Watershed health

July 2018

Minnesota River – Headwaters Watershed Monitoring and Assessment Report

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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List of acronyms

CD County Ditch

CI Confidence Interval

CR County Road

CSAH County State Aid Highway

CWA Clean Water Act

DNR Minnesota Department of Natural Resources

DO Dissolved oxygen

EPA U.S. Environmental Protection Agency

EQuIS Environmental Quality Information System

EX Exceeds Criteria (Bacteria)

EXP Exceeds Criteria, Potential Impairment

EXS Exceeds Criteria, Potential Severe Impairment

FS Full Support

FWMC Flow Weighted Mean Concentration

HUC Hydrologic Unit Code

IBI Index of Biotic Integrity

IF Insufficient Information

IWM Intensive watershed monitoring

LRVW Limited Resource Value Water

MCL Maximum contaminant level

MDH Minnesota Department of Health

MPCA Minnesota Pollution Control Agency

MSHA Minnesota Stream Habitat Assessment

MTS Meets the Standard

N Nitrogen

Nitrate-N Nitrate Plus Nitrite Nitrogen

NA Not Assessed

NHD National Hydrologic Dataset

NH3 Ammonia

NS Not Supporting

NT No Trend

NWR

OP Orthophosphate

PCB Poly Chlorinated Biphenyls

PFOS perfluorooctane sulfate

SWAG Surface Water Assessment Grant

TALU Tiered Aquatic Life Uses

TKN Total Kjeldahl Nitrogen

TMDL Total Maximum Daily Load

TP Total Phosphorous

TSS Total Suspended Solids

UAA Use Attainability Analysis

USGS United States Geological Survey

WID Waterbody Identification Number

WPLMN Watershed Pollutant Load Monitoring Network

Executive summary

The Minnesota River - Headwaters watershed is dominated by small, shallow basins with the exceptions of Big Stone and Lac qui Parle lakes. Both are long, run of the river reservoirs. These basins are impaired for recreation use, with the potential to produce nuisance algal blooms. The Minnesota Department of Natural Resources (DNR) fish community data revealed Big Stone Lake was noted as vulnerable to a future aquatic life use impairment, and stressor analysis indicated watershed disturbance is playing a role in aquatic community health. Many challenges lie ahead attempting to maintain and restore current water quality on these large dynamic basins that provide recreational use to the local citizen and visitors that support local economies. As recreational water quality degrades appeal to potential users will wane, negative consequences result (property value, small business success, quality of life, state park usage, recreational fishing). Many small, shallow basins were not addressed in this assessment effort; data on these basins was limited to single surveys. Recreational use of these basins is likely to involve waterfowl observation and hunting. Maintaining healthy native vegetation populations by curbing excessive nutrients and dense algae growth will be beneficial to attracting desirable waterfowl populations.

Of the stream reaches monitored and assessed in this effort, 80% failed to meet aquatic life use criteria, while 88% of stream reaches failed aquatic recreation use criteria. Water chemistry datasets showed high nutrient concentrations and some elevated total suspended solid concentrations were present in the watershed. Past listings for turbidity (Yellow Bank River) and fecal coliform (Yellow Bank River, North Branch Yellow Bank River, South Branch Yellow Bank River) were all confirmed by more recent data collection and will remain on the impaired waters list following this effort. Restoration work has been underway since the initial listings.

Fish communities in the streams were significant drivers of aquatic life impairments. Of the streams, 75% had fish communities and 38% had macroinvertebrate communities not meeting aquatic life use standards. Fish and macroinvertebrate communities both indicated impairment on 33% of the streams. A reach on Stony Run Creek, and an Unnamed Creek that is a tributary to Emily Creek, had existing aquatic life impairments based on fish that were confirmed by current assessments. One of the factors contributing to fish communities failing standards was the abundance of tolerant fish species. Some of the most abundant fish in the watershed are considered tolerant and many fish samples were dominated by these species. Altered hydrology, sedimentation, lack of habitat, physical barriers (e.g. perched culverts.), and excess nutrients are all issues negatively affecting the biological communities in the streams.

For macroinvertebrate communities within the watershed, several streams met aquatic life standards, but were not fully supporting aquatic life due to failing fish communities and/or water chemistry impairments. Streams that supported healthy macroinvertebrate communities tended to have relatively good habitat, stable flow, and a vegetated riparian corridor of trees and/or perennial grasses.

Groundwater protection concerns within the watershed include both quantity and quality. Quality concerns include high levels of naturally occurring elements, and high levels of nitrate from human activities. Groundwater withdrawals, and especially surface water withdrawals have increased. Whether the recharge rates for groundwater are not surpassed by withdrawals is the quantity concern. Data from one location has not shown a change in groundwater levels in the last four decades within the watershed. Additional groundwater monitoring data would be important in helping conserve groundwater resources.

Currently, wetlands comprise 9.2% of the watershed area (46,000 acres) based on the National Wetland Inventory, with emergent vegetation wetlands being the most widespread. Historically, based on Natural Resources Conservation Service soil survey data (SSURGO) wetlands accounted for 27% of the watershed area (134,000 acres). About 66% of the historic wetlands have been lost in the watershed. Based on MPCA statewide survey data for the temperate prairies ecoregion, wetland vegetation conditions should range between fair-poor for 80% of the wetlands in the watershed. Depressional wetland macroinvertebrate data from MPCA statewide surveys estimate the macroinvertebrate communities are predicted to fare better with 41% rated good.

Altered hydrology, sediment, and excess nutrients considerably affect the quality of the aquatic resources of the watershed. Implementation of best management practices, such as conservation tillage, cover crops, and other practices would aid in protecting, and improving the groundwater, wetlands, streams, and lakes of the watershed.

Introduction

Water is one of Minnesota's most abundant and precious resources. The Minnesota Pollution Control Agency (MPCA) is charged under both federal and state law with the responsibility of protecting the water quality of Minnesota's water resources. MPCA's water management efforts are tied to the 1972 Federal Clean Water Act (CWA), which requires states to adopt water quality standards to protect their water resources and the designated uses of those waters, such as for drinking water, recreation, fish consumption and aquatic life. States are required to provide a summary of the status of their surface waters and develop a list of waterbodies that do not meet established standards. Such waters are referred to as "impaired waters" and the state must make appropriate plans to restore these waters, including the development of total maximum daily loads (TMDLs). A TMDL is a comprehensive study determining the assimilative capacity of a waterbody, identifying all pollution sources causing or contributing to impairment, and an estimation of the reductions needed to restore a waterbody so that it can once again support its designated use.

The MPCA currently conducts a variety of surface water monitoring activities that support our overall mission of helping Minnesotans protect the environment. To successfully prevent and address problems, decision makers need good information regarding the status of the resources, potential and actual threats, options for addressing the threats and data on the effectiveness of management actions. The MPCA's monitoring efforts are focused on providing that critical information. Overall, the MPCA is striving to provide information to assess, and ultimately, to restore or protect the integrity of Minnesota's waters.

The passage of Minnesota's Clean Water Legacy Act in 2006 provided a policy framework and the initial resources for state and local governments to accelerate efforts to monitor, assess, restore, and protect surface waters. This work is implemented on an on-going basis with funding from the Clean Water Fund created by the passage of the Clean Water Land, and Legacy Amendment to the state constitution. To facilitate the best use of agency and local resources, the MPCA has developed a watershed monitoring strategy, which uses an effective and efficient integration of agency and local water monitoring programs to assess the condition of Minnesota's surface waters, and to allow for coordinated development and implementation of water quality restoration and improvement projects.

The strategy behind the watershed monitoring approach is to intensively monitor streams and lakes within a major watershed to determine the overall health of water resources, identify impaired waters, and to identify waters in need of additional protection. The benefit of the approach is the opportunity to begin to address most, if not all, impairments through a coordinated TMDL process at the watershed scale, rather than the reach-by-reach and parameter-by-parameter approach often historically employed. The watershed approach will more effectively address multiple impairments resulting from the cumulative effects of point and non-point sources of pollution and further the CWA goal of protecting and restoring the quality of Minnesota's water resources.

This watershed-wide monitoring approach was implemented in the Minnesota River-Headwaters Watershed beginning in the summer of 2015. This report provides a summary of all water quality assessment results in the Minnesota River-Headwaters Watershed and incorporates all data available for the assessment process including watershed monitoring, volunteer monitoring and monitoring conducted by local government units.

The watershed monitoring approach

The watershed approach is a 10-year rotation for monitoring and assessing waters of the state on the level of Minnesota's 80 major watersheds. The major benefit of this approach is the integration of monitoring resources to provide a more complete and systematic assessment of water quality at a geographic scale useful for the development and implementation of effective TMDLs, project planning, effectiveness monitoring, and protection strategies. The following paragraphs provide details on each of the four principal monitoring components of the watershed approach. For additional information see: Watershed Approach to Condition Monitoring and Assessment (MPCA 2008) (http://www.pca.state.mn.us/publications/wq-s1-27.pdf).

Watershed pollutant load monitoring

The Watershed Pollutant Load Monitoring Network (WPLMN) is a long-term statewide river monitoring network initiated in 2007 and designed to obtain pollutant load information from 199 river monitoring sites throughout Minnesota. Monitoring sites span three ranges of scale:

Basin – major river main stem sites along the Mississippi, Minnesota, Rainy, Red, Des Moines, Cedar, and St. Croix rivers

Major Watershed – tributaries draining to major rivers with an average drainage area of 1,350 square miles (8-digit HUC scale)

Subwatershed – major branches or nodes within major watersheds with average drainage areas of approximately 300-500 square miles

The program utilizes state and federal agencies, universities, local partners, and MPCA staff to collect water quality and flow data to calculate nitrogen, phosphorus, and sediment pollutant loads.

Intensive watershed monitoring

The intensive watershed monitoring (IWM) strategy utilizes a nested watershed design allowing the sampling of streams within watersheds from a coarse to a fine scale (Figure 1). Each watershed scale is defined by a hydrologic unit code (HUC). These HUCs define watershed boundaries for waterbodies within a similar geographic and hydrologic extent. The foundation of this approach is the 80 major watersheds (8-HUC) within Minnesota. Using this approach many of the smaller headwaters and tributaries to the main stem river are sampled in a systematic way so that a more holistic assessment of the watershed can be conducted and problem areas identified without monitoring every stream reach. Each major watershed is the focus of attention for at least 1 year within the 10-year cycle.

River/stream sites are selected near the outlet of each of three watershed scales, 8-HUC, aggregated 12-HUC and 14-HUC (Figure 2). Within each scale, different water uses are assessed based on the opportunity for that use (i.e., fishing, swimming, supporting aquatic life such as fish and insects). The major river watershed is represented by the 8-HUC scale. The outlet of the major 8-HUC watershed (purple dots in Figure 2) is sampled for biology (fish and macroinvertebrates), water chemistry and fish contaminants to allow for the assessment of aquatic life, aquatic recreation and aquatic consumption use support. The aggregated 12-HUC is the next smaller subwatershed scale which generally consists of major tributary streams with drainage areas ranging from 75 to 150 mi^2. Each aggregated 12-HUC outlet (green dots in Figure 2) is sampled for biology and water chemistry for the assessment of aquatic life and aquatic recreation use support. Within each aggregated 12-HUC, smaller watersheds (14 HUCs, typically 10-20 mi^2), are sampled at each outlet that flows into the major aggregated 12-HUC tributaries. Each of these minor subwatershed outlets is sampled for biology to assess aquatic life use support (red dots in Figure 2).

Figure 1. The intensive watershed monitoring design.

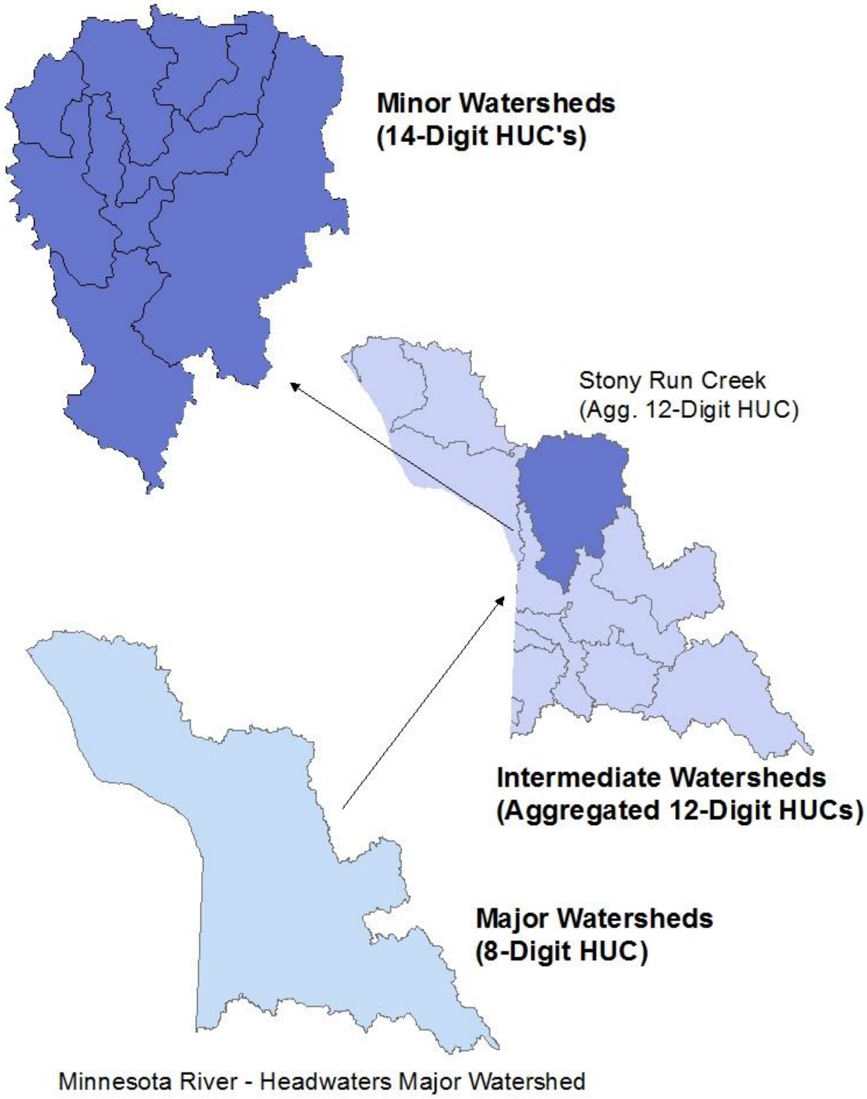
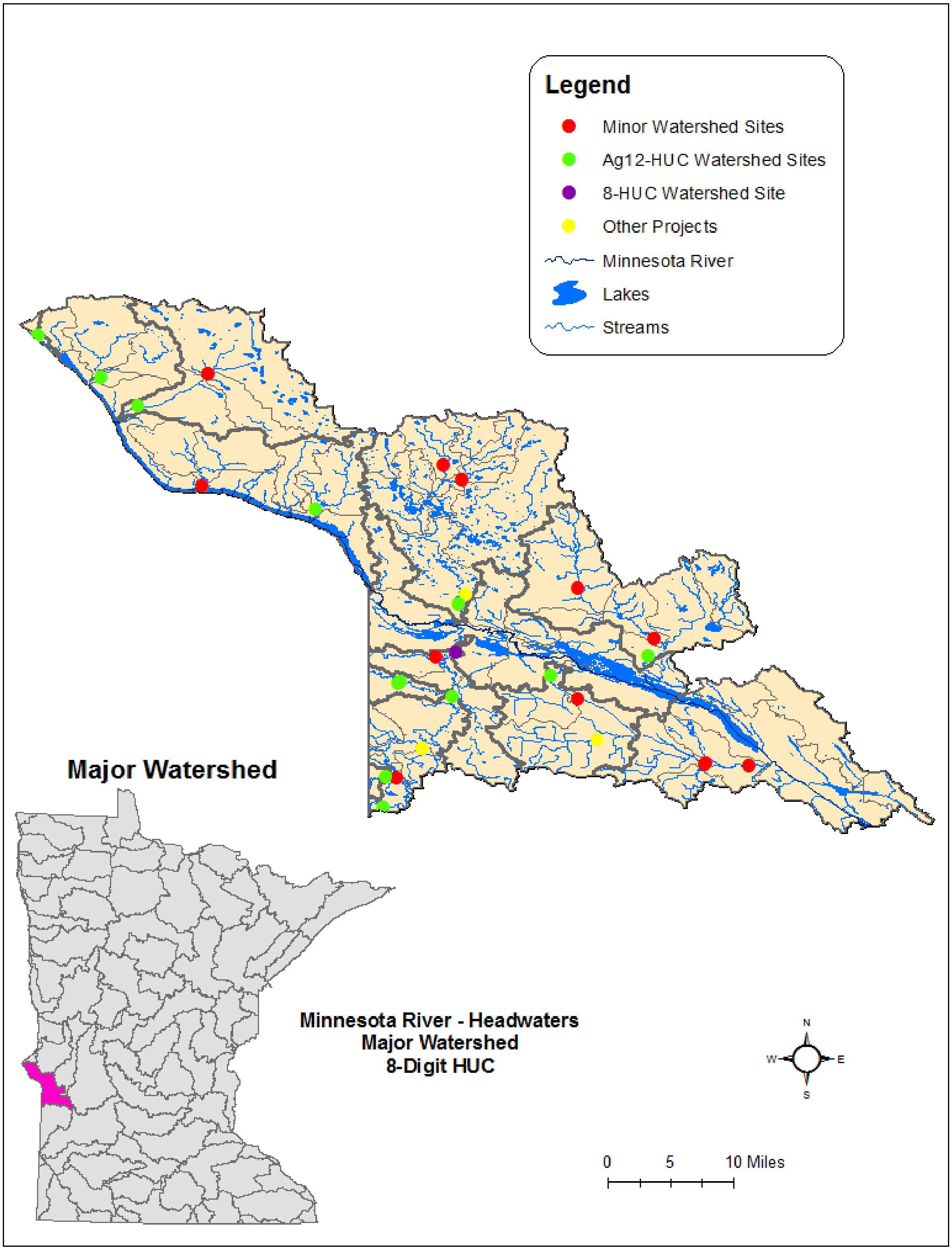


Figure 2. Intensive watershed monitoring sites for streams in the Minnesota River-Headwaters Watershed.



Lake monitoring

Lakes most heavily used for recreation (all those greater than 500 acres and at least 25% of lakes 100-499 acres) are monitored for water chemistry to determine if recreational uses, such as swimming and wading, are being supported and where applicable, where fish community health can be determined. Lakes are prioritized by size, accessibility (can the public access the lakes), and presence of recreational use.

Specific locations for sites sampled as part of the intensive monitoring effort in the Minnesota River-Headwaters Watershed are shown in Figure 3 and are listed in Appendices 2.1 and 2.2.

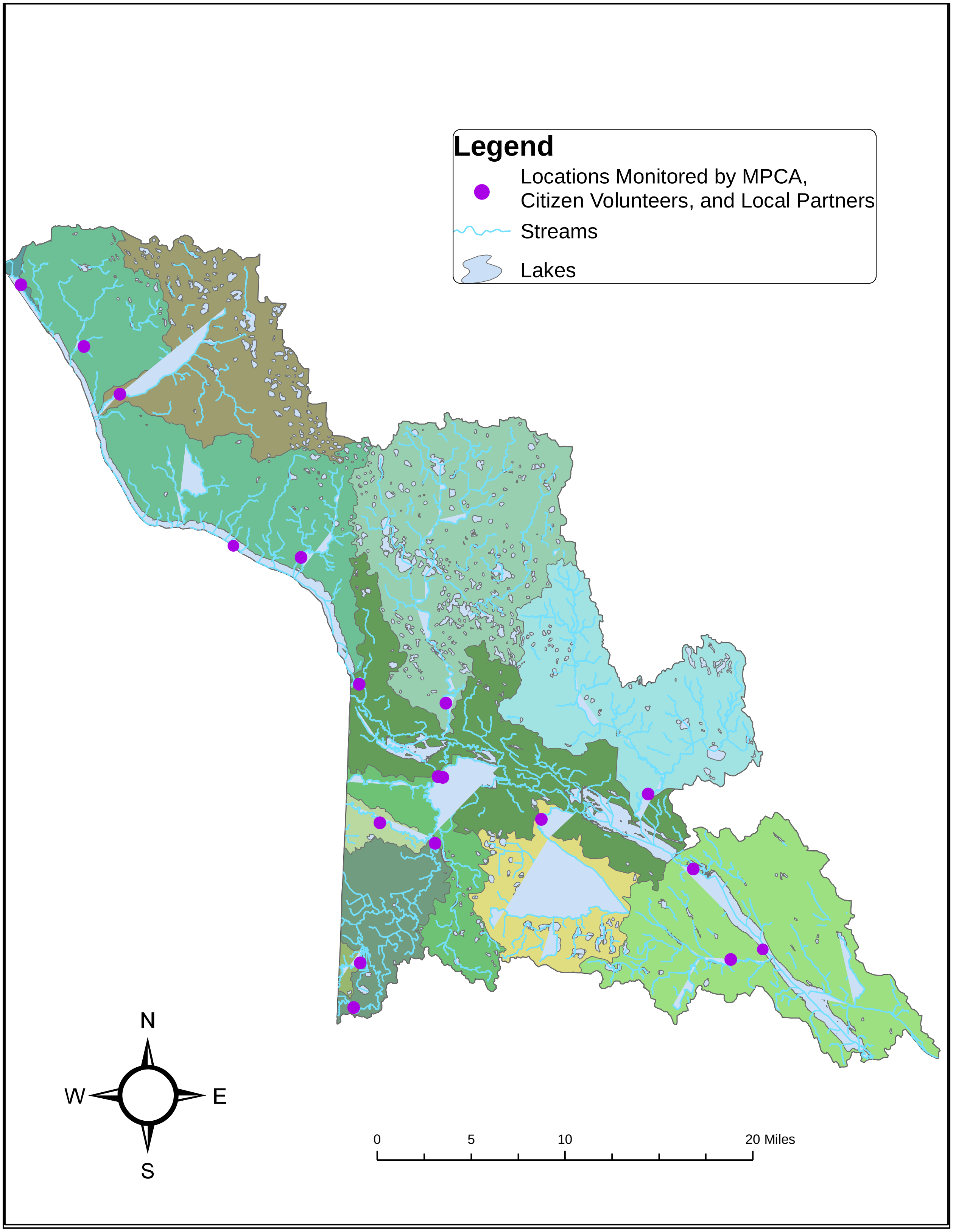
Citizen and local monitoring

Citizen and local monitoring is an important component of the watershed approach. The MPCA and its local partners jointly select the stream sites and lakes to be included in the IWM process. Funding passes from MPCA through Surface Water Assessment Grants (SWAGs) to local groups such as counties, soil and water conservation districts, watershed districts, nonprofits and educational institutions to support lake and stream water chemistry monitoring. Local partners use the same monitoring protocols as the MPCA, and all monitoring data from SWAG projects are combined with the MPCA's to assess the condition of Minnesota lakes and streams. Preplanning and coordination of sampling with local citizens and governments helps focus monitoring where it will be most effective for assessment and observing long-term trends. This allows citizens/governments the ability to see how their efforts are used to inform water quality decisions and track how management efforts affect change. Many SWAG grantees invite citizen participation in their monitoring projects and their combined participation greatly expand our overall capacity to conduct sampling.

The MPCA also coordinates two programs aimed at encouraging long term citizen surface water monitoring: the Citizen Lake Monitoring Program and the Citizen Stream Monitoring Program. Like the permanent load monitoring network, having citizen volunteers monitor a given lake or stream site monthly and from year to year can provide the long-term picture needed to help evaluate current status and trends. Citizen monitoring is especially effective at helping to track water quality changes that occur in the years between intensive monitoring years.

Figure 3 provides the locations where citizen monitoring data were used for assessment in the Minnesota River-Headwaters Watershed.

Figure 3. Monitoring locations of local groups, citizens and the MPCA lake monitoring staff in the Minnesota River-Headwaters Watershed.



Assessment methodology

The CWA requires states to report on the condition of the waters of the state every two years. This biennial report to Congress contains an updated list of surface waters that are determined to be supporting or non-supporting of their designated uses as evaluated by the comparison of monitoring data to criteria specified by Minnesota Water Quality Standards (Minn. R. ch. 7050 2008; https://www.revisor.leg.state.mn.us/rules/?id=7050). The assessment and listing process involves dozens of MPCA staff, other state agencies and local partners. The goal of this effort is to use the best data and best science available to assess the condition of Minnesota's water resources. For a thorough review of the assessment methodologies see: *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment 305(b) Report and 303(d) List (MPCA 2012)*. https://www.pca.state.mn.us/sites/default/files/wq-iw1-04.pdf.

Water quality standards

Water quality standards are the fundamental benchmarks by which the quality of surface waters are measured and used to determine impairment. These standards can be numeric or narrative in nature and define the concentrations or conditions of surface waters that allow them to meet their designated beneficial uses, such as for fishing (aquatic life), swimming (aquatic recreation), or human consumption (aquatic consumption). All surface waters in Minnesota, including lakes, rivers, streams, and wetlands are protected for aquatic life and recreation where these uses are attainable. Numeric water quality standards represent concentrations of specific pollutants in water that protect a specific designated use. Narrative standards are statements of conditions in and on the water, such as biological condition, that protect their designated uses.

Protection of aquatic recreation means the maintenance of conditions safe and suitable for swimming and other forms of water recreation. In streams, aquatic recreation is assessed by measuring the concentration of *E. coli* bacteria in the water. To determine if a lake supports aquatic recreational activities its trophic status is evaluated, using total phosphorus (TP), Secchi depth and chlorophyll-a as indicators. Lakes that are enriched with nutrients and have abundant algal growth are eutrophic and do not support aquatic recreation.

Protection of consumption means protecting citizens who eat fish from Minnesota waters or receive their drinking water from waterbodies protected for this beneficial use. The concentrations of mercury and polychlorinated biphenyls (PCBs) in fish tissue are used to evaluate whether or not fish are safe to eat in a lake or stream and to issue recommendations regarding the frequency that fish from a particular waterbody can be safely consumed. For lakes, rivers, and streams that are protected as a source of drinking water, the MPCA primarily measures the concentration of nitrate in the water column to assess this designated use.

Protection of aquatic life means the maintenance of a healthy aquatic community, including fish, invertebrates and plants. Biological monitoring, the sampling of aquatic organisms, is a direct means to assess aquatic life use support, as the aquatic community tends to integrate the effects of all pollutants and stressors over time. To effectively use biological indicators, the MPCA employs the Index of Biotic Integrity (IBI). This index is a scientifically validated combination of measurements of the biological community (called metrics). An IBI is comprised of multiple metrics that measure different aspects of aquatic communities (e.g., dominance by pollution tolerant species, loss of habitat specialists). Metric scores are summed together and the resulting index score characterizes the biological integrity or "health" of a site. The MPCA has developed stream IBIs for fish and macroinvertebrates since these communities can respond differently to various types of pollution. The MPCA also uses a lake fish IBI developed by the DNR to determine if lakes are meeting aquatic life use. Because the lakes, rivers, and streams in Minnesota are physically, chemically, and biologically diverse, IBIs are developed separately for different stream classes and lake class groups to account for this natural variation. Further interpretation of biological community data is provided by an assessment threshold or biocriteria against which an IBI score can be compared within a given stream class. In general, an IBI score above this threshold is indicative of aquatic life use support, while a score below this threshold is indicative of non-support. Additionally, chemical parameters are measured and assessed against numeric standards developed to be protective of aquatic life. For streams, these include pH, dissolved oxygen (DO), un-ionized ammonia nitrogen, chloride, total suspended solids, pesticides, and river eutrophication. For lakes, pesticides and chlorides contribute to the overall aquatic life use assessment.

Protection for aquatic life uses in streams and rivers are divided into three tiers: Exceptional, General, and Modified. Exceptional Use waters support fish and macroinvertebrate communities that have minimal changes in structure and function from the natural condition. General Use waters harbor "good" assemblages of fish and macroinvertebrates that can be characterized as having an overall balanced distribution of the assemblages and with the ecosystem functions largely maintained through redundant attributes. Modified Use waters have been extensively altered through legacy physical modifications which limit the ability of the biological communities to attain the General Use. Currently the Modified Use is only applied to streams with channels that have been directly altered by humans (e.g., maintained for drainage, riprapped). These tiered uses are determined before assessment based on the attainment of the applicable biological criteria and/or an assessment of the habitat. For additional information, see: http://www.pca.state.mn.us/index.php/water/water-permits-and-rules/water-rulemaking/tiered-aquatic-life-use-talu-framework.html).

Table 1. Proposed tiered aquatic life use standards.

Proposed tiered aquatic life use	Acronym	Proposed use class code	Description
Warm water General	WWg	2Bg	Warm water Stream protected for aquatic life and recreation, capable of supporting and maintaining a balanced, integrated, adaptive community of warm or cool water aquatic organisms that meet or exceed the General Use biological criteria.
Warm water Modified	WWm	2Bm	Warm water Stream protected for aquatic life and recreation, physically altered watercourses (e.g., channelized streams) capable of supporting and maintaining a balanced, integrated, adaptive community of warm or cool water aquatic organisms that meet or exceed the Modified Use biological criteria, but are incapable of meeting the General Use biological criteria as determined by a Use Attainability Analysis
Warm water Exceptional	WWe	2Be	Warm water Stream protected for aquatic life and recreation, capable of supporting and maintaining an exceptional and balanced, integrated, adaptive community of warm or cool water aquatic organisms that meet or exceed the Exceptional Use biological criteria.
Coldwater General	CWg	2Ag	Coldwater Stream protected for aquatic life and recreation, capable of supporting and maintaining a balanced, integrated, adaptive community of cold water aquatic organisms that meet or exceed the General Use biological criteria.
Coldwater Exceptional	CWe	2Ae	Coldwater Stream protected for aquatic life and recreation, capable of supporting and maintaining an exceptional and balanced, integrated, adaptive community of cold water aquatic organisms that meet or exceed the Exceptional Use biological criteria.

A small percentage of stream miles in the state (~1% of 92,000 miles) have been individually evaluated and re-classified as a Class 7 Limited Resource Value Water (LRVW). These streams have previously demonstrated that the existing and potential aquatic community is severely limited and cannot achieve aquatic life standards either by: a) natural conditions as exhibited by poor water quality characteristics, lack of habitat or lack of water; b) the quality of the resource has been significantly altered by human activity and the effect is essentially irreversible; or c) there are limited recreational opportunities (such as fishing, swimming, wading or boating) in and on the water resource. While not being protective of aquatic life, LRVWs are still protected for industrial, agricultural, navigation and other uses. Class 7 waters are also protected for aesthetic qualities (e.g., odor), secondary body contact, and groundwater for use as a potable water supply. To protect these uses, Class 7 waters have standards for bacteria, pH, DO and toxic pollutants.

Assessment units

Assessments of use support in Minnesota are made for individual waterbodies. The waterbody unit used for river systems, lakes and wetlands is called the “assessment unit”. A stream or river assessment unit usually extends from one significant tributary stream to another or from the headwaters to the first tributary. A stream “reach” may be further divided into two or more assessment reaches when there is a change in use classification (as defined in Minn. R. ch. 7050) or when there is a significant morphological feature, such as a dam or lake, within the reach. Therefore, a stream or river is often segmented into multiple assessment units that are variable in length. The MPCA is using the 1:24,000 scale high resolution National Hydrologic Dataset (NHD) to define and index stream, lake and wetland assessment units. Each river or stream reach is identified by a unique waterbody identifier (known as its WID), comprised of the U.S. Geological Survey (USGS) eight-digit hydrologic unit code (8-HUC) plus a three-character code that is unique within each HUC. Lake and wetland identifiers are assigned by the DNR. The Protected Waters Inventory provides the identification numbers for lake, reservoirs and wetlands. These identification numbers serve as the WID and are composed of an eight-digit number indicating county, lake and bay for each basin.

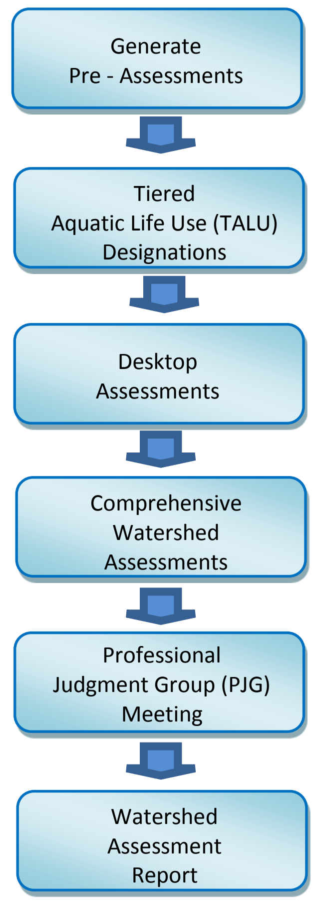
It is for these specific stream reaches or lakes that the data are evaluated for potential use impairment. Therefore, any assessment of use support would be limited to the individual assessment unit. The major exception to this is the listing of rivers for contaminants in fish tissue (aquatic consumption). Over the course of time it takes fish, particularly game fish, to grow to “catchable” size and accumulate unacceptable levels of pollutants, there is a good chance they have traveled a considerable distance. The impaired reach is defined by the location of significant barriers to fish movement such as dams upstream and downstream of the sampled reach and thus often includes several assessment units.

Determining use attainment

For beneficial uses related to human health, such as drinking water or aquatic recreation, the relationship is well understood and thus the assessment process is a relatively simple comparison of monitoring data to numeric standards. In contrast, assessing whether a waterbody supports a healthy aquatic community is not as straightforward and often requires multiple lines of evidence to make use attainment decisions with a high degree of certainty. Incorporating a multiple lines of evidence approach into MPCA’s assessment process has been evolving over the past few years. The current process used to assess the aquatic life use of rivers and streams is outlined below and in Figure 4.

The first step in the aquatic life assessment process is largely an automated process performed by logic programmed into a database application where all data from the 10 year assessment window is gathered; the results are referred to as 'Pre-Assessments'. Data filtered into the "Pre-Assessment" process is then reviewed to insure that data is valid and appropriate for assessment purposes. Tiered use designations are determined before data is assessed based on the attainment of the applicable biological criteria and/or an assessment of the habitat. Stream reaches are assigned the highest aquatic life use attained by both biological assemblages on or after November 28, 1975. Streams that do not attain the Exceptional or General Use for both assemblages undergo a Use Attainability Analysis (UAA) to determine if a lower use is appropriate. A Modified Use can be proposed if the UAA demonstrates that the General Use is not attainable as a result of legal human activities (e.g., drainage maintenance, channel stabilization) which are limiting the biological assemblages through altered habitat. Decisions to propose a new use are made through UAA workgroups which include watershed project managers and biology leads. The final approval to change a designated use is through formal rulemaking.

Figure 4. Flowchart of aquatic life use assessment process.



The next step in the aquatic life assessment process is a comparison of the monitoring data to water quality standards. Pre-assessments are then reviewed by either a biologist or water quality professional, depending on whether the parameter is biological or chemical in nature. These reviews are conducted at the workstation of each reviewer (i.e., desktop) using computer applications to analyze the data for potential temporal or spatial trends as well as gain a better understanding of any extenuating circumstances that should be considered (e.g., flow, time/date of data collection, or habitat).

The next step in the process is a Comprehensive Watershed Assessment meeting where reviewers convene to discuss the results of their desktop assessments for each individual waterbody. Implementing a comprehensive approach to water quality assessment requires a means of organizing and evaluating information to formulate a conclusion utilizing multiple lines of evidence. Occasionally, the evidence stemming from individual parameters are not in agreement and would result in discrepant assessments if the parameters were evaluated independently. However, the overall assessment considers each piece of evidence to make a use attainment determination based on the preponderance of information available. See the *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment 305(b) Report and 303(d) List* (MPCA 2016) https://www.pca.state.mn.us/sites/default/files/wq-iw1-04j.pdf for guidelines and factors considered when making such determinations.

The last step in the assessment process is the Professional Judgment Group meeting. At this meeting, results are shared and discussed with entities outside of the MPCA that may have been involved in data collection or that might be responsible for local watershed reports and project planning. Information obtained during this meeting may be used to revise previous use attainment decisions (e.g., sampling events that may have been uncharacteristic due to annual climate or flow variation, local factors such as impoundments that do not represent the majority of conditions on the WID). Waterbodies that do not meet standards and therefore do not attain one or more of their designated uses, are considered impaired waters and are placed on the draft 303(d) Impaired Waters List. Assessment results are also included in watershed monitoring and assessment reports.

Watershed overview

The Minnesota River – Headwaters major watershed in West-Central Minnesota covers parts of South Dakota, Minnesota, and a very small portion of North Dakota. This watershed is the furthest upstream major watershed in the Minnesota River Basin. Within Minnesota, the watershed begins near the town of Browns Valley between Lake Traverse and Big Stone Lake at the state border. It then follows along Big Stone Lake and the Minnesota River in a southeasterly direction to roughly the town of Watson. The main feature of the watershed is the Minnesota River and its impressive valley, a remnant of the Glacial River Warren. Several large lakes (Big Stone, Marsh, and Lac qui Parle) are associated with the Minnesota River and its valley. These large lakes and the Minnesota River essentially bisect the watershed within Minnesota.

Total watershed area for the entire 8 digit HUC (07020001) is 2,132 square miles (1,364,543 acres), of which Minnesota's portion totals 784 square miles (501,796 acres). Six Minnesota counties make up the watershed. From largest percentage to least: Big Stone (52.3%), Lac qui Parle (29.8%), Swift (7.5%), Chippewa (5.6%), Traverse (4.4%), and Stevens (0.3%) (NRCS 2007). Towns within the watershed include Browns Valley, Beardsley, Barry, Clinton, Ortonville (the largest), Odessa, Nassau, Bellingham, Louisburg, Correll, and Milan.

Most of the Minnesota River – Headwaters watershed lies within the Northern Glaciated Plains U. S. Environmental Protection Agency (EPA) Level III ecoregion, while a smaller southeastern portion lies within the Western Corn Belt Plains ecoregion (Figure 5). The Northern Glaciated Plains ecoregion typically has irregular glacially formed topography, low to moderate precipitation, and a short growing season (Omernik and Gallant 1988). The Western Corn Belt Plains ecoregion consist of level to gently rolling dissected glacial till plains, hilly loess plains, and morainal hills (Omernik and Gallant 1988). Similar to the EPA's ecoregions, the USDA categorizes land resource areas. Like the ecoregions, most of the watershed lies within the Rolling Till Prairie major land resource areas, with an even smaller portion in Central Iowa and Minnesota Till Prairie (Figure 6). Both of these land resource areas support prairie vegetation and are extensively cultivated. Resource concerns in the Central Iowa and Minnesota Till Prairie include, water erosion, excess surface and subsurface water, and poor water quality (USDA 2006). Resource concerns in the Rolling Till Prairie include wind erosion, water erosion, maintaining soil organic matter, soil productivity, soil wetness, and management of soil moisture (USDA 2006).

Figure 5. The Minnesota River-Headwaters Watershed within the Northern Glaciated Plains and Western Corn Belt Plains ecoregion of West-Central Minnesota.

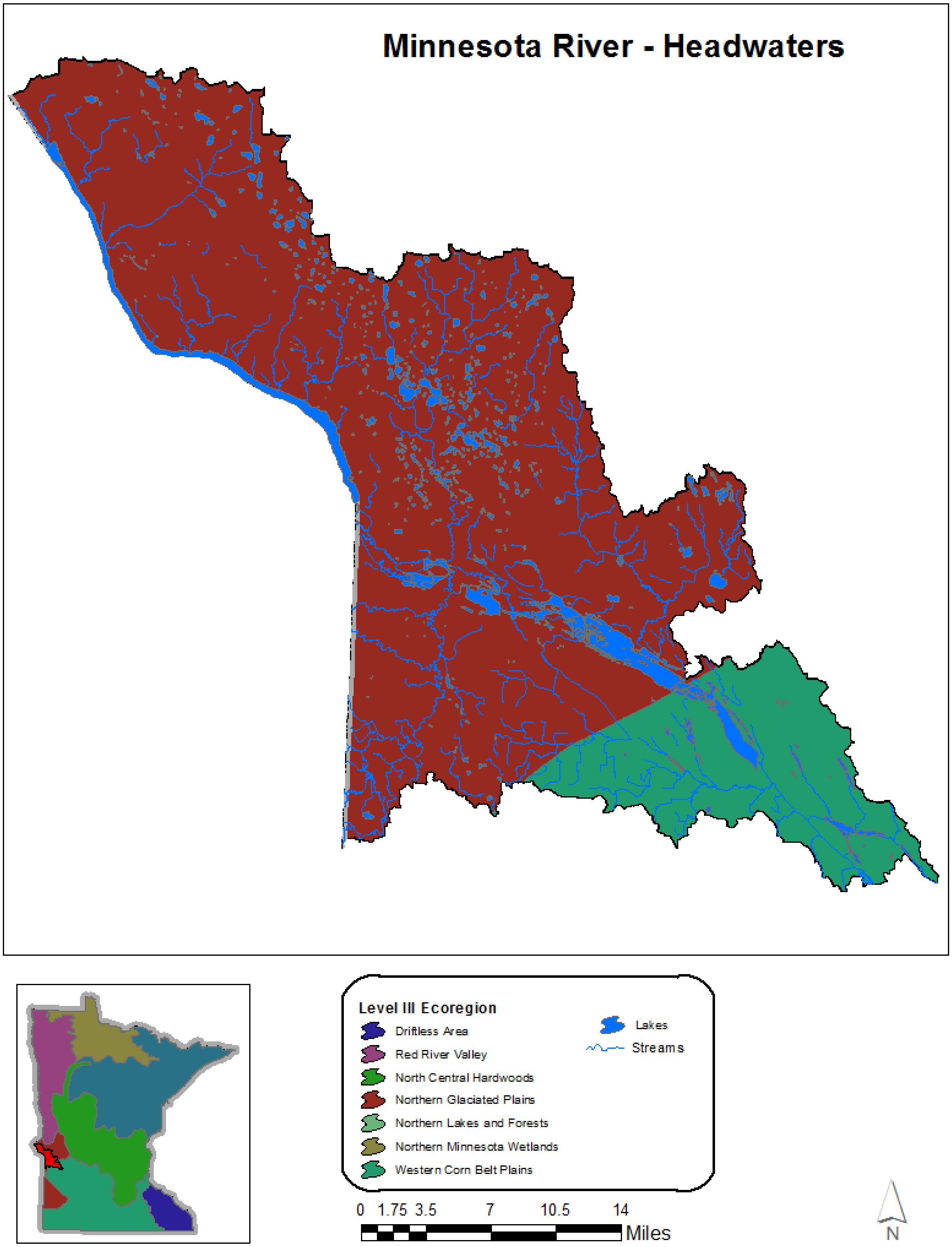
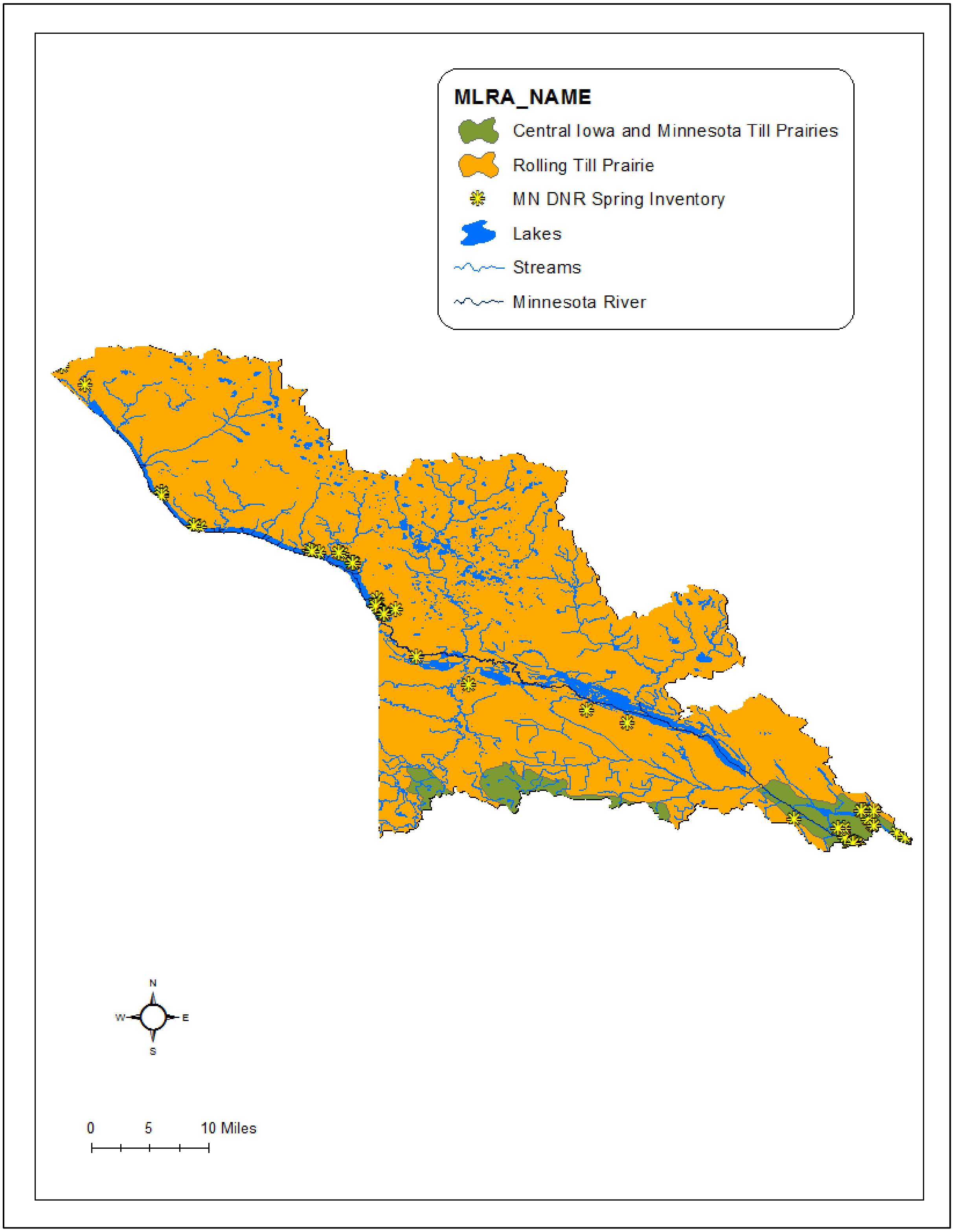


Figure 6. Major Land Resource Areas and springs in the Minnesota River-Headwaters Watershed.



Land use summary

Agriculture is a significant land use component in the Minnesota River-Headwaters Watershed (Figure 7). Cropland accounts for 53.6% of the area in the watershed. Of the cropland, approximately 90% is under two-year corn/soybean rotation (NRCS 2007). Other crops within the watershed include small grains, sugar beets, and hay (DNR 2017g). There are approximately 741 farms within the watershed, with 180-499 acres the most frequent size (NRCS 2007). Animal production is also a major component of agriculture within the watershed. There are approximately 174 permitted animal feeding operations, and a total of 422,296 animals in the watershed. Of the total animals, 11,001 are beef cattle, 6,140 dairy cattle, 89,999 chickens, 87,627 swine, 224,877 turkeys, and 2,652 other animals (NRCS 2007).

Considering the watershed occurs in a region that was historically prairie, rangeland (26.7%) accounts for the second largest percentage of land use. Rangeland can be natural prairie, hay, or quite frequently pastureland. Forest and shrubs only make up 1.7% of the watershed area. Frequently, bottomland forest occurs along the Minnesota River and many of the streams.

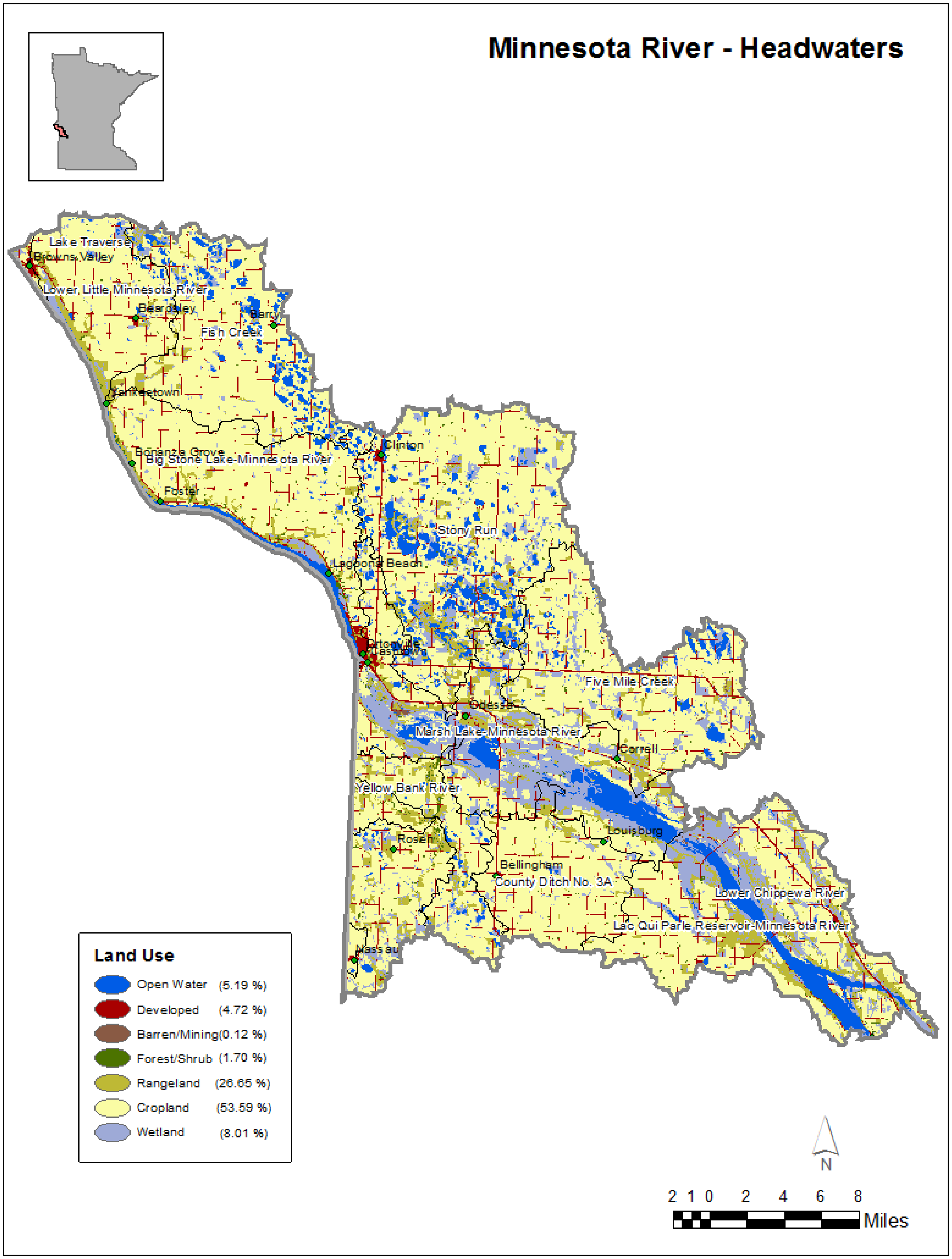
Wetlands have a considerable presence on the landscape. Numerous lakes and prairie potholes occur along the northern margin of the watershed. There are also significant wetlands along the Minnesota River. Open water in the watershed comprises 5.2% of the watershed area, wetlands another 8.0% of the area according to the National Land Cover Database.

Development makes up 4.7% of the watershed area. Most of the watershed is rural, with several small towns. The population of the watershed is 6,791 people, which equates to 8.7 people per square mile (DNR 2017g). Ortonville, the watersheds largest town, has a population of less than 2,000 people. Barren/Mining comprises 0.1% of the watershed area.

Many changes have occurred in the watershed since the first settlement by Europeans. According to Marschner Pre-European Settlement Landcover: prairie comprised 87.2%, wet prairie 8.3%, lakes (open water) 2.2%, river bottom forest 2.2%, and oak openings and barrens 0.1% of the historical watershed area (DNR 2017g). Since settlement, the majority of historic prairie has been converted to cropland. Many wetlands and wet prairies have been drained by ditching and subsurface tile for cropland as well. Much of the length of natural streams has been channelized to provide efficient movement of water off the landscape. Ditches were also dug to drain areas that had no natural surface drainage. Artificial drainage significantly impacts stream hydrology by reducing the amount of water storage on the landscape, contributing to shorter duration higher flow events, as well as reduced baseflow, and longer duration lower flows.

Notable areas of public land exist in this unique watershed protecting natural areas. Federal land makes up 5.5% of the land area, state ownership another 8.7%, and conservancies 0.2%. Big Stone National Wildlife Refuge (11,586 acres) is located in the Minnesota River valley near Odessa. Numerous U.S. Fish and Wildlife Service Waterfowl Production areas occur in the watershed, protecting prairie potholes and upland nesting cover for waterfowl. The DNR administers many areas protecting the natural landscape. One of the largest is Lac qui Parle Wildlife Management Area (24,337 acres) encompassing much of the area around Lac qui Parle Reservoir, an important stopping area for migratory waterfowl. Numerous smaller Wildlife Management Areas also occur, often centered around prairie potholes. For parks and recreation areas, Big Stone Lake State Park (1,131 acres) can be found on the shores of its namesake lake. A portion of Lac qui Parle State Park is also found within the watershed.

Figure 7. Land use in the Minnesota River-Headwaters Watershed (National Land Cover Database 2011).



Surface water hydrology

In the Minnesota River-Headwaters, there are a total of 1,064 miles of streams (NRCS 2007). Streams in this watershed are all direct tributaries to the Minnesota River and its associated lakes. The Minnesota River begins at the outlet of Big Stone Lake in Ortonville, and flows roughly southeast approximately 45 river miles to the outlet of Lac qui Parle Lake near Watson. The next downstream major watershed is the Minnesota River – Yellow Medicine. As the receiving water for nearly all waterbodies within the watershed, streams on the northern side of the Minnesota River and associated lakes typically flow roughly south, or southeast to meet up with the river and lakes. South of the Minnesota River and associated lakes, streams typically arise in the Coteau des Prairie, and roughly flow northeast to meet up with the river, or lakes. The largest tributary to the Minnesota River within the watershed is the Yellow Bank River. Other tributaries include, Little Minnesota River, Fish Creek, West Salmonsen Creek, Meadowbrook Creek, Whetstone River, Stony Run Creek, County Ditch 3A, Five Mile Creek, and Emily Creek. The large lakes within the watershed include Big Stone Lake, Marsh Lake, and Lac qui Parle Lake. Many prairie potholes and lakes can be found along the northern margin of the watershed. Some of these lakes include Long Tom, Bentsen, Thielke, Shible, and numerous unnamed lakes.

All of the streams within the watershed are classified as warmwater streams. With the topography along the Minnesota River Valley, many springs are present (Figure 6). Some streams may have localized areas with a colder thermal regime due to groundwater influence.

With many areas of the watershed relatively flat topography, and the widespread presence of agriculture in the watershed, many of the streams within the watershed have been channelized (ditched) to increase the acreage and productivity of cropland. Based on the MPCA's Altered Watercourse Project (Figure 8) approximately half of the stream miles in the watershed have been ditched. Without the Minnesota River included: 46% of the stream miles are altered, 27% are natural channels, 18% fall under the "No Definable Channel" category, and 9% are considered impounded reaches (Figure 9). Sections within the "No Definable Channel" category typically are intermittent grass waterways, none distinguishable channels thru wetlands or streams that have gone underground as part of a tile network. Calculations without the "No Definable Channel" category typically increases the percentage of altered streams. Channelization on the landscape within this watershed typically occurs in areas of flat topography and poor drainage, often in the headwater reaches of the streams (Figure 9). Natural channels within the watershed often occur in the downstream reaches of the streams, near the confluences with the Minnesota River (Figure 9). Many of these natural sections occur along the bluff of the Minnesota River Valley. Steeper topography and larger sized streams makes channelization more difficult. Oftentimes channelization is related to adjacent land use, with the highest likelihood of channelization occurring next to cropland.

Subsurface tiling to increase cropland acreage and productivity is another widespread component of a drainage network in an agricultural watershed. Prevalence of drain tile in a watershed has a significant impact on stream hydrology. Watersheds with significant tiling often see shortened durations and an increase in the magnitudes of high flow events, as well as more extreme periods of low flow.

Figure 8. Map of percent modified streams by major watershed (8-HUC).

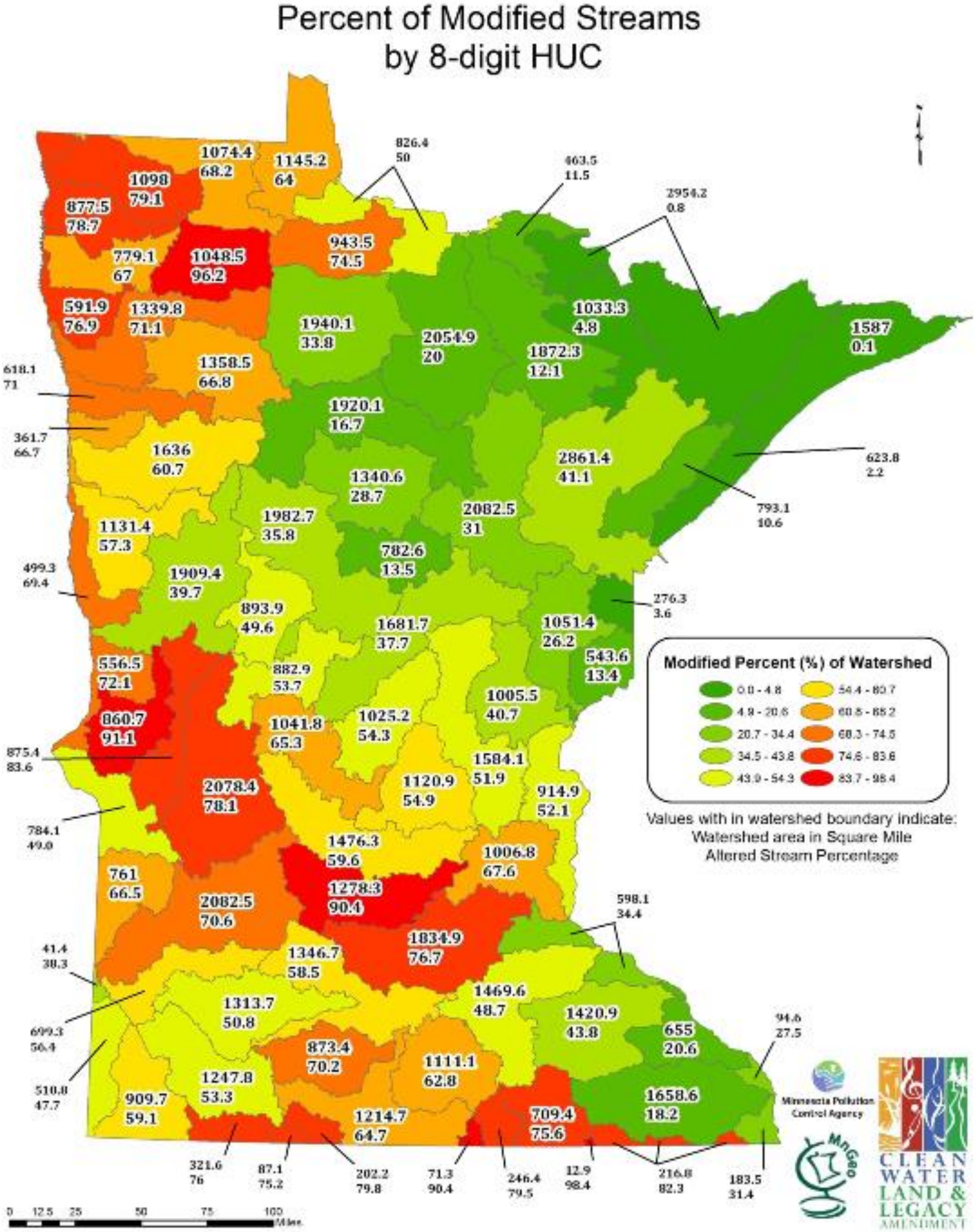
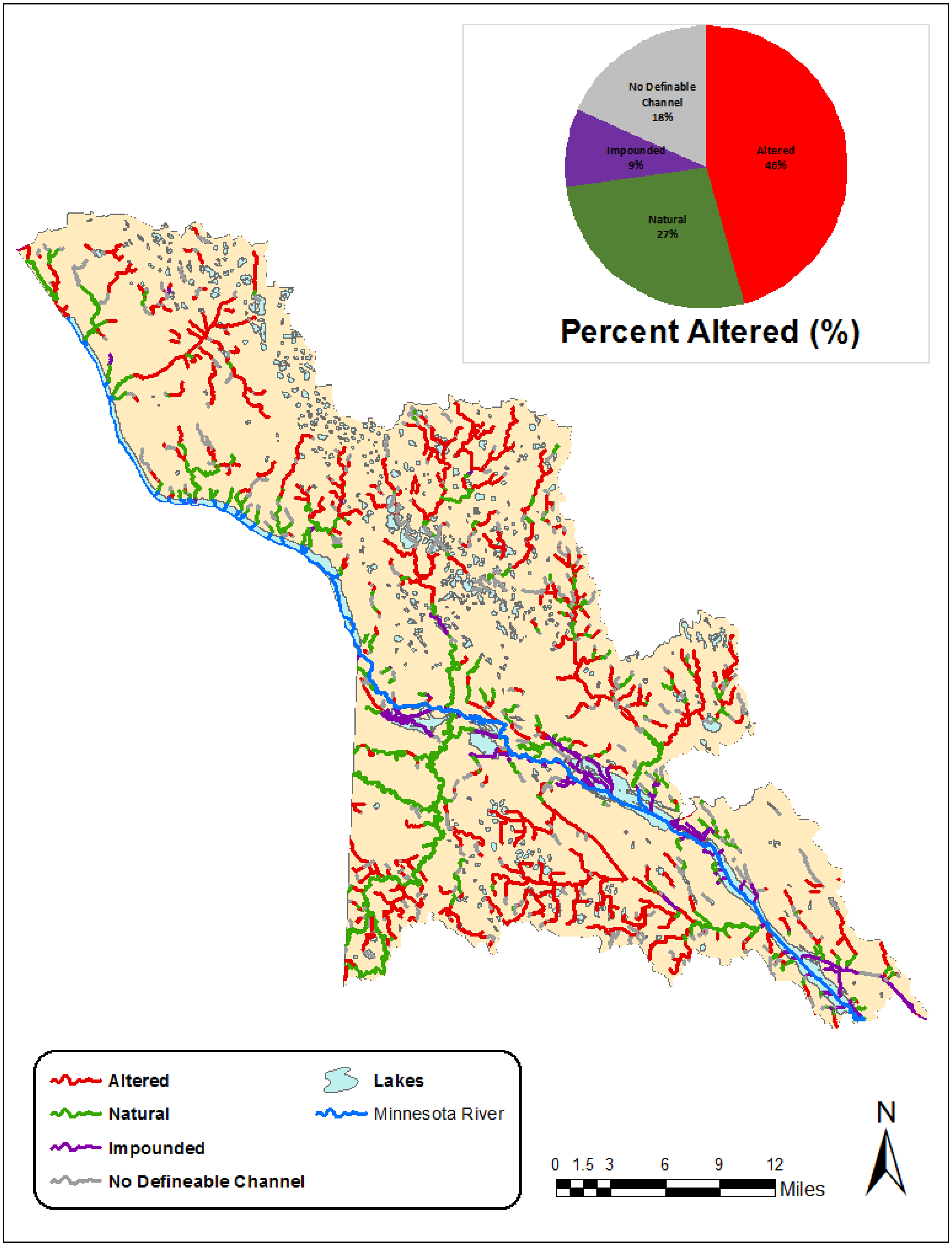


Figure 9. Comparison of natural to altered streams in the Minnesota River-Headwaters Watershed (percentages derived from the Statewide Altered Water Course project).

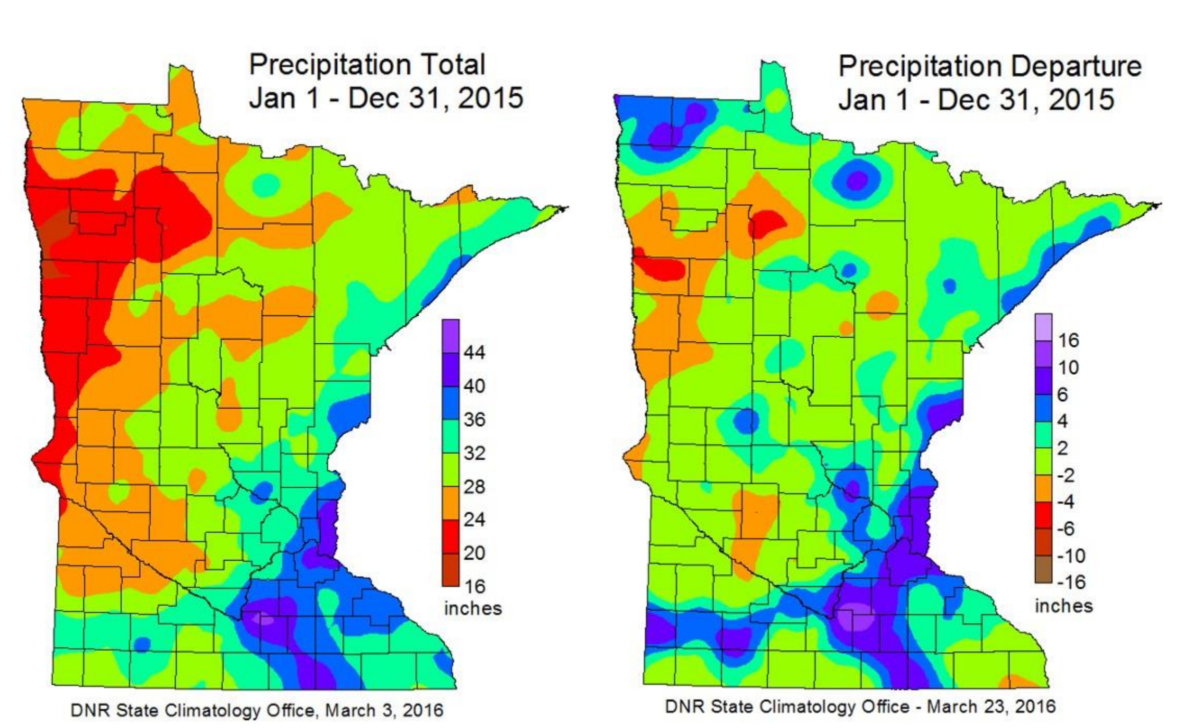


Climate and precipitation

Minnesota has a continental climate, marked by warm summers and cold winters. The mean annual temperature for Minnesota is 4.6˚C (NOAA, 2016); the mean (1981-2010) summer (June-August) temperature for the Minnesota River-Headwaters River Watershed is 20.5˚C and the mean winter (December-February) temperature is -8.88˚ C (DNR: Minnesota State Climatology Office, 2017a).

Precipitation is an important source of water input to a watershed. Figure 10 displays two representations of precipitation for calendar year 2015. On the left is total precipitation, showing the typical pattern of increasing precipitation toward the eastern portion of the state. According to this figure, the Minnesota River-Headwaters River Watershed area received 20 to 28 inches of precipitation in 2015. The display on the right shows the amount that precipitation levels departed from normal. The watershed area experienced precipitation that ranged from 4r inches below normal to 2 inches above normal in 2015.

Figure 10. Statewide precipitation total (*left*) and precipitation departure (*right*) during 2015 (Source: DNR State Climatology Office, 2017b)



The Minnesota River-Headwaters Watershed is located within the West-Central precipitation region. Figure 12 display the areal average representation of precipitation in West-Central Minnesota for 20 and 100 years, respectively. An areal average is a spatial average of all the precipitation data collected within a certain area presented as a single dataset. Though rainfall can vary in intensity and time of year, rainfall totals in the West-Central region display no significant trend over the last 20 years. However, precipitation in West-Central Minnesota exhibits a significant rising trend over the past 100 years ($p<0.01$). This is a strong trend and matches similar trends throughout Minnesota.

Figure 11. Precipitation trends in West-Central Minnesota (1996-2015) with 5-year running average (Source: WRCC, 2017).

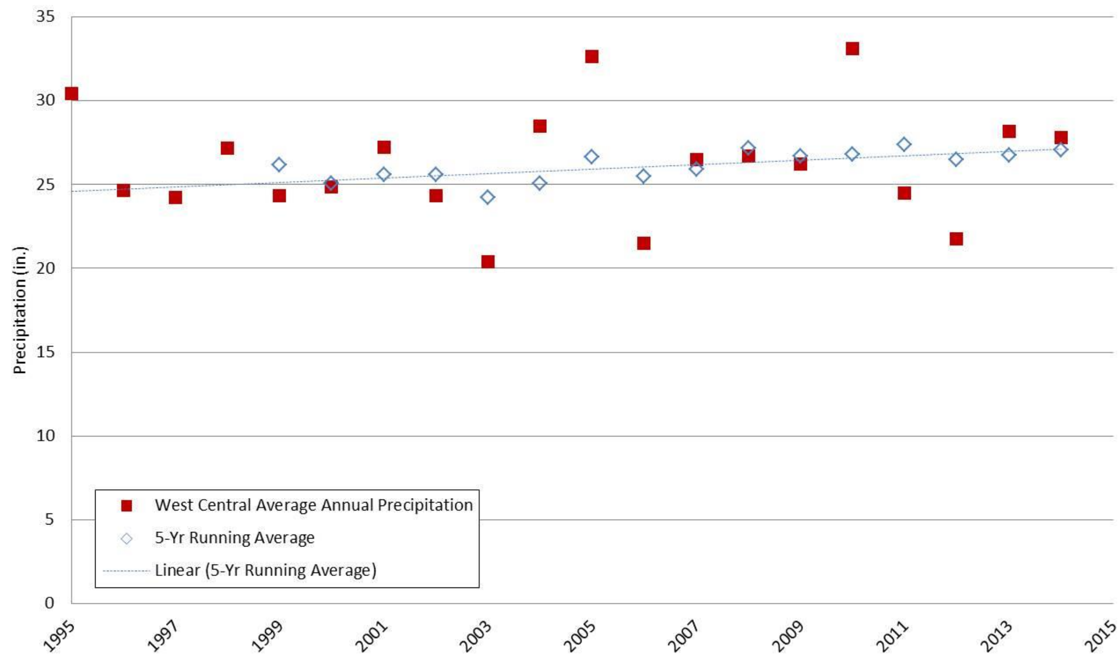
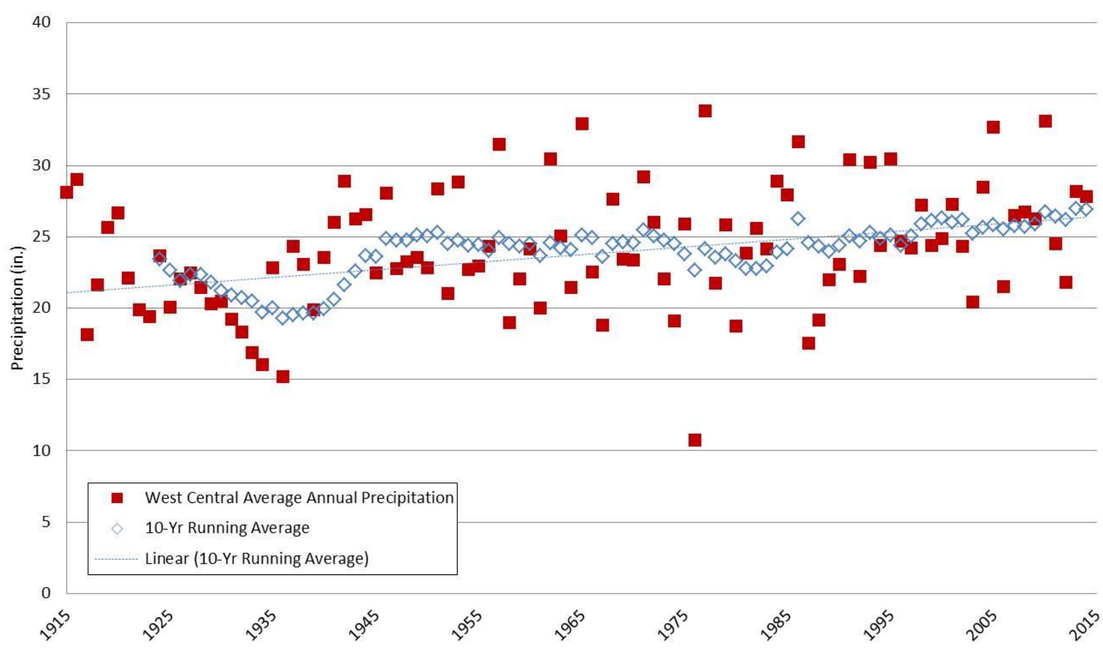


Figure 12. Precipitation trends in West-Central Minnesota (1916-2015) with 10-year running average (Source: WRCC, 2017).



Hydrogeology

Hydrogeology is the study of the interaction, distribution and movement of groundwater through the rocks and soil of the earth. The geology of a region strongly influences the quantity of groundwater available, the quality of the water, the sensitivity of the water to pollution, and how quickly the water will be able to recharge and replenish the source aquifer. This branch of geology is important to understand as it indicates how to manage groundwater withdrawal and land use and can determine if mitigation is necessary.

The Minnesota River-Headwaters Watershed contains features of three of Minnesota's Groundwater provinces: the Western, Central, and Arrowhead Provinces. Arrowhead and Central province features are centered on the Minnesota River at the center of the watershed. The small portion of the Arrowhead Province in the watershed is characterized Precambrian metamorphic rocks exposed at the surface or covered by thin layers of till. Groundwater here is found in fractures and faults. A larger portion of the watershed is characterized by the Central Province, where there are sandy aquifers in sandy and clayey glacial drift. The Western Province features are clayey drift over top the bedrock with aquifers of limited extent. (DNR, 2017b)

Groundwater potential recharge

Groundwater recharge is one of the most important parameters in the calculation of water budgets, which are used in general hydrologic assessments, aquifer recharge studies, groundwater models, and water quality protection. Recharge is a highly variable parameter, both spatially and temporally, making accurate estimates at a regional scale difficult to produce. The MPCA contracted the USGS to develop a statewide estimate of recharge using the Soil-Water-Balance Code (SWB). The result is a gridded data structure of spatially distributed recharge estimates that can be easily integrated into regional groundwater studies. The full report of the project as well as the gridded data files are available at: https://gisdata.mn.gov/dataset/geos-gw-recharge-1996-2010-mean.

Recharge of these aquifers is important and limited to areas located at topographic highs, those with surficial sand and gravel deposits, and those along the bedrock-surficial deposit interface. Typically, recharge rates in unconfined aquifers are estimated at 20 to 25% of precipitation received, but can be less than 10% of precipitation where glacial clays or till are present (USGS, 2007). For the Minnesota River-Headwaters Watershed, the average annual potential recharge rate to surficial materials ranges from 0.8 to 5.4 inches per year, with a mean of 2.8 inches per year. The statewide average potential recharge is estimated to be 4 inches per year with 85% of all recharge ranging from 3 to 8 inches per year (USGS, 2015).

Wetlands

Currently there are approximately 46,000 wetland acres in the Minnesota River - Headwaters Watershed, roughly equivalent to 9.2% of its total area (based on the National Wetlands Inventory). Emergent vegetation wetlands comprise the majority of this wetland acreage and are well distributed across the watershed (Figure 13). Scrub-shrub wetlands and forested wetlands account for a minor component (< 1%) of the watershed's wetland profile as would be expected given its location within the Northern Glaciated Plains ecoregion. The topography and soil types – and thus the type and distribution of wetlands – was largely determined by the region's glacial history. The Minnesota River - Headwaters lies within glacial till of the Des Moines lobe as it retreated to the northwest about 12,000 years ago (MNGS 1997). The northeast region of the watershed is an area of stagnation moraine where the slow-melting, stagnant glacial ice – due to the insulation of accumulated sediment on top of the ice – resulted in a rugged topography after the ice had fully melted. This area of the watershed is notable for its numerous shallow lakes and prairie pothole wetlands (Figure 13). The western and southwestern portions of the watershed are characterized by ground moraine with a gentle, rolling topography and thus fewer lake and wetland basins. Bisecting the watershed is the Minnesota River valley that was formed by the Glacial River Warren as it funneled water from Glacial Lake Agassiz to the southeast in various stages from about 11,700 to 9,500 years ago (Wright, 1990). Currently, the Minnesota River as well as extensive lakes (naturally and artificially created), riverine wetlands, floodplain wetlands, oxbows, and backwaters occupy this valley. The majority of the watershed's forested and scrub-shrub wetlands occur in the river valley associated in large part with the Minnesota River (Figure 13).

Prior to European settlement, wetlands were much more prevalent throughout the watershed. Considering that wetland soil features typically persist after artificial drainage, soil survey data can provide an estimate of historical wetland extent and serve as a baseline for comparisons with current wetland acreage. The Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, based on a summation of map units classified as "poorly drained" or "very poorly drained", yields an estimate of approximately 134,000 acres of wetlands (27% of watershed area) occurring in the Minnesota River - Headwaters watershed prior to European settlement (Soil Survey Staff, NRCS 2013). The current wetland area estimate for the watershed, based on the original 1980s National Wetland Inventory, is about 46,000 acres. A comparison of these two periods (i.e., pre-settlement vs. 1980s) shows an overall estimate of 66% wetland loss for the watershed. Wetland losses are not distributed evenly across the watershed, which can likely be attributed to the differences in topography mentioned in the previous paragraph and its impacts on the suitability for agriculture and artificial drainage (Figure 14).

Figure 13. Wetland types and their distribution across the Minnesota River – Headwaters Watershed.

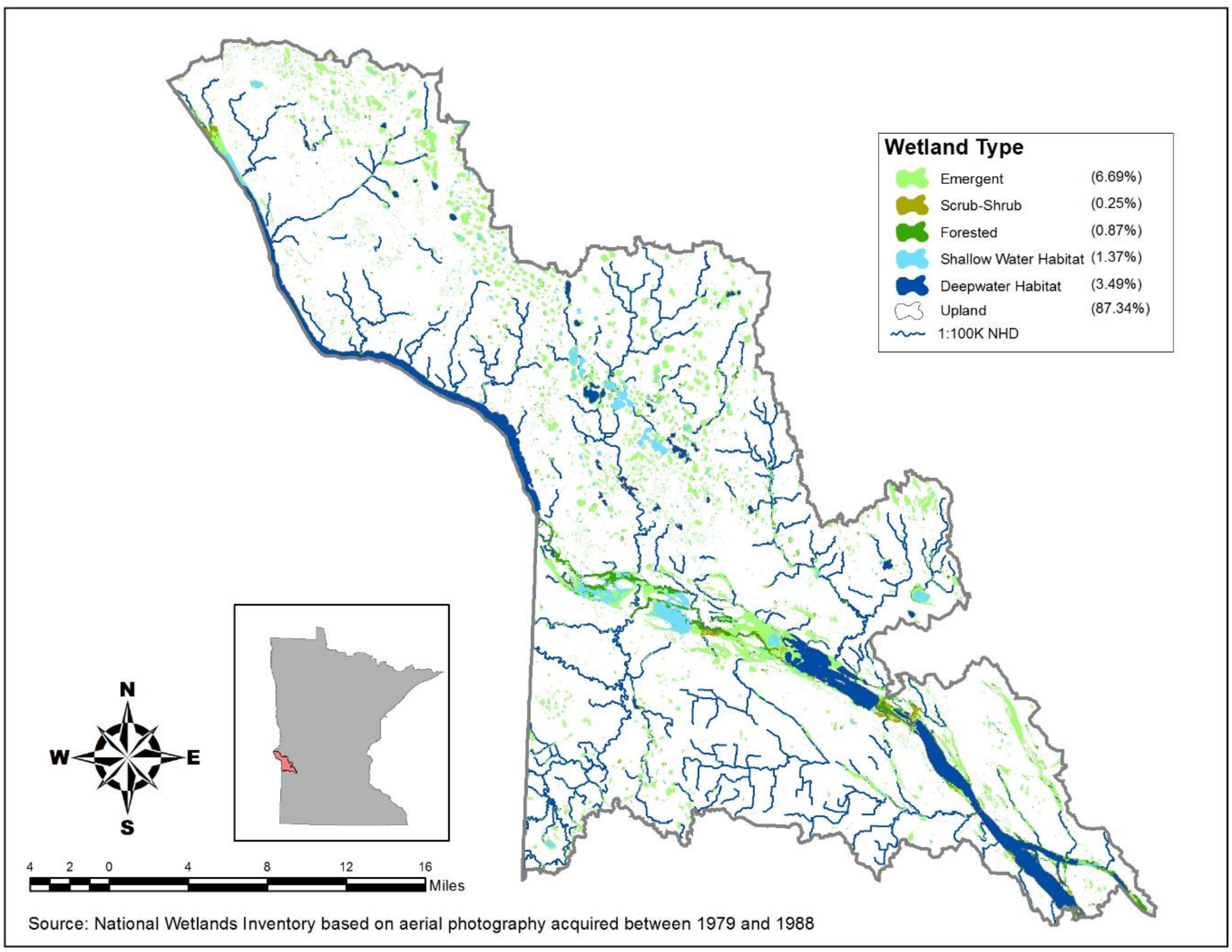
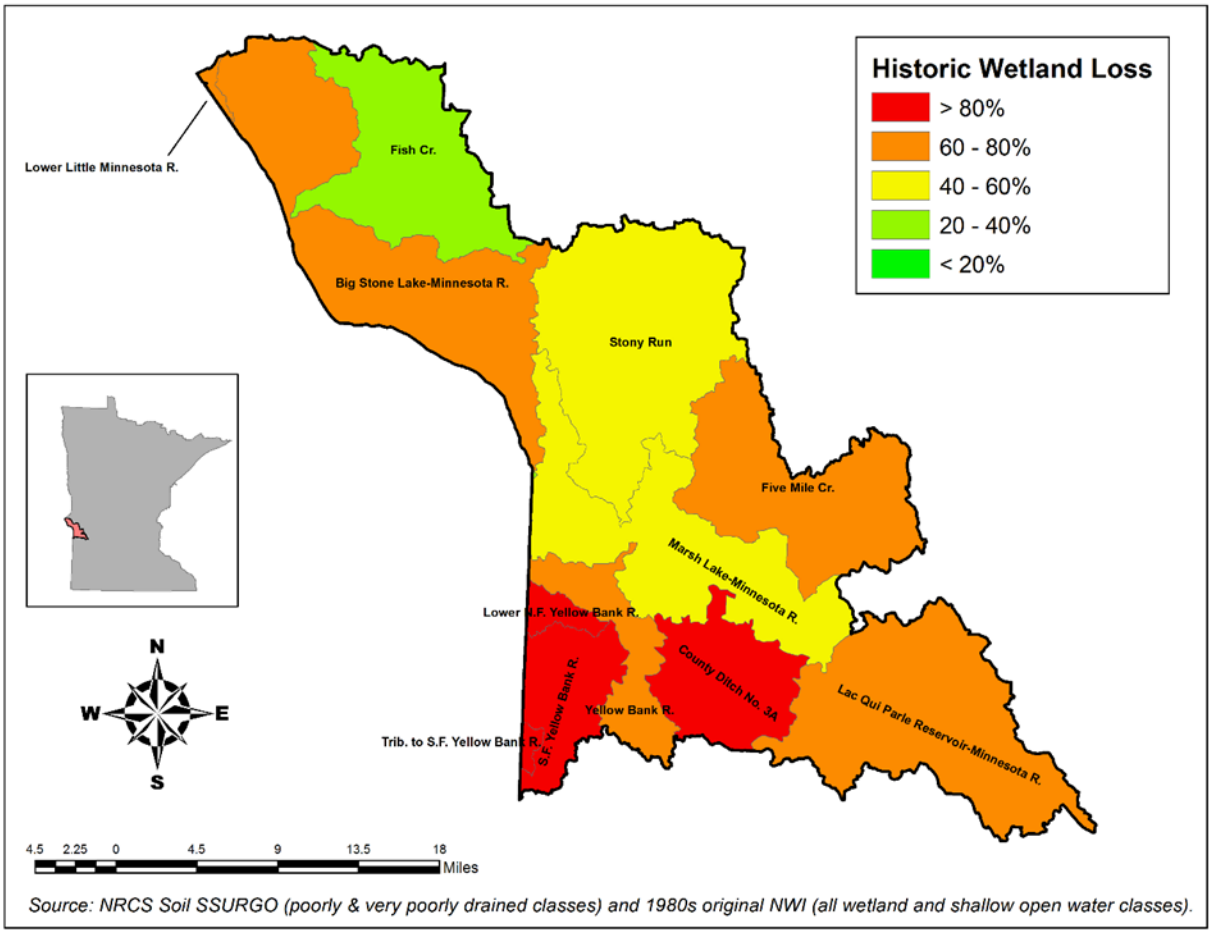


Figure 14. Estimated historic wetland loss in each subwatershed based on a comparison of "poorly drained" and "very poorly drained" soil types (SSURGO database) to wetland extent in 2011 (NWI update).



Watershed-wide data collection methodology

Lake water sampling

MPCA sampled Big Stone, Lac qui Parle, and Marsh lakes in 2015, as part of the Clean Water Legacy Surface Water Monitoring project for the purpose of enhancing the dataset for lake assessment of aquatic recreation. There is currently one volunteer enrolled in the MPCA's Citizen Lake Monitoring Program that is conducting lake monitoring within the watershed. Sampling methods are similar among monitoring groups and are described in the document entitled "*MPCA Standard Operating Procedure for Lake Water Quality*" found at http://www.pca.state.mn.us/publications/wq-s1-16.pdf. The lake recreation use assessment requires eight observations/samples within a 10-year period (June to September) for phosphorus, chlorophyll-a and Secchi depth. Chloride, sulfate, and nitrates are sampled at a subset of waters that have been identified as being impacted by chloride inputs, are designated wild rice waters, or have a designated drinking water use.

Stream water sampling

Thirteen water chemistry stations were sampled from May through September in 2015, and again June through August of 2016, to provide sufficient water chemistry data to assess all components of the aquatic life and recreation use standards. Following the IWM design, water chemistry stations were placed at the outlet of each aggregated 12 HUC subwatershed that was >40 square miles in area (purple circles and green circles in Figure 2. A Surface Water Assessment Grant (SWAG) was awarded to the Lac qui Parle-Yellow Bank Watershed District to conduct intensive water chemistry (10X) monitoring at 13 stations (See Appendix 2.1 for locations of stream water chemistry monitoring sites. See Appendix 1 for definitions of stream chemistry analytes monitored in this study). Two 10X monitoring stations were located in the Big Stone Lake subwatershed to characterize the inputs of smaller tributaries to Big Stone Lake. A 10X monitoring station was not established in the Whetstone River subwatershed due to much of the subwatershed being within South Dakota and sites within Minnesota would be impacted by backflow from the Minnesota River.

Stream flow methodology

The MPCA and the DNR joint stream water quantity and quality monitoring data for dozens of sites across the state on major rivers, at the mouths of most of the state's major watersheds, and at the mouths of some aggregated 12-HUC subwatersheds are available at the DNR/MPCA Cooperative Stream Gaging webpage at: http://www.dnr.state.mn.us/waters/csg/index.html.

Lake biological sampling

Big Stone Lake was monitored for fish community health in the Minnesota River Headwaters. While data from the last 10 years contributed to the watershed assessments, all data utilized for the 2017 assessment was collected in 2015.

To measure the health of aquatic life at each lake, a fish IBI was calculated based on monitoring data collected in the lake. A fish classification framework was developed to account for natural variation in community structure, which is attributed to area, maximum depth, alkalinity, shoreline complexity, and geographic location. As a result, an IBI is available for four different groups of lake classes (Schupp Lake Classification, DNR). Each IBI class uses a unique suite of metrics, scoring functions, impairment thresholds, and confidence intervals (CIs). IBI scores higher than the impairment threshold and upper CI indicate that the lake supports aquatic life. Scores below the impairment threshold and lower CI indicate that the lake does not support aquatic life. When an IBI score falls within the upper and lower confidence limits additional information may be considered when making the impairment decision such as the consideration of potential local and watershed stressors and additional monitoring information (e.g., water chemistry, physical habitat, plant surveys, and observations of local land use activities).

Stream biological sampling

The biological monitoring component of the IWM in the Minnesota River-Headwaters Watershed was completed during the summer of 2015. A total of 22 sites were newly established across the watershed and sampled. These sites were located near the outlets of most minor HUC-14 watersheds. In addition, three existing biological monitoring stations within the watershed were revisited in 2015. These monitoring stations were initially established as part of a random Minnesota River Basin wide survey in 2001, biocriteria development survey in 2003, or as part of a 2010 and 2015 random statewide survey. While data from the last 10 years contributed to the watershed assessments, the majority of data utilized for the 2017 assessment was collected in 2015. A total of 21 WIDs were sampled for biology in the Minnesota River-Headwaters Watershed. Waterbody assessments to determine aquatic life use support were conducted for 23 WIDs. Biological information that was not used in the assessment process, such as data older than 10 years, will be crucial to the stressor identification process and will also be used as a basis for long term trend results in subsequent reporting cycles.

To measure the health of aquatic life at each biological monitoring station, IBIs, specifically fish and macroinvertebrate IBIs, were calculated based on monitoring data collected for each of these communities. A fish and macroinvertebrate classification framework was developed to account for natural variation in community structure which is attributed to geographic region, watershed drainage area, water temperature and stream gradient. As a result, Minnesota's streams and rivers were divided into seven distinct warm water classes and two cold-water classes, with each class having its own unique fish IBI and macroinvertebrate IBI. Each IBI class uses a unique suite of metrics, scoring functions, impairment thresholds, and confidence intervals (CIs) (For IBI classes, thresholds and CIs, see Appendix 3.1). IBI scores higher than the impairment threshold and upper CI indicate that the stream reach supports aquatic life. Contrarily, scores below the impairment threshold and lower CI indicate that the stream reach does not support aquatic life. When an IBI score falls within the upper and lower confidence limits additional information may be considered when making the impairment decision such as the consideration of potential local and watershed stressors and additional monitoring information (e.g., water chemistry, physical habitat, observations of local land use activities). For IBI results for each individual biological monitoring station, see Appendices 4.1 and 4.2.

Fish contaminants

The DNR fisheries staff collect most of the fish for the Fish Contaminant Monitoring Program. In addition, MPCA's biomonitoring staff collect up to five piscivorous (top predator) fish and five forage fish near the HUC8 pour point, as part of the Intensive Watershed Monitoring. All fish collected by the MPCA are analyzed for mercury and the two largest individual fish of each species are analyzed for PCBs.

Captured fish were wrapped in aluminum foil and frozen until they were thawed, scaled (or skinned), filleted, and ground to a homogenized tissue sample. Homogenized fillets were placed in 60 mL glass jars with Teflon™ lids and frozen until thawed for lab analysis. The Minnesota Department of Agriculture Laboratory analyzed the samples for mercury and PCBs. If fish were tested for perfluorochemicals (PFCs), whole fish were shipped to AXYS Analytical Laboratory, which analyzed the homogenized fish fillets for 13 PFCs. Of the measured PFCs, only perfluorooctane sulfonate (PFOS) is reported because it bioaccumulates in fish to levels that are potentially toxic and a reference dose has been developed.

From the fish contaminant analyses, MPCA determines which waters exceed impairment thresholds. The Impaired Waters List is prepared by the MPCA and submitted every even year to the EPA. The MPCA has included waters impaired for contaminants in fish on the Impaired Waters List since 1998. Impairment assessment for PCBs (and PFOS when tested) in fish tissue is based on the fish consumption advisories prepared by the Minnesota Department of Health (MDH). If the consumption advice is to restrict consumption of a particular fish species to less than a meal per week the MPCA considers the lake or river impaired. The threshold concentration for impairment (consumption advice of one meal per month) is an average fillet concentration of 0.22 mg/kg for PCBs (and 0.200 mg/kg for PFOS).

Monitoring of fish contaminants in the 1970s and 1980s showed high concentrations of PCBs were primarily a concern downstream of large urban areas in large rivers, such as the Mississippi River, and in Lake Superior. Therefore, PCBs are now tested where high concentrations in fish were measured in the past and the major watersheds are screened for PCBs in the watershed monitoring collections.

Before 2006, mercury in fish tissue was assessed for water quality impairment based on MDH's fish consumption advisory, the same as PCBs. With the adoption of a water quality standard for mercury in edible fish tissue, a waterbody has been classified as impaired for mercury in fish tissue if 10% of the fish samples (measured as the 90th percentile) exceed 0.2 mg/kg of mercury. At least five fish samples of the same species are required to make this assessment and only the last 10 years of data are used for the assessment. MPCA's Impaired Waters List includes waterways that were assessed as impaired prior to 2006 as well as more recent impairments.

Pollutant load monitoring

Intensive water quality sampling occurs at all WPLMN sites. Thirty-five samples per year are allocated for basin and major watershed sites and 25 samples per season (ice out through October 31) for subwatershed sites. Because concentrations typically rise with streamflow for many of the monitored pollutants, and because of the added influence elevated flows have on pollutant load estimates, sampling frequency is greatest during periods of moderate to high flow. All major snowmelt and rainfall events are sampled. Low flow periods are also sampled although sampling frequency is reduced as pollutant concentrations are generally more stable when compared to periods of elevated flow.

Water sample results and daily average flow data are coupled in the $FLUX_{32}$ pollutant load model to estimate the transport (load) of nutrients and other water quality constituents past a sampling station over a given period of time. Loads and flow weighted mean concentrations (FWMCs) are calculated for total suspended solids (TSS), total phosphorus (TP), dissolved orthophosphate, nitrate plus nitrite nitrogen (NO_3+NO_2-N), and total Kjeldahl nitrogen (TKN).

More information can be found at the WPLMN website.

Groundwater monitoring

Groundwater quality

The MPCA's Ambient Groundwater Monitoring Program monitors trends in statewide groundwater quality by sampling for a comprehensive suite of chemicals including nutrients, metals, and volatile organic compounds. These Ambient wells represent a mix of deeper domestic wells and shallow monitoring wells. The shallow wells interact with surface waters and exhibit impacts from human activities more rapidly. Available data from federal, state and local partners are used to supplement reviews of groundwater quality in the region.

Groundwater quantity

Monitoring wells from the DNR Observation Well Network track the elevation of groundwater across the state. The elevation of groundwater is measured as depth to water in feet and reflects the fluctuation of the water table as it rises and falls with seasonal variations and anthropogenic influences. Data from these wells and others are available at:
http://www.dnr.state.mn.us/waters/groundwater_section/obwell/waterleveldata.html

Groundwater/surface water withdrawals

The Department of Natural Resources permits all high capacity water withdrawals where the pumped volume exceeds 10,000 gallons/day or 1 million gallons/year. Permit holders are required to track water use and report back to the DNR yearly. Information on the program and the program database are found at: http://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/wateruse.html

Wetland monitoring

The MPCA is actively developing methods and building capacity to conduct wetland quality monitoring and assessment. Our primary approach is biological monitoring—where changes in biological communities may be indicating a response to human-caused impacts. The MPCA has developed IBIs to monitor the macroinvertebrate condition of depressional wetlands that have open water and the Floristic Quality Assessment (FQA) to assess vegetation condition in all of Minnesota's wetland types. For more information about the wetland monitoring (including technical background reports and sampling procedures) please visit the MPCA wetland monitoring and assessment webpage.

The MPCA currently does not monitor wetlands systematically by watershed. Alternatively, the overall status and trends of wetland quality in the state and by major ecoregion is being tracked through probabilistic monitoring. Probabilistic monitoring refers to the process of randomly selecting sites to monitor; from which, an unbiased estimate of the resource can be made. Regional probabilistic survey results can provide a reasonable approximation of the current wetland quality in the watershed.

Individual aggregated 12-HUC subwatershed results

Aggregated 12-HUC subwatersheds

Assessment results for aquatic life and recreation use are presented for each Aggregated HUC-12 subwatershed within the Minnesota River-Headwaters. The primary objective is to portray all the full support and impairment listings within an aggregated 12-HUC subwatershed resulting from the complex and multi-step assessment and listing process. This scale provides a robust assessment of water quality condition at a practical size for the development, management, and implementation of effective TMDLs and protection strategies. The graphics presented for each of the aggregated HUC-12 subwatersheds contain the assessment results from the 2017 Assessment Cycle as well as any impairment listings from previous assessment cycles. Discussion of assessment results focuses primarily on the 2015 intensive watershed monitoring effort, but also considers available data from the last ten years.

The proceeding pages provide an account of each aggregated HUC-12 subwatershed. Each account includes a brief description of the aggregated HUC-12 subwatershed and summary tables of the results for each of the following: a) stream aquatic life and aquatic recreation assessments, and b) lake aquatic life and recreation assessments. Following the tables is a narrative summary of the assessment results and pertinent water quality projects completed or planned for the aggregated HUC-12 subwatershed. A brief description of each of the summary tables is provided below.

Stream assessments

A table is provided in each section summarizing aquatic life and aquatic recreation assessments of all assessable stream reaches within the aggregated HUC-12 subwatershed (i.e., where sufficient information was available to make an assessment). Primarily, these tables reflect the results of the 2017 assessment process (2018 EPA reporting cycle); however, impairments from previous assessment cycles are also included and are distinguished from new impairments via cell shading (see footnote section of each table). These tables also denote the results of comparing each individual aquatic life and aquatic recreation indicator to their respective criteria (i.e., standards); determinations made during the desktop phase of the assessment process (see Figure 4). Assessment of aquatic life is derived from the analysis of biological (fish and invert IBIs), DO, total suspended solids, chloride, pH, TP, chlorophyll-a, biochemical oxygen demand and un-ionized ammonia (NH3) data, while the assessment of aquatic recreation in streams is based solely on bacteria (Escherichia coli) data. Included in each table is the specific aquatic life use classification for each stream reach: cold-water community (2A); cool or warm water community (2B); or indigenous aquatic community (2C). Where applicable and sufficient data exists, assessments of other designated uses (e.g., class 7, drinking water, aquatic consumption) are discussed in the summary section of each aggregated HUC-12 subwatershed as well as in the Watershed-wide results and discussion section.

Lake assessments

A summary of lake water quality is provided in the aggregated HUC-12 subwatershed sections where available data exists. This includes aquatic recreation (phosphorus, chlorophyll-a, and Secchi) and aquatic life, where available (chloride and fish IBI). Similar to streams, parameter level and over all use decisions are included in the table.

Lower Little Minnesota River Aggregated 12-HUC HUC 0702000103-01

The Lower Little Minnesota River subwatershed is the northwestern most subwatershed in the Minnesota River – Headwaters watershed (Figure 15). This subwatershed and the upstream associated Upper Little Minnesota River subwatershed drain a total of 326 square miles (209,167 acres) of South Dakota, and a small portion of North Dakota and Minnesota. Of the 113 square miles (72,928 acres) consisting of the Lower Little Minnesota River subwatershed, the Minnesota portion only consists of 2.0 square miles (1,254 acres), comprising of Traverse and Big Stone Counties. The primary waterbody within the watershed is the Little Minnesota River, which originates on the Coteau des Prairies in South Dakota, and flows southeast into Big Stone Lake. Within the Minnesota portion of the subwatershed, the 4.8 mile length of the Little Minnesota River is considered warmwater with a natural stream channel, with only one small channelized tributary. Station 15MN001 was sampled at the pour point for biology and water chemistry.

The Lower Little Minnesota River subwatershed is predominately rural, with the majority of the land used as cropland (44.4%) and rangeland (35.4%). Open water comprises 5.6%, development 5.6%, and wetlands account for 5.5% of the watershed landscape. Forest (3.2%) and barren land (0.4%) account for the lowest percentages of land use within the watershed. In the Minnesota portion of the subwatershed, Browns Valley is the only town present.

Table 2. Aquatic life and recreation assessments on stream reaches: Lower Little Minnesota River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

WID ***Reach name,*** *Reach description*	**Biological Station ID**	**Reach length (miles)**	**Use class***	**Aquatic life indicators:**										**Aquatic life**	**Aquatic rec. (Bacteria)**
				Fish IBI	**Invert IBI**	**Dissolved oxygen**	**TSS**	**Secchi Tube**	**Chloride**	**pH**	**Ammonia -NH_3**	**Pesticides**	**Eutrophication**		
07020001-508 ***Little Minnesota River,*** *MN/SD border to Big Stone Lk*	15MN001	4.75	WWg	MTS	EXS	IF	IF	MTS	MTS	MTS	MTS	--	IF	IMP	IMP

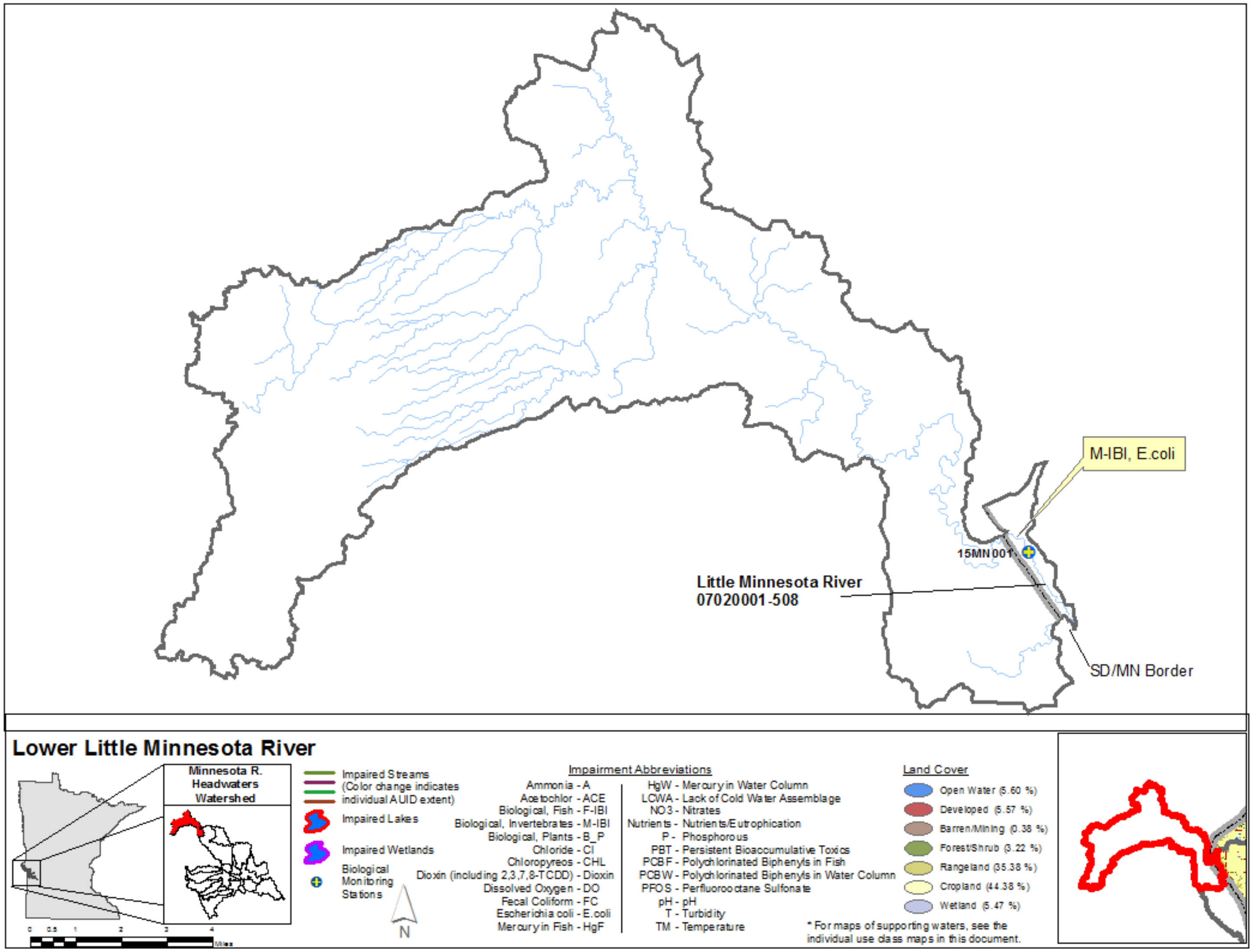
Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: = existing impairment, listed prior to 2016 reporting cycle; = new impairment; = full support of designated use; = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Summary

The Little Minnesota River was the only reach assessed for aquatic life use standards. There was one biological monitoring station (15MN001) sampled in 2015 (Table 2, Figure 15). The fish community included 21 species of fish, with five species considered sensitive (27% of the individuals). The fish IBI score was above yet near the general use threshold. The fish community may be more susceptible to impairment in the future if there is further degradation within the watershed. The aquatic macroinvertebrate community demonstrated an IBI score below the general use threshold. Predominantly tolerant taxa were collected at 15MN001 and excess sedimentation in the channel bed and along the banks was evident during the macroinvertebrate sampling visit in August of 2015. The Little Minnesota River will be listed as impaired for aquatic life use based upon aquatic macroinvertebrate data.

Extensive water chemistry datasets were available on this reach of the Little Minnesota River downstream from the South Dakota border and prior to the confluence with Big Stone Lake. Erratic flow patterns are clear when looking at gauge data and sampler comments, suggesting altered hydrology is playing a large role in water quality. Dramatic flow changes can negatively affect channel morphology, directly influencing sediment loading. Total suspended solid (TSS) concentrations were elevated early in the open water season and during rain events; clarity in the stream improved later in the summer. Nutrient levels are elevated above standard; insufficient response data was available. Consistently elevated bacteria concentrations triggered a new listing indicating conditions are not supporting aquatic recreational use.

Figure 15. Currently listed impaired waters by parameter and land use characteristics in the Lower Little Minnesota River Aggregated 12-HUC.



Big Stone Lake-Minnesota River Aggregated 12-HUC HUC 0702000104-01

The Big Stone Lake-Minnesota River subwatershed lies in the northwest of the Minnesota portion of the major watershed (Figure 16). Big Stone Lake and the Minnesota/South Dakota border bisect this subwatershed. Total area for the subwatershed is 218 square miles (139,520 acres), with the Minnesota portion consisting of 135 square miles (86,251 acres). Big Stone County makes up the majority of the subwatershed, with a northern portion of the subwatershed also consisting of Traverse County. The predominate waterbody within the subwatershed would be Big Stone Lake, with most of the streams in the subwatershed consisting of smaller direct tributaries to Big Stone Lake. In the Minnesota portion of the watershed, most stream flow is to the southwest. Within Minnesota, altered stream reaches make up 38.0% of the reach lengths, with most of the channelization occurring in the headwaters. As streams descend to join Big Stone Lake, natural channel conditions predominate (38.0% of the stream reach lengths). Reaches determined to consist of 'No Definable Channel' make up 22.4%, while impounded reaches make up 1.4% of the reach lengths. All monitored reaches in Minnesota were determined to fall under the general use TALU designation and are warmwater. With the topography along the shore of Big Stone Lake, springs are prevalent and many streams may have a slightly colder thermal regime, but still fall under the warmwater classification. Notable streams in Minnesota include West Salmonsen Creek, represented by the monitoring station 15MN107 sampled for biology, as well as Meadowbrook Creek (15MN009), which was monitored for biology and water chemistry. Another larger tributary to Big Stone Lake monitored for biology and water chemistry includes Unnamed Creek at the station 15MN002.

Land use within the Big Stone Lake-Minnesota River subwatershed is dominated by cropland (44.4%), followed by rangeland (35.4%). Open water makes up 5.6% of the area, while 5.5% of the watershed is wetland, and 3.2% is forest. Development covers 5.6% of the subwatershed area, and barren land accounts for 0.4% of the subwatershed area. Most of the subwatershed is rural, with the only towns consisting of Beardsley, and portions of Ortonville, and Browns Valley.

Table 3. Aquatic life and recreation assessments on stream reaches: Big Stone Lake-Minnesota River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

WID Reach name, Reach description	Biological station ID	Reach length (miles)	Use class*	Aquatic life indicators:											
				Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides	Eutrophication	Aquatic life	Aquatic rec. (Bacteria)
07020001-541, Unnamed creek, *Unnamed cr to Big Stone Lk*	15MN002	3.48	WWg	EXS	MTS	IF	MTS	MTS	IF	MTS	MTS	--	IF	IMP	IMP
07020001-504, Unnamed creek (West Salmonsen Creek)*, Unnamed cr to Big Stone Lk*	15MN107	6.11	WWg	IF	MTS	IF	MTS	MTS	--	MTS	MTS	--	IF	IF	IMP
07020001-568, Unnamed creek (Meadowbrook Creek)*, 340th St to Big Stone Lk*	15MN009	5.43	WWg	EXS	EXS	IF	MTS	MTS	MTS	MTS	MTS	--	IF	IMP	IMP

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: = existing impairment, listed prior to 2016 reporting cycle; = new impairment; = full support of designated use; = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 4. Lake water aquatic recreation assessments: Big Stone Lake-Minnesota River Aggregated 12-HUC.

Lake name	DNR ID	Area (acres)	Max depth (ft)	Assessment method	Ecoregion	Secchi Trend	Aquatic life indicators:			Aquatic recreation indicators:			Aquatic life use	Aquatic recreation use
							Fish IBI	Chloride	Pesticides	Total phosphorus	Chlorophyll-a	Secchi		
Big Stone	06-0152-00	11889	15	Shallow Lake	NGP	I	MTS	MTS	--	EX	EX	MTS	FS	NS

Abbreviations for Ecoregion: **DA** = Driftless Area, **NCHF** = North Central Hardwood Forest, **NGP** = Northern Glaciated Plains, **NLF** = Northern Lakes and Forests, **NMW** = Northern Minnesota Wetlands, **RRV** = Red River Valley, **WCBP** = Western Corn Belt Plains
Abbreviations for Secchi Trend: **D** = decreasing/declining trend, **I** = increasing/improving trend, **NT** = no detectable trend, **--** = not enough data
Abbreviations for Indicator Evaluations: **--** = No Data, **MTS** = Meets Standard; **EX** = Exceeds Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **FS** = Full Support (Meets Criteria); **NS** = Not Support (Impaired, exceeds standard)
Key for Cell Shading: ☐ = existing impairment, listed prior to 2016 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.

Summary

Two of the three monitored stream reaches were assessed and found impaired for aquatic life use standards using fish within the Big Stone Lake-Minnesota River subwatershed. Aquatic macroinvertebrates are attaining aquatic life expectations for general use streams at two of three AUIDs in this subwatershed. The fish assemblage at Unnamed Creek was sampled twice at station 15MN002 in 2015. Despite decent stream habitat conditions, significant portion of the fish samples consisted of fish species considered tolerant (>95% of individuals). Both visits resulted in similar FIBI scores that fell considerably below the lower confidence limit resulting in an impairment based on the fish community.

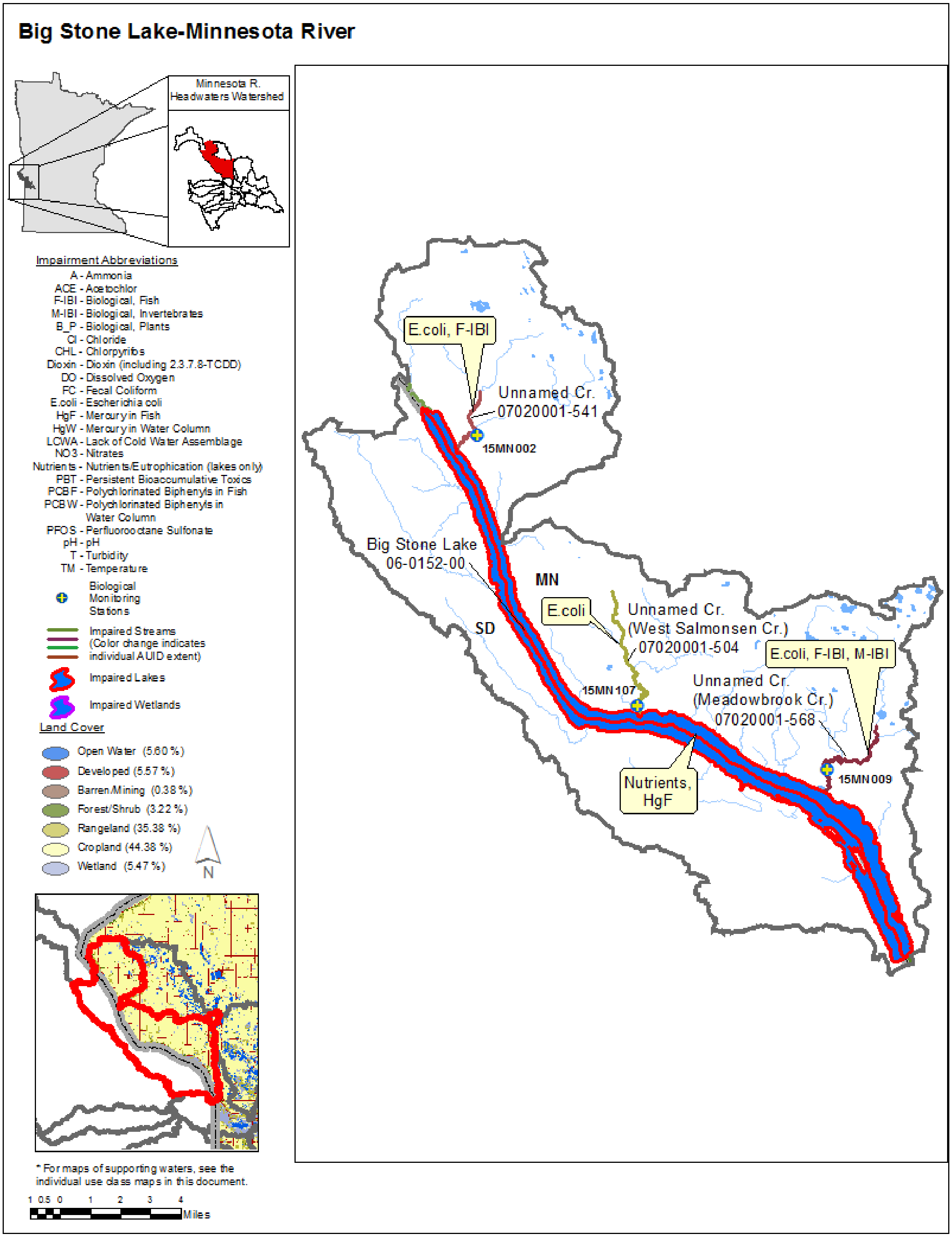
Fish community data in West Salmonsen Creek was determined insufficient to assess for aquatic life at this time. More fish community data is needed in order to determine the influence of such things as the close proximity to Big Stone Lake, the effects of a perched culvert, and a confirmation of the initial low FIBI score. In West Salmonsen Creek, the macroinvertebrate community may be benefitting from relatively stable flow and high gradient, shade and ample woody debris (i.e., habitat) provided by the forested riparian corridor at the biological monitoring station (15MN107), as well as decent riparian vegetation for a long stretch upstream of the station. Follow-up monitoring of the macroinvertebrate community at 15MN107 occurred in summer 2017. The resulting MIBI score was 69, even higher than it's already supporting MIBI score of 59 obtained from the 2015 sample, thus verifying the original assessment of a supporting macroinvertebrate community in this creek.

Three small tributaries to Big Stone Lake had relatively large water chemistry datasets, the majority aquatic life related parameters met their applicable standards. Elevated phosphorus concentrations highlighted the datasets, no response data was available to support a complete river eutrophication assessment. While the streams may not be impacted by the elevated concentrations, receiving lakes can be negatively impacted by watershed contributions of phosphorus, as algal growth increases as the water slows. Elevated bacteria concentrations are common to all three tributaries, resulting in new impairments for poor aquatic recreation use.

Big Stone Lake is vital regionally for a number of recreational uses; extensive lake eutrophication datasets were available. Total phosphorus (TP) data has historically been in violation of eutrophication standard; in past assessments chlorophyll-a (algae) levels were low, so an impairment could not be assigned. Anecdotally, there have been documented algal blooms; in 1925 a large blue-green algal bloom was blamed for the death of over 120 hogs that were drinking from the lake (Wilmot Enterprise, 1925). The MPCA has received calls over the years, reporting dense blooms. However, samples collected did not coincide with the occurrence of blooms. In the most recent dataset, algae was documented during sampling trips and concentrations of chlorophyll-a were high. While TP and chl-a datasets triggered a recreation use impairment during this assessment effort, Secchi data still appears to be meeting criteria with a long term trend of increasing water clarity. It is likely the result of a type of algae common to this basin; Aphanizomenon. This is a large algae, shaped like grass clippings and it allows for considerable light to penetrate through the water column, even during algae blooms. This large dynamic basin should be prioritized for restoration and protection work by local planners to prevent further degradation that will eventually have impacts on local businesses that rely on recreational enthusiasts drawn to the unique basin. In addition, the basin's role in hydrology, sediment and nutrient transport in the headwater region of one of Minnesota's most troubled waterways should put it at the forefront of water quality discussion in this area.

Fish community data collected by DNR allowed for an aquatic life use assessment on Big Stone Lake. Nearshore and gamefish surveys conducted in 2015 revealed a fish IBI score just meeting standard for a lake of this type. Positive metrics included high insectivore and small benthic species counts, while high tolerant species (n=6) and low proportion of top carnivore biomass were the lowest negative metrics. Score the Shore survey data indicated slightly above average shoreline conditions compared to statewide average, watershed disturbance was ranked high as a possible stressor. The borderline nature of the fish community and high watershed disturbance suggests the basin is considered vulnerable to future aquatic life use impairment.

Figure 16. Currently listed impaired waters by parameter and land use characteristics in the Big Stone Lake-Minnesota River Aggregated 12-HUC.



Fish Creek Aggregated 12-HUC

HUC 0702000104-02

Fish Creek subwatershed lies to the north within the Minnesota portion of the major watershed (Figure 17). As a larger direct tributary to Big Stone Lake, this subwatershed bisects the Minnesota portion of the Big Stone Lake-Minnesota River subwatershed. Lying entirely within Minnesota, this subwatershed covers 80 square miles (51,200 acres) and parts of Big Stone and Traverse Counties. The primary stream consists of Fish Creek, which flows to the southwest to meet with Big Stone Lake. The majority of the stream reaches within the watershed have been altered (76.9%), while only 8.0% of the stream reaches remain natural, primarily the higher gradient portion of Fish Creek before it meets Big Stone Lake. No definable channel makes up 15.1% of the reach lengths within the subwatershed. The only monitored stream reach within the subwatershed is warmwater and primarily channelized, falling under the TALU designation of modified use. The monitoring stations 15MN003 sampled for biology and water chemistry, and 15MN005 sampled for biology represent the reach.

This subwatershed is predominantly rural, with cropland dominating the landscape with 75.6% of the subwatershed. After the last glaciation, numerous “prairie potholes” are present with open water covering 9.3% of the landscape, and wetlands comprising 5.2% of the subwatershed area. Rangeland accounts for 5.1%, development 4.3%, forest 0.3%, and barren land 0.1% of the subwatershed area. The only small town present in the watershed is Barry.

Table 5. Aquatic life and recreation assessments on stream reaches: Fish Creek Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

WID ***Reach name,*** *Reach description*	**Biological station ID**	**Reach length (miles)**	**Use class***	**Aquatic life indicators:** Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides	Eutrophication	**Aquatic life**	**Aquatic rec. (Bacteria)**
07020001-571, Fish Creek*, Headwaters to CSAH 33*	15MN003, 15MN005	8.36	WWm	EXS	EXS	IF	MTS	MTS	MTS	MTS	MTS	--	IF	IMP	IMP

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: = existing impairment, listed prior to 2016 reporting cycle; = new impairment; = full support of designated use; = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 6. Lake assessments: Fish Creek Aggregated 12-HUC.

Lake name	DNR ID	Area (acres)	Max depth (ft)	Assessment method	Ecoregion	Secchi trend	Aquatic life indicators:			Aquatic recreation indicators:			Aquatic life use	Aquatic recreation use
							Fish IBI	Chloride	Pesticides	Total phosphorus	Chlorophyll-a	Secchi		
Unnamed	06-0251-00	37	10	Shallow Lake	NGP	--	--	IF	--	IF	IF	IF	IF	IF

Abbreviations for Ecoregion: **DA** = Driftless Area, **NCHF** = North Central Hardwood Forest, **NGP** = Northern Glaciated Plains, **NLF** = Northern Lakes and Forests, **NMW** = Northern Minnesota Wetlands, **RRV** = Red River Valley, **WCBP** = Western Corn Belt Plains
Abbreviations for Secchi Trend: **D** = decreasing/declining trend, **I** = increasing/improving trend, **NT** = no detectable trend, **--** = not enough data
Abbreviations for Indicator Evaluations: **--** = No Data, **MTS** = Meets Standard; **EX** = Exceeds Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **FS** = Full Support (Meets Criteria); **NS** = Not Support (Impaired, exceeds standard)
Key for Cell Shading: ☐ = existing impairment, listed prior to 2016 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.

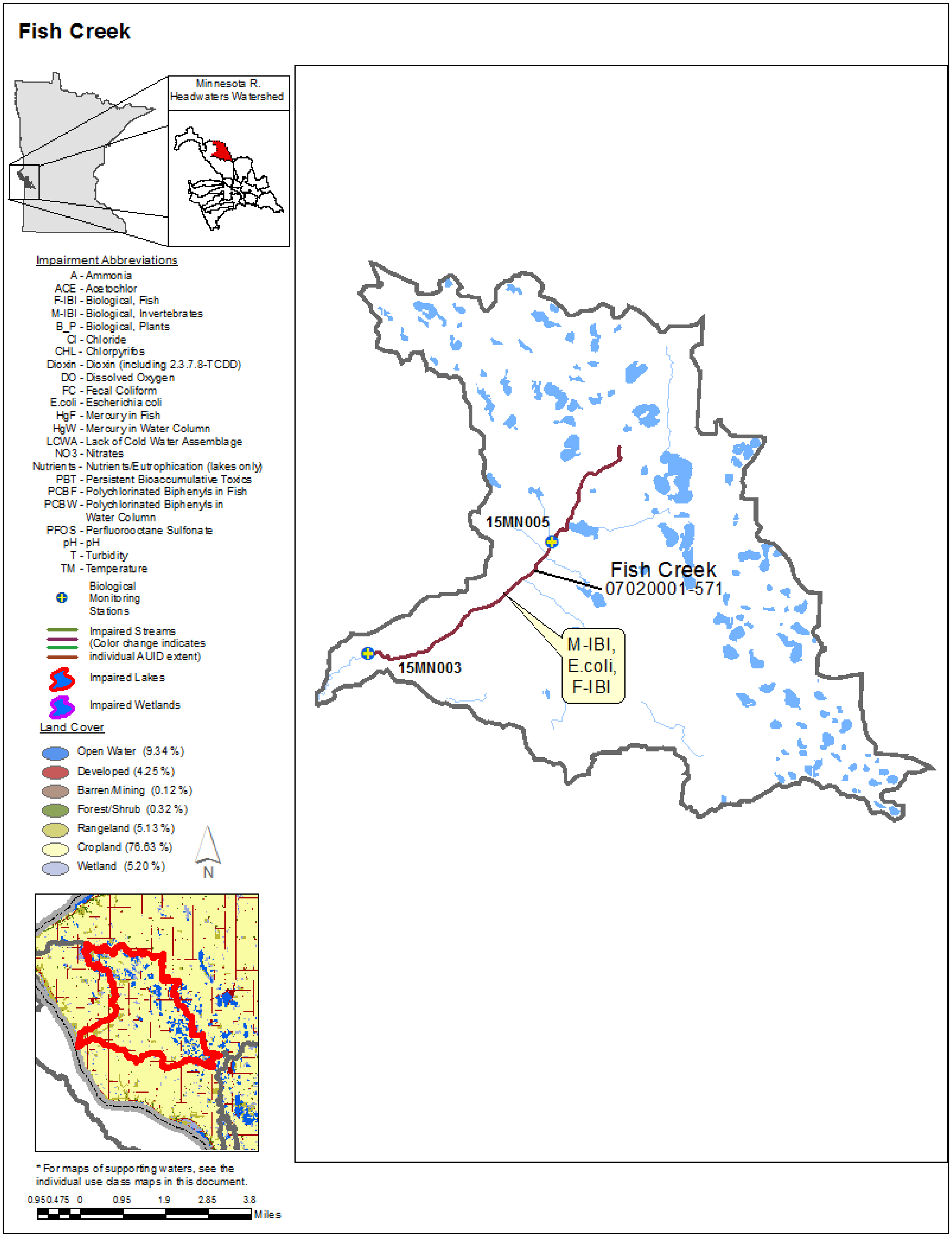
Summary

One reach, represented by two stations was assessed for aquatic life use on Fish Creek. The fish community at both stations scored 0, well below the modified use threshold and lower confidence interval. Fish samples at each station had very few taxa (<5), and were overwhelmingly dominated by tolerant and very tolerant species of fish (>93% of individuals). A perched culvert at the road crossing at 15MN003 may have an impact on the upstream fish community. Excess nutrients and altered hydrology – due to extensive channelization in the watershed – both likely contribute to a macroinvertebrate and fish community that fails to meet aquatic life expectations for a modified use stream. Dense mats of duckweed in the sampling reaches provided evidence of high nutrients and lack of flow, and prohibited macroinvertebrate sample collection at the upstream station on Fish Creek (15MN005). Based on fish and macroinvertebrate community data, Fish Creek is impaired for aquatic life use.

The majority of water chemistry related aquatic life use indicators met applicable standards for the headwaters reach of Fish Creek. Notable was elevated TP concentrations across four years of sampling at one downstream station. Erratically fluctuating DO concentrations are often symptomatic of excessive nutrients in a river system. A complete river eutrophication assessment would have required another year of DO flux data. Significant daily flux in DO concentrations can be problematic for aquatic communities; DO may be stressing the aquatic life on Fish Creek.

Lake data was limited to one data point collected during national lake monitoring efforts on an unnamed basin in 2012. The few lake basins within this subwatershed are similarly shallow and small, recreational use is typically limited waterfowl enthusiasts. Traditional lake eutrophication goals may not be commonly associated with basins of this type; however maintaining good water quality and clarity will encourage native plant communities that are more attractive to a variety of waterfowl species.

Figure 17. Currently listed impaired waters by parameter and land use characteristics in the Fish Creek Aggregated 12-HUC.



Whetstone River Aggregated 12-HUC HUC 0702000107-01

West-centrally located within the Minnesota River-Headwaters watershed lies the Whetstone River subwatershed (Figure 18). Most of the 25 square mile (16,000 acres) subwatershed is in South Dakota, with only 0.09 square miles (60 acres) within Big Stone County, Minnesota. Upstream contributing subwatersheds drain an additional 512 square miles (327,885 acres) of South Dakota. Originating on the Coteau des Prairie, the primary waterbody within the subwatershed is the Whetstone River, with only 0.3 miles between the Minnesota/South Dakota border and it's confluence with the Minnesota River. Most of this reach is considered impounded. No biological or water chemistry monitoring stations are present on the Whetstone river during the 2015 monitoring effort.

Land use within this subwatershed comprises of 63.8% cropland, 12.5% rangeland, 8.2% developed, 7.9% wetland, 5.1% open water, 2.4% forest, and 0.1% of the subwatershed area is barren. The town of Big Stone City, South Dakota is found within the subwatershed.

Table 7. Aquatic life and recreation assessments on stream reaches: Whetstone River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

WID ***Reach name,*** *Reach description*	**Biological station ID**	**Reach length (miles)**	**Use class***	**Aquatic life indicators:** Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides	Eutrophication	**Aquatic life**	**Aquatic rec. (Bacteria)**
07020001-539, Whetstone River*, MN/SD border to Minnesota R*		0.30	WWg	--	--	IF	MTS	--	--	MTS	IF	--	--	IF	IF

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
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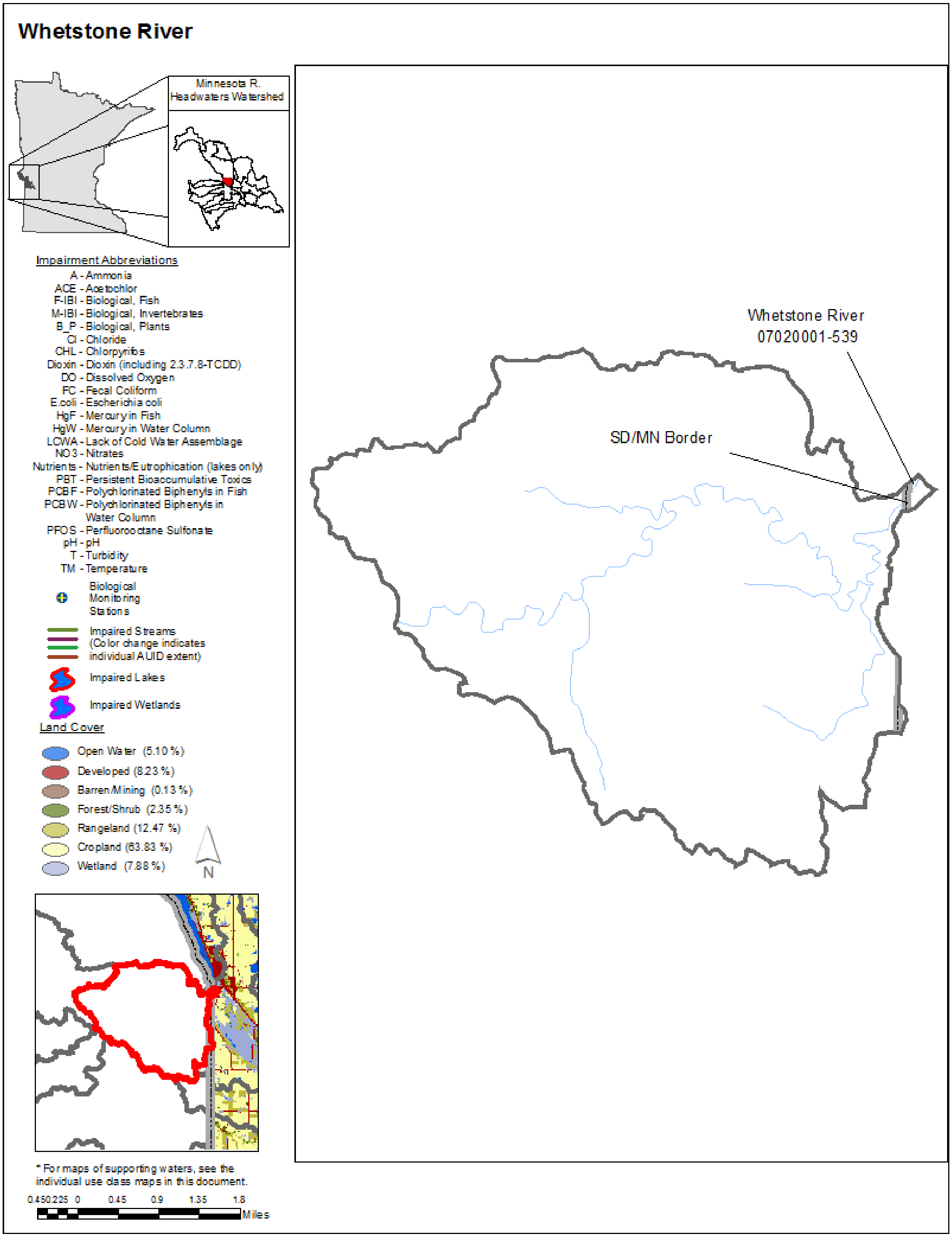
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Summary

The biological communities in the Whetstone River were not monitored in 2015. With only a short reach in Minnesota in close proximity to the Minnesota River, conditions on this reach did not meet the criteria for the establishment of a biological monitoring station.

This short reach of the Whetstone River had water chemistry data collected at a station near the South Dakota/Minnesota border. The monitoring station was close to the Minnesota River raising questions regarding impoundment and backflow issues. Aquatic life use related parameters all met applicable criteria although datasets were relatively light. Bacteria dataset had no violations but was small, making a complete assessment for aquatic recreation use not possible.

Figure 18. Currently listed impaired waters by parameter and land use characteristics in the Whetstone River Aggregated 12-HUC.



Marsh Lake-Minnesota River Aggregated 12-HUC HUC 0702000111-01

Centrally located within the major watershed is the Marsh Lake-Minnesota River subwatershed covering 104 square miles (66,560 acres) (Figure 19). Of this area, 0.96 square miles (614 acres) is present in South Dakota. Big Stone, Lac qui Parle, and a smaller portion of Swift County make up the subwatershed. The dominant waterbodies include the Minnesota River and Marsh Lake, which bisect the subwatershed. Streams within the subwatershed consist of smaller direct tributaries to either the Minnesota River or Marsh Lake. Of the stream reaches not including the Minnesota River, 15.4% of the reach lengths are altered, 31.8% of the reach lengths are natural channels, with 38.1% considered impounded, and 14.6% falling under the “No Definable Channel” category. The presence of the Minnesota River, and its backwaters, as well as Marsh Lake likely increase the percentages of impounded and no definable channel waterways.

Cropland (41.5%) is the dominate land use within the subwatershed, followed by 31.5% of the subwatershed area consisting of wetlands. Rangeland accounts for 10.2%, while 10.1% of the area is open water. Lower percentages of land use occur for development (5.3%), forest (0.9%), and barren (0.5%). Presence of the Minnesota River, Marsh Lake, and the various wetland areas within the Minnesota River valley contribute to the higher percentages of wetland and open water within the watershed. Big Stone National Wildlife Refuge and Lac qui Parle Wildlife Management Area also contribute to higher percentages of natural areas within the subwatershed. Towns present in the subwatershed include with the largest being Ortonville, Odessa, and Correll.

Table 8. Lake assessments: Marsh Lake-Minnesota River Aggregated 12-HUC.

Lake name	DNR ID	Area (acres)	Max depth (ft)	Assessment method	Ecoregion	Secchi Trend	Aquatic life indicators: Fish IBI	Chloride	Pesticides	Aquatic recreation indicators: Total phosphorus	Chlorophyll-a	Secchi	Aquatic life use	Aquatic recreation use
Marsh	06-0001-00	3856	--	Shallow Lake	NGP	--	--	NA	--	NA	NA	NA	NA	NA
Unnamed Pool	06-0460-00	4	--	--	NGP	--	--	--	--	--	--	IF	IF	IF

Abbreviations for Ecoregion: DA = Driftless Area, NCHF = North Central Hardwood Forest, NGP = Northern Glaciated Plains, NLF = Northern Lakes and Forests, NMW = Northern Minnesota Wetlands, RRV = Red River Valley, WCBP = Western Corn Belt Plains
Abbreviations for Secchi Trend: D = decreasing/declining trend, I = increasing/improving trend, NT = no detectable trend, -- = not enough data
Abbreviations for Indicator Evaluations: -- = No Data, **MTS** = Meets Standard; **EX** = Exceeds Standard; **IF** = Insufficient Information
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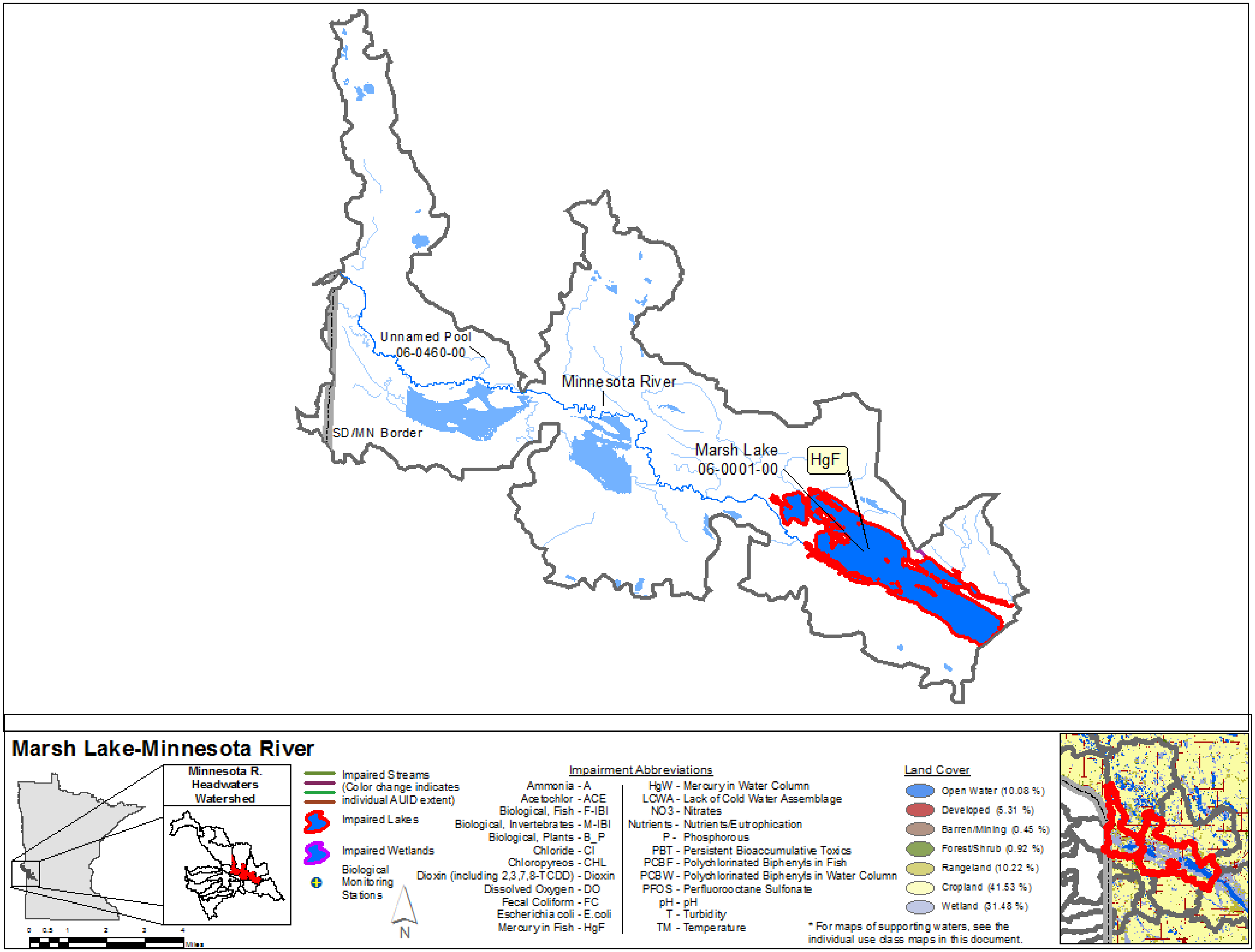
Key for Cell Shading: = existing impairment, listed prior to 2014 reporting cycle; = new impairment; = full support of designated use; = insufficient information.

Summary

Within the Marsh Lake-Minnesota River subwatershed, no streams were monitored. Most of the smaller tributaries in this subwatershed failed to meet the criteria for biological monitoring station establishment

Marsh Lake was previously reviewed during the Minnesota River large river assessment in 2016, during that assessment it was determined that based on residence time the waterbody is most appropriately compared to stream criteria. Therefore, the waterbody was not assessed during this effort. The 2016 assessment did show that nutrients and TSS are elevated. Bacteria concentrations are low. For information on Marsh lake refer to the Minnesota River monitoring and assessment report (https://www.pca.state.mn.us/mn-river-study).

Figure 19. Currently listed impaired waters by parameter and land use characteristics in the Marsh Lake-Minnesota River Aggregated 12-HUC.



Stony Run Aggregated 12-HUC HUC 0702000108-01

Stony Run subwatershed is located in the north-central region of Minnesota's portion of the major watershed (Figure 20). This 129 square mile (82,432 acre) subwatershed lies entirely within Minnesota and encompasses mostly Big Stone County, and a small portion of Stevens County. The primary stream within the subwatershed is Stony Run, which flows south to its confluence with the Minnesota River. Of the stream, 59.3% of the reach lengths in the subwatershed are altered, with only 16.3% of the reach lengths natural channels. No definable channel makes up 22.1% of the stream reach lengths and impounded 2.3%. Stony Run is a warmwater stream, with upstream reaches designated as modified use, and the downstream natural channel reaches designates as general use under the TALU framework. Important lakes within the subwatershed include Thielke, Bentsen, and Long Tom. Monitoring stations within the subwatershed include 15MN012 and 15MN013 sampled for biology, and 15MN010 as the pour point of Stony Run, which was sampled for biology and water chemistry.

Within the Stony Run subwatershed, cropland (66.1%) accounts for the majority of land use. With the numerous lakes and prairie potholes, open water accounts for 10.3%, and wetlands account for 11.1% of the subwatershed area. Rangeland occupies 7.3%, developed 4.4%, forest 0.8%, and barren 0.1% of the subwatershed area. Predominantly rural, the only town present is Clinton.

Table 9. Aquatic life and recreation assessments on stream reaches: Stony Run Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

WID *Reach name, Reach description*	Biological station ID	Reach length (miles)	Use class*	Aquatic life indicators: Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides	Eutrophication	Aquatic life	Aquatic rec. (Bacteria)
***07020001-560, Unnamed creek**, Unnamed cr to Unnamed cr*	15MN013	2.77	WWm	EXS	MTS	IF	IF	IF	--	IF	IF	--	IF	IMP	--
***07020001-559, Unnamed creek**, Unnamed cr to Unnamed cr*	15MN012	2.34	WWg	EXS	--	IF	IF	IF	--	IF	IF	--	IF	IMP	--
***07020001-538, Stony Run Creek**, Bentsen Lk to Unnamed lk (06-0060-00)*		5.53	WWg	--	--	NA	NA	NA	--	NA	NA	--	NA	NA	IF
***07020001-536, Stony Run Creek**, Long Tom Lk to Unnamed cr*		2.85	WWg	--	--	IF	MTS	MTS	--	MTS	IF	--	IF	IF	IMP
***07020001-531, Stony Run Creek**, Unnamed cr to Minnesota R*	15MN010	5.20	WWg	EXS	EXS	IF	IF	MTS	MTS	MTS	MTS	--	IF	IMP	IMP

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information

Abbreviations for Use Support Determinations: -- = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)

Key for Cell Shading: = existing impairment, listed prior to 2014 reporting cycle; = new impairment; = full support of designated use; = insufficient information.

Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water

*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 10. Lake assessments: Stony Run Aggregated 12-HUC.

Lake name	DNR ID	Area (acres)	Max depth (ft)	Assessment method	Ecoregion	Secchi Trend	Aquatic life indicators:			Aquatic recreation indicators:			Aquatic life use	Aquatic recreation Use
							Fish IBI	Chloride	Pesticides	Total Phosphorus	Chlorophyll-a	Secchi		
Long Tom	06-0029-00	135	15	Shallow Lake	NGP	--	--	--	--	EX	EX	EX	--	NS
Unnamed	06-0044-00	84	--	Shallow Lake	NGP	--	--	--	--	IF	IF	IF	--	IF
Unnamed	06-0060-00	55	13	Shallow Lake	NGP	--	--	--	--	EX	EX	MTS	--	NS
Bentsen	06-0090-01	378	--	Shallow Lake	NGP	--	--	IF	--	IF	IF	IF	IF	IF
Thielke	06-0102-00	402	4	Shallow Lake	NGP	--	--	IF	--	IF	IF	IF	IF	IF

Abbreviations for Ecoregion: DA = Driftless Area, NCHF = North Central Hardwood Forest, NGP = Northern Glaciated Plains, NLF = Northern Lakes and Forests, NMW = Northern Minnesota Wetlands, RRV = Red River Valley, WCBP = Western Corn Belt Plains
Abbreviations for Secchi Trend: D = decreasing/declining trend, I = increasing/improving trend, NT = no detectable trend, -- = not enough data
Abbreviations for Indicator Evaluations: -- = No Data, **MTS** = Meets Standard; **EX** = Exceeds Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **FS** = Full Support (Meets Criteria); **NS** = Not Support (Impaired, exceeds standard)
Key for Cell Shading: ☐ = existing impairment, listed prior to 2014 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.

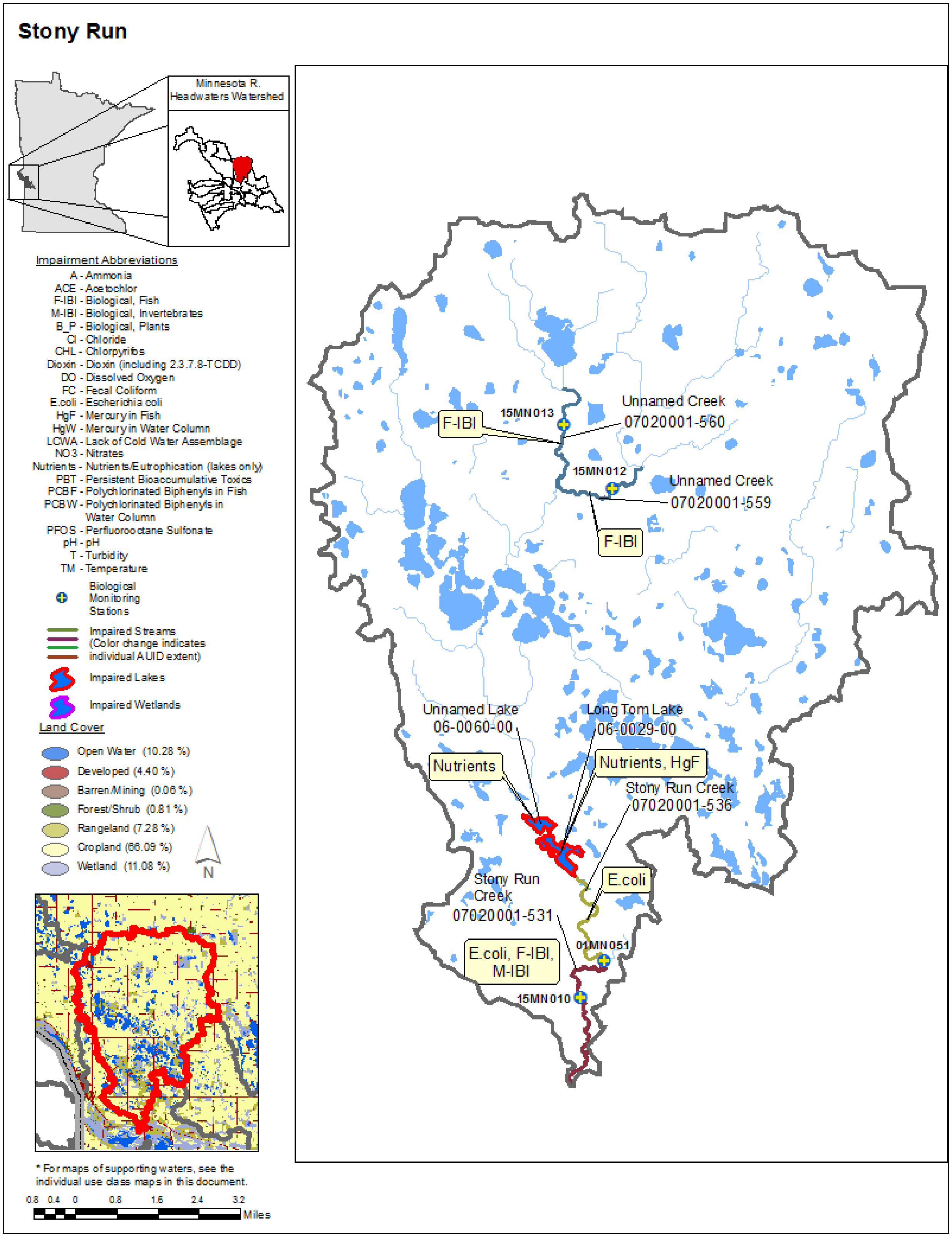
Summary

Three reaches in the Stony Run subwatershed were assessed for aquatic life use using biological community data. Both Unnamed Creeks were sampled for fish in 2015 with FIBI scores of 0, leading to a new aquatic life use impairment based on the fish assemblage in each reach. Excess nutrients, and the resulting diurnal swing in DO may be affecting the fish community on both of these reaches. Stony Run Creek was previously listed as impaired for fish in 2004. Fish community data sampled on this reach in 2015 at station 15MN010 supports the existing impairment. Macroinvertebrates represent a new aquatic life impairment on Stony Run Creek, corroborating the existing fish impairment from a previous assessment cycle. Monitoring crews noted severe bank erosion and excess sediments on the streambed, suggesting that altered hydrology may be contributing to an unstable channel and impaired biological communities. Both the existing fish impairment (first listed in 2004) and macroinvertebrate data from another station sampled in 2001 (MIBI = 33, four points below threshold) suggest that this has been an ongoing issue for many years.

Water chemistry data from this subwatershed is highlighted by grossly elevated TP and bacteria concentrations. Nuisance concentrations of *E.coli* leads to poor recreational water quality, triggering new impairments on Stony Run Creek. Water quality in Stony Run Creek just downstream of Long Tom Lake is clearly impacted by lake processes and stagnant stream conditions considering control structures (dams) both upstream and downstream of the station location. A single un-ionized ammonia violation from 2011 could be the result of nutrient cycling by algal communities in upstream hypereutrophic lakes. Dissolved oxygen (DO) concentrations display excessive diurnal flux that could be problematic to aquatic communities, a listing for DO was not pursued during this effort taking into account violation magnitude and unrepresentative stream conditions at station location.

Five lakes had aquatic recreation use data available, Long Tom and an unnnamed lake (06-0060-00) had enough to render a complete lake eutrophication assessment. Data collected between 2011 and 2016 show elevated TP and high algae (chlorophyll-a) and low transparency (Secchi) in both lakes, triggering new aquatic recreation use listings. Contributing land use modifications, inputs from upstream waterbodies and internal loading lead to poor aquatic recreation use conditions in shallow lakes in this region. Lakes act as sinks from nearby sources of nutrients; once in the lake, wind mixing can cause nutrients to continue cycling in the basin driving algae blooms. Restoring and maintaining good recreational water quality can be beneficial to a variety of public uses (i.e. canoe, kayak, waterfowl enthusiasts).

Figure 20. Currently listed impaired waters by parameter and land use characteristics in the Stony Run Aggregated 12-HUC.



Tributary to South Fork Yellow Bank River Aggregated 12-HUC HUC 0702000110-03

The tributary to South Fork Yellow Bank River subwatershed is located in the south-central region of the major watershed (Figure 21). This subwatershed has a drainage area of 49 square miles (31,456 acres), of which only 2 square miles (1,512 acres) are a part of Lac qui Parle County, Minnesota. The only waterbody within Minnesota is Unnamed Creek, which flows east to its confluence with the South Fork of the Yellow Bank River. Within Minnesota, the majority of the stream reaches are natural (72.7%), with only 8.5% of the stream reach lengths are altered. No definable channel makes up 18.7% of the stream reaches. The monitored reach of Unnamed Creek is warmwater, and designated general use under the TALU framework. It is represented by the station 15MN023, which was sampled for biology and water chemistry.

Land use within the subwatershed includes: 63.3% cropland, 28.0% rangeland, 4.7% developed, 2.8% wetland, 1.0% forest, and 0.2% of the subwatershed area is open water. Nassau is the only town present in the subwatershed.

Table 11. Aquatic life and recreation assessments on stream reaches: Trib. To South Fork Yellow Bank River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

WID ***Reach name,*** *Reach description*	**Biological station ID**	**Reach length (miles)**	**Use class***	**Aquatic life indicators:**										**Aquatic life**	**Aquatic rec. (Bacteria)**
				Fish IBI	**Invert IBI**	**Dissolved oxygen**	**TSS**	**Secchi Tube**	**Chloride**	**pH**	**Ammonia -NH_3**	**Pesticides**	**Eutrophication**		
07020001-551, Unnamed creek, *Headwaters to S Fk Yellow R*	15MN023	4.87	WWg	EXS	EXS	NA	MTS	MTS	MTS	MTS	MTS	--	IF	IMP	IMP

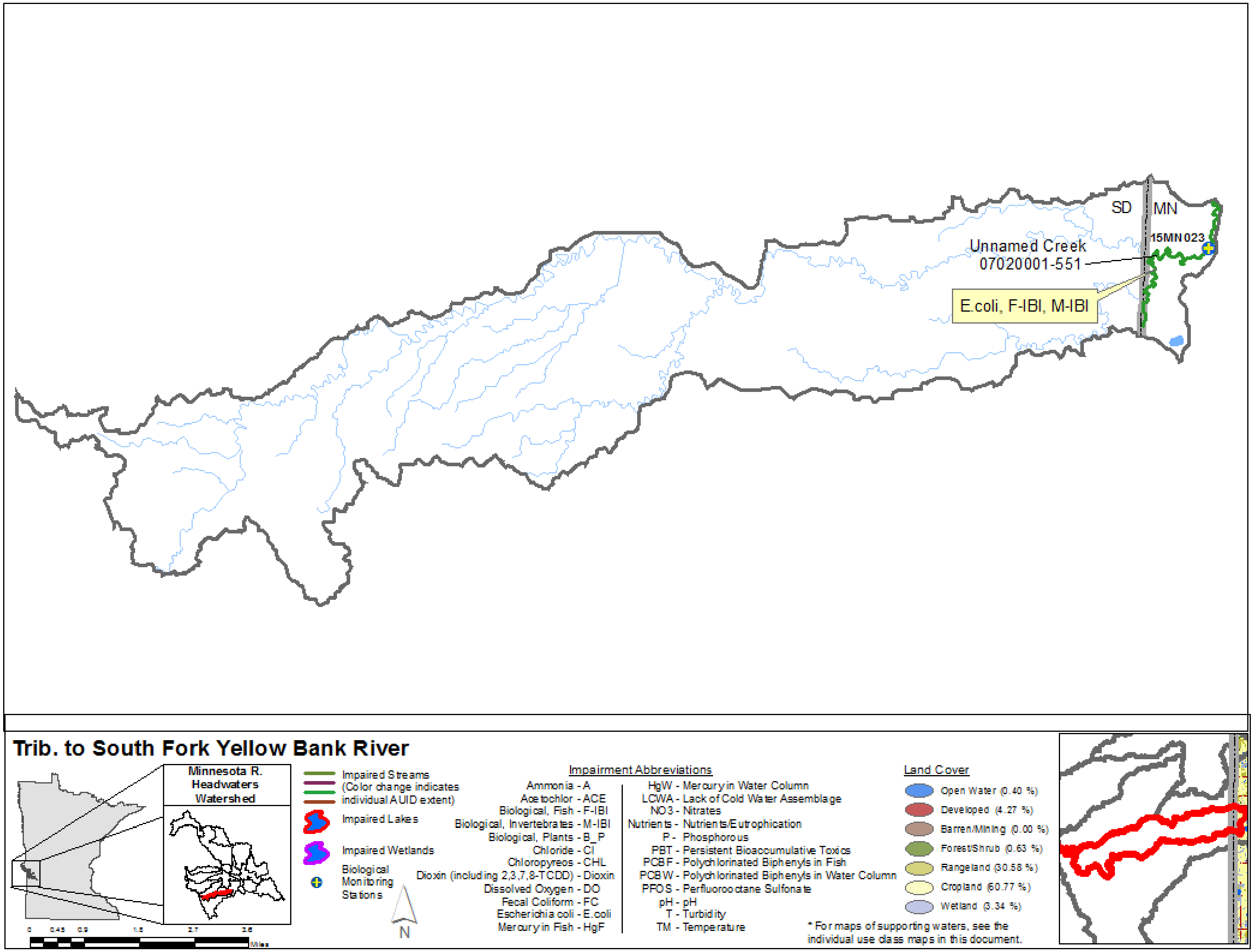
Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: = existing impairment, listed prior to 2014 reporting cycle; = new impairment; = full support of designated use; = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Summary

One monitored reach in this subwatershed was assessed for aquatic life use using biological community data. Fish and macroinvertebrates were sampled in 2015 at monitoring station 15MN023. Both communities performed poorly with a FIBI score below the general use threshold and lower confidence interval, and an MIBI score below the general use threshold and within the 90% confidence limit. Unnamed Creek will be listed as a new aquatic life impairment for fish and macroinvertebrates.

Water chemistry data was limited to one reach within this small subwatershed. Total phosphorus (TP) seasonal average was grossly elevated, fueling dense vegetation growth and exacerbating daily fluctuations in DO concentrations. The DO dataset indicates a number of violations. However, monitoring station was immediately downstream of a wetland and stagnant conditions were observed. Aquatic recreation use listing was driven by violating individual and summarized monthly *E.coli* concentrations.

Figure 21. Currently listed impaired waters by parameter and land use characteristics in the Trib. To South Fork Yellow Bank River Aggregated 12-HUC.



South Fork Yellow Bank River Aggregated 12-HUC HUC 0702000110-02

The South Fork Yellow Bank River subwatershed is the southernmost subwatershed within the major watershed (Figure 22). The drainage area encompasses 164 square miles (105,158 acres) of South Dakota and Minnesota. Minnesota's portion of the subwatershed totals 36 square miles (23,022 acres) within Lac qui Parle County. The South Fork of the Yellow Bank River originates on the Coteau de Prairie, flowing northeast to join with the North Fork of the Yellow Bank River. Within Minnesota, much of the length of the South Fork Yellow Bank River is a natural channel. In Minnesota, 46.9% of the stream reaches are natural, while 41.1% are altered. No definable channel makes up 11.9% of the reach lengths. The South Fork of the Yellow Bank River is a warmwater stream with a TALU determination of general use. Three monitoring stations represent the South Fork of the Yellow Bank River: 15MN021, 15MN095, and 15MN099. Biology was sampled at all three stations, while water chemistry was sampled at 15MN021 and 15MN099.

Throughout the watershed, the dominate land use is cropland (45.5%), followed by rangeland (41.0%). Wetlands occupy 6.1% of the subwatershed area. While development covers 4.4%, open water 2.3%, forest 0.7%, and barren land 0.1% of the subwatershed area. No towns are present in the Minnesota portion of the subwatershed.

Table 12. Aquatic life and recreation assessments on stream reaches: South Fork Yellow Bank River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

WID ***Reach name,*** *Reach description*	**Biological station ID**	**Reach length (miles)**	**Use class***	**Aquatic life indicators:** Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides	Eutrophication	**Aquatic life**	**Aquatic rec. (Bacteria)**
07020001-526, Yellow Bank River, South Fork, *MN/SD border to N Fk Yellow Bank R*	15MN021, 15MN095, 15MN099	27.20	WWg	EXS	MTS	MTS	MTS	MTS	MTS	MTS	MTS	--	IF	IMP	IMP

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: -- = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: = existing impairment, listed prior to 2014 reporting cycle; = new impairment; = full support of designated use; = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

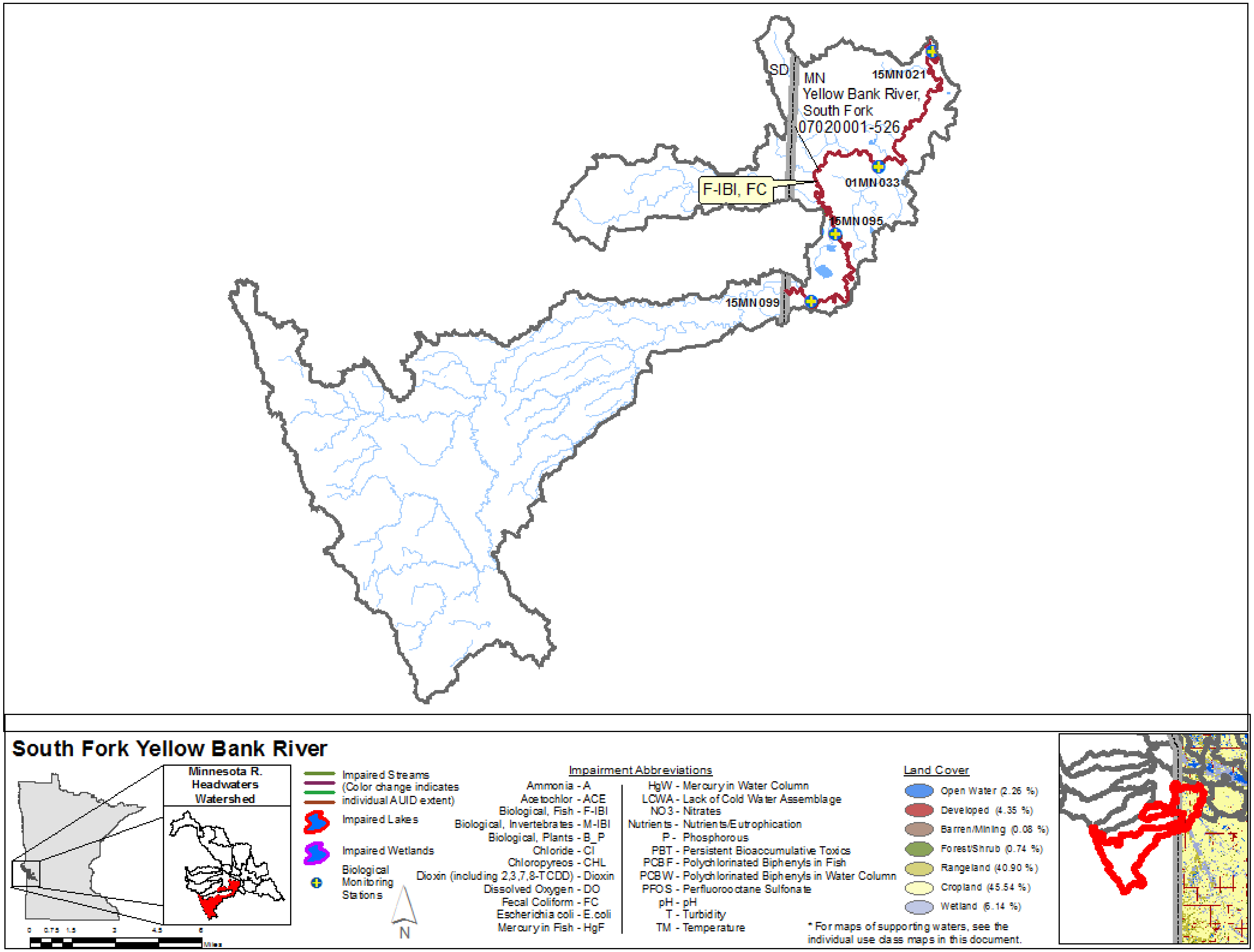
Summary

Three stations cover the length the South Fork Yellow Bank River, from the South Dakota border, to the confluence with the North Fork Yellow Bank River. All were sampled for fish in 2015. Along this length, it appears the fish community improves as you move downstream, as well as the habitat conditions within the river. In this reach, FIBI scores range from below the threshold and within the confidence limit at the upstream portion, below the threshold and below the confidence limit in the middle portion, and just above but within the confidence limit near the downstream end of the reach. Consequently, the reach will be impaired for aquatic life based on the fish community.

Aquatic macroinvertebrate community data, across four stations and two time periods (2001 and 2015), indicate that the South Fork Yellow Bank River is currently attaining aquatic life use goals but is barely doing so. At one of the monitoring stations the MIBI fails general use criteria by two points and supporting MIBI scores are all close to the impairment threshold. If it were not for the fish impairment this assessment unit would be a high priority for developing a watershed protection strategy.

Numerous water quality stations were located on this long reach of the South Fork Yellow Bank River providing robust datasets for assessment. Total phosphorus seasonal average was in violation of criteria, response data was not available for comparison. Total suspended solids (TSS) dataset had six violations scattered amongst stations across the entire reach, overall conditions met standards. Secchi tube data was extensive, with no violations over ten years. The next downstream reach of the Yellow Bank River is impaired for TSS. Compounding effects of marginal TSS issues in upstream reaches could be driving more significant problems downstream. A fecal coliform impairment was added in 2006, restoration is underway, and more recent *E.coli* data confirms the initial aquatic recreation use listing.

Figure 22. Currently listed impaired waters by parameter and land use characteristics in the South Fork Yellow Bank River Aggregated 12-HUC.



Lower North Fork Yellow Bank River Aggregated 12-HUC HUC 0702000109-01

The Lower North Fork Yellow Bank River subwatershed has a total area of 75 square miles (47,744 acres) in South Dakota and Minnesota (Figure 23). Of total area, 7 square miles (4,728 acres) occur in Minnesota, within Lac qui Parle County. Contributing subwatersheds in South Dakota upstream of the Lower North Fork Yellow Bank River subwatershed add the influence of another 137 square miles (87,827 acres) of drainage area. The primary waterbody within the subwatershed is the North Fork Yellow Bank River, which flows to the east to where it joins the South Fork Yellow Bank River. Within Minnesota, much of the North Fork Yellow Bank River consists of a natural channel. In the subwatershed, 77.6% of the reach lengths are natural, and 11.7 % of the reach lengths are altered. No definable channel accounts for 10.7% of the reach lengths. The North Fork of the Yellow Bank is a warmwater stream with a general use TALU determination. This subwatershed is represented by the monitoring station 15MN400, which was sampled for biology and water chemistry.

In the entire subwatershed, cropland accounts for 69.7% of the land use. Rangeland occupies 14.5%, wetlands 6.9%, development 5.9%, forest 1.4%, open water 1.1%, and barren land 0.5% of the subwatershed area. No towns occur in the Minnesota portion of the subwatershed.

Table 13. Aquatic life and recreation assessments on stream reaches: Lower North Fork Yellow Bank River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

WID ***Reach name,*** *Reach description*	**Biological station ID**	**Reach length (miles)**	**Use class***	**Aquatic life indicators:** Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides	Eutrophication	**Aquatic life**	**Aquatic rec. (Bacteria)**
07020001-510, Yellow Bank River, North Fork*, MN/SD border to Yellow Bank R*	15MN400	8.90	WWg	EXS	MTS	IF	MTS	MTS	MTS	MTS	MTS	--	IF	IMP	IMP

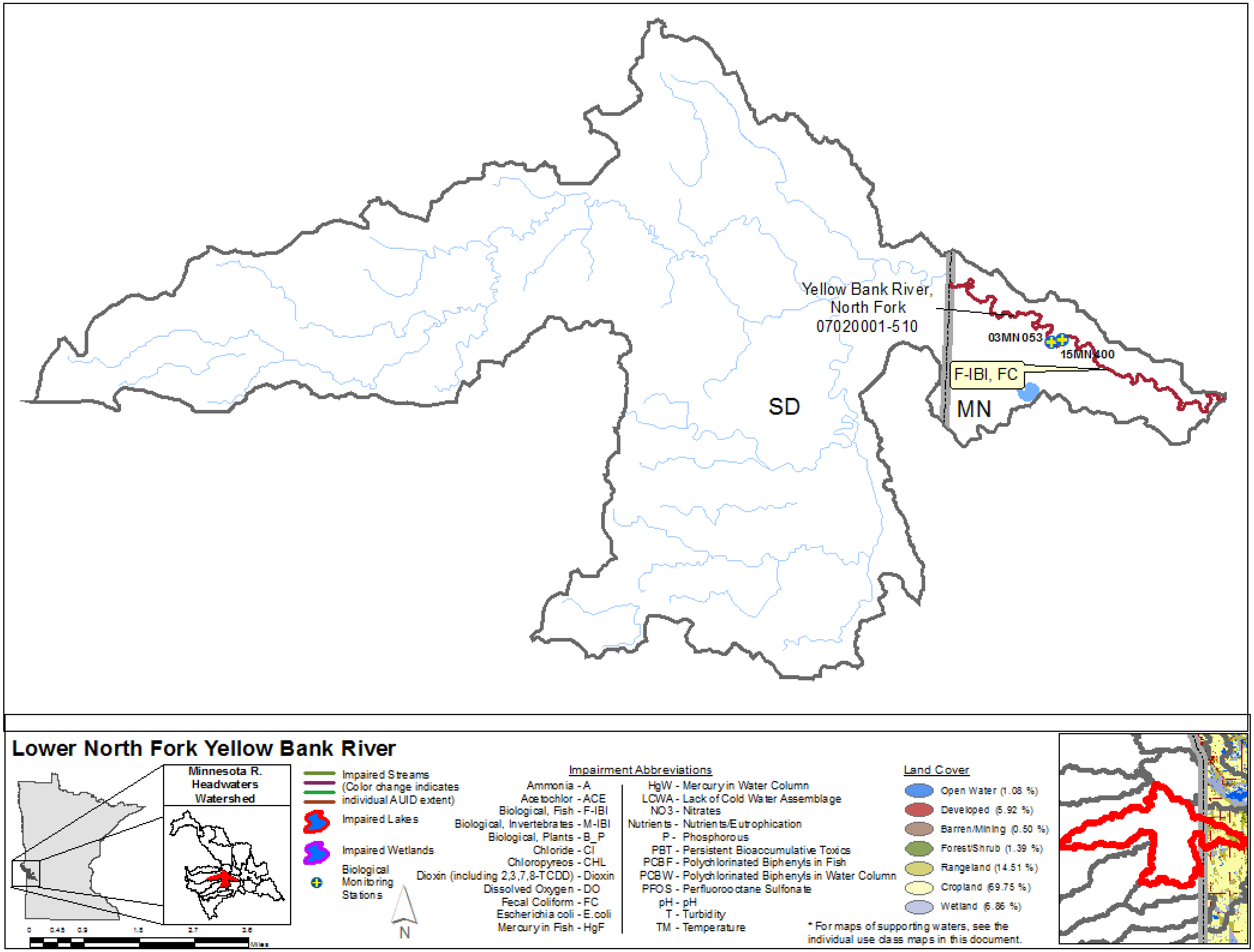
Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: = existing impairment, listed prior to 2014 reporting cycle; = new impairment; = full support of designated use; = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Summary

The mainstem reach of the North Fork Yellow Bank River was assessed for aquatic life following biological sampling in 2015 at the station 15MN400. While the macroinvertebrate community met aquatic life standards, the fish community scored below the threshold and just slightly above the lower confidence limit. Over 70% of the individuals in the fish sample are considered tolerant taxa. This reach will be listed as impaired for aquatic life based on the fish assemblage.

Water chemistry data was also available on this stretch of the North Fork Yellow Bank River. No response data available for a complete river eutrophication assessment, TP seasonal average from 2015 and 2016 was elevated. Dissolved oxygen data reveals daily flux is potentially problematic for aquatic communities; excessive nutrients in the system can fuel organic processes occurring throughout the day causing erratic swings. Minor violations occurred in the remainder of aquatic life use datasets. A fecal coliform impairment was added in 2006, restoration work is underway. Recent data confirms that the recreational use of the stream is still impaired.

Figure 23. Currently listed impaired waters by parameter and land use characteristics in the Lower North Fork Yellow Bank River Aggregated 12-HUC.



Yellow Bank River Aggregated 12-HUC — HUC 0702000110-01

On the south side of the Minnesota River occurs the 35 square mile (22,611 acre) Yellow Bank River subwatershed (Figure 24). Of the total subwatershed area, only 2 square miles (1,427 acres) occur in South Dakota. The entire Minnesota portion of the subwatershed falls within Lac qui Parle County. The primary waterbody in the subwatershed is the mainstem Yellow Bank River, which begins at the joining of the South Fork and North Fork Yellow Bank River, and flows north to its confluence with the Minnesota River. Within Minnesota, 37.4% of the stream reaches are altered, 49.3% are natural channels, while no definable channel accounts for 13.2% of the reach lengths. All of the monitored stream reaches in the Yellow Bank subwatershed are warmwater, and designated general use under the TALU framework. The pour point of the Yellow Bank River is represented by the monitoring station 03MN054, which was sampled for biology and water chemistry. A tributary to the Yellow Bank River was also monitored for biology at the station 15MN032.

Cropland (69.2%) is the dominant land use within the subwatershed. Rangeland occupies 13.2% of the landscape. Wetlands occur on 8.9% of the subwatershed area, while open water accounts for 2.5% and forest 1.7% of the area. Development consists of 4.3% and barren land 0.1% of the subwatershed area. No towns are present in the subwatershed.

Table 14. Aquatic life and recreation assessments on stream reaches: Yellow Bank River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

WID *Reach name,* *Reach description*	Biological station ID	Reach length (miles)	Use class	Aquatic life indicators: Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides	Eutrophication	Aquatic life	Aquatic rec. (Bacteria)
***07020001-561, Unnamed creek**, MN/SD border to Yellow Bank R*	15MN032	6.30	WWg	EXS	--	IF	IF	IF	--	IF	IF	--	IF	IMP	--
***07020001-525, Yellow Bank River**, N Fk Yellow Bank R to Minnesota R*	03MN054	12.01	WWg	EXS	EXS	MTS	EXS	EXS	MTS	MTS	MTS	--	IF	IMP	IMP

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: ☐ = existing impairment, listed prior to 2014 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 15. Lake assessments: Yellow Bank River Aggregated 12-HUC.

							Aquatic life indicators:			Aquatic recreation indicators:				
Lake name	DNR ID	Area (acres)	Max depth (ft)	Assessment method	Ecoregion	Secchi Trend	Fish IBI	Chloride	Pesticides	Total phosphorus	Chlorophyll-a	Secchi	Aquatic life use	Aquatic recreation use
Unnamed	37-0183-00	80				--				IF		IF		IF

Abbreviations for Ecoregion: DA = Driftless Area, NCHF = North Central Hardwood Forest, NGP = Northern Glaciated Plains, NLF = Northern Lakes and Forests, NMW = Northern Minnesota Wetlands, RRV = Red River Valley, WCBP = Western Corn Belt Plains
Abbreviations for Secchi Trend: D = decreasing/declining trend, I = increasing/improving trend, NT = no detectable trend, -- = not enough data
Abbreviations for Indicator Evaluations: -- = No Data, **MTS** = Meets Standard; **EX** = Exceeds Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **FS** = Full Support (Meets Criteria); **NS** = Not Support (Impaired, exceeds standard)
Key for Cell Shading: = existing impairment, listed prior to 2014 reporting cycle; = new impairment; = full support of designated use; = insufficient information.

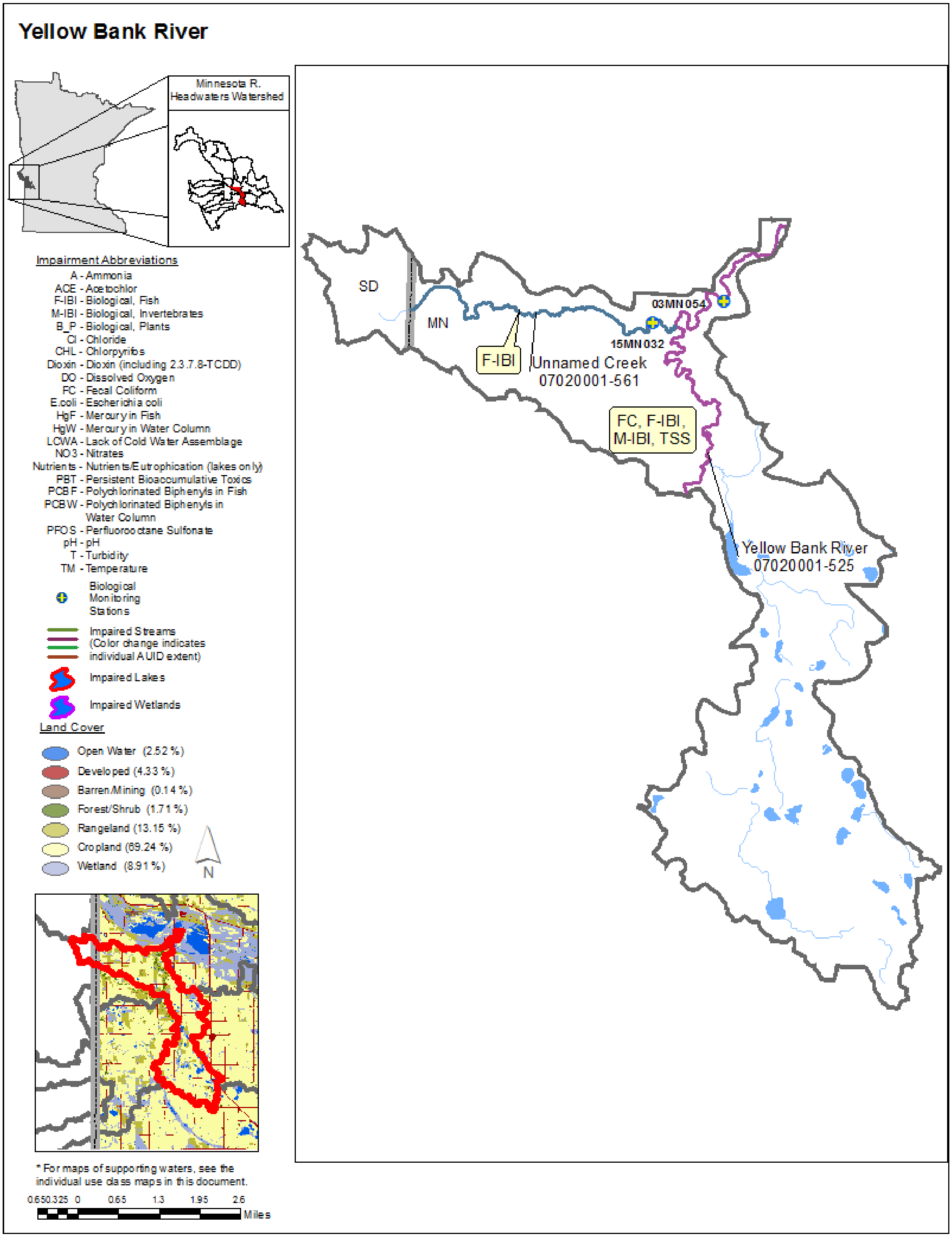
Summary

Two reaches within this subwatershed were assessed for aquatic life use. Unnamed Creek was only sampled for fish in 2015 at station 15MN032. Despite somewhat favorable habitat conditions at the site, the fish community consisted of only four taxa, all considered tolerant, resulting in a FIBI score below the threshold and lower confidence limit. Due to the poor composition of the fish community, this reach will be listed as impaired for aquatic life.

The mainstem Yellow Bank River was sampled twice for fish in 2015 at station 03MN054. One of these samples almost met the standard, while the second sample was below the lower confidence limit. Fish species considered detritivores were abundant at this site. Aquatic macroinvertebrates failed to meet aquatic life expectations for a general use stream in a section of the Yellow Bank River. At station 03MN054 habitat evaluations suggest that sedimentation and bank erosion are issues in this river, corroborating the existing turbidity impairment on this stream reach. The most predominant mayflies collected at this station were Tricorythodes and Caenis, both of which have operculate gills that protect against abrasion from suspended sediment. This reach of the Yellow Bank River is impaired for aquatic life based on both fish and macroinvertebrate assemblages.

Extensive water chemistry datasets available from a downstream station on this outlet reach of the Yellow Bank River. The reach was previously assessed not supporting for aquatic life use in 2010 based on turbidity data, since the listing restoration work is underway. More recently, TSS and Secchi tube datasets confirm the initial listing with numerous violations occurring seasonally since 2010. Sediment loading is a common theme in downstream reaches of HUC8 tributaries across the Minnesota River basin. A fecal coliform impairment was added in 2006, restoration work is underway, and more recent *E.coli* data confirms the initial aquatic recreation use listing. Total phosphorus seasonal average is in clear violation, chlorophyll-a data does not show increased algal production.

Figure 24. Currently listed impaired waters by parameter and land use characteristics in the Yellow Bank River Aggregated 12-HUC.



County Ditch No. 3A Aggregated 12-HUC HUC 0702000111-03

South-centrally located within the Minnesota portion of the major watershed (Figure 25), County Ditch 3A is a 49 square mile (31,328 acres) subwatershed in Lac qui Parle County. The primary stream course flows north to Marsh Lake. The highest percentage of channelization (84.0%) within Minnesota's subwatersheds of the major watershed occurs in this subwatershed. Natural stream reaches only account for 3.8% of the reach lengths, while no definable channel 11.7%, and impounded 0.4% of the reach lengths. The warmwater Unnamed Creek includes two monitored reaches. The upstream reach of Unnamed Creek is designated modified use under TALU, and is represented by monitoring stations 10EM067 and 15MN025, both sampled for biology. The downstream reach on Unnamed Creek is designated general use, and is represented by the pour point station 15MN024, which was sampled for both biology and water chemistry.

Besides channelization, this subwatershed also has the highest percentage of land used as cropland, at 84.6% of the subwatershed area. Other uses include 6.1% wetland, 5.6% developed, 2.8% rangeland, 0.6% forest, and 0.2% open water. The towns of Bellingham and Louisburg occur in this subwatershed.

Table 16. Aquatic life and recreation assessments on stream reaches: County Ditch No. 3A Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

WID ***Reach name***, *Reach description*	**Biological station ID**	**Reach length (miles)**	**Use class***	**Aquatic life indicators:** Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides	Eutrophication	**Aquatic life**	**Aquatic rec. (Bacteria)**
07020001-569, Unnamed creek, *Headwaters to CSAH 38*	10EM067, 15MN025	16.03	WWm	EXS	MTS	IF	IF	IF	--	IF	IF	--	IF	IMP	--
07020001-570, Unnamed creek*, CSAH 38 to Marsh Lk*	15MN024	4.81	WWg	EXS	EXS	IF	IF	MTS	MTS	MTS	MTS	--	IF	IMP	IMP

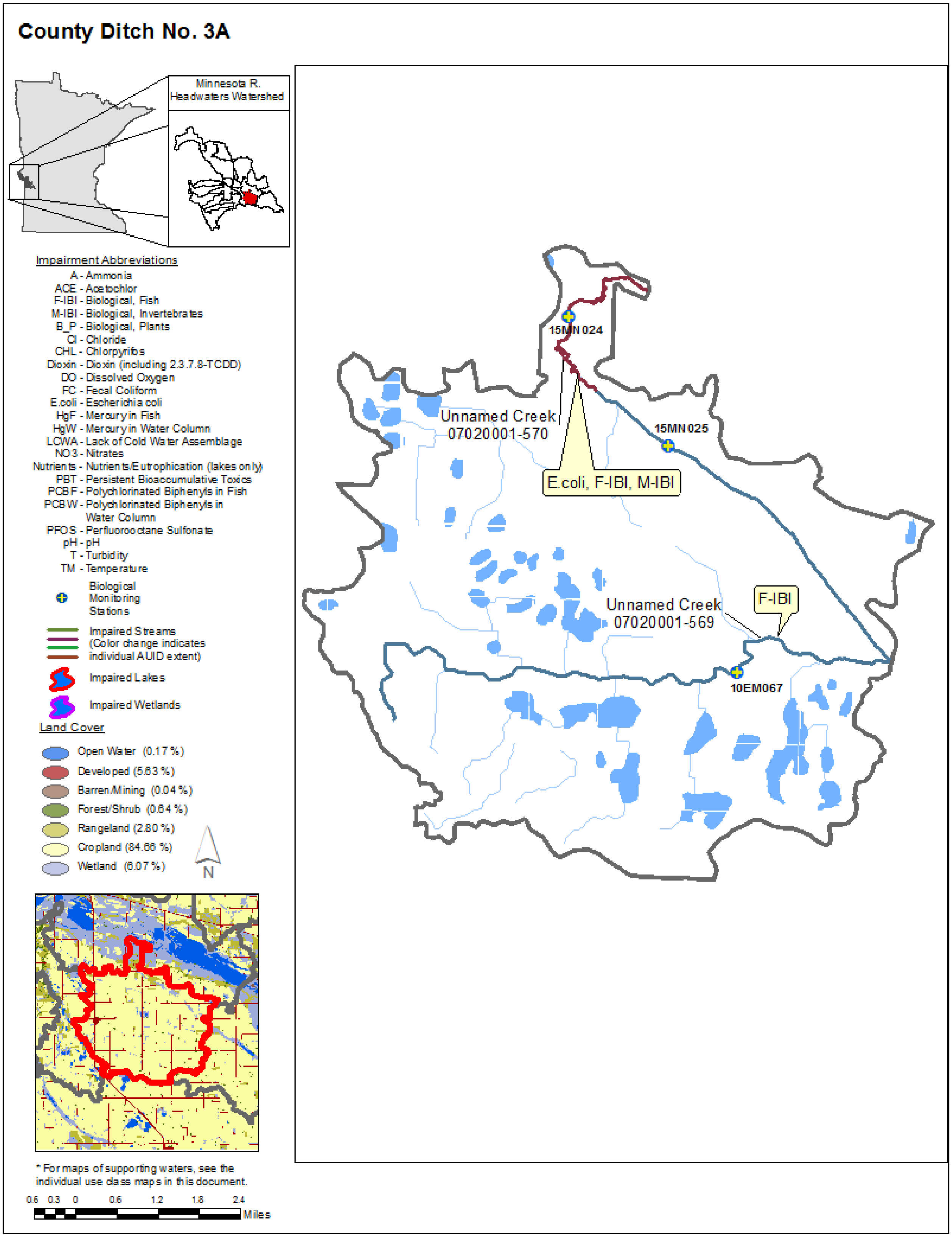
Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: = existing impairment, listed prior to 2014 reporting cycle; = new impairment; = full support of designated use; = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Summary

Within the County Ditch 3A subwatershed, two reaches were assessed for aquatic life use using biological communities. The upstream reach of Unnamed Creek held a macroinvertebrate community meeting modified use aquatic life standards. For the fish community, conditions seem to deteriorate as you travel downstream. At the upstream station (10EM067) sampled in 2010 and 2015, FIBI scores for both samples met the modified use threshold. At the downstream station on this reach (15MN025), significant sedimentation and nutrient issues resulted in a fish community dominated by tolerant fish species (96-100% of the individuals) and an FIBI score of 0. Consequently, this reach will be added as a new aquatic life impairment for the fish assemblage. The downstream reach of Unnamed Creek is represented by one station (15MN024) sampled twice in 2015. Both samples resulted in FIBI scores below the general use threshold and lower confidence limit resulting in a fish assemblage impairment for aquatic life. Despite some channelized portions on this reach, enough of the reach still remained as natural channels and the channelized portions were considered restorable, a general use TALU determination was made. In Unnamed Creek, the aquatic macroinvertebrate community failed to attain aquatic life goals for a general use stream, and thus represents a new impairment on the Impaired Waters List. On an upstream reach of Unnamed Creek, a neighboring station (15MN025) was not sampled on the same day due to insufficient water levels, while the next station (10EM067) further upstream could be sampled. At this time, according to the U.S. Drought Monitor, the region was not in any stage of drought, suggesting that altered watershed hydrology may play a part in the observed biological impairments.

Aquatic life use related water chemistry parameters met applicable standards on the downstream reach of this subwatershed. Sediment concentrations were low, with the exception of a single exceedance from late August 2015. Altered surface water hydrology intensifies flow fluctuations degrading stream channels and increasing sediment loads, a common water quality issue across southern and western portions of Minnesota. Bacteria data summarized monthly across 2015 and 2016 revealed poor recreational water quality, resulting in a new impairment for aquatic recreation use.

Figure 25. Currently listed impaired waters by parameter and land use characteristics in the County Ditch No. 3A Aggregated 12-HUC.



Five Mile Creek Aggregated 12-HUC HUC 0702000111-02

In the eastern portion of the major watershed, north of the Minnesota River lies the Five Mile Creek subwatershed (Figure 26). The drainage area of this subwatershed encompasses 89 square miles (57,171 acres) of Big Stone and Swift Counties. The primary watercourse is Five Mile Creek, which flows south to meet Marsh Lake. Of the stream reaches in the subwatershed, 55.3% of the reach lengths are altered and 22.9% are natural channels. No definable channel accounts for 21.6% of the reach lengths, and impounded reaches 0.1%. All of the monitored reaches on Five Mile Creek are warmwater, with the upstream most reach designated modified use, and the two downstream reaches designated general use under the TALU framework. The upstream most reach is represented by the monitoring station 15MN018, sampled for biology. An intermediate reach of Five Mile Creek was also sampled for biology at 15MN017. The pour point station (15MN016) on the downstream most reach was sampled for biology and water chemistry.

The majority of the subwatershed is used for cropland (74.8%). Developed and barren areas consist of 5.1% and 0.1% of the subwatershed area respectively. With numerous lakes and prairie potholes in the subwatershed, wetlands account for 10.9% and open water 3.4% of the landscape. Shible Lake is one of the monitored lakes within the subwatershed. Rangeland accounts for 4.7% and forest 0.9% of the land. No towns are present in this rural subwatershed.

Table 17. Aquatic life and recreation assessments on stream reaches: Five Mile Creek Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

WID ***Reach name***, *Reach description*	**Biological station ID**	**Reach length (miles)**	**Use class***	**Aquatic life indicators:** Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides	Eutrophication	**Aquatic life**	**Aquatic rec. (Bacteria)**
07020001-562, County Ditch 2, *Unnamed cr to Unnamed cr*	15MN018	1.64	WWm	MTS	--	IF	IF	IF	--	IF	IF	--	IF	SUP	--
07020001-574, County Ditch 2 (Five Mile Creek), *-96.1283, 45.2472 to T121 R43W S31, south line*	15MN017	1.41	WWg	EXS	MTS	IF	IF	IF	--	IF	IF	--	IF	IMP	--
07020001-521, Unnamed creek (Five Mile Creek), *Unnamed cr to Marsh Lk*	15MN016	6.19	WWg	EXS	MTS	IF	MTS	MTS	MTS	MTS	MTS	--	MTS	IMP	IMP

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information

Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)

Key for Cell Shading: = existing impairment, listed prior to 2014 reporting cycle; = new impairment; = full support of designated use; = insufficient information.

Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water

*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 18. Lake assessments: Five Mile Creek Aggregated 12-HUC.

Lake name	DNR ID	Area (acres)	Max Depth (ft)	Assessment method	Ecoregion	Secchi Trend	Aquatic life indicators:			Aquatic recreation indicators:			Aquatic life use	Aquatic recreation use
							Fish IBI	Chloride	Pesticides	Total phosphorus	Chlorophyll-a	Secchi		
Unnamed	06-0005-00	48	--	Shallow Lake	NGP	--	--	--	--	IF	IF	IF	--	IF
Shible	76-0141-00	234	8	Shallow Lake	NGP	--	--	--	--	EX	MTS	IF	--	IF

Abbreviations for Ecoregion: DA = Driftless Area, NCHF = North Central Hardwood Forest, NGP = Northern Glaciated Plains, NLF = Northern Lakes and Forests, NMW = Northern Minnesota Wetlands, RRV = Red River Valley, WCBP = Western Corn Belt Plains
Abbreviations for Secchi Trend: D = decreasing/declining trend, I = increasing/improving trend, NT = no detectable trend, -- = not enough data
Abbreviations for Indicator Evaluations: -- = No Data, **MTS** = Meets Standard; **EX** = Exceeds Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **FS** = Full Support (Meets Criteria); **NS** = Not Support (Impaired, exceeds standard)
Key for Cell Shading: ☐ = existing impairment, listed prior to 2014 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.

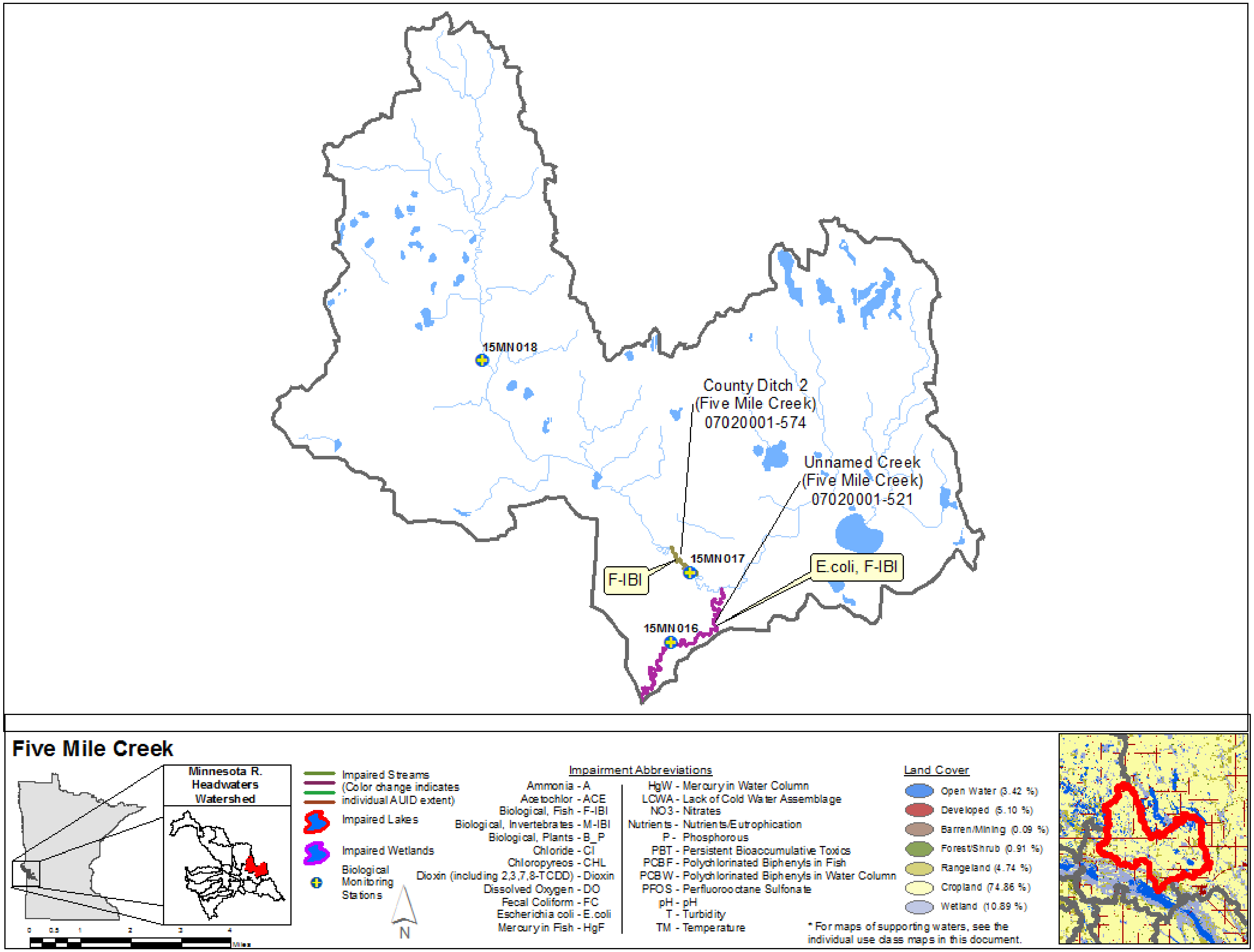
Summary

Three reaches in the Five Mile Creek subwatershed were assessed for aquatic life using biological data. The furthest upstream reach, County Ditch 2, met the modified use aquatic life standard for the fish assemblage. County Ditch 2 could not be sampled for aquatic macroinvertebrates due to extremely low water levels at the time of the August monitoring visit. The two lower reaches of Five Mile Creek attain general aquatic life use goals for aquatic macroinvertebrates. The intermediate reach on County Ditch 2/Five Mile Creek failed to meet the aquatic life standard for general use, with an FIBI score below the threshold and lower confidence limit. Tolerant and very tolerant fish species made up the majority of the fish sample (98% and 80% respectively). A new aquatic life fish impairment for this reach will be listed. The lowest reach on Five Mile Creek scored similarly, with and FIBI score below both the threshold and lower confidence limit for general use. This reach will also be impaired for aquatic life fish. Tolerant and very tolerant fish species were also prevalent in the sample at the station 15MN016.

Three reaches of Five Mile creek (County Ditch 2) had water chemistry data available during this assessment effort, most notably the downstream reach sampled by local partners in 2015 and 2016. All aquatic life use related water chemistry parameters met applicable water quality standards. A relatively intact riparian corridor provides infiltration of sediment and nutrients from surface water runoff prior to reaching the waterway. Bacteria data summarized by month across two years of collection indicated poor recreational water quality, resulting in a new impairment for aquatic recreation use.

Shible Lake was monitored by local partners in 2015 and 2016. The TP seasonal average was skewed by an outlier (797 ug/L) sample collected in July 2016, removing that data point would reduce the average to meeting the standard. Response variables are conflicting (chlorophyll-a meeting, Secchi exceeds), resulting in an inconclusive assessment during this effort. This lake should be a high priority for protection efforts within this subwatershed; reducing watershed inputs of phosphorus will help prevent the basin from becoming impaired. Recreational use on this basin is likely to involve waterfowl observation and hunting, maintaining natural vegetation patterns by curbing dense algae growth that chokes out sunlight will be beneficial.

Figure 26. Currently listed impaired waters by parameter and land use characteristics in the Five Mile Creek Aggregated 12-HUC.



Lac qui Parle Reservoir-Minnesota River Aggregated 12-HUC HUC 0702000112-01

The Lac qui Parle Reservoir-Minnesota River subwatershed is the eastern-most watershed within the major watershed (Figure 27). This subwatershed encompasses an area of 118 square miles (75,622 acres) in Lac qui Parle, Chippewa, and Swift counties. The Minnesota River and Lac qui Parle Reservoir bisect this subwatershed. Emily Creek is one of the primary tributaries to the Lac qui Parle Reservoir. Channelization occurs on 33.9% of the stream reach lengths within the subwatershed, while natural channels compose 20.7% of the reach lengths. No definable channel compose 21.7% and impounded 23.7% of the reach lengths. Minnesota River backwaters and Lac qui Parle Reservoir likely contribute to the increased percentage of impounded and not definable stream reaches. All monitored stream reaches in the subwatershed are warmwater, general use reaches. Both sampled for biology, Unnamed Creek is represented by monitoring station 01MN019, and the upstream reach of Emily Creek is represented by 15MN027. The downstream most reach on Emily Creek was monitored for chemistry at 15MN026, and biology at 15MN401.

Land use within the subwatershed includes: 52.5% cropland, 20.4% wetland, 12.0% rangeland, 9.5% open water, 4.6% development, 0.8% forest, and 0.2% barren. Minnesota River backwaters and Lac qui Parle Reservoir likely contribute to higher percentages of wetland and open water within the subwatershed. Lac qui Parle Wildlife Management Area as well as a portion of Lac qui Parle State Park is present within the subwatershed. Milan is the only town present within the subwatershed.

Table 19. Aquatic life and recreation assessments on stream reaches: Lac qui Parle Reservoir-Minnesota River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

WID ***Reach name, Reach description***	**Biological station ID**	**Reach length (miles)**	**Use class***	**Aquatic life indicators:**										**Aquatic life**	**Aquatic rec. (Bacteria)**
				Fish IBI	**Invert IBI**	**Dissolved oxygen**	**TSS**	**Secchi Tube**	**Chloride**	**pH**	**Ammonia -NH_3**	**Pesticides**	**Eutrophication**		
07020001-548, Unnamed creek, *Unnamed cr to Emily Cr*	01MN019	1.37	WWg	EXS	--	IF	IF	IF	--	IF	IF	--	IF	IMP	--
07020001-576, Emily Creek*, 290th St to Unnamed cr*	15MN027	2.10	WWg	EXS	EXS	IF	IF	IF	--	IF	IF	--	IF	IMP	--
07020001-547, Emily Creek*, Unnamed cr to Lac Qui Parle Lk*	15MN401	6.18	WWg	EXS	EXS	IF	MTS	MTS	MTS	MTS	MTS	--	IF	IMP	IMP

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: = existing impairment, listed prior to 2014 reporting cycle; = new impairment; = full support of designated use; = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 20. Lake assessments: Lac qui Parle Reservoir-Minnesota River Aggregated 12-HUC.

Lake name	DNR ID	Area (acres)	Max Depth (ft)	Assessment method	Ecoregion	Secchi Trend	Aquatic Life Indicators: Fish IBI	Chloride	Pesticides	Aquatic Recreation Indicators: Total phosphorus	Chlorophyll-a	Secchi	Aquatic life use	Aquatic recreation use
Lac Qui Parle (SE Bay)	37-0046-01	3573		Shallow Lake	NGP	I	--	MTS	--	EX	EX	IF	NS	NS
Lac Qui Parle (NW Bay)	37-0046-02	2095		Shallow Lake	NGP	--	--	MTS	--	EX	EX	EX	IF	NS

Abbreviations for Ecoregion: DA = Driftless Area, NCHF = North Central Hardwood Forest, NGP = Northern Glaciated Plains, NLF = Northern Lakes and Forests, NMW = Northern Minnesota Wetlands, RRV = Red River Valley, WCBP = Western Corn Belt Plains
Abbreviations for Secchi Trend: D = decreasing/declining trend, I = increasing/improving trend, NT = no detectable trend, -- = not enough data
Abbreviations for Indicator Evaluations: -- = No Data, **MTS** = Meets Standard; **EX** = Exceeds Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **FS** = Full Support (Meets Criteria); **NS** = Not Support (Impaired, exceeds standard)
Key for Cell Shading: = existing impairment, listed prior to 2014 reporting cycle; = new impairment; = full support of designated use; = insufficient information.

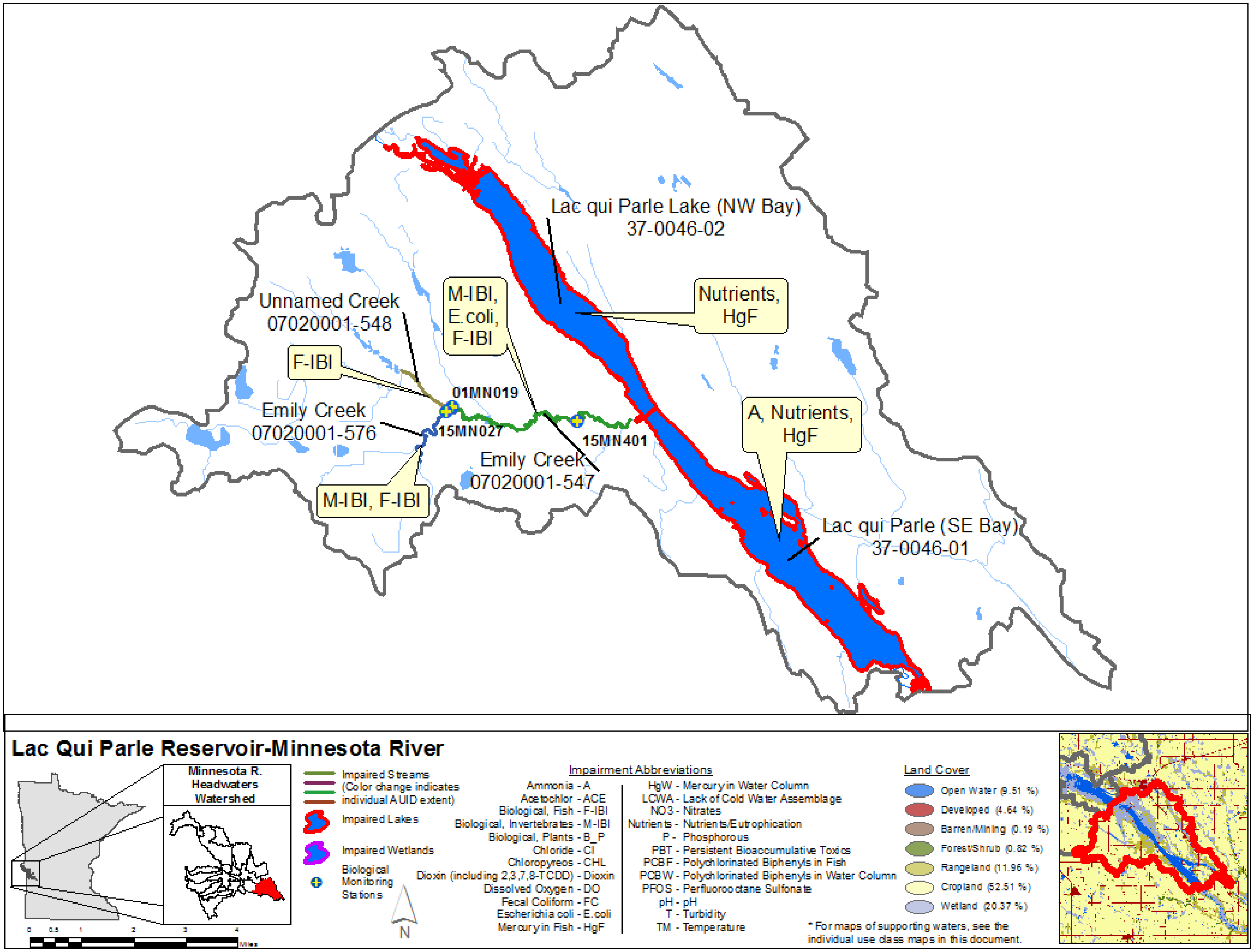
Summary

Three reaches within the subwatershed were assessed for aquatic life using biological data. Unnamed Creek was previously listed as impaired for fish in 2004. Fish community data from 2015 at station 01MN019 confirms impairment for fish with an FIBI below the general use threshold and lower confidence limit. Conditions at this site seemed wetland dominated with fine sediments, wetland vegetation, and an indistinct channel. Upon review of historical imagery, it appears the channel has evolved more wetland characteristics over the years, likely due to cattle trampling. The upstream reach on Emily Creek was sampled for biology at station 15MN027 in 2015. The fish community scored below the general use threshold, but within the confidence interval resulting in a new aquatic life impairment for fish. Tolerant species made up a significant portion of the fish sample. Similarly, the downstream reach of Emily Creek will also be impaired for aquatic life for fish. The fish sample at 15MN401 scored below the general use threshold and lower confidence interval. This sample was also dominated by tolerant fish species. Sedimentation also seems to be an issue on the downstream reach as well, with silt substrates prevalent at the station. Sections of Emily Creek where biological monitoring was conducted had impaired macroinvertebrate communities. Both samples were dominated by taxa that can withstand low DO concentrations, suggesting that excess nutrients and high productivity may be a concern in this watershed. Presence of the stonefly genus Perlesta at 15MN027 contrasts somewhat with this preliminary “diagnosis”. However, abrupt changes in stream gradient upstream and noted within this sample reach may provide riffle-like microhabitats where there is enough turbulence and oxygenation to support less tolerant taxa such as stoneflies.

Elevated nutrient concentrations highlight the water chemistry datasets for Emily Creek, potentially fueling large fluctuations in the DO data. Large swings in DO concentrations can be a stressor to aquatic communities. Bacteria concentrations are elevated causing poor conditions for aquatic recreation.

Lac qui Parle Lake was best assessed against lake eutrophication criteria based on residence time. Lac qui Parle Lake was assessed as two different basins, water quality was in poor condition for aquatic recreation use. Large, shallow, wind driven basins are notorious for mixing numerous times throughout the open water months, driving internal loading that resuspends sediments and nutrients increasing availability to algae communities. Work to address watershed inputs of phosphorus will be critical for this basin, as internal loading will continue to be a problem.

Figure 27. Currently listed impaired waters by parameter and land use characteristics in the Lac qui Parle Reservoir-Minnesota River Aggregated 12-HUC.



Watershed-wide results and discussion

Assessment results and data summaries are included below for the entire HUC-8 watershed unit of the Minnesota River-Headwaters, grouped by sample type. Summaries are provided for lakes, streams, and rivers in the watershed for the following: aquatic life and recreation uses, aquatic consumption results, load monitoring data results, transparency trends, and remote sensed lake transparency. Waters identified as priorities for protection or restoration work were also identified. Additionally, groundwater and wetland monitoring results are included where applicable.

Following the results are a series of graphics that provide an overall summary of assessment results by designated use, impaired waters, and fully supporting waters within the entire Minnesota River-Headwaters River Watershed.

Stream water quality

Twenty-four stream reaches were reviewed for assessment (Table 21). Throughout the watersheds, 21 reaches are non-supporting for aquatic life and/or recreation. Of those streams, 19 are non-supporting for aquatic life and 14 are non-supporting for aquatic recreation. A single stream reach was supporting aquatic life use.

Of the assessed streams found to be not supporting of aquatic life, 18 streams were found to have an impaired fish assemblage, while nine streams were found to have an impaired macroinvertebrate assemblage. Eight streams had impaired fish and macroinvertebrate assemblages. Two of the fish assemblage impairments were existing and carried forward with current data. There were no existing macroinvertebrate impairments in this watershed. Three impairments for fish, one impairment for macroinvertebrates occurred on modified use class reaches. Aquatic life water chemistry parameters (total suspended solids, Secchi tube) were not supporting on one stream, which was also an existing impairment carried forward. Two reaches met aquatic life standards for fish (1 modified use, 1 general use), and eight stream reaches met aquatic life standards for macroinvertebrates (2 modified use, 6 general use).

Table 21. Assessment summary for stream water quality in the Minnesota River-Headwaters Watershed.

				Supporting		Non-supporting			
Watershed	**Area (acres)**	**# Total WIDs**	**# Assessed WIDs**	**# Aquatic life**	**# Aquatic recreation**	**# Aquatic life**	**# Aquatic recreation**	**Insufficient data**	**# Delistings**
Minnesota River-Headwaters **HUC 8**	**501,796**	**24**	**24**	**0**	**0**	**19**	**14**	**5**	**0**
Lower Little Minnesota River	1,251	1	1	0	0	1	1	0	0
Big Stone Lake-Minnesota River	86,251	3	3	0	0	2	3	1	0
Fish Creek	51,060	1	1	0	0	1	1	0	0
Whetstone River	60	1	1	0	0	0	0	2	0
Stony Run	82,485	5	5	0	0	3	2	2	0

Watershed	Area (acres)	# Total WIDs	# Assessed WIDs	Supporting		Non-supporting		Insufficient data	# Delistings
				# Aquatic life	# Aquatic recreation	# Aquatic life	# Aquatic recreation		
Lower North Fork Yellow Bank River	4,728	1	1	0	0	1	1	0	0
Yellow Bank River	21,186	2	2	0	0	2	2	0	0
South Fork Yellow Bank River	23,022	1	1	0	0	1	1	0	0
Trib. To South Fork Yellow Bank River	1,512	1	1	0	0	1	1	0	0
Five Mile Creek	57,173	3	3	1	0	2	1	0	0
County Ditch No. 3A	31,331	2	2	0	0	2	1	0	0
Lac qui Parle Reservoir-Minnesota River	75,626	3	3	0	0	3	1	0	0

Lake water quality

Of the lakes within the Minnesota River Headwaters Watershed, 14 greater than 10 acres had some type of assessment information available (Table 22). The availability of biological index data during this assessment cycle provided an opportunity to make complete aquatic life use assessments on lakes. No lakes were found to fully support aquatic recreation use, Big Stone Lake was found to be fully supporting for aquatic life use based on fish community data. While the larger basins in this watershed have been previously assessed, none were listed impaired for aquatic recreation use prior to this effort. Five lakes (Long Tom, Unnamed, Big Stone, and Lac qui Parle basins) had aquatic recreation use impairments added based on lake eutrophication data. Lac qui Parle Lake found to be not supporting aquatic life use based on fish community data. Insufficient data was available for aquatic life or aquatic recreation use assessments on ten lakes. Subwatersheds not included in the table below did not have lake data available.

Table 22. Assessment summary for lake water chemistry in the Minnesota River-Headwaters Watershed.

Watershed	Area (acres)	Lakes >10 acres	Supporting		Non-supporting		Insufficient data	# Delistings
			# Aquatic life	# Aquatic recreation	# Aquatic life	# Aquatic recreation		
Minnesota River Headwaters **HUC 8**	**798445**	**14**	**1**	**0**	**1**	**5**	**10**	**0**
Big Stone Lake – Minnesota River	139119	1	1	0	0	1	0	0
Fish Creek	50999	2	0	0	0	0	2	0

Watershed	Area (acres)	Lakes >10 acres	Supporting: # Aquatic life	Supporting: # Aquatic recreation	Non-supporting: # Aquatic life	Non-supporting: # Aquatic recreation	Insufficient data	# Delistings
Stony Run Creek	82413	5	0	0	0	2	5	0
Five Mile Creek	57131	2	0	0	0	0	2	0
Marsh Lake - Minnesota River	66613	2	0	0	0	0	1	0
Lac qui Parle Reservoir – Minnesota River	75573	2	0	0	1	2	0	0

Fish contaminant results

Mercury and polychlorinated biphenyls (PCBs) have been analyzed in fish tissue samples collected from six lakes in the Minnesota River-Headwaters watershed. Samples were collected by DNR fisheries staff from 1979 to 2016. The fish collected in the Minnesota River are not included in this assessment.

Four of the six lakes are on the 2018 Impaired Waters Inventory (IWI) for mercury in fish tissue (Table 23). Big Stone National Wildlife Refuge East and West Pools were sampled in 2013 and 2011, respectively, and mercury concentrations were below the threshold for impairment (0.2 mg/kg). The four lakes on the IWI qualified for inclusion in the Minnesota Statewide Mercury TMDL.

PCBs were tested in representative species from all lakes except the Big Stone NWR pools. PCB concentrations were mostly less than the reporting limits. The highest PCB concentration was 0.1 mg/kg in a Bigmouth buffalo composite sample from Big Stone Lake, which is below the threshold for impairment.

Perfluorochemicals were measured in a few Bluegill sunfish and Walleye from Big Stone Lake and Bluegill sunfish in Lac Qui Parle Lake in 2007 and 2009. All results of PFOS were less than the reporting limits, except for the Bluegill in Lac Qui Parle Lake. In 2007, the EPA analyzed the samples and had a reporting limit of 0.92 µg/kg. In 2009, the samples were analyzed by AXYS Analytical Ltd, which had a reporting limit around 5.0 µg/kg (0.005 mg/kg). The Bluegill from Lac qui Parle, collected in 2007, had a measurable concentration of 1.31 µg/kg, which was below the reporting limit for AXYS.

Table 23. Fish contaminants: summary of fish length, mercury, PCBs, and PFOS by waterway-species-year.

							Length (in)			Mercury (mg/kg)			PCBs (mg/kg)				PFOS (µg/kg)			
DOWID	Waterway	Species	Year	Anat-omy[1]	Total Fish	Number Samples	Mean	Min	Max	Mean	Min	Max	N	Mean	Max	< RL	N	Mean	Max	< RL
06000100	MARSH*	Common Carp	1994	FILSK	9	9	22.1	15.9	30.2	0.086	0.055	0.110	4	0.018	0.043					
		Northern pike	2000	FILSK	8	8	24.3	18.8	30.1	0.083	0.030	0.220								
			2009	FILSK	14	14	21.1	12.7	30.6	0.109	0.063	0.170								
			2015	FILSK	15	15	21.4	16.0	34.8	0.127	0.081	0.230								
		Walleye	1994	FILSK	10	10	17.6	12.8	23.0	0.205	0.094	0.540	2	0.01	0.01	Y				
			2009	FILSK	15	15	17.4	13.5	26.1	0.137	0.072	0.407								
		Yellow perch	1994	FILSK	8	1	9.5	9.5	9.5	0.110	0.110	0.110								
06002900	LONG TOM*	Black crappie	1999	FILSK	10	1	8.1	8.1	8.1	0.170	0.170	0.170								
			2005	FILSK	9	1	8.5	8.5	8.5	0.238	0.238	0.238								
		Common Carp	1999	FILSK	3	1	16.5	16.5	16.5	0.050	0.050	0.050	1	0.01	0.01	Y				
			2005	FILSK	2	1	22.8	22.8	22.8	0.133	0.133	0.133								
			2014	FILSK	1	1	15.2	15.2	15.2	0.034	0.034	0.034								
		Northern pike	2005	FILSK	4	4	28.9	27.8	30.4	0.333	0.297	0.395								
		Walleye	1999	FILSK	8	8	18.7	13.5	23.7	0.664	0.250	1.200								
			2014	FILSK	6	6	12.5	11.3	13.5	0.258	0.210	0.288								
		Yellow perch	2014	FILSK	3	1	8.4	8.4	8.4	0.233	0.233	0.233								
06015200	BIG STONE*	Bigmouth buffalo	1994	FILSK	3	3	21.9	18.2	28.7	0.057	0.010	0.150	1	0.012	0.012					
		Bluegill sunfish	2003	FILSK	5	1	6.8	6.8	6.8	0.113	0.113	0.113								
			2007	FILSK	12	2	7.0	6.6	7.3	0.061	0.052	0.070					1	0.92	0.92	Y
			2009	FILSK	1	1	7.1	7.1	7.1								1	4.74	4.74	Y
		Black bullhead	1985	FILET	9	1	10.4	10.4	10.4	0.050	0.050	0.050	1	0.05	0.05	Y				
			2015	FILET	5	1	13.1	13.1	13.1	0.037	0.037	0.037								
		Common Carp	1979	WHORG	10					0.020	0.020	0.020								
			1985	FILSK	4	1	20.2	20.2	20.2	0.030	0.030	0.030	1	0.05	0.05	Y				
		Common Carp	1992	FILSK	21	4	24.6	17.2	31.2	0.036	0.022	0.054	2	0.016	0.021					
			1994	FILSK	10	10	22.1	10.7	33.7	0.032	0.010	0.058	3	0.01	0.01	Y				
			2003	FILSK	2	1	29.1	29.1	29.1	0.111	0.111	0.111	1	0.01	0.01	Y				
			2007	FILSK	1	1	29.9	29.9	29.9	0.081	0.081	0.081								
			2008	FILSK	3	1	22.8	22.8	22.8	0.023	0.023	0.023								
		Freshwater Drum (Sheepshead)	1985	FILSK	5	1	10.8	10.8	10.8	0.030	0.030	0.030	1	0.05	0.05	Y				
		Northern pike	2000	FILSK	3	3	25.5	22.0	28.7	0.123	0.110	0.150								
			2007	FILSK	5	5	25.2	22.1	27.6	0.106	0.063	0.140								
			2008	FILSK	8	8	21.6	15.5	24.8	0.146	0.099	0.217								

							Length (in)			Mercury (mg/kg)			PCBs (mg/kg)				PFOS (µg/kg)			
DOWID	Waterway	Species	Year	Anat-omy[1]	Total Fish	Number Samples	Mean	Min	Max	Mean	Min	Max	N	Mean	Max	< RL	N	Mean	Max	< RL
		Smallmouth buffalo	1985	FILSK	5	2	20.4	16.3	24.5	0.045	0.020	0.070	2	0.075	0.1					
		Walleye	1979	WHORG	5					0.130	0.130	0.130								
			1992	FILSK	18	3	18.0	14.6	22.2	0.145	0.056	0.310	1	0.02	0.02					
			1994	FILSK	10	10	18.2	14.5	22.5	0.125	0.076	0.250	2	0.010	0.011					
			2003	FILSK	6	6	17.8	14.3	23.5	0.251	0.157	0.359								
			2006	FILSK	8	8	16.1	12.0	25.5	0.206	0.078	0.580								
			2007	FILSK	6	6	18.5	15.3	23.5	0.297	0.104	0.498								
			2008	FILSK	8	8	15.7	11.1	20.0	0.138	0.067	0.258								
			2009	FILSK	7	7	16.4	11.0	19.7								7	4.92	5.03	Y
			2011	FILSK	7	7	16.4	12.6	23.3	0.128	0.051	0.226								
			2015	FILSK	8	8	17.0	13.0	21.9	0.168	0.059	0.253								
		White bass	2000	FILSK	8	1	13.3	13.3	13.3	0.140	0.140	0.140	1	0.01	0.01	Y				
			2003	FILSK	5	5	14.4	13.4	15.5	0.256	0.152	0.392	1	0.01	0.01	Y				
			2007	FILSK	5	5	14.3	13.0	16.0	0.280	0.161	0.431								
			2008	FILSK	8	8	12.7	10.1	14.5	0.195	0.041	0.367								
			2014	FILSK	11	9	12.7	10.3	15.8	0.193	0.118	0.363								
		White sucker	1985	FILSK	5	1	14.2	14.2	14.2	0.060	0.060	0.060	1	0.05	0.05	Y				
		Yellow perch	1992	FILSK	8	1	11.5	11.5	11.5	0.035	0.035	0.035								
			2003	FILSK	8	1	10.7	10.7	10.7	0.100	0.100	0.100								
			2007	FILSK	10	1	10.2	10.2	10.2	0.089	0.089	0.089								
			2008	FILSK	10	10	9.7	6.7	11.9	0.122	0.091	0.135								
			2011	FILSK	10	2	10.0	8.9	11.0	0.047	0.040	0.054								
			2015	FILSK	10	1	9.0	9.0	9.0	0.064	0.064	0.064								
37004600	LAC QUI PARLE*	Bluegill sunfish	2007	FILSK	8	1	7.7	7.7	7.7	0.106	0.106	0.106					1	1.31	1.31	
		Black crappie	1988	FILSK	7	1	8.6	8.6	8.6	0.070	0.070	0.070								
			2007	FILSK	11	1	9.1	9.1	9.1	0.044	0.044	0.044								
			2009	FILSK	10	2	10.9	10.3	11.5	0.067	0.061	0.073								
			2016	FILSK	10	1	10.5	10.5	10.5	0.083	0.083	0.083								
		Common Carp	1988	FILSK	9	3	23.0	21.7	24.1	0.073	0.050	0.090	3	0.05	0.05	Y				
			1994	FILSK	8	8	20.0	15.7	24.2	0.077	0.034	0.096	3	0.01	0.01	Y				
			2009	FILSK	4	1	23.0	23.0	23.0	0.047	0.047	0.047								
		Channel catfish	2009	FILET	6	1	21.4	21.4	21.4	0.141	0.141	0.141								
		Freshwater Drum (Sheepshead)	2016	FILSK	5	1	13.2	13.2	13.2	0.064	0.064	0.064								

DOWID	Waterway	Species	Year	Anat- omy[1]	Total Fish	Number Samples	Length (in)			Mercury (mg/kg)			PCBs (mg/kg)				PFOS (µg/kg)			
							Mean	Min	Max	Mean	Min	Max	N	Mean	Max	< RL	N	Mean	Max	< RL
		Northern pike	2000	FILSK	6	6	23.0	16.7	29.7	0.077	0.050	0.130								
			2009	FILSK	8	8	26.2	19.3	34.9	0.135	0.080	0.162								
		Walleye	1988	FILSK	25	8	18.6	14.1	24.7	0.230	0.130	0.450	1	0.05	0.05	Y				
			1994	FILSK	10	10	18.5	13.2	29.4	0.213	0.073	0.510	2	0.011	0.012					
			2009	FILSK	8	8	19.6	13.0	28.3	0.195	0.094	0.431								
			2016	FILSK	8	8	16.1	11.0	23.5	0.147	0.103	0.222								
		White bass	1988	FILSK	5	1	11.8	11.8	11.8	0.160	0.160	0.160	1	0.05	0.05	Y				
		Yellow perch	1994	FILSK	8	1	8.7	8.7	8.7	0.077	0.077	0.077								
37035100	BIG STONE NWR EAST POOL	Common Carp	2013	FILSK	2	1	27.8	27.8	27.8	0.110	0.110	0.110								
		Walleye	2013	FILSK	5	5	15.4	13.4	17.8	0.116	0.092	0.144								
		Yellow perch	2013	FILSK	5	1	9.3	9.3	9.3	0.088	0.088	0.088								
37035600	BIG STONE NWR WEST POOL	Bluegill sunfish	2011	FILSK	8	2	8.4	8.0	8.7	0.134	0.129	0.139								
		Black crappie	2011	FILSK	4	1	8.4	8.4	8.4	0.220	0.220	0.220								
		Common Carp	2011	FILSK	3	1	27.3	27.3	27.3	0.152	0.152	0.152								
		Northern pike	2011	FILSK	10	10	16.3	14.4	19.7	0.158	0.115	0.199								

* Impaired for mercury in fish tissue as of 2016 Draft Impaired Waters List; categorized as EPA Class 4a for waters covered by the Statewide Mercury TMDL.

** Impaired for mercury in fish tissue as of 2014 Draft Impaired Waters List; categorized as EPA Class 5 for waters needing a TMDL.

1 Anatomy codes: FILSK – edible fillet, skin-on; FILET—edible fillet, skin-off; WHORG—whole organism.

Pollutant load monitoring

The WPLMN has two sites within the Minnesota River (Headwaters) watershed as shown in Table 24. Data within this report will largely focus on the major watershed site with more extensive detail provided on the basin site within the MPCA's "Minnesota River Large River Report," published in 2017.

Table 24. WPLMN stream monitoring sites for the Minnesota River (Headwaters) watershed.

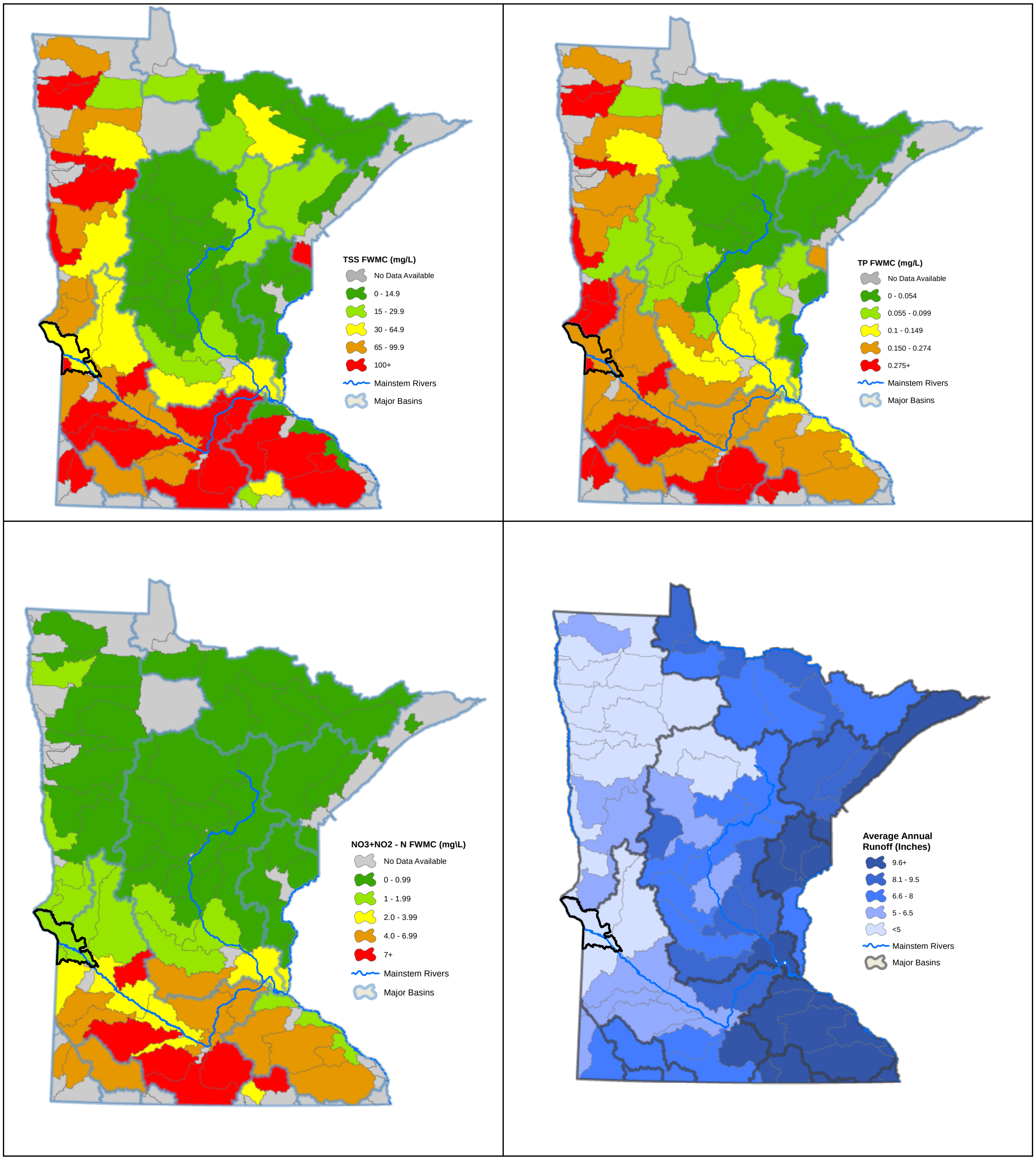
Site Type	Stream Name	USGS ID	DNR/MPCA ID	EQuIS ID
Basin	Minnesota River nr Lac Qui Parle, MN	05301000	E22007001	S004-649
Major Watershed	Yellow Bank River nr Odessa, CSAH40	05293000	E22012001	S003-091

Average annual FWMCs of TSS, TP, and NO3+NO2-N by major watershed are presented below (Figure 28), with the Minnesota River (Headwaters) watershed highlighted. Water runoff, a significant factor in pollutant loading, is also shown. Water runoff is the portion of annual precipitation that makes it to a river or stream; thus it can be expressed in inches.

As a general rule, elevated levels of TSS and NO3+NO2-N are regarded as "non-point" source derived pollutants originating from many small diffuse sources such as urban or agricultural runoff. Excess TP can be attributed to both non-point as well as point sources such as industrial or wastewater treatment plants. Major "non-point" sources of phosphorus include dissolved phosphorus from fertilizers and phosphorus adsorbed to and transported with sediment during runoff.

Excessive TSS, TP, and NO3+NO2-N in surface waters impacts fish and other aquatic life, as well as fishing, swimming and other recreational uses. High levels of NO3+NO2-N is a concern for drinking water.

Figure 28. 2007-2015 Average annual TSS, TP, and NO3-NO2-N flow weighted mean concentrations, and runoff by major watershed.

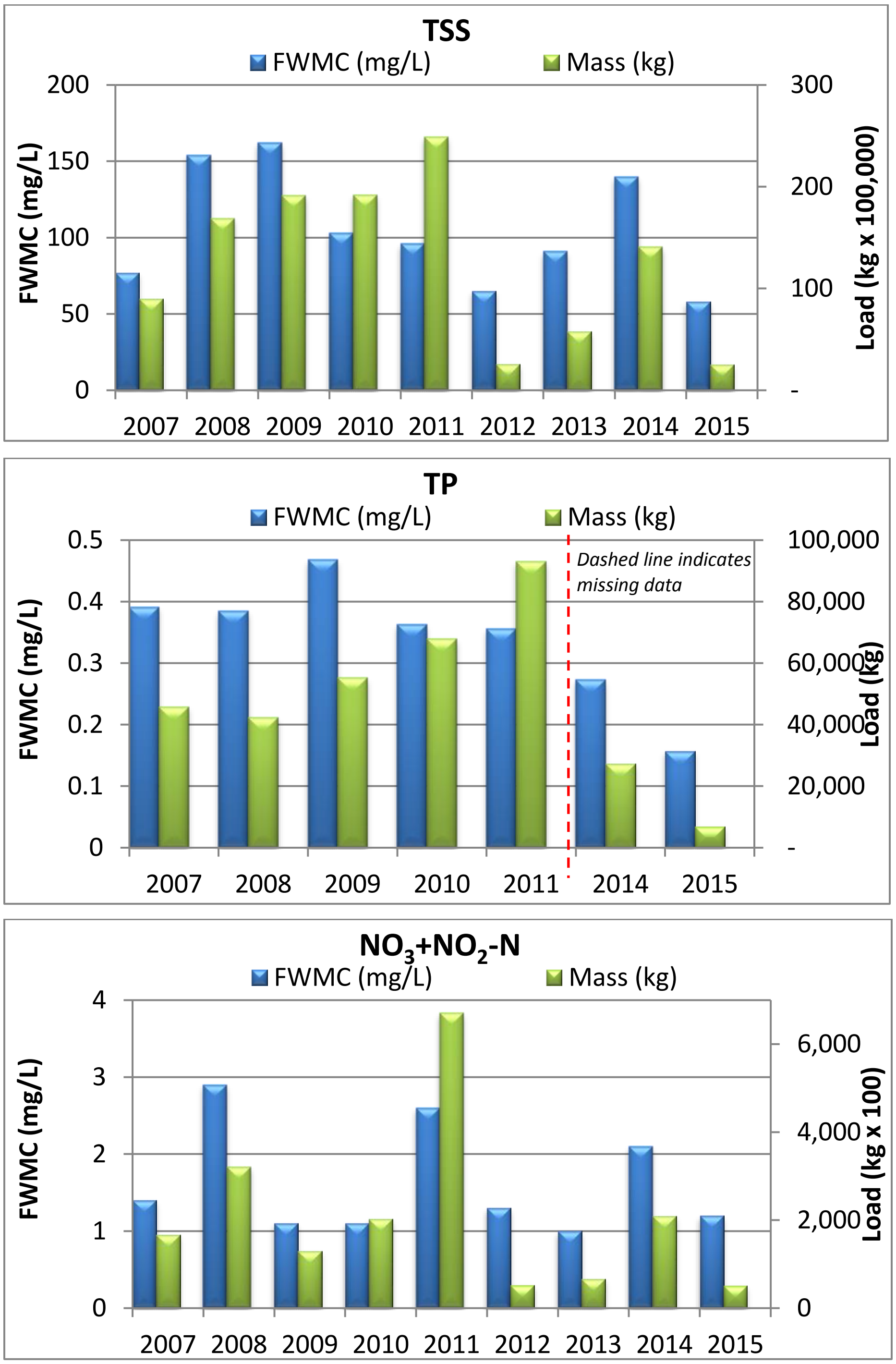


When compared with other major watersheds throughout the state, Figure 28 shows the average annual TSS, TP, and NO3+NO2-N FWMCs to be several times higher for the Minnesota River (Headwaters) watershed than watersheds in north central and northeast Minnesota, but in line with the agriculturally rich watersheds found in the northwest and southern regions of the state.

More information, including results for subwatershed stations, can be found at the WPLMN website.

Substantial year-to-year variability in water quality occurs for most rivers and streams, including the Minnesota River (Headwaters). Results for individual years are shown in the charts ([Figure 29](#)) below for the Yellow Bank River. TSS and TP had the highest FWMC in 2009 and the highest load in 2011. In 2009, there were record concentrations of TSS and TP during snow melt and a large June rainfall event. During snowmelt, there were two TP samples that were almost ten times the water quality standard. In 2011, there were several rainfall events throughout the season with relatively high concentrations. During the largest event of the year, starting on June 21, NO3+NO2-N concentrations were recorded up to 13.5 mg/L with approximately 40% of the annual NO3+NO2-N load passing through the watershed in a three-day period.

Figure 29. TSS, TP, and NO3+NO2-N Flow Weighted Mean Concentrations and loads for the Yellow Bank River near Odessa, MN.



Groundwater monitoring

Groundwater quality

Approximately 75% of Minnesota's population receives their drinking water from groundwater, undoubtedly indicating that clean groundwater is essential to the health of its residents. The MPCA's Ambient Groundwater Monitoring Program monitors trends in statewide groundwater quality by sampling for a comprehensive suite of chemicals including nutrients, metals, and volatile organic compounds. These ambient groundwater wells represent a mix of deeper domestic wells and shallow monitoring wells. The shallow wells interact with surface waters and exhibit impacts from human activities more rapidly. Available data from federal, state and local partners are used to supplement reviews of groundwater quality in the region.

There are currently no MPCA Ambient Groundwater Monitoring wells within the Minnesota River Headwaters Watershed. However, a baseline study conducted by the MPCA (1998) found that the groundwater quality in this region is considered poor when compared to other areas with similar aquifers. Exceedances of drinking water standards for manganese and boron were the primary concern for those from natural sources, and nitrate as the primary concern associated with anthropogenic sources.

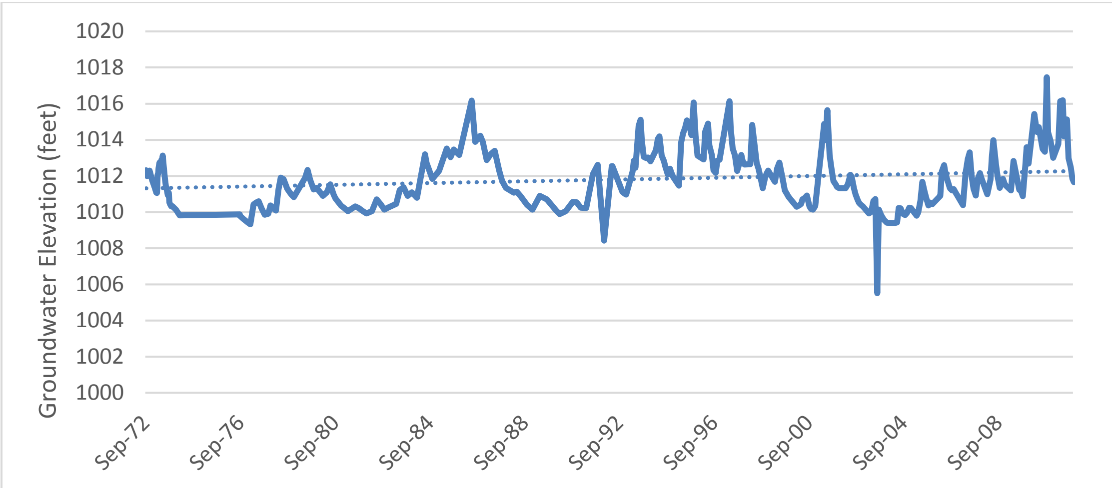
A more recent MPCA report on the statewide condition of Minnesota's groundwater found that groundwater in the southwest region has fairly high nitrate concentrations; approximately 20% of the shallow sand and gravel aquifer wells exceed the maximum contaminant level (MCL) of 10 mg/L (Kroening, Ferrey, 2013).

Another source of information on groundwater quality comes from the MDH. Mandatory testing for arsenic, a naturally occurring but potentially harmful contaminant for humans, of all newly constructed wells has found that 10.7% of all wells installed from 2008 to 2015 have arsenic levels above the MCL for drinking water of 10 micrograms per liter (MDH, 2016a). The Minnesota River Headwaters Watershed includes portions of Big Stone, Swift, Lac qui Parle and Chippewa Counties. Results from Big Stone and Swift counties showed 15.1% of new wells constructed, in both counties, exceeded the MCL for arsenic. Lac qui Parle and Chippewa showed 5.1% and 7.8% above the MCL, respectively.

Groundwater quantity

The DNR maintains a statewide network of water level wells to assess groundwater resources, evaluate trends and plan for the future. While there are a number of deep wells within the Minnesota River-Headwaters watershed, a shallower, water table well is more reactive to recharge and withdrawals. Groundwater elevations (below the monitoring point of 1018 feet) from well #243630 near Correll, are displayed below. The water level shows a rising trend that is statistically significant ($p<0.01$). Fluctuations in water level are common and expected with seasonal change and varied precipitation. (DNR, 2018)

Figure 30. Water table elevations in Well #243630 (sealed), 1972-2011.



The DNR also permits all high capacity water withdrawals where the pumped volume exceeds 10,000 gallons per day or one million gallons per year. Permit holders are required to track water use and report back to the DNR annually. The changes in withdrawal volume detailed in this groundwater report are a representation of water use and demand in the watershed and are taken into consideration when the DNR issues permits for water withdrawals. Other factors not discussed in this report but considered when issuing permits include: interactions between individual withdrawal locations, cumulative effects of withdrawals from individual aquifers, and potential interactions between aquifers. This holistic approach to water allocations is necessary to ensure the sustainability of Minnesota's groundwater resources.

The three largest permitted consumers of water in the state for 2015 are (in order) power generation, public water supply (municipals), and irrigation (DNR, 2017c). According to the most recent DNR Permitting and Reporting System (MPARS), in 2015 the withdrawals within the Minnesota River Headwaters Watershed are primarily utilized for agricultural irrigation (70%) while the rest are used for water supply, livestock watering, industrial processing and other special categories.

Figure 31 displays total high capacity withdrawal locations within the watershed with active permit status in 2013. Permitted groundwater withdrawals are displayed below as blue triangles and surface water withdrawals as red squares. During 1996 to 2015, groundwater withdrawals within the Minnesota River Headwaters Watershed exhibit a significant increasing withdrawal trend ($p<0.05$) and surface water withdrawals have increased even more significantly ($p<0.001$) (Figure 32).

Figure 31. Locations of active status permitted high capacity withdrawals in 2015 within the Minnesota River Headwaters Watershed.

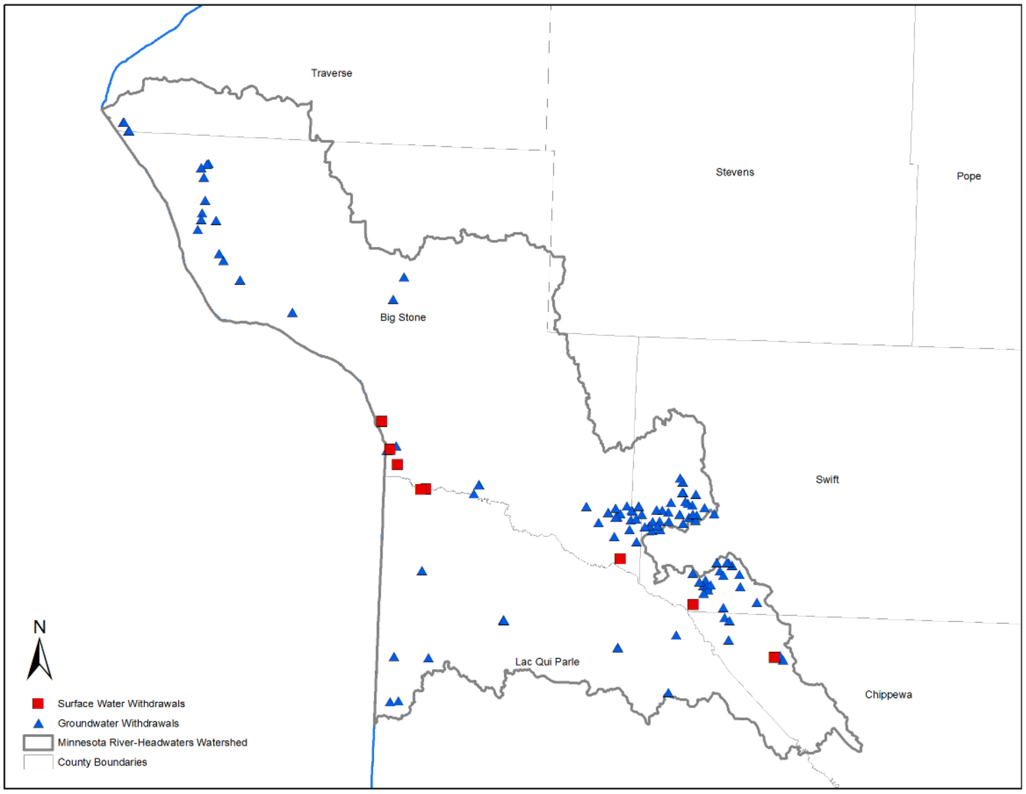
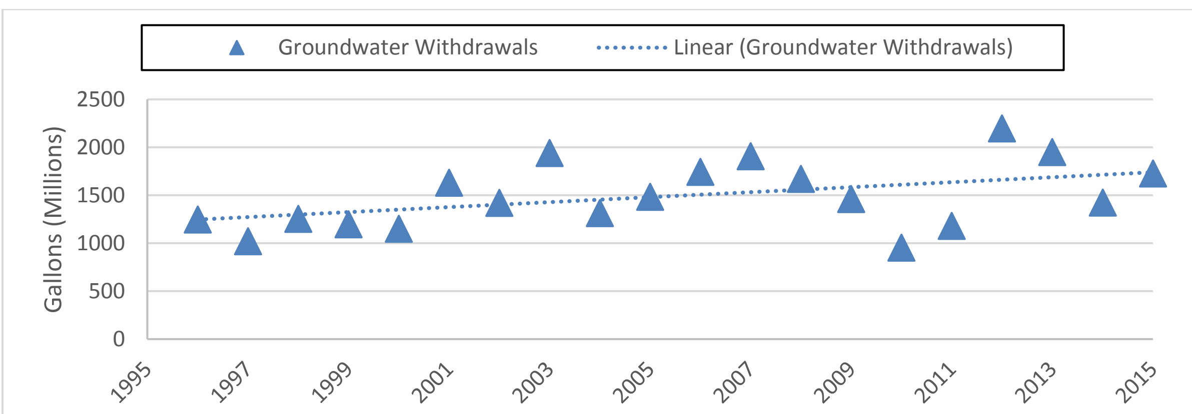
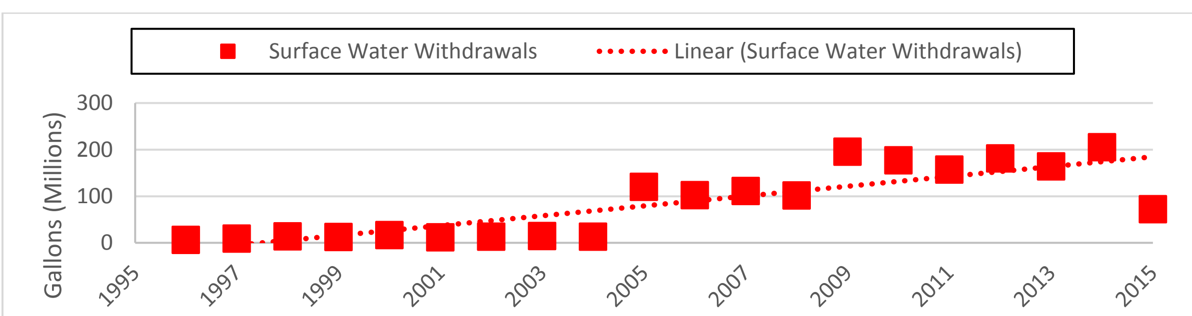


Figure 32. Total annual groundwater (above) and surface water (below) withdrawals in the Minnesota River-Headwaters Watershed (1996-2015).

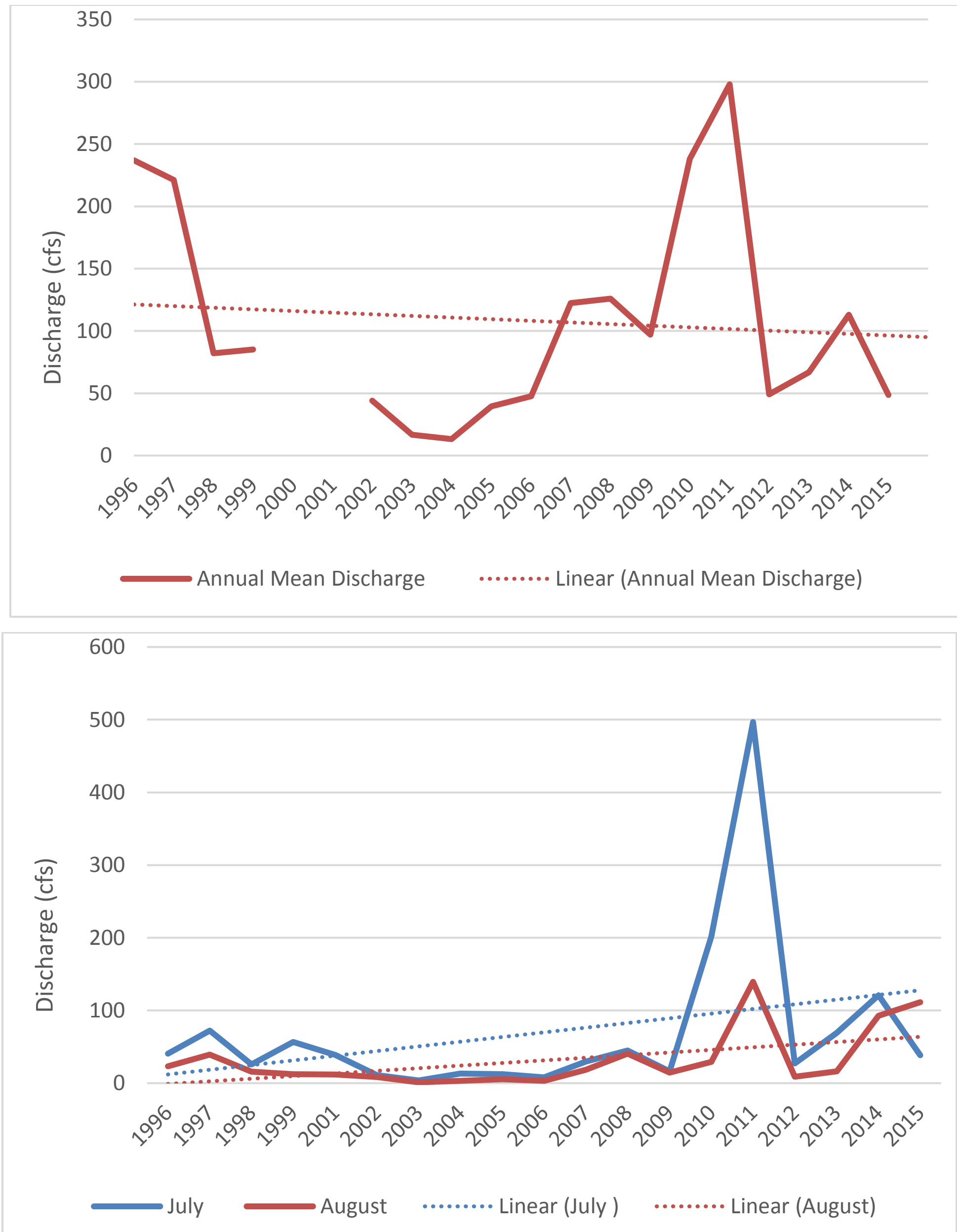




Stream flow

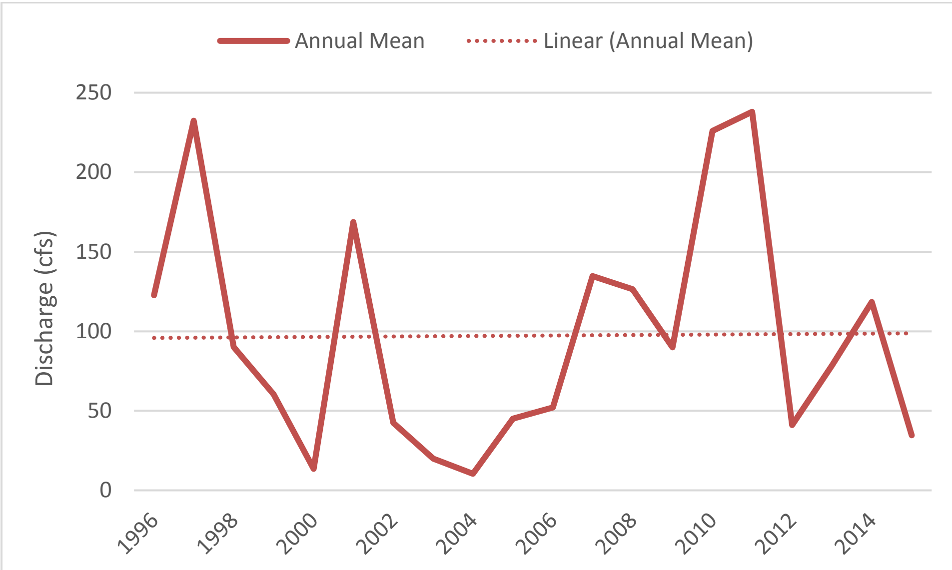
Stream flow data from the United States Geological Survey's real-time streamflow gaging station on the Yellow Bank River near Odessa, Minnesota were analyzed for annual mean annual discharge and summer (July and August) monthly mean discharge from 1996-2015 (Figure 33). Visually, the data appear to be declining annually and rising in the summer months, but these changes are not at a statistically significant rate. By way of comparison at a state level, summer month flows have declined at a statistically significant rate at a majority of streams selected randomly for a study of statewide trends (Streitz, 2011).

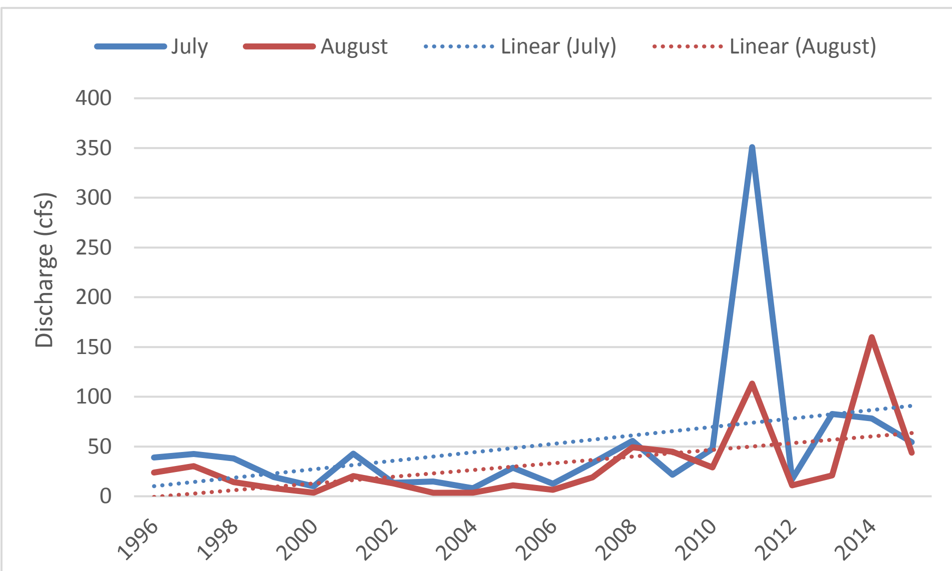
Figure 33. Annual (above) and summer (below) mean discharge for the Yellow Bank River near Odessa, MN (1996-2015) (Source: DNR, 2017d).



Annual mean and summer discharge from the Whetstone River near the South Dakota/Minnesota border is displayed below in Figure 34. Annual mean discharge has not changed significantly over this time period, but July and August mean discharge have both increased at a statistically significant rate ($p<0.10$).

Figure 34. Annual (above) and summer (below) mean discharge for the Whetstone River near Big Stone City, SD (1996-2015) (Source: DNR, 2017e).





Wetland condition

Statewide wetland surveys have revealed that biological condition, based on floristic quality and aquatic macroinvertebrate indicators, in the Temperate Prairies ecoregion is relatively poor (Table 25). Since the Minnesota River – Headwaters watershed lies entirely within the Temperate Prairies ecoregion, it is expected that approximately 80% of wetlands (i.e., all wetland types) in this watershed have fair-poor vegetation condition. Depressional wetlands are a prominent feature in the watershed in areas of glacial moraine. Based on results from naturally formed basins in the Temperate Prairies ecoregion, it is likely that macroinvertebrate community condition is better, with an estimated 41% good (Table 25), in depressional wetlands that remain in the Minnesota River - Headwaters watershed. The predominance of invasive wetland plants such as narrow-leaf cattail (Typha angustifolia), hybrid cattail (Typha X glauca), and reed canary grass (Phalaris arundinacea) is believed to contribute to the difference between macroinvertebrate and vegetation condition results. Invasive plant species are likely to have a more direct impact on the composition and structure of the native plant community due to their tolerance of nutrient enrichment, hydrologic alterations and toxic pollutants (Galatowisch 2012). However, it should also be noted that comparison of the vegetation and macroinvertebrate results is somewhat of an apples-to-oranges comparison due to macroinvertebrate condition results being limited to depressional wetlands.

Table 25. Biological wetland condition statewide and by major ecoregions according to vegetation and macroinvertebrate indicators. Vegetation results are expressed by extent (i.e., percentage of wetland acres) and include virtually all wetland types (MPCA 2015). Macroinvertebrate results represent natural depressional wetlands (e.g., prairie potholes) that typically have open water and are expressed as the percentage of wetland basins (Genet 2015). Depressional wetland monitoring is focused in Mixed Wood Plains and Temperate Prairie ecoregions (as opposed to statewide) where it is a more prevalent type.

Vegetation condition in all wetlands

Condition Category	Mixed Wood Shield	Mixed Wood Plains	Temperate Prairies
Exceptional	64%	6%	7%
Good	20%	12%	11%
Fair	16%	42%	40%
Poor		40%	42%

Macroinvertebrate condition in depressional wetlands

Condition Category	Mixed Wood Plains	Temperate Prairies
Good	46%	41%
Fair	34%	30%
Poor	20%	27%

Figure 35. Stream Tiered Aquatic Life Use Designations in the Minnesota River - Headwaters Watershed.

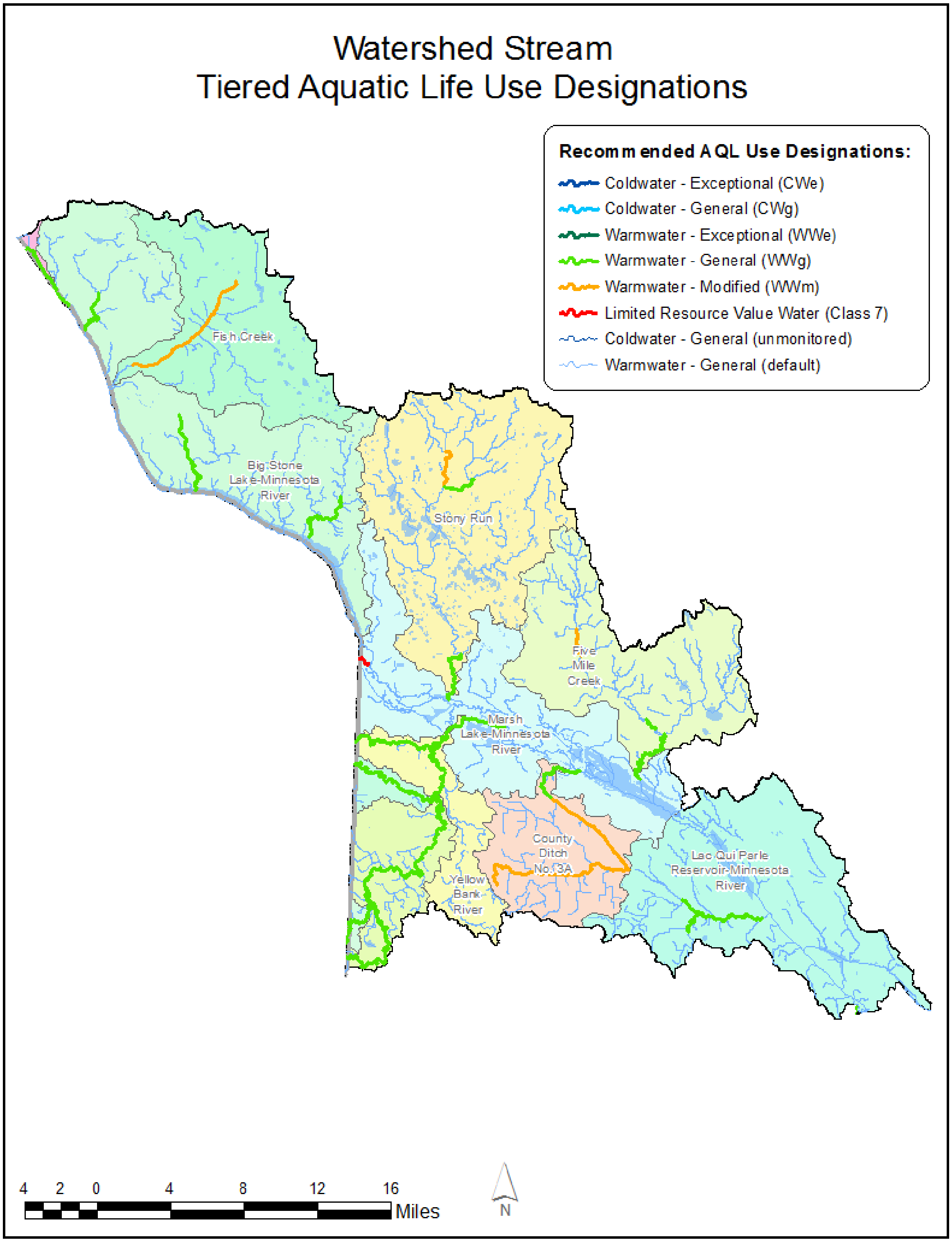
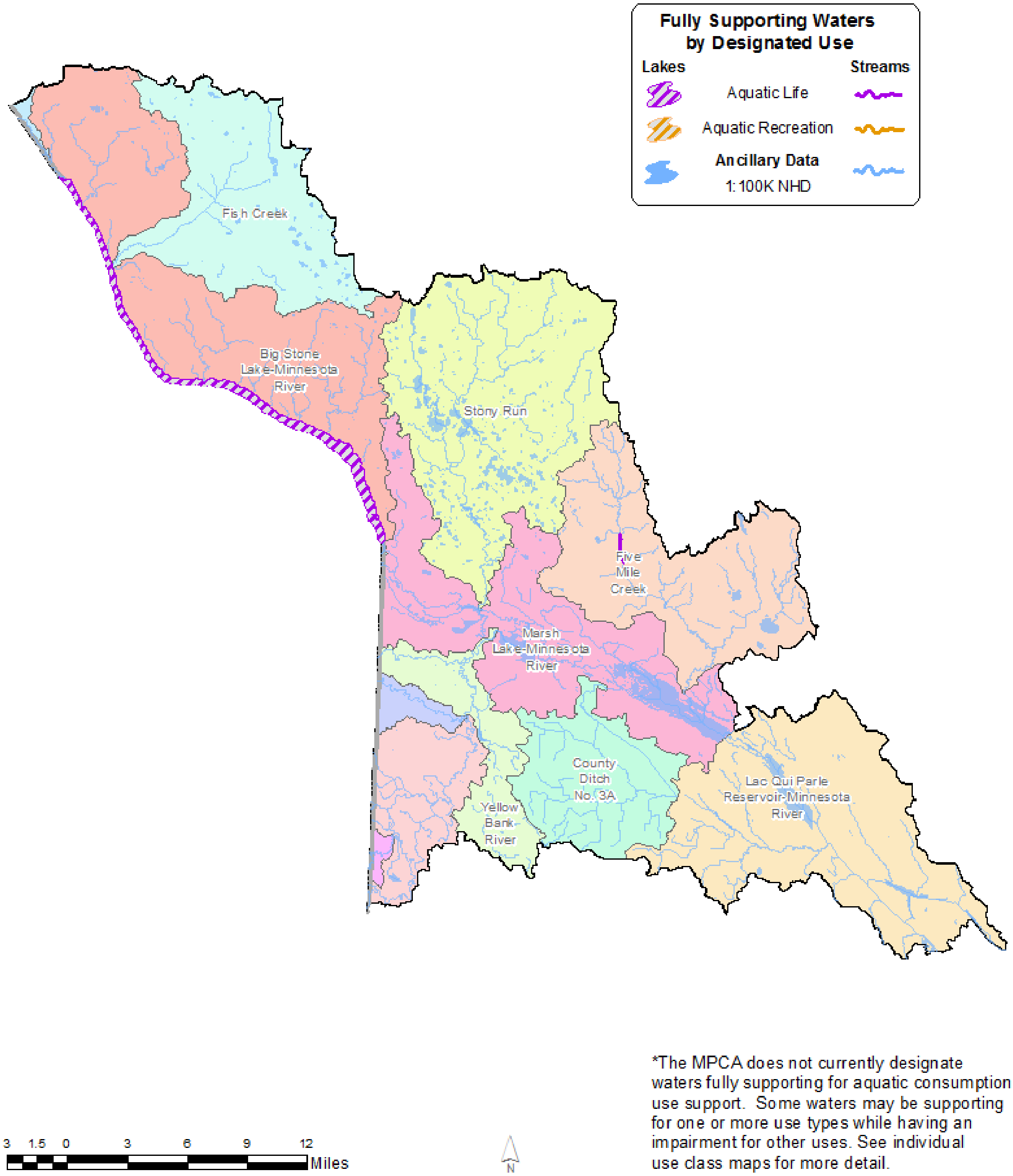


Figure 36. Fully supporting waters by designated use in the Minnesota River-Headwaters Watershed.



*The MPCA does not currently designate waters fully supporting for aquatic consumption use support. Some waters may be supporting for one or more use types while having an impairment for other uses. See individual use class maps for more detail.

Figure 37. Impaired waters by designated use in the Minnesota River-Headwaters Watershed.

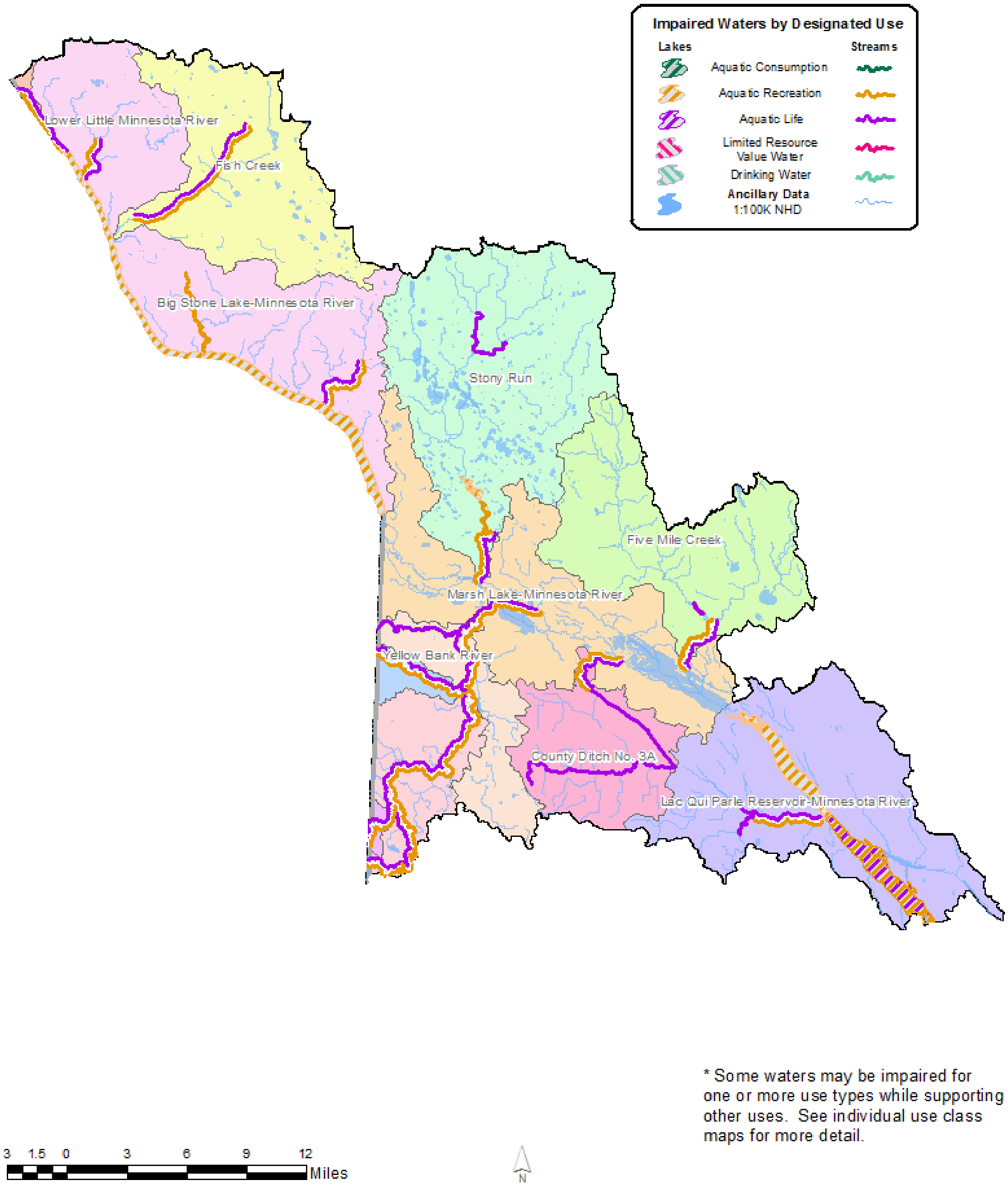


Figure 38. Aquatic consumption use support in the Minnesota River-Headwaters Watershed.

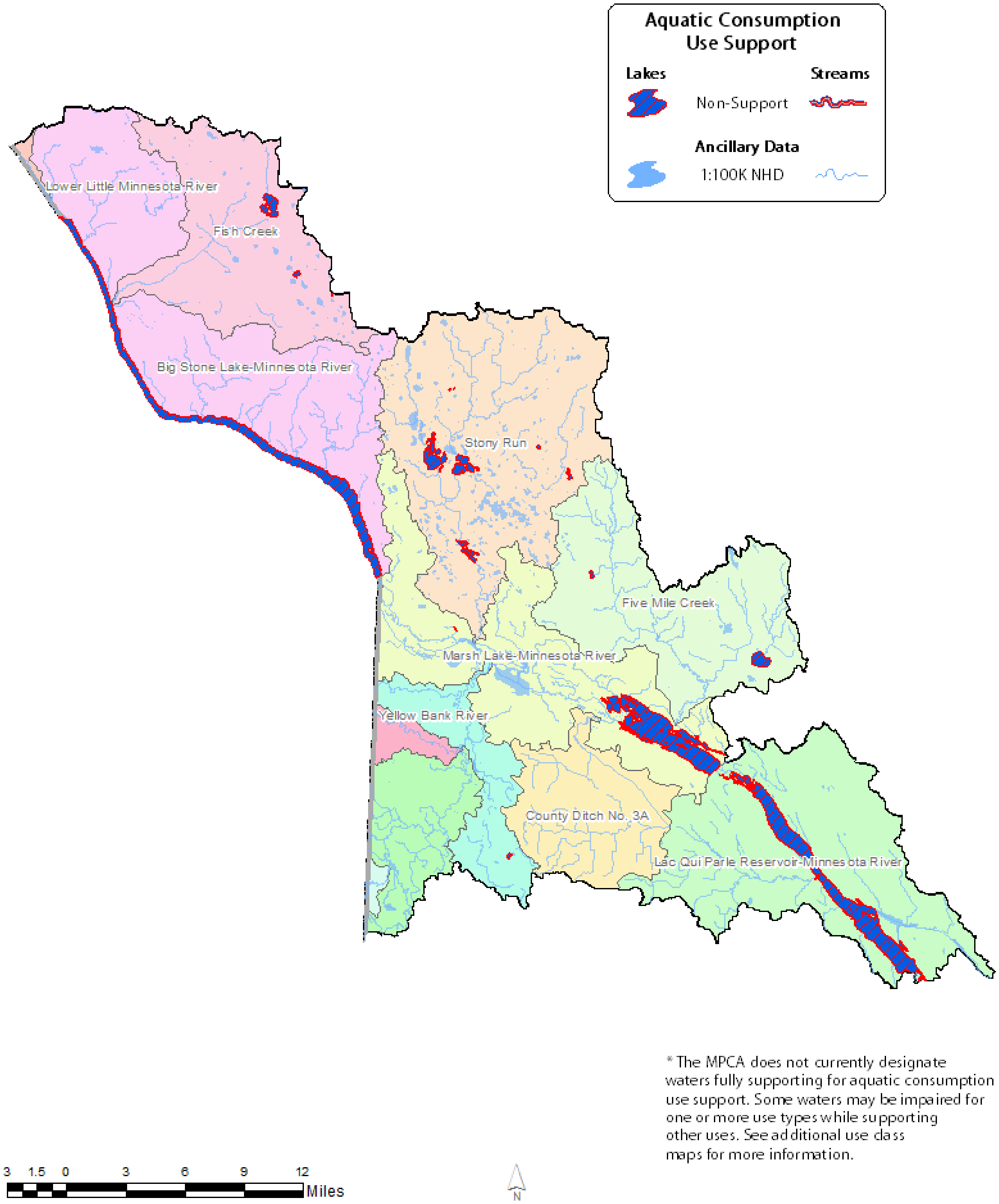


Figure 39. Aquatic life use support in the Minnesota River-Headwaters Watershed.

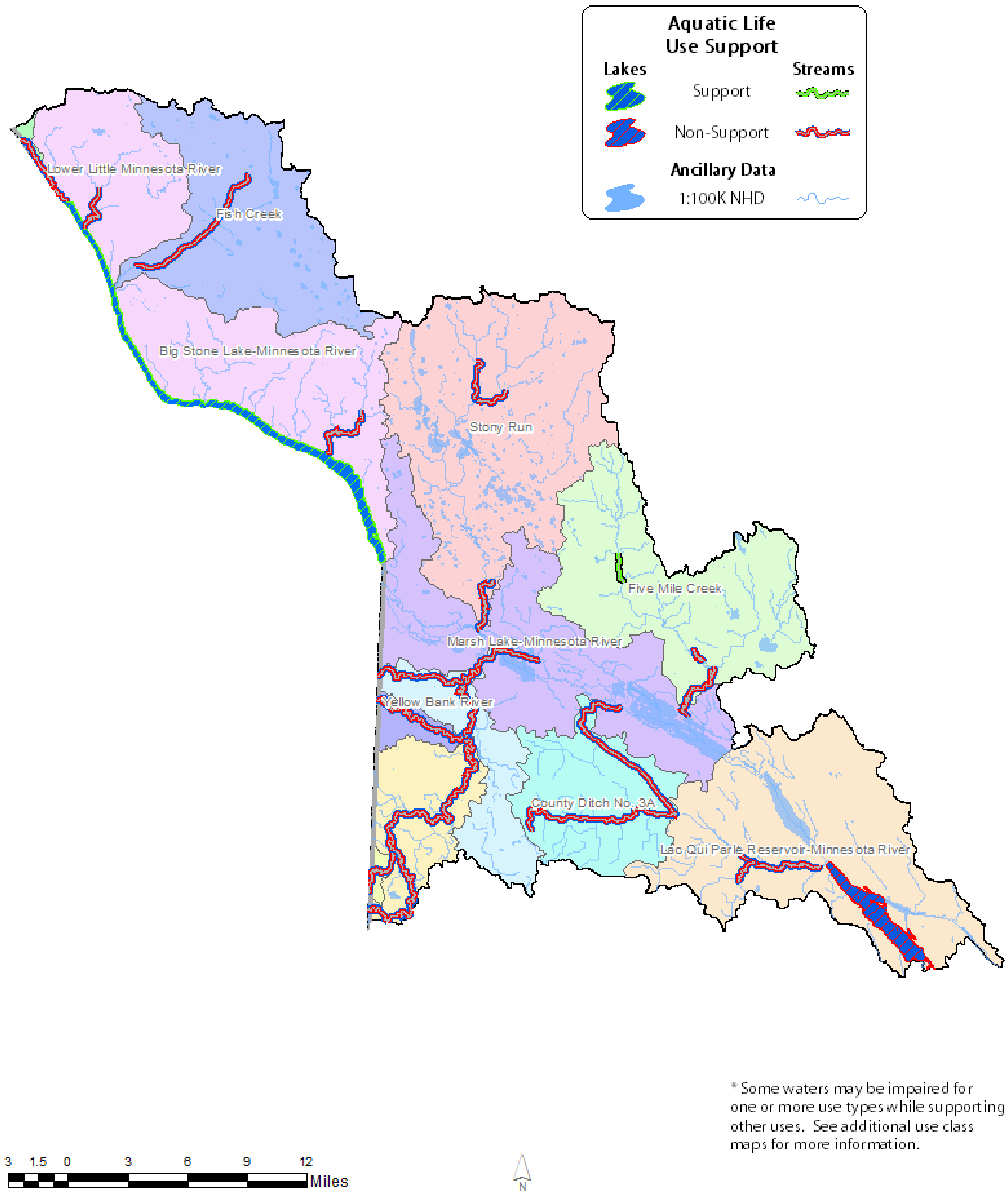
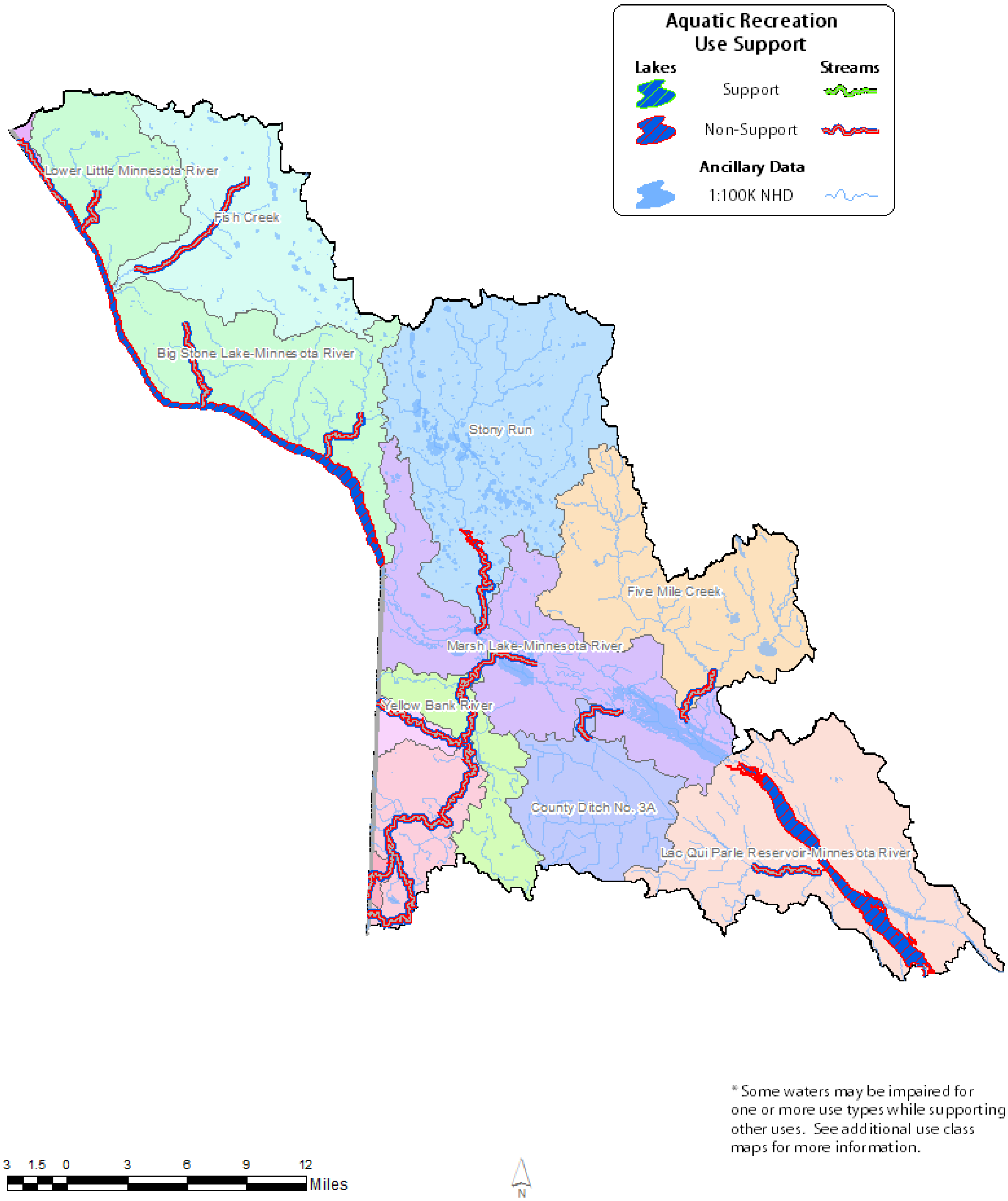


Figure 40. Aquatic recreation use support in the Minnesota River-Headwaters Watershed.



Transparency trends for the Minnesota River-Headwaters Watershed

MPCA completes annual trend analysis on lakes and streams across the state based on long-term transparency measurements. The data collection for this work relies heavily on volunteers across the state and also incorporates any agency and partner data submitted to EQuIS.

The trends are calculated using a Seasonal Kendall statistical test for waters with a minimum of eight years of transparency data; Secchi disk measurements in lakes and Secchi Tube measurements in streams.

Citizen volunteer monitoring occurs at one stream and two lakes in the watershed. Long-term trend analysis indicates increasing water clarity in Big Stone and Lac qui Parle (SE Basin) lakes.

Table 26. Water clarity trends.

Minnesota River-Headwaters HUC 07020001	Streams	Lakes
Number of sites w/increasing trend	--	2
Number of sites w/decreasing trend	--	--
Number of sites w/no trend	1	--

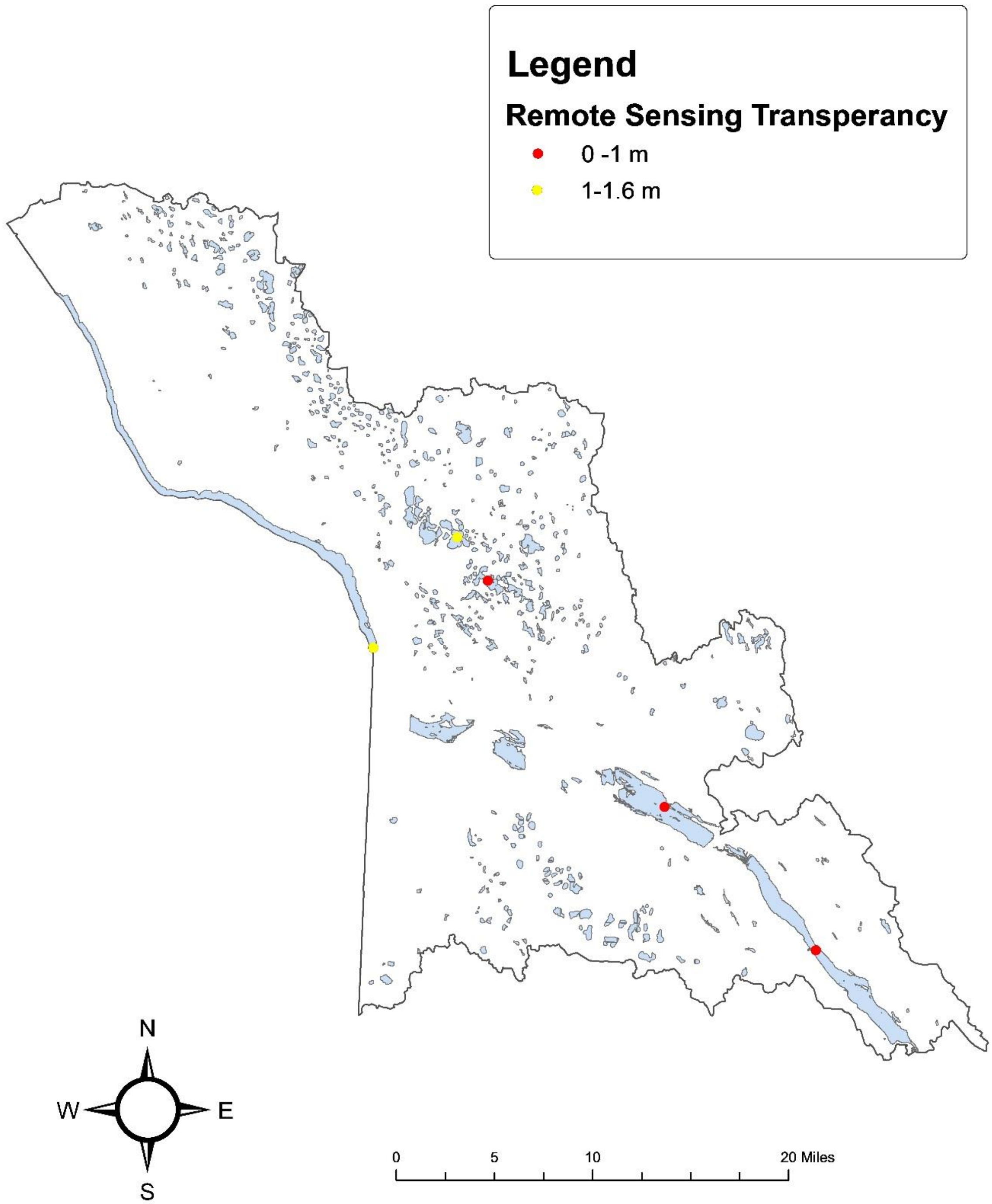
In June 2014, the MPCA published its final trend analysis of river monitoring data located statewide based on the historical Milestones Network. The network is a collection of 80 monitoring locations on rivers and streams across the state with good, long-term water quality data. The period of record is generally more than 30 years, through 2010, with monitoring at some sites going back to the 1950s. While the network of sites is not necessarily representative of Minnesota's rivers and streams as a whole, they do provide a valuable and wide-spread historical record for many of the state's waters. Starting in 2017, the MPCA will be switching to the Pollutant Load Monitoring Network for long-term trend analysis on rivers and streams. Data from this program has much more robust sampling and will cover over 100 sites across the state.

Remote sensing for lakes in the Minnesota River – Headwaters Watershed

The University of Minnesota, in partnership with MPCA, conducts remote sensing of lake clarity. The information provides a snapshot of water transparency during late summer over a span of 30 years. Secchi disk transparency data is paired with satellite imagery to come up with estimates of water clarity across the state. While there are limitations to the data, such as cloud cover, vegetation, or stained water altering the estimated Secchi transparency, it does provide information to help prioritize monitoring and protection efforts on lakes which do not have water quality data.

Six lakes had remote sensing data available within the Minnesota River Headwaters Watershed. Four of those basins had data indicating the late summer transparency was less than one meter, while two had transparencies between 1 and 1.6 meters. Big Stone Lake had the greatest remote sensing transparency (1.6 m), while Bentken Lake has the lowest (0.7 m). The use of transparency data for assessment is based on Secchi disk clarity measurement only, which is tied to the aquatic recreation use standard.

Figure 41. Remotely sensed Secchi transparency on lakes in the Minnesota River-Headwaters Watershed.



Priority waters for protection and restoration in the Minnesota River – Headwaters Watershed

The MPCA and DNR have been developing methods to help identify waters that are high priority for protection and restoration activities. Protecting lakes and streams from degradation requires consideration of how human activities impact the lands draining to the water. In addition, helping to determine the risk for degradation allows for prioritization to occur; so limited resources can be directed to waters that would benefit most from implementation efforts.

The results of the analysis are provided to watershed project teams for use during Watershed Restoration and Protection Strategy and One Watershed One Plan or other local water plan development. The results of the analysis are considered a preliminary sorting of possible protection priorities and should be followed by a discussion and evaluation with other resource agencies, project partners and stakeholders. Other factors that are typically considered during the protection prioritization process include: whether a water has an active lake or river association, is publically accessible, presence of wild rice, presence of invasive, rare or endangered species, as well as land use information and/or threats from proposed development. Opportunities to gain or enhance multiple natural resource benefits ("benefit stacking") is another consideration during the final protection analysis. At present, the prioritization methodology has been developed for lakes based on recreation use and is summarized below (MPCA 2017). Stream Protection and Prioritization method development is nearing completion. Waterbodies identified during the assessment process as vulnerable to impairment are also included in the summary below.

The results for selected indicators and the risk priority ranking for each lake are shown in Appendix 6. Protection priority should be given to lakes that are particularly sensitive to an increase in phosphorus with a documented decline in water quality (measured by Secchi transparency), a comparatively high percentage of developed land use in the area, or monitored phosphorus concentrations close to the water quality standard. In the Minnesota River Headwaters Watershed, the greatest protection priority is recommended for Shible Lake, with a small load reduction goal and mean TP nearly meeting standard (this data analysis only includes data through 2015).

Many of streams in the watershed failed to meet biological criteria, even though elevated TSS and TP concentrations did not trigger new impairments on those reaches they should be prioritized for further stressor investigation. The streams with elevated TSS concentrations include Little Minnesota River and Stony Run Creek. The streams with elevated TP concentrations include Little Minnesota River, Yellow Bank River, Stony Run Creek, Emily Creek, and Fish Creek.

Summaries and recommendations

Streams within the Minnesota River – Headwaters Watershed all show the cumulative effects of the human activity in the watershed. Of the indicators for aquatic life, fish communities seem to be impacted the most. Out of 19 aquatic life impairments, the fish assemblage contributed to 18 of the impairments, while the macroinvertebrate assemblage contributed to 9 aquatic life impairments. Eight stream reaches had both fish and macroinvertebrate communities that failed to meet aquatic life standards. Two stream reaches had existing aquatic life impairments based on the fish assemblage, which were carried forward using current data. There were no existing macroinvertebrate aquatic life impairments. Out of the four monitored modified use reaches, the fish community contributed to impairments on three reaches, while macroinvertebrates contributed to an aquatic life impairment on one. Many of the fish samples were dominated by fish species considered tolerant, to very tolerant of pollution (>50% of the individuals). Fish samples with an abundance of tolerant species typically score lower for the FIBI. All of the three most frequent fish collected during the fish sampling are considered generalists, and are considered tolerant to varying degrees. The most abundant fish found (fathead minnow), both in numbers and number of stations found, is considered a generalist, tolerant, and very tolerant. Some of the other frequent fish in the samples considered tolerant include creek chub (3rd most abundant fish, 2nd most frequent at stations) and white sucker (4th most abundant fish, 5th most frequent at stations). Some of the issues affecting the fish communities include: altered hydrology due to channelization and tiling, lack of instream habitat due to channelization, sedimentation brought about by altered hydrology and surrounding land use. Physical barriers to fish movement such as perched culverts at road crossings and dams can also substantially impact the fish communities found in streams.

A modified use reach on County Ditch 2 was fully supporting for aquatic life. The fish assemblage was the only parameter used for this assessment. The fish assemblage was also found to be supporting general use aquatic life standards in the Little Minnesota River. This reach scored close to the general use threshold, and degradation in this watershed could easily contribute to failing aquatic life standards in the future. Protection strategies could prevent future impairment. Of the 40 species of fish found, some sensitive fish species were found in the watershed. These species include in order of abundance: carmine shiner (10th), hornyhead chub (12th), iowa darter (17th), rock bass (22nd), slenderhead darter (23rd), stonecat (24th), and greater redhorse (29th). The macroinvertebrate assemblage was supporting aquatic life standards on eight stream reaches (2 modified use, 6 general use). A combination of good habitat, stable flow, and vegetated riparian corridors contributed to these healthy aquatic macroinvertebrate communities.

Many of the tributaries throughout this watershed did not have obvious water chemistry issues that triggered impairments during this assessment effort. However, the biological communities were being impacted and stressor identification will help determine the parameters to pursue improvements upon. The Yellow Bank River will remain the only tributary officially listed for TSS. Preserving upland surface water storage areas can reduce severity of high flow events, bank instability, channel incision and surface water runoff, which typically elevate sediment loading to these tributaries. Stream buffers on many occasions provide a source for water to infiltrate naturally. Investing time and financial resources now will help target high priority areas to focus protection and restoration efforts.

Past fecal coliform datasets triggered three aquatic recreation use listings throughout this watershed in 2006; more recent bacteria data confirmed the initial listings during this assessment cycle. Concentrated animal activity within stream or immediately adjacent to the flood plain is typically associated with high bacteria levels. Limiting concentrated domesticated and wildlife access to these areas could yield lower bacteria levels.

Lake water quality within this watershed was poor. Land use is highly altered, and basins in this area are shallow; both are significant factors that will make restoration or even maintaining the current conditions a challenge. Big Stone Lake has been suspect of poor water quality, past data collection may have not completely characterized conditions; data summarized during this assessment window resulted in a new listing. Follow up work should continue to focus on input sources both Minnesota and neighboring jurisdictions in an attempt to curb external loading into a system already under the stress of internal loading. Downstream waterbodies (such as Lac qui Parle) are also impacted with high phosphorus and resulting algal blooms. As prolonged dense algal blooms grow in severity over time, negative effects on human enjoyment and local economies will become more pronounced. Recreational enjoyment is severely impacted when lakes have frequent heavy algae blooms throughout the summer months which typically are fueled by unnaturally elevated nutrient concentrations. Poor water quality can result in reduced economic benefits to local businesses that rely on healthy recreational opportunities in the area. Controlling the nutrient inputs to these lakes can engage citizens at a local level. Keeping native shoreline buffers intact, preventing yard waste input, maintaining complaint septic systems, and reducing or eliminating fertilizer use are all potential practices to investigate locally. Agriculture is the heart and soul of this region and much of southwestern Minnesota, a healthy balance of supporting successful households while maintaining beneficial water quality has to be a long-term compromise. Issues such as altered surface hydrology, overland runoff, and water treatment plant compliance should also be addressed. Internal loading on shallow lake basins is difficult to manage. Setting reasonable expectations and devoting time and financial resources to develop long-term restoration and protection strategies will be required for these lakes.

Lake protection and prioritization modeling indicated Shible Lake would see the greatest benefit of targeted reduction of phosphorus inputs. Paired with the current assessment data revealing this basin is nearly impaired, it would be a good candidate for protection of current conditions to prevent further degradation into an impaired state.

Groundwater protection should be considered both for quantity and quality. Concerns for quality are possible high levels of naturally-occurring elements in drinking water and nitrate from human activities. The concerns for quantity are based on comparing the amount of water withdrawn versus the amount of water being recharged to the aquifer. Groundwater withdrawals in the watershed have increased significantly and surface water withdrawals more so. However, groundwater levels in the monitoring well reviewed have not decreased significantly over almost 40 years of monitoring. However, one location does not represent the entire watershed, so continued mindfulness of water users and additional monitoring of groundwater quantity will provide the information needed to conserve the resource in the watershed.

Wetlands are in poor condition in the watershed. Estimates indicate that 66% of the wetlands in the watershed have been lost, and of what remains, 80% would have only fair to poor vegetation, such as narrow leaf and hybrid cattail and reed canary grass. Macroinvertebrate communities in the wetlands are estimated to be good in only 40% of the wetlands. Protection of remaining high quality wetlands in this watershed is encouraged.

The Minnesota River – Headwaters Watershed is a dynamic watershed consisting of significant natural areas and productive agricultural land. Protection of the existing wetlands, groundwater, lakes and streams would benefit the watershed by either maintaining, or even improving the quality of these resources. Considerable issues threatening the aquatic resources in the watershed include altered hydrology, sediment, and excess nutrients. Effort to minimize altered hydrology such as increasing water storage on the landscape and better water management in the drainage systems could help decrease the effect of altered hydrology on the aquatic resources. The negative effects of sediment and excess nutrients on the aquatic resources may be prevented by reducing erosion, and nutrient runoff from fields thru the use of cover crops, conservation tillage, maintaining buffer strips and intact riparian corridors, and better nutrient management. Best management practices should be a priority in the watershed to maintain or improve the quality of aquatic resources.

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Appendix 1. Water chemistry definitions

Dissolved oxygen (DO) - Oxygen dissolved in water required by aquatic life for metabolism. Dissolved oxygen enters into water from the atmosphere by diffusion and from algae and aquatic plants when they photosynthesize. Dissolved oxygen is removed from the water when organisms metabolize or breathe. Low DO often occurs when organic matter or nutrient inputs are high, and light inputs are low.

Escherichia coli (*E. coli*) - A type of fecal coliform bacteria that comes from human and animal waste. E. coli levels aid in the determination of whether or not fresh water is safe for recreation. Disease-causing bacteria, viruses and protozoans may be present in water that has elevated levels of E. coli.

Nitrate plus Nitrite – Nitrogen - Nitrate and nitrite-nitrogen are inorganic forms of nitrogen present within the environment that are formed through the oxidation of ammonia-nitrogen by nitrifying bacteria (nitrification). Ammonia-nitrogen is found in fertilizers, septic systems and animal waste. Once converted from ammonia-nitrogen to nitrate and nitrite-nitrogen, these species can stimulate excessive levels of algae in streams. Because nitrate and nitrite-nitrogen are water soluble, transport to surface waters is enhanced through agricultural drainage. The ability of nitrite-nitrogen to be readily converted to nitrate-nitrogen is the basis for the combined laboratory analysis of nitrate plus nitrite-nitrogen (nitrate-N), with nitrite-nitrogen typically making up a small proportion of the combined total concentration. These and other forms of nitrogen exist naturally in aquatic environments; however, concentrations can vary drastically depending on season, biological activity, and anthropogenic inputs.

Orthophosphate (OP)- Orthophosphate is a water soluble form of phosphorus that is readily available to algae (bioavailable). While orthophosphates occur naturally in the environment, river and stream concentrations may become elevated with additional inputs from waste water treatment plants, noncompliant septic systems and fertilizers in urban and agricultural runoff.

pH - A measure of the level of acidity in water. Rainfall is naturally acidic, but fossil fuel combustion has made rain more acid. The acidity of rainfall is often reduced by other elements in the soil. As such, water running into streams is often neutralized to a level acceptable for most aquatic life. Only when neutralizing elements in soils are depleted, or if rain enters streams directly, does stream acidity increase.

Total Kjeldahl nitrogen (TKN) - The combination of organically bound nitrogen and ammonia in wastewater. TKN is usually much higher in untreated waste samples then in effluent samples.

Total phosphorus (TP) - Nitrogen (N), phosphorus (P) and potassium (K) are essential macronutrients and are required for growth by all animals and plants. Increasing the amount of phosphorus entering the system therefore increases the growth of aquatic plants and other organisms. Excessive levels of Phosphorous over stimulate aquatic growth and resulting in the progressive deterioration of water quality from overstimulation of nutrients, called eutrophication. Elevated levels of phosphorus can result in: increased algae growth, reduced water clarity, reduced oxygen in the water, fish kills, altered fisheries and toxins from cyanobacteria (blue green algae) which can affect human and animal health.

Total suspended solids (TSS) – TSS and turbidity are highly correlated. Turbidity is a measure of the lack of transparency or "cloudiness" of water due to the presence of suspended and colloidal materials such as clay, silt, finely divided organic and inorganic matter and plankton or other microscopic organisms. The greater the level of TSS, the murkier the water appears and the higher the measured turbidity.

Higher turbidity results in less light penetration which may harm beneficial aquatic species and may favor undesirable algae species. An overabundance of algae can lead to increases in turbidity, further compounding the problem.

Unionized ammonia (NH3) - Ammonia is present in aquatic systems mainly as the dissociated ion $NH4^+$, which is rapidly taken up by phytoplankton and other aquatic plants for growth. Ammonia is an excretory product of aquatic animals. As it comes in contact with water, ammonia dissociates into $NH4^+$ ions and ^-OH ions (ammonium hydroxide). If pH levels increase, the ammonium hydroxide becomes toxic to both plants and animals.

Appendix 2.1. Intensive watershed monitoring water chemistry stations in the Minnesota River – Headwaters Watershed

EQuIS ID	Biological station ID	WID	Waterbody name	Location	Aggregated 12-digit HUC
S000-158	03MN053	07020001-510	Yellow Bank River, North Fork	CSAH-7, North OF ROSEN	Lower North Fork Yellow Bank River
S008-469	03MN054	07020001-525	Yellow Bank River	At CSAH 40, 2.5 mi. SW of Odessa	Yellow Bank River
S000-732	15MN001	07020001-508	Little Minnesota River	At CSAH 4/4th St, in Browns Valley	Lower Little Minnesota River
S006-557	15MN002	07020001-541	Trib to Big Stone Lake	At 250TH ST, 3 MI SW OF BEARDSLEY, MN	Big Stone Lake-Minnesota River
S002-881	15MN003	07020001-571	Fish Creek	At CSAH 33, 3 mi. S of Beardsley	Fish Creek
S008-470	15MN009	07020001-568	Meadowbrook Creek	At CSAH 9, 6 mi. SW of Clinton	Big Stone Lake-Minnesota River
S008-471	15MN010	07020001-531	Stony Run Creek	At 430th St, 1 mi. NW of Odessa	Stony Run Creek
S008-472	15MN016	07020001-521	Five Mile Creek	At 580th Ave, 5 mi. NW of Appleton	Five Mile Creek
S003-090	15MN021	07020001-526	Yellow Bank River, South Fork	Twp Road 6.25 MI NW OF BELLINGHAM, MN	South Fork Yellow Bank River
S008-473	15MN023	07020001-551	Trib. to Yellow Bank River, South Fork	At 290th St, 1 mi. N of Nassau	Trib. To South Fork Yellow Bank River
S008-474	15MN024	07020001-570	Trib to Marsh Lake	At 370th St, 4 mi. NE of Bellingham	County Ditch 3A
S008-475	15MN026	07020001-547	Emily Creek	At 300th St, 5 mi. SW of Milan	Lac Qui Parle Reservoir-Minnesota River
S008-476	15MN099	07020001-526	Yellow Bank River, South Fork	Upstream of 111th Ave, 1.5 mi. S of Nassau	South Fork Yellow Bank River

Appendix 2.2. Intensive watershed monitoring biological monitoring stations in the Minnesota River – Headwaters Watershed

WID	Biological station ID	Waterbody name	Biological station location	County	Aggregated 12-digit HUC
07020001-548	01MN019	Unnamed trib. to Emily Creek	Upstream of CR 28,, in Hantho Twp.	Lac Qui Parle	0702000112-01
07020001-526	01MN033	Yellow Bank River, South Fork	Upstream of CR 32, 5 mi. W of Bellingham	Lac Qui Parle	0702000110-02
07020001-531	01MN051	Stony Run Creek	Downstream US 12, 5 mi. E of Ortonville	Big Stone	0702000108-01
07020001-510	03MN053	Yellow Bank River, North Fork	CR 7, 7 mi S of Ortonville	Lac Qui Parle	0702000109-01
07020001-525	03MN054	Yellow Bank River	CR 40, 2.5 mi. SW of Odessa	Lac Qui Parle	0702000110-01
07020001-569	10EM067	Unnamed ditch	Adjacent to CSAH 32, 3 mi. SW of Louisberg	Lac Qui Parle	0702000111-03
07020001-508	15MN001	Little Minnesota River	Upstream of CSAH 4/4th St, in Browns Valley	Traverse	0702000103-01
07020001-541	15MN002	Trib. to Big Stone Lake	Downstream of 250th St, 2 mi. W of Beardsley	Big Stone	0702000104-01
07020001-571	15MN003	Fish Creek	Upstream of CSAH 33, 3 mi. S of Beardsley	Big Stone	0702000104-02
07020001-571	15MN005	Fish Creek	Upstream of CSAH 3, 3.5 mi. E of Beardsley	Big Stone	0702000104-02
07020001-568	15MN009	Meadowbrook Creek	Downstream of CSAH 9, 6 mi. SW of Clinton	Big Stone	0702000104-01
07020001-531	15MN010	Stony Run Creek	Downstream of 430th St, 1 mi. NW of Odessa	Big Stone	0702000108-01
07020001-559	15MN012	Trib. to Munnwyler Lake	Upstream of CR 71, 5 mi. SE of Clinton	Big Stone	0702000108-01
07020001-560	15MN013	Trib. to Munnwyler Lake	Upstream of 320th St, 3.5 mi. SE of Clinton	Big Stone	0702000108-01
07020001-521	15MN016	Five Mile Creek	Downstream of 580th Ave, 5 mi. NW of Appleton	Big Stone	0702000111-02
07020001-574	15MN017	Five Mile Creek	Upstream of Swift CR 54, 5 mi. NW of Appleton	Big Stone	0702000111-02
07020001-562	15MN018	County Ditch 2	Upstream of Hwy 12, 7 mi. NE of Odessa	Big Stone	0702000111-02
07020001-526	15MN021	Yellow Bank River, South Fork	Upstream of 356th St, 4 mi. NW of Bellingham	Lac Qui Parle	0702000110-02
07020001-551	15MN023	Trib. to Yellow Bank River, South Fork	Upstream of 290th St, 1 mi. N of Nassau	Lac Qui Parle	0702000110-03
07020001-570	15MN024	Trib. to Marsh Lake	Downstream of 370th St, 4 mi. NE of Bellingham	Lac Qui Parle	0702000111-03
07020001-569	15MN025	Trib. to Marsh Lake	Downstream of 221st Ave, 1.5 mi. W of Louisberg	Lac Qui Parle	0702000111-03
07020001-576	15MN027	Emily Creek	Downstream of MN 119, 7 mi. W of Milan	Lac Qui Parle	0702000112-01

WID	Biological station ID	Waterbody name	Biological station location	County	Aggregated 12-digit HUC
07020001-561	15MN032	Trib. to Yellow Bank River	Downstream of CR 51, 3.5 mi. SW of Odessa	Lac Qui Parle	0702000110-01
07020001-526	15MN095	Yellow Bank River, South Fork	Upstream of 290th St, 1.5 mi. NE of Nassau	Lac Qui Parle	0702000110-02
07020001-526	15MN099	Yellow Bank River, South Fork	Downstream of 111th Ave, 1.5 mi. S of Nassau	Lac Qui Parle	0702000110-02
07020001-504	15MN107	West Salmonsen Creek	Upstream of MN 7, 9 mi. SE of Beardsley	Big Stone	0702000104-01
07020001-510	15MN400	Yellow Bank River, North Fork	Downstream of CSAH 7, 6.5 mi. SW of Odessa	Lac Qui Parle	0702000109-01
07020001-547	15MN401	Emily Creek	Adjacent to CR 66, 5 mi. W of Milan	Lac Qui Parle	0702000112-01

Appendix 3.1. Minnesota statewide IBI thresholds and confidence limits

Class #	Class name	Use class	Exceptional use threshold	General use threshold	Modified use threshold	Confidence limit
Fish						
1	Southern Rivers	2B, 2C	71	49	NA	±11
2	Southern Streams	2B, 2C	66	50	35	±9
3	Southern Headwaters	2B, 2C	74	55	33	±7
10	Southern Coldwater	2A	82	50	NA	±9
4	Northern Rivers	2B, 2C	67	38	NA	±9
5	Northern Streams	2B, 2C	61	47	35	±9
6	Northern Headwaters	2B, 2C	68	42	23	±16
7	Low Gradient	2B, 2C	70	42	15	±10
11	Northern Coldwater	2A	60	35	NA	±10
Invertebrates						
1	Northern Forest Rivers	2B, 2C	77	49	NA	±10.8
2	Prairie Forest Rivers	2B, 2C	63	31	NA	±10.8
3	Northern Forest Streams RR	2B, 2C	82	53	NA	±12.6
4	Northern Forest Streams GP	2B, 2C	76	51	37	±13.6
5	Southern Streams RR	2B, 2C	62	37	24	±12.6
6	Southern Forest Streams GP	2B, 2C	66	43	30	±13.6
7	Prairie Streams GP	2B, 2C	69	41	22	±13.6
8	Northern Coldwater	2A	52	32	NA	±12.4
9	Southern Coldwater	2A	72	43	NA	±13.8

Appendix 3.2. Biological monitoring results – fish IBI (assessable reaches)

National Hydrography Dataset (NHD) Assessment Segment WID	Biological station ID	Stream segment name	Drainage area Mi^2	Fish class	Threshold	FIBI	Visit date
HUC 12: 0702000103-01 (Lower Little Minnesota River)							
07020001-508	15MN001	Little Minnesota River	453.22	1	49	49.72	6/17/2015
HUC 12: 0702000104-01 (Big Stone Lake-Minnesota River)							
07020001-504	15MN107	Unnamed creek (West Salmonsen Creek)	26.59	3	55	53.9	6/16/2015
07020001-541	15MN002	Unnamed creek	32.84	2	50	17.32	6/16/2015
07020001-541	15MN002	Unnamed creek	32.84	2	50	17.48	7/27/2015
07020001-568	15MN009	Unnamed creek (Meadowbrook Creek)	17.99	3	55	51.74	6/11/2015
HUC 12: 0702000104-02 (Fish Creek)							
07020001-571	15MN003	Fish Creek	77.45	2	35	0	6/9/2015
07020001-571	15MN005	Fish Creek	50.8	2	35	0	6/9/2015
HUC 12: 0702000108-01 (Stony Run)							
07020001-531	01MN051	Stony Run Creek	120.53	2	50	19.41	7/16/2001
07020001-531	15MN010	Stony Run Creek	127.35	2	50	39.02	6/18/2015
07020001-559	15MN012	Unnamed creek	18.75	3	55	0	6/17/2015
07020001-560	15MN013	Unnamed creek	9.66	3	33	0	6/17/2015
HUC 12: 0702000109-01 (Lower North Fork Yellow Bank River)							
07020001-510	03MN053	Yellow Bank River, North Fork	208.38	2	50	39.67	6/25/2003
07020001-510	15MN400	Yellow Bank River, North Fork	208.59	2	50	42.99	7/8/2015
HUC 12: 0702000110-01 (Yellow Bank River)							
07020001-525	03MN054	Yellow Bank River	459.47	1	49	46.79	6/24/2003
07020001-525	03MN054	Yellow Bank River	459.47	1	49	47.18	7/7/2015
07020001-525	03MN054	Yellow Bank River	459.47	1	49	20.51	7/27/2015
07020001-561	15MN032	Unnamed creek	9.19	3	55	28.46	6/10/2015
HUC 12: 0702000110-02 (South Fork Yellow Bank River)							
07020001-526	01MN033	Yellow Bank River, South Fork	197.73	2	50	50.1	7/17/2001
07020001-526	15MN099	Yellow Bank River, South Fork	109.27	2	50	43.1	6/16/2015

National Hydrography Dataset (NHD) Assessment Segment WID	Biological station ID	Stream segment name	Drainage area Mi^2	Fish class	Threshold	FIBI	Visit date
07020001-526	15MN021	Yellow Bank River, South Fork	213.08	2	50	53.94	7/8/2015
07020001-526	15MN095	Yellow Bank River, South Fork	111.86	2	50	23.44	7/8/2015
HUC 12: 0702000110-03 (Trib. To South Fork Yellow Bank River)							
07020001-551	15MN023	Unnamed creek	48.62	2	50	20.85	6/10/2015
HUC 12: 0702000111-02 (Five Mile Creek)							
07020001-521	15MN016	Unnamed creek (Five Mile Creek)	86.48	2	50	32.48	7/9/2015
07020001-562	15MN018	County Ditch 2	22.12	7	15	20.8	7/9/2015
07020001-574	15MN017	County Ditch 2 (Five Mile Creek)	49.81	2	50	15.24	6/9/2015
HUC 12: 0702000111-03 (County Ditch No. 3A)							
07020001-569	10EM067	Unnamed creek	20.13	3	33	48.57	8/24/2010
07020001-569	10EM067	Unnamed creek	20.13	3	33	38.02	6/9/2015
07020001-569	15MN025	Unnamed creek	34.76	2	35	0	6/17/2015
07020001-570	15MN024	Unnamed creek	47.79	2	50	0	6/10/2015
07020001-570	15MN024	Unnamed creek	47.79	2	50	34.38	8/3/2015
HUC 12: 0702000112-01 (Lac Qui Parle Reservoir-Minnesota River)							
07020001-547	15MN401	Emily Creek	33.8	2	50	33.51	8/3/2015
07020001-548	01MN019	Unnamed creek	15.22	3	55	0	6/27/2001
07020001-548	01MN019	Unnamed creek	15.22	3	55	2.41	6/15/2015
07020001-576	15MN027	Emily Creek	6.82	3	55	46.24	6/15/2015

Appendix 3.3. Biological monitoring results-macroinvertebrate IBI (assessable reaches)

National Hydrography Dataset (NHD) Assessment Segment WID	Biological station ID	Stream segment name	Drainage area Mi^2	Invert class	Threshold	MIBI	Visit date
HUC 12: 0702000103-01 (Lower Little Minnesota River)							
07020001-508	15MN001	Little Minnesota River	453.22	5	37	31.58	8/4/2015
HUC 12: 0702000104-01 (Big Stone Lake – Minnesota River							
07020001-504	15MN107	Unnamed creek (West Salmonsen Creek)	26.59	7	41	59.31	8/4/2015
07020001-504	15MN107	Unnamed creek (West Salmonsen Creek)	26.59	7	41	68.98	8/16/2017
07020001-541	15MN002	Unnamed creek	32.84	5	37	40.63	8/4/2015
07020001-568	15MN009	Unnamed creek (Meadowbrook Creek)	17.99	5	37	25.77	8/5/2015
07020001-568	15MN009	Unnamed creek (Meadowbrook Creek)	17.99	5	37	31.15	8/5/2015
HUC 12: 0702000104-02 (Fish Creek)							
07020001-571	15MN003	Fish Creek	77.45	7	22	21.06	8/4/2015
HUC 12: 0702000108-01 (Stony Run)							
07020001-531	01MN051	Stony Run Creek	120.53	5	37	33.34	9/13/2001
07020001-531	15MN010	Stony Run Creek	127.35	5	37	23.28	8/5/2015
07020001-560	15MN013	Unnamed creek	9.66	7	22	23.11	8/4/2015
HUC 12: 0702000109-01 (Lower North Fork Yellow Bank River)							
07020001-510	03MN053	Yellow Bank River, North Fork	208.38	7	41	32.56	8/19/2003
07020001-510	15MN400	Yellow Bank River, North Fork	208.59	5	37	38.21	8/5/2015
HUC 12: 0702000110-01 (Yellow Bank River)							
07020001-525	03MN054	Yellow Bank River	459.47	5	37	35.27	8/19/2003
07020001-525	03MN054	Yellow Bank River	459.47	5	37	39.8	9/9/2003
07020001-525	03MN054	Yellow Bank River	459.47	5	37	34.07	8/6/2015

National Hydrography Dataset (NHD) Assessment Segment WID	Biological station ID	Stream segment name	Drainage area Mi^2	Invert class	Threshold	MIBI	Visit date
HUC 12: 0702000110-02 (South Fork Yellow Bank River)							
07020001-526	01MN033	Yellow Bank River, South Fork	197.73	5	37	39.65	9/14/2001
07020001-526	15MN021	Yellow Bank River, South Fork	213.08	5	37	44.27	8/5/2015
07020001-526	15MN095	Yellow Bank River, South Fork	111.86	7	41	46.42	8/6/2015
07020001-526	15MN099	Yellow Bank River, South Fork	109.27	7	41	38.71	8/6/2015
HUC 12: 0702000110-03 (Trib. To South Fork Yellow Bank River)							
07020001-551	15MN023	Unnamed creek	48.62	7	41	32.56	8/6/2015
HUC 12: 0702000111-02 (Five Mile Creek)							
07020001-521	15MN016	Unnamed creek (Five Mile Creek)	86.48	5	37	41.78	8/5/2015
07020001-574	15MN017	County Ditch 2 (Five Mile Creek)	49.81	7	41	40.86	8/5/2015
HUC 12: 0702000111-03 (County Ditch No. 3A)							
07020001-569	10EM067	Unnamed creek	20.13	7	22	28.91	8/19/2010
07020001-569	10EM067	Unnamed creek	20.13	7	22	34.54	8/19/2010
07020001-569	10EM067	Unnamed creek	20.13	7	22	22.61	8/6/2015
07020001-570	15MN024	Unnamed creek	47.79	7	41	16.04	8/5/2015
HUC 12: 0702000112-01 (Lac qui Parle Reservoir – Minnesota River)							
07020001-547	15MN401	Emily Creek	33.8	7	41	31.81	8/10/2015
07020001-576	15MN027	Emily Creek	6.82	7	41	34.09	8/6/2015

Appendix 4.1. Fish species found during biological monitoring surveys

Common name	Quantity of stations where present	Quantity of individuals collected
Bigmouth Buffalo	2	38
Bigmouth Shiner	6	103
Black Bullhead	4	9
Blacknose Dace	14	298
Blackside Darter	8	121
Bluntnose Minnow	9	53
Brassy Minnow	12	650
Brook Stickleback	18	298
Carmine Shiner	7	150
Central Mudminnow	7	22
Central Stoneroller	10	462
Channel Catfish	1	2
Common Carp	7	75
Common Shiner	16	1384
Creek Chub	21	1288
Fathead Minnow	21	2090
Golden Redhorse	4	77
Greater Redhorse	1	6
Green Sunfish	7	24
Hornyhead Chub	6	108
Hybrid Minnow	2	2
Hybrid Sunfish	1	1
Iowa Darter	10	59
Johnny Darter	11	104
Largescale Stoneroller	1	5
Northern Pike	4	7
Orangespotted Sunfish	1	2
Quillback	1	4
Rock Bass	4	14
Sand Shiner	4	176
Shorthead Redhorse	6	11
Slenderhead Darter	4	12
Spotfin Shiner	1	1
Stonecat	2	12
Tadpole Madtom	1	1
Walleye	3	3
White Bass	1	3
White Sucker	15	807
Yellow Bullhead	3	5
Yellow Perch	2	11

Appendix 4.2. Macroinvertebrate species found during biological monitoring surveys

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
Ablabesmyia	6	20
Acari	12	56
Acentrella parvula	1	1
Acerpenna	3	10
Aeshna	2	4
Aeshna umbrosa	2	3
Aeshnidae	3	7
Amphipoda	1	3
Anacaena	2	2
Anax junius	1	
Anopheles	1	1
Argia	1	1
Atherix	3	7
Atrichopogon	2	2
Aulodrilus	2	5
Baetidae	2	4
Baetis	9	83
Baetis brunneicolor	2	21
Baetis flavistriga	2	8
Baetis intercalaris	8	51
Belostoma flumineum	5	
Berosus	1	2
Brachycentrus numerosus	1	2
Brillia	11	65
Caenis	2	28
Caenis youngi	1	1
Caenis diminuta	15	256
Callibaetis	1	2
Calopterygidae	8	28
Calopteryx	3	16
Calopteryx aequabilis	4	11
Cambaridae	1	1
Ceraclea	1	1
Ceratopogonidae	1	1
Ceratopogoninae	2	3
Ceratopsyche	6	37
Ceratopsyche morosa	5	117
Ceratopsyche slossonae	3	55
Cheumatopsyche	16	457
Chironomidae	1	1

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
Chironomini	9	15
Chironomus	4	42
Cladotanytarsus	6	9
Coenagrionidae	10	95
Conchapelopia	1	1
Corixidae	4	16
Corynoneura	6	32
Crangonyx	1	9
Cricotopus	17	424
Cryptochironomus	7	11
Culicidae	1	1
Desmopachria convexa	1	1
Dicranota	1	2
Dicrotendipes	11	113
Diplocladius cultriger	2	2
Dubiraphia	15	101
Empididae	3	3
Enchytraeus	6	15
Endochironomus	2	6
Ephemeridae	1	1
Ephydridae	7	18
Eukiefferiella	1	1
Fallceon	1	1
Ferrissia	6	29
Forcipomyiinae	1	1
Fridericia	2	5
Gammarus	1	1
Gerridae	4	9
Glyptotendipes	7	113
Gomphus fraternus	1	
Gonomyia	1	1
Gyrinus	1	
Haliplus	2	6
Helichus	1	1
Helicopsyche borealis	4	8
Hemerodromia	8	12
Heptagenia	7	57
Heptageniidae	1	6
Hetaerina americana	2	2
Hexagenia	4	4
Hexagenia limbata	1	1
Hirudinea	8	14

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
Hyalella	11	796
Hydraena	1	1
Hydrobiidae	2	2
Hydrophilidae	2	2
Hydropsyche	7	69
Hydropsyche betteni	5	23
Hydropsyche incommoda	1	2
Hydropsyche placoda	1	1
Hydropsyche simulans	1	2
Hydropsychidae	11	142
Hydroptila	11	60
Hydroptilidae	7	14
Hydrozoa	1	1
Ischnura	1	1
Isonychia	5	14
Labiobaetis dardanus	3	7
Labiobaetis frondalis	1	8
Labiobaetis propinquus	1	3
Labrundinia	9	48
Leptoceridae	3	4
Leucrocuta	1	1
Limnephilidae	2	2
Limnophyes	4	4
Liodessus	1	1
Lymnaeidae	5	12
Maccaffertium	2	7
Maccaffertium terminatum	2	4
Macronychus glabratus	6	81
Mayatrichia ayama	1	1
Metriocnemus	1	1
Micropsectra	10	141
Microtendipes	5	13
Naididae	3	3
Nais	9	17
Nanocladius	8	15
Nectopsyche	2	10
Nectopsyche candida	1	1
Nectopsyche diarina	9	32
Nematoda	1	5
Neoplasta	2	3
Neoplea striola	4	4
Neoporus	1	1

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
Nigronia	1	1
Nyctiophylax	1	1
Ochrotrichia	3	7
Ochthebius	3	3
Odontomyia /Hedriodiscus	4	4
Oecetis avara	1	3
Oecetis furva	1	2
Oligochaeta	1	34
Optioservus	5	22
Orconectes	17	31
Orthocladiinae	6	15
Orthocladius	4	4
Paracladopelma	1	1
Paracymus	2	2
Parakiefferiella	1	1
Paralauterborniella nigrohalterale	1	7
Parametriocnemus	4	17
Paraphaenocladius	1	2
Paratanytarsus	16	235
Paratendipes	5	19
Peltodytes	1	2
Perlesta	1	4
Phaenopsectra	9	46
Phryganeidae	1	1
Physa	1	31
Physella	15	340
Physidae	2	10
Pisidiidae	13	121
Planorbella	2	3
Planorbidae	1	12
Polycentropodidae	2	2
Polycentropus	1	1
Polypedilum	18	579
Procladius	8	20
Pseudosmittia	2	2
Pseudosuccinea columella	4	10
Pteronarcys	1	
Ptilostomis	1	2
Pycnopsyche	2	5
Ranatra	1	1
Rheocricotopus	6	12

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
Rheotanytarsus	14	123
Sciomyzidae	1	1
Scirtidae	1	2
Sialis	1	3
Sigara	2	2
Simulium	9	72
Stagnicola	2	44
Stenacron	11	56
Stenelmis	13	223
Stenochironomus	8	17
Tanypodinae	3	4
Tanytarsini	10	31
Tanytarsus	13	138
Telopelopia okoboji	1	1
Thienemanniella	18	133
Thienemannimyia	1	2
Thienemannimyia Gr.	18	268
Tipula	1	1
Tipulidae	1	1
Trepaxonemata	1	2
Trichocorixa	1	2
Tricorythodes	10	323
Tubificinae	10	26
Tvetenia	2	14
Zavrelimyia	6	14

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Appendix 5. Minnesota Stream Habitat Assessment results

Habitat information documented during each fish sampling visit is provided. This table conveys the results of the Minnesota Stream Habitat Assessment (MSHA) survey, which evaluates the section of stream sampled for biology and can provide an indication of potential stressors (e.g., siltation, eutrophication) impacting fish and macroinvertebrate communities. The MSHA score is comprised of five scoring categories including adjacent land use, riparian zone, substrate, fish cover and channel morphology, which are summed for a total possible score of 100 points. Scores for each category, a summation of the total MSHA score, and a narrative habitat condition rating are provided in the tables for each biological monitoring station. Where multiple visits occur at the same station, the scores from each visit have been averaged. The final row in each table displays average MSHA scores and a rating for the aggregated HUC-12 subwatershed.

# Visits	Biological station ID	Reach name	Land use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish cover (0-17)	Channel morph. (0-36)	MSHA score (0-100)	MSHA rating
2	15MN001	Little Minnesota River	0	6.8	15.2	11.5	17.5	51.0	Fair
		Average Habitat Results: *Lower Little Minnesota River Aggregated 12 HUC*	**0**	**6.8**	**15.2**	**11.5**	**17.5**	**51.0**	**Fair**
3	15MN002	Trib. to Big Stone Lake	0.8	10.8	18.6	10.3	28.3	69.0	Good
2	15MN009	Meadowbrook Creek	0.6	8.5	17.3	12.5	25.5	64.4	Fair
3	15MN107	West Salmonsen Creek	2.1	8.2	10.5	11.7	13.3	45.7	Fair
		Average Habitat Results: *Big Stone Lake-Minnesota River Aggregated 12 HUC*	**1.3**	**9.3**	**15.2**	**11.4**	**22.0**	**59.1**	**Fair**
2	15MN003	Fish Creek	0	9	7.3	10.5	9	35.8	Poor
1	15MN005	Fish Creek	0	7	1	10	4	22	Poor
		Average Habitat Results: *Fish Creek Aggregated 12 HUC*	**0.0**	**8.3**	**5.2**	**10.3**	**7.3**	**31.2**	**Poor**
1	01MN051	Stony Run Creek	1.5	8	19.45	3	21	52.95	Fair
2	15MN010	Stony Run Creek	2.5	7	14.5	13	19.5	56.5	Fair
1	15MN012	Trib. to Munnwyler Lake	0	9	15.3	12	18	54.3	Fair
2	15MN013	Trib. to Munnwyler Lake	0.5	9.0	6.4	12.0	9.0	36.9	Poor
		Average Habitat Results: *Stony Run Aggregated 12 HUC*	**1.3**	**8.2**	**12.7**	**10.8**	**16.0**	**49.0**	**Fair**
1	03MN053	Yellow Bank River, North Fork	0	8.5	18.3	13	33	72.8	Good
# Visits	**Biological station ID**	**Reach name**	**Land use (0-5)**	**Riparian (0-15)**	**Substrate (0-27)**	**Fish cover (0-17)**	**Channel morph. (0-36)**	**MSHA score (0-100)**	**MSHA rating**
2	15MN400	Yellow Bank River, North Fork	0.0	7.0	10.9	15.0	17.0	49.9	Fair
		Average Habitat Results: *Lower North Fork Yellow Bank River Aggregated 12 HUC*	**0.0**	**7.5**	**13.3**	**14.3**	**22.3**	**57.5**	**Fair**
4	03MN054	Yellow Bank River	3.1	9.8	15.0	9.3	22.5	59.6	Fair
1	15MN032	Trib. to Yellow Bank River	5.0	14.0	12.5	9.0	21.0	61.5	Fair

Average Habitat Results: ***Yellow Bank River Aggregated 12 HUC***			**3.5**	**10.6**	**14.5**	**9.2**	**22.2**	**60.0**	**Fair**
1	01MN033	Yellow Bank River, South Fork	0.0	7.0	16.8	8.0	27.0	58.8	Fair
2	15MN021	Yellow Bank River, South Fork	1.3	8.0	16.2	13.5	18.5	57.4	Fair
2	15MN095	Yellow Bank River, South Fork	0.0	8.5	5.6	8.5	12.0	34.6	Poor
2	15MN099	Yellow Bank River, South Fork	0.0	10.5	9.0	10.0	12.5	42.0	Poor
Average Habitat Results: ***South Fork Yellow Bank River Aggregated 12 HUC***			**0.4**	**8.7**	**11.2**	**10.3**	**16.1**	**46.7**	**Fair**
2	15MN023	Trib. to Yellow Bank River, South Fork	0	9.25	8.35	14	12	43.6	Poor
Average Habitat Results: ***Trib. To South Fork Yellow Bank River Aggregated 12 HUC***			**0**	**9.25**	**8.35**	**14**	**12**	**43.6**	**Poor**
2	15MN016	Five Mile Creek	0.0	7.0	17.1	14.0	21.0	59.1	Fair
2	15MN017	Five Mile Creek	0.0	8.5	10.0	7.5	13.5	39.5	Poor
1	15MN018	County Ditch 2	0.8	10.5	3.0	1.0	1.0	16.3	Poor
Average Habitat Results: ***Five Mile Creek Aggregated 12 HUC***			**0.2**	**8.3**	**11.4**	**8.8**	**14.0**	**42.7**	**Poor**
3	10EM067	Unnamed ditch	0.0	9.3	12.5	3.7	8.7	34.2	Poor
3	15MN024	Trib. to Marsh Lake	2.2	9.7	16.3	6.7	5.7	40.5	Poor
1	15MN025	Trib. to Marsh Lake	0.0	10.0	2.0	1.0	4.0	17.0	Poor
Average Habitat Results: ***County Ditch No. 3A Aggregated 12 HUC***			**0.9**	**9.6**	**12.6**	**4.6**	**6.7**	**34.4**	**Poor**
# Visits	**Biological station ID**	**Reach name**	**Land use (0-5)**	**Riparian (0-15)**	**Substrate (0-27)**	**Fish cover (0-17)**	**Channel morph. (0-36)**	**MSHA score (0-100)**	**MSHA rating**
2	01MN019	Unnamed trib. to Emily Creek	0.6	7.0	2.5	12.0	16.0	38.1	Poor
2	15MN027	Emily Creek	0.0	8.0	12.3	12.0	18.0	50.3	Fair
2	15MN401	Emily Creek	2.5	11.5	4.4	11.5	7.0	36.9	Poor
Average Habitat Results: ***Lac Qui Parle Lake-Minnesota River Aggregated 12 HUC***			**1.0**	**8.8**	**6.4**	**11.8**	**13.7**	**41.8**	**Poor**

Qualitative habitat ratings

= Good: MSHA score above the median of the least-disturbed sites (MSHA>66)

= Fair: MSHA score between the median of the least-disturbed sites and the median of the most-disturbed sites (45 < MSHA < 66)

= Poor: MSHA score below the median of the most-disturbed sites (MSHA<45)

Appendix 6. Lake protection and prioritization results

Lake ID	Lake Name	Mean TP	Trend	% Disturbed Land Use	5% load reduction goal	Priority
06-0050-00	Otrey	235.0	Insufficient Data	66%	288	C
06-0090-01	Bentsen	133.0	Insufficient Data	74%	293	C
06-0102-00	Thielke	291.0	Insufficient Data	66%	151	C
06-0170-00	Barry	472.0	Insufficient Data	77%	190	C
06-0251-00	Unnamed (Taffe)	241.0	Insufficient Data	82%	25	C
06-0424-00	Unnamed	325.0	Insufficient Data	32%	22	C
76-0141-00	Shible	67.0	Insufficient Data	73%	36	B