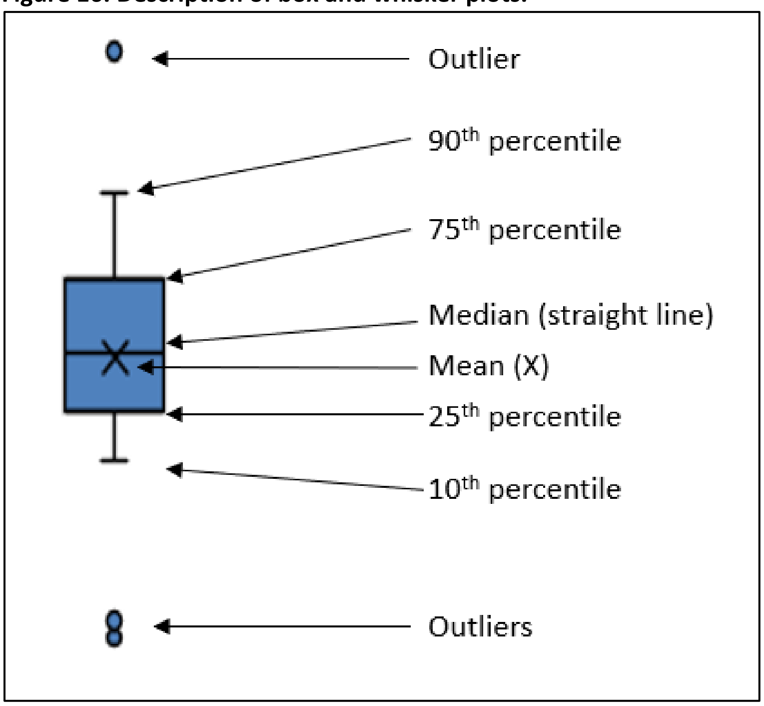
Table 8. Pollutant trends for Root River near Mound Prairie (H43007002) 2008-2020 (MPCA, 2020).

	Flow corrected trend (at any given flow)
Nitrate	No significant trend
TP	Significantly decreasing
TSS	Significantly decreasing

Trend analyses cannot yet be conducted for the five remaining WPLMN sites. Box and whisker plots (Figure 16) displaying water quality data collected between 2013 through 2022 for TSS, nitrate and TP are displayed in

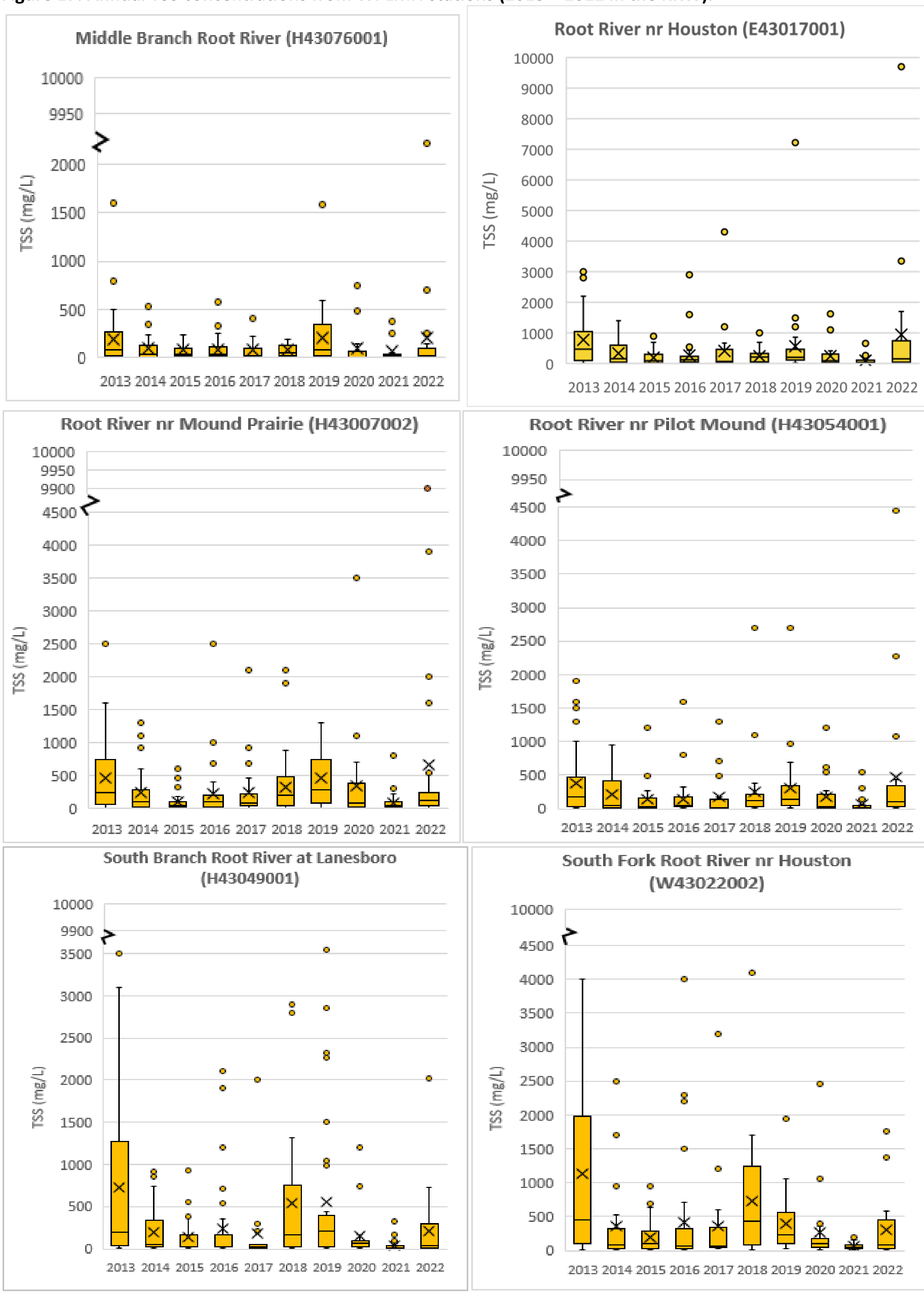
Figure 17, Figure 18, and Figure 19 respectively.

Figure 16. Description of box and whisker plots.



A notable pattern for TSS is that average concentrations are consistently above the 65 mg/L TSS standard across all five WPLMN sites (Figure 17). This is because the WPLMN monitoring targets storm events in an effort to accurately quantify pollutant export from the RRW. Because of this, TSS concentrations do not necessarily reflect average conditions of streams throughout an entire year. For larger TSS and TP graphics for each site, please see Appendix H. In the five WPLMN stations, average nitrate concentrations are consistently below 10 mg/L (Figure 18). This is due to the stations' location in the RRW (lower in the watershed with larger drainage areas). Elevated nitrate concentrations are more evident at stations in headwater portions of the RRW with high groundwater influence. TP is generally above the 0.150 mg/L standard across all five WPLMN stations (Figure 19). While average TP is elevated, response variables (chlorophyll-a, DO, and biological oxygen demand) are not. This indicates that eutrophication is not an issue at these locations in the RRW at this time. Trend analysis for many of these sites will likely be conducted in 2024.

Figure 17. Annual TSS concentrations from WPLMN stations (2013 – 2022 in the RRW).



Note: 2021 and 2022 had limited sampling of TSS at all stations (0-3 samples collected).

Figure 18. Annual nitrate + nitrite concentrations from WPLMN stations (2013-2022) in the RRW.

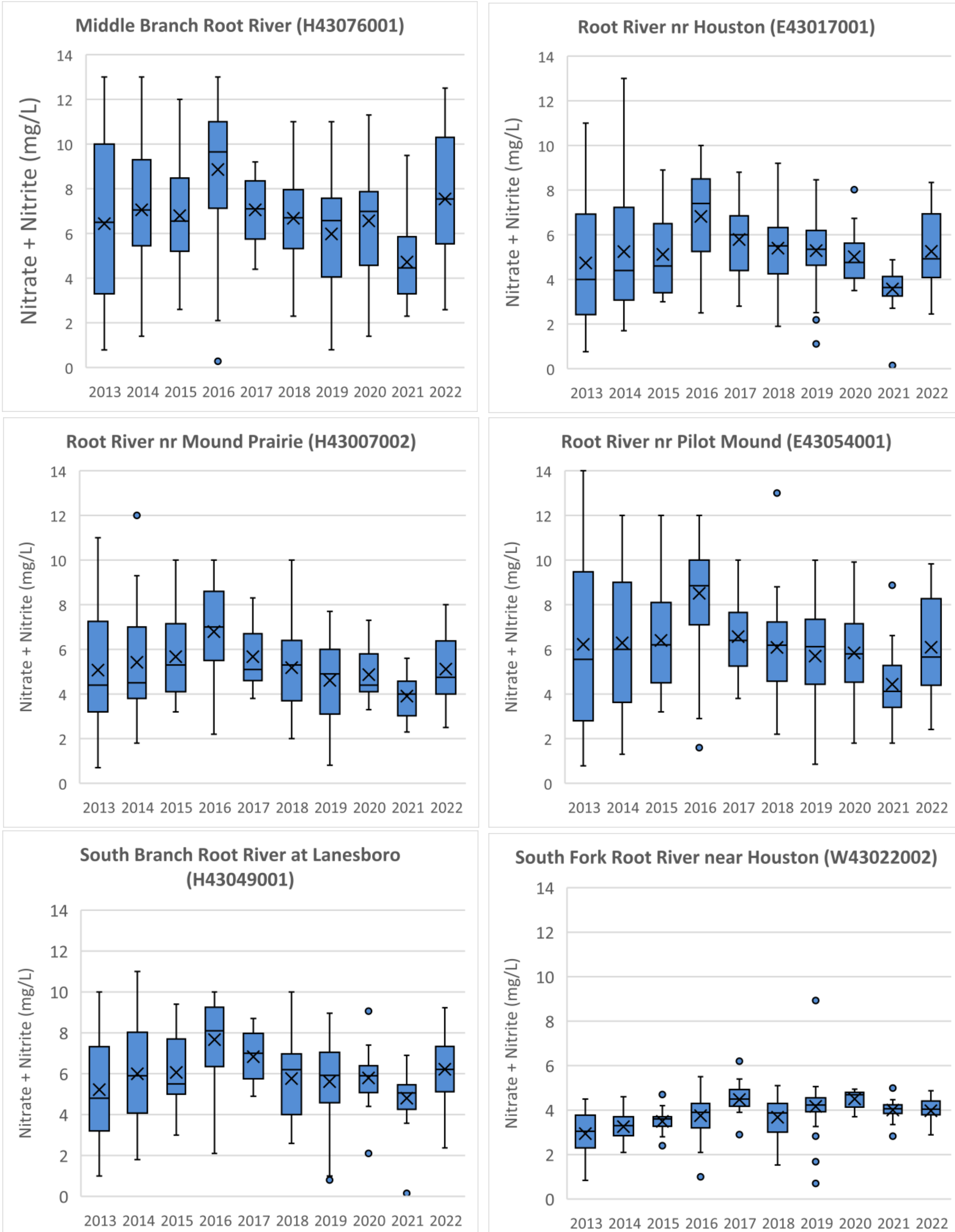
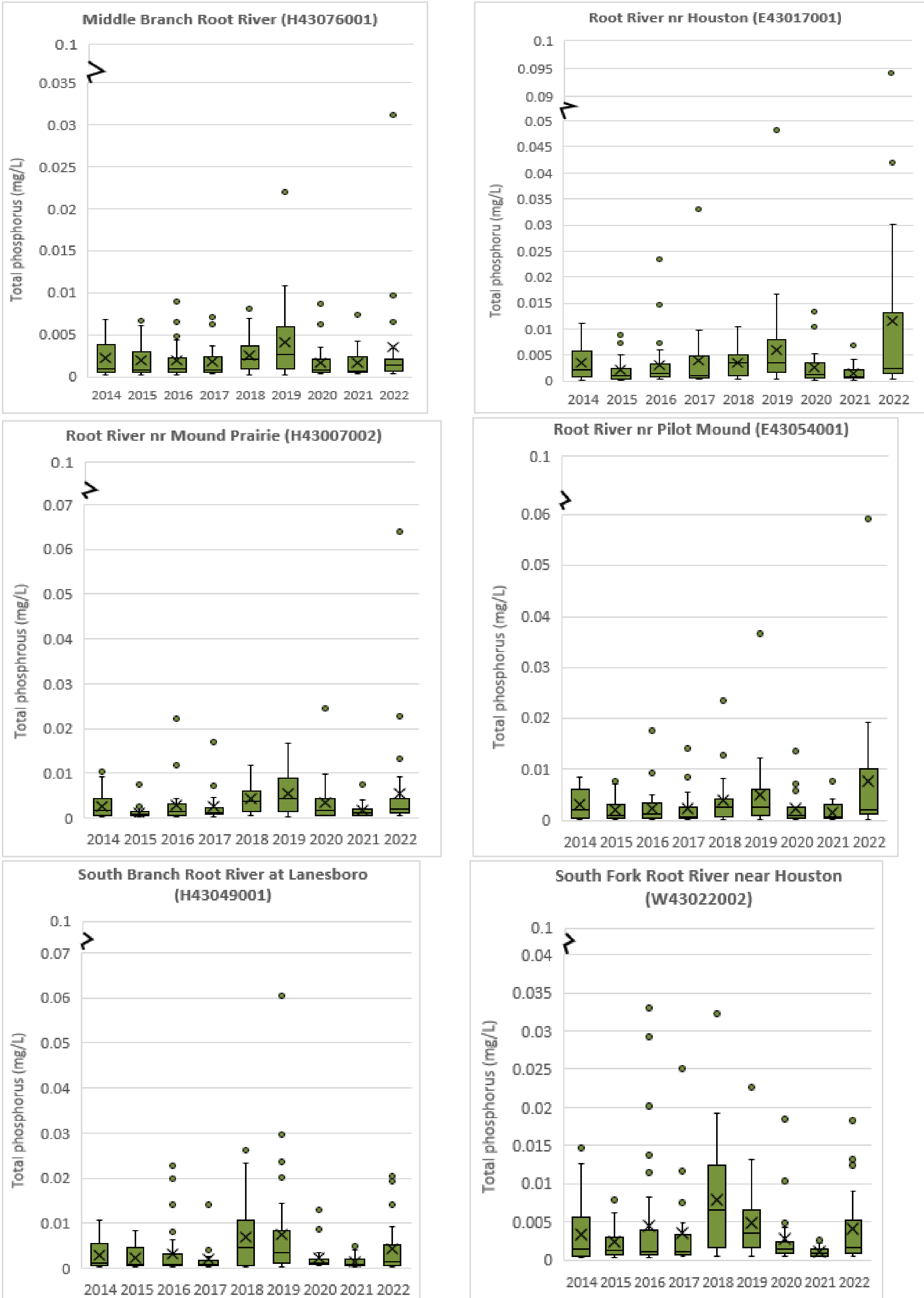
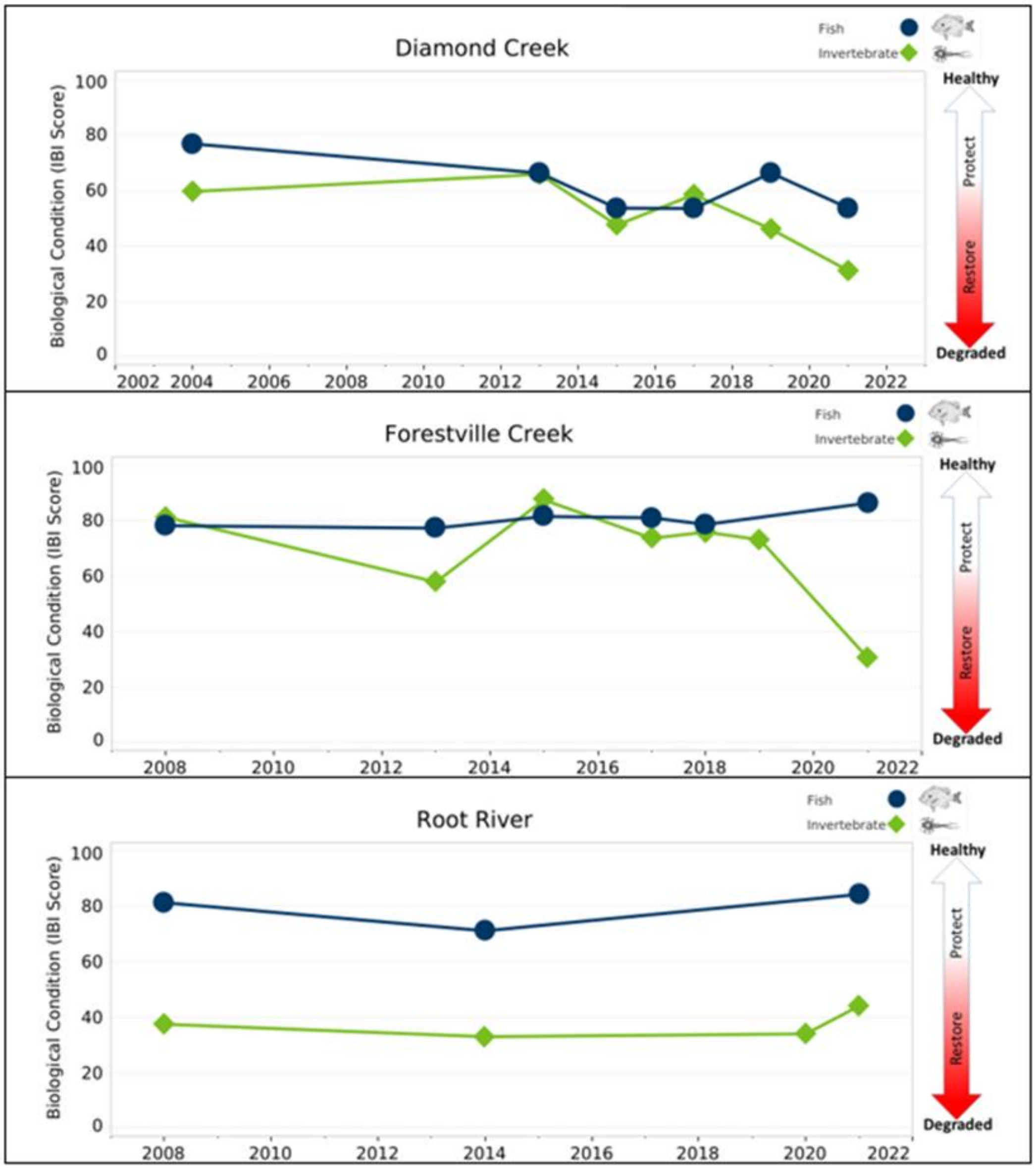


Figure 19. Annual TP concentrations from WPLMN sites (2014-2022) in the RRW.



Data from the three LTBM sites is not extensive enough to conduct an official trend analysis (Figure 20). Fish communities from Diamond Creek (04LM115), Forestville Creek (08LM020) and Root River (08LM057) are remaining steady and in healthy condition. Macroinvertebrate communities from these three locations are closer to being degraded. Additional monitoring will inform future trend analyses.

Figure 20. Fish and macroinvertebrate data from LTBM sites (2004-2022) in the RRW.



Generally speaking, data results from WPLMN sites and LTBM sites are remaining steady across most sites. Elevated measurements of certain pollutants are linked to sampling that occurred following a storm event (communication with MPCA staff on 03/30/2023). For historical trends and to access future trend reports, please see MPCA's WPLMN webpage: https://www.pca.state.mn.us/water/watershed-pollutant-load-monitoring.

DNR Long Term Fisheries Monitoring Data:

The Lanesboro Area Fisheries Office (DNR) continues to implement its Long-Term Monitoring Program (LTM) in Driftless Area streams across southeast Minnesota (see Figure 28 for site locations). This LTM dataset can help describe the relative importance of abiotic (i.e. flow, temperature) and biotic (i.e. aquatic vegetation, fish community size) drivers, as well as evaluate management actions implemented to enhance managed fish populations. Collectively, these 25 LTM sites on 22 streams (7 within the RRW) represent a half-century of change in the Driftless Area. Several individual sites have between 35 and 47 years of continuous annual sampling. The LTM dataset represents a long-term experimental approach to identify key trends, evaluate primary management activities, and test several trout-related ecological theories.

Figure 21 and Figure 22 below depict the changes in regional abundance of brown trout across southeast Minnesota. Metrics include median annual abundance of adults per mile, young-of-year per mile, greater than 12 inches per mile, and pounds per acre. Across the southeastern Minnesota region, the data is showing a dramatic increase in the number of young and adult brown trout. There are many factors that could be impacting this increase, but it is likely that decreases in water temperature are playing a big role in supporting larger brown trout populations (DNR communication 8/25/2023). See Section 3 for more information about decreasing water temperatures.

Figure 21. Estimated adult and young of year (YOY) brown trout population across all LTM sites (1970-2022).

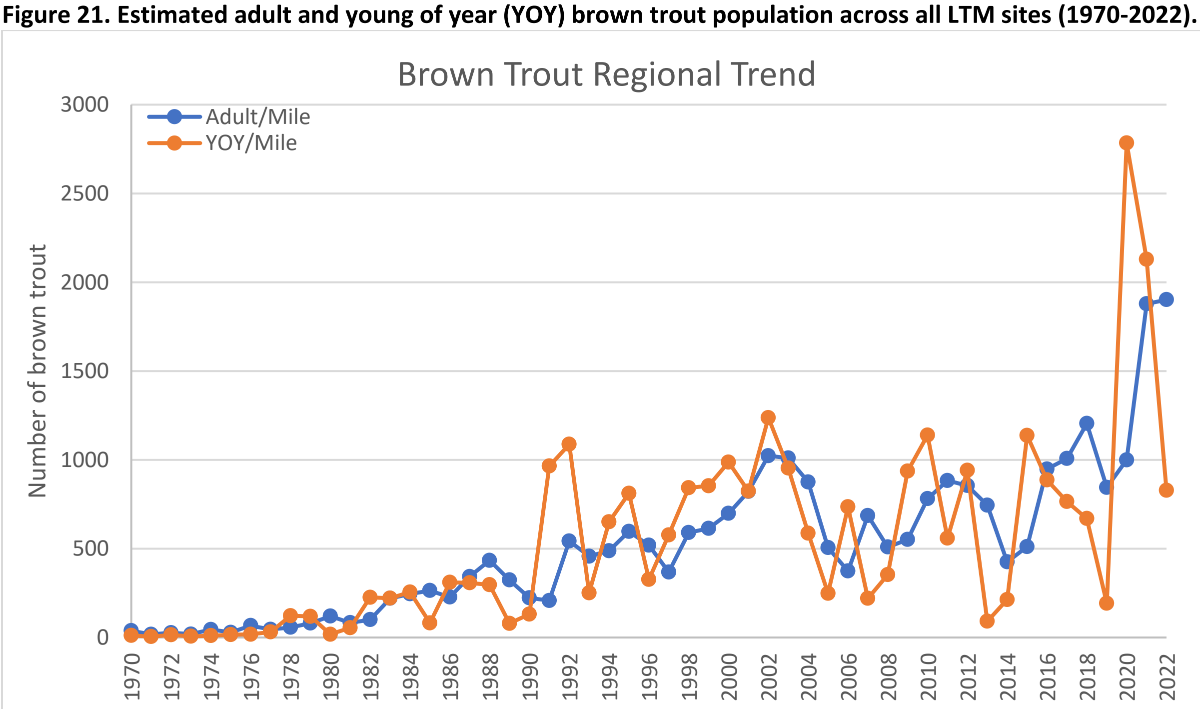
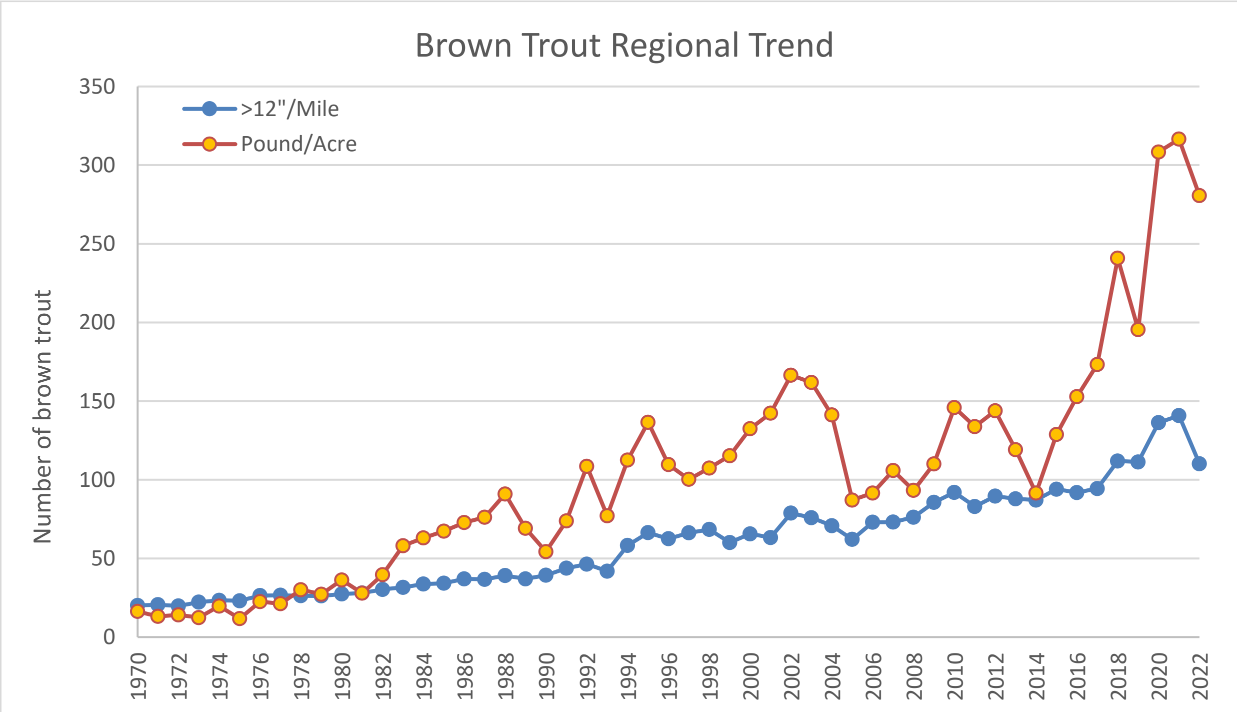


Figure 22. Count of Brown trout size class (>12") and weight (lbs) across all LTM sites (1970 - 2022).



Groundwater trends

The RRFSP includes a nitrate monitoring network that conducts bi-weekly monitoring of groundwater and surface water to establish long-term nitrate trends. A majority of the sites have nitrate data beginning in 2010, while the remaining began in 2013. The hatchery sites included below are equipped with continuous nitrate sensors. Eight of the 12 sites have significant nitrate trends (Table 9).

Table 9. NO3-N trends for SE MN NO3-N Monitoring Network in hydrostratigraphic order (RRFSP and Barry, Runkel, Alexander 2023).

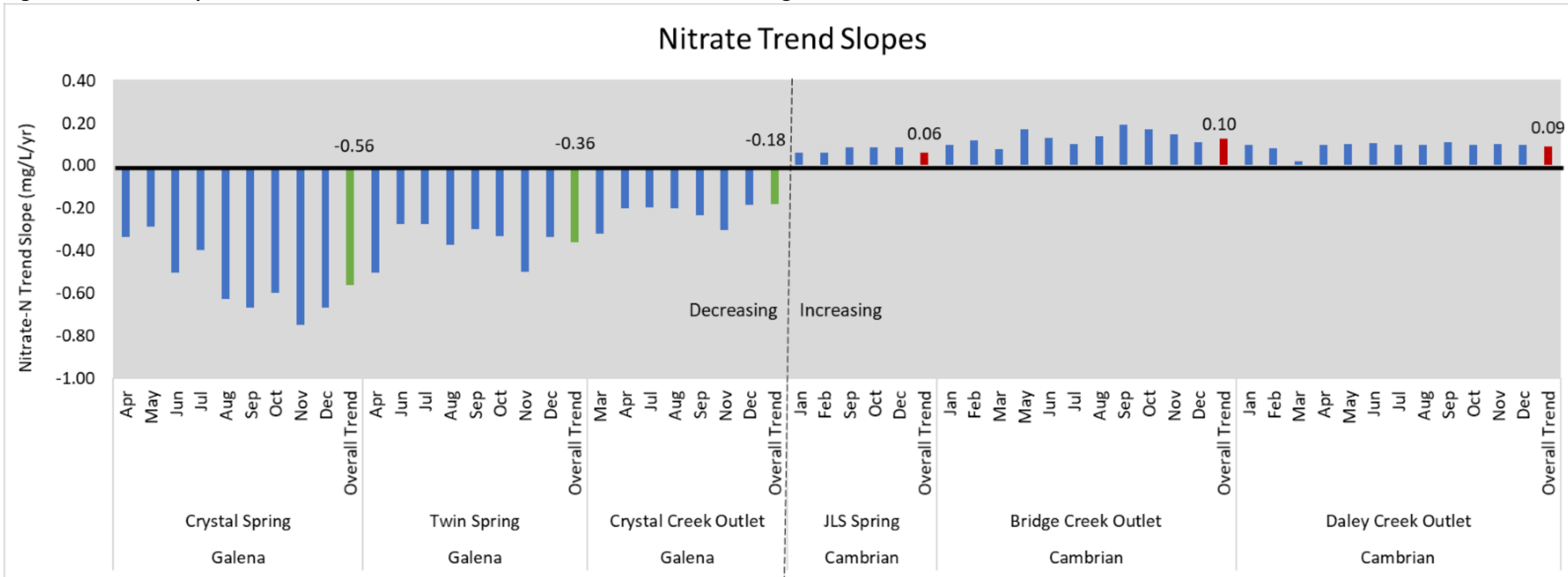
Site	Type	Watershed	Formation	Trend Year Period	NO3-N Trend	NO3-N Trend Slope (mg/L/yr)
Crystal Spring	Spring	Crystal Creek	Galena-Stewartville	2010-2021	↓	-0.56
Twin Springs	Spring	Crystal Creek	Galena-Lowermost Prosser	2010-2021	↓	-0.36
Crystal Creek Outlet	Stream	Crystal Creek	Galena Group	2010-2021	↓	-0.18
Burr Oak	Spring	Willow Creek	Galena-Cummingsville	2010-2021	-	No Trend
Rainy Spring	Spring	Canfield Creek	Galena-Cummingsville	2010-2021	-	No Trend
Fountain West	Spring	Rice Creek	Galena-Cummingsville	1976-2021	-	No Trend
Lanesboro Fish Hatchery	Spring	Duschee Creek	Oneota/Jordan	1981-2021	↑	+0.07
Bridge Creek Outlet	Stream	Bridge Creek	Oneota/Jordan/St. Lawrence/Tunnel City/Wonewoc	2010-2021	↑	+0.10
Daley Creek	Stream	Daley Creek	Oneota/Jordan/St. Lawrence/Tunnel City/Wonewoc	2013-2021	↑	+0.09
Peterson Fish Hatchery	Spring	Root River/Camp Hayward Ck	Upper Lone Rock	1990-2021	↑	+0.08
Jerry Lee Spring	Spring	Bridge Creek	Upper Lone Rock	2013-2021	↑	+0.06
Rostvold Spring	Spring	Bridge Creek/Lower South Fork	Upper Lone Rock	2013-2021	-*	No Trend

*Signal for increasing trend, but classified as no trend since the lower 95% confidence interval contained zero

The following patterns in nitrate were identified through this trend analysis (RRFSP and Barry, Runkel, Alexander 2023):

- Shallower Galena aquifers had decreasing (or no) nitrate trends while deeper/older Cambrian aquifers had increasing nitrate trends (Figure 23). There are a variety of factors that affect trends including precipitation, land management, land use (percent row crop) and residence time of springs. In shallow aquifers, impacts from nitrate reduction efforts can be more easily identified, measured, or assessed. In deeper Cambrian aquifers, longer residence times do not allow for easy, direct assessments of BMPs on the landscape. It is important to continuously consider these many factors when assessing nitrate trends. Particularly for deep aquifers, nitrate reduction efforts are an investment with a long-term outlook.
- Crystal Spring, Twin Spring and Crystal Creek all showed decreasing trends; nitrate concentrations decrease the most in the month of November.
- Sites in the Bridge Creek Watershed receive groundwater from Upper Lone Rock and Jordan (Cambrian) aquifers and see increasing nitrate trends across all months of the year. For Bridge Creek, highest nitrate concentration increases peak in May, September, and October.

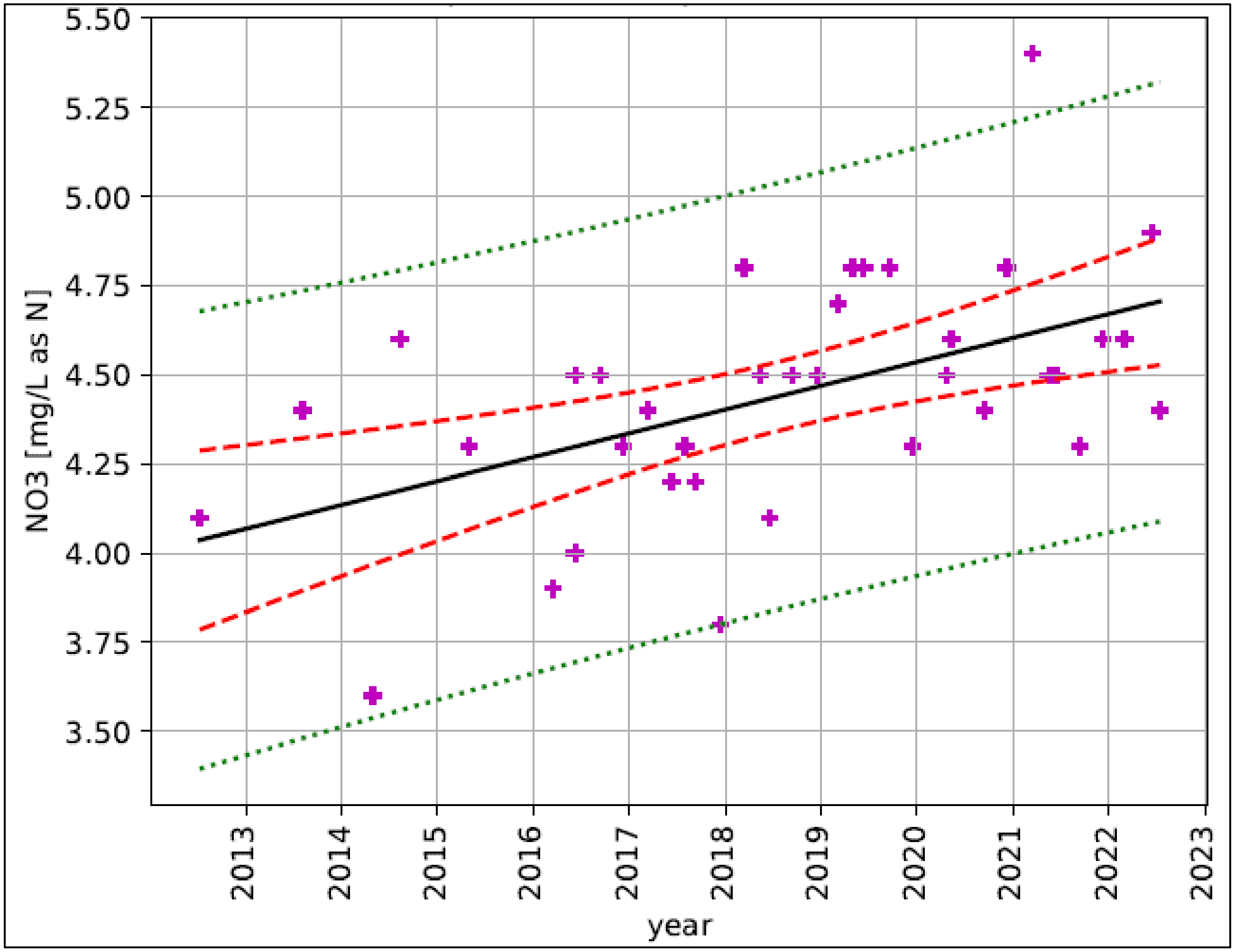
Figure 23. Trend slopes for NO3-N concentrations from RRFSP NO3-N Monitoring Network sites.



MDA's Chatfield DWSMA Monitoring

Chatfield DWSMA had additional recent monitoring due to Part 2 of MDA's Groundwater Protection Rule. Currently, Chatfield DWSMA is at Level 1 of the MDA Protection Rule as the nitrate concentration within the municipal supply well was at least 5.4 mg/L, but less than 8 mg/L, within the last 10 years. Recent data show the overall nitrate trend is increasing (Figure 24). This increasing trend in nitrate isn't necessarily a reflection of current nitrate leaching rates, as there has been focused implementation in the area of the Chatfield DWSMA. Springshed mapping or groundwater age dating may aid in better understanding of how historic and current land uses are influencing nitrate trends in this DWSMA.

Figure 24. NO3-N concentration trends for Chatfield DWSMA. Provided by MDH.



Purple marks indicate monitoring data, black line represents regression line, red-dashed line notes 95% confidence interval, green-dotted line represents 95% prediction interval.

3. Climate impacts

Changes in climate have been documented not only globally, but locally in the RRW. Climate summaries for Minnesota watersheds are provided by the DNR through their Watershed Health Assessment Framework (WHAF) tool (DNR 2019). In the RRW, air temperature and precipitation records from 1895 to 2018 display changes in climate (Figure 25, Figure 26, Figure 27). Overall, data shows that the RRW is experiencing warmer temperatures and wetter conditions. Warming is most notable during the winter months and more precipitation is observed during spring and summer.

Figure 25. Monthly minimum air temperature distribution and departure from record mean temperature for the RRW (degrees Fahrenheit). DNR, 2019.

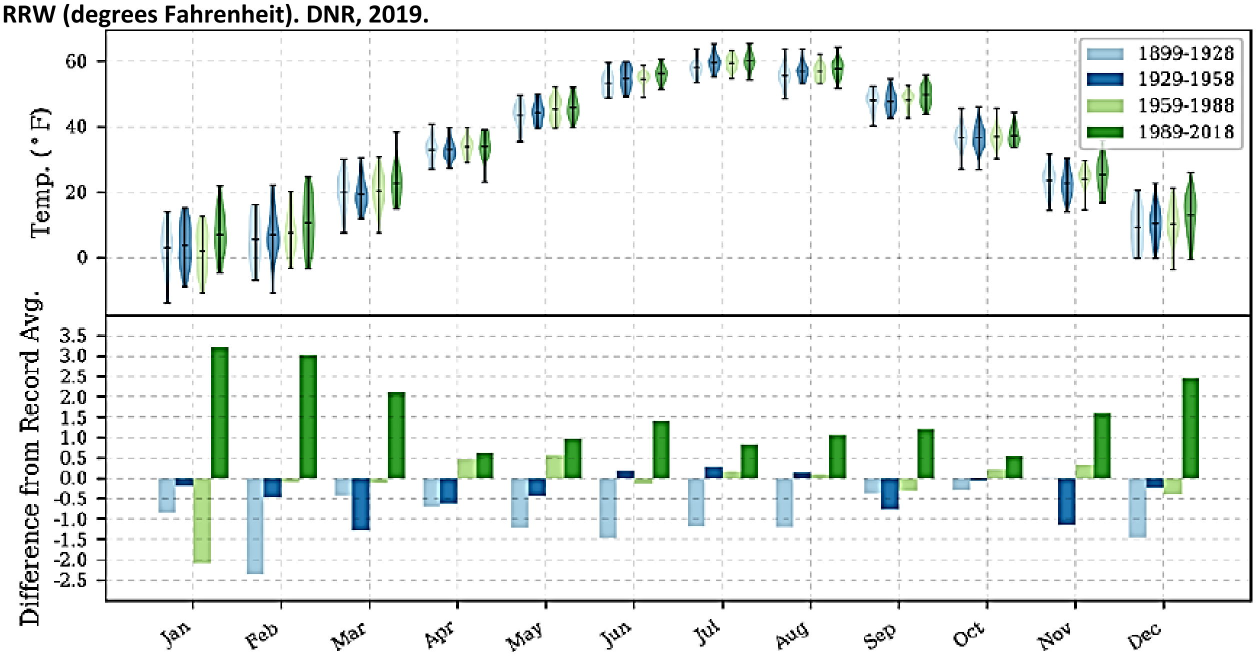


Figure 26. Annual average air temperature in degrees Fahrenheit for RRW. DNR, 2019.

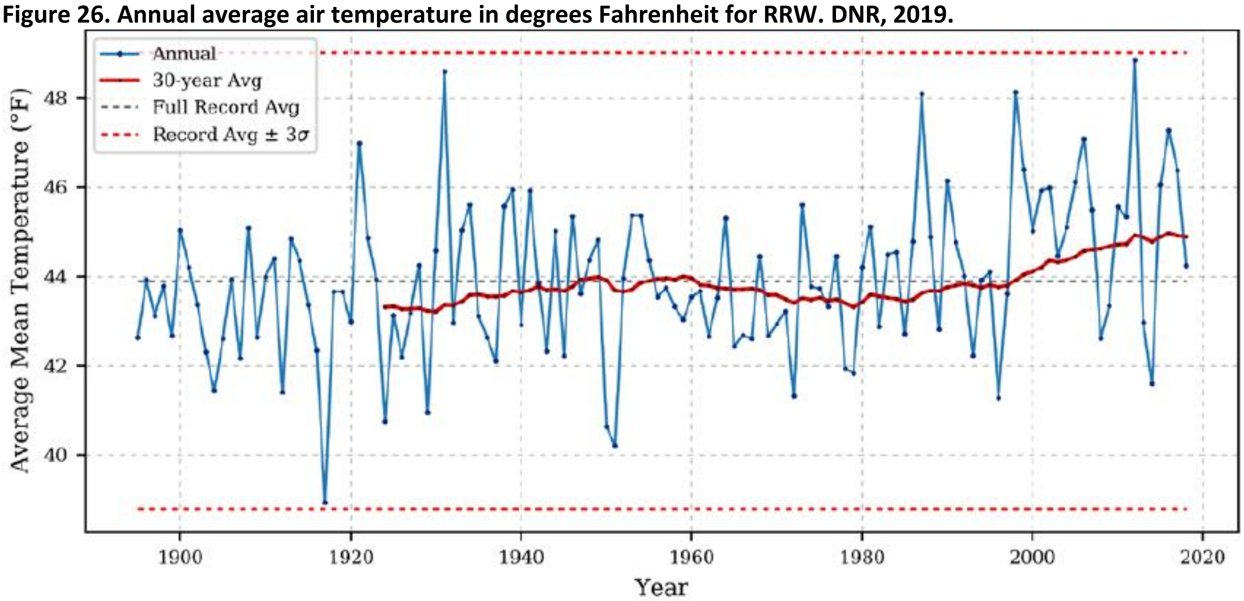
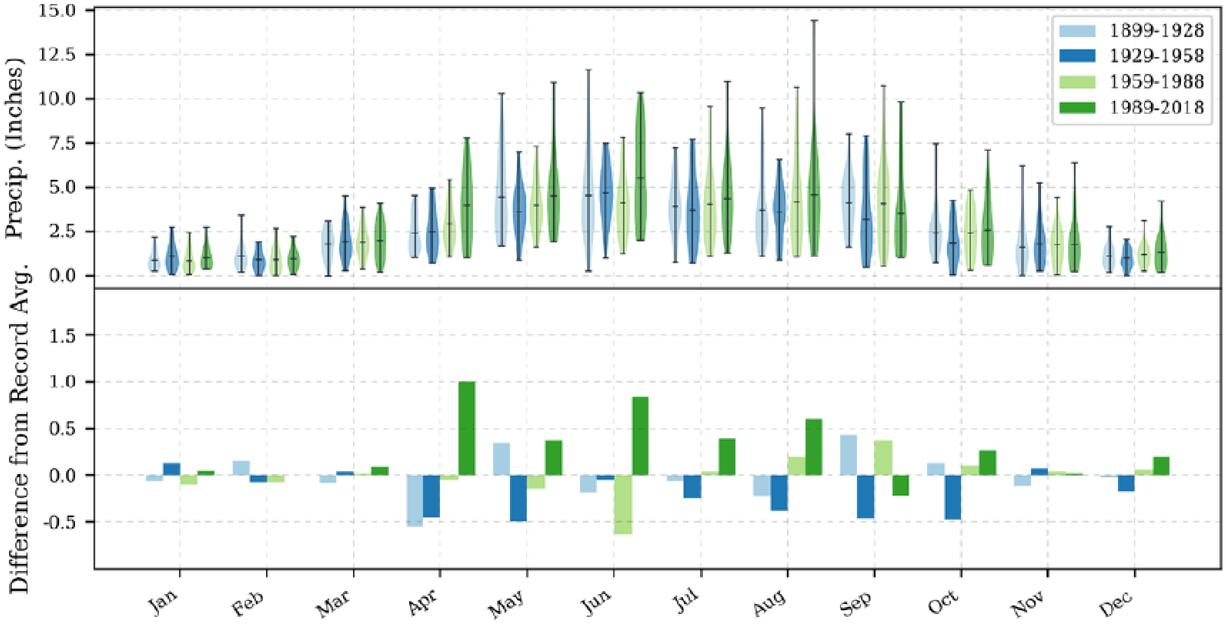


Figure 27. Monthly precipitation distribution and departure from record mean precipitation (inches). DNR 2019.



DNR has also been tracking hydrologic trends in the RWW using data from 1890 through 2020 (Root River gage at Houston, Minnesota). Hydrologic data includes average precipitation, average stream flow and average peak flows. In the Root River, 1991 was the year when significant changes in hydrologic conditions occurred (DNR 2022). Since 1991, the following has been noted for the Root River at Houston, Minnesota:

- Average annual precipitation has increased by five inches;
- Low flows are occurring 65% less often;
- The Root River rises 40% faster at this location and;
- River base flows are more than doubling in the month of August.

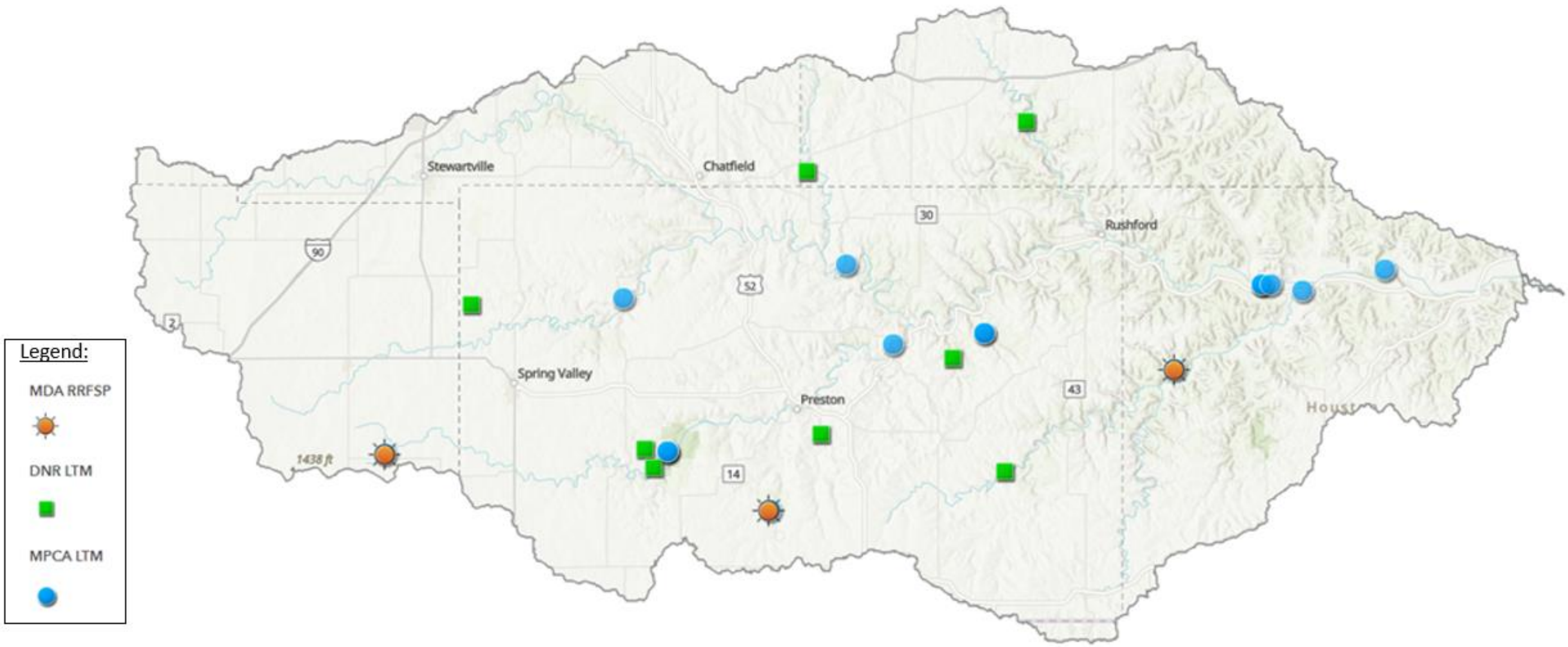
These impacts from climate change have consequences to water quality in the RRW. Recommendations for addressing these issues are outlined in Section 8 and center around the need for increased water storage to slow the flow of runoff.

An observed positive consequence of increased precipitation and river baseflows is an increase in groundwater inputs to rivers and streams in the RRW. Increased groundwater inputs are evident through DNR monitoring of stream temperatures for trout designations (Hoxmeier & Dieterman 2019). The result is that DNR staff are proposing more trout designated streams due to the expansion of coldwater streams across the southeast region of Minnesota, including the RRW.

Even while a changing climate is making evident the need for more water storage on the landscape, "warmer and wetter" is not the only management consideration. State climatologists predict that in addition to strong storms and wet periods, we will experience significant drought periods with low stream flows (Blumenfeld 2023). Extended periods of low flows can stress fish and macroinvertebrates. In 2021 and 2022, anglers in southeast Minnesota regularly reported concerns to state agencies about low flows in area trout streams (McCormick 2023). During these times of low flows, aquatic life may congregate in areas of deep water refuge. When storm events occur, a pulse of runoff (and potentially contaminants) may enter surface waters with very little dilution due to low water levels. These scenarios can result in additional stress to aquatic life and in some situations result in aquatic life mortality. In aforementioned 2021 and 2022, there were major trout stream fish kills in the Lewiston area resulting from storm events following prolonged low flow periods. See Section 2.2 for additional discussion on fish kills.

The MPCA and sister agencies are committed to monitoring for stream temperature, flow, water quality and fisheries. This data supports measuring impacts from a changing climate as well as other program initiatives. This is accomplished through continued support of long-term monitoring stations across the state and within the RRW (Figure 28).

Figure 28. Long term monitoring stations in the RRW from state agencies.



4. Pollutant sources

Water quality monitoring in the RRW confirms that primary pollutants of surface waters include sediment, nitrogen/nitrate, and bacteria (*E. coli*). Permitted point sources in the watershed have remained consistent since 2016. In support of on-going pollution reduction efforts, state agencies have completed multiple studies that provide better understanding of pollutant sources and transport to groundwater and surface water in the RRW (Table 10 below).

Table 10. Studies that identify major sources of sediment in the RRW.

Sediment fingerprinting for sources and transport pathways in the Root River, southeastern Minnesota. (Belmont 2011).	This study used geochemical tracers to verify the variability of historic erosion in the RRW, the amount of readily erodible legacy sediment and confirms that the dominant source of sediment is legacy nonfield sediment from near channel sources, such as floodplains and streambanks.
Identifying Sediment Sources and Sinks in the Root River, Southeastern Minnesota (Stout et al 2014).	This publication summarizes a shift in hydrologic regime and subsequent sediment fluxes, identifies near channel sources as the dominant sediment load contributor and that suspended sediment in the river today is from floodplains and terraces.
An integrated sediment budget for the RRW, southeastern Minnesota. (Belmont et al 2016).	This study investigated sediment inputs from major tributaries of the Root River: North Branch Root River, Middle Branch Root River, South Branch Root River, Rush Creek, Money Creek and South Fork Root River.
Root River Field to Stream Partnership Field Runoff Factsheets (MDA 2022 and MDA 2022b)	Continued monitoring of four fields across 12-years provides invaluable insight into when agricultural fields have the highest impact to water quality.
Root HSPF Modeled scenarios (MPCA 2023)	Simulates pollutant loading for TSS, TP and total nitrogen. HSPF model extended to Water Year 2021.

Generally, the following findings from the studies above identify nonpermitted sources as primary contributors to the sediment load in the RRW:

- Recent (post European settlement) agricultural soil erosion and streambank erosion are prominent sediment sources in the majority of the RRW. Of these two sources, streambank sources are the more significant supplier of excess sediment in the RRW HUC-8, although specific HUC-10s may differ.
- When considering soil erosion sediment sources across the RRW's landscape, sediment fingerprinting determined that agricultural fields, floodplains, and hillslopes are the three major soil erosion sediment sources.
- May and June are high risk periods for sediment loss. Seventy-five percent of the sediment load at the edge-of-field scale occurs at these times.
- Nonpoint and in-channel sources contribute a majority of sediment as compared to permitted point sources.

Table 11. Studies that identify major sources of nutrients in the RRW.

Root River Field to Stream Partnership	The RRFSP is a unique water monitoring project located in southeast Minnesota. This partnership combines rigorous data collection, strong personal relationships, and real conservation action. The RRFSP project uses both edge-of-field and in-stream monitoring to characterize water quality in three study areas within the RRW.
Nitrate-Nitrogen in the Springs and Trout Streams of Minnesota. Minnesota Groundwater Association Newsletter (Watkins et al 2013)	This publication studied the relationship between row crop land use and nitrate-nitrogen concentration in baseflows of 100 trout stream watersheds in the karstlands of Southeast Minnesota. A regression line was produced to estimate the concentration of nitrate in streams according to percentage of row crop in the drainage areas.
Nitrogen in Minnesota Surface Waters (MPCA 2013)	MPCA led this study of nitrogen in surface waters to better understand nitrogen conditions in Minnesota's surface waters, along with the sources, pathways, trends, and potential ways to reduce nitrate in waters.
MN Nutrient Reduction Strategy (MPCA 2014) and 5-year Progress Update (MPCA 2020)	Minnesota's NRS and 5-year progress report outline how Minnesota can reduce nutrient pollution in its lakes and streams and reduce the impact downstream. The strategy specifies goals and provides a framework for reducing nitrogen levels by 10-20% by 2025, with much higher long-term reductions by 2040.
***MDA Groundwater Videos* (see: https://www.mda.state.mn.us/segwresources)**	A series of animated videos were produced to explain not only how groundwater moves in landscapes of the RRW, but also how contaminants like nitrate-nitrogen move.
Geologic controls on groundwater and surface water flow in southeastern Minnesota and its impact on nitrate concentrations in streams (MGS 2014)	Provides understanding of geologic controls (aquifer depth, aquitards, bedrock characteristics) on nitrate transport in the region, including nitrate in groundwater that is the source of baseflow to RRW streams.
Minnesota's Nitrogen Fertilizer Management Plan (MDA 2019)	The State of Minnesota's blueprint for preventing and minimizing the impacts of nitrogen fertilizer on groundwater.
Examination of soil water nitrate: N concentrations from common land covers and cropping systems in southeast Minnesota karst (Kuehner, Dogwiler, Kjaersgaard 2020)	This five-year study (2011-2015) used lysimeters to measure nitrate concentrations from nine different land covers and cropping systems in southeast Minnesota. Cultivated row crop settings ranged from 8.0 – 28.0 mg/L nitrate.
Groundwater Pollutant Transfer and Export from a Northern Mississippi Valley Loess Hills Watershed (Masarik, K.C. et al. 2007)	Describes groundwater as the chief agent responsible for transporting nitrate to streams. Therefore, baseflow conducts a majority of the nitrate load.
Synthesizing multifaceted characterization techniques to refine a conceptual model of groundwater sources to springs in valley settings (Minnesota, USA) (Barry, John et al. 2023)	Describes the groundwater flow for Lanesboro State Fish Hatchery spring by combining findings from previous studies with recent dye tracing & geochemical sampling.
Combining high resolution spring monitoring, dye tracing, watershed analysis, and outcrop	The description of the Ordovician Galena Group's (SE MN) aquifer characteristics is summarized using continuous spring

and borehole observations to characterize the Galena Karst, Southeast Minnesota, USA (Barry, John et al. 2020)	monitoring, dye tracing and hydrograph separation methods. Nitrate dilution following recharge (precipitation/snow melt), estimate of annual nitrate loading, and assessment of agricultural pollutant sources and agricultural BMPs effectiveness are explained.

From these studies and publications (Table 11), we understand the following about nitrate:

- Nitrogen in surface water originates primarily from row cropped farm fields where nitrogen inputs (fertilizers and animal manure) have been applied.
- Nitrate reaches groundwater by percolating through the soil profile; a transport process known as “leaching.”
- Of nitrogen applied, 80% is lost through sub-surface leaching and is detected as nitrate in tile drainage, groundwater, springs, and the baseflow of coldwater trout streams.
- Dissolved phosphorus (and nitrate) losses in surface runoff are highest in March and often occurred during frozen ground conditions.
- 25% of the runoff in May and June produces over 50% of annual nutrient (dissolved phosphorus and nitrate) loss at the edge-of-field scale.
- Nitrate concentrations in rivers across the State of Minnesota (including in the southeast region) are trending up or show no trend; meaning in some areas, higher concentrations of nitrate are being detected over time.

Table 12. Studies that provide support of major bacteria (*E. coli*) sources in the RRW.

Regional Fecal Coliform TMDL (MPCA 2006) and Fecal Coliform Implementation Plan (MPCA 2007)	The TMDL study described the magnitude of *E. coli* impairments in 20 surface waters of the Lower Mississippi and Cedar River basins. The Implementation Plan is a coordinating document developed to guide the source-reduction activities needed to meet the TMDL requirements.
Growth, Survival, and Genetic Structure of E. coli found in Ditch Sediments and Water at the Seven Mile Creek Watershed. (Sadowsky et al. 2010)	This study examined the fecal inputs and distribution of *E. coli* in water and sediments of the Seven Mile Creek Watershed (Nicollet County, Minnesota). Results of this study highlight the presence of naturalized versus newly acquired strains of *E. coli* and related water quality implications.
Effect of Sediment Particle and Temperature on Fecal Bacteria Mortality Rates and the Fecal Coliform/Fecal Streptococci Ratio. (Howell et. al. 1996)	This study looked at the connection between fecal coliform survival rates and temperature and sediment size. Fecal coliform mortality rates decreased as sediment particle size became finer and as temperature decreased.
Bacterial Pollution in Runoff from Agricultural Lands. (Baxter-Potter and Gilliland 1988)	This study looked at fecal coliform concentrations in surface waters within agricultural land use. While fecal coliform concentrations nearly always exceed water quality standards in waters where manure applications have occurred, several factors play into account.

General conclusions about *E. coli* and fecal coliform bacteria studies (Table 12) are:

- There are many types of fecal coliform bacteria and not all cause health issues for humans. When a water is impaired by *E. coli*, it does not mean it should not be used for recreational use.
- Bacteria comes from many sources, including mainly agricultural runoff (livestock manure), and inadequately treated domestic sewage and wildlife.
- *E. coli* sources can be tied to stream flow. When flows are low and *E. coli* concentrations are high, the source is likely a continuous source (Subsurface sewage treatment systems [SSTS]). When flows are high and *E. coli* concentrations are high, the source is likely from land runoff.
- Monitoring tools like DNA tracing are effective in determining bacteria source (e.g. human, swine, bovine or wildlife) but are not practical for large scale areas due to cost.
- *E. coli* bacteria can persist in sediment. In some cases, *E. coli* strains in specific areas can become naturalized. This could result in naturally elevated *E. coli* concentrations unrelated to recent pollutant loading.

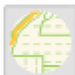
Priority subwatershed pollutant source assessment

The initial WRAPS Report (MPCA 2016) for the RRW contained an extensive pollutant source section that covered priority pollutants at the HUC-8 scale. For the remainder of this section, pollutant sources for local priority subwatersheds will be summarized. These priority HUC-12 subwatersheds lie within 2024-2025 priority HUC-10 subwatersheds for the Root River Planning Work Group including:

- Headwaters of Middle Branch Root River (North Fork Bear Creek, South Fork Bear Creek, Spring Valley Creek)
- Headwaters of South Branch Root River
- Money Creek (Upper Money Creek)
- Mill Creek
- Carey Creek/Cary's Creek
- South Fork Root River (Riceford Creek)

All priority subwatersheds (Figure 2) have an overview map with similar symbology (Table 13).

Table 13. Legend for subwatershed overview maps.

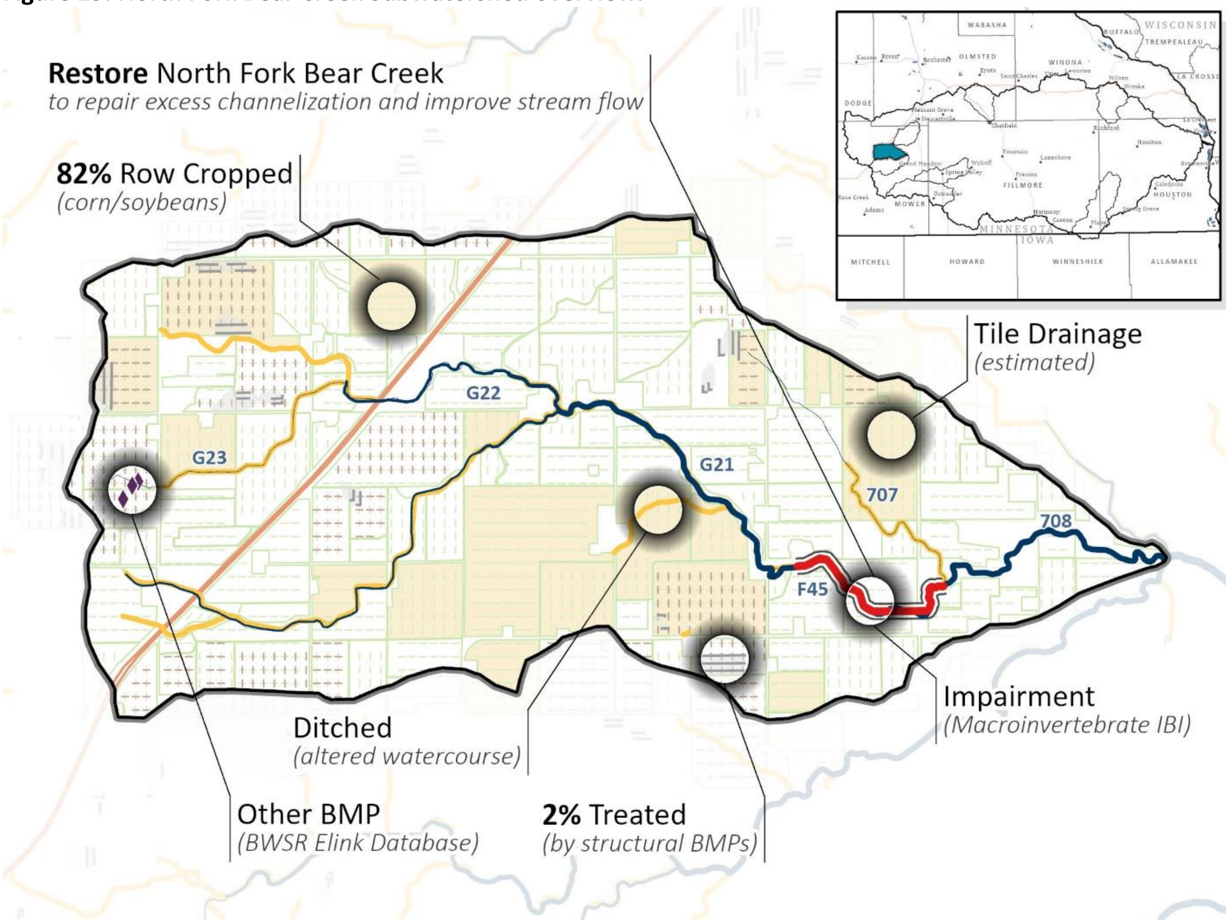
Map legend icon	Description
 Row Cropped	Acres of row crops based on six-year average of USDA's Cropland Data Layer (taken from Root River ACPF dataset). Indicated by green dashes/grids.
 Treated	Known treated acres based on WSU's Root River BMP Mapping project. Not indicated by a specific color or shape, but rather, a statement.
 Tile Drained	Estimated agricultural land drained by subsurface tile. Based on "Normalized vegetation index" layer (USA NAIP Imagery). Indicated by solid tan color.
 Ditched	Altered watercourses identified by DNR's WHAF tool. Indicated by yellow lines.
 Other BMP	BMPs reported by MPCA's Healthier Watersheds webpage/Board of Water and Soil Resources (BWSR's) eLINK database. Indicated by purple diamonds.

See Appendix D for additional map descriptions. Pollutant sources largely contributing to water quality issues are summarized in this section. For detailed pollutant source information, see Appendix E.

4.1 North Fork Bear Creek: 070400080201

The North Fork Bear Creek Subwatershed (Figure 29) lies in eastern Mower County and is a headwater subwatershed. Streams in the North Fork Bear Creek are mostly channelized ditches and have highly altered hydrology from agricultural drainage tile. Limited habitat and very slow flows are likely impacting aquatic life, mostly macroinvertebrates. The fish community is meeting aquatic life standards at this time.

Figure 29. North Fork Bear Creek Subwatershed overview.

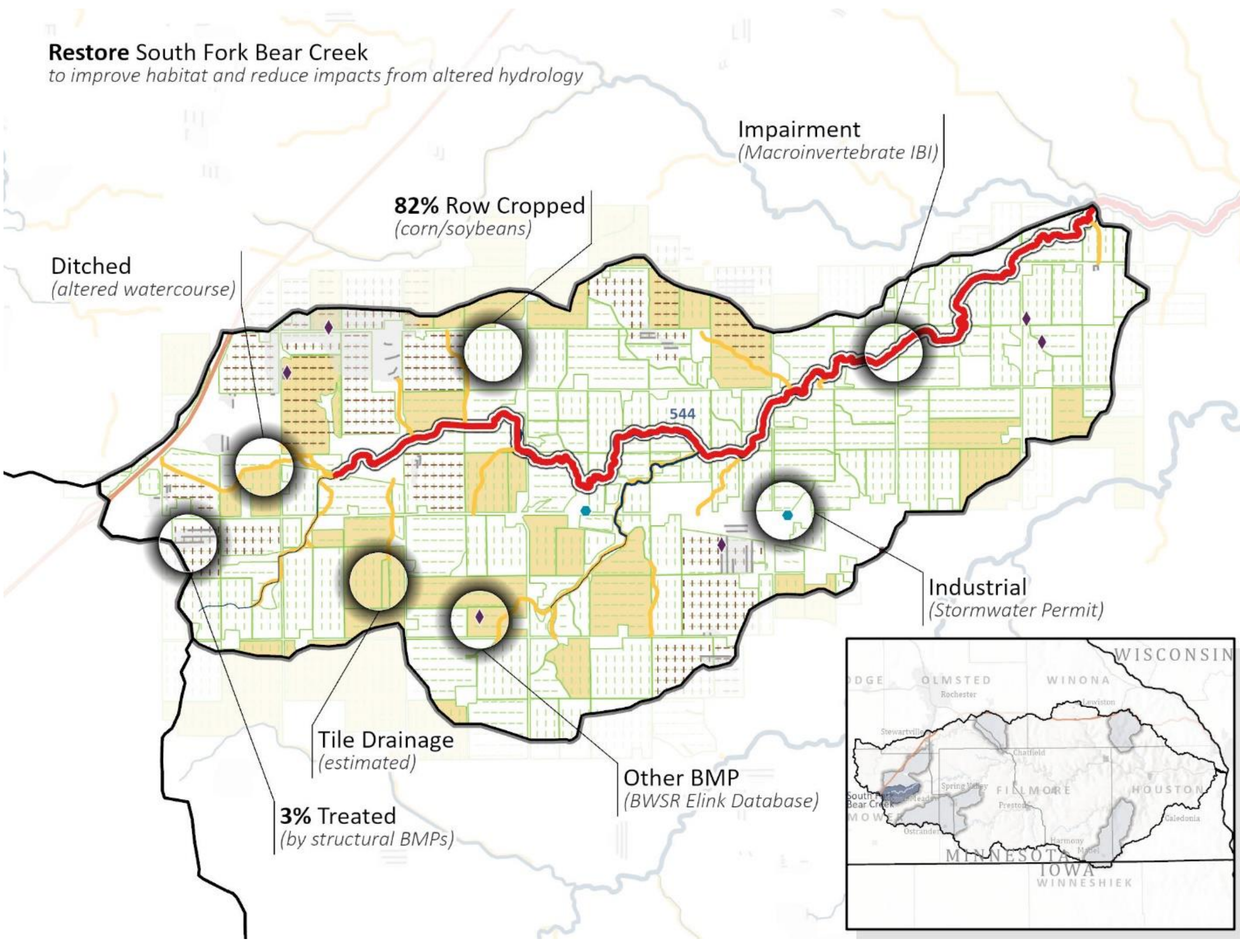


Nonpoint sources such as cropland runoff and streambanks are sources of sediment impacting the quality of habitat for macroinvertebrates in the North Fork Bear Creek Subwatershed. Altered hydrology is driving the contributions of these sources because it is promoting channelization, has increased peak flow, and is decreasing available water storage. See Appendix E for additional discussion of pollutant sources.

4.2 South Fork Bear Creek: 070400080202

Similar to the North Fork Bear Creek Subwatershed, the South Fork Bear Creek Subwatershed (Figure 30) is a headwater dominated by ditch systems. Lower in the subwatershed, the stream returns to a more natural channel. SID was conducted on the headwaters in Cycle 1 but not re-visited in Cycle 2 because it was not deemed a priority at the time (lower portions of Bear Creek were studied for Cycle 2 SID). Habitat is a stressor to the macroinvertebrate community, but pollutants (TSS and nitrate) are inconclusive stressors. Notes from MPCA field staff indicated that the macroinvertebrate community represented a wetland-like community. This means that the aquatic life can tolerant slow, stagnant water that often occurs in ditch systems with little flow.

Figure 30. South Fork Bear Creek Subwatershed overview.



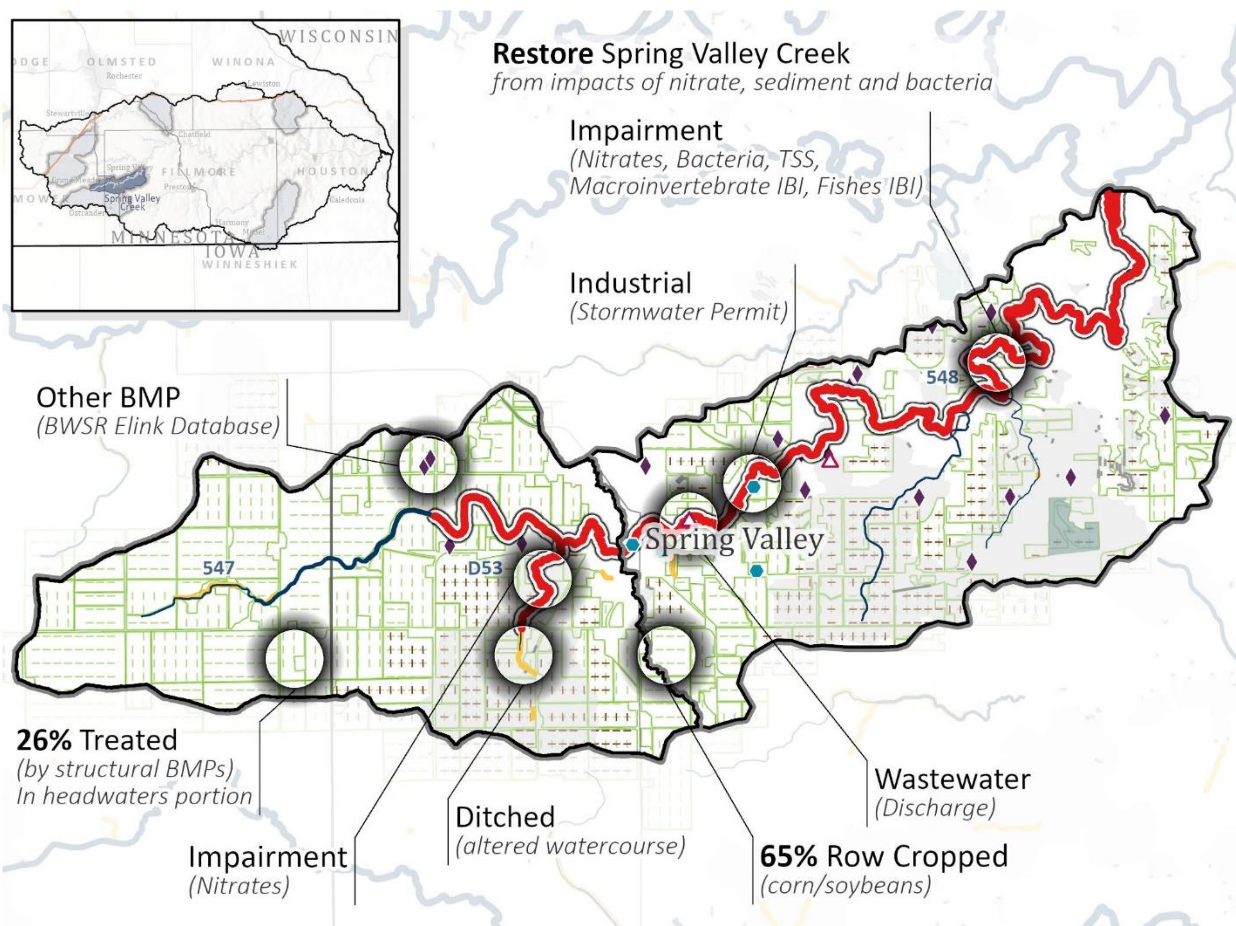
Lack of available stream flow and channelization are driving the water quality issues observed in the South Fork Bear Creek Subwatershed. Flow data collected by DNR since 2008 indicates that the stream has long periods of very low flow in late summer each year. Because of this lack of flow, there is less aquatic habitat available than there would be at higher flows. Less oxygen is also a consequence of low stream flow. The SID report (MPCA 2015) noted that the primary available habitats were stream banks and overhanging vegetation; both are highly dependent on water level and stream flow.

Additional monitoring is needed to confirm whether TSS and/or nitrate are influencing the macroinvertebrate impairment. Cycle 1 SID found that the macroinvertebrate community around monitoring station 08LM058 were mostly nitrate tolerant. Of the macroinvertebrates sampled, nearly 40% were identified as being TSS tolerant. No nitrate or TSS intolerant individuals were identified. See Appendix E. for more discussion on potential pollutant sources for South Fork Bear Creek.

4.3 Spring Valley Creek: 070400080205

The Spring Valley Creek Subwatershed (Figure 31) begins in eastern Mower County and crosses into Fillmore County. The town of Spring Valley is in the center of the HUC-12. While agriculture is the dominant land use, deciduous forest is the third highest land cover, making up 27% of the subwatershed. There is a notable shift in the landscape downstream of the town of Spring Valley, where more forestland is present. In this report, the headwaters portion of the subwatershed, upstream of the town of Spring Valley, is a focal point for recommended strategies. Pollutant sources and water quality issues for the entire HUC-12 are discussed in Appendix E.

Figure 31. Spring Valley Creek Subwatershed overview.

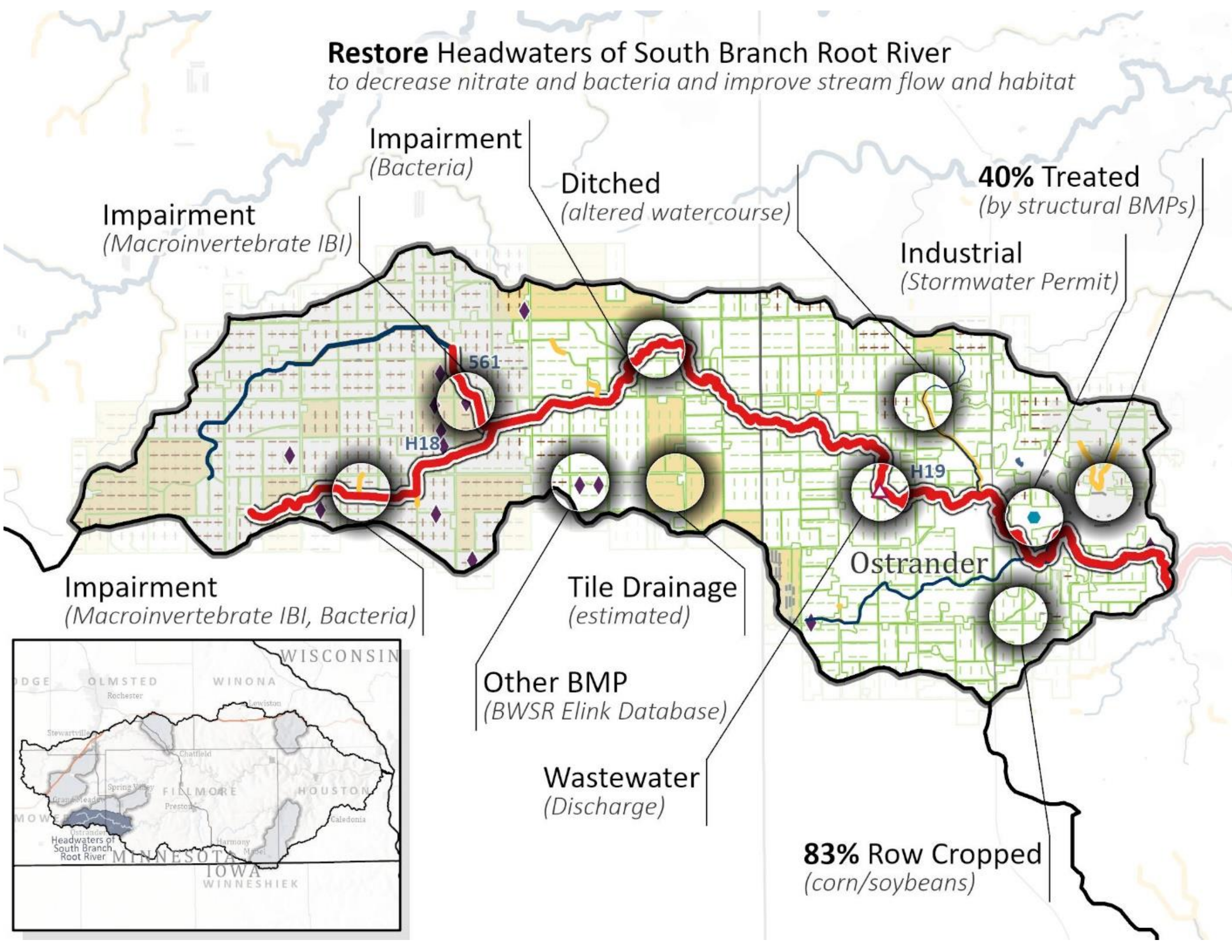


Cropland and streambanks are playing a large role in delivering sediment and nitrate to the Spring Valley Creek Subwatershed. Livestock pastures, field runoff and manure applications are also promoting sediment and bacteria loads. The Spring Valley WWTP discharges nitrate at levels that can be significant under certain conditions (see Appendix E for more discussion). The WWTP now has a nitrogen effluent limit and proposed construction to address nitrate in effluent. Elevated temperature is also impacting aquatic life, a consequence of ponded springs. See the pollutant source assessment in Appendix E. for further information.

4.4 Headwaters of South Branch Root River: 070400080401

The Headwaters of South Branch Root River Subwatershed (Figure 32) shares nearly equal sized areas of eastern Mower and western Fillmore counties. Historic aerial imagery conducted of this subwatershed by Mower SWCD staff indicates that the area was largely covered by wetlands prior to agricultural drain tile installation. The South Branch Root River Subwatershed is a focused study area for the RRFSP. The partnership conducts in-stream and edge-of-field monitoring to determine nitrate, phosphorus, and sediment in runoff and drain tile water (see Section 2.1). This information is valuable to help understand how BMPs can be best suited for water quality benefits.

Figure 32. Headwaters of South Branch Root River Subwatershed overview.

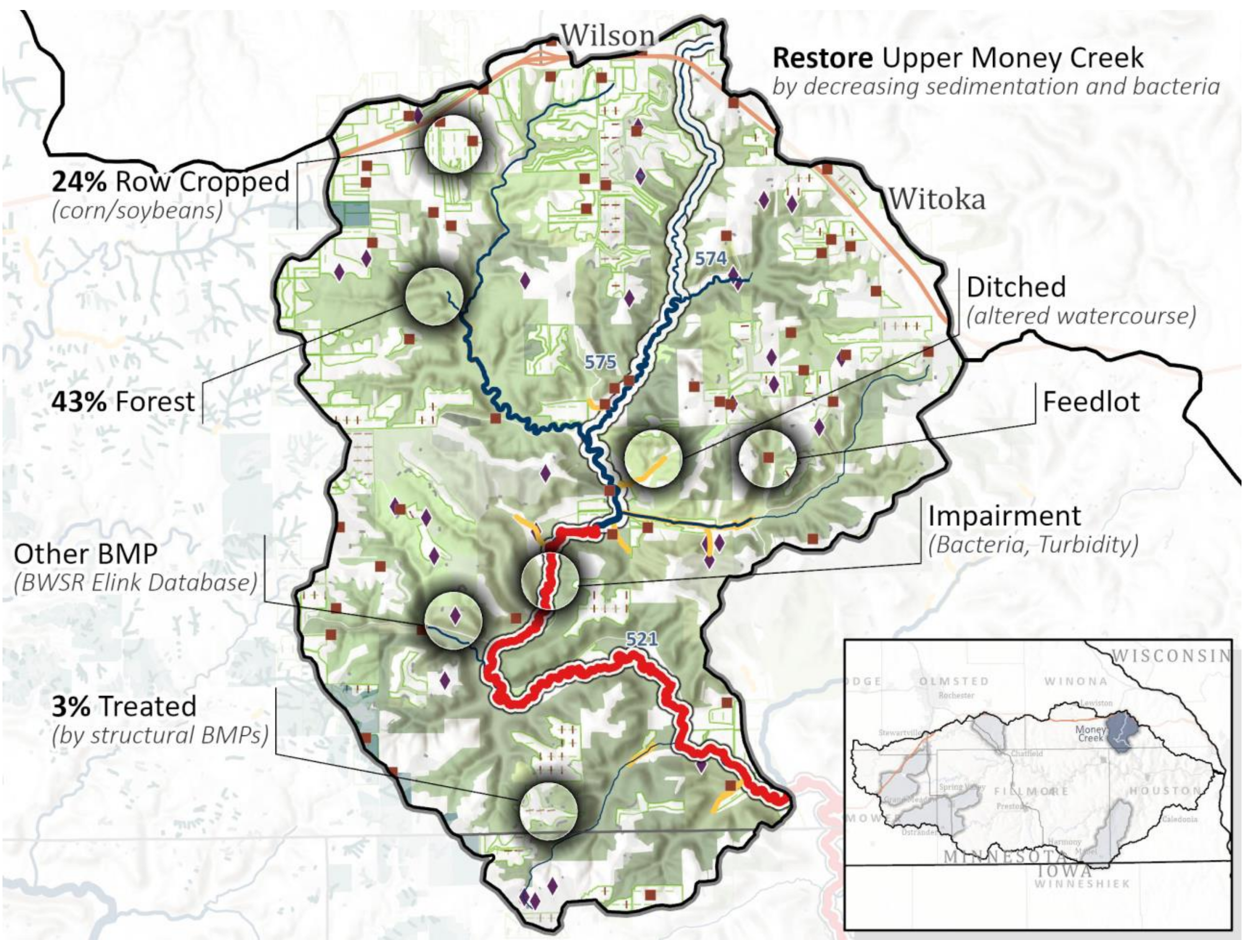


Cropland is contributing significant nitrate and sediment loads to the Headwaters of the South Branch Root River. Streambanks are equally contributing sediment which is exacerbated by altered hydrology (drain tile and channelization). Non-National Pollutant Discharge Elimination System (NPDES) feedlots, manure runoff from farm fields and pastures, and SSTS are very likely contributing to the bacteria load in this subwatershed. Permitted sources are not playing a large role in pollutant loading, however Ostrander WWTP discharges nitrate at levels that can be potentially significant under certain conditions. The WWTP now has a nitrogen effluent limit and a schedule of compliance to address nitrate in effluent. See Appendix E. for more discussion on potential pollutant sources for this subwatershed.

4.5 Upper Money Creek: 070400080601

The Upper Money Creek Subwatershed (Figure 33) lies mostly in Winona County with the southern portion in Houston County. The dominant land use in this subwatershed is deciduous forest and aquatic life designated use is currently supported. Most of the streams in this headwater area are coldwater, trout designated streams. The Upper Money Creek Subwatershed is known as having high stream gradients which play an important role in the transportation of sediment.

Figure 33. Upper Money Creek Subwatershed overview.

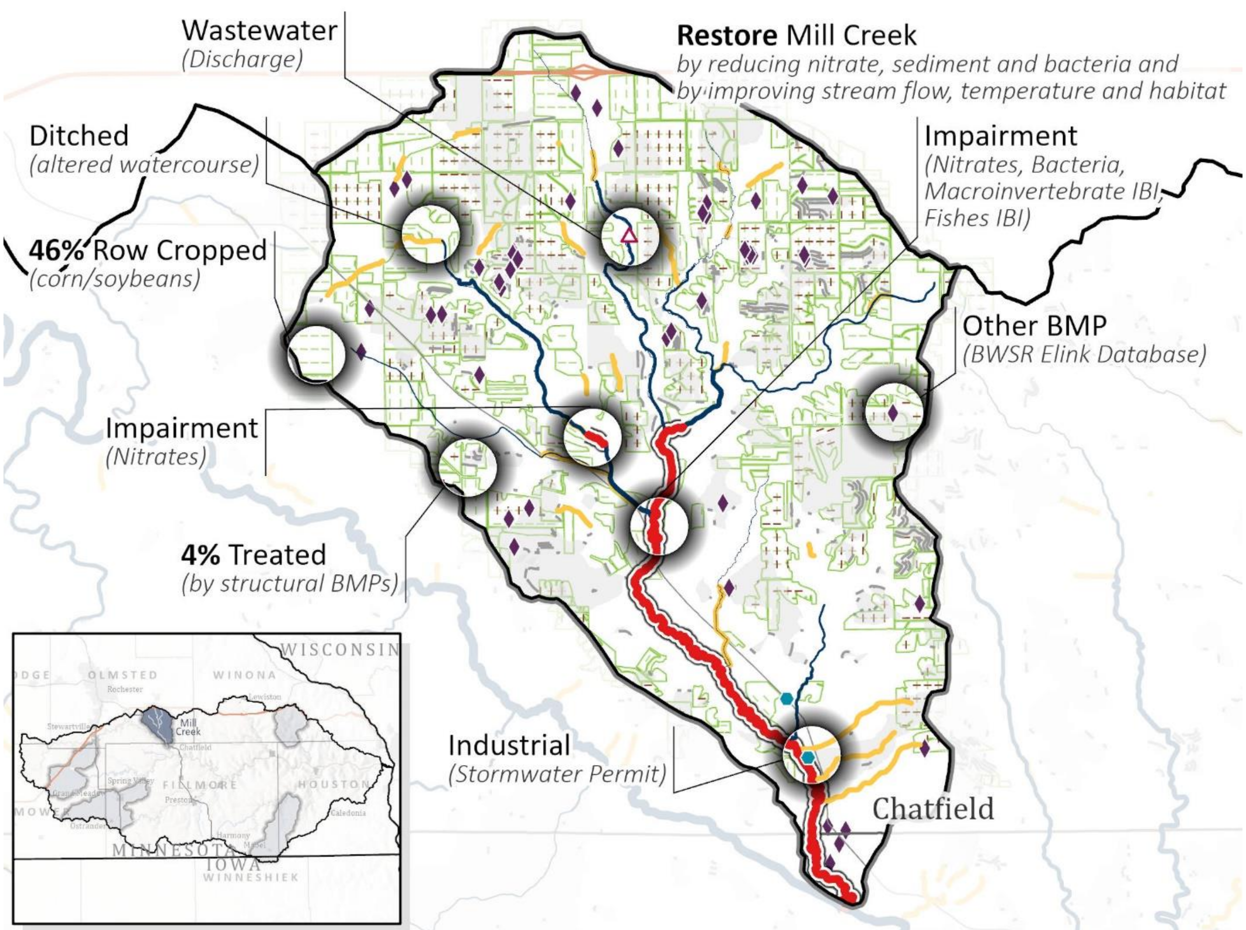


No NPDES-permitted facilities exist in the Upper Money Creek Subwatershed. Streambanks are contributing the dominant sediment load to the creek. Cropland and pastures may also be contributing sediment loading to the stream, particularly those in close proximity to the stream channel. Non-NPDES feedlots, runoff from fields where manure has been applied, and pastures are likely contributing bacteria loads to Upper Money Creek. See Appendix E. for more discussion on potential pollutant sources for Upper Money Creek.

4.6 Mill Creek: 070400080107

The Mill Creek Subwatershed (Figure 34) covers approximately 32 square miles and lies almost completely within Olmsted County, with the southern downstream portion in Fillmore County. Row crop agriculture dominates the landscape, covering 46% of the subwatershed. The town of Chatfield is located at the bottom of the subwatershed and is a vulnerable DWSMA due to nitrate. Headwater tributaries to Mill Creek begin as altered/modified ditches and then transition to natural channels. Drainage tile may be present but is not as dense as more western Root River Subwatersheds. Headwater soils have a lower erodibility factor than soils in the middle of the subwatershed. The WSU mapping project has indicated that 1,361 acres of the Mill Creek Subwatershed are currently being treated by structural BMPs, approximately 4% of the subwatershed.

Figure 34. Mill Creek Subwatershed overview.

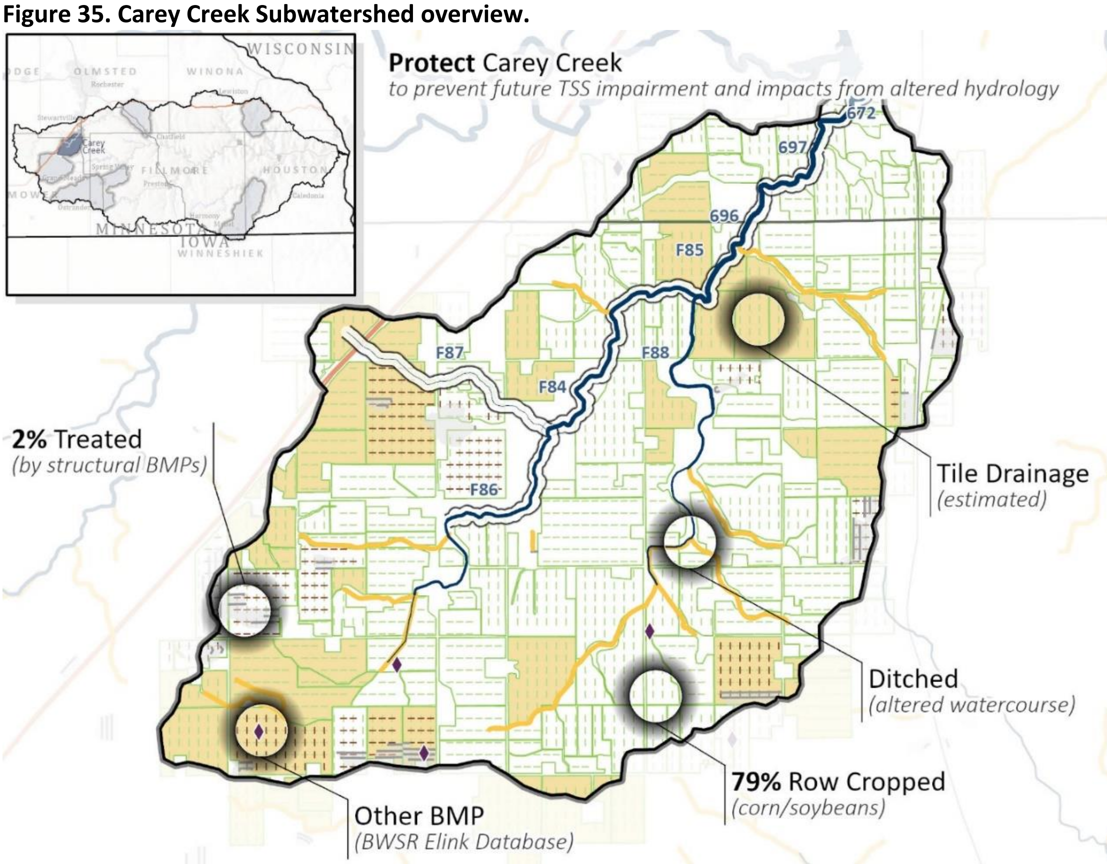


Cropland and streambanks are supplying the dominant sediment loads to Mill Creek. Leaching of commercial fertilizers applied on cropland are contributing a significant nitrate load. Non-NPDES feedlots and manure runoff from farm fields are likely contributing bacteria and may be contributing nitrate to Mill Creek. Altered hydrology, primarily channelized stream channels are driving impacts to aquatic habitat and stream flow. See Appendix E. for more discussion on potential pollutant sources for Mill Creek.

4.7 Carey (Carys) Creek: 070400080105

The Carey Creek Subwatershed (Figure 35) covers approximately 32 square miles and lies in eastern Mower County and southwestern Olmsted County. Row crop agriculture dominates the landscape, covering 79% of the subwatershed. There are currently no water quality impairments in the Carey Creek Subwatershed. The headwaters of Carey Creek are modified channels and then transition to a more natural stream moving downstream. There is currently no fish data to categorize the fish community for Carey Creek. Monitoring by DNR, likely occurring in 2024, will provide insight on the presence of any rare or vulnerable fish species. Carey Creek is a Root River 1W1P protection priority area for stream bank restoration and upland BMP implementation for 2024/2025. Approximately 67 acres of the Carey Creek Subwatershed is currently being treated by structural BMPs. This is roughly 2% of the total subwatershed area.

Figure 35. Carey Creek Subwatershed overview.

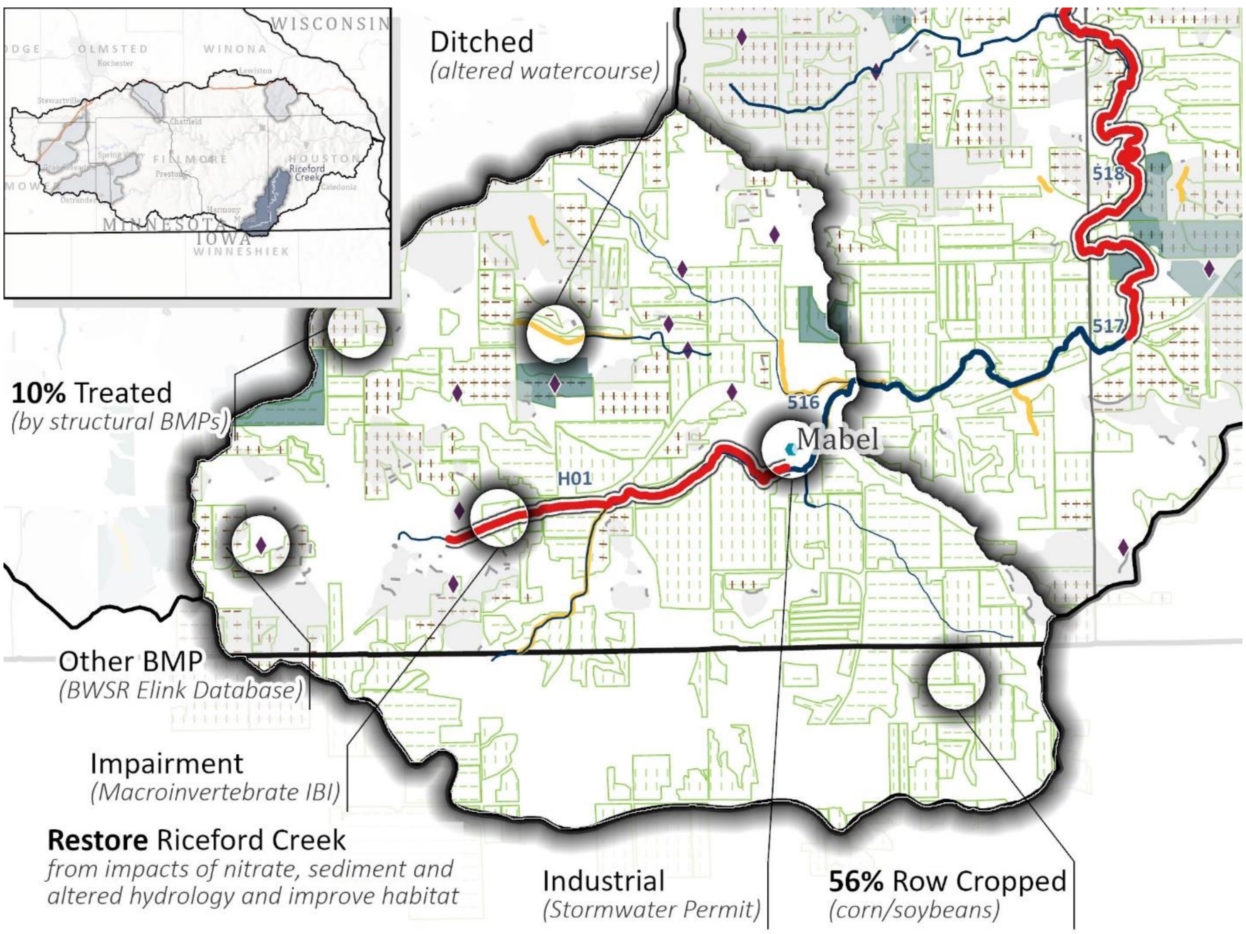


To protect Carey Creek from future degradation, streambanks and cropland should be prioritized as they are likely dominant sources of sediment. Reducing the impacts from altered hydrology, particularly agricultural drain tile and stream channelization, will improve available aquatic habitat and stream flow. See Appendix E for more discussion on potential pollutant sources for Carey Creek.

4.8 Riceford Creek: 070400080804

The entire Riceford Creek Subwatershed (Figure 36) covers approximately 65 square miles in southeastern RRW. Portions of Iowa drain into the headwater channels. This report will focus on the 21 square mile headwater portion of the Riceford Creek Subwatershed upstream of Mabel. See the Root River TMDL (MPCA 2024a) for pollutant sources for the entire Riceford Creek Subwatershed.

Figure 36. Riceford Creek Subwatershed overview; headwater section only.



In this headwater area, streambanks are contributing the highest sediment load to Riceford Creek. This is amplified by the presence of altered hydrology, particularly ditched watercourses and channelized streams. Cropland is a significant source of nitrate from leaching commercial fertilizer and land applied manure. Sediment runoff from cropland is also contributing sediment. See Appendix E. for more discussion on potential pollutant sources for Riceford Creek.

4.9 Pollutant source summary

Table 14 below summarizes significant pollutant sources in the priority subwatersheds. For each subwatershed, a low (L), medium (M) or high (H) ranking has been given to potential pollutant sources discussed in this section. Smaller, superscript letters identify specific pollutants or stressors that may contribute to water quality issues noted for each subwatershed. For example, in North Fork Bear Creek, altered hydrology is the playing a highly significant role in water quality issues. It is driving habitat (HB) and stream flow (FL) stressors. In channel and cropland are ranked as moderate/medium pollutant sources impacting habitat and stream flow. Feedlot ranking was based on number of feedlot facilities in shoreland, with no manure storage and/or with pastures that may be under-managed. More discussion on pollutant sources is contained in Appendix E.

Table 14. Pollutant source summary for priority subwatersheds in the RRW.

HUC-12 subwatershed	Point source	In channel	Cropland	Feedlot	SSTS	Altered hydrology (ditching, drain tile and channelization)
North Fork Bear	-	M $^{HB\ and\ FL}$	M $^{HB\ and\ FL}$	-	-	H $^{HB\ and\ FL}$
South Fork Bear	-	M ^{HB}	M ^{HB}	-	-	H ^{HB}
Spring Valley Creek	L ^{NT}	H ^{SD}	H ^{NT}/ M ^{SD}	M ^{BT}	L ^{BT}	L ^{SD}/H ^{FL}
HW South Branch Root	L $^{NT\ and\ BT}$	H ^{SD}	H $^{SD\ and\ NT}$	M $^{BT\ and\ NT}$	M ^{BT}	H ^{SD}
Upper Money Creek	-	H ^{SD}	M ^{SD}	M ^{BT}	L ^{BT}	L ^{SD}
Mill Creek	L $^{NT,\ SD,\ BT}$	H ^{SD}	H $^{NT\ and\ SD}$	M $^{BT\ and\ NT}$	-	M $^{FL\ and\ HB}$
Carey Creek	-	H ^{SD}	H ^{SD}	-	-	H $^{HB,\ SD\ and\ FL}$
Riceford Creek	-	H ^{SD}	H ^{NT} / M ^{SD}	M ^{NT}	-	M $^{HD,\ FL\ and\ SD}$

Degree of pollutant significance key: L = Low, M = medium, H = high, - = not a priority.

Stressor/pollutant code key: NT = NO3-N, SD = sediment, HB = habitat, FL = stream flow, BT = Bacteria.

Pollutant sources and stressors/pollutants identified in this section can be addressed through specific strategies. Sections 7 and 8 of this report outlines available tools and recommendations to help address impacts from these pollutant sources.

5. TMDL summary

Ten new TMDLs have been written for eight water bodies in the RRW. This includes two for nitrate, seven for TSS, and one for *E. coli* (Table 15). Some impairments will be covered by a downstream TMDL as indicated. Refer to MPCA 2023a for the TMDL report.

Table 15. TMDLs addressing impairments in the 2024 RRW TMDL report.

WID	Water body name	Use class	Listing year	Target completion year	Affected designated use [a]	Listing Parameter	TMDL Pollutant	Category 4A upon TMDL approval [b]
07040008-536	Mill Creek	2Ag	2020	2022	AQL	Macroinvertebrate bioassessment	Nitrate	No
						Fish bioassessment	TSS	Yes
			2022	2022	DW	Nitrate	Nitrate	Yes
07040008-A47	Unnamed Creek (Mill Creek Tributary)	2Ag	2022	2022	DW	Nitrate	Nitrate	Yes*
07040008-A18	Bear Creek (Lost Creek)	2Ag	2022	2022	AQL	TSS	TSS	Yes
						Fish bioassessments	TSS	Yes
						Macroinvertebrate bioassessment	Nitrate	No
07040008-540	Upper Bear Creek	2Ag	2012	2022	AQL	Fish bioassessments	Nitrate	No
						Macroinvertebrate bioassessment	TSS	Yes
07040008-548	Spring Valley Creek	2Ag	2022	2022	AQL	TSS	TSS	Yes
			2012			Fish bioassessments	TSS	Yes
						Macroinvertebrate bioassessment	Nitrate	No
			2022		DW	Nitrate	Nitrate	Yes
07040008-D53	Unnamed creek (Spring	2Ag	2022	2022	DW	Nitrate	Nitrate	Yes*

WID	Water body name	Use class	Listing year	Target completion year	Affected designated use [a]	Listing Parameter	TMDL Pollutant	Category 4A upon TMDL approval [b]
	Valley Creek Tributary)							
07040008-511	South Fork Root River	2Ag	2022	2022	AQR	*E. coli*	*E. coli*	Yes
07040008-559	Camp Creek	2Ag	2012	2022	AQL	Temperature		No
						Fish bioassessments	TSS	Yes
						Macroinvertebrate bioassessment	Nitrate	No
07040008-518	Riceford Creek	2Ag	2012	2022	AQL	Macroinvertebrate bioassessment	Nitrate	No
							TSS	Yes
07040008-H01	Riceford Creek	2Bg	2020	2022	AQL	Macroinvertebrate bioassessment	Nitrate	No
							TSS	Yes

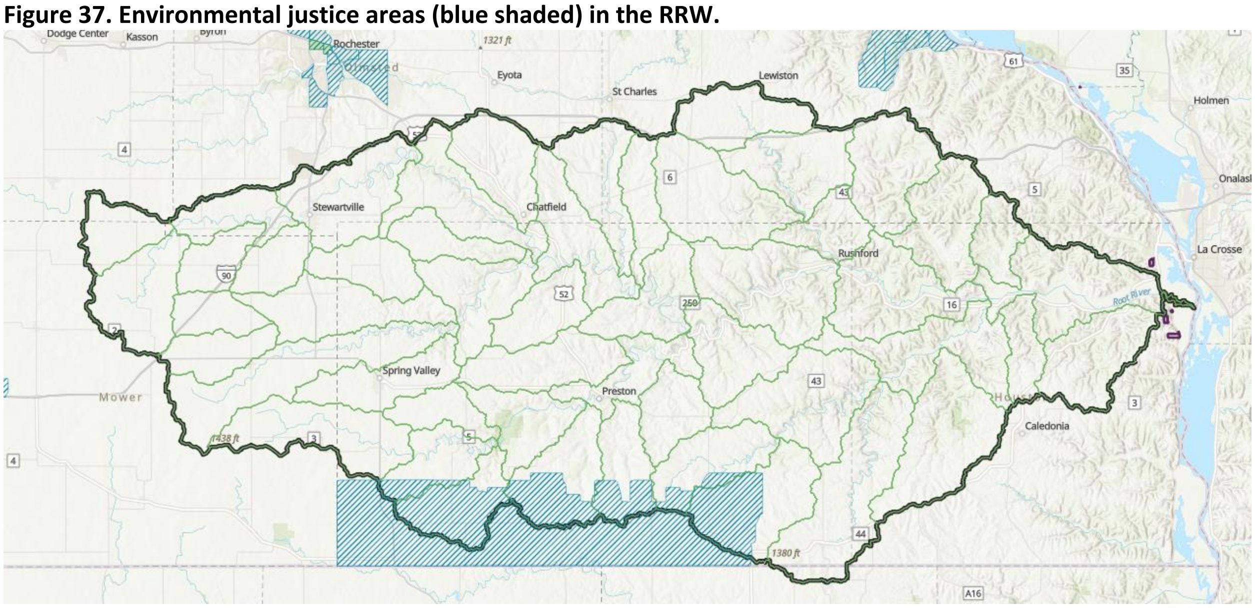
* Impairment will be addressed by a downstream TMDL.

Implementation strategies to restore impaired waters addressed by the 2024 RRW TMDL are described in the TMDL report. Please refer to Section 5 of the TMDL.

6. Environmental justice

The environmental justice (EJ) component of WRAPS Update work aims to provide fair treatment and meaningful involvement of underserved and/or under-represented communities. In the RRW, low income and non-English speaking communities represent EJ communities located in the watershed (Figure 37). It is recommended that outreach for private wells and septic systems be focused in these areas so these communities can be informed of cost share opportunities for well or septic upgrades, if needed. The MPCA has grant funds from the Clean Water Fund and low interest Clean Water Partnership loan funds available to address septic system upgrade needs for low income households. The RRW is located on the traditional homelands of the Dakota Oyate. However, no part of the RRW is located within the boundary of a federally recognized Tribal Nation.

Figure 37. Environmental justice areas (blue shaded) in the RRW.



7. Prioritizing and targeting

This report serves as a resource for watershed partners to better understand where in the RRW to prioritize implementation, what water quality issues are of top importance, and which practices are best suited to address issues. The following section identifies updated tools, information, and recommendations to assist local partners in their future implementation of practices in the RRW.

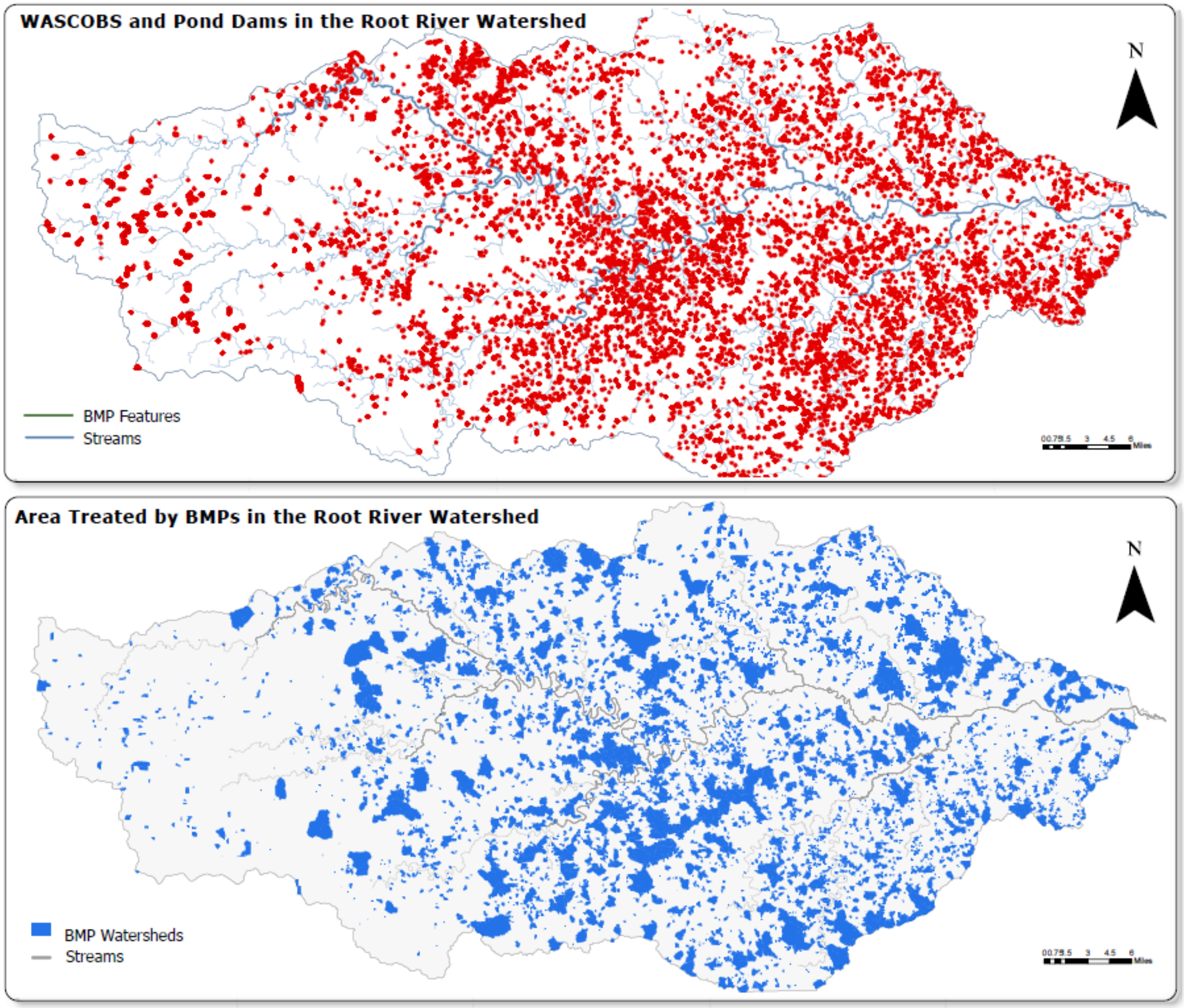
7.1 Updated targeting tools and studies

Several tools have been recently developed aiming to make implementation more efficient and effective. MPCA has coordinated the following tools and studies to aid in prioritizing specific areas in the RRW for implementation:

Winona State University's Root River Watershed Structural BMP Mapping Project:

The Root BMP Mapping project spanned 2019 through 2022. The purpose was to identify and map all WASCOBs present in the RRW and include the treated drainage area (Figure 38). Other structural BMPs (terraces, pond dams, strip cropping, grassed waterways, and contour buffer strips) were also mapped in the Rush Creek, North Branch Root, Middle Branch Root, South Branch Root and South Fork Root HUC-10s. It was determined that approximately 24% the RRW is treated with the BMPs mapped for this project. This information can be paired with Agricultural Conservation Planning Framework (ACPF) model outputs to verify where model-recommended BMP locations already have a BMP in place. It can also be used to better understand the density of BMPs in a specific location (see Section 2.4). GIS files of the Root BMP Mapping project are available upon request by contacting the MPCA watershed project manager for the RRW.

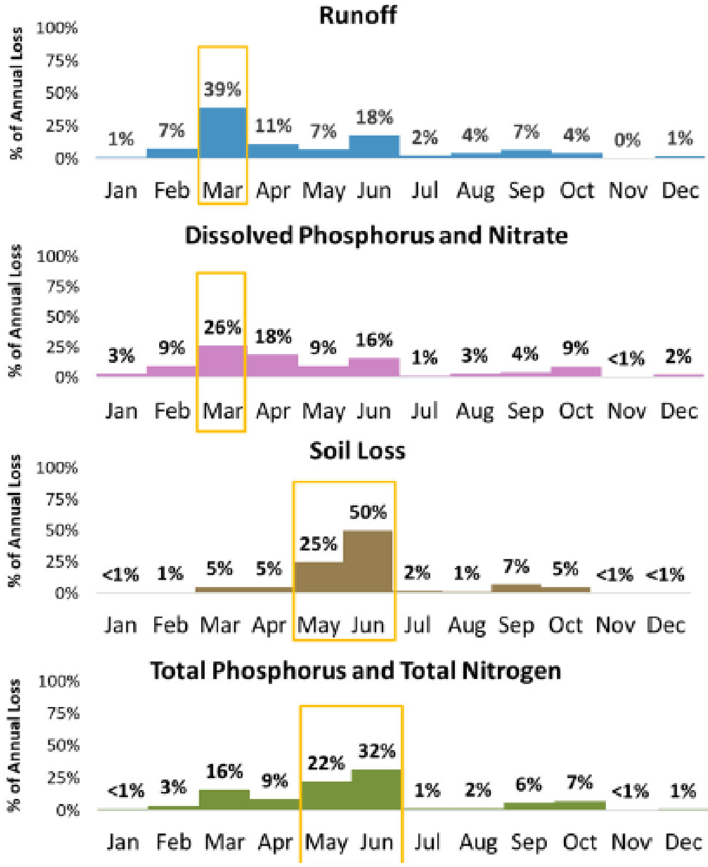
Figure 38. Mapped WASCOBs and treated acres identified in WSU's Root BMP Mapping project.



Root River Field to Stream Partnership

Continued monitoring of the RRFSP sites across 12-years provides invaluable insight into when agricultural fields have the highest impact to water quality. Recent data concludes that structural practices to address runoff are most needed in critical runoff months of March through July (Figure 39). Edge-of-field monitoring has also identified highest risk areas. Areas subject to ephemeral gully erosion are high runoff risk areas and need to be targeted to reduce soil loss and phosphorus.

Figure 39. Timing of surface runoff, sediment, and nutrient loss from RRFSP sites (MDA 2022).



Root River Watershed HSPF Model extension:

The MPCA coordinated with Tetra Tech Inc. to extend the simulation period of Hydrologic Simulation Program-Fortran (HSPF) Model for the RRW from Water Year 2015 to Water Year 2021. The complete simulation for the RRW's HSPF model is now 10/1/2007 through 9/30/2021. This newly extended model was used to produce outputs from various scenarios to create water quality recommendations (see Section 4.2). Examples of these scenarios include: TSS loads from point sources versus nonpoint sources in specific HUC-12s, total nitrogen loads from point sources versus nonpoint sources in specific HUC-12s, and peak flow reductions following various degrees of WASCOB implementation.

Restoration and protection priorities based on local needs:

The Root River 1W1P Work Group was consulted throughout the scoping and development of this WRAPS Update Report. Select subwatersheds were focused on so that local partners could get as much information as possible on the areas of the RRW that are priorities for upcoming work. In depth discussion of these eight priority subwatersheds is located in Appendix E. In addition to these priority areas, local partners requested additional insight on waters with more than one impairment, waters near the impairment threshold, waters with high intensity use, and waters where hydrology and flow are key drivers in condition. Reference Appendix F and Table 17 for this information.

SID priority areas:

The Root River SID Update report (MPCA 2022) identifies specific locations across the 13 SID priority subwatersheds. SID targeted areas within the eight priority WRAPS Update subwatersheds are below. For recommendations on additional SID areas, see Appendix G.

Table 16. Priority issues from 2022 RRW SID work in WRAPS priority watersheds.

Subwatershed	Priority issue
Headwaters Mill Creek	Nitrate reduction
Headwaters Spring Valley Creek (SW of Spring Valley)	TSS reduction
Headwaters Spring Valley Creek (07040008-D53 and 07040008-F98)	Nitrate reduction
Headwaters Riceford Creek	TSS reduction (trapping/controlling practices)
Headwaters South Fork Root River	Altered hydrology – lack of flow in summer months

Streams near impairment threshold:

During the assessment of Cycle 2 monitoring data, several sections of streams were flagged as having parameters vulnerable to impairment (Table 4). These rivers and streams are currently meeting water quality standards, but data show certain parameters nearing impairment thresholds. Vulnerable waters should be prioritized for implementation activities so they can be protected from future impairment. Priority ranking of the vulnerable waters (Table 17) was conducted so that partners can better dedicate resources to waters with higher recreational use and presence of trout.

Table 17. Prioritization of nearly impaired water bodies in the RRW.

Water body	WID	Water quality concern	Recreational use (Trout designation)	Overall prioritization ranking
Middle Branch Root River	07040008-528*	Water transparency and TSS	High – canoe access at HWY 21 (No)	High
Trout Run Creek	04070008-G88	Water transparency and TSS	Medium (Yes)	High
Rush Creek	07040008-523	Water transparency and TSS	Medium (Yes)	High
Unnamed Creek (Rush Creek trib)	07040008-685	Ammonia and DO	Low (Yes)	High
Root River	07040008-520	Water transparency and TSS	High – State water trail (No)	High
Wisel Creek	07040008-513	Macroinvertebrates	Medium (No)	Medium
Thompson Creek	07040008-507**	Water transparency and TSS	Medium (Yes)	Medium
Crystal Creek	07040008-601	Fish and macroinvertebrates	Medium/Low – no easement (Yes)	Medium
Pine Creek	07040008-526	Macroinvertebrates	High (Yes)	Medium

***MNWILD brook trout in Torkelson Creek which flows into this river reach.**

****MNWILD brook trout in upstream reach.**

Work Tools for Local Partners:

Along with this WRAPS Update Report, several tools were produced by MPCA to aid local partners in prioritizing implementation:

Root River WRAPS ArcGIS Online Map:

A mapping tool was developed to better assist local partners in efficiently identifying priority locations for implementation activities. Map layers help visually display important Cycle 2 monitoring and WRAPS Update information including new impairments and priority areas for implementation. The Root River WRAPS Update Map is maintained by the MPCA staff and accessible to local government unit (LGU) staff.

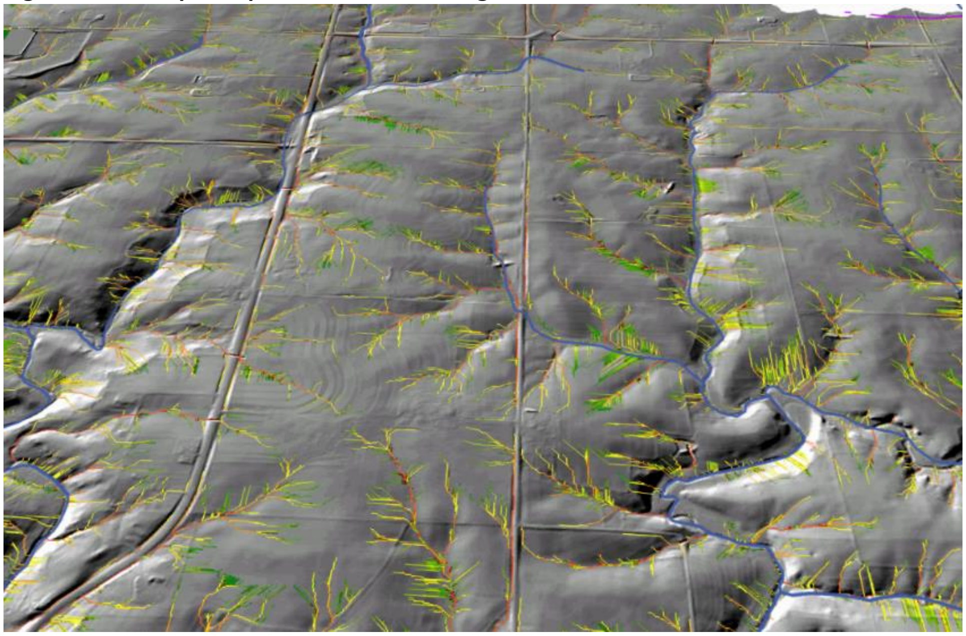
Supplemental Feedlot Information:

A factsheet was produced by MPCA staff identifying potentially high-risk feedlots in WRAPS Update priority subwatersheds. These feedlots were identified by aerial imagery review and ranked due to feedlot location and components (lack of manure storage). This factsheet was presented to county feedlot officers in Fillmore and Winona Counties for consideration in their inspection schedules.

Watershed Tools for Decision Support

ACPF, Prioritize Target Measure Application (PTMApp), and LiDAR based terrain analysis data have been created or updated since the original Root River WRAPS was published in 2016. Underlying this data is a recently updated hydrologically modified digital elevation model (hDEM) that was greatly improved from the original and significantly improves the modeling of the surficial flow of water across the landscape of this watershed. The updated hDEM, which was funded through MPCA, enabled improved terrain modeling and enhanced outputs from the ACPF and PTMApp tools. One example of the outputs of this data is the availability of terrain products such as an accurate hill shade DEM and stream power index (SPI) layer (Figure 40). The SPI data helps identify areas of the landscape where the potential for erosion and transport of pollutants from the land surface is greatest.

Figure 40. Example of product created using hill shade DEM and SPI.



The ACPF and PTMApp tools are helpful in identifying locations of structural and vegetive agricultural BMPs on the landscape. These tools can site practices common to the RRW such as grassed waterways, terraces, water and sediment control basins, and fields suitable for cover crops. As an example, the RRW ACPF tool identified a potential location for two WASCOBS and the contributing drainage area for those two practices (Figure 41).

The ACPF and PTMApp tools can also assess small and large scale impacts from pollutants (sediment, phosphorus, and N). The ACPF tool can derive a runoff risk at a small watershed scale and evaluate the economics of BMPs. PTMApp can apply pollution reduction benefits to specific practices, evaluate source assessment of field scale catchments, and optimize which suite of practices are more cost effective in meeting pollution reduction goals. An additional recent data product that complements the modeled practice locations is a map of existing practices within the RRW that was recently completed (Figure 38). Utilizing all of these tools together will greatly assist in decision support for local practitioners' and landowners' water quality implementation efforts.

Figure 41. Example outputs from RRW ACPF and SPI tool. Left shows two potential WASCOB locations. Right shows grassed waterways found in the steeply sloped landscapes.

Root River Watershed GRAPS:

As previously mentioned, the GRAPS report for the RRW is not yet completed. However, Figure 42, Figure 43, Figure 44, Figure 45, and Figure 46 provide information to assist in targeting locations to continue groundwater restoration and protection. For additional information about these graphics contact MDH staff.

Figure 42. Number of drinking water wells per section in the Root River 1W1P planning boundary as of 6/22/2023. Provided by MDH.

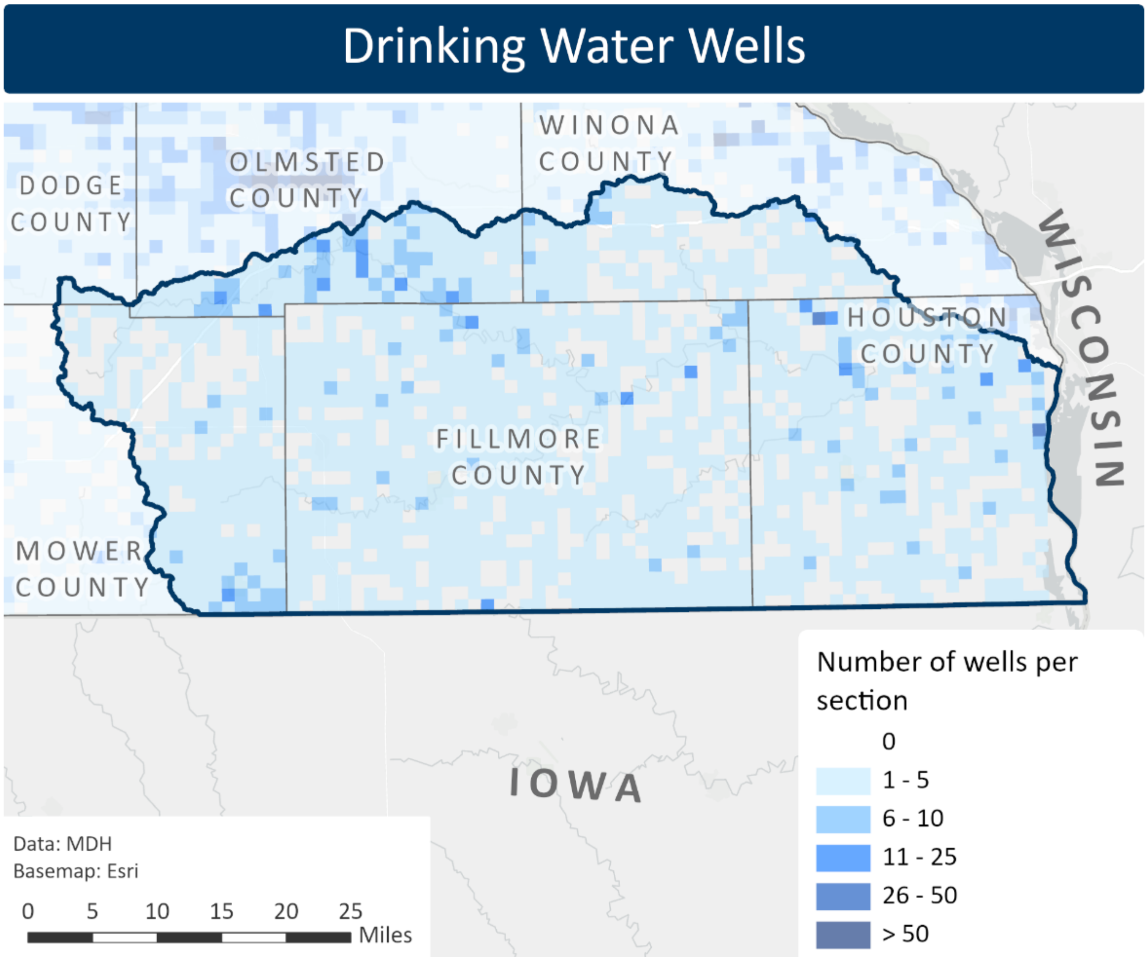
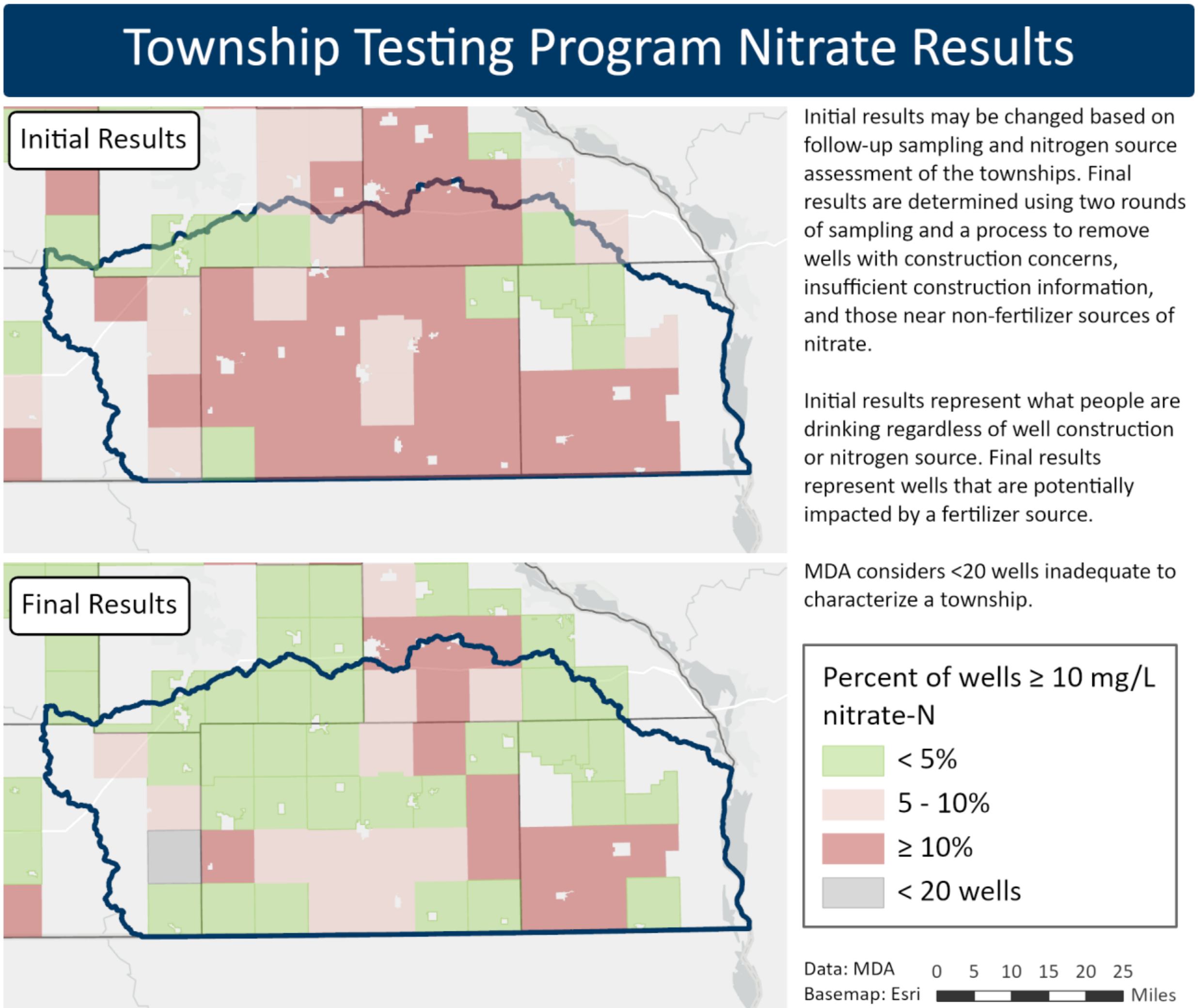
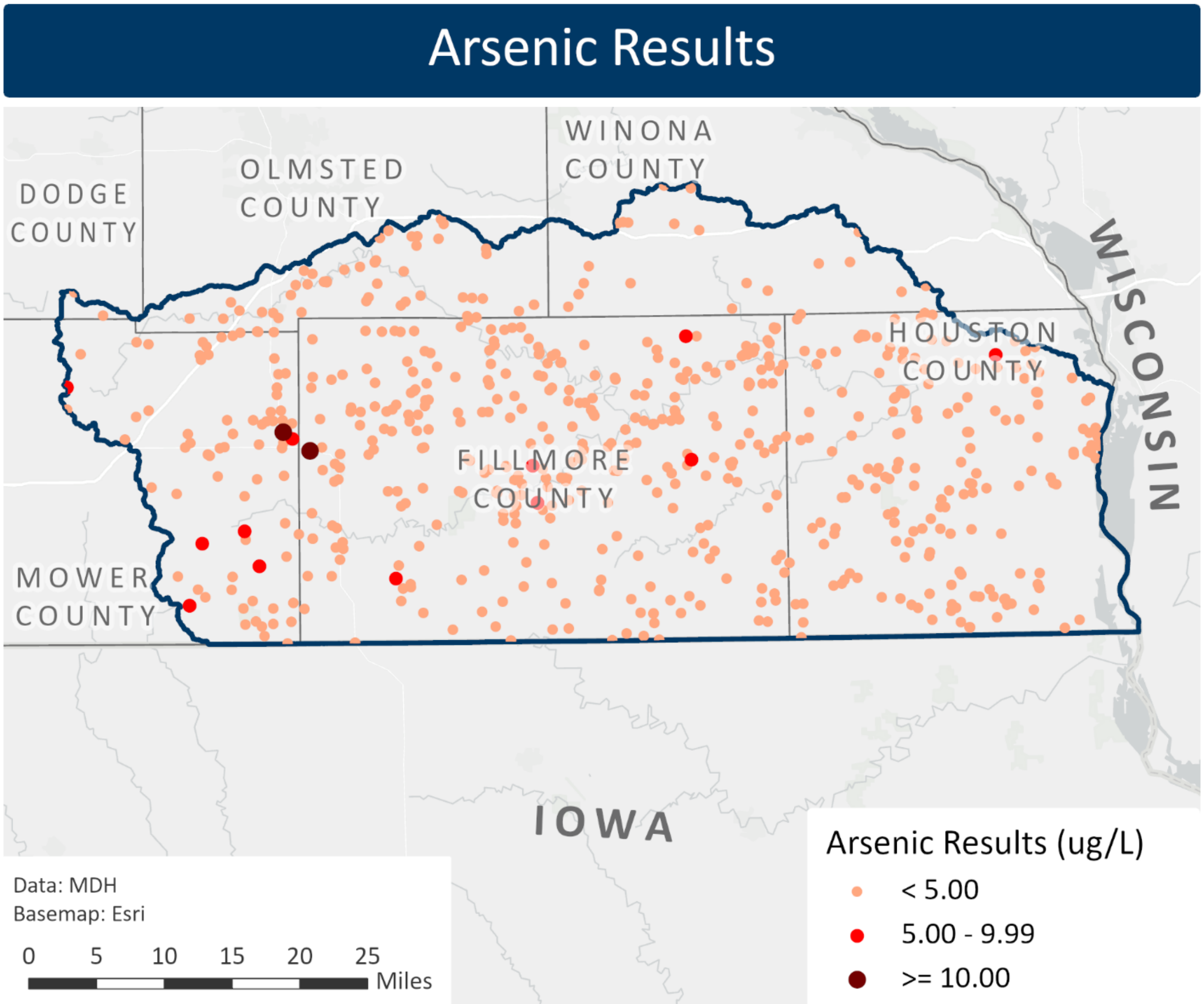


Figure 43. Initial and final township nitrate testing within the Root River 1W1P planning boundary. Provided by MDA.



Based on MDA's Township Testing program.

Figure 44. Arsenic results from public and private drinking well samples in the Root River 1W1P planning boundary (2005 – June 22, 2023). Provided by MDH.



EPA maximum for community water systems is 10 µg/L but the goal is 0 µg/L (communications with MDH staff on August 23, 2023).

Figure 45. Drinking Water Supply Management Areas in Root River 1W1P planning boundary. Provided by MDH.

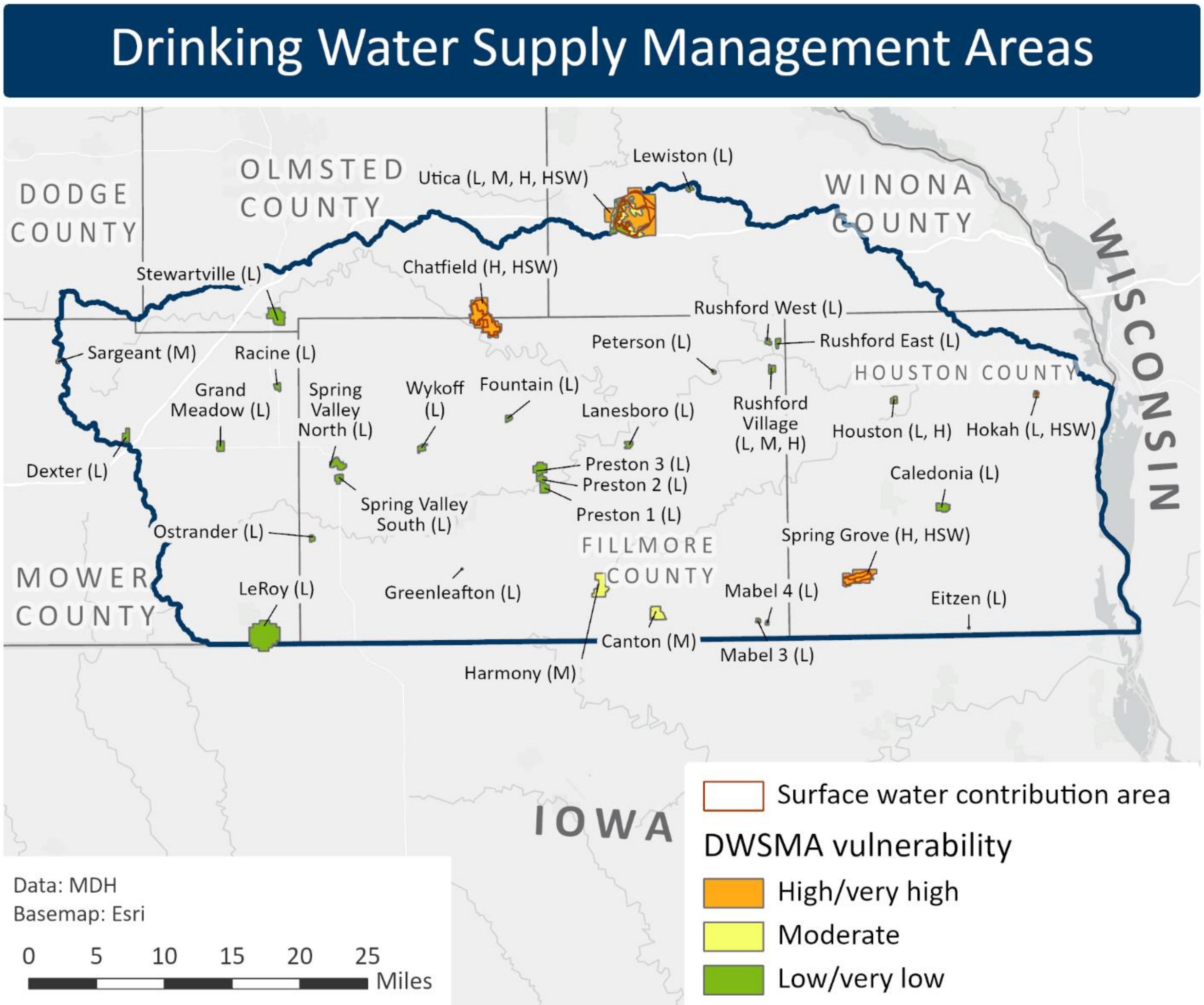
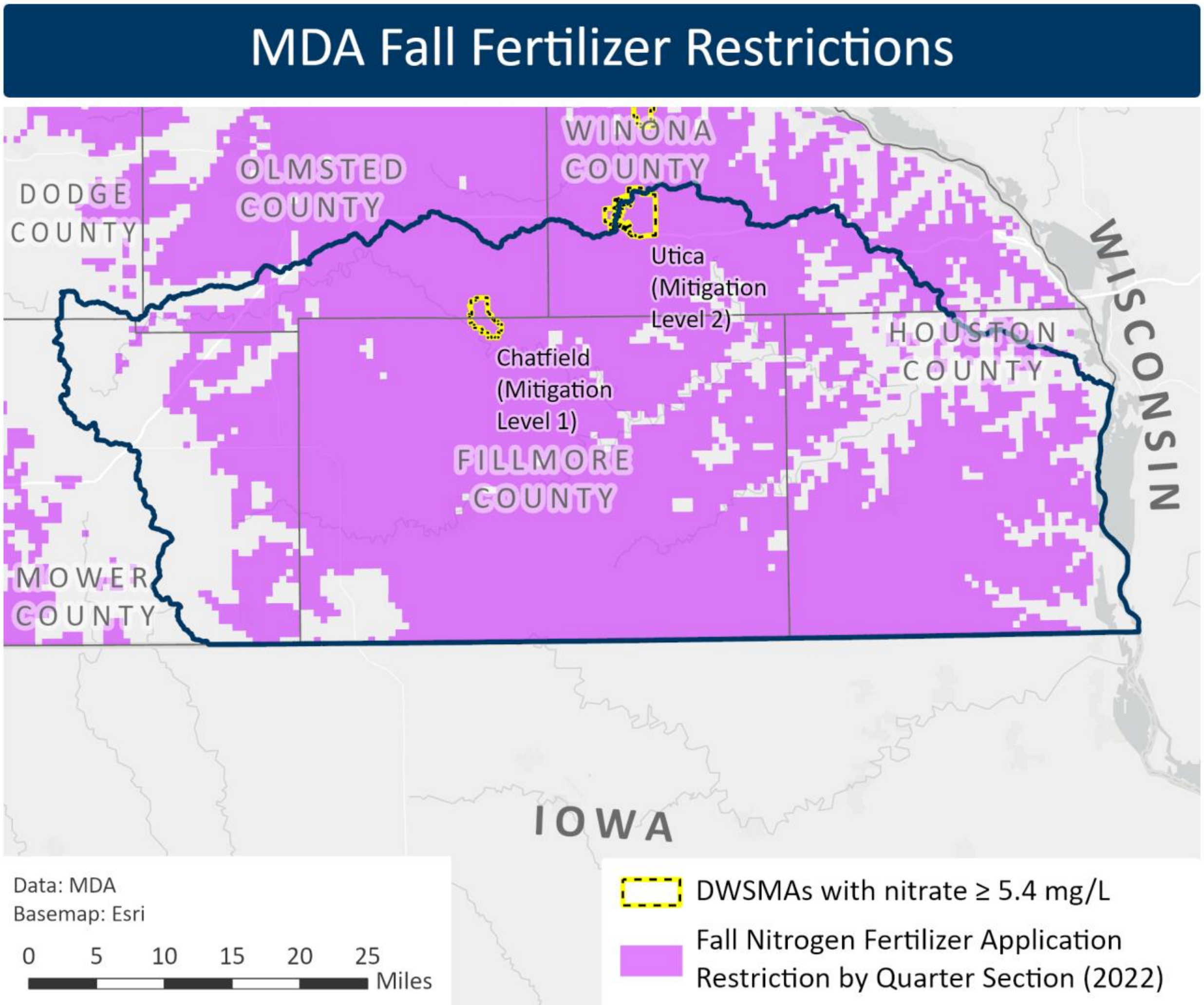


Figure 46. Locations of MDA Fall Fertilizer Restrictions in the Root River 1W1P planning boundary.



Other tools provided by partners:

- DNR WHAF (stream prioritization protection tool, and other tools and information)
- ACPF: target SPI and runoff risk tool (Houston Engineering/St. Mary's University)
  - Updated in 2022/2023 to include new HSPF model inputs.
  - Will be housed in National ACPF Hub (managed by Iowa State University).
- PTMApp (Board of Water and Soil Resources (BWSR)/Houston Engineering/St. Mary's University)
- MDA's Runoff Risk Advisory Tool

8. Restoration and protection strategies

WRAPS Update work included further application of Hydrologic Simulation Program-Fortran Scenario Application Manager (HSPF-SAM) to simulate implementation of pollutant reduction strategies in the RRW; these simulations help to understand approximate pollutant reductions that would correspond to various levels of BMP adoption in specific subwatersheds of the RRW. The following section also includes recommended strategies pertaining to Cycle 2 SID work, climate resiliency and fish kill risk minimization. These strategies should be considered within the greater context of existing strategies described in the 1W1P document. Recommended strategies (see Section 8.1) for the eight priority subwatersheds were established in collaboration between MPCA and local watershed partner staff.

HSPF-SAM Scenario work:

The MPCA coordinated with Tetra Tech Inc. in 2021 to complete an HSPF-SAM exercise with local RRW partners. The goal of this exercise was to get estimated pollutant reductions and cost effectiveness of certain implementation scenarios (Table 18). Local partners agreed upon adoption levels of BMPs, based on what they saw as most practical (note that Scenario #9 was based on an unrealistic, but desirable adoption level). Pollutant reduction estimates were developed for sediment, total nitrogen and TP.

Table 18. BMP scenarios for the RRW HSPF-SAM exercise.

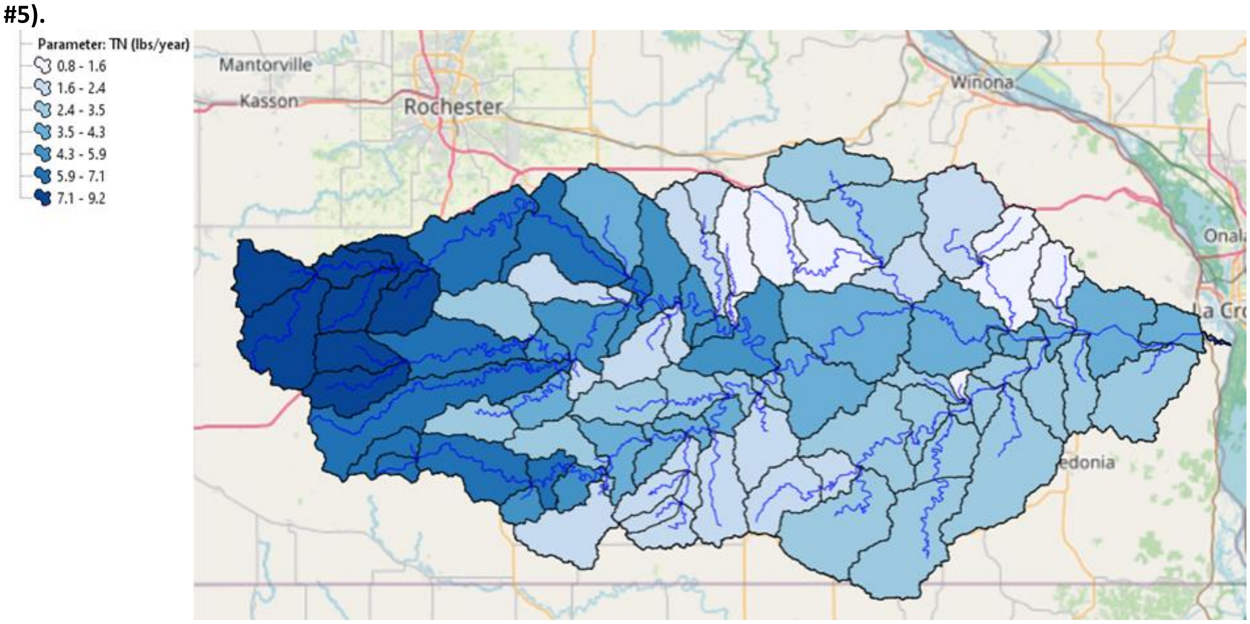
Scenario	Type	BMP Type(s)	Adoption Level(s) on Suitable Lands	Cost per acre in SAM 2.0 BMP Database
1	Individual practice scenarios	Streambank/in-channel restoration	10%	$13,471.92 (per mile)
2		Cover crops	15%	$37.98
3		Contour buffer strips	30%	$6.54
4		Grade stabilization structures	15%	Varies significantly in Ag BMP Handbook for MN
5		Conservation cover perennials	15%	$99.23
6		Nutrient management	30%	$27.92
7		Grassed waterways	30%	$14.18
8		WASCOBs	15%	$49.33
9	Combination scenarios	Cover crops and grade stabilization structures	100%	A minimum of $101.49
10		Grassed waterways and WASCOBs	30% and 15%	

Table 19 shows resulting estimated pollutant reductions of the scenarios at the watershed outlet of the HUC-8 (near Hokah). The report also includes what reductions could be possible if adoption rates were implemented at the HUC-12 level. For example, Figure 47 shows that and estimated reduction of 7.1% to 9.2% in nitrogen is estimated for the eastern headwaters of the RRW if 15% of suitable land is converted into conservation cover perennials (scenario #5). The entire HSPF-SAM report is available by contacting MPCA staff.

Table 19. SAM predicted pollutant reduction (%) in sediment, total nitrogen and TP for BMP scenarios at the HUC-8 outlet in the RRW.

Scenario	BMP Type(s) (Adoption Level on Suitable Acres)	Percent Reduction in Load		
		Sediment	Total nitrogen	TP
1	Streambank/in-channel restoration (10%)	11.0%	0.1%	6.3%
2	Cover crops (15%)	2.0%	2.5%	1.8%
3	Contour buffer strips (30%)	2.4%	4.3%	4.6%
4	Grade stabilization structures (15%)	0.4%	0.1%	0.4%
5	Conservation cover perennials (15%)	1.1%	3.6%	2.1%
6	Nutrient management (30%)	0.0%	2.1%	2.7%
7	Grassed waterways (30%)	2.0%	1.7%	3.3%
8	WASCOBs (15%)	2.0%	4.2%	4.5%
9	Cover crops and grade stabilization structures (100%)	14.4%	17.3%	13.6%
10	Grassed waterways (30%) and WASCOBs (15%)	3.8%	5.8%	7.5%

Figure 47. Percent reduction of total nitrogen for scenario of 15% perennial vegetation BMP adoption (Scenario #5).



SID recommended strategies:

The RRW SID Update report (MPCA 2022) identified several areas where specific restoration work is needed to address biological impairments. Strategies identified below (Table 20) are for select priority subwatersheds highlighted in this report. For strategies across all SID priority areas, see Appendix G and the RRW SID Update Report.

Table 20. SID recommended strategies for WRAPS priority subwatersheds.

Parameter	Subwatershed (WID)	Recommended strategy
Nitrate	Riceford Creek (07040008-518)	Better understanding land use variability and N applications may promote potential restoration activities
	South Branch Root River (07040008-H18)	Monitoring nitrate contributions from agricultural field tile may help identify priority restoration areas.
	Spring Valley Creek tributary (07040008-D55)	Nitrate reduction through nutrient management is necessary to reduce nitrate hot spots.
Sediment	Headwaters of Riceford Creek (07040008-H01)	Structural practices including runoff control practices, managed pastures and address gullies and steep ravines.
	Mill Creek Headwaters (07040008-536)	Investigate spring inflows and areas of habitat improvement projects for TSS/transparency.
	Spring Valley Creek tributary (07040008-D51)	Pasture management and bank rehabilitation needed to stabilize severe bank erosion.
Habitat	Headwaters South Branch Root River (07040008-601)	Improve available stream flow, particularly in summer months. Consider alternative approaches to ditch clean-outs as they significantly impact available habitat.

Climate resiliency and hydrology strategies

As called out in the RRW SID Update Report (MPCA 2022), hydrology is tied to nearly all stressors to aquatic life, and therefore, is one of the most important variables impacting stream health in the RRW. Climate and land use are driving changes in hydrology which alter stream flow and sediment transport. The following strategies are recommended to help reduce influence of increased precipitation and higher peak flows.

- **Water storage**: The Root River CWMP cites a 25% reduction of the 2-year peak discharge by 2030. To help refine this goal, MPCA staff used HSPF to estimate a storage goal. It was determined that an additional **0.35 inches of runoff per acre** would need be to stored across the HUC-8 RRW to achieve the 25% peak flow reduction goal. **This equates to an additional 38,689 acre-feet of storage.**
- **Floodplain restorations** are needed especially because most of the sediment carried by the Root River comes from in-channel sources. Currently, trout designated streams are a priority for local watershed partners for habitat improvement which, for some projects, also includes floodplain restoration. It is recommended that warm water sections be the focus for future floodplain restoration projects including **North Branch Root River (near Eagle Bluff), Deer Creek, Upper and Lower Bear Creeks, and the lower warmwater section of the South Fork Root River**.
- **Wetland restorations** are needed in headwater areas to promote additional water storage. Headwater areas would include the following HUC-12s: **Headwaters North Branch (070400080102), Evanger Church (070400080102), South Fork Bear Creek (070400080202), North Fork Bear Creek (070400080201), Deer Creek (070400080206) and Headwaters South Branch Root River (070400080401).** The DNR's WHAF Tool can be used to identify areas in these headwater areas where wetland restoration would be most successful. See DNR WHAF Tool

(https://arcgis.dnr.state.mn.us/ewr/whaf2/) and refer to layer, "Restorable Wetland Index, 2019."

Local priority restoration strategies:

Every two years, the Root River CWMP Planning Work Group creates a work plan for implementation. Practices are approved by the Local Policy Committee and are funded by watershed based implementation funds (WBIF). Priorities for the RRW 2024-2025 work plan (Table 21) are detailed in Priority resource concerns from the draft 2024-2025 work plan for the RRW CWMP.

Table 21. Priority resource concerns from the draft 2024-2025 work plan for the RRW CWMP.

Priority resource concerns
Plan and implement BMPs which address Total Nitrogen (TN), Pesticides and Bacteria entering Groundwater in Drinking Water Supplies (Public and Private).
Plan and implement BMPs which address Sediment, TN, TP, Bacteria and Excess Runoff entering Surface Water in Streams and Rivers.
Plan and implement BMPs which address Excess Runoff entering Surface Water causing Flooding.
Promote adoption of BMPs by increasing engagement and communication with local landowners/agricultural producers, to increase understanding of on-farm production issues, identify solutions to overcome fiscal and operational hurdles to conservation practice implementation and communicate the benefits of implementation activities.
Improve or maintain communities' cultural, economic, natural and water resources by promoting decisions which enhance the livability of a community, characterized by a healthy environment, access to recreational and economic opportunities, high public safety and financial stability.

Mitigating and preventing fish kills:

As noted in Section 2.2, fish kill events in recent history include South Branch Whitewater (2015), Garvin Brook (2019), Trout Valley Creek (2021) and Rush Creek (2022). The following strategies can be viewed as prevention via awareness, source control and treatment respectively; all are recommended to reduce fish kill risk in the RRW and more generally in SE Minnesota:

- Proactive communications initiated in 2023, and to be continued indefinitely: use outreach tools, media, etc. to:
  - Summarize recent fish kills in southeast Minnesota and describe the problem;
  - Describe the high risk condition for fish kills in southeast Minnesota (see Section 2.2);
  - Direct land managers to tools and data that are helpful in mitigating fish kill risk;
    - Make the MDA runoff risk advisory tool (MDA 2022a) a focal point of outreach;
- Watch weather, use best practices and observe setbacks when applying manure, commercial fertilizer, and pesticides;
  - Identify high risk fields (e.g. steeply sloped alfalfa, silage, canning crop fields that may get summer manure applications) and make them focal points for outreach (Figure 48);

- Use feedlot inspections as outreach opportunities; including in-field land application inspections in priority locations such that manure application fields and rates are examined;

In order to prevent fish kills on trout streams and all waters, vegetative and structural BMPs in critical areas are needed to reduce surface runoff following intense storms. See Section 7.1, “Watershed Tools for Decision Support” and discussion below for additional information about how SPI can be used in targeting efforts. Materials are available to help communicate methods for minimizing fish kills at: [Minimizing fish kills in Minnesota | Minnesota Pollution Control Agency (state.mn.us)](#).

Figure 48. Summary of [MDA's Runoff Risk Advisory Tool](#).

MDA’s Runoff Risk Advisory Tool

MDA’s Runoff Risk Advisory Tool is recommended to identify high risk areas of runoff. Utilizing this tool, landowners can be aware of when surface runoff is most likely. Within the Runoff Risk Advisory Tool, “Stream Power Index (SPI)” identifies concentrated flow areas at the field scale. Local partners can use SPI with aerial imagery to identify fields without structural BMPs that could prevent contaminants from reach surface waters through runoff (grassed waterways, ponds, terraces, etc.).

It is recommended that the information from the Runoff Risk Advisory Tool be used in conjunction with ACPF as an implementation planning tool for local partners. Targeted communication in high-risk areas about fish kill prevention is a pro-active strategy that may reduce the likelihood of future fish kills. It is also recommended that the Runoff Risk Advisory Tool be paired with Manure Management Plan (MMP) reviews to identify where improved manure management can be applied.

8.1 Summary of strategies and goals

The following strategies and goals apply to the eight priority subwatersheds discussed in this report.

Table 22. Strategies and goals for WRAPS Update priority subwatersheds in the RRW.

HUC-12	Water body (last 4 WID digits)	Issue(s)	Recommended strategies	Goal
North Fork Bear Creek	North Fork Bear Creek (-F45)	• Poor aquatic habitat* • Lack of stream flow*	• Wetland restorations (via Conservation Reserve Enhancement Program [CREP] or RIM) • CRP prairie filter strips • Floodplain restoration • WASCOBs • Soil health practices • Two-stage ditch sections	Improve North Fork Bear Creek's available in-stream flow by reducing altered hydrology and stream channelization.
South Fork Bear Creek	South Fork Bear Creek (-544)	• Poor aquatic habitat • Altered watercourses	• Wetland restorations (via CREP or RIM) • CRP prairie filter strips • Floodplain restoration • WASCOBs • Soil health practices • Two-stage ditch sections	Improve South Fork Bear Creek's available in-stream flow by reducing upland runoff, increasing water storage capacity in critical areas, and restoring channelized sections where feasible.
Spring Valley Creek	Spring Valley Creek (-548) Unnamed Creek (-D53)	• Nitrate • TSS • *E. coli*	• Prairie filter strips • Soil health practices • WASCOBs • Sinkhole/karst outreach • Reduced fertilizer N inputs • SSTS compliance • Feedlot compliance and manure storage (including pastures) • Spring Valley WWTP nitrate reduction (construction)	Reduce nitrate and TSS concentrations to water quality standard (10 mg/L and 40 mg/L, respectively). Address noncompliant feedlots (including pastures) and septic systems to reduce *E. coli* concentrations.
Headwaters South Branch Root River	Judicial Ditch 1 (-561) South Branch Root River (-H18) South Branch Root River (-H19)	• Nitrate • *E. coli* • Flow (low flow)	• Wetland restorations (via CREP or RIM) • CRP prairie filter strips	Reduce nitrate and TSS concentrations to water quality standards, increase available

HUC-12	Water body (last 4 WID digits)	Issue(s)	Recommended strategies	Goal
		• Lack of aquatic habitat	• Soil health practices • WASCOBs • Grassed waterways • Controlled drainage • SSTS compliance • Feedlot compliance and manure storage • Continuation of Root River Field to Stream project • Ostrander WWTP nitrate reduction.	stream flow in late summer and reduce *E. coli* concentrations.
Upper Money Creek	Money Creek (-521)	• Turbidity (TSS) • *E. coli*	• WASCOBs • Grade stabilization structures • Cover crops • Feedlot and septic compliance	Reduce the peak stream flow of Money Creek and *E. coli* concentrations in stream.
Mill Creek	Mill Creek (-536) Unnamed Creek/Mill Creek Tributary (-A47)	• Nitrate • TSS • *E. coli* • Flow (altered hydrology) • Poor aquatic habitat	• Feedlot compliance (including pastures) • Soil health practices • Soil health outreach/education • WASCOBs and terraces • Reduced N fertilizer inputs	Reduce TSS runoff from uplands in the headwaters, add water storage to reduce stream peak flow, reduce *E. coli* concentrations and reduce average N concentrations to water quality standard.
Carey Creek	Carey Creek (-F85) Unnamed Creek/Carey Creek HW (-F87)	• Protect from future TSS impairment • Protect from channelization	• CRP Prairie strips • Habitat/in-channel improvement	Protect from TSS impairment by reducing sediment loading from streambank.
Riceford Creek	Riceford Creek (-H01) Riceford Creek (-518)	• Nitrate • TSS • Habitat • Flow alteration	• Flood control structure(s) • Floodplain re-connection • WASCOBs • Soil health practices • Reduced N fertilizer inputs	Reduce TSS concentrations by adding more water storage to the landscape and reduce average N concentrations to water quality standard.

***Need to be verified by future stressor identification.**

8.2 Watershed-wide strategies and goals

The strategies and goals in Table 23 can be applied across the entire HUC-8 RRW.

Table 23. Root River Watershed-wide strategies and goals.

Issue	Recommended strategies	Goal
Fish kill mitigation	• MDA's Runoff Risk Advisory Tool / SPI • Identify high risk runoff areas during MMP review. • Communicate with landowners on targeting high risk areas for implementation. • Incent creation of adequate manure storage. • Incent continuous living cover.	Mitigate fish kills through targeted/proactive communication, identifying high risk areas at the field scale, MMP review, and implementation of structural, vegetative, and process BMPs.
Water storage	• Add an additional 38,689 acre-feet of water storage.	Achieve a 25% reduction in peak flow at outlet of RRW HUC-8.
Climate change resiliency	• Floodplain restorations • Wetland restorations (DNR WHAF tool).	
Nitrate reduction	• Continue to incentivize nitrate reduction BMPs • Continue to provide private well nitrate monitoring • Continue to monitor surface waters, springs and groundwater wells for nitrate. • Coordinate between state and local staff to share updated nitrate data and trends.	Continue to provide outreach, education and technical assistance for nitrate reduction efforts in surface and groundwater.

9. Future watershed monitoring needs

The following waters in Table 24 are recommended for future monitoring, subject to resource availability. This additional monitoring will be needed in addition to or included into Cycle 3 IWM to validate water conditions:

Table 24. Priority waters recommended for future monitoring in the RRW.

Water body name (WID)	Type of monitoring needed
Watson Creek (07040008-552)	Additional macroinvertebrate monitoring could support de-listing.
South Fork Root River (07040008-511)	Additional STUBE data could support TSS delisting.
South Fork Root River (07040008-508)	Additional macroinvertebrate and TSS monitoring at 08LM009 during more stable flows needed to support macroinvertebrate and TSS correction.
North Branch Root River (07040008-716)	Additional macroinvertebrate monitoring at 08LM032 could support de-listing.
Kedron Creek (07040008-543)	Additional biological monitoring on WID at a more representative location is suggested.

Water body name (WID)	Type of monitoring needed
South Fork Bear Creek (07040008-544)	Additional biological monitoring is suggested and additional TSS and N monitoring is needed to solidify macroinvertebrate stressors.
Root River (07040008-522)	Additional macroinvertebrate monitoring requested to validate potential de-listing. Both upstream and downstream WIDs are proposed delistings.
North Fork Bear Creek (07040008-F45)	TSS and nitrate monitoring needed to determine biological stressors.
Carey Creek (07040008-F85)	Re-establish volunteer monitoring stations (S004-319) for STUBE collection and consider future chloride monitoring in headwaters (07040008-F87).

Future watershed needs also include additional monitoring project and funding needs (Table 25 and Table 26). These needs will require coordination between multiple organizations to be accomplished:

Table 25. Additional monitoring project and funding needs for the RRW.

Future need	Collaboration required
Additional monitoring of contaminants of emerging concern in Spring Valley Creek.	MPCA and MDH
Continued support (including funding) of RRFSP sites: South Branch Root, Crystal Creek and Bridge Creek	MPCA, MDA, DNR, BWSR, SWCDs and Counties
Identifying un/undersewered communities	MPCA and Counties
Partnering existing Nitratax sonde deployment with other data loggers	MPCA and DNR
Expanded shallow well monitoring	MDH, MGS, DNR and MPCA
Groundwater monitoring well in Crystal Creek Subwatershed	DNR and MPCA
Funding mechanism that would provide financial incentives for voluntary landowners for monitoring well installs.	MPCA, BWSR and MDH
Monitoring additional parameters from existing well network.	MDH, MGS, DNR and MPCA
Continue to support SE MN well network: on-going maintenance and financial support	All State and Local partners
Outreach and MMPs for feedlot producers in SE MN (particularly for 300 AU size	Counties and SWCDs
Better understand how much baseflow originates from groundwater versus surface water in the upper reaches of Mill Creek Subwatershed (070400080107)	DNR, MGS and MPCA
Springshed mapping for Riceford Creek, particularly area around middle section (07040008-518) and Mill Creek (focus on Chatfield DWSMA).	DNR, MGS, MPCA, MDA and MDH

Table 26. Additional needs from Root River One Watershed, One Plan.

Resource	Future need	Action #
Springsheds	Install additional, strategically located long-term groundwater observation wells in cooperation with the DNR to monitor water levels.	GW-5.4
	Continue research to define sinkhole locations and map springsheds in plan area.	GW-5.5
Trout Streams	Determine the location and value of existing fish barriers relevant to trout fisheries management and AIS control.	LF-3.1

10. Public outreach

Public outreach

Public outreach refers to communication of information, education, outreach, marketing, training, technical assistance, and other methods of working with stakeholders to achieve water resource management goals. In this second cycle of the watershed approach, there was less emphasis on public outreach for the WRAPS Update Report. This is because of active engagement already occurring in the water via Root River CWMP, and because outreach activities were not identified as a WRAPS Update priority task.

Although public outreach was not a focus of this WRAPS Update Report, several outreach initiatives were supported by MPCA. An example to highlight is a series of karst resources produced through a partnership between MDA and MPCA. Videos, infographics and educational "Karst Trunks" use realistic graphics, animation, and aerial footage to illustrate unique karst geologic features, the complex movement of water to bedrock aquifers and streams, and the vulnerability to contaminants like nitrate. These resources are available at https://www.mda.state.mn.us/segwresources.

Public notice for comments

An opportunity for public comment on the draft WRAPS Update Report was provided via a public notice in the State Register from February 20, 2024, through March 21, 2024. There were no comments received and responded to as a result of the public comment period.

11. References

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