Watershed health

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Kettle River Watershed Monitoring and Assessment Report

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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List of acronyms

AQL Aquatic Life

AQR Aquatic Recreation

CD County Ditch

CI Confidence Interval

CLMP Citizen Lake Monitoring Program

CR County Road

CSAH County State Aid Highway

CSMP Citizen Stream Monitoring Program

CWA Clean Water Act

CWLA Clean Water Legacy Act

DOP Dissolved Orthophosphate

EPA United States Environmental Protection Agency

EQuIS Environmental Quality Information System

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

K Potassium

LRVW Limited Resource Value Water

MCES Metropolitan Council Environmental Services

MNDNR Minnesota Department of Natural Resources

MDA Minnesota Department of Agriculture

MDH Minnesota Department of Health

MINLEAP Minnesota Lake Eutrophication Analysis Procedure

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

OP Orthophosphate

P Phosphorous

PCB Poly Chlorinated Biphenyls

PWI Protected Waters Inventory

RNR River Nutrient Region

SWAG Surface Water Assessment Grant

SWCD Soil and Water Conservation District

SWUD State Water Use Database

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 Kettle River Watershed is a Minnesota treasure. This watershed is an outdoor enthusiast's playground, with two Minnesota state parks and several recreational areas in and around this watershed. Providing ample opportunity for locals and travelers alike to enjoy activities such as fishing, paddling, climbing, camping, and taking in the scenic views. Maintaining the beauty and water quality of the Kettle River Watershed should remain a top priority.

Water quality conditions throughout the Kettle River Watershed are generally categorized as good to great. The statewide adoption of the Tiered Aquatic Life Use (TALU) framework allowed MPCA to designate several exceptional use (highest quality habitat) streams within the watershed. Biologists sampled two fish species recognized by the state as species of special concern: lake sturgeon and gilt darter. Aquatic life (AQL) use standards are met on 78% of the assessed stream reaches, and 61% of lakes sampled for fish (4 out of 13 lakes had inconclusive assessments). Aquatic recreation (AQR) use standards were met on only 46% of stream reaches sampled for *E. coli* bacteria. The poor performance of AQR results in streams is largely driven by the Grindstone River subwatershed, in which none of the six assessed streams support recreation uses at this time. Roughly, 50% of the lakes assessed for AQR use met standards. Nearly half of the new AQR impairment listings are found within the Pine River subwatersheds, which indicates restoration efforts are needed.

Mercury in fish tissue remains an issue for the Kettle River Watershed. With 13 of the 16 tested lakes listed as impaired for high mercury in fish tissue. Of those 13 lakes, 9 have high enough levels for the Minnesota Statewide Mercury TMDL. Along with Mercury, fish tissues were tested for polychlorinated biphenyls (PCBs) at 7 lakes. None of these samples came back with a detectable level of PCB.

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 water bodies 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 water body 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 (CWLA) 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 Kettle River Watershed beginning in the summer of 2016. This report provides a summary of all water quality assessment results in the Kettle River 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 strategy utilizes a nested watershed design allowing the sampling of streams within watersheds from coarse to fine scale (Figure 1). Each watershed scale is defined by a hydrologic unit code (HUC). These HUCs define watershed boundaries for water bodies 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 are sampled in a systematic way. Insuring a more holistic assessment of the watershed and problem areas can be identified without monitoring every stream reach. Each major watershed is the focus of attention for at least one-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 1). 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 dot 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, it 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.

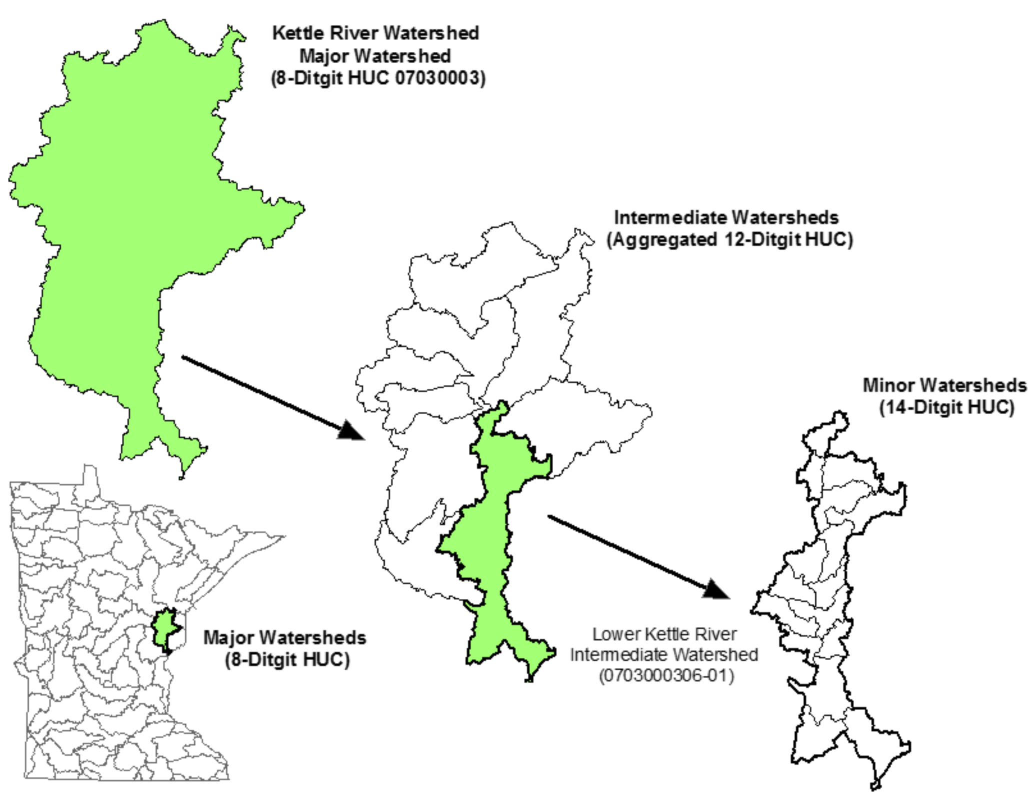
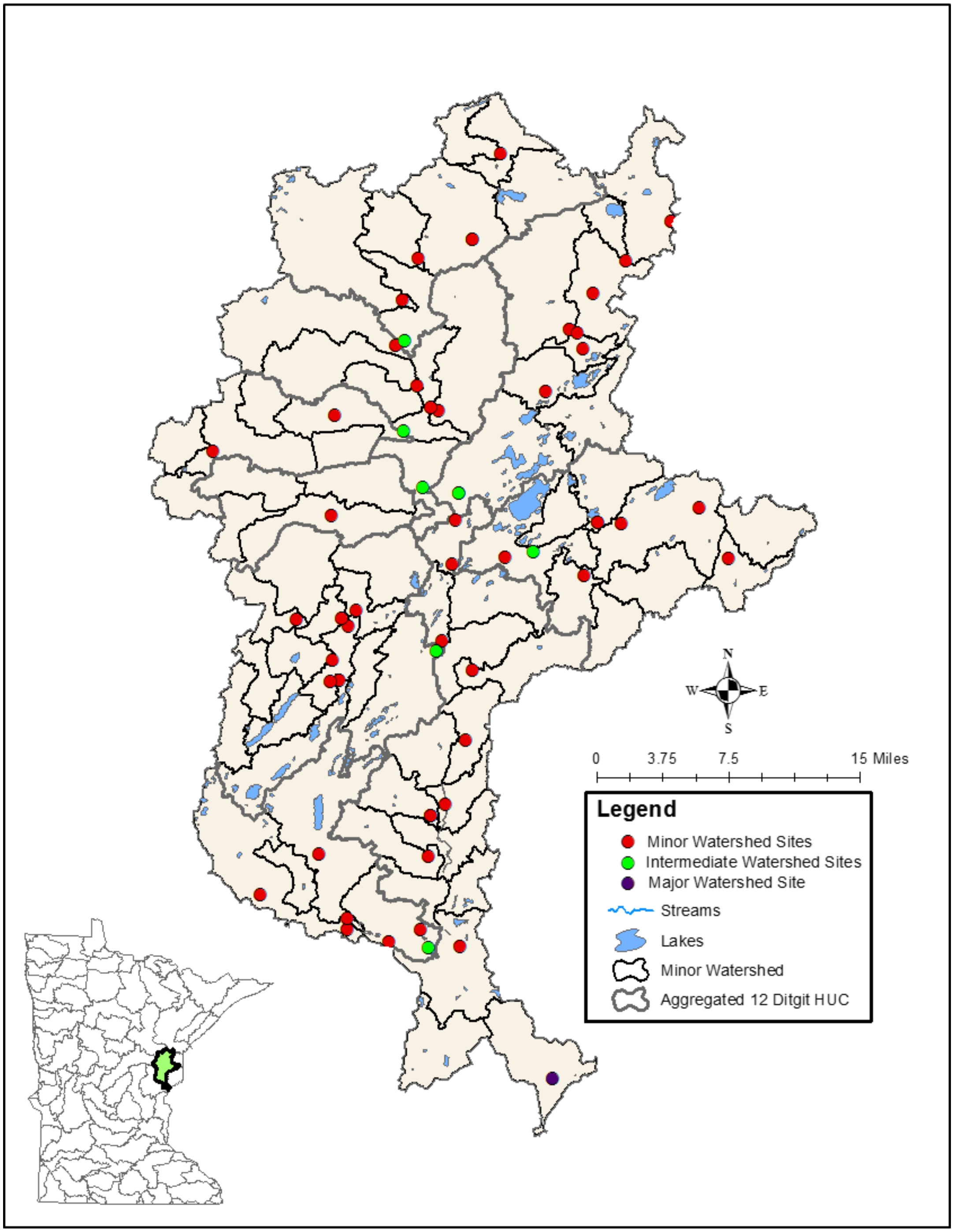


Figure 2. Intensive watershed monitoring sites for streams in the Kettle River Watershed.



Lake monitoring

Lakes most heavily used for recreation 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 (greater than 100 acres), accessibility (can the public access the lakes), and presence of recreational use.

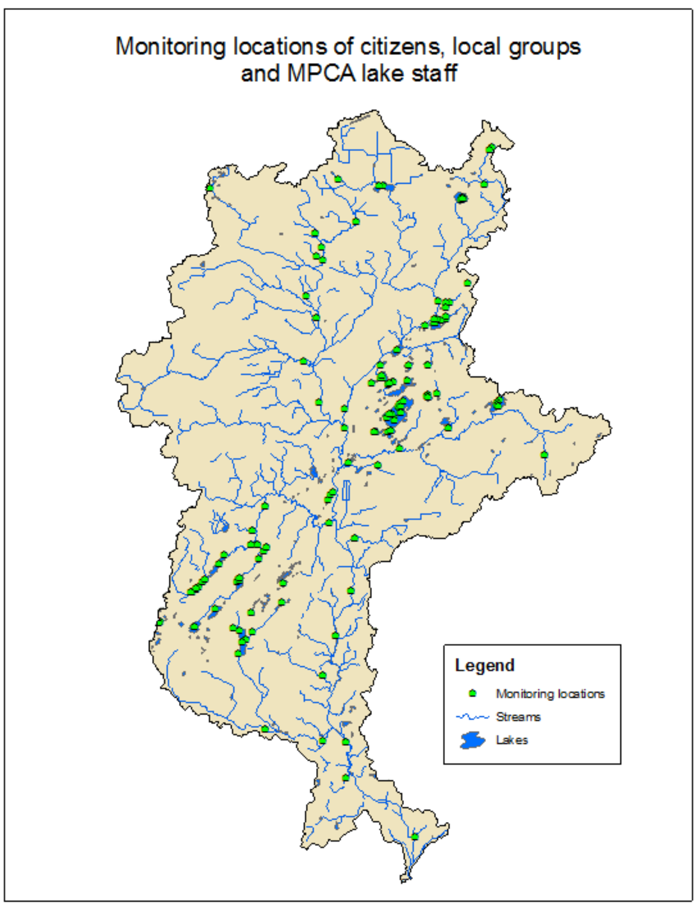
Specific locations for sites sampled as part of the intensive monitoring effort in the Kettle River Watershed are shown in [Figure 2](#) and are listed in [Appendices 2.1 and 2.2](#).

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 intensive watershed monitoring (IWM) process. Funding passes from MPCA through a Surface Water Assessment Grant(s) (SWAG) to local groups such as counties, soil and water conservation districts (SWCDs), 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 (CLMP) and the Citizen Stream Monitoring Program (CSMP). 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 an illustration of the locations where citizen monitoring data were used for assessment in the Kettle River Watershed.

Figure 3. Monitoring locations of local groups, citizens and the MPCA lake monitoring staff in the Kettle River 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, 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 water body 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, macroinvertebrates, 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 Minnesota Department of Natural Resources (MNDNR) to determine if lakes are meeting aquatic life use. Because the lakes, rivers, and streams in Minnesota are physically, chemically, and biologically diverse, IBI's 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, 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). These tiered aquatic life uses are determined before assessment based on the attainment of the applicable biological criteria and/or an assessment of the habitat (MPCA 2015). 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. Tiered aquatic life use standards.

Tiered aquatic life use	Acronym	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.

Tiered aquatic life use	Acronym	Use class code	Description
Cold water Exceptional	CWe	2Ae	Cold water 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, dissolved oxygen 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 United States Geological Survey (USGS) 8-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 MNDNR. The Protected Waters Inventory (PWI) 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.

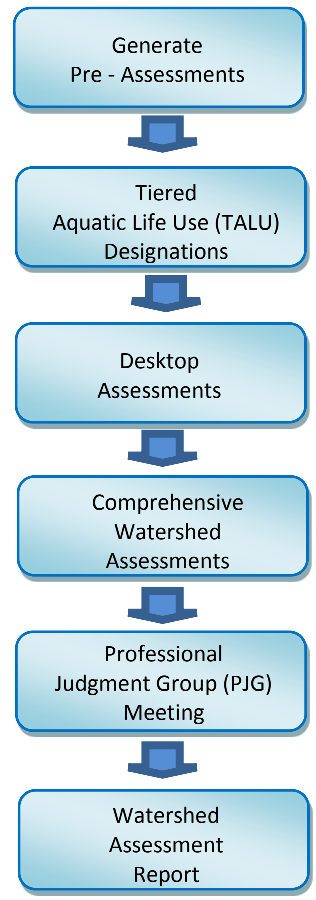
It is for these specific stream reaches or lakes that the data are evaluated for potential use impairment. Therefore, any assessment of use support would be limited to the individual assessment unit. The major exception to this is the listing of rivers for contaminants in fish tissue (aquatic consumption). 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 aquatic life 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.

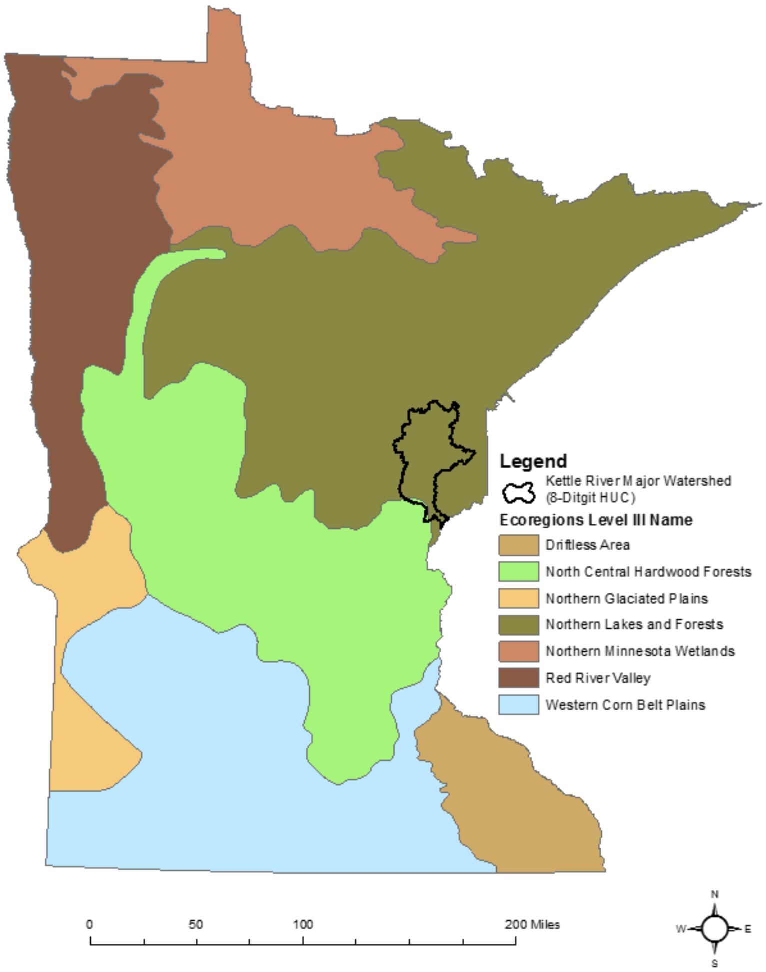
The last step in the assessment process is the Professional Judgment Group meeting. Here results are shared and discussed with entities outside of the MPCA that may have been involved in data collection or that might be responsible for local watershed reports and project planning. Information obtained 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

Located in east central Minnesota, the Kettle River Watershed is approximately 672,924 acres. That acreage is largely made of forests and wetlands. Flowing mainly southward, the Kettle River pours into the St. Croix River in Minnesota's St. Croix State Park. The western headwater streams reach out into Aitkin and Kanabec counties, though the Kettle River mainly flows through Carlton and Pine counties.

Much of the Kettle River Watershed is within the Northern Lakes and Forest ecoregion of Omernick level III Ecoregions (Omernik & Gallant, 1988). A sliver of the watershed falls in the Northern Central Hardwood Forest. Much of the Northern Lakes and Forest region is known for its glacial soils, mixing of pine and hardwood forests, and wealth of glacial lakes and wetlands. This ecoregion is typically not well suited for most cropland agriculture due to soil types and shorter growing seasons. The Northern Central Hardwood Forest ecoregion acts as a transitional zone between what many see as the pine forested north and the agricultural plains and prairies of southwestern Minnesota. This region has longer growing season and soils that are more farmable. On a rough scale, we can see how these ecoregion descriptions relate to the land use in the watershed. Much of the northern portion is covered in wetlands and forests dotted with lakes. Moving south there is a slight change from wetlands to forests. In this transition, larger amounts of rangeland and croplands appear. In this watershed, the cropland is mostly hay fields though there are some small fields of row crops.

Figure 5. The Kettle River Watershed within the Northern Lakes and Forest and Northern Central Hardwood Forests ecoregions of East Central Minnesota.

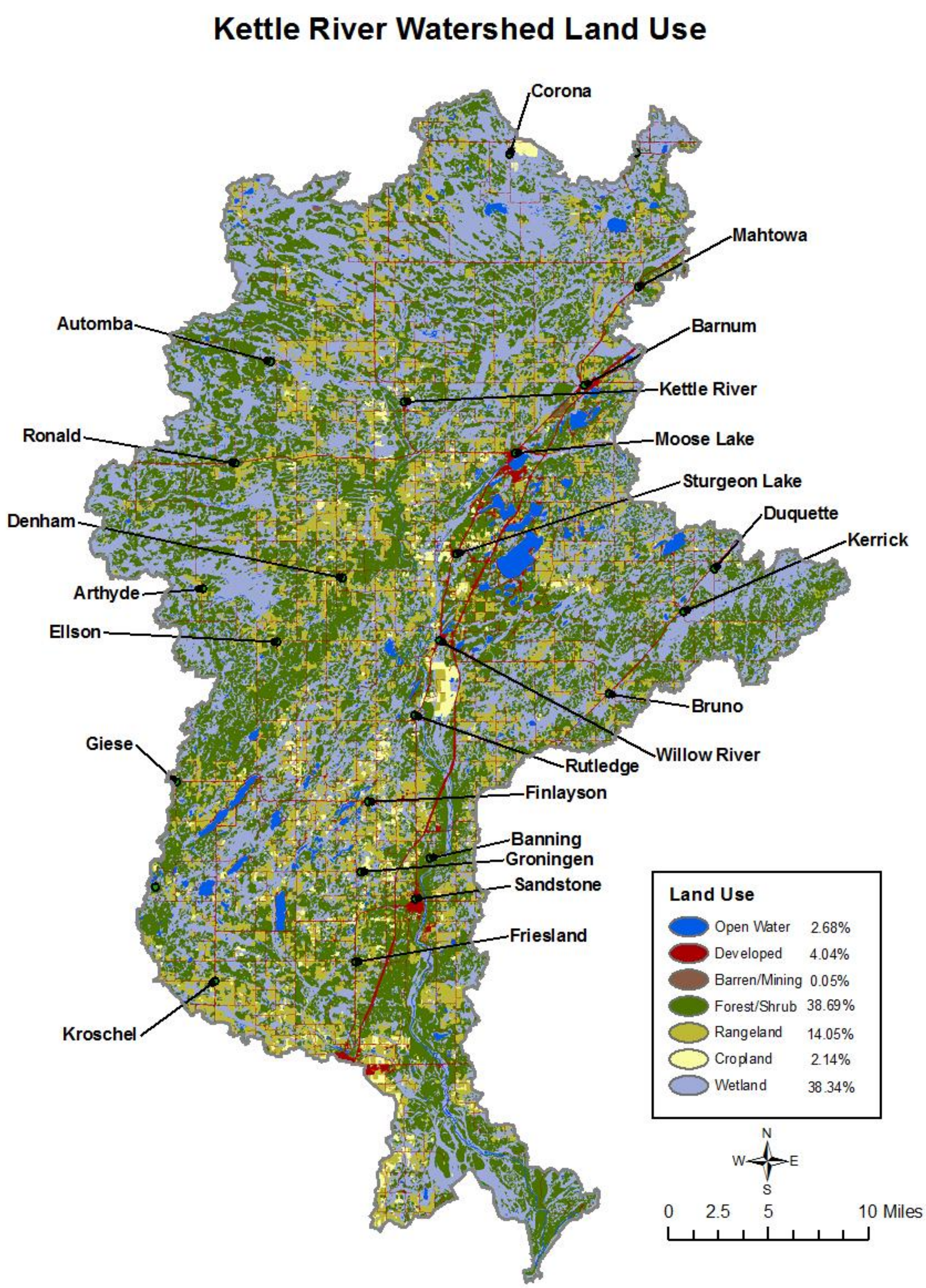


Land use summary

Just over three quarters of the Kettle River Watershed is privately owned. A little more than 22% is owned by state land, another 1% is county, federal, or conservancies (NRCS). In addition, a small percentage is tribal owned.

A large part of this watershed is covered in forests and wetlands, as can be seen in Figure 7. Both Forest/Shrub and Wetlands make up about 38% of the watershed individually. The next largest land use is rangeland at 14%. Rangeland is scattered thought the watershed, but starts becoming more noticeable along the southwestern edge. Cropland only makes up around 2% of the watershed, and is mostly found around Rangeland. This watershed is not heavily developed. Much of the area that is developed is along the Highway 35 corridor that runs north and south between the Twin Cities and Duluth.

Figure 6. Land use in the Kettle River Watershed.



Surface water hydrology

In the northern most part of the watershed, the Kettle River starts in a small complex of altered stream channels four miles east of Cromwell, and just north of state highway 210. The river then flows south 1.5 miles through Little Kettle Lake, a shallow 11 acre lake. From there it continues south meeting up with a ditch flowing out of Kettle Lake (ID-09004900). After passing Kettle Lake, the river turns westward then southeast. Just after the river starts meandering southwest, the river changes from being altered and starts flowing in its natural path. Two and a half miles further south Heikkila Creek joins the Kettle River flowing in from the Northwest. Once Joined with Heikkila Creek the Kettle River flows another two miles south where it joins with the West Branch Kettle River. The West Brach Kettle River starts in Section One Lake, two miles west of the city of Wright. Starting out the West Brach Kettle River winds its way thought several small lakes including Mattlia and another Kettle Lake (ID-09007400).

Once it leaves the small chain of lakes, it continues southeasterly joining the Kettle River. Further downstream the Kettle River meets up with the Dead Moose River. The Dead Moose River starts in the West, and flows north for a stretch before dropping southeast. After the Kettle River joins the Dead Moose, it continues south past the town of Kettle River. Further south of town the Kettle River is met by Silver Creek. Silver Creek runs nearly parallel with the Dead Moose River. Further downstream the Kettle River is joined by Gillespie Brook. Gillespie Brook is the first larger river system to join the Kettle River from the east. The headwaters for Gillespie Brook are in Kalevala and Skelton townships of Carlton County. These flow east for a short time then swoop gently southwest.

The next river the Kettle meets is the Split Rock River. Split Rock River starts to the southeast in Atkin County's White Pine and Millward townships. This area has a system of ditches that connects with the Mississippi River – Brainerd and Snake River Watersheds. This ditched system flows northward into Split Rock Lake (ID-01000200). After the lake, the Split Rock River remains a natural channel as it winds its way further north than east to the Kettle River. Continuing downstream the Kettle River intersects with Birch Creek. Birch Creek starts in Atkin County's Millward Township and flows easterly towards the town of Denham. Once the creek reaches Denham it dips south, northeast, then east to the Kettle River.

It is only a short distance down the Kettle River when the Moose Horn River. The Moose Horn River and Moose Horn HUC 12 are a long system that reaches to the far northeastern corner of the Kettle Watershed. Three headwater streams of the Moose Horn get their start in small lakes including Wild Rice (ID-09002300), Park (ID- 09002900), and two unnamed lakes (ID-09002700, 09009200). Wild Rice Lake is northern most lake in its HUC 12, and it is where the Moose Horn River starts. The Moose Horn flows south past Bob Lake (ID- 09002600), then winds its way to Park Lake Creek. Park Lake Creek flows south out of Park Lake, and over Park Lake dam. The Moose Horn continues southwest, soon paralleling county road 61 and joining with Kind Creek. After King Creek, the Moose Horn River continues southward until it joins with the West Branch Moose Horn River. The West Branch Moose Horn starts in the north snaking its way southwest then eastward to meet up with the mainstem Moose Horn. After the West Branch and Moose Horn rivers converge, the Moose Horn flows past the city of Barnum and under highway 35. After highway 35, it hits the Hanging Horn chain of lakes. First, it enters Hanging Horn Lake (ID-09003800) on the north end of the lake, and exits on the northwest corner. This is followed by Eddy Lake (ID-09003900), entering and exiting on the northern edge of the lake. After Eddy Lake, the river flows past the City of Moose Lake and enters Moosehead Lake (ID-09004100) on the northeastern edge. The Portage River, flowing in from the east, also enters Moosehead Lake. From Moosehead Lake, the Moose Horn River exits on the southwestern edge and continues southwest until it joins with the Kettle River. Here the Kettle River continues south 4.8 miles when it is joined by the Willow River from the east.

The Willow River HUC 12 has three river branches, Hay Creek the Willow Mainstem and the Little Willow. The Willow River Starts 5.5 miles northeast of the city of Kerrick and flows west until it joins Hay Creek from the north. After Hay Creek, Willow Creek starts flowing southward towards Willow Lake (ID-58007500). Within Willow Lake, Willow Creek and the Little Willow River merge and flow east past Passenger Lake (ID-58007600) then Big Slough Lake (ID-58007700). From there the Willow River continues until it reaches the north end of Stanton Lake (ID-58011100). Stanton Lake, just north of the Town of Willow River, held what was the Willow River Dam. This dam was damaged during the 2016 summer floods, draining much of Stanton Lake. After the dam, the Willow River then continues south and west to meet the Kettle River. Here the Kettle River continues southward past the city of Rutledge.

Near Rutledge, the Pine River joins with the Kettle River. The Pine River's headwaters are small tendrils that flow into Pine (ID-01000100) and Big Pine (ID-58013800) Lakes. After flowing over Big Pine Lake Dam, the river flows northeast through a short channelized reach on its way to the Little Pine River. The Little Pine River starts in Eleven Lake (ID-33000100) then flows northeast to Upper Pine Lake (ID-58013000) then through Little Pine Lake (ID-58012900). After Little Pine Lake, the Little Pine River turns north and joins with the larger Pine River. The Pine River continues northward as it meets with Rhine Creek. Rhine Creek starts with several small streams gathering in Rhine Lake (ID-58013600). Rhine Creek makes its way through a wetland complex with little to no definable channel before forming a channel flowing south and east to join with the Pine River. Next, the Pine River winds northward meeting up with Bremen Creek from the west and eventually Medicine Creek from the South. After Medicine Creek, the Pine River flows eastward south of the Town of Rutledge.

After Rutledge, the Kettle is joined by Cane Creek from the East. Cane Creek's headwaters are channelized reaches that run into Stevens Lake (ID-58005900). Much of Cane Creek is natural, but a section of channelized stream flowing under state Highway 35. In this reach, a constructed structure drops the creek three to four feet under the highway and a few miles before entering the Kettle. Then the Kettle itself flows under Highway 35 and continues south though Banning State Park, past the city of Sandstone, through Robinson Park, and over the once flooded Big Spring Falls.

Seven miles later the Kettle meets up with the Grindstone River. There are two main branches to the Grindstone River. The North Branch Grindstone starts north of Grindstone Lake (ID-58012300), and flows out the southern end of the lake towards the city of Hinckley. The South Branch starts in the west and flows south and east joining the North Brach Grindstone River north of Hinckley, in the Grindstone Reservoir (ID-58012100). The Grindstone Reservoir is created by the Grindstone Dam at the southeast end of the reservoir. Once the river leaves the Reservoir it becomes the Grindstone River. From here, the river flows east along the northern edge of Hinckley, under Highway 35, and to the Kettle River. At the convergence with the Grindstone River, the Kettle River continues southeast about 15 miles before entering the St. Croix River.

The Kettle River Watershed is a large network of streams and rivers, many of which are natural. Just over 26% of the watershed is channelized (Figure 7, Figure 8), mainly in the small tendril streams in the headwaters.

Figure 7. Map of percent altered streams by major watershed (8-HUC).

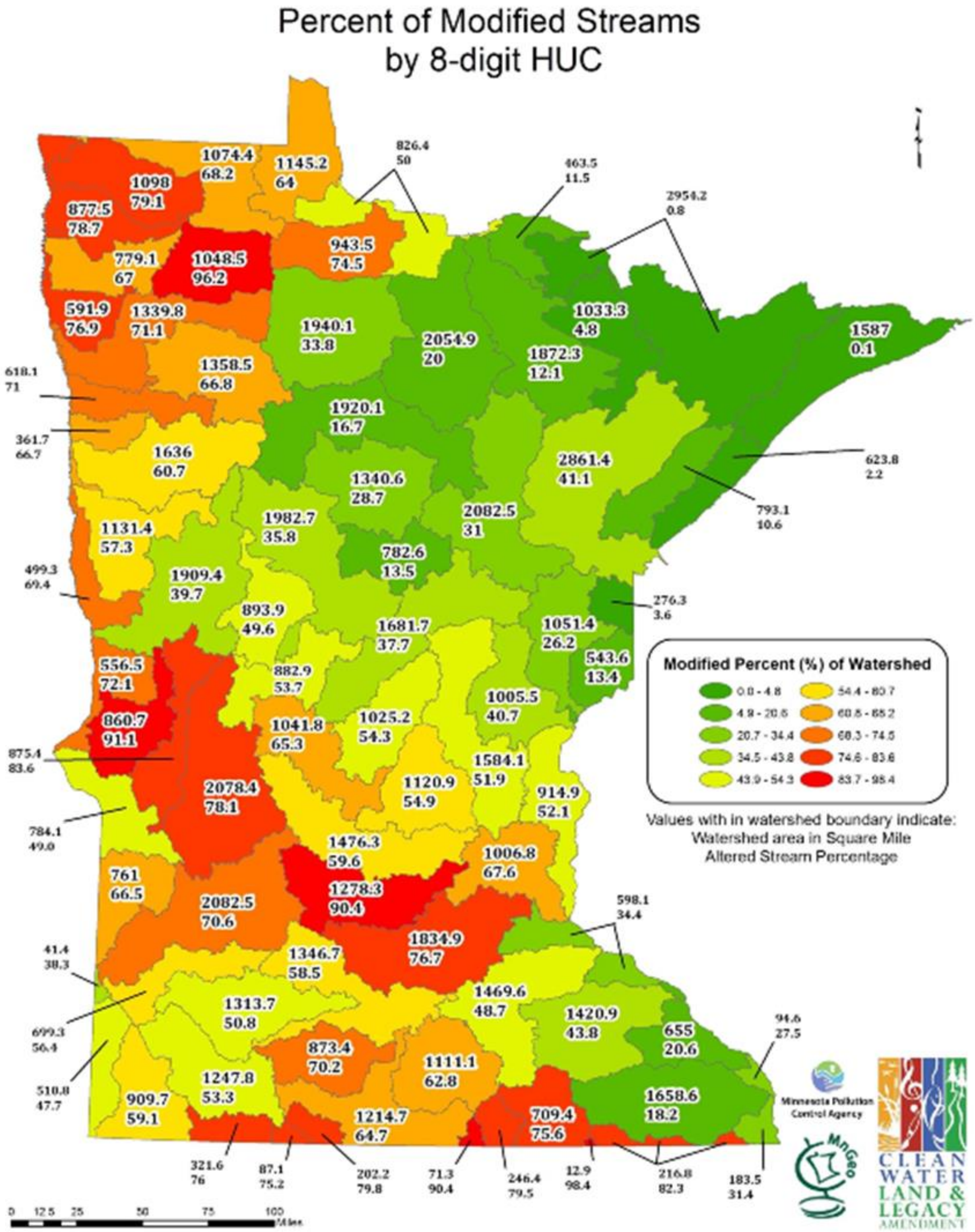
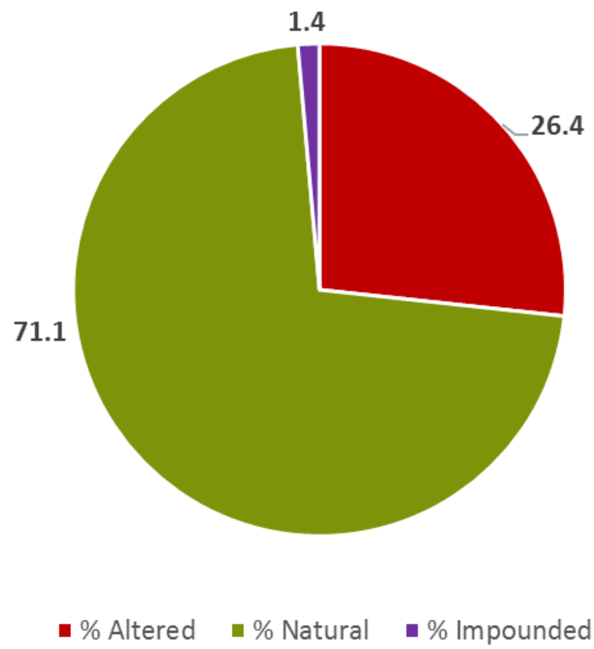


Figure 8. Comparison of natural to altered streams in the Kettle Watershed

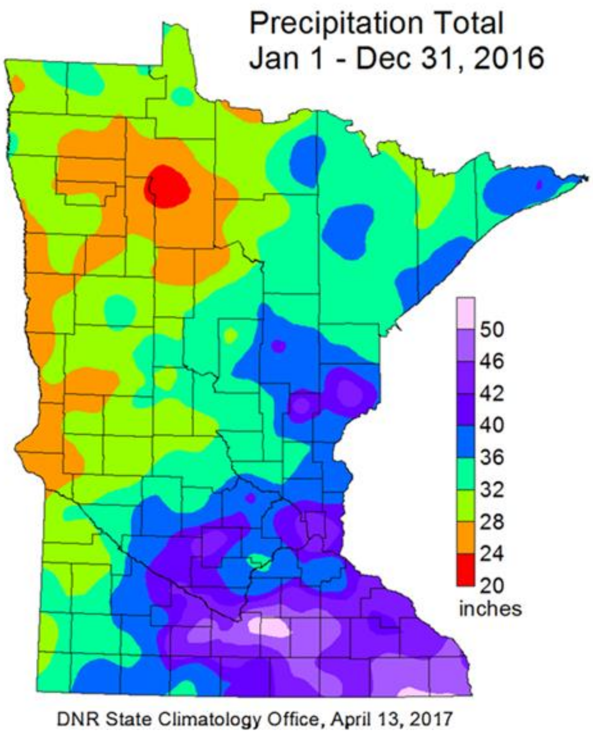


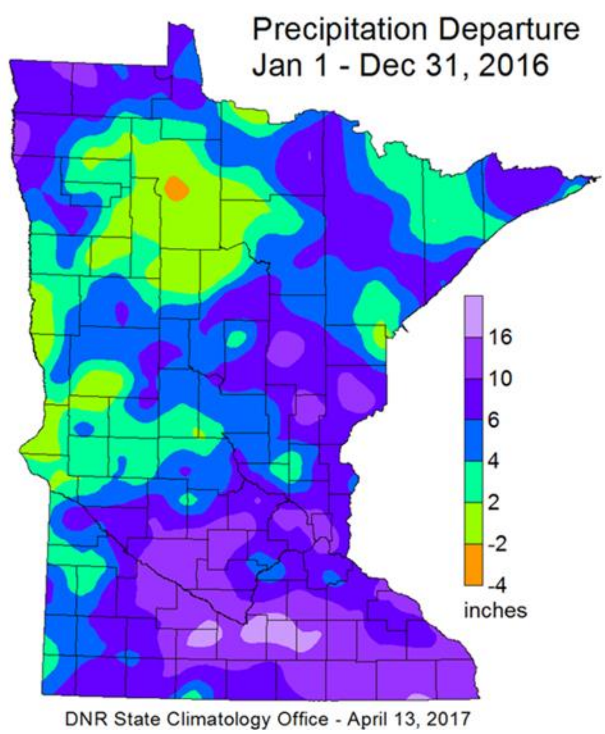
Climate and precipitation

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 summer (June-August) temperature for the Kettle River Watershed is 18.9˚C and the mean winter (December-February) temperature is -10.3˚ C (MNDNR: Minnesota State Climatology Office, 2019).

Precipitation is an important source of water input to a watershed. Figure 9 displays two representations of precipitation for calendar year 2016. On the left is total precipitation, showing the typical pattern of increasing precipitation toward the southeastern portion of the state. According to this figure, the Kettle River Watershed area received 36 to 50 inches of precipitation in 2016. The display on the right shows the amount that precipitation levels departed from normal. The watershed area experienced precipitation that ranged from six to sixteen inches above normal in 2016.

Figure 9. Statewide precipitation total (left) and precipitation departure (right during 2016 (Source: MNDNR State Climatology Office, 2019b).





The Kettle River Watershed is located within the East-Central precipitation region. Figure 10 and Figure 11 display the areal average representation of precipitation in East-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 East-Central region display no significant trend over the last 20 years. However, precipitation in East-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 10. Precipitation trends in East-Central Minnesota (1996-2015) with five-year running average (Source: WRCC, 2017)

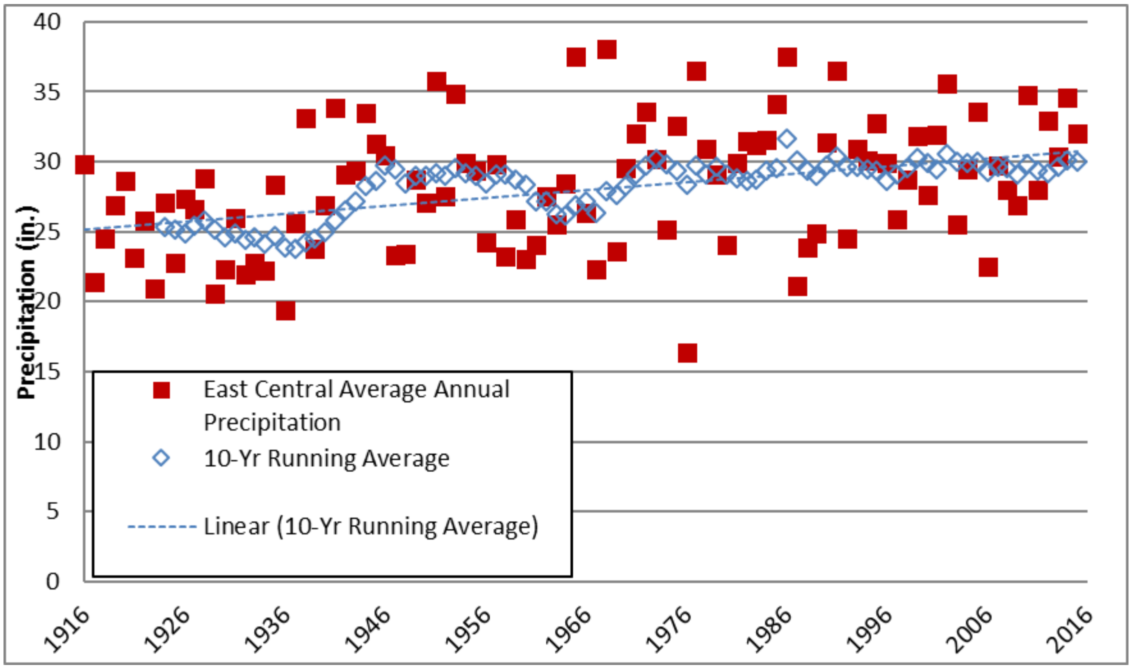
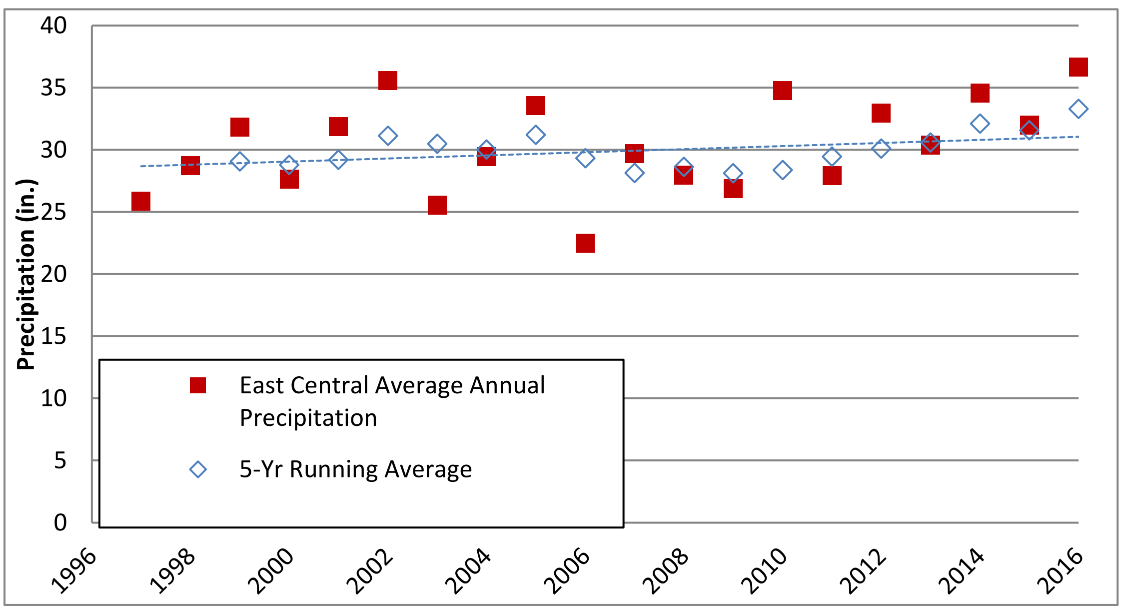


Figure 11. Precipitation trends in East-Central Minnesota (1916-2015) with 10-year running average (Source: WRCC, 2017)



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 Kettle River Watershed contains features of three of Minnesota's Groundwater provinces: the Metro, Central and Arrowhead Provinces. The Metro Province, present in the center of the watershed, is characterized by "sand aquifers in generally thick (greater than 100-feet) sandy and clayey glacial drift overlying Precambrian sandstone and Paleozoic sandstone, limestone, and dolostone aquifers". The northern and southern extents of the watershed are characterized by the Central Province, where there are sandy aquifers in sandy and clayey glacial drift. The portion of the Arrowhead Province in the watershed along the main stem of the Kettle River and straddling the Pine/Carlton County border is characterized Precambrian metamorphic rocks exposed at the surface or covered by thin layers of till. Groundwater here is found in fractures and faults. (MNDNR, 2017a)

Groundwater Potential Recharge

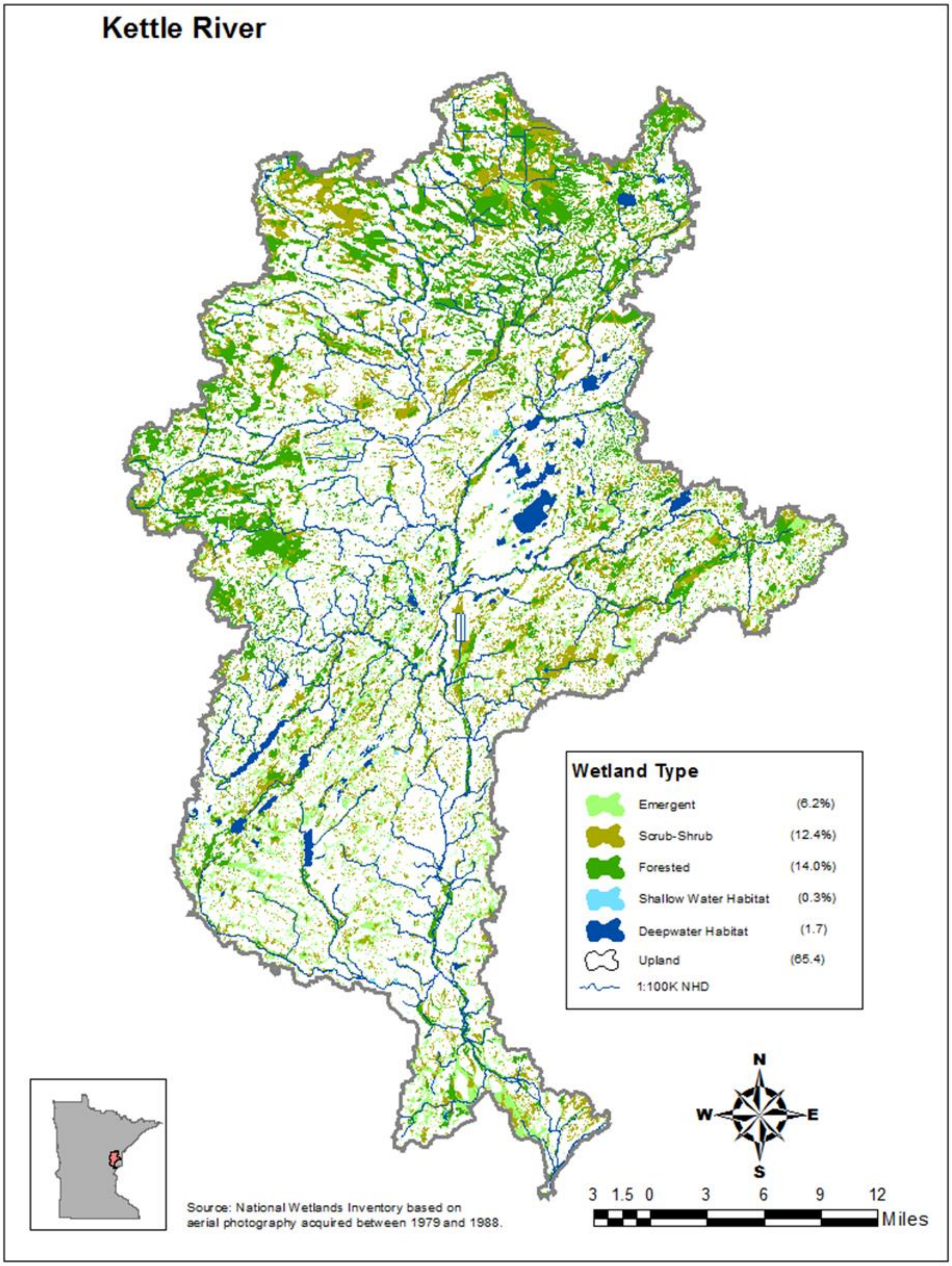
Groundwater recharge is one of the most important parameters in the calculation of water budgets, which are used in general hydrologic assessments, aquifer recharge studies, groundwater models, and water quality protection. Recharge is a highly variable parameter, both spatially and temporally, making accurate estimates at a regional scale difficult to produce. The MPCA contracted the US Geological Survey to develop a statewide estimate of recharge using the SWB – Soil-Water-Balance Code. 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 Kettle River Watershed, the average annual potential recharge rate to surficial materials ranges from 0.6 to 12.8 inches per year, with a mean of 6.8 inches per year. The statewide average potential recharge is estimated to be 4 inches per year with 85% of all recharge ranging from three to eight inches per year (USGS, 2015).

Wetlands

Excluding open water portions of lakes and rivers, the Kettle River Watershed has approximately 220,670 acres of wetlands, which is equivalent to 32.8% of the watershed area. Forested wetlands comprise 14% of the watershed area, and are the most common wetland class in the watershed, just edging out scrub-shrub wetlands, which make up an estimated 12% of the watershed. Emergent and shallow water habitat wetlands round out the wetland areas at 6% and 0.3% respectively. Peatlands comprise 28% of the wetland extent in the Kettle River Watershed. Often called "bogs" peatlands are wetlands with thick deposits of partially decomposed plant material that accumulates as peat. Peatlands can occur as forested, shrub dominated or open herbaceous emergent dominated wetland communities. These estimates of wetland extent and distribution are from the original Minnesota National Wetland Inventory (NWI), based primarily of circa 1982-spring leaf-off imagery. Minnesota's wetland inventory has recently, been updated and is available as preliminary data statewide, though this data is not yet finalized, thus it was not used in these wetland calculations. More information on the NWI update project is available at http://www.dnr.state.mn.us/eco/wetlands/nwi_proj.html.

Figure 12 Wetlands and surface water as percentages in the Kettle River Watershed. Wetland data are from the Original Minnesota National Wetlands Inventory.



The Kettle River Watershed surface geology is complex but it is dominated by ground moraine resulting from the Superior Lobe, during the Wisconsin Glaciation period. Ground moraine is particularly prominent in the central region of the watershed trending from SW to NE. Stagnation and end moraine features are prominently featured in the protruding east central region of the watershed. Peatland complexes occur along the edge of the ground moraine, especially in the NW and the stagnation moraine in the east central region of the watershed in response to flatter elevations. The moraine complexes and the flatter elevation geologic features are either strongly conducive to formation of wetland or in the case of the peatland areas are inherently wetland. Wetlands are well distributed across the Kettle Watershed and comprise an important surface water feature. Many Kettle River Watershed wetlands, especially those with mineral substrates are associated with the stream system.

Wetland Loss Estimates

Nearly the entire extent of the Kettle River Watershed is in the Mixed Wood Shield Ecoregion; except a thin margin area along the southwest edge of the watershed, occurs within the Mixed Wood Plains Ecoregion.

Conversion or loss of wetlands appears to have been limited in the Kettle Watershed, compared to watersheds in the southern and western region of Minnesota. Watershed specific estimates of historic wetland extent in the Kettle Watershed cannot be computed, since SURRGO (Soil Survey Geographic Database) data is not available for Pine County. SURRGO data are needed to quantify soil units classed as ‘Poorly Drained’ or ‘Very-Poorly Drained’ as proxies of historic and contemporary wetland extent. However, the Kettle Watershed is entirely within the larger multiple county, north-central region of Minnesota identified as “Greater Than 80% Historic Wetland” used for administration of the Minnesota Wetland Conservation Act (Minn. R. ch. 8420).

Special Wetland Features

Wetlands in the Kettle River Watershed are important reserves and habitats of unique plant communities supporting over 25 endangered, threatened or special concern listed; plant, bird, reptile/amphibian and macroinvertebrate species. Of special note is the 800-acre Kettle River Scientific and natural Area (SNA), which extends ~ 2 mi. north of CSAH 48 on the eastside of the Kettle River, is a state prohibited discharge Outstanding Resource Value Water (ORVW) designated by Minn. R. ch. 7050.0335. Wetland habitats occupy much of this SNA and support numerous rare communities and listed species including the special concern Louisiana Waterthrush and American water pennywort (Hydrocotyle Americanna), along with the threatened bog bluegrass (Poa paludigena).

Characteristic floodplain native plant communities present within this SNA are Black Ash dominated Northern Terrace Forrest (FFn57a) and Northern Floodplain Forest - Silver Maple-Sensitive Fern Floodplain Forest (FFn67a) (MNDNR 2003).

Watershed-wide data collection methodology

Lake water sampling

MPCA and local partners (Pine and Carlton County SWCDs) collected chemistry data on 32 lakes within the 10-year assessment window. Historically, volunteers enrolled in the Citizen Lake Monitoring Program (CLMP) have conducted Secchi transparency monitoring on 42 lakes within the watershed on behalf of MPCA. 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 transparency depth.

Stream water sampling

SWAGs were awarded to the Pine County and Carton County SWCDs to collect assessment level data at nine IWM stream stations from May through September in 2016, and again June through August of 2017. These data provided sufficient water chemistry data to assess all components of the aquatic life and recreation use standards. Following the IWM design, water chemistry stations were primarily placed at the outlet of each aggregated 12 HUC subwatershed that was >40 square miles in area (purple circles and green circles/triangles in (Figure 2; 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). Due to the lack of a road crossing access near the outlet of the Birch Creek aggregated 12-HUC subwatershed, an intensive chemistry collection station was instead placed downstream at the next road crossing (in the Lower Kettle River aggregated 12-HUC). Volunteers enrolled in the CSMP supplied Secchi tube transparency data at fourteen stream stations in the watershed.

Stream flow methodology

MPCA and the MNDNR 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 MNDNR/MPCA Cooperative Stream Gaging webpage at: http://www.dnr.state.mn.us/waters/csg/index.html.

Lake biological sampling

Thirteen lakes were monitored for fish community health in the Kettle River Watershed. While data from the last 10 years contributed to the watershed assessments, the majority of data utilized for the 2018 assessment was collected in 2012-2017. Waterbody assessments to determine aquatic life use support were completed for nine lakes; four lakes had insufficient data.

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 that 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, MNDNR). 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 intensive watershed monitoring in the Kettle River Watershed was completed during the summer of 2016 and 2017. Forty-four sites were newly established and sampled across the watershed. These sites were located near the outlets of most minor HUC-14 watersheds. In addition, 15 existing biological monitoring stations within the watershed were revisited between 2016 and 2017. Some of these monitoring stations were initially established as part of a random St. Croix River Basin survey in 1996 or 2006. While data from the last 10 years contributed to the watershed assessments, the majority of data utilized for the 2018 assessment was collected in 2016 and 2017. Forty-two WIDs were sampled for biology in the Kettle River Watershed. Waterbody assessments to determine aquatic life use support were conducted for 41 WIDs. Biological information that was not used in the assessment process 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, indices of biological integrity (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 MNDNR 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 polychlorinated biphenyls (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 poly- and perfluoroalkyl substances (PFAS), whole fish were shipped to AXYS Analytical Laboratory, which analyzed the homogenized fish fillets for 13 PFAS. Of the measured PFAS, 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 U.S. Environmental Protection Agency (EPA). 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 (DOP), nitrate plus nitrite nitrogen (NO_3+NO_2-N), and total Kjeldahl nitrogen (TKN).

More information can be found at the [WPLMN website https://www.pca.state.mn.us/water/watershed-pollutant-load-monitoring.](https://www.pca.state.mn.us/water/watershed-pollutant-load-monitoring)

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 / Surface Water Withdrawals

The Minnesota MNDNR 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 MNDNR yearly. Information on the program and the program database are found at: http://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/wateruse.html.

Stream Flow

MPCA and the MNDNR jointly monitor stream water quantity and quality at 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. Information and data on these sites are available at the MNDNR/PCA Cooperative Stream Gaging webpage at: http://www.dnr.state.mn.us/waters/csg/index.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 https://www.pca.state.mn.us/water/wetland-monitoring.

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 Kettle River Watershed. 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 2018 Assessment Cycle as well as any impairment listings from previous assessment cycles. Discussion of assessment results focuses primarily on the 2016 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 2018 assessment process (2020 U.S. Environmental Protection Agency [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 macroinvertebrate IBIs), dissolved oxygen, total suspended solids, chloride, pH, total phosphorus, chlorophyll-a, biochemical oxygen demand and un-ionized ammonia (NH_3) 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) or cool or warm water community (2B). 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.

Upper Kettle River Aggregated 12-HUC HUC 0703000301-04

Located in the northwestern most corner of the Kettle River Watershed, this subwatershed is largely in Carlton County with the western edge in Aitkin County. The Upper Kettle River subwatershed drains 126.4 square miles, making up about 12% of the total Kettle Watershed. There are two main river branches in this subwatershed the West Branch Kettle and the Kettle River mainstem. This subwatershed contains several small lakes, many of which are unnamed. Though it does contain two lakes named Kettle and one Little Kettle. Most of these lakes are under 100 acres with the exception of the eastern Kettle Lake, which is just over 441 acres. Considering the area of all the lakes and streams in this subwatershed, the open water land use coverage is only 1.4%. What it lacks in open water it makes up for in wetland coverage at 54.5%, which is the highest percentage in the Kettle River Watershed. After wetland coverage, forest cover is the second highest land use coverage at 31.5%. Other land uses such as cropland, developed, and rangeland coverages are relatively low at 0.8, 2.2 and 9.6% respectively (Figure 15).

Table 2. Aquatic life and recreation assessments on stream reaches: Upper Kettle 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	Eutrophication	**Aquatic life**	**Aquatic rec. (Bacteria)**
07030003-511, *Kettle River*, *Headwaters to W Br Kettle R*	16SC043	19.31	WWg	EXS	MTS	IF	IF	IF	--	IF	IF	IF	IMP	--
07030003-512, *Kettle River*, *West Branch*, *Headwaters (Section One Lk 09-0069-00) to Kettle R*	16SC035	17.23	WWg	MTS	MTS	IF	IF	IF	--	IF	IF	IF	SUP	--
07030003-529, *Kettle River,* *W Br Kettle R to Dead Moose R*	16SC042	4.29	WWg	MTS	MTS	IF	IF	MTS	MTS	MTS	MTS	IF	SUP	IMP
07030003-615, *Unnamed ditch*, *Unnamed ditch to Kettle R*	16SC039	2.55	WWg	MTS	MTS	IF	IF	IF	--	IF	IF	IF	SUP	--

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 3. Lake assessments: Upper Kettle River Aggregated 12-HUC.

Lake name	MNDNR 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		
Kettle	09-0049-00	263	2.5	Deep	NLF	--	--	MTS	--	IF	MTS	EXS	IF	IF
Merwin	09-0058-00	49	16	Deep	NLF	--	--	IF	--	EXS	EXS	MTS	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; **EXS** = 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.

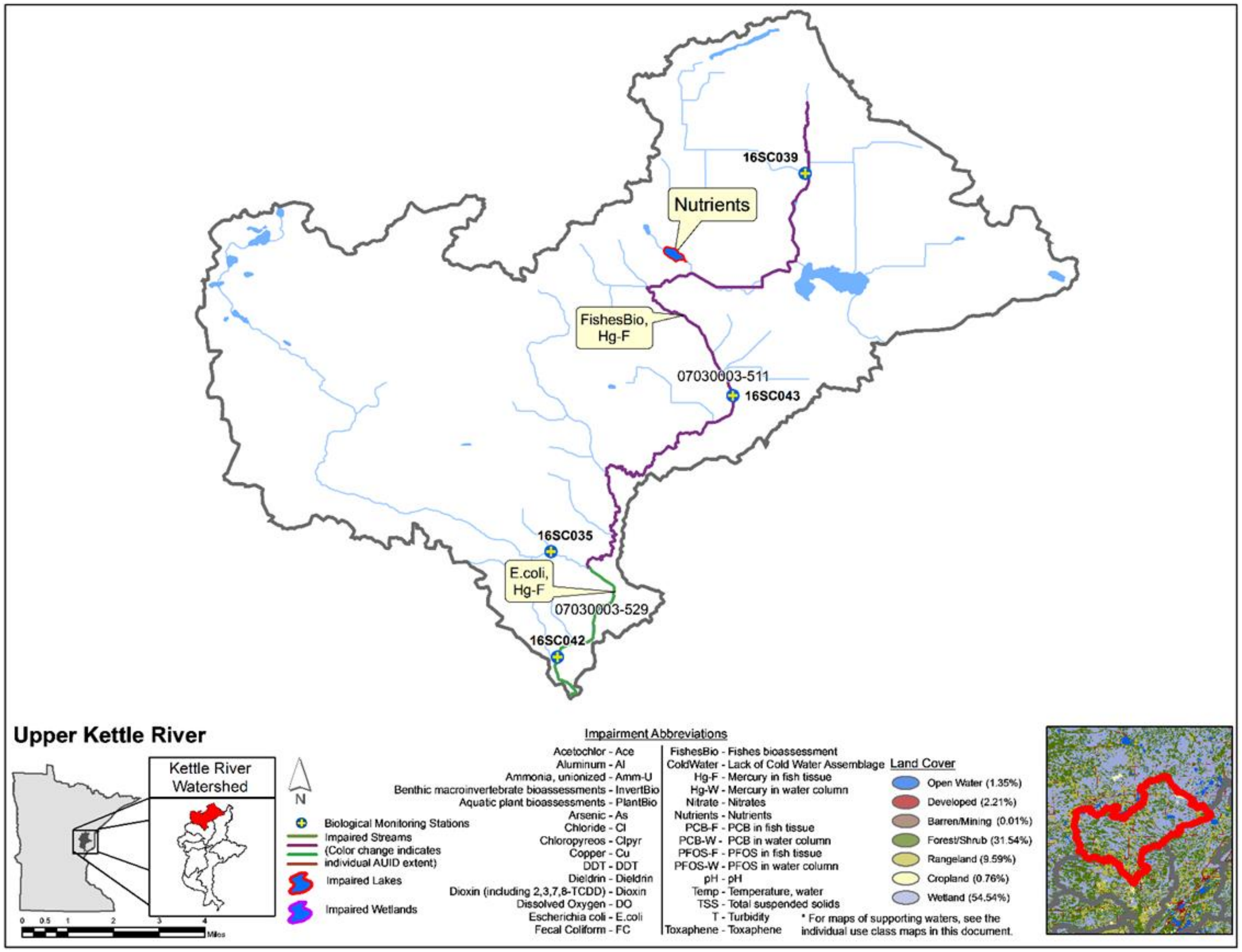
Summary

Fish and macroinvertebrates were sampled at four locations within this subwatershed. Three stations met the standards for both fish and macroinvertebrates. One station on the Kettle River, 16SC043, did not meet the standard for fish IBI, but passed for macroinvertebrate IBI (Table 2). This station was sampled twice, once in 2016 and again in 2017. Both assemblages initially fell below the standard, but samples were collected following a heavy rain event, so a second sample was taken to determine if rain-influenced flows depressed the initial scores. The macroinvertebrate score rebounded by nearly 50 points in 2017, easily passing the impairment threshold. Conversely, the 2017 fish community scored even lower than the 2016 sample, confirming the impairment. Even with one fish biota impairment, this subwatershed still contains sensitive and pollution intolerant fish and macroinvertebrates. The most abundant fish species are the Longnose Dace and Burbot. The majority of individuals and sensitive fish species were captured at station 16SC042, the downstream most site in this subwatershed. High numbers of sensitive macroinvertebrate EPT taxa were captured at three stations in the subwatershed (16SC042, 16SC043, 16SC035).

The Kettle River (-529) does not currently support recreation uses (Table 3). Bacteria samples collected near the outlet of the subwatershed indicate that *E. coli* concentrations are chronically elevated in the mid-summer months (July and August). Other chemistry parameters monitored suggest supporting conditions for the biological communities.

Two lakes in this subwatershed had sufficient data for recreation use assessment. Both lakes exhibit elevated phosphorus concentrations. Merwin Lake does not support recreation use based on recent data with excess algae present. Kettle Lake data were inconclusive in determining a support status; nutrients are elevated, but chl-a is very low and Secchi is likely limited by depth or vegetation. Kettle Lake appears to function more as a wetland than a lake.

Figure 13. Currently listed impaired waters by parameter and land use characteristics in the Upper Kettle Aggregated 12-HUC.



Middle Kettle River Aggregated 12-HUC

HUC 0703000301-01

The Middle Kettle Watershed drains just over 113 square miles and makes up about 10.7% of the total Kettle River Watershed. This subwatershed is located Pine, Carlton, and Aitkin Counties, and contains the city of Kettle River. Within the Middle Kettle subwatershed, the Kettle River flows thought the center, with three larger rivers joining it. The Dead Moose River and Silver Rivers flow into the Kettle from the west and the Gillespie Brook flows in from the east. This subwatershed has very few lakes or ponds, which is evident in the land use of only 1% open water. Forests and wetlands make up the dominant land use coverage at 41 and 40.3%. Rangeland area makes up 13.2% of the land use for the subwatershed.

Table 4. Aquatic life and recreation assessments on stream reaches: Middle Kettle 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	Eutrophication	**Aquatic life**	**Aquatic rec. (Bacteria)**
07030003-509, Gillespie Brook, Headwaters to Kettle R	16SC030	11.59	WWg	MTS	MTS	IF	IF	IF		IF	IF	IF	SUP	
07030003-510, Kettle River, Dead Moose R to Gillespie Bk	92SC018, 96SC040	4.62	WWg	MTS	MTS	IF	IF	IF		IF	IF	IF	SUP	
07030003-537, Dead Moose River, Headwaters to Kettle R	16SC033	15.12	WWg	MTS	MTS	IF	IF	IF		IF	IF	IF	SUP	
07030003-552, Kettle River, Carlton/Pine County line to Birch Cr	10EM024	4.82	WWg	MTS	MTS	IF	IF	MTS	MTS	MTS	MTS	IF	SUP	SUP
07030003-592, Silver Creek, Unnamed cr to Unnamed cr	16SC050	7.33	WWg	MTS	MTS	IF	IF	IF		IF	IF	IF	SUP	

Abbreviations for Indicator Evaluations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **MTS** = Meets criteria; **EXP** = Exceeds criteria, potential impairment; **EXS** = Exceeds criteria, potential severe impairment; **EX** = Exceeds criteria (Bacteria)

Abbreviations for Use Support Determinations: **NA** = Not Assessed, **IF** = Insufficient Information, **NS** = Non-Support, FS = Full Support

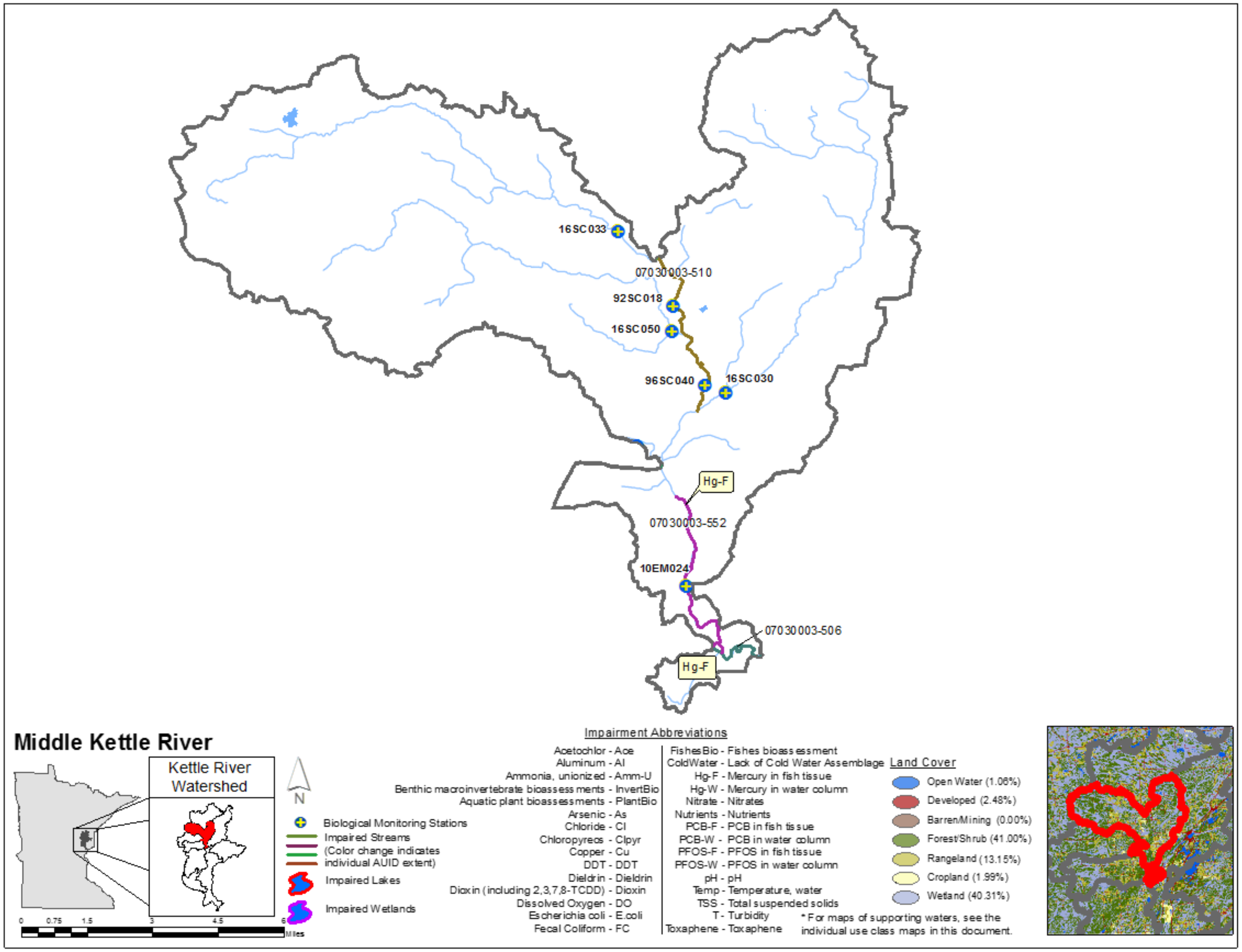
Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use.

Summary

Fish were sampled at six locations and macroinvertebrates were sampled at five, over five assessed reaches. All stations that were sampled met the standards for either fish or fish and macroinvertebrates. The two highest scoring fish sites, 10EM024 and 96SC040, also had the highest number of sensitive species collected. Some of the most abundant sensitive species were the Burbot, Longnose Dace, and Mottled Sculpin. In addition to being pollutant sensitive species, these three species also prefer cooler water temperatures and rocky substrates.

The Kettle River (-552) currently supports recreation uses, but may be vulnerable to a future impairment and is in need of protection. Bacteria concentrations are elevated at times, and capable of exceeding the acute standard. Two upstream river sections were newly identified in 2018 as having excessing bacteria concentrations. Other chemistry samples taken on this portion of the Kettle River meet individual standards. Suspended sediment concentrations are low, and oxygen concentrations are supportive of aquatic life. Nutrients are elevated and concentrations spike following high flow events, but the dataset is too small to assess for eutrophication.

Figure 14. Currently listed impaired waters by parameter and land use characteristics in the Middle Kettle River Aggregated 12-HUC.



Split Rock River Aggregated 12-HUC HUC 0703000301-03

The Split Rock River Watershed drains just over 61.6 square miles and only makes up 5.9% of the total Kettle River Watershed. The western half of this subwatershed is largely in Atkin County with the eastern half between Carlton and Pine Counties. Within this subwatershed, the Split Rock River is the main river system, flowing in eastern direction to the Kettle River. The headwaters of the Split Rock River are in the northeast corner of Solana State Forest. Within the state forest, there are a system of ditches that cross both watershed and basin boundaries to the Mississippi River-Brainerd Watershed and the Upper Mississippi Basin. The web of ditches is likely a factor of the predominance of wetlands in this part of the watershed. Wetland land use covers about 43% of the subwatershed, making it the second dominant land use. The greatest land use cover is forest at just shy of 45% of the subwatershed. This is the highest percentage of forestation of the subwatersheds. On the other end, this subwatershed has the lowest percentages for both developed land and rangelands at nearly 2 and 8.6%. There is also a very low percentage of open water, which is evident in the low number of lakes present in this subwatershed.

Table 5. Aquatic life and recreation assessments on stream reaches: Split Rock 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	Eutrophication	Aquatic life	Aquatic rec. (Bacteria)
07030003-513, Split Rock River, Headwaters to Kettle R	16SC026, 16SC028, 16SC077	21.82	WWg	MTS	MTS	IF	IF	IF	MTS	MTS	MTS	IF	SUP	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

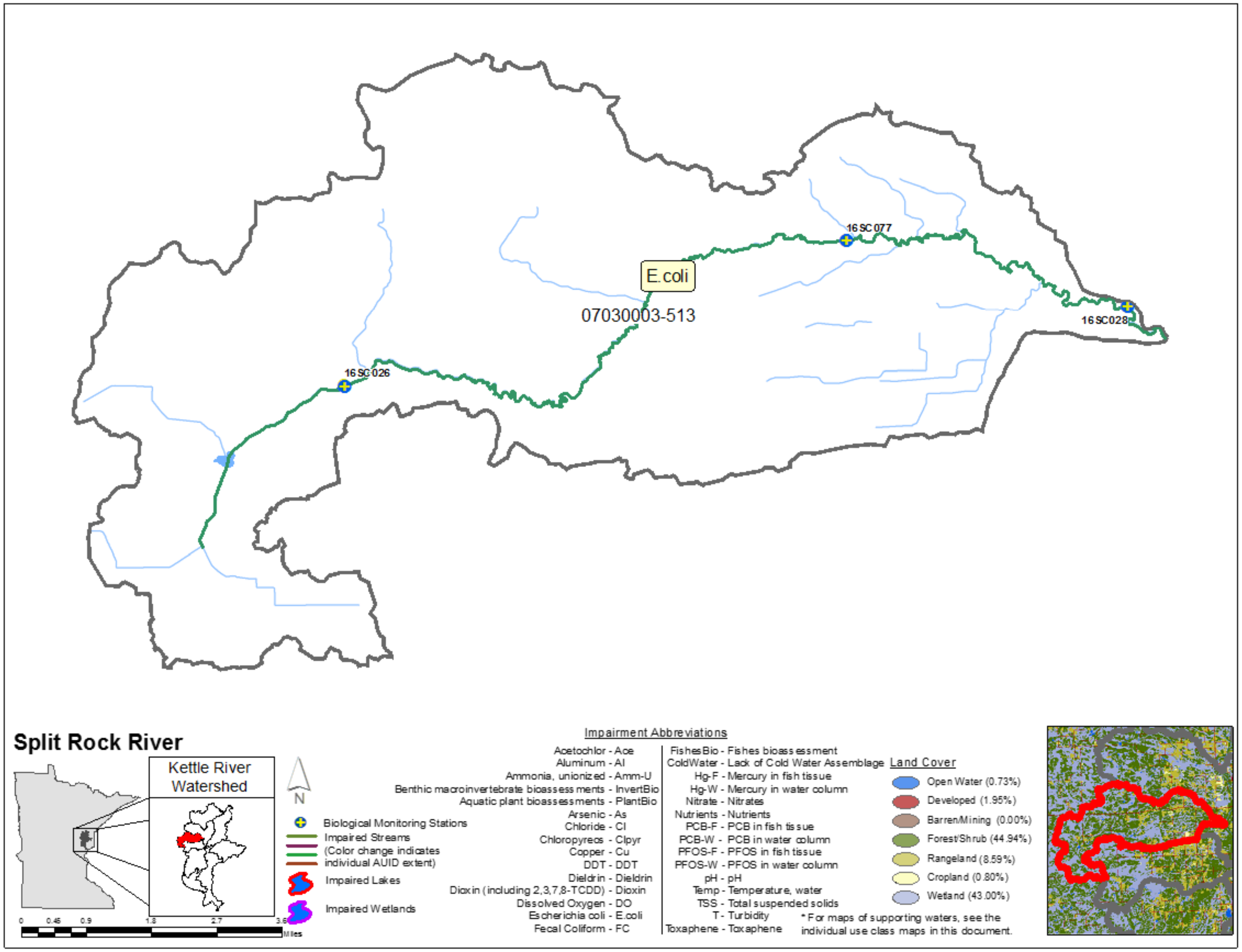
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Summary

Fish and macroinvertebrates were sampled at three locations on one assessed stream reach of Split Rock River. Two of the three sites score above standards for both fish and macroinvertebrate s. The third site, 16SC026, scored below standards but within the confidence interval for both biota. 16SC026 is located on a deep channelized section of the Split Rock River that is connected to complex of wetland ditches that overreach the both watershed and basin boundaries. Poor habitat and low dissolved oxygen levels are likely factors in why this site scored lower than the other two downstream sampling locations. With the downstream two sites scoring above standards and the upstream site still within the confidence intervals of the threshold, the reach is passing standards for aquatic life.

The Split Rock River does not currently support recreation use. Bacteria concentrations are continually elevated and two months exceed the chronic standard for *E. coli*. Efforts to decrease bacteria concentrations in this subwatershed will benefit downstream receiving waters. River nutrient data is mostly from 2016 and reflective of a wet season; concentrations spiked as flows peaked and elevated nutrients lingered as water levels receded. Dissolved oxygen, pH and Secchi tube transparency all have occasional exceedances in their datasets. The combined chemistry data do not show egregious exceedances, but indicate potential stress to the aquatic communities.

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



Birch Creek Aggregated 12-HUC HUC 0703000301-02

Birch Creek Watershed drains just over 50 square miles and is the smallest subwatershed at 4.8% of the Kettle River Watershed. Approximately one third of this subwatershed is in Aitkin County with the remaining part in Pine County. The main river is Birch Creek, which flows west to east a little over 17 miles. On its way to the Kettle River, it passes just south of the town of Denham. Similar to much of the Kettle River Watershed, this subwatershed is dominated by forests and wetlands at 40.7 and 38.7% respectively. Unlike many of the other subwatersheds, Birch Creek subwatershed has the lowest percentage of open water land use coverage with under 1%.

Table 6. Aquatic life and recreation assessments on stream reaches: Birch Creek Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

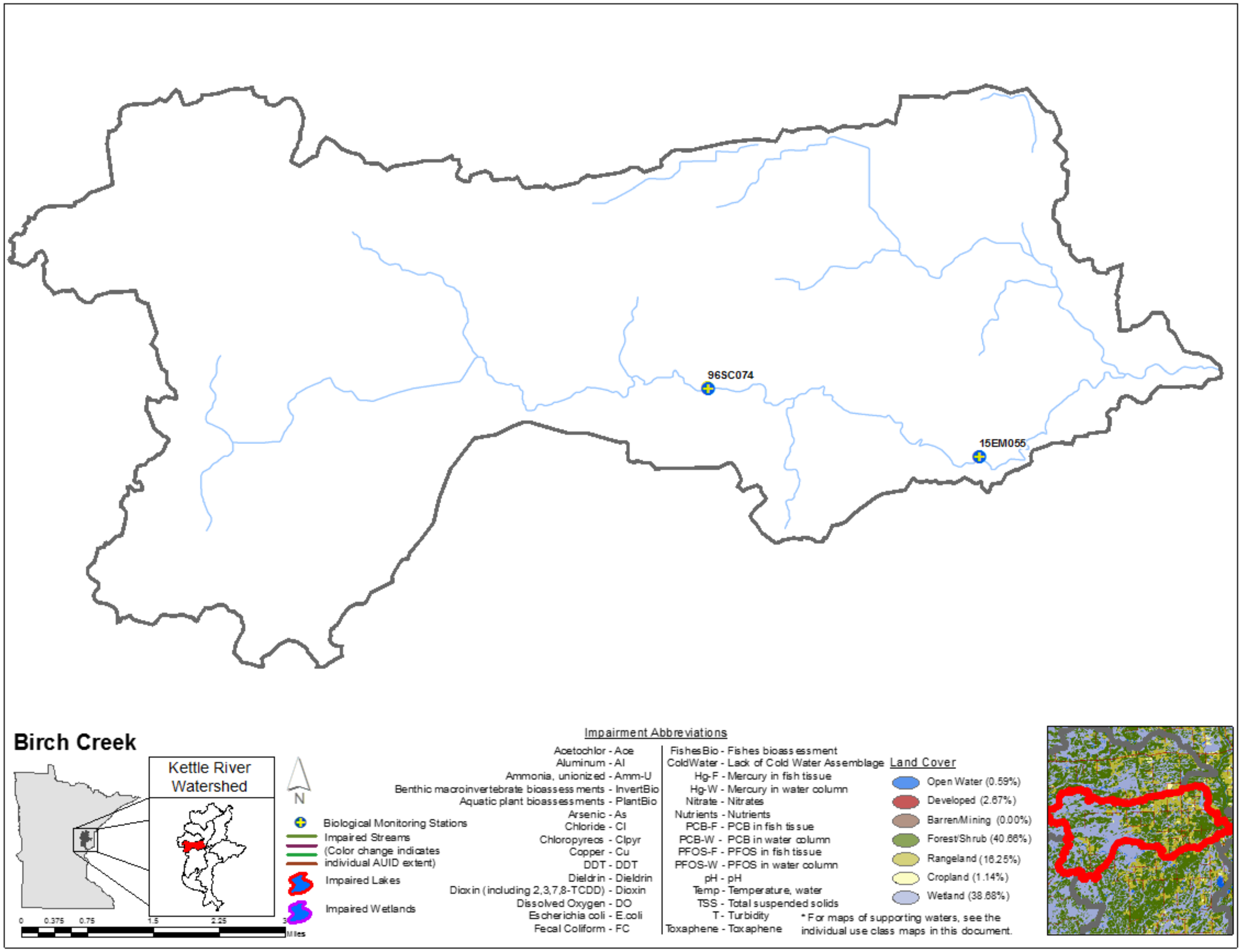
WID ***Reach name,*** *Reach description*	**Biological station ID**	**Reach length (miles)**	**Use class**	**Aquatic life indicators:** Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Eutrophication	**Aquatic life**	**Aquatic rec. (Bacteria)**
07030003-514, Birch Creek, Headwaters to Kettle R	15EM055, 96SC074	17.23	WWg	MTS	MTS	IF	IF	IF		IF	IF	IF	SUP	NA

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

Fish and macroinvertebrates were sampled at two locations on Birch Creek. Both stations met the standards for fish and macroinvertebrates. Station 96SC074 has a long historic record of biological sampling from 1996 through 2000. Historically this site has done a fair job of meeting biological standards. It is only the 2016 sample that has current and assessable data, though the 2016 samples score on the lower end of the historic range for both fish and macroinvertebrates it still met standards. Looking at both 96SC074 and 15EM055, the most abundant fish species are White Sucker, Central Mudminnow, and Mottled Sculpin. Of these three, Mottled Sculpin is considered a pollutant sensitive species that also prefers colder water temperatures.

Figure 16. Currently listed impaired waters by parameter and land use characteristics in the Birch Creek Aggregated 12-HUC.



Pine River Aggregated 12-HUC HUC 0703000304-01

The Pine River Watershed drains over 144 square miles and makes up 13.7% of the Kettle River Watershed. It is largely located in Pine County, though the western edge crosses into Aitkin and Kanabec Counties. The main river system in this subwatershed is the Pine River, which makes a 23-mile trip from Big Pine Lake to the Kettle River near the town of Rutledge. Other river systems to note in this subwatershed are the Little Pine and Bremen Creek. The Little Pine Creek runs northward 10.4 miles from its start in Lake Eleven through Upper Pine and Little Pine Lakes to the Pine River. Bremen Creek's headwaters start in the far southeastern section of the Solana State Forest, from there the river flows southeast eight miles to reach the Pine River. Lakes are more common in the southern part of the Kettle Watershed. This subwatershed has a higher open water percentage at 3.6% than the last four subwatersheds to the north. Forestry (37.8%) and wetland (35.42%) land use coverages are still at the top two coverages for this subwatershed.

Table 7. Aquatic life and recreation assessments on stream reaches: Pine 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	Eutrophication	**Aquatic life**	**Aquatic rec. (Bacteria)**
07030003-560, Little Pine Creek, Little Pine Lk to Pine R	16SC010	1.62	WWg	MTS	MTS	IF	IF	IF		IF	IF	IF	SUP	
07030003-568, Bremen Creek, Unnamed cr to Unnamed cr	16SC017	2.54	WWg	MTS	MTS	IF	IF	IF		IF	IF	IF	SUP	
07030003-602, Unnamed creek, Unnamed cr to Pine Lk		2.26				IF	IF	MTS	MTS	IF		IF	IF	SUP
07030003-609, Rhine Creek, Unnamed cr to Pine R	16SC059	0.50	WWg	MTS	MTS	IF	IF	IF		IF	IF	IF	SUP	

07030003-620, Bremen Creek, Headwaters to Little Bremen Cr	16SC016	4.71	WWg	MTS	MTS	IF	IF	IF		IF	IF	IF	SUP	
07030003-631, Pine River, Headwaters to Pine Lk		1.83	WWg			IF	IF	MTS	IF	IF		IF	IF	NS
07030003-633, Pine River, Big Pine Lk to Little Pine	16SC011	3.45	WWg	MTS	EXS	IF	IF			IF	IF		IMP	IF
07030003-634, Pine River, Little Pine Cr to Bremen Cr	16SC015	5.76	WWg	MTS	EXS	IF	IF	MTS		MTS	IF	IF	IMP	IF
07030003-624, Pine River, Bremen Cr to Kettle R	10EM072, 16SC062, 98SC021	13.75	WWe	MTS	MTS	IF	MTS	MTS	MTS	MTS	MTS	MTS	SUP	SUP

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 8. Lake assessments: Pine River Aggregated 12-HUC.

Lake name	MNDNR 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		
Pine	01-0001-00	376	28	Deep Lake	NLF	D	IF	MTS	- -	EXS	EXS	EXS	IF	NS
Eleven	33-0001-00	308	13	Deep Lake	NLF	- -	MTS	MTS	- -	EXS	EXS	EXS	FS	NS
Fox	58-0102-00	186	14	Deep Lake	NLF	- -	MTS	MTS	- -	EXS	EXS	EXS	FS	NS

Bass	58-0128-00	33	12	Deep Lake	NLF	NT	- -	- -	- -	MTS	MTS	MTS	- -	FS
Little Pine	58-0129-00	79	17	Deep Lake	NLF	I	- -	- -	- -	- -	- -	EXS	- -	IF
Upper Pine	58-0130-00	226	15	Deep Lake	NLF	NT	MTS	IF	- -	MTS	MTS	EXS	FS	FS
Indian	58-0132-00	74	15	Deep Lake	NLF	- -	- -	- -	- -	- -	- -	IF	- -	IF
Rhine	58-0136-00	114	7	Deep Lake	NLF	D	- -	- -	- -	EXS	EXS	EXS	- -	NS
Bass	58-0137-00	223	20	Deep Lake	NLF	NT	IF	MTS	- -	MTS	MTS	MTS	IF	FS
Big Pine	58-0138-00	389	22	Deep Lake	NLF	NT	IF	MTS	- -	EXS	EXS	EXS	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; **EXS** = 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

Fish and macroinvertebrates were sampled at nine locations within this subwatershed. The locations are divided between seven stream reaches. All nine locations and all seven stream reaches met the standards for fish. Stations 16SC011 and 16SC015, did not meet macroinvertebrate IBI standards.16SC011 had a duplicate sample taken, both macroinvertebrate assemblages fell below the standard. Though station 16SC011 consistently did poorly for macroinvertebrates, fish were diverse and scored well. Further downstream at 16SC015, the fish assemblage had a higher percentage of tolerant fish and nearly failed to meet the standard. The next stream segment on the Pine River (-624), starts after the confluence of Bremen Creek and runs to the Kettle River. There were three station locations along this reach; all of them surpassed both general and exceptional standards for fish. Generally, the fish communities in this subwatershed are doing well.

Nutrients in the headwaters portion of the Pine River (-631) exceed the north regional standard and contribute to the downstream nutrient impairments in both Pine and Big Pine lakes. Suspended sediments in the headwaters do not appear problematic, despite a few exceedances of the TSS standard. Overall, chemistry data are insufficient to assess aquatic life use in the headwaters of the Pine River.

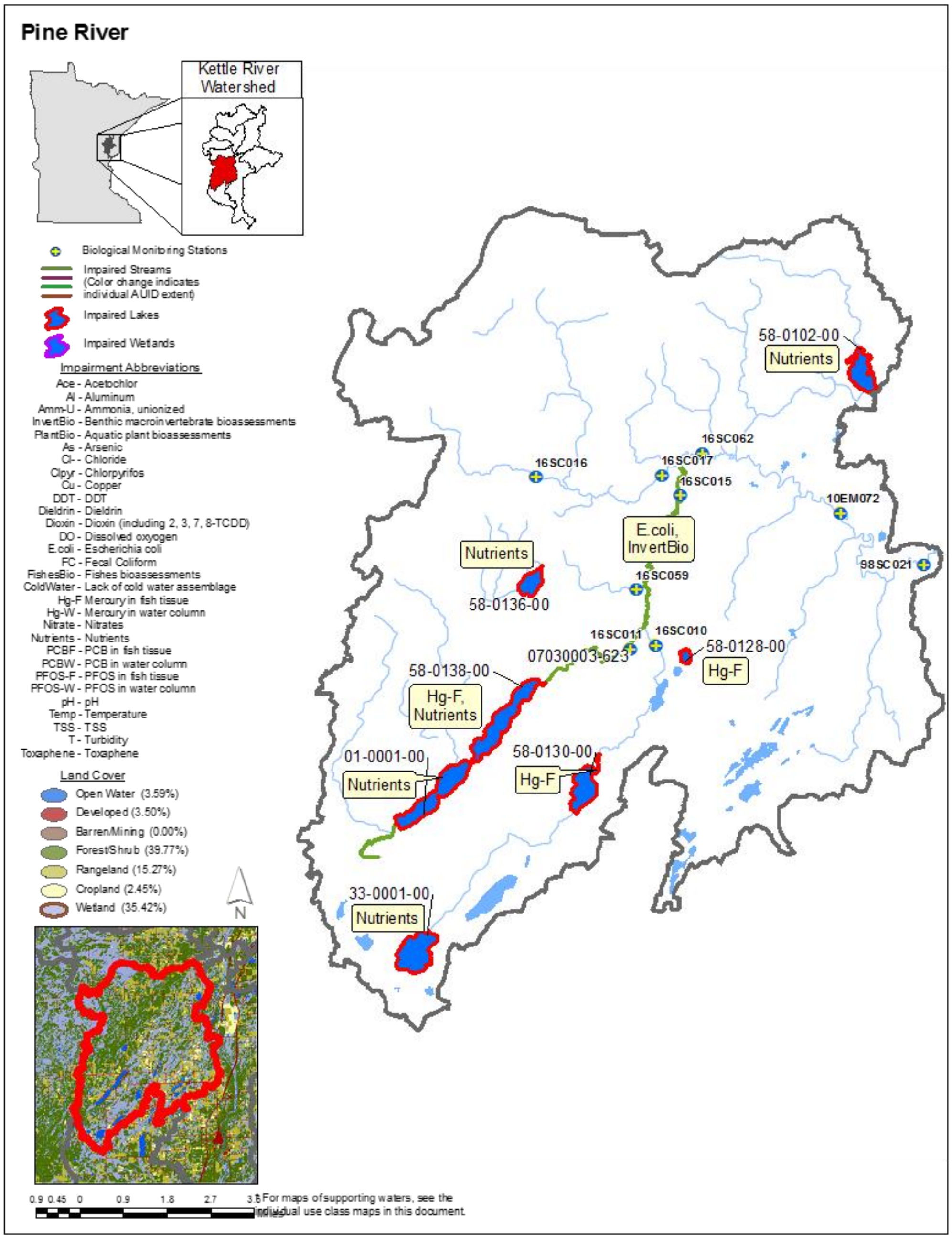
The outlet of the Pine River (-624) provided some of the best chemistry data in the entire Kettle River Watershed. Nutrients and suspended sediments both meet regional standards, with numerous ‘non-detect’ samples of TSS. A lack of early morning dissolved oxygen data is the only parameter preventing a full support assessment of aquatic life use based solely on chemistry. The available data strongly suggest support for the biological communities.

That same outlet of the Pine River and an unnamed norther tributary to Pine Lake both fully support recreation uses. The headwaters of the Pine River (-631), upstream of Pine Lake does not currently support recreation. All three of these river sections exhibited elevated bacteria concentrations during July monitoring events, but only the headwaters portion tripped the chronic standard.

Eight lakes in this subwatershed were assessed for recreation use and only three Upper Pine Lake and Bass Lake (58-0128 near Finlayson), and Bass Lake (58-0137 at the Pine, Aitkin and Kanabec County corner) fully support recreation. Five lakes do not support recreation uses; 2018 assessments confirmed four previous listings (Table 8), and identified a new fifth (Lake Eleven). Little Pine Lake was not formally assessed for recreation, but CLMP volunteer supplied data show that clarity is low, but improving.

The MNDNR provided fish-IBI assessment comments on six lakes. Three lakes fully support aquatic life (Eleven, Fox and Upper Pine). The other three lakes have insufficient information due to the survey results either falling right at the impairment threshold (Big Pine), high uncertainty because of conflicting results from two different surveys (Pine), or survey data being too old to assess confidently (Bass Lake, at the western county line). Pine and Big Pine lakes were both flagged as vulnerable to future impairment based on the most recent data. Protection efforts affecting the vulnerable lakes should be implemented to prevent degradation of the fisheries.

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



Grindstone River Aggregated 12-HUC HUC 0703000305-01

The Grindstone River Watershed drains 86.8 square miles and makes up about 8.3% of the total Kettle River Watershed. This subwatershed is located in Kanabec and Pine Counties, and contains the northern half of Hinckley. Within the Grindstone River subwatershed, there are four main assessed rivers and several smaller ditched systems. Of the main river systems, the South Branch Grindstone and North Branch Grindstones are the largest two. The South Branch flows southeast about 17.3 miles before being joined by the North Branch. The North Branch Grindstone starts north of Grindstone Lake, and flows out the southern edge of the lake and continues south totaling 11.1 miles. Both North and South Branches join just north of the city of Hinckley forming the Grindstone River. The Grindstone River then flows another 6.7 miles until it reaches the Kettle River. Most of the lakes in this subwatershed are in the north, and are relatively small compared to the 525-acre Grindstone Lake. Overall, the percentage of open water in this subwatershed is 2.4%. Though forest (34.2%) and wetland (30%) land use covers are still the dominant two land uses, rangeland (24.8%) comes in at a close third. Compared to the other subwatersheds the Grindstone River has the lowest percentage of wetland area and the highest percentage of rangeland land use cover.

Table 9. Aquatic life and recreation assessments on stream reaches: Grindstone 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	Eutrophication	Aquatic life	Aquatic rec. (Bacteria)
07030003-501, Grindstone River, Grindstone Reservoir to Kettle R	16SC001, 98SC009	6.74	WWg	MTS	MTS	IF	MTS	MTS	MTS	MTS	MTS	IF	SUP	IMP
07030003-516, Grindstone River, South Branch, Headwaters to Grindstone R	16SC076, 16SC086, 96SC063	17.34	WWg	MTS	MTS	IF	MTS	MTS	MTS	MTS	MTS	IF	SUP	IMP
07030003-526, Judicial Ditch 1, Headwaters to S Br Grindstone R		5.93	WWg			NA	NA	NA	MTS	NA		NA	NA	IMP

07030003-541, Grindstone River, North Branch, Headwaters to Grindstone Lk		2.12	WWg			NA	NA	NA	NA	NA		NA	NA	IF
07030003-543, Grindstone River, North Branch, Grindstone Lk to T42 R21W S28, south line	16SC081	2.03	CWg	IF	IF	NA	NA	NA	MTS	NA	IF	NA	IF	NA
07030003-544, Grindstone River, North Branch, T42 R21W S33, north line to Grindstone R	16SC082	6.97	WWg	MTS	MTS	IF	MTS	MTS	MTS	MTS	MTS	MTS	SUP	IMP
07030003-546, Unnamed creek, Miller Lk to Grindstone Lk		3.21	WWg			NA	NA	NA	MTS	NA		NA	NA	IMP
07030003-550, Spring Creek, Headwaters to Grindstone R	10SC001	3.74	CWg	EXS	MTS	EXS	IF	IF	MTS	MTS	IF	IF	IMP	IMP
07030003-601, Unnamed creek, Headwaters to Grindstone Lk		0.39	WWg			NA	NA	NA	MTS	NA		NA	NA	IF
07030003-614, Unnamed creek, Unnamed ditch to N Br Grindstone R		0.30	WWg					EXS					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)
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: Grindstone River Aggregated 12-HUC.

Lake name	MNDNR ID	Area (acres)	Max depth (ft)	Assessment method	Ecoregion	Secchi Trend	Aquatic life indicators: Fish IBI	Aquatic life indicators: Chloride	Aquatic life indicators: Pesticides ***	Aquatic recreation indicators: Total phosphorus	Aquatic recreation indicators: Chlorophyll-a	Aquatic recreation indicators: Secchi	Aquatic life use	Aquatic recreation use
Five	33-0003-00	54	29	Deep Lake	NLF	NT	- -	IF	- -	MTS	MTS	MTS	IF	FS
Grindstone	58-0123-00	525	153	Lake Trout	NLF	NT	MTS	MTS	- -	EXS	EXS	EXS	FS	NS
Elbow	58-0126-00	99	33	Deep Lake	NLF	- -	- -	- -	- -	EXS	IF	EXS	- -	NS
Miller	58-0135-00	76	15	Deep Lake	NLF	- -	- -	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; **EXS** = 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

Fish and macroinvertebrates were sampled at eight locations, on five stream reaches. Two stream reaches had healthy communities of fish and macroinvertebrates. One stream reach had insufficient information to make a confident assessment based on the biological communities. Two other reaches had healthy macroinvertebrate communities but not healthy fish communities. The South Branch Grindstone has historically been on the impaired waters list for fish biota since 2002. The current assessment of this reach used three sampling stations, two new locations and one historic. The downstream most site, 16SC076, had a fish IBI score greater than the threshold. However, the other two stations, 16SC086 and 96SC063, did not. Station 96SC063 had two assessable visits and 16SC086 had one. All three of these visits had low diversity and low numbers of total fish captured. Of the fish that were captured the communities contained higher percentage of pollutant tolerant fishes. Spring Creek is a new impairment for fish biota. Station 10SC001 was sampled in 2010 and in 2016. Both of these samples lacked cold water fish species such as trout. Thought the water temperature readings indicated that the temperature of the stream is likely sufficient to support cold water fish species.

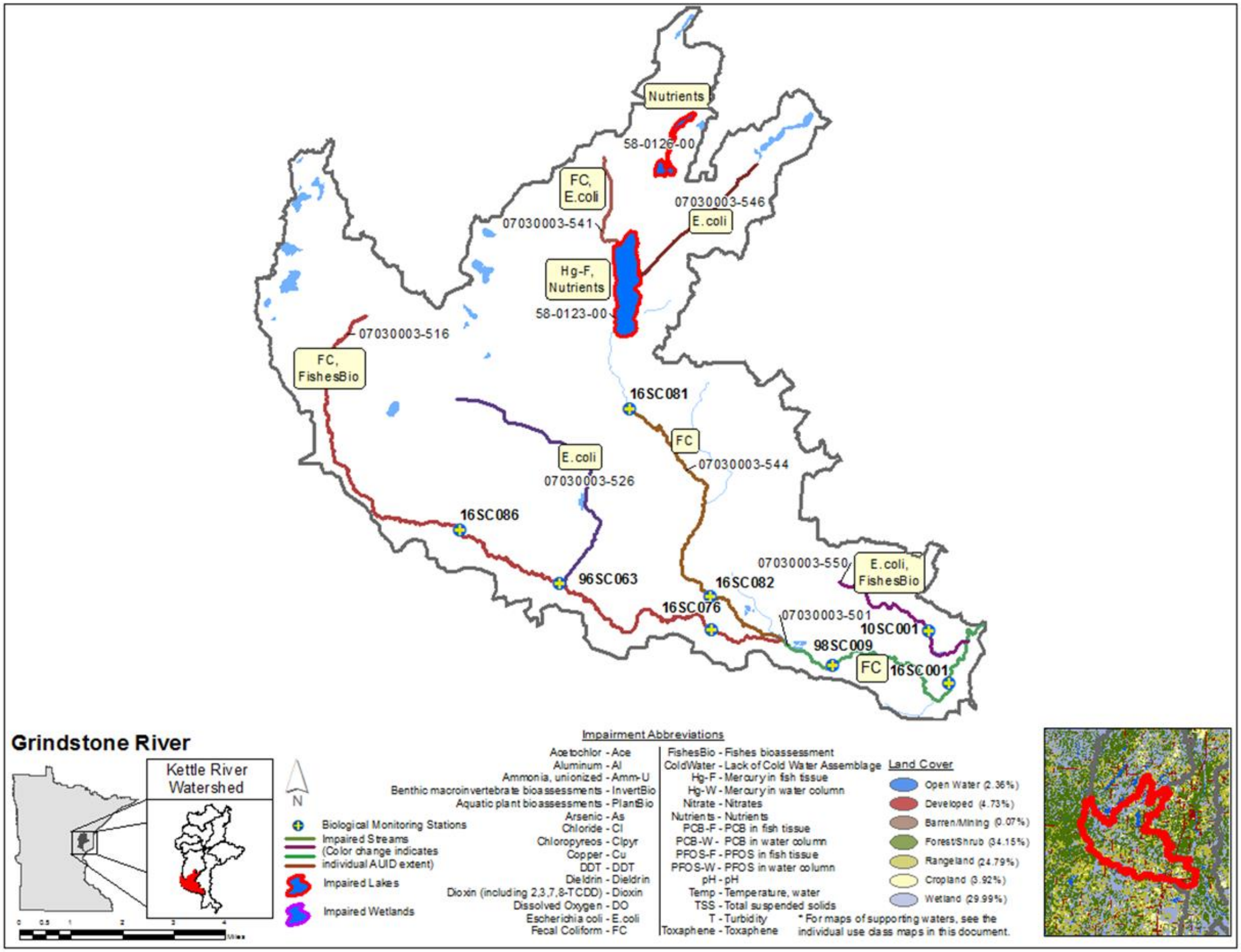
Chronically elevated bacteria concentrations are problematic throughout this subwatershed. Three new and four old impairment listings were confirmed during this round of recreation use assessments along the Grindstone River and Spring Creek (Table 9). Three other river sections have insufficient information for assessment, due to a lack of the required number of samples or low confidence in the data reliability. Best management practices to reduce bacteria concentrations in this subwatershed should be implemented, in an effort to improve the recreational value of the stream resources.

Chemistry data reviewed during aquatic life use assessments show low suspended solids throughout the subwatershed. Nutrients are elevated in the South Branch Grindstone River and in Spring Creek. Nutrients measured in the North Branch were well below the regional standard. An eutrophication response (e.g. excess plant or algae growth, fluctuation in oxygen) to elevated nutrients was not observed in any of the monitored stream sections. Overall, chemistry conditions suggest supporting conditions for the biological communities.

Three lakes were assessed for recreation uses in this subwatershed. Only one lake (Lake Five) fully supports recreation; the other two (Grindstone and Elbow lakes) do not support recreation uses based on new data. It is worth noting that Grindstone Lake has excellent water quality compared to similarly sized lakes, but it is held to more stringent standards deemed protective of the lake trout population within the lake.

The MNDNR assessed Grindstone Lake for aquatic life use support and found it to be fully supporting. The two surveys conducted were most positively influenced by the high proportion of pollution intolerant species, and the overall lack of tolerant species (only black bullhead were captured, but in low quantity). Lake trout were among the most common species by biomass captured in gillnets. A Score the Shore survey indicated overall high quality nearshore habitat. This basin is a valuable resource for the area because of the lake trout, and it deserves adequate protection and restoration strategies.

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



Lower Kettle River Aggregated 12-HUC HUC 0703000306-01

The Lower Kettle River subwatershed is at the heart of the Kettle River Watershed, with all of the other subwatersheds draining into it. It is both the longest and largest of the subwatersheds, draining 194 square miles and making up 18.5% of the total watershed. It is fully contained in Pine County. This subwatershed starts at the confluence of the Kettle and Moose Horn Rivers and flows south until the Kettle River reaches the St. Croix River in St. Croix State Park. Near the center of the subwatershed is Banning State Park and Robinson Park, which encases part of the Kettle River mainstem near the city of Sandstone. The Kettle River takes main stage in this subwatershed, though it also contains several tributaries such as Cane and Skunk Creeks. Lakes in this subwatershed are lightly scattered throughout, and on average are not much bigger than 70 to 80 acres. The open water land use coverage is just over 2%, which is lower than the other subwatersheds around it. Similar to many of the other subwatersheds forest and wetland land use are the largest coverages at 42 and 30%. Though croplands are not one of the top land use coverages, the Lower Kettle subwatershed has the highest percentage in the Kettle River Watershed.

Table 11. Aquatic life and recreation assessments on stream reaches: Lower Kettle River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

				Aquatic life indicators:										
WID ***Reach name*****,** *Reach description*	**Biological station ID**	**Reach length (miles)**	**Use class**	**Fish IBI**	**Invert IBI**	**Dissolved oxygen**	**TSS**	**Secchi Tube**	**Chloride**	**pH**	**Ammonia -NH_3**	**Eutrophication**	**Aquatic life**	**Aquatic rec. (Bacteria)**
07030003-502, Kettle River, Grindstone R to St Croix R	16SC002, 96SC033	16.95	WWg	MTS	MTS	IF	MTS	MTS	MTS	MTS	MTS	MTS	SUP	SUP
07030003-503, Kettle River, Willow R to Pine R	06SC020, 92SC015	5.50	WWe	MTS	MTS	IF	EXS	MTS		MTS	IF	IF	SUP	
07030003-505, Kettle River, Moose Horn R to Willow R	16SC063, 92SC017	4.87	WWe	MTS	MTS	IF	IF	MTS	MTS	MTS	MTS	IF	SUP	SUP
07030003-525, Cane Creek, Headwaters to Kettle R	16SC012	5.97	WWg	MTS	EXS	IF	IF	IF		IF	IF	IF	IMP	

07030003-528, Kettle River, Pine R to former Dam (at Sandstone)	16SC083, 92SC011	12.87	WWg	MTS	MTS	IF	MTS	MTS	MTS	IF	MTS	MTS	SUP	SUP
07030003-617, Friesland Ditch, RR tracks to Kettle River	16SC006	3.08	WWg	EXS	EXS	IF	IF	IF		MTS	IF	IF	IMP	
07030003-618, Skunk Creek, Unnamed creek to Kettle R	16SC007	3.25	WWg	EXS	MTS	IF	IF	IF		IF	IF	IF	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 12. Lake assessments: Lower Kettle River Aggregated 12-HUC.

Lake name	MNDNR 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		
McCormick	58-0058-00	59	17	Deep Lake	NLF	- -	- -	MTS	- -	EXS	EXS	EXS	IF	NS
Little Mud	58-0106-00	16	25	Deep Lake	NLF	- -	- -	MTS	- -	EXS	EXS	EXS	IF	NA
Long	58-0107-00	77	24	Deep Lake	NLF	NT	- -	MTS	- -	IF	EXS	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; **EXS** = 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

Biological communities were sampled at 11 stations on seven stream reaches. Much of this subwatershed is the lower mainstem of the Kettle River. Four of the seven reaches are on the main Kettle River. All four of these reaches had healthy fish communities. Two of the reaches furthest upstream are proposed to be designated exceptional use. An exceptional use designation is considered when a reach consistently holds high quality biological assemblages. The lower two stream reaches are not currently being considered for exceptional use designations, though their fish IBI scores were all well above the standard. In concert with this, two species on the list of state recognized species of special concern, Lake Sturgeon and Gilt Darters, were captured at several of the sampling locations along the Kettle River.

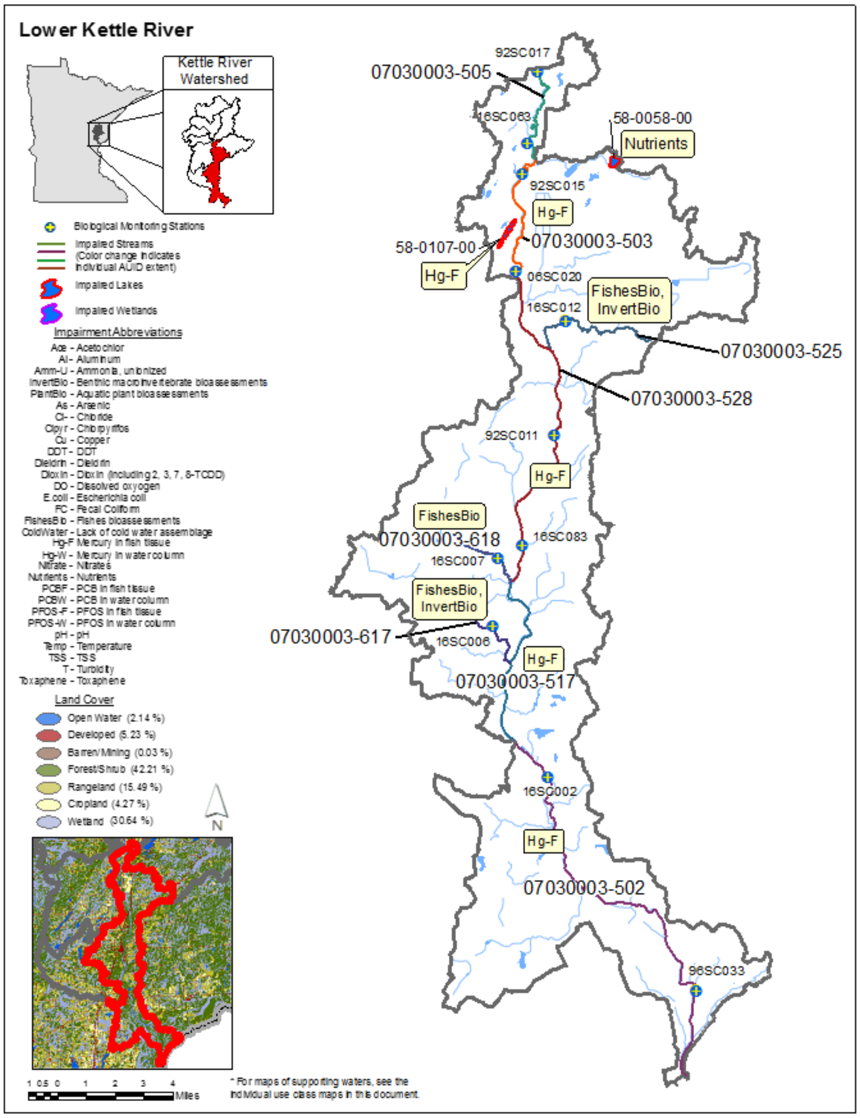
Though much of the lower Kettle River is doing well for biota, the small tributaries sampled in this subwatershed are struggling to meet biological standards. The three assessed tributaries, were all found to be impaired for fish and or macroinvertebrates. On Cane Creek, both fish and macroinvertebrates are listed as impaired. This station is located adjacent to highway 35 and holds a large fish passage barrier before the creek drops below the highway. As both the number of fish and the diversity of species captured was unexpectedly low given the habitat assessed in the stream reach score was high. A fish passage barrier does not explain the impact on the failing macroinvertebrate assemblage. Friesland Ditch is another tributary to the Kettle River that did not meet standards for fish or macroinvertebrates. The few fish captured at this station were dominated by Brook Stickleback and Central Mudminnows, both tolerant species. Habitat assessments at this station point to a possible problems with bank stability and sediments covering useful fish and macroinvertebrate habitat. Skunk Creek is on a cold water reach just south of the city of Sandstone. Skunk Creek site 16SC007 received three visits, though only two were assessable for fish. All three samples were limited in both number of fish and number of species captured. There were no more than four fish species captured, most of which were tolerant species. Habitat assessments done on 16SC007 indicate good habitat. Culverts downstream are a listed fish passage barrier, and could be limiting the ability of fish to colonize Skunk Creek. There is also a known creosote problem near Skunk Creek not far from the site.

Overall chemistry data characterize this large subwatershed as having nutrient concentrations often near or above the regional standard. Suspended sediment concentrations are generally low, but show occasional exceedances at the WPLMN site, and begin to increase in the most downstream portion of the Kettle River (-502). Other conventional chemistry samples meet their respective standards, or are insufficient for assessments.

All three Kettle River sections fully support recreation use based on new data (upstream to downstream; -505, -528, -502); however, concentrations tend to fluctuate, and increase as you move further downstream. A central section of the Kettle River (-528) and the outlet section (-502) have both been identified as vulnerable to future recreation use impairments and should be protected to prevent new listings.

McCormick Lake was assessed as not supporting recreation uses, due to nutrients and algae concentrations clearly exceeding the ecoregion standards. Data from Long Lake were inconclusive, and Little Mud Lake was not assessed due to a poorly located monitoring site which ended up being more representative of fringe wetland conditions than the lake itself. Chloride concentrations in all three lakes are extremely low.

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



Moose River Aggregated 12-HUC HUC 0703000302-01

Located on the northeastern edge of the Kettle River Watershed, the Moose Horn River subwatershed is primarily in Carlton County with its southern point in Pine County. The Moose Horn River subwatershed drains 141 square miles, making up 13.4% of the total Kettle River Watershed. The three larger river systems are the Moose Horn, West Branch Moose Horn, and the Portage River. The largest of the three is the Moose Horn, which flows 36.7 miles from north to southwest past the cities of Barnum, Moose Lake, and Sturgeon Lake. The West Branch flows nearly 14 miles southeast to meet the Moose Horn River just north of Barnum. The Portage River meets the Moose Horn in Moosehead Lake, after flowing thought Moose Lake State Park. There are many lakes in this subwatershed, the largest being Island Lake at 516 acres, but many are over 100 acres. Considering this, this subwatershed has the highest open water land use coverage in the Kettle River Watershed at 4.6%. This subwatershed is also the highest for developed land use at 6.1%. These percentages are still low in comparison to land use covers of wetlands at 40.4% and forestry at 35%.

Table 13. Aquatic life and recreation assessments on stream reaches: Moose Horn 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	Eutrophication	Aquatic life	Aquatic rec. (Bacteria)
07030003-521, Moose Horn River, W Br Moose Horn R to Hanging Horn Lk	16SC032	3.32	WWg	MTS	MTS	IF	IF	MTS		MTS	IF	MTS	SUP	
07030003-531, Moose Horn River, Hanging Horn Lk to Kettle R	16SC024, 16SC031	13.14	WWg	MTS	MTS	MTS	MTS	MTS	MTS	MTS	MTS	MTS	SUP	SUP
07030003-535, Moose Horn River, Headwaters (Wild Rice Lk 09-0023-00) to T48 R18W S34, south line	16SC055	11.13	CWg	MTS	MTS	IF	IF	IF		IF	IF	IF	SUP	
07030003-547, King Creek, Headwaters to Moose Horn R	16SC046	3.80	CWg	MTS	MTS	IF	IF	IF		IF	IF	IF	SUP	

07030003-628, Moose Horn River, West Branch, Unnamed cr to Moose Horn R	16SC034	5.09	WWe	MTS	MTS								SUP	
07030003-629, Moose Horn River, T47 R18W S4, north line to Unnamed cr	16SC056	2..38	WWe	MTS	MTS	IF	IF	IF		IF	IF	IF	SUP	
07030003-630, Moose Horn River, Unnamed cr to W Br Moose Horn R	16SC048	6.75	WWg	MTS	MTS	IF	IF	IF		IF	IF	IF	SUP	

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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.
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.

Water Resources

Table 14. Lake assessments: Moose Horn River Aggregated 12-HUC.

Lake name	MNDNR 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		
Twentynine	09-0022-00	48	25	Deep Lake	NLF	- -	- -	IF	- -	EXS	EXS	IF	IF	NS
Wild Rice	09-0023-00	54	5*	Deep Lake	NLF	- -	- -	MTS	- -	MTS	- -	- -	IF	IF
Bob	09-0026-00	76	29	Deep Lake	NLF	- -	- -	IF	- -	MTS	MTS	MTS	IF	FS
Park	09-0029-00	375	16	Deep Lake	NLF	I	MTS	IF	- -	MTS	MTS	MTS	FS	FS
Bear	09-0034-00	98	31	Deep Lake	NLF	NT	- -	IF	- -	MTS	MTS	MTS	IF	FS

Little Hanging Horn	09-0035-00	113	70	Deep Lake	NLF	I	- -	IF	- -	MTS	MTS	MTS	IF	FS
Hanging Horn	09-0038-00	403	84	Deep Lake	NLF	NT	MTS	IF	- -	IF	IF	MTS	FS	IF
Eddy	09-0039-00	24	37	Deep Lake	NLF	D	- -	- -	- -	- -	- -	EXS	- -	IF
Moosehead	09-0041-00	280	18	Deep Lake	NLF	NT	- -	MTS	- -	IF	IF	EXS	IF	IF
Moose	09-0043-00	127	67	Deep Lake	NLF	- -	- -	IF	- -	MTS	IF	MTS	IF	FS
Echo	09-0044-00	103	47	Deep Lake	NLF	- -	- -	IF	- -	MTS	MTS	MTS	IF	FS
Coffee	09-0045-00	68	53	Deep Lake	NLF	- -	- -	IF	- -	MTS	IF	MTS	IF	FS
Island	58-0062-00	516	42	Deep Lake	NLF	I	MTS	MTS	- -	MTS	EXS	MTS	FS	FS
Sand	58-0081-00	495	47	Deep Lake	NLF	NT	IF	MTS	- -	MTS	MTS	MTS	IF	FS

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
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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

Fish and macroinvertebrate were sampled at eight locations on seven assessed stream reaches. All eight locations met standards for both fish and macroinvertebrates, including two cold water and two exceptional use reaches. In this subwatershed Longnose Dace, a sensitive species, was captured at seven of the eight locations and was in the top three most abundant species present. Brook Trout were captured at 16SC055, the only place in our recent survey to capture Brook Trout in the Kettle Watershed. The West Fork of the Moose Horn (16SC034) had one of the most diverse macroinvertebrate assemblages of any station sample in the entire state. The presence of cold water macroinvertebrate taxa throughout the Moose Horn River Watershed suggests pervasive and stable groundwater flow conditions and adequate temperature buffering to allow for their persistence. From a biological point of view, the watershed is of high quality.

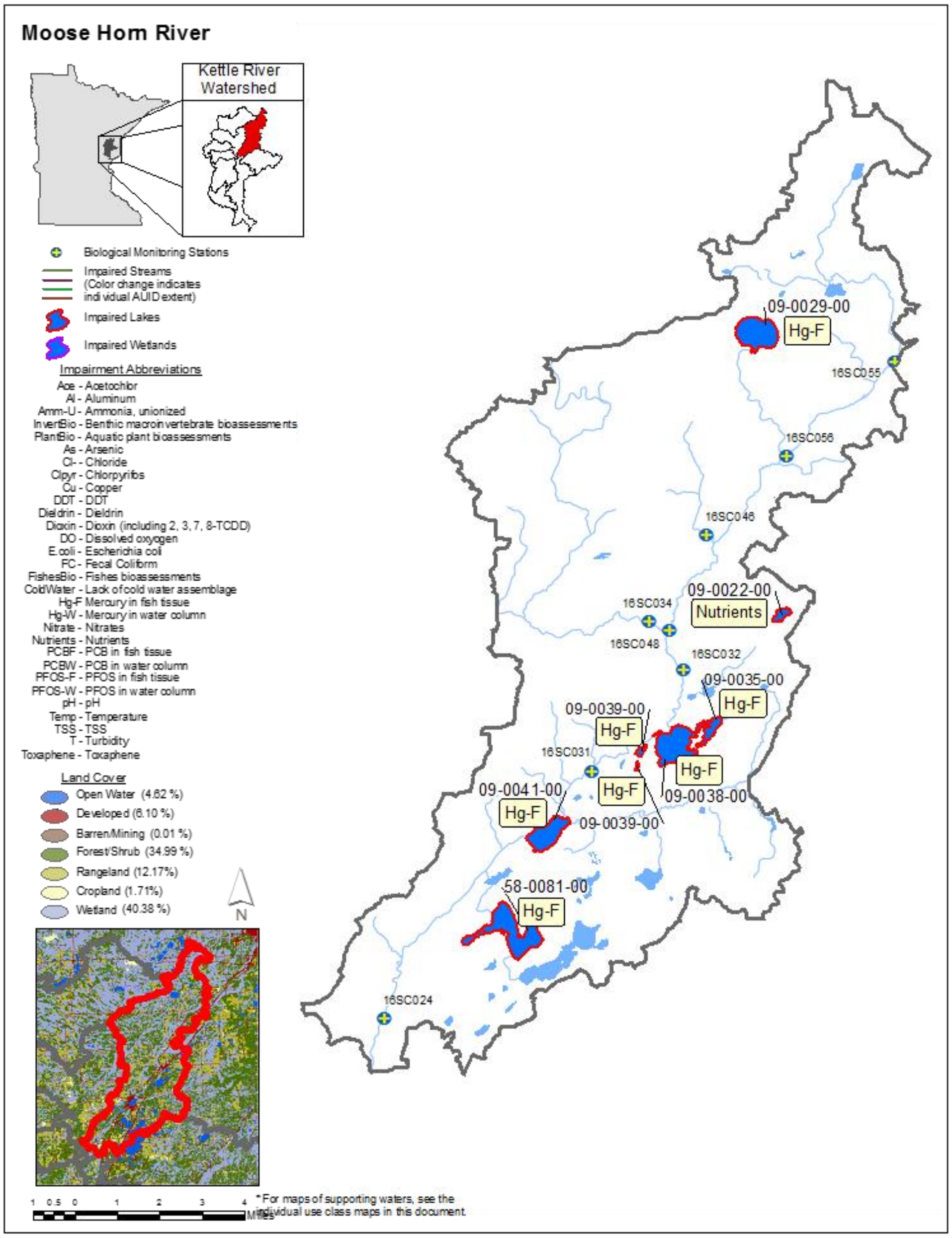
The Moose Horn River subwatershed collectively has some of the best water quality in the entire Kettle River Watershed. Stream chemistry from the main stem of the Moose Horn River (-521, and -531) characterize the subwatershed as having low nutrient and suspended sediment concentrations. Overall chemistry data meet standards when present in sufficient quantities and suggest supporting conditions for the biological communities.

The outlet of the Moose Horn River (-531) is the only river section in this subwatershed that had recreation use data for review. Assessment of those data indicate full support for recreation uses; bacteria concentrations tend to peak in the month of June, but are continually low enough to easily meet the chronic standard.

Twelve lakes underwent full assessments in 2018, and only one (Lake Twentynine) does not support recreation use; nine other lakes were found to be fully supporting of recreation uses, and three of them also have increasing trends in Secchi transparency (Table 14). Two lakes previously deemed fully supporting recreation were newly assessed as inconclusive due to not meeting data minimums (Hanging Horn Lake), or due to seasonal means hovering right around ecoregion standards (Moosehead Lake). Both of these lakes have been flagged as vulnerable to future impairment, and should be protected to prevent further degradation. Two other lakes were also flagged as vulnerable and are in need of protection. Eddy Lake exhibits a declining trend in Secchi transparency, and Island Lake is very near the ecoregion standards (chl-a exceeds).

The MNDNR assessed three lakes as fully supporting aquatic life use (Park, Hanging Horn, and Island lakes); one additional assessment had insufficient information due to conflicting fisheries surveys (Sand Lake). The three fully supporting lakes were most positively influenced by things like high proportions of pollution intolerant species (Hanging Horn and Island lakes); high biomass counts of top carnivore species (Hanging Horn and Park lakes); low numbers of tolerant species (Park Lake) and moderate to high quality nearshore habitat (Island and Hanging Horn, respectively). The aquatic life use assessments also found instances of low numbers of vegetative or benthic dwelling species which lowered IBI scores.

Figure 20. Currently listed impaired waters by parameter and land use characteristics in the Moose Horn River Aggregated 12-HUC.



Willow River Aggregated 12-HUC HUC 0703000303-01

The Willow River subwatershed is nearly 134 square miles making up 12.7% of the Kettle River Watershed. It is largely contained in Pine County but the northern most areas are in Carlton County. It is also bracketed by General C.C. Andrews State Forest to the west and the Nemadji State Forest to the east. Reaching between is the Willow River, which runs over 30 miles east to west until meeting the Kettle River near the city of Willow River. Scattered throughout the Willow River subwatershed are several lakes and ponds. Including Sturgeon Lake, the largest lake in the Kettle River Watershed. With all the lakes, the open water land use cover is 4.3% of the subwatershed putting only slightly below the Moose Horn River subwatershed. Consistent with much of the other subwatersheds forest and wetland coverage dominate the land use coverage for the Willow River subwatershed.

Table 15. Aquatic life and recreation assessments on stream reaches: Willow 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	Eutrophication	Aquatic life	Aquatic rec. (Bacteria)
07030003-548, Larsons Creek, T44 R17W S5, south line to Willow River	16SC068	3.09	CWg	NA	MTS	IF	IF	IF		IF	IF	IF	SUP	
07030003-575, Little Willow River, Unnamed cr to Unnamed cr	16SC020	2.05	WWg	MTS	MTS	IF	IF	IF		IF	IF	IF	SUP	
07030003-619, Hay Creek, Headwaters to Willow R	16SC023	9.69	WWg	EXS	MTS	IF	IF	IF		IF	IF	IF	IMP	
07030003-621, Willow River, Headwaters to Big Slough Lk outlet	16SC069, 16SC072, 16SC073	23.69	WWg	MTS	MTS	IF	MTS	MTS	MTS	MTS	MTS	MTS	SUP	SUP
07030003-622, Willow River, Big Slough Lk outlet to Kettle R	16SC074	8.19	WWe	MTS	MTS	IF	IF	IF		IF	IF	IF	SUP	

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 16. Lake assessments: Willow River Aggregated 12-HUC.

Lake name	MNDNR 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		
Oak	58-0048-00	462	18	Deep Lake	NLF	NT	EXS	IF	- -	EXS	EXS	EXS	NS	NS
Sturgeon	58-0067-00	1645	40	Deep Lake	NLF	NT	MTS	MTS	- -	MTS	MTS	MTS	FS	FS
Eleven	58-0068-00	103	49	Deep Lake	NLF	I	- -	- -	- -	IF	MTS	MTS	- -	FS
Dago	58-0073-00	100	20	Deep Lake	NLF	I	- -	- -	- -	MTS	MTS	MTS	- -	FS
Passenger	58-0076-00	61	22	Deep Lake	NLF	- -	- -	MTS	- -	IF	IF	MTS	IF	IF
Rush	58-0078-00	75	35	Deep Lake	NLF	NT	- -	- -	- -	- -	- -	MTS	- -	IF
Stanton	58-0111-00	78	15	Deep Lake	NLF	- -	- -	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; **EXS** = 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

This watershed contained seven sample locations on five stream reaches. Of these five reaches, four were assessable for both fish and macroinvertebrate. Macroinvertebrate passed assessments for all five reaches. The one reach that was not assessed for fish was Larsons Creek. Larsons Creek is the only reach that is cold water, and was once a reproducing Brook Trout stream. Though the water temperature remains cold at the site location, it is thought that there are too many beaver dams blocking trout from assessing adequate habitat. The macroinvertebrate community at Larsons Creek meets criteria, but has relatively few cold water individuals and taxa compared to other cold water streams in the region. Hay Creek (16SC023) passed assessments for macroinvertebrates, but not for fish. This location was sampled in 2016 and 2017 for both assemblages. Both samples were lacking in the number of fish captured and in species diversity. Macroinvertebrate s scored just below the threshold in 2016, and just above in 2017. Despite the mixed messages between fish and macroinvertebrate s from Hay and Larsons Creeks, the lowest stream reach on the Willow River met the criteria for exceptional use for both assemblages, suggesting that the overall condition of the watershed provides for stable flows, high quality habitats, and a community of fish and bugs very near to native conditions.

The upper main stem of the Willow River (-621) fully supports recreational use. Bacteria concentrations are all below the chronic standard, except for a single sample collected during flood conditions in late June 2016.

Other general chemistry parameters suggest fully supporting conditions for the biological communities along the upper portion of the Willow River. The river eutrophication assessment meets regional standards. Dissolved oxygen concentrations show occasional exceedances. Both pH and DO appear to be influenced by the upstream wetland complex, and parameter exceedances tend to occur following rain events that produce high flows (i.e. wetland flushes). Concentrations of suspended sediments, chloride and un-ionized ammonia meet standards.

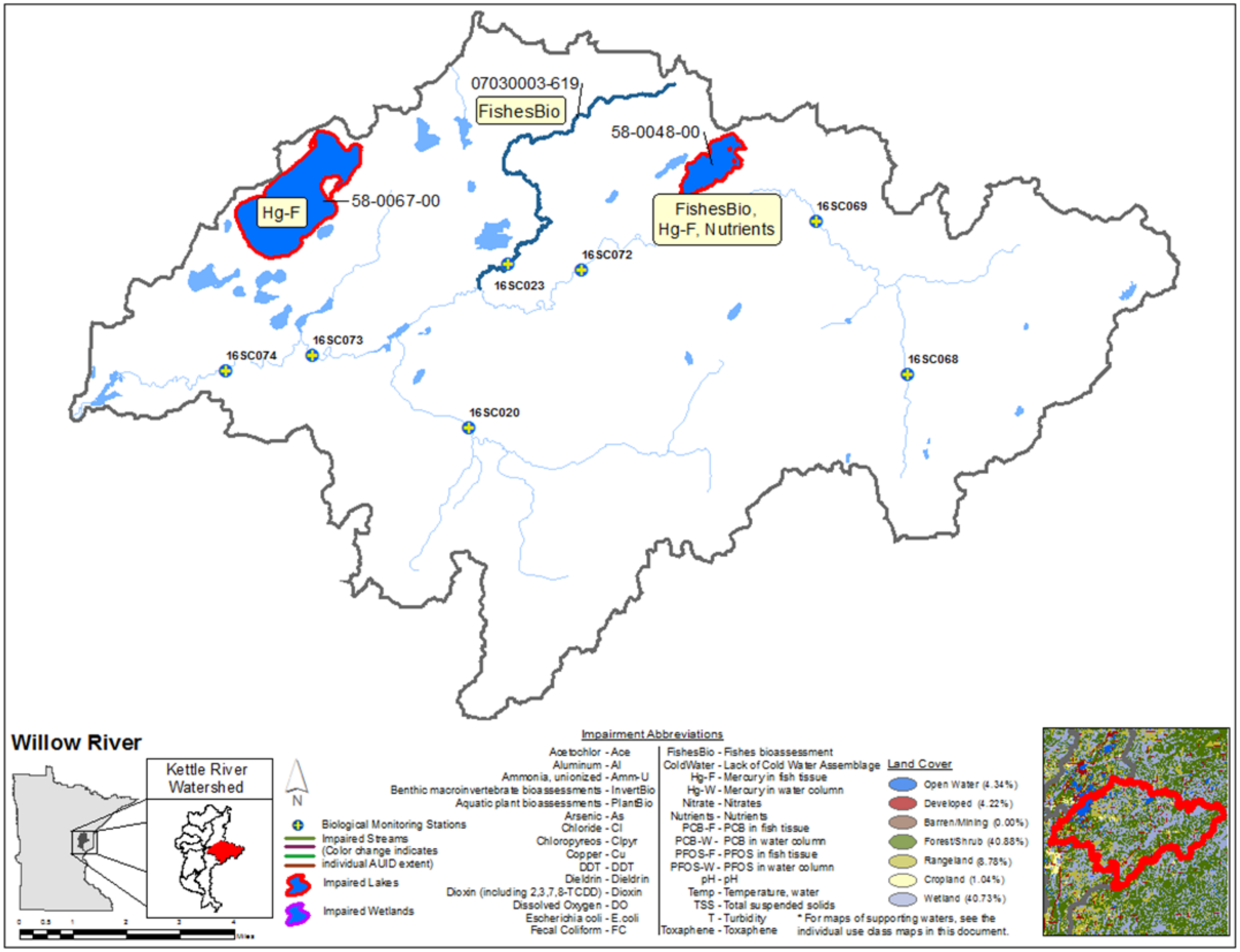
Four lakes in this subwatershed have sufficient chemistry data for recreation use assessments. Three of them (Sturgeon, Eleven and Dago lakes) fully support recreation use. Lake Eleven is vulnerable to a future recreation use impairment due to seasonal concentrations of phosphorus and chlorophyll-a approaching the NLF standards. The fourth lake (Oak Lake) does not support recreation use, as all three parameters exceed NLF standards.

The MNDNR assessed two lakes for aquatic life use based on multiple fish IBI surveys (Sturgeon and Oak lakes). Sturgeon Lake fully supports aquatic life use and the assessment was positively influenced by an abundance of pollution intolerant species, a high number of cyprinid species present in nearshore sampling gear, and an overall low percentage of watershed disturbance. Sturgeon Lake would benefit from protection strategies to prevent resource degradation.

Oak Lake does not currently support aquatic life use; two out of three surveys were below the threshold for impairment. Staff noted a relatively low number of pollution intolerant species, and a high proportion of omnivorous species; both metrics negatively affected the assessment. Overall watershed disturbance is classified as low, but nearshore habitat disturbances are deemed moderate based on a 2016 Score the Shore survey.

CLMP volunteers monitored Passenger and Rush lakes. Neither lake has enough data for a formal assessment, but available data do suggest the lakes have low levels of algae and likely meet standards.

Figure 21. Currently listed impaired waters by parameter and land use characteristics in the Willow 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 Kettle River Watershed, 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 Kettle River Watershed.

Stream water quality

Forty-four of the 123 stream WIDs were assessed (Table 17), 32 streams are fully supporting of aquatic life and eight streams are fully supporting of aquatic recreation. Meaning of the assessed WIDs 78% are supporting aquatic life and under 50% supporting aquatic recreation. The Grindstone River Watershed is a large driver of the percentage of recreational impairments with six WIDs failing standards in that subwatershed alone.

Table 17. Assessment summary for stream water quality in the Kettle River Watershed.

				Supporting		Non-supporting		
Watershed	**Area (acres)**	**# Total WIDs**	**# Assessed WIDs**	**# Aquatic life**	**# Aquatic recreation**	**# Aquatic life**	**# Aquatic recreation**	**Insufficient data**
Kettle Watershed **HUC 8**	672927	**123**	**44**	**32**	**8**	**7**	**9**	**9**
Upper Kettle River	80882	9	4	3	0	1	1	1
Middle Kettle River	72326	14	5	5	0	0	0	0
Split Rock River	39461	9	1	1	0	0	1	0
Birch Creek	32023	4	1	1	0	0	0	0

				Supporting		Non-supporting		
Watershed	**Area (acres)**	**# Total WIDs**	**# Assessed WIDs**	**# Aquatic life**	**# Aquatic recreation**	**# Aquatic life**	**# Aquatic recreation**	**Insufficient data**
Moose Horn River	90326	14	7	7	1	0	0	0
Willow River	85750	9	5	4	1	1	0	0
Pine River	92197	22	7	5	1	0	0	1 and 2
Grindstone River	55558	19	6	3	0	1	6	4
Lower Kettle River	124403	23	7	3	3	3	0	1

Lake water quality

The Kettle River Watershed only has about 120 lakes that are greater than 10 acres in size. Thirty-two lakes were assessed against NLF ecoregion standards for recreation use, and half of them fully support that beneficial use. Thirteen lakes were assessed for aquatic life use by the MNDNR, and eight of them are fully supporting that beneficial use. The Moose Horn River aggregated 12-HUC (0703000302-01) has the most lakes that fully support recreation (Table 19). Protection strategies will be an important part of future management efforts in the Moose Horn River subwatershed. Restoration and protection efforts should also prioritize the Pine River and Grindstone River aggregated 12-HUCs; Pine R. 12-HUC has the most nutrient listings and Grindstone R. 12-HUC has the only lake in the Kettle River Watershed that supports a Lake Trout population (Grindstone Lake).

Table 18. Assessment summary for lake water chemistry in the Kettle River Watershed.

			Supporting		Non-supporting			
Watershed	Area (acres)	Lakes >10 acres	# Aquatic life	# Aquatic recreation	# Aquatic life	# Aquatic recreation	Insufficient data	# Delistings
07030003	**672,924**	**121**	**8**	**16**	**1**	**11**	**32**	**07030003**
Upper Kettle River	80,947	9	- -	- -	- -	1	3	0703000301-04
Moose Horn River	90,401	27	3	9	- -	1	14	0703000302-01
Willow River	85,818	22	1	3	1	1	3	0703000303-01
Pine River	92,259	23	3	3	- -	5	5	0703000304-01
Grindstone River	55,608	16	1	1	- -	2	3	0703000305-01
Lower Kettle River	124,505	22	- -	- -	- -	1	4	0703000306-01

Fish contaminant results

Mercury and polychlorinated biphenyls (PCBs) have been analyzed in fish tissue samples collected from the Kettle River and 16 lakes in the watershed. Samples were collected by MNDNR fisheries staff from 1981 to 2016 and MPCA biomonitoring staff collected fish from the Kettle River in 2016.

Thirteen of the 16 tested lakes are on the 2018 Impaired Waters Inventory (IWI) for mercury in fish tissue (Table 22). Nine of the lakes on the IWI qualified for inclusion in the Minnesota Statewide Mercury TMDL.

PCBs were tested in representative species from seven lakes and the Kettle River. All PCB concentrations were near or less than the reporting limits and were, therefore, well below the 0.2-ppm threshold for impairment.

Table 19. Fish contaminants: summary of fish length, mercury and PCBs by waterway-species-year

							Length (in)			Mercury (mg/kg)			PCBs (mg/kg)			
WID	Waterway	Species	Year	Anatomy[1]	Total Fish	Number Samples	Mean	Min	Max	Mean	Min	Max	N	Mean	Max	< RL
07030003-502	KETTLE RIVER**	Channel catfish	1992	FILET	1	1	26.4	26.4	26.4	0.550	0.550	0.550	1	0.046	0.046	
07030003-503			2002	FILET	1	1	27.0	27.0	27.0	0.882	0.882	0.882	1	0.01	0.01	Y
07030003-505		Golden redhorse	1992	FILSK	7	1	16.3	16.3	16.3	0.300	0.300	0.300				
07030003-506			2016	FILSK	5	5	16.9	15.1	17.9	0.322	0.250	0.469	2	0.025	0.025	Y
07030003-508		Northern pike	1988	FILSK	5	1	19.0	19.0	19.0	1.400	1.400	1.400	1	0.022	0.022	
07030003-510			1992	FILSK	12	6	19.7	14.7	25.3	0.292	0.180	0.540	2	0.012	0.014	
07030003-511			2002	FILSK	2	2	21.6	20.8	22.4	0.255	0.222	0.288				
07030003-517			2007	FILSK	5	5	15.9	12.0	18.9	0.234	0.146	0.381				
07030003-519			2016	FILSK	2	2	20.4	18.7	22.0	0.188	0.121	0.254	2	0.025	0.025	Y
07030003-528		Rock bass	1992	FILSK	15	2	5.8	5.7	5.9	0.160	0.110	0.210				
07030003-529		Silver redhorse	2002	FILSK	5	1	19.4	19.4	19.4	0.304	0.304	0.304				
07030003-551		Smallmouth bass	1992	FILSK	5	1	10.1	10.1	10.1	0.270	0.270	0.270				
07030003-552			2007	FILSK	5	5	11.2	10.0	12.6	0.170	0.124	0.230				
		Walleye	1992	FILSK	12	5	16.0	12.6	21.4	0.524	0.280	0.680	3	0.012	0.016	
			2002	FILSK	4	4	14.3	12.5	17.0	0.222	0.161	0.335				
			2016	FILSK	3	3	62.9	15.4	155.1	0.225	0.193	0.264	2	0.025	0.025	Y
		White sucker	1988	FILSK	10	1	14.1	14.1	14.1	0.190	0.190	0.190	1	0.01	0.01	Y
09-0029-00	PARK*	Black bullhead	2012	FILET	5	1	12.5	12.5	12.5	0.038	0.038	0.038				
		Black crappie	1999	FILSK	10	1	9.0	9.0	9.0	0.040	0.040	0.040				
		Bluegill sunfish	1999	FILSK	10	1	7.1	7.1	7.1	0.050	0.050	0.050				
			2012	FILSK	5	1	7.3	7.3	7.3	0.038	0.038	0.038				
		Largemouth bass	2012	FILSK	2	2	13.2	13.0	13.3	0.130	0.099	0.160				
		Northern pike	1999	FILSK	7	7	24.1	18.9	30.5	0.216	0.110	0.360	1	0.01	0.01	Y
			2012	FILSK	6	6	23.0	17.5	26.9	0.172	0.099	0.249				
		Walleye	1999	FILSK	8	8	18.9	15.3	21.3	0.226	0.080	0.420				
			2012	FILSK	3	3	20.0	16.9	22.7	0.183	0.097	0.247				
		White sucker	1999	FILSK	2	1	18.8	18.8	18.8	0.050	0.050	0.050				
09-0035-00	LITTLE HANGING HORN*	Bluegill sunfish	2000	FILSK	6	1	7.1	7.1	7.1	0.140	0.140	0.140				
		Northern pike	2000	FILSK	6	6	22.2	17.0	28.8	0.367	0.240	0.470				
		White sucker	2000	FILSK	7	1	13.5	13.5	13.5	0.250	0.250	0.250				
09-0038-00	HANGING HORN**	Black crappie	2000	FILSK	10	1	9.1	9.1	9.1	0.190	0.190	0.190				
		Cisco (Lake herring)	2005	FILSK	5	1	10.7	10.7	10.7	0.227	0.227	0.227				
		Northern pike	1983	FILSK	16	4	24.5	18.4	31.4	0.665	0.510	0.840				
			2005	FILSK	7	7	23.5	17.2	30.2	0.734	0.428	1.057				

WID	Waterway	Species	Year	Anatomy[1]	Total Fish	Number Samples	Length (in) Mean	Min	Max	Mercury (mg/kg) Mean	Min	Max	PCBs (mg/kg) N	Mean	Max	< RL
			2010	FILSK	15	15	23.6	17.0	31.8	0.652	0.447	0.954				
			2015	FILSK	11	11	27.2	15.1	36.7	0.837	0.484	1.182				
		Walleye	1983	FILSK	4	1	15.2	15.2	15.2	0.780	0.780	0.780				
			2000	FILSK	6	6	16.2	11.0	22.5	0.922	0.650	1.440				
			2005	FILSK	3	3	21.8	18.0	25.5	1.504	1.080	2.150				
		White sucker	2000	FILSK	4	1	17.5	17.5	17.5	0.130	0.130	0.130				
09-0039-00	EDDY**	Bluegill sunfish	1998	FILSK	6	1	6.9	6.9	6.9	0.110	0.110	0.110				
		Northern pike	1998	FILSK	5	5	20.7	17.3	29.3	0.486	0.250	0.980				
		Walleye	1998	FILSK	3	3	15.6	14.2	16.6	0.407	0.330	0.520				
		White sucker	1998	FILSK	6	1	16.9	16.9	16.9	0.340	0.340	0.340				
09-0041-00	MOOSEHEAD**	Black crappie	2014	FILSK	10	1	8.4	8.4	8.4	0.273	0.273	0.273				
		Northern pike	1984	FILSK	15	4	23.9	16.0	30.5	0.435	0.250	0.690				
			2014	FILSK	9	9	21.6	16.4	26.8	0.548	0.312	0.683				
		Walleye	1984	FILSK	5	1	14.0	14.0	14.0	0.300	0.300	0.300				
			2007	FILSK	5	5	17.7	14.5	20.0	0.642	0.216	1.039				
			2014	FILSK	8	8	18.3	14.7	22.9	1.046	0.376	1.377				
		White sucker	2014	FILSK	5	1	16.1	16.1	16.1	0.271	0.271	0.271				
33-0001-00	ELEVEN	Bluegill sunfish	1998	FILSK	10	1	6.7	6.7	6.7	0.050	0.050	0.050				
		Northern pike	1998	FILSK	10	10	17.8	14.8	26.5	0.081	0.046	0.130	1	0.01	0.01	Y
		Walleye	1998	FILSK	10	10	15.9	13.1	19.3	0.078	0.058	0.096				
33-0003-00	FIVE	Black crappie	2007	FILSK	8	8	8.3	7.5	9.0	0.031	0.010	0.084				
		Northern pike	1982	FILSK	6	2	21.2	19.0	23.3	0.355	0.310	0.400				
58-0048-00	OAK*	Black crappie	2010	FILSK	3	1	7.9	7.9	7.9	0.067	0.067	0.067				
		Bluegill sunfish	2010	FILSK	3	1	7.0	7.0	7.0	0.040	0.040	0.040				
		Northern pike	2010	FILSK	8	8	20.2	18.1	22.9	0.167	0.139	0.205				
		White sucker	2010	FILSK	3	1	16.1	16.1	16.1	0.044	0.044	0.044				
58-0067-00	STURGEON*	Black bullhead	1991	FILET	6	1	12.6	12.6	12.6	0.095	0.095	0.095	1	0.01	0.01	Y
		Black crappie	2011	FILSK	10	2	8.8	7.8	9.8	0.068	0.052	0.084				
		Bluegill sunfish	1991	FILSK	10	1	6.9	6.9	6.9	0.050	0.050	0.050				
		Largemouth bass	1991	FILSK	6	1	9.2	9.2	9.2	0.140	0.140	0.140				
		Northern pike	1986	FILSK	12	3	22.5	17.0	28.6	0.173	0.140	0.230				
			1991	FILSK	22	5	22.9	13.9	34.9	0.318	0.110	0.610	3	0.01	0.01	Y
			2011	FILSK	7	7	21.0	17.6	30.8	0.299	0.146	0.531				
		Walleye	1986	FILSK	15	3	17.4	13.5	21.9	0.213	0.190	0.250	1	0.05	0.05	Y
			1991	FILSK	20	4	19.5	13.7	25.3	0.225	0.120	0.310	3	0.01	0.01	Y
		White sucker	1991	FILSK	3	1	16.6	16.6	16.6	0.030	0.030	0.030	1	0.01	0.01	Y

WID	Waterway	Species	Year	Anatomy[1]	Total Fish	Number Samples	Length (in)			Mercury (mg/kg)			PCBs (mg/kg)			
							Mean	Min	Max	Mean	Min	Max	N	Mean	Max	< RL
		Yellow bullhead	2011	FILET	5	1	10.3	10.3	10.3	0.160	0.160	0.160				
		Yellow perch	1991	WHORG	10	1	6.2	6.2	6.2	0.081	0.081	0.081				
58-0081-00	SAND*	Black bullhead	2012	FILET	5	1	11.2	11.2	11.2	0.201	0.201	0.201				
		Bluegill sunfish	2012	FILSK	10	2	7.5	7.1	7.8	0.142	0.126	0.157				
		Northern pike	2012	FILSK	6	6	20.3	17.9	24.0	0.264	0.211	0.319				
58-0107-00	LONG*	Bluegill sunfish	1998	FILSK	10	1	6.0	6.0	6.0	0.074	0.074	0.074				
		Largemouth bass	1998	FILSK	1	1	14.1	14.1	14.1	0.310	0.310	0.310				
		Northern pike	1998	FILSK	10	10	19.4	16.4	26.5	0.164	0.110	0.290				
		White crappie	1998	FILSK	2	1	9.4	9.4	9.4	0.064	0.064	0.064				
58-0123-00	GRINDSTONE*	Bluegill sunfish	2012	FILSK	10	2	7.2	6.8	7.5	0.108	0.090	0.125				
		Lake trout	2012	FILSK	2	2	17.4	14.4	20.3	0.145	0.125	0.165				
		Northern pike	2012	FILSK	6	6	22.2	18.4	26.2	0.313	0.209	0.423				
		Rainbow smelt	2012	NHOV	5	1	7.8	7.8	7.8	0.179	0.179	0.179				
58-0127-00	LITTLE BASS	Largemouth bass	1981	WHORG	1	1	15.8	15.8	15.8	0.290	0.290	0.290				
		Northern pike	1981	FILSK	4	1	18.8	18.8	18.8	0.260	0.260	0.260	1	0.025	0.025	Y
			1984	FILSK	3	1	20.3	20.3	20.3	0.530	0.530	0.530				
58-0128-00	BASS**	Bluegill sunfish	1994	FILSK	10	1	5.6	5.6	5.6	0.100	0.100	0.100				
		Brown bullhead	1994	FILET	8	1	8.9	8.9	8.9	0.290	0.290	0.290				
		Northern pike	1994	FILSK	7	3	20.3	17.2	23.2	0.573	0.370	0.750	1	0.01	0.01	Y
58-0130-00	UPPER PINE*	Black crappie	1993	FILSK	10	1	7.6	7.6	7.6	0.170	0.170	0.170				
		Northern pike	1993	FILSK	19	3	21.7	17.4	26.7	0.280	0.150	0.360	1	0.01	0.01	Y
		White sucker	1993	FILSK	8	1	11.1	11.1	11.1	0.046	0.046	0.046				
58-0138-00	BIG PINE*	Black crappie	1999	FILSK	7	1	9.3	9.3	9.3	0.030	0.030	0.030				
		Bluegill sunfish	1999	FILSK	10	1	6.6	6.6	6.6	0.040	0.040	0.040				
		Northern pike	1984	FILSK	5	1	23.5	23.5	23.5	0.370	0.370	0.370				
			1999	FILSK	8	8	23.9	18.6	35.2	0.155	0.070	0.270	1	0.012	0.012	Y
		Walleye	1984	FILSK	12	3	22.5	18.6	26.8	1.210	0.740	1.680				
			1999	FILSK	7	7	17.8	14.3	21.6	0.224	0.140	0.320	1	0.01	0.01	Y

* Impaired for mercury in fish tissue as of 2018 Draft Impaired Waters Inventory; categorized as EPA Category 4a for waters covered by the Statewide Mercury TMDL.

** Impaired for mercury in fish tissue as of 2018 Draft Impaired Waters Inventory; categorized as EPA Category 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 monitoring sites located within the Kettle River Watershed as shown in Table 20.

Table 20. WPLMN Stream Monitoring Sites for the Kettle River Watershed

Site Type	Stream Name	USGS ID	MNDNR/MPCA ID	EQuIS ID
Major watershed	Kettle River nr Sandstone, MN48	05336700	W35070001	S000-121
Subwatershed	Kettle River nr Willow River, Long Lake Rd	NA	H35051002	S007-954

*Water samples are collected at a different location than the USGS flow gaging station. The EQuIS ID and MNDNR/MPCA ID are the locations where the actual samples are collected.

Average annual FWMCs of TSS, TP, and NO_3+NO_2-N for major watershed stations statewide are presented in Figure 24, with the Kettle River 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; expressed in inches.

As a general rule, elevated levels of TSS and NO_3+NO_2-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 NO_3+NO_2-N in surface waters impacts fish and other aquatic life, as well as fishing, swimming and other recreational uses. Segments of the Kettle River are designatated as recreational, wild, and scenic under the Minnesota State Wild and Scenic Rivers Program. The Kettle River flows directly into the Saint Croix River, which is recognized as a National Scenic Riverway. Recurring algal blooms have been reported on Lake Saint Croix, a naturally occuring lake that the Saint Croix River flows through just before its confluence with the Mississippi River.

More information, including results for the above monitoring stations, can be found at the WPLMN website https://www.pca.state.mn.us/water/watershed-pollutant-load-monitoring.

When compared to the other basin and major watershed sites within the Saint Croix River Basin, the average annual TP FWMCs for the Kettle River are slightly elevated. Average annual TSS and NO_3+NO_2-N FWMCs for the Kettle River are relatively low, as they are throughout the rest of the Saint Croix River Basin. When compared to other basin and major watershed sites throughout Minnesota, average annual TSS, TP, and NO_3+NO_2-N FWMCs for the Kettle River are lower than most (Figure 22).

Substantial year-to-year variability in water quality occurs for most rivers and streams, including the Kettle River. Results for individual years are shown in Figure 23 and Figure 24 below. Elevated TSS and TP loads observed in 2016 are due in part to historic flooding that took place throughout the Kettle River Watershed in July 2016.

Annual TSS FWMCs have not exceeded the River Nutrient Region standard of 15 mg/L at either Kettle River monitoring site during the period of WPLMN monitoring. Of water samples collected, 11% exceed the River Nutrient Region standard at the Kettle River nr Sandstone, MN48, and 21% of samples exceed the standard at the Kettle River nr Willow River. Annual TP FWMCs at Kettle River near Sandstone, MN48 have exceeded the River Nutrient Region standard of 0.05 mg/L during six of the eight years for which WPLMN monitoring data is available. Annual TP FWMCs at Kettle River near Willow River exceed the River Nutrient Region standard during one of the two years for which data is available. Of water samples collected, 44% exceed the River Nutrient Region standard at the Kettle River near Sandstone, MN48, and 43% of samples exceed the standard at the Kettle River near Willow River. Individual samples are not intended to represent standard flow conditions.

Figure 22. 2007-2016 Average annual TSS, TP, and NO3-NO2-N flow weighted mean concentrations, and runoff by major watershed.

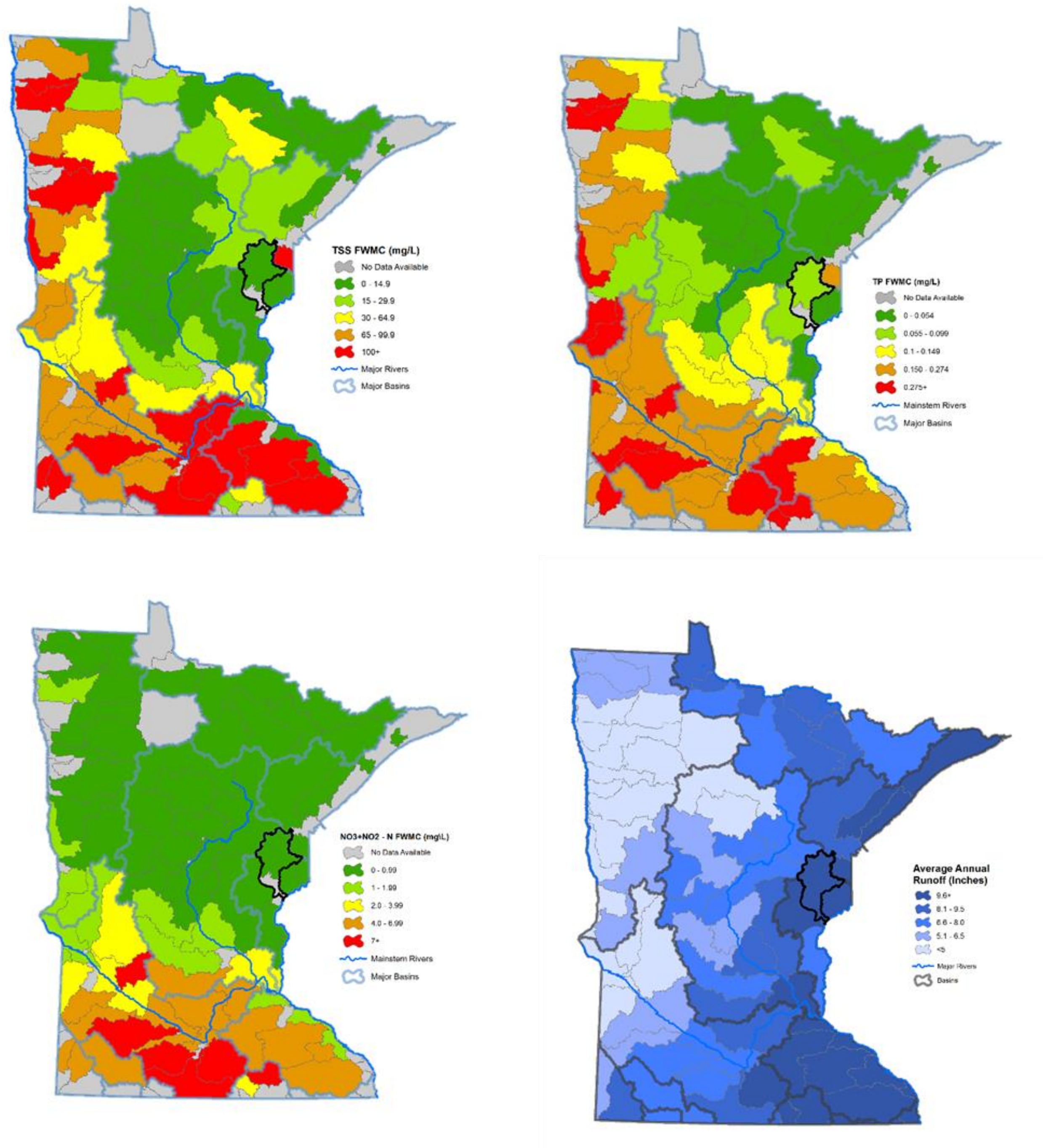
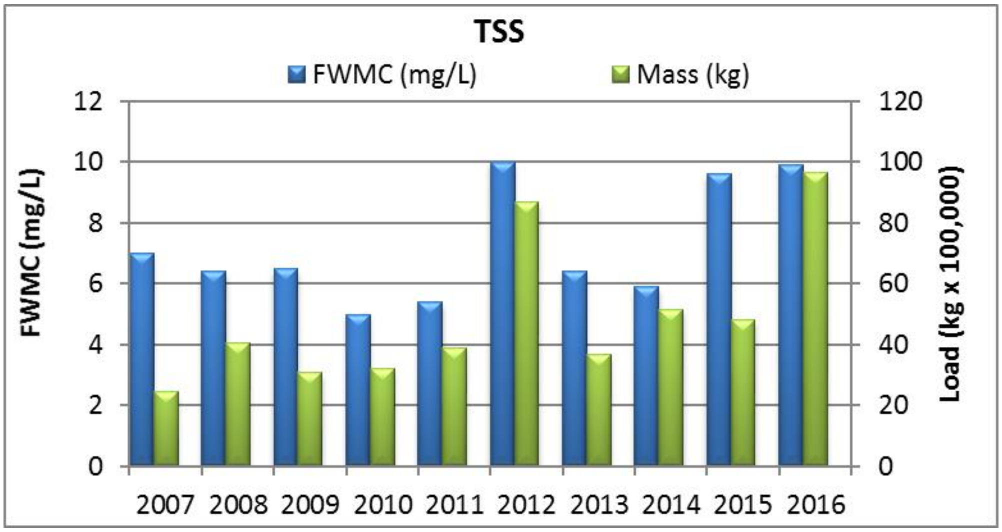
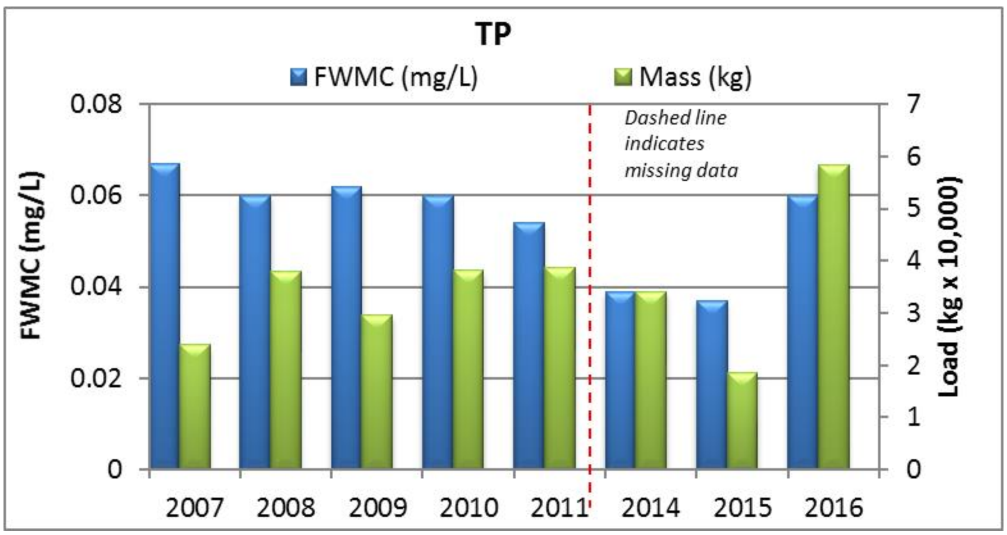


Figure 23. TSS, TP, and NO3+NO2-N Flow Weighted Mean Concentrations and Loads for the Kettle River near Sandstone, MN48 monitoring site.





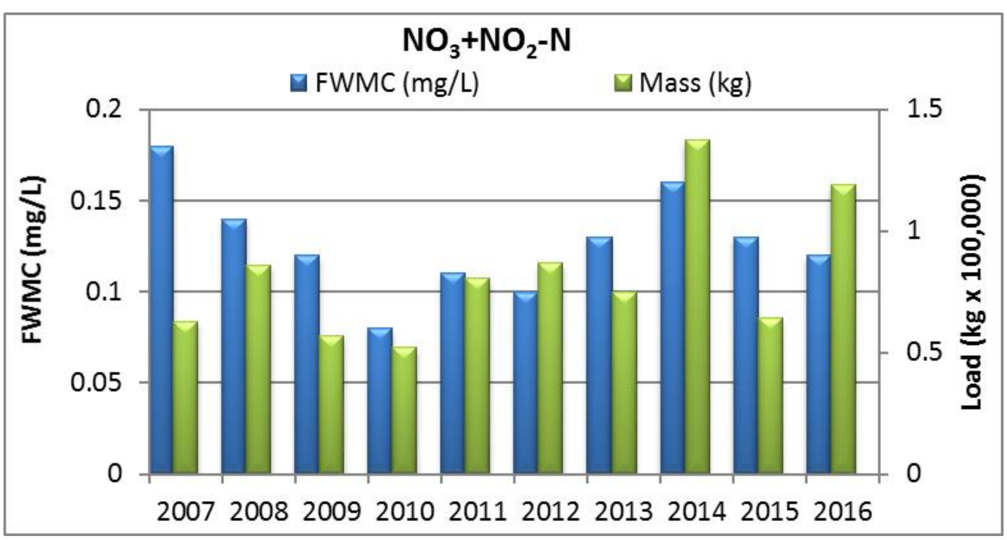
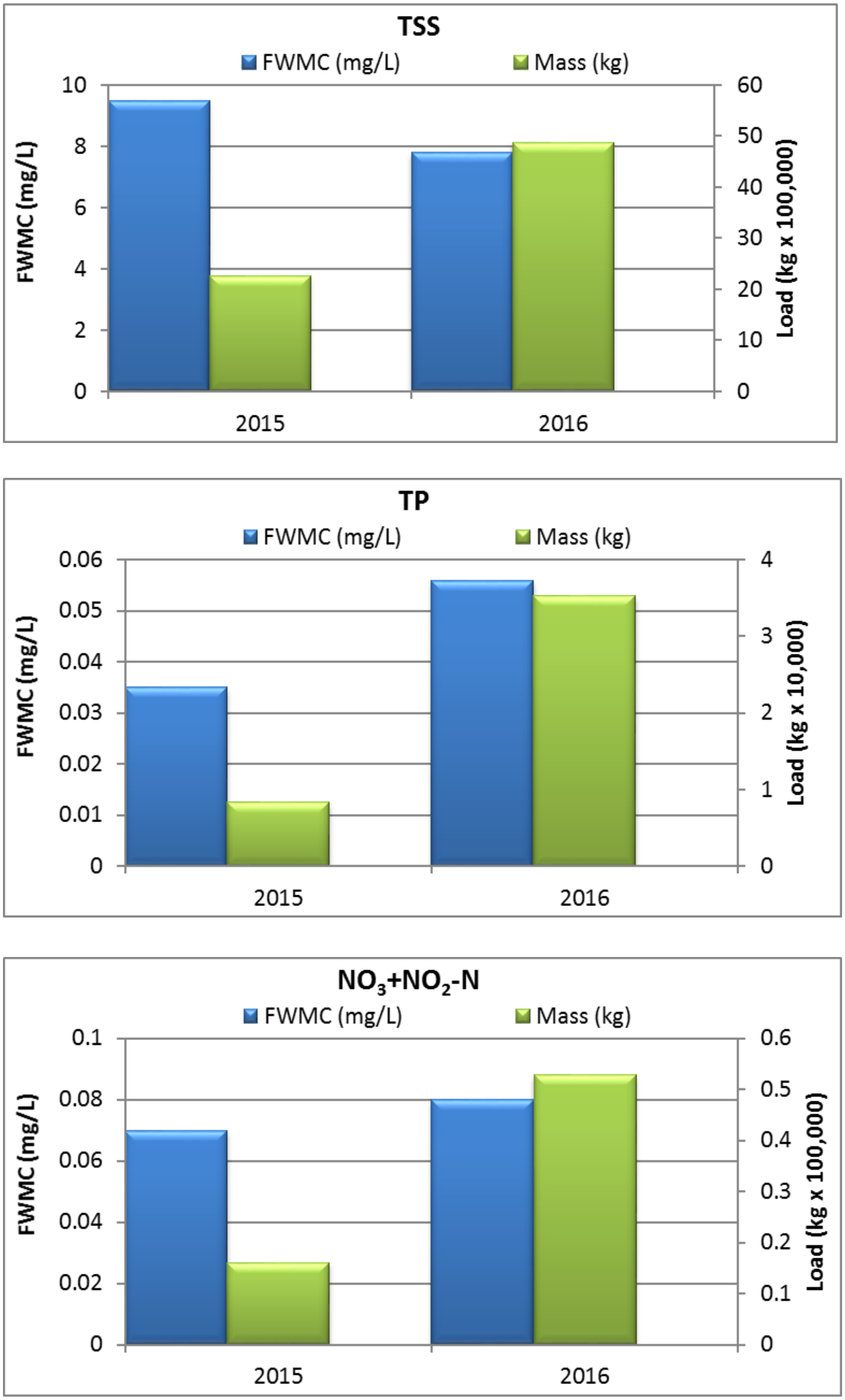
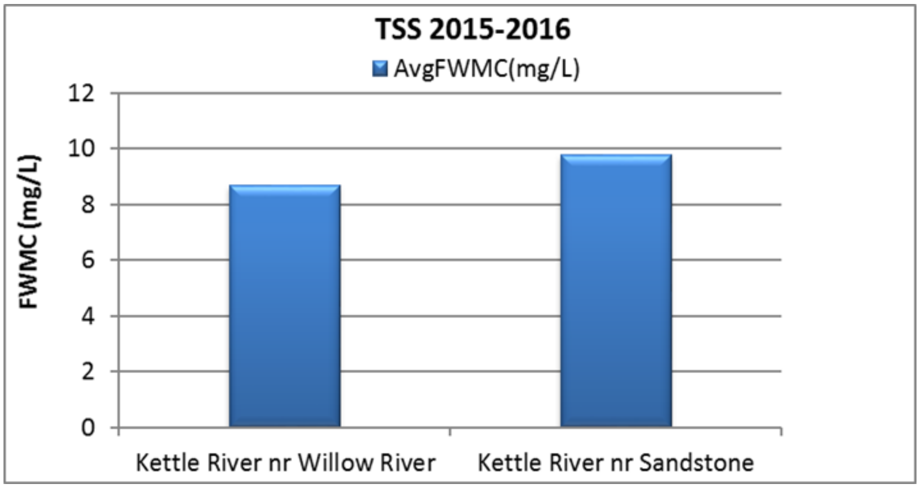


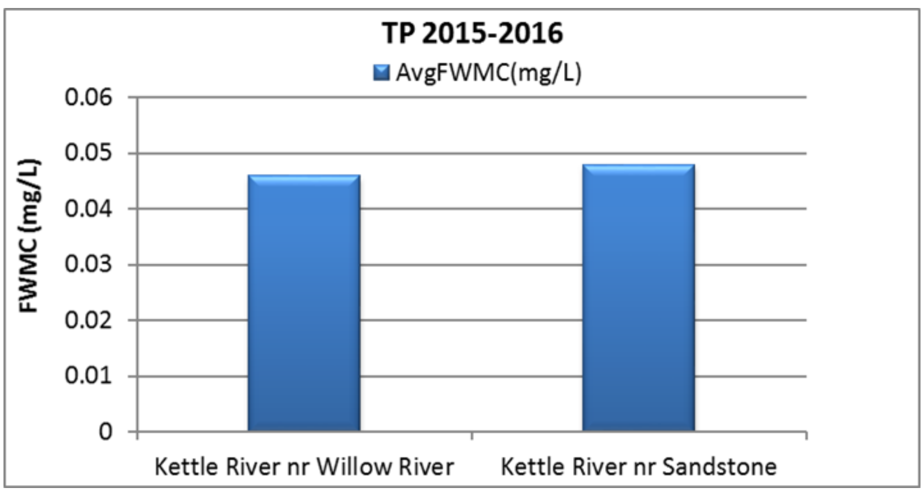
Figure 24. 2015-2016 TSS, TP, and NO3+NO2-N Flow Weighted Mean Concentrations and Loads for the Kettle River near Willow River, Long Lake Rd monitoring site.

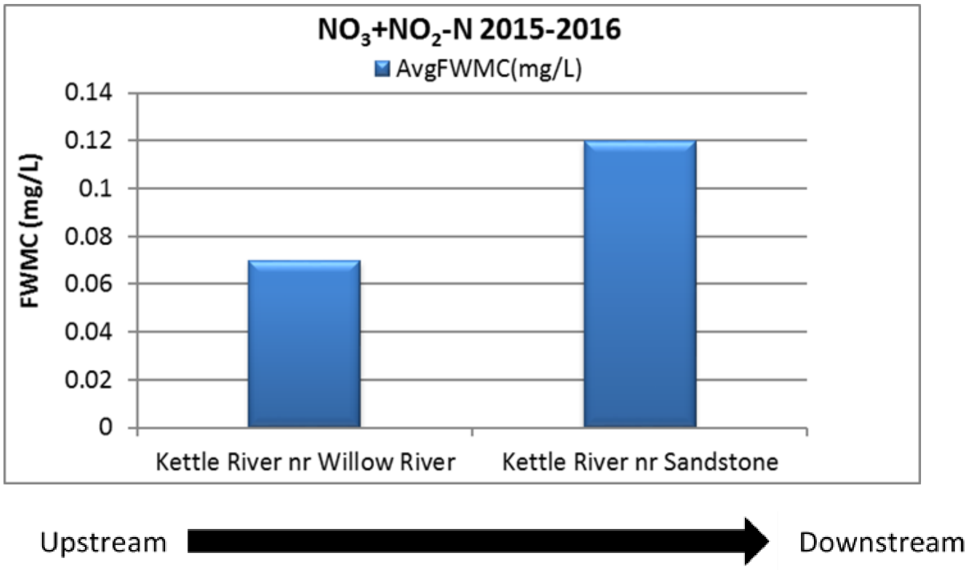


A review of data for the period in which monitoring at both Kettle River sites overlap (Figure 25) show that NO_3+NO_2-N FWMCs nearly double between the upstream monitoring site near Willow River and the downstream monitoring site near Sandstone. NO_3+NO_2-N FWMCs remain relatively low at both monitoring sites despite the observed increase. TSS and TP FWMCs are stable across the watershed.

Figure 25. 2015-2016 TSS, TP, and NO3+NO2-N Flow Weighted Mean Concentrations for the upstream Kettle River near Willow River monitoring site and the downstream Kettle River near Sandstone, MN48 monitoring site.





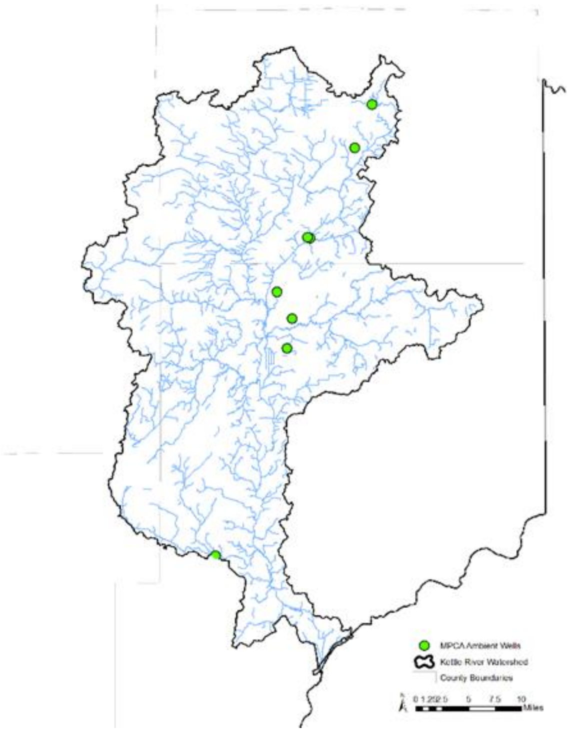


Groundwater monitoring

Groundwater Quality

Approximately 75% of Minnesota's population receives their drinking water from groundwater, so clean groundwater is essential to the health of its residents. The Minnesota Pollution Control Agency'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.

Figure 26. MPCA Ambient Groundwater Monitoring wells within the Kettle River Watershed



There are currently eight MPCA Ambient Groundwater Monitoring wells within the Kettle River Watershed. Data from these wells indicate the presence of naturally occurring minerals like iron and manganese. Additionally, the data show low-level fluctuating chloride concentrations, though it is unclear whether the fluctuations are a result of chloride use aboveground.

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 an average of 10% of all wells installed from 2008 to 2016 have arsenic levels above the MCL for drinking water of 10 micrograms per liter (MDH, 2019a). The Kettle River Watershed includes portions of Pine, Carlton, Aitkin and Kanabec counties. Arsenic levels above the MCL in new wells was rare in Pine and Kanabec counties, with only 2.7, and 2.6%. Detections above the MCL were only slightly more frequent in Carlton and Aitkin counties at 9.0% and 5.8%, respectively. (MDH 2019b)

Groundwater Quantity

The Minnesota Department of Natural Resources (MNDNR) maintains a statewide network of water level wells to assess groundwater resources, evaluate trends and plan. While there are a number of deep wells within the Kettle River Watershed, a shallower, water table well is more reactive to recharge and withdrawals. Groundwater elevations from wells #244281 near Willow River and #244276 near Hinckley are displayed below. Fluctuations in water level are common and expected with seasonal change and varied precipitation.

Figure 27. Water table elevations in Well #244281 near Willow River, 1982-2016

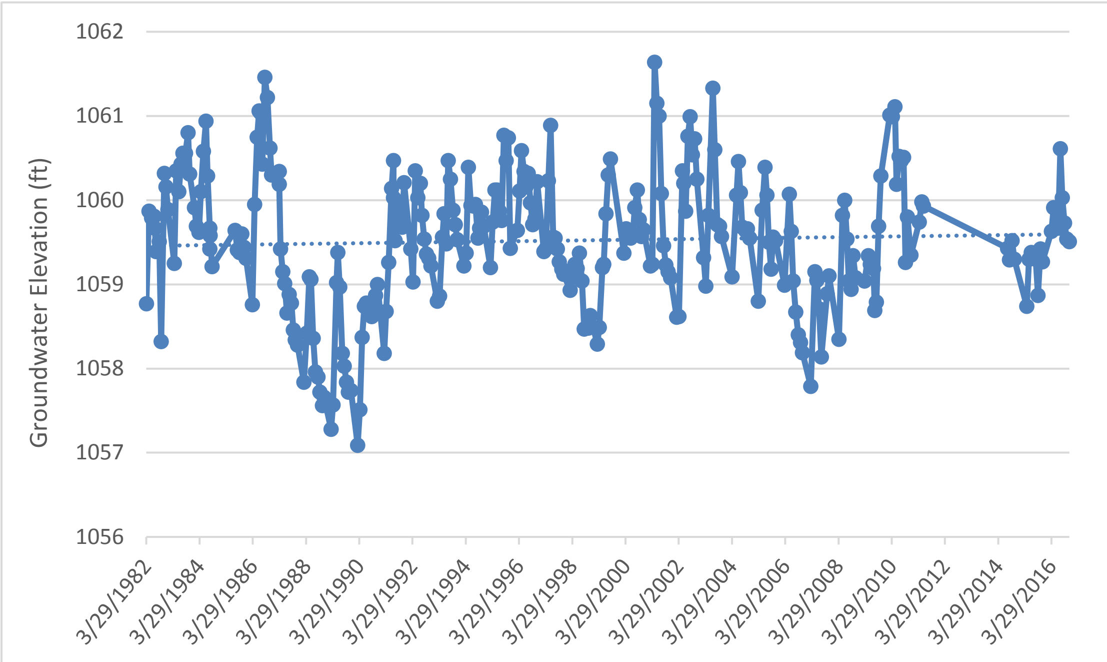
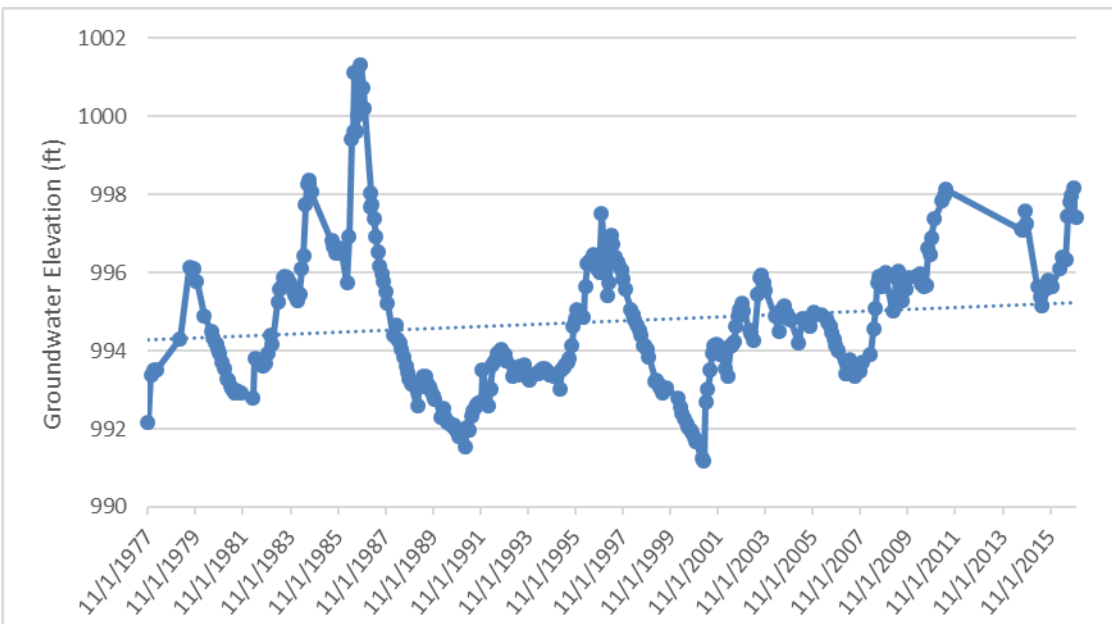


Figure 28. Water table elevations in Well #244276 near Hinckley, 1977-2016



The MNDNR 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 MNDNR 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 MNDNR 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 2016 are (in order) power generation, public water supply (municipals), and irrigation (MNDNR, 2017b). According to the most recent MNDNR Permitting and Reporting System (MPARS), in 2016 the withdrawals within the Kettle River Watershed are primarily used for water supplies and livestock watering.

Figure 29 displays total high capacity withdrawal locations within the watershed with active permit status in 2016. Permitted groundwater withdrawals are displayed below as blue triangles and surface water withdrawals as red squares. During 1997 to 2016, groundwater withdrawals within the Kettle River Watershed exhibit a significant increasing withdrawal trend ($p<0.01$) and surface water withdrawals have increased even more significantly ($p<0.001$) (Figure 30).

Figure 29. Locations of active status permitted high capacity withdrawals in 2016 within the Kettle River Watershed

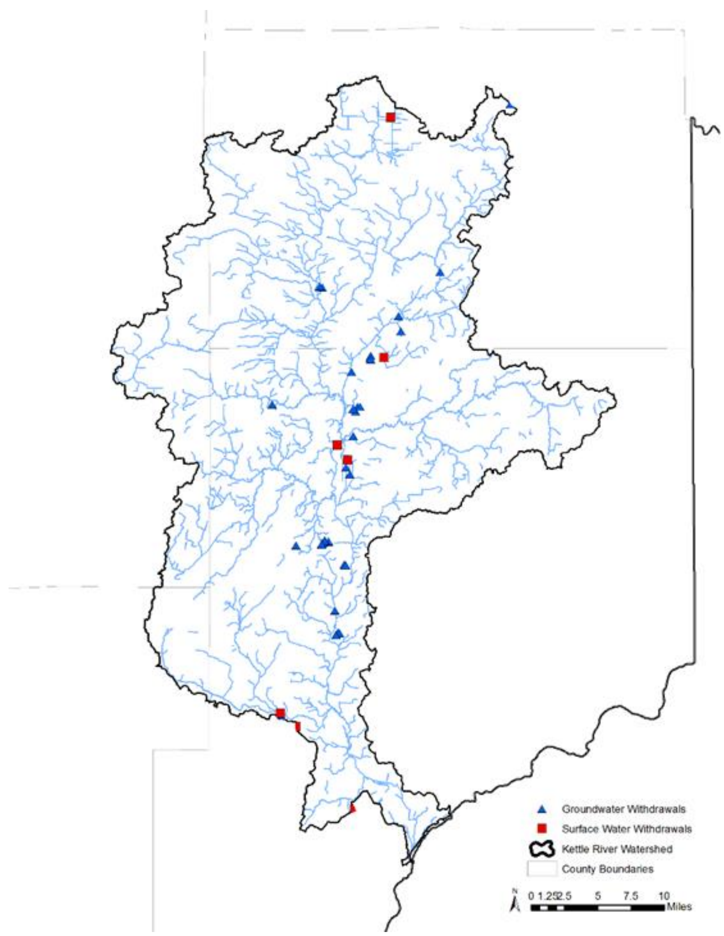
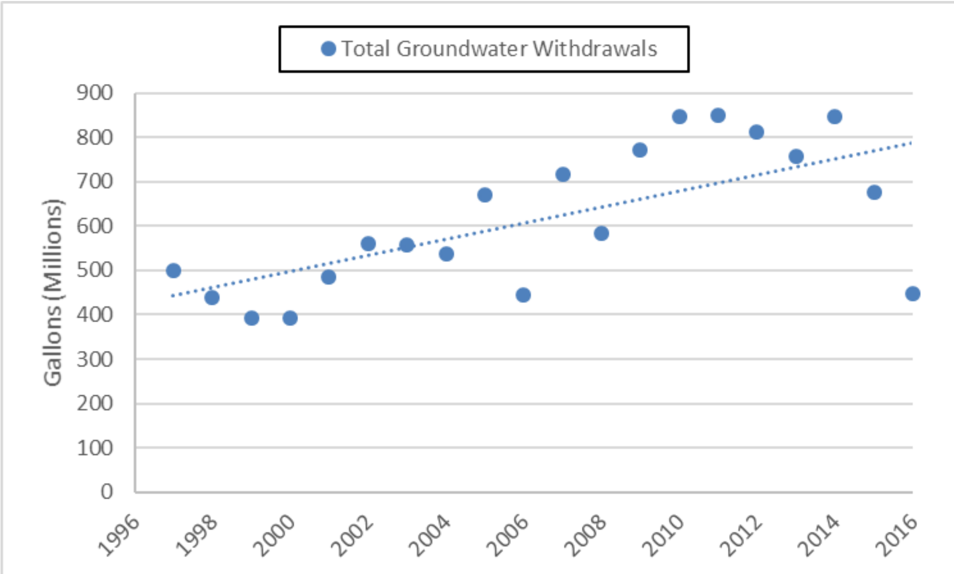
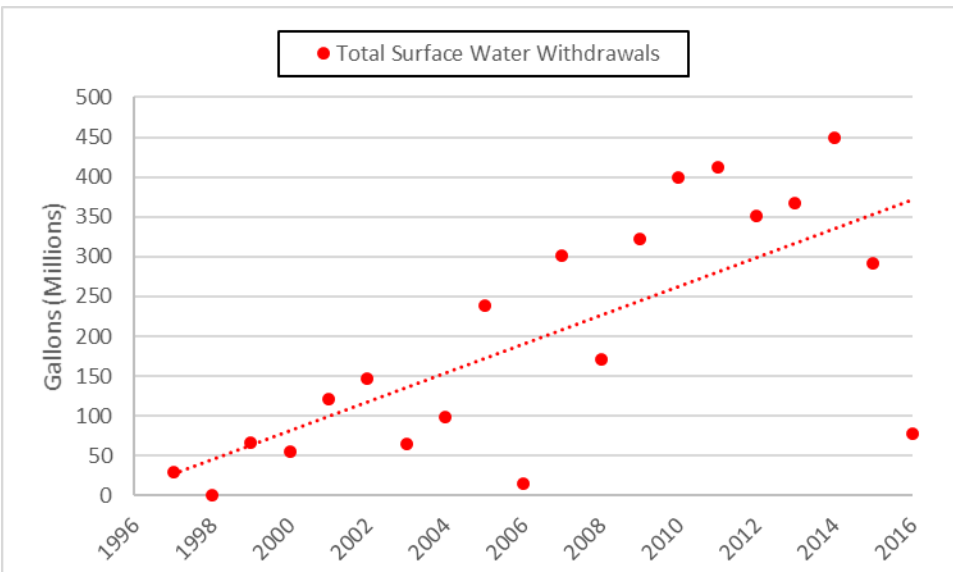


Figure 30. Total annual groundwater (above) and surface water (below) withdrawals in the Kettle River Watershed (1997-2016)

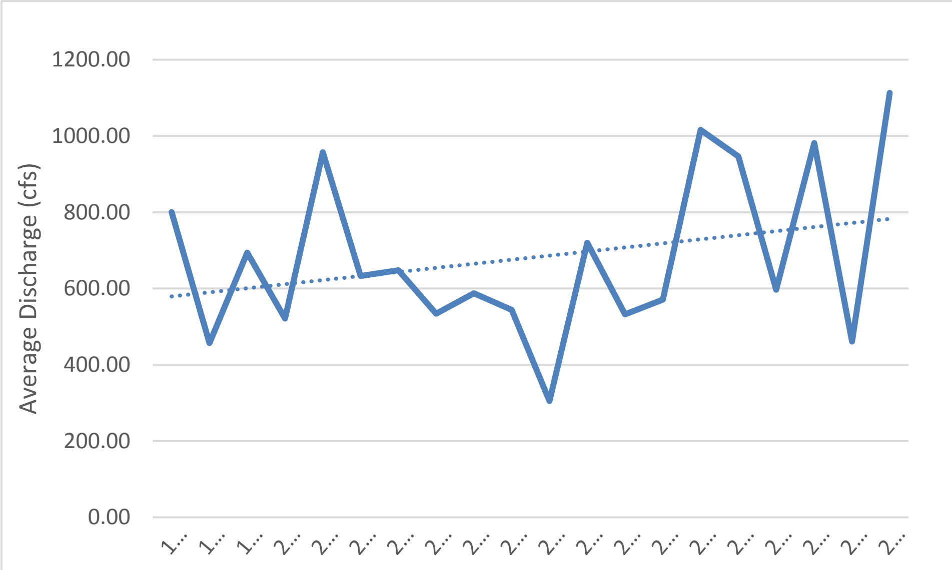


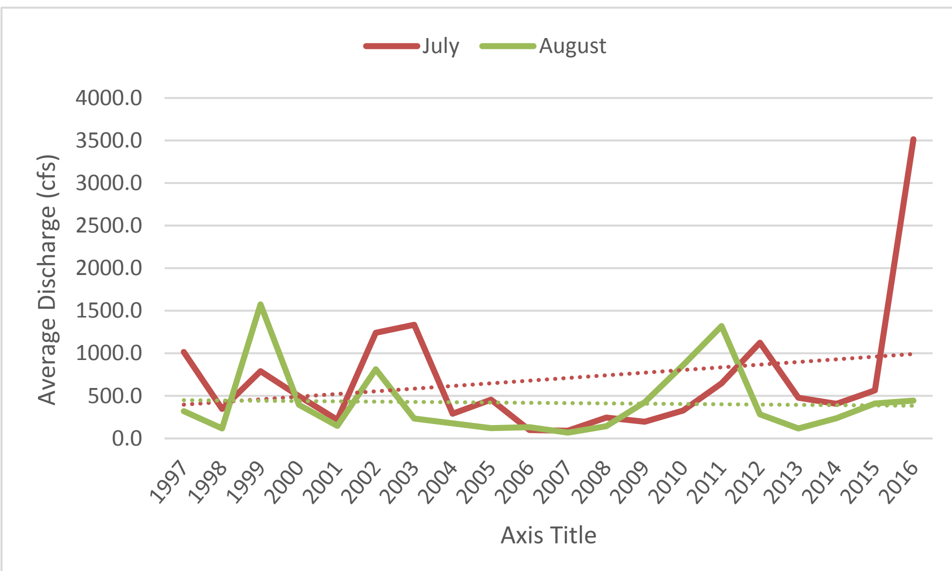


Stream flow

Stream flow data from the United States Geological Survey's real-time streamflow gaging station on the Kettle River near Sandstone, Minnesota were analyzed for average annual discharge and summer (July and August) monthly average discharge from 1997-2016 (Figure 31). The data fluctuate, but these changes illustrate seasonality of flow and responses to precipitation and are not statistically significant. 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 31. Average Annual (above) and Summer (below) mean discharge for the Kettle River near Sandstone, MN (1997-2016) (Source: USGS 2019)





Wetland condition

The Kettle River Watershed occurs nearly entirely within the Mixed Wood Shield Ecoregion. Wetland condition, in this ecoregion is very good, compared to other Minnesota ecoregions. Based on plant community floristic quality, 84% of the wetlands in the Mixed Wood Shield Ecoregion are estimated to be in Exceptional or Good condition, and an estimated 0% are in Poor condition (Table 21). In Minnesota's other two ecoregions, wetland condition is essentially opposite. In these locations, over 80% of existing wetland area is in either Fair or Poor condition.

Table 21. Wetland biological condition by major ecoregions based on floristic quality. Results are expressed as an extent (i.e., percentage of wetland acres) and include essentially all wetland types (MPCA 2015).

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%

As with stream and lake quality, many stressors can contribute to decreased wetland quality or condition. Altered hydrology, excessive sediment and/or nutrient, and toxic pollutant loading can all affect wetland quality. These stressors often promote establishment and spread of pollution tolerant invasive plants including narrow-leaf cattail (*Typha angustifolia*), hybrid cattail (*Typha* X *glauca*), and reed canary grass (*Phalaris arundinacea*). These invasive plants often outcompete native species due to their tolerance of nutrient enrichment, hydrologic alterations and toxic pollutants such as chlorides (Galatowitsch 2012) and thus strongly influence the composition and structure of affected wetland communities.

In the Kettle River Watershed, as with other HUC8 watersheds located in the Mixed Wood Shield ecoregion, monitoring and management resources allocated to water quality should focus on protecting the existing high quality wetland resource present in the watershed. These efforts should include limiting pollutant discharges and avoiding or minimizing hydrologic alternations that adversely affect wetland condition and facilitate establishment and spread of invasive species known, to rapidly, and dramatically affect wetland quality.

Figure 32. Stream Tiered Aquatic Life Use Designations in the Kettle River Watershed.

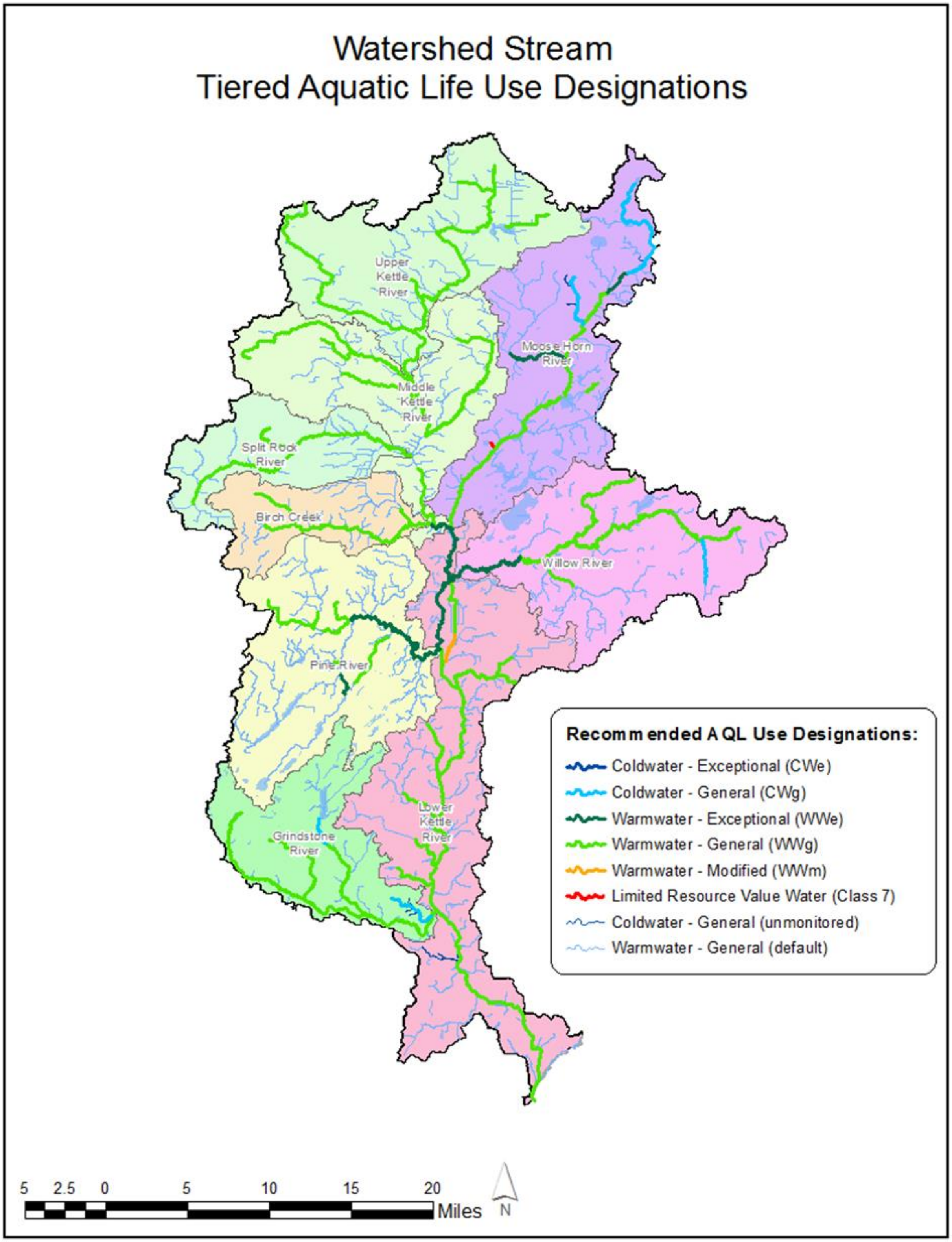


Figure 33. Fully supporting waters by designated use in the Kettle River Watershed.

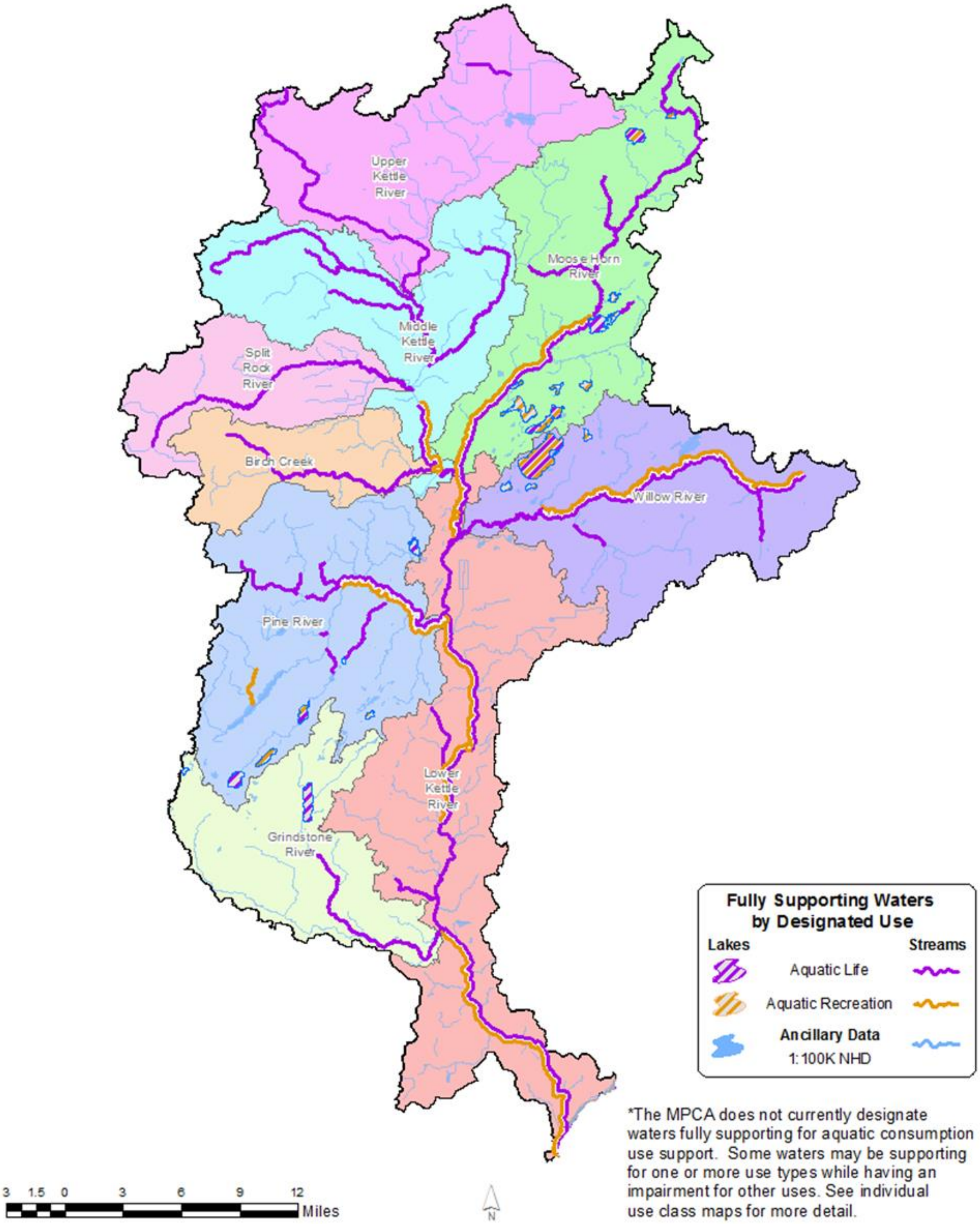


Figure 34. Impaired waters by designated use in the Kettle River Watershed.

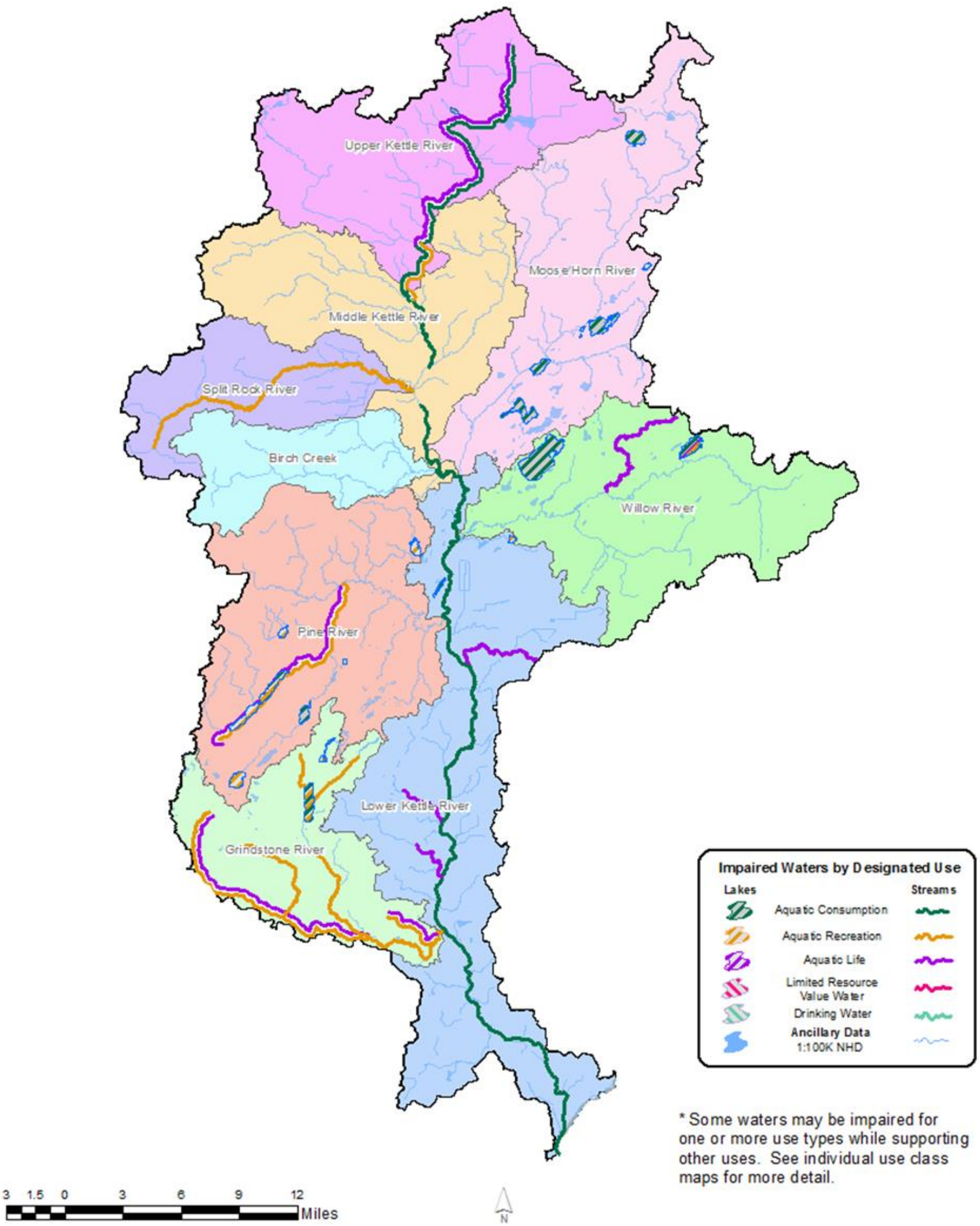


Figure 35. Aquatic consumption use support in the Kettle River Watershed.

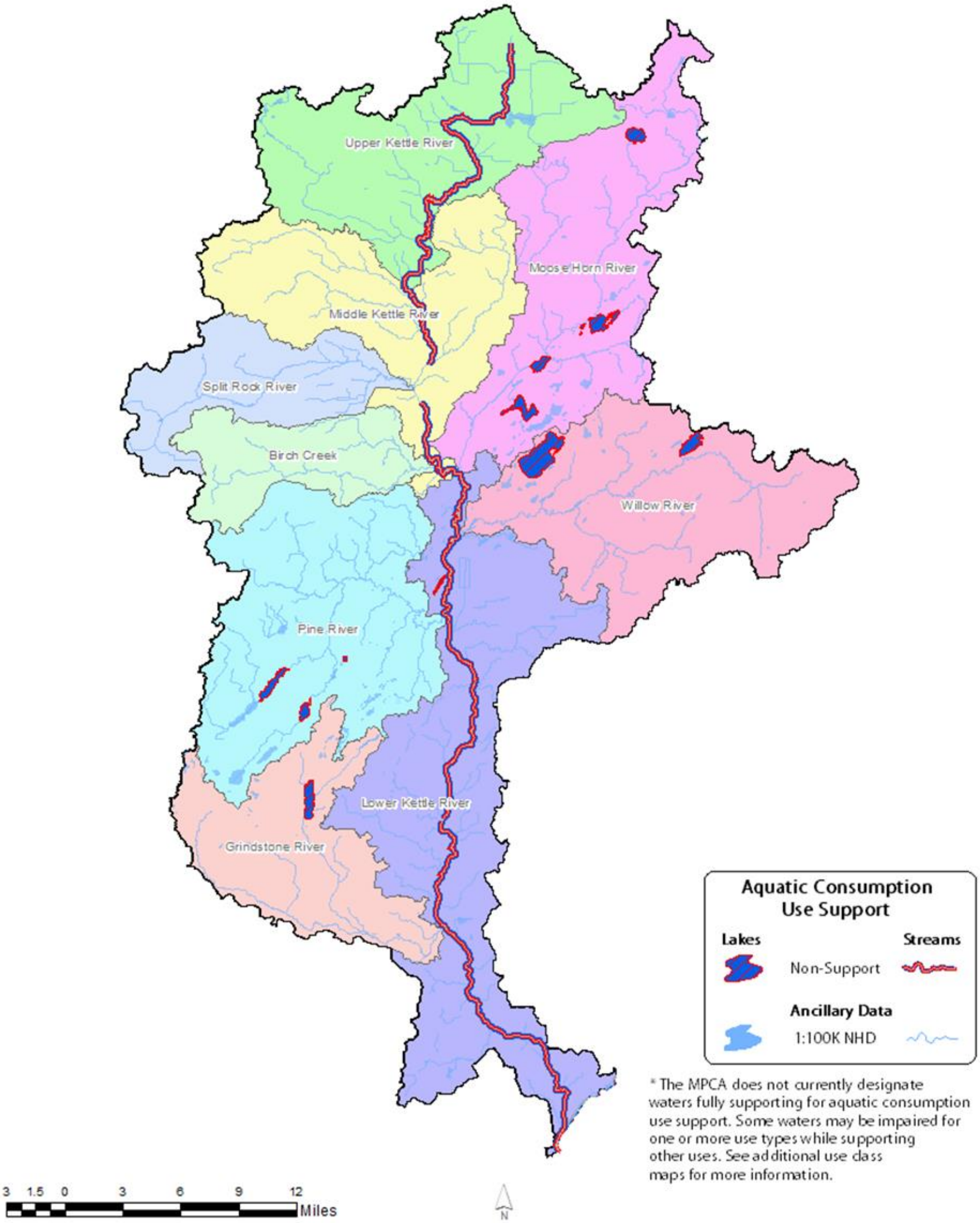


Figure 36. Aquatic life use support in the Kettle River Watershed.

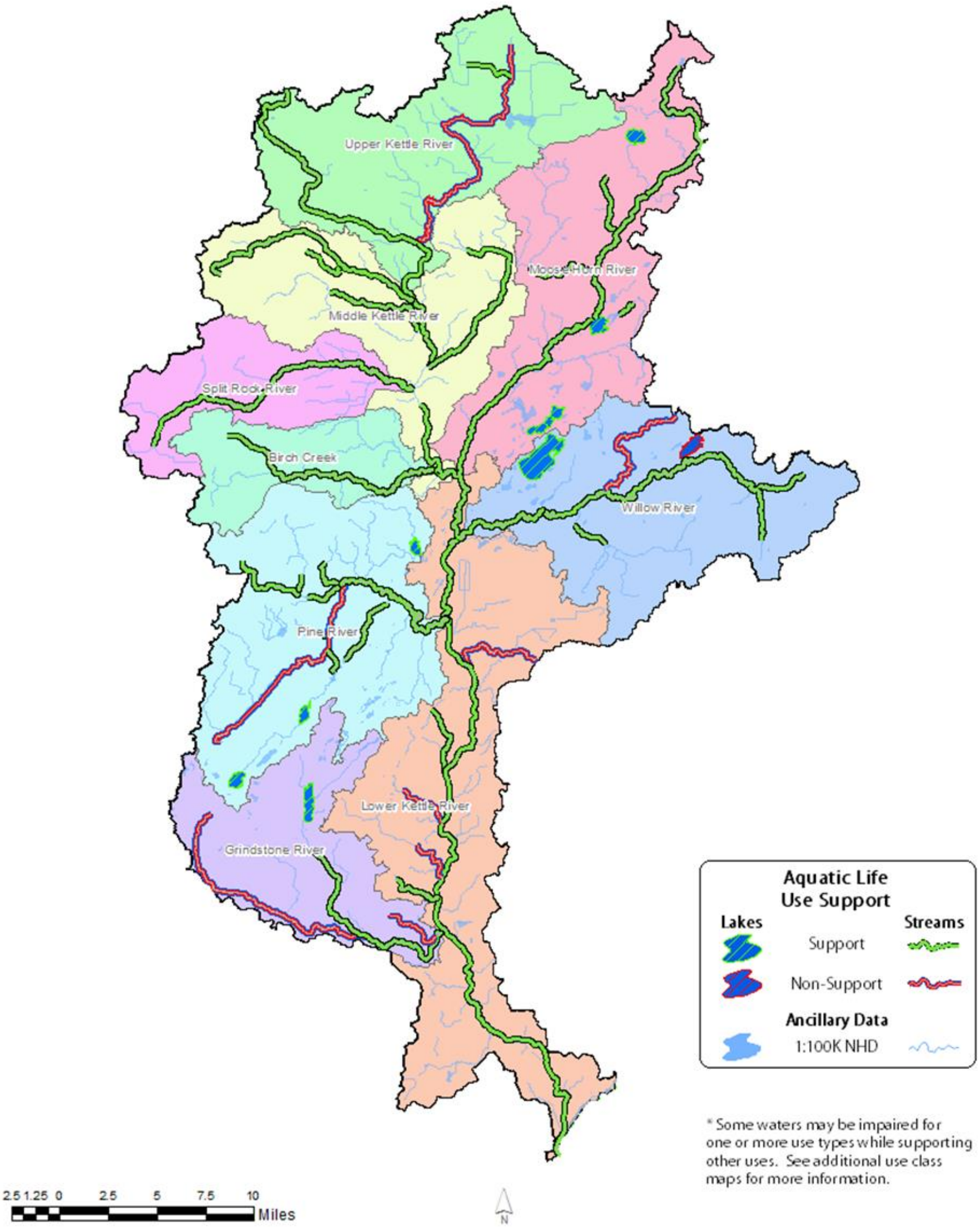
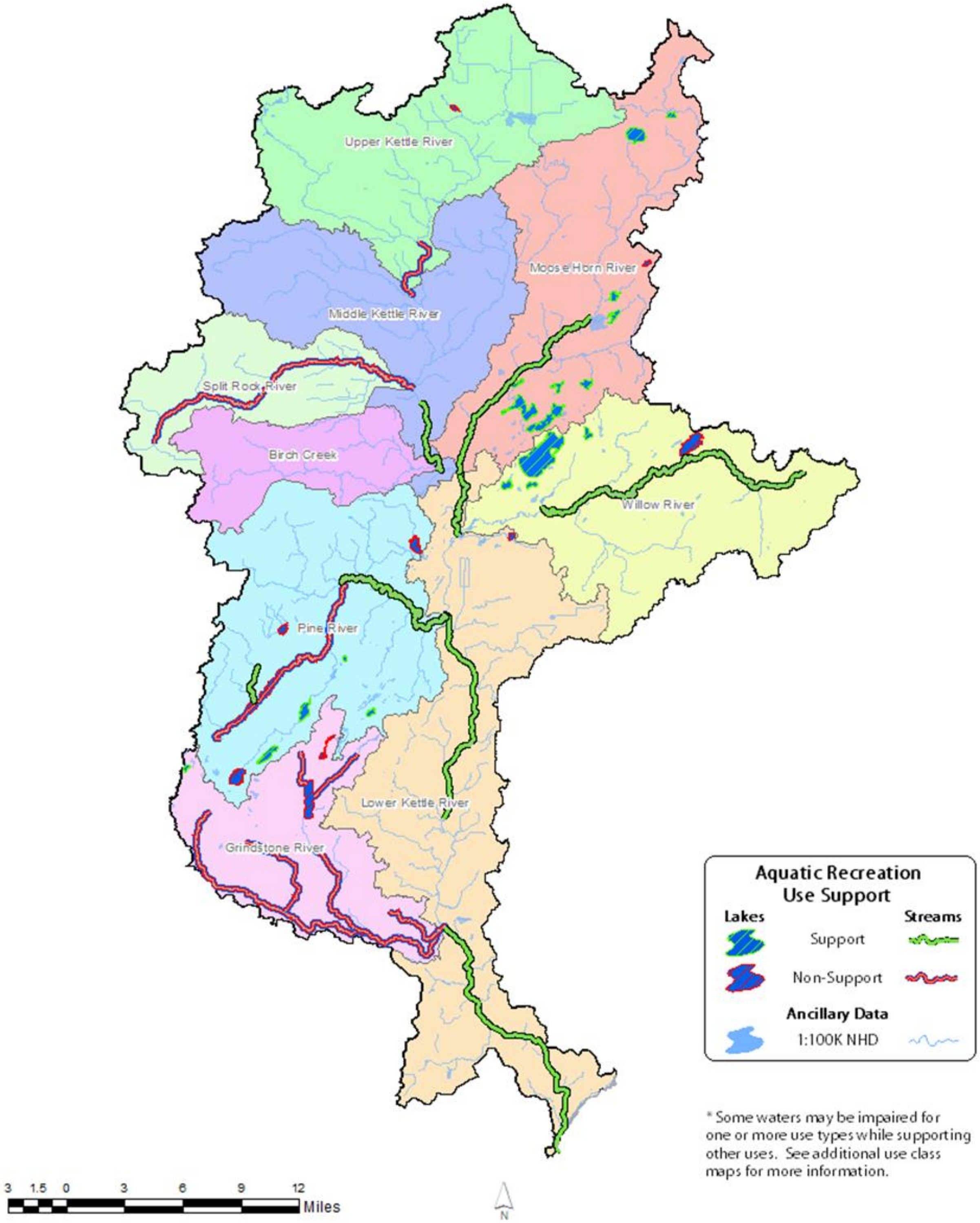


Figure 37. Aquatic recreation use support in the Kettle River Watershed.



Transparency trends for the Kettle River 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 calculated trends use a Seasonal Kendall statistical test for waters with a minimum of eight years of Secchi disk measurements in lakes and Secchi tube measurements in streams.

Citizen volunteer monitoring occurs at 14 stream locations and on 42 lakes in the watershed. There is strong evidence of a watershed-wide increasing trend in transparency based on stream measurements. Many volunteer monitored lakes do not yet have enough data (or sufficient coverage) for watershed-wide trend analysis, but individual lake analyses show that the number of increasing trends outnumber decreasing trends.

Table 22. Water Clarity Trends

Kettle River Watershed; 07030003	Streams	Lakes
Number of sites w/increasing trend	1	6
Number of sites w/decreasing trend	1	3
Number of sites w/no trend	4	16

Priority waters for protection and restoration in the Kettle River Watershed

The MPCA, MNDNR, and BWSR have developed 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 WRAPS 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. 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 Kettle River Watershed, highest protection priority is suggested for six lakes: Sturgeon, Moosehead, Island, Bear, Sand and Oak lakes. Even though Pine and Big Pine lakes are listed for excess nutrients, they were also identified as priorities as the health of the fish communities were near the impairment threshold. Four other lakes identified as being vulnerable to future recreation use impairments and in need of protection are: Hanging Horn, Eddy, Eleven and Long lakes.

The results for selected indicators and risk priority ranking for each stream are shown in Appendix 7. Stream protection is driven by how close the stream is to having an impaired biological community, density of roads and disturbed land use in the immediate and larger drainage area, and how much land is protected in the watershed. In the Kettle River Watershed, four Exceptional Use streams were identified as high priority: Little Pine Creek (-560), the west branch of the Moose Horn River (-628), Pine River (-624) and Kettle River (-505). Additionally, three General Use streams, the Grindstone River

(-501) and the Moose Horn River (-521), and Larson's Creek (-548) also scored as high priority for protection efforts. While these streams currently meet standards, work done to maintain current conditions is important to prevent future impairment listings.

Summaries and recommendations

Water quality thought out the Kettle River Watershed generally in good to great condition. With the onset of TALU, the Kettle River Watershed now has several exceptional use streams spread out in four aggregated 12-HUC watersheds. Aquatic life standards were found to be supporting in 78% of the stream reaches assessed. Aquatic recreation is only supporting around 46% of the assessed stream reaches. In part this is due to Grindstone River Watershed, were six of the six reaches assessed are not meeting standards. Without the Grindstone River, the percentage would be closer to 77%.

Biologically the Kettle River Watershed is doing well. There were 58 fish and 378 macroinvertebrate species captured by the MPCA in 2016 and 2017. At least two of the fish species, Lake Sturgeon and Gilt Darters, are on the state recognized list of species of special concern. Over the watershed, the top three most prevalent fish species are White Suckers, Johnny Darters, and Central Mudminnows. All three species being common thought out the state. Burbot and Longnose Dace, two sensitive and cool water species, were in the top 10 most abundant species. This speaks to the generally good biological conditions throughout the watershed.

Much of the watershed is sprinkled with small lakes. There are relatively few assessable lakes larger than 10 acres. Thirty-two lakes were assessed for recreational use by the MPCA and thirteen for aquatic life by MNDNR. Of the lakes assessed for recreational use, only half were found to be fully supporting recreational use. Protection strategies will be an important part of future management efforts in the Moose Horn River subwatershed. Restoration and protection efforts should also prioritize the Pine River and Grindstone River aggregated 12-HUCs; Pine River 12-HUC has the most nutrient listings and Grindstone River 12-HUC has the only lake in the Kettle River Watershed that supports a Lake Trout population (Grindstone Lake).

Fish tissue from the Kettle River and 16 lakes was analyzed for Mercury and polychlorinated biphenyls (PCBs) between 1981 and 2016. Thirteen of the 16 tested lakes are on the 2018 Impaired Waters Inventory (IWI) for mercury in fish tissue (Table 22). Nine of the lakes on the impaired waters inventory for mercury were high enough for the Minnesota Statewide Mercury TMDL. Fish from seven lakes were tested for PCBs, but all samples came back lower than laboratory detection limits.

Groundwater protection should be considered for both quantity and quality. Concerns for quality are possible high levels of naturally occurring elements in drinking water as well as chloride 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. Groundwater levels do not appear to have decreased in monitored locations across the watershed. Continued mindfulness of water users and additional monitoring of groundwater quantity will provide the information needed to conserve the resource in the watershed.

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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 - Orthophosphate (OP) 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 wastewater 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 Kettle River Watershed

EQuIS station ID	Biological station ID	WID	Waterbody name	Location	Aggregated 12-digit HUC
S008-822	16SC042	07030003-529	Kettle River	At Hwy 73, 2 mi. NW of Kettle River	0703000301-04
S008-823	16SC028	07030003-513	Split Rock River	At CR 166, 4 mi. SW of Kettle River	0703000301-03
S001-674	16SC024	07030003-531	Moose Horn River	Moose Horn R at CSAH-46 Brg, 0.5 MI W of Sturgeon Lk	0703000302-01
S001-270	16SC001	07030003-501	Grindstone River	At Hwy 48, 2 mi. E of Hinckley	0703000305-01
S001-642	92SC017	07030003-505	Kettle River	At CR 52, 1.5 mi. SW of Sturgeon Lake	0703000306-01
S005-393	10EM024	07030003-552	Kettle River	At CR 46, 3 mi. W of Sturgeon Lake	0703000301-01
S006-553	98SC021	07030003-624	Pine River	At CR 61, 0.5 mi. S of Rutledge	0703000304-01
S008-824	96SC033	07030003-502	Kettle River	Head of the Rapids Rd canoe landing in St Croix state park	0703000306-01
S006-554	16SC074	07030003-621	Willow River	At Military Rd, 4.5 mi SE of Sturgeon Lake	0703000303-01

Appendix 2.2-Intensive watershed monitoring biological monitoring stations in the Kettle River Watershed

WID	Biological station ID	Waterbody name	Biological station location	County	Aggregated 12-digit HUC
07030003-511	16SC043	Kettle River	Upstream of CSAH 4, 6.5 mi. S of Cromwell	Carlton	0703000301-04
07030003-512	16SC035	Kettle River, West Branch	Downstream of Hwy 73, 4 mi. NW of Kettle River	Carlton	0703000301-04
07030003-529	16SC042	Kettle River, West Branch	Upstream of Hwy 73, 2 mi. NW of Kettle River	Carlton	0703000301-04
07030003-615	16SC039	Unnamed Ditch	Adjacent to Cattle Dr, 4 mi. SE of Cromwell	Carlton	0703000301-04
07030003-616	16SC036	Heikkila Creek	Upstream of CR 129, 6 mi. N of Kettle River	Carlton	0703000301-04
7030003-509	16SC030	Gillespie Brook	Downstream of Hwy 73, 3 mi. SE of Kettle River	Carlton	0703000301-01
07030003-510	92SC018, 96SC040	Kettle River	Korohonen Rd., 1/2 mi. W. of Kettle River | Jct. of S.H. 27 & 73, 5 mi. W. of Moose Lake	Carlton	0703000301-01
07030003-537	16SC033	Dead Moose River	Upstream of Brown Rd, 2 mi. NW of Kettle River	Aitkin, Carlton	0703000301-01
07030003-552	10EM024	Kettle River	Upstream and downstream of CSAH 46, 3 mi. W of Sturgeon Lake	Pine	0703000301-01
07030003-592	16SC050	Silver Creek	Upstream of Korhonen Rd, 1mi. S of Kettle River.	Carlton	0703000301-01
07030003-513	16SC026, 16SC028, 16SC077	Split Rock River	Downstream of CR 75, 10 mi. NW of Denham | Downstream of Walczak Rd, 4 mi. SW of Kettle River | Downstream of Split Rock Rd, 6 mi. SW of Kettle River	Aitkin, Carlton	0703000301-03
07030003-514	15EM055, 96SC074	Birch Creek	Adjacent to Denham Crossing Rd, 1 mi. SE of Denham | Rd. btn. S 21/22, 2 mi. W. of Denham	Aitkin, Pine	0703000301-02
07030003-521	16SC032	Moose Horn River	Upstream of Main St, in Barnum	Carlton	0703000302-01
07030003-531	16SC024, 16SC031	Moose Horn River	Upstream of CSAH 46, 1 mi. W of Sturgeon Lake | Adjacent to Hwy 61, 1.5 mi NE of Moose Lake	Carlton, Pine	0703000302-01
07030003-535	16SC055	Moose Horn River	Downstream of Town Hall Rd, 8.4 mi. SW of Carlton	Carlton	0703000302-01
07030003-547	16SC046	King Creek	Upstream of Mt Nelson Rd, 3 mi. N of Barnum	Carlton	0703000302-01
07030003-628	16SC034	Moose Horn River	Downstream of CR 157, 1 mi. NW of Barnum	Carlton	0703000302-01
07030003-629	16SC056	Moose Horn River	Downstream of CSAH 4, W side of Mahtowa	Carlton	0703000302-01
07030003-630	16SC048	Moose Horn River	Upstream of Point Rd, 0.9 mi. N of Barnum	Carlton	0703000302-01
07030003-548	16SC068	Larsons Creek	Upstream of CR 154, 3 mi. E of Kerrick	Pine	0703000303-01
07030003-575	16SC020	Little Willow River	Upstream of River Rd, 3 mi. NW of Bruno	Pine	0703000303-01
07030003-619	16SC023	Hay Creek	Upstream of CSAH 46, 4 mi. NW of Kerrick	Pine	0703000303-01
07030003-621	16SC069, 16SC072, 16SC073	Willow River	Downstream of Hwy 23, 2.5 mi. N of Kerrick | Downstream of CR 46, 4.2 mi. NW of Kerrick |	Pine	0703000303-01

			Downstream of Military Rd, 4 mi. E of Willow River		
07030003-622	16SC074	Willow River	Adjacent to Forest Rd 340E, 2.5 mi. E of Willow River	Pine	0703000303-01
07030003-560	16SC010	Little Pine Creek	Upstream of Dahlstein Rd, 3 mi. NW of Finlayson	Pine	0703000304-01
07030003-568	16SC017	Bremen Creek	Downstream of Chokecherry Rd, 5 mi. NW of Rutledge	Pine	0703000304-01
07030003-609	16SC059	Rhine Creek	Downstream of Norway Spruce Rd (CSAH 36), 3.6 mi. NW of Finlayson	Pine	0703000304-01
07030003-620	16SC016	Bremen Creek	Upstream of Maple Rd, 8 mi. W of Rutledge	Aitkin, Pine	0703000304-01
07030003-623	16SC011, 16SC015	Pine River	Upstream of Dahlstein Rd, 3 mi. NW of Finlayson | Downstream of CR 150, 4 mi. W of Rutledge	Aitkin, Pine	0703000304-01
07030003-624	10EM072, 16SC062, 98SC021	Pine River	0.25 mi. downstream of CR 151, 2 mi. NW of Rutledge | Upstream of Denham Rd (CSAH 40), 4.5 mi. NW of Rutledge | At County Hwy 61, .5 mi. S of Rutledge (MNDNR site 1)	Pine	0703000304-01
07030003-501	16SC001, 98SC009	Grindstone River	Upstream of Hwy 48, 2 mi. E of Hinckley | N. side of C.R. 140, 1 mi. E. of Hinckley	Pine	0703000305-01
07030003-516	16SC076, 16SC086, 96SC063	Grindstone River	Upstream Two Rivers Rd, 2 mi. W of Hinckley | Downstream of old Velvet St, 7 mi. NW of Hinckley | Rd. btn. S 17/18, 4 mi. N.W. of Hinckley	Kanabec, Pine	0703000305-01
07030003-543	16SC081	Grindstone River	Upstream of CSAH 26 (Friesland Rd), 4 mi. NW of Hinckley	Pine	0703000305-01
07030003-544	16SC082	Grindstone River	Upstream of Two Rivers Rd, 2 mi. NW of Hinckley	Pine	0703000305-01
07030003-550	10SC001	Spring Creek	Downstream of Old Government Rd, 2.5 mi. E of Hinckley	Pine	0703000305-01
07030003-502	16SC002, 96SC033	Kettle River	Upstream of Hwy 48, 4 mi. W of Hinckley | @ Kennedy Brook in St. Croix State Park	Pine	0703000306-01
07030003-503	06SC020, 92SC015	Kettle River	Downstream of CR 61, in Rutledge | 1/2 mi. S.W. of Willow River	Pine	0703000306-01
07030003-505	16SC063, 92SC017	Kettle River	Upstream CSAH 48, in Willow River | near crossing of C.S.A.H. 52 & C.R. 160	Pine	0703000306-01
07030003-525	16SC012	Cane Creek	Upstream of Cane Creek Rd, 2.5 mi SE of Rutledge	Pine	0703000306-01
07030003-528	16SC083, 92SC011	Kettle River	South of CSAH 30, E of Sandstone | S.H. 23, 2.5 mi. W. of Askov	Pine	0703000306-01
07030003-617	16SC006	Friesland Ditch	Upstream of Old Government Rd, 2 mi. S of Sandstone	Pine	0703000306-01
07030003-618	16SC007	Skunk Creek	Upstream of S Government Rd, 1 mi. SW of Sandstone	Pine	0703000306-01

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	71	49	NA	±11
2	Southern Streams	2B	66	50	35	±9
3	Southern Headwaters	2B	74	55	33	±7
10	Southern Coldwater	2A	82	50	NA	±9
4	Northern Rivers	2B	67	38	NA	±9
5	Northern Streams	2B	61	47	35	±9
6	Northern Headwaters	2B	68	42	23	±16
7	Low Gradient	2B	70	42	15	±10
11	Northern Coldwater	2A	60	35	NA	±10
Macroinvertebrate						
1	Northern Forest Rivers	2B	77	49	NA	±10.8
2	Prairie Forest Rivers	2B	63	31	NA	±10.8
3	Northern Forest Streams RR	2B	82	53	NA	±12.6
4	Northern Forest Streams GP	2B	76	51	37	±13.6
5	Southern Streams RR	2B	62	37	24	±12.6
6	Southern Forest Streams GP	2B	66	43	30	±13.6
7	Prairie Streams GP	2B	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-Bioloigcal 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: 0703000301-04 (Upper Kettle River)							
07030003-511	16SC043	Kettle River	55.75	7	42	40.42	8/17/2016
07030003-511	16SC043	Kettle River	55.75	7	42	29.75	9/5/2017
07030003-512	16SC035	Kettle River, West Branch	38.78	7	42	54.94	8/23/2016
07030003-529	16SC042	Kettle River	124.00	5	47	91.78	8/17/2016
07030003-615	16SC039	Unnamed Creek	7.85	6	42	47.19	8/24/2016
07030003-616	16SC036	Heikkila Creek	10.98	7	42	38.81	8/24/2016
HUC 12: 0703000301-01 (Middle Kettle River)							
07030003-509	16SC030	Gillespie Brook	31.17	6	42	80.95	8/23/2016
07030003-510	92SC018	Kettle River	159.72	5	47	76.51	7/24/2012
07030003-510	96SC040	Kettle River	189.42	5	47	91.08	8/25/2016
07030003-537	16SC033	Dead Moose River	28.47	6	42	77.33	8/23/2016
07030003-552	10EM024	Kettle River	297.82	5	47	69.87	6/24/2010
07030003-552	10EM024	Kettle River	297.82	5	47	92.38	6/16/2015
07030003-552	10EM024	Kettle River	297.82	5	47	92.89	8/15/2016
07030003-592	16SC050	Silver Creek	19.74	6	42	66.31	8/29/2016
HUC 12: 0703000301-03 (Split Rock River)							
07030003-513	16SC026	Split Rock River	17.14	7	42	40.55	9/13/2017
07030003-513	16SC028	Split Rock River	61.41	5	47	77.56	8/24/2016
07030003-513	16SC077	Split Rock River	46.34	6	42	68.63	8/30/2016
HUC 12: 0703000301-02 (Birch Creek)							
07030003-514	15EM055	Birch Creek	34.47	6	42	55.46	6/16/2015
07030003-514	96SC074	Birch Creek	28.17	6	42	61.34	6/15/2016
HUC 12: 0703000302-01 (Moose Horn River)							
07030003-521	16SC032	Moose Horn River	78.53	5	47	94.65	8/16/2016

National Hydrography Dataset (NHD) Assessment Segment WID	Biological station ID	Stream segment name	Drainage area Mi^2	Fish class	Threshold	FIBI	Visit date
07030003-531	16SC024	Moose Horn River	139.75	5	47	65.84	9/6/2017
07030003-531	16SC024	Moose Horn River	139.75	5	47	51.20	8/18/2016
07030003-531	16SC031	Moose Horn River	89.24	5	47	86.41	8/16/2016
07030003-535	16SC055	Moose Horn River	14.72	11	35	45.92	8/23/2016
07030003-547	16SC046	King Creek	4.18	11	35	36.31	8/23/2016
07030003-628	16SC034	Moose Horn River, West Fork	29.18	6	68	83.18	8/16/2016
07030003-629	16SC056	Moose Horn River	22.97	6	68	76.85	8/17/2016
07030003-630	16SC048	Moose Horn River	45.92	6	42	74.73	8/16/2016
HUC 12: 0703000303-01 (Willow River)							
07030003-548	16SC068	Larsons Creek	7.89	11	35	31.46	6/22/2016
07030003-548	16SC068	Larsons Creek	7.89	11	35	23.89	8/31/2016
07030003-575	16SC020	Little Willow River	30.29	6	42	81.20	8/24/2016
07030003-619	16SC023	Hay Creek	14.43	6	42	0	9/5/2017
07030003-619	16SC023	Hay Creek	14.43	6	42	49.52	8/24/2016
07030003-621	16SC069	Willow River	31.88	6	42	77.23	6/15/2016
07030003-621	16SC069	Willow River	31.88	6	42	80.66	8/10/2016
07030003-621	16SC072	Willow River	45.23	7	42	60.74	9/1/2016
07030003-621	16SC073	Willow River	110.16	5	47	91.49	8/24/2016
07030003-622	16SC074	Willow River	120.66	5	61	79.40	8/31/2016
HUC 12: 0703000304-01 (Pine River)							
07030003-560	16SC010	Little Pine Creek	16.13	6	68	72.00	8/31/2016
07030003-568	16SC017	Bremen Creek	28.52	6	42	66.92	6/14/2016
07030003-609	16SC059	Rhine Creek	7.78	6	42	54.30	8/31/2016
07030003-620	16SC016	Bremen Creek	8.01	6	42	56.58	9/12/2016
07030003-623	16SC011	Pine River	29.06	6	42	79.95	8/22/2016
07030003-623	16SC015	Pine River	57.67	5	47	49.55	8/17/2016

National Hydrography Dataset (NHD) Assessment Segment WID	Biological station ID	Stream segment name	Drainage area Mi²	Fish class	Threshold	FIBI	Visit date
07030003-624	10EM072	Pine River	120.77	5	61	71.52	6/29/2010
07030003-624	10EM072	Pine River	120.77	5	61	84.42	6/16/2015
07030003-624	16SC062	Pine River	88.87	5	61	74.43	8/31/2016
07030003-624	98SC021	Pine River	143.89	5	61	87.25	8/30/2016
HUC 12: 0703000305-01 (Grindstone River)							
07030003-501	16SC001	Grindstone River	82.07	5	47	73.17	6/14/2016
07030003-501	98SC009	Grindstone River	78.92	5	47	78.21	6/13/2016
07030003-501	98SC009	Grindstone River	78.92	5	47	83.39	8/10/2016
07030003-516	16SC076	Grindstone River, South Branch	34.74	6	42	64.44	6/14/2016
07030003-516	16SC086	Grindstone River, South Branch	19.91	7	42	25.23	6/23/2016
07030003-516	96SC063	Grindstone River, South Branch	25.68	7	42	28.41	8/22/2013
07030003-516	96SC063	Grindstone River, South Branch	25.68	7	42	31.83	6/30/2015
07030003-543	16SC081	Grindstone River, North Branch	23.89	11	35	19.57	8/17/2016
07030003-544	16SC082	Grindstone River, North Branch	35.77	6	42	84.72	6/16/2016
07030003-550	10SC001	Spring Creek	3.43	11	35	21.49	6/29/2010
07030003-550	10SC001	Spring Creek	3.43	11	35	19.69	8/25/2016
HUC 12: 0703000306-01 (Lower Kettle River)							
07030003-502	16SC002	Kettle River	999.43	4	38	70.68	9/23/2016
07030003-502	96SC033	Kettle River	1043.50	4	38	85.62	9/11/2017
07030003-503	06SC020	Kettle River	656.52	4	67	84.78	9/12/2017
07030003-503	06SC020	Kettle River	656.52	4	67	83.36	8/21/2014
07030003-505	16SC063	Kettle River	500.66	4	67	84.45	9/12/2017
07030003-505	92SC017	Kettle River	492.87	5	61	82.20	9/7/2017
07030003-525	16SC012	Cane Creek	13.80	6	42	44.03	8/31/2016

National Hydrography Dataset (NHD) Assessment Segment WID	Biological station ID	Stream segment name	Drainage area Mi^2	Fish class	Threshold	FIBI	Visit date
07030003-528	16SC083	Kettle River	857.15	4	38	69.39	9/8/2016
07030003-528	92SC011	Kettle River	836.35	4	38	85.19	9/8/2016
07030003-617	16SC006	Friesland Ditch	9.18	6	42	27.35	8/25/2016
07030003-618	16SC007	Skunk Creek	8.97	6	42	22.37	8/31/2016
07030003-618	16SC007	Skunk Creek	8.97	6	42	0	9/12/2017

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: 0703000301-04 (Upper Kettle River)							
07030003-615	16SC039	Unnamed Creek	7.85	4	51	55.88	8/2/16
07030003-529	16SC042	Kettle River	124.00	3	53	67.36	8/2/16
07030003-511	16SC043	Kettle River	55.75	4	51	38.32	8/2/16
07030003-511	16SC043	Kettle River	55.75	4	51	82.47	9/11/17
07030003-512	16SC035	Kettle River, West Branch	38.78	4	51	77.03	8/2/16
07030003-616	16SC036	Heikkila Creek	10.98	4	51	4.14	8/2/16
HUC 12: 0703000301-01 (Middle Kettle River)							
07030003-510	96SC040	Kettle River	189.42	3	53	68.95	8/3/16
07030003-552	10EM024	Kettle River	297.82	3	53	63.53	8/19/15
07030003-552	10EM024	Kettle River	297.82	3	53	70.28	8/17/16
07030003-510	96SC040	Kettle River	189.42	3	53	73.43	8/3/16
07030003-509	16SC030	Gillespie Brook	31.17	3	53	59.13	8/1/16
07030003-552	10EM024	Kettle River	297.82	3	53	67.44	8/16/10
07030003-537	16SC033	Dead Moose River	28.47	3	53	62.38	8/1/16
07030003-592	16SC050	Silver Creek	19.74	3	53	77.06	8/1/16
HUC 12: 0703000301-03 (Split Rock River)							
07030003-513	16SC028	Split Rock River	61.41	3	53	60.84	8/3/16
07030003-513	16SC077	Split Rock River	46.34	3	53	77.73	8/3/16
07030003-513	16SC026	Split Rock River	17.14	4	51	42.89	8/3/16
HUC 12: 0703000301-02 (Birch Creek)							
07030003-514	96SC074	Birch Creek	28.17	3	53	52.79	8/8/16
07030003-514	15EM055	Birch Creek	34.47	3	53	75.01	8/19/15

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: 0703000301-04 (Upper Kettle River)							
07030003-615	16SC039	Unnamed Creek	7.85	4	51	55.88	8/2/16
07030003-529	16SC042	Kettle River	124.00	3	53	67.36	8/2/16
07030003-511	16SC043	Kettle River	55.75	4	51	38.32	8/2/16
07030003-511	16SC043	Kettle River	55.75	4	51	82.47	9/11/17
07030003-512	16SC035	Kettle River, West Branch	38.78	4	51	77.03	8/2/16
07030003-616	16SC036	Heikkila Creek	10.98	4	51	4.14	8/2/16
HUC 12: 0703000302-01 (Moose Horn River)							
07030003-630	16SC048	Moose Horn River	45.92	3	53	67.55	8/3/16
07030003-628	16SC034	Moose Horn River, West Fork	29.18	3	82	81.67	8/2/16
07030003-521	16SC032	Moose Horn River	78.53	3	53	57.32	8/3/16
07030003-531	16SC031	Moose Horn River	89.24	3	53	64.60	8/3/16
07030003-531	16SC024	Moose Horn River	139.75	4	51	70.47	8/8/16
07030003-531	16SC024	Moose Horn River	139.75	4	51	76.67	9/11/17
07030003-535	16SC055	Moose Horn River	14.72	8	32	49.66	8/2/16
07030003-629	16SC056	Moose Horn River	22.97	4	76	90.42	8/2/16
07030003-547	16SC046	King Creek	4.18	8	32	60.60	8/2/16
HUC 12: 0703000303-01 (Willow River)							
07030003-621	16SC069	Willow River	31.88	3	53	44.50	8/4/16
07030003-575	16SC020	Little Willow River	30.29	3	53	70.13	8/9/16
07030003-619	16SC023	Hay Creek	14.43	3	53	52.36	8/4/16
07030003-621	16SC073	Willow River	110.16	3	53	76.02	8/4/16
07030003-619	16SC023	Hay Creek	14.43	3	53	55.54	9/11/17
07030003-548	16SC068	Larsons Creek	7.89	8	32	35.76	8/4/16
07030003-621	16SC072	Willow River	45.23	3	53	67.82	8/4/16
07030003-622	16SC074	Willow River	120.66	4	76	92.98	8/4/16
07030003-621	16SC069	Willow River	31.88	3	53	44.50	8/4/16

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: 0703000304-01 (Pine River)							
07030003-624	16SC062	Pine River	88.87	4	76	83.33	8/15/16
07030003-568	16SC017	Bremen Creek	28.52	3	53	67.81	8/15/16
07030003-634	16SC015	Pine River	57.67	3	53	28.28	8/15/16
07030003-609	16SC059	Rhine Creek	7.78	4	51	78.08	8/15/16
07030003-633	16SC011	Pine River	29.06	4	37	44.72	8/16/16
07030003-624	98SC021	Pine River	143.89	3	82	68.96	8/16/16
07030003-624	10EM072	Pine River	120.77	3	82	87.04	8/19/15
07030003-624	10EM072	Pine River	120.77	3	82	76.98	9/2/10
07030003-633	16SC011	Pine River	29.06	4	37	46.87	8/16/16
07030003-560	16SC010	Little Pine Creek	16.13	4	76	71.62	8/16/16
07030003-620	16SC016	Bremen Creek	8.01	3	53	47.34	8/15/16
HUC 12: 0703000305-01 (Grindstone River)							
07030003-501	16SC001	Grindstone River	82.07	3	53	58.50	8/23/16
07030003-516	96SC063	Grindstone River, South Branch	25.68	4	51	57.96	8/19/15
07030003-550	10SC001	Spring Creek	3.43	8	32	31.71	8/16/10
07030003-550	10SC001	Spring Creek	3.43	8	32	22.31	8/25/09
07030003-516	16SC076	Grindstone River, South Branch	34.74	3	53	55.17	8/23/16
07030003-501	98SC009	Grindstone River	78.92	3	53	55.89	8/18/16
07030003-516	96SC063	Grindstone River, South Branch	25.68	4	51	65.27	9/13/17
07030003-516	96SC063	Grindstone River, South Branch	25.68	4	51	82.42	8/27/13
07030003-550	10SC001	Spring Creek	3.43	8	32	42.00	8/18/16
07030003-516	16SC076	Grindstone River, South Branch	34.74	3	53	54.17	8/23/16
07030003-543	16SC081	Grindstone River, North Branch	23.89	3	53	58.48	8/18/16
07030003-544	16SC082	Grindstone River, North Branch	35.77	3	53	74.37	8/23/16
07030003-516	16SC086	Grindstone River, South Branch	19.91	4	51	57.24	8/18/16

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: 0703000306-01 (Lower Kettle River)							
07030003-617	16SC006	Friesland Ditch	9.18	4	51	20.80	8/17/16
07030003-505	92SC017	Kettle River	492.87	1	77	77.16	9/11/17
07030003-528	92SC011	Kettle River	836.35	1	49	68.19	8/17/16
07030003-503	92SC015	Kettle River	642.84	1	77	83.85	8/9/16
07030003-505	16SC063	Kettle River	500.66	1	77	83.97	8/8/16
07030003-503	92SC015	Kettle River	642.84	1	77	97.90	9/11/17
07030003-503	06SC020	Kettle River	656.52	1	77	63.74	9/17/14
07030003-503	06SC020	Kettle River	656.52	1	77	81.46	8/16/16
07030003-502	96SC033	Kettle River	1043.50	1	49	40.54	8/23/16
07030003-618	16SC007	Skunk Creek	8.97	8	32	37.77	8/17/16
07030003-502	16SC002	Kettle River	999.43	1	49	50.60	8/24/16
07030003-525	16SC012	Cane Creek	13.80	3	53	43.70	8/16/16
07030003-618	16SC007	Skunk Creek	8.97	8	32	55.14	9/12/17

Appendix 4.1-Fish species found during biological monitoring surveys

Common name	Quantity of stations where present	Quantity of individuals collected
black bullhead	14	156
black crappie	7	9
blacknose dace	22	390
blacknose shiner	3	5
blackside darter	4	79
bluegill	23	117
brassy minnow	8	29
brook stickleback	20	236
brook trout	1	4
burbot	36	621
central mudminnow	47	905
central stoneroller	2	6
channel catfish	1	1
chestnut lamprey	5	9
common shiner	44	2927
creek chub	41	1374
fathead minnow	11	61
finescale dace	1	3
Gen: Ichthyomyzon	3	25
Gen: redhorses	5	44
gilt darter	4	33
golden redhorse	21	138
golden shiner	13	57
greater redhorse	3	10
green sunfish	4	25
hornyhead chub	17	611
hybrid Phoxinus	1	3
hybrid sunfish	2	4
Iowa darter	5	20
johnny darter	51	1465
lake sturgeon	2	2
lamprey ammocoete	19	229
largemouth bass	20	104
logperch	27	501
longnose dace	38	1148
mimic shiner	2	19
mottled sculpin	31	390
northern hogsucker	13	72
northern pike	33	138
northern redbelly dace	10	70
pearl dace	11	118

Common name	Quantity of stations where present	Quantity of individuals collected
pumpkinseed	4	7
rainbow trout	1	1
rock bass	33	318
sand shiner	1	2
shorthead redhorse	27	286
silver redhorse	6	49
slenderhead darter	15	52
smallmouth bass	26	359
southern brook lamprey	7	40
spotfin shiner	3	94
spottail shiner	1	1
stonecat	7	9
tadpole madtom	8	40
walleye	13	36
white sucker	53	1517
yellow bullhead	2	2
yellow perch	26	138

Appendix 4.2-Macroinvertebrate species found during biological monitoring surveys

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
Ablabesmyia	44	218
Acari	39	215
Acentrella	7	14
Acentrella parvula	8	27
Acentrella turbida	12	71
Acerpenna	34	229
Acerpenna pygmaea	9	100
Acricotopus	2	3
Acroneuria	28	129
Acroneuria abnormis	2	4
Acroneuria lycorias	3	3
Aeshna	7	21
Aeshna umbrosa	4	5
Aeshnidae	10	14
Agnetina	3	9
Amphiagrion	2	2
Amphinemura	1	1
Amphipoda	2	9
Anacaena	7	19
Anafroptilum	2	15

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
Anax	1	1
Anax junius	2	2
Ancyronyx variegatus	19	42
Anopheles	4	11
Antocha	3	7
Argia	3	3
Atherix	24	133
Atrichopogon	4	5
Baetidae	12	41
Baetis	21	299
Baetis brunneicolor	15	207
Baetis flavistriga	32	269
Baetis intercalaris	13	87
Baetisca	5	13
Basiaeschna janata	10	10
Belostoma flumineum	21	67
Bezzia	1	3
Bittacomorpha	1	1
Boyeria	5	7
Boyeria vinosa	22	35
Brachycentrus numerosus	18	134
Brachycentrus occidentalis	1	19
Branchiobdellida	2	2
Brillia	20	44
Caecidotea	10	67
Caenis	14	81
Caenis diminuta	19	72
Caenis hilaris	16	78
Calopterygidae	12	23
Calopteryx	26	92
Calopteryx aequabilis	13	41
Calopteryx maculata	1	2
Cambaridae	7	7
Cambarus	3	3
Campeloma	2	2
Campeloma decisum	2	2
Capniidae	3	3
Cardiocladius	3	8
Ceraclea	18	44
Ceratopogonidae	2	3
Ceratopogoninae	21	57
Ceratopsyche	13	133

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
Ceratopsyche alhedra	4	18
Ceratopsyche bronta	6	12
Ceratopsyche morosa	6	99
Ceratopsyche slossonae	5	14
Ceratopsyche sparna	10	143
Cheumatopsyche	50	663
Chimarra	19	168
Chimarra socia	1	2
Chironomidae	3	4
Chironomini	8	8
Chironomus	6	299
Chrysops	1	1
Cladotanytarsus	3	3
Clinocera	1	1
Clinotanypus	5	7
Coenagrionidae	16	39
Conchapelopia	11	13
Cordulegaster	5	5
Cordulegaster maculata	1	1
Corduliidae	7	10
Corixidae	6	14
Corydalidae	3	3
Corydalus	2	2
Corynoneura	13	34
Crambidae	1	1
Crangonyx	6	15
Cricotopus	37	160
Cryptochironomus	4	4
Cryptotendipes	2	4
Culicidae	5	7
Cyrnellus fraternus	1	1
Demicryptochironomus	2	2
Diamesa	1	1
Dicranota	7	21
Dicrotendipes	8	76
Dineutus	2	2
Diplectrona modesta	1	1
Dipseudopsidae	1	1
Dixa	1	46
Dixella	4	27
Dixidae	2	2
Dolophilodes distinctus	1	2

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
Dromogomphus spinosus	1	1
Dubiraphia	39	237
Dytiscidae	4	4
Ectopria	1	3
Elmidae	1	3
Empididae	5	5
Endochironomus	4	56
Epeorus	3	7
Ephemera	4	14
Ephemerella	10	72
Ephemerella subvaria	1	2
Ephemerellidae	8	22
Ephoron	2	3
Ephydridae	14	33
Epitheca	5	13
Epitheca canis	4	4
Epoicocladius	1	1
Erpetogomphus designatus	1	1
Eukiefferiella	15	45
Eurylophella	15	49
Ferrissia	36	286
Forcipomyia	1	1
Forcipomyiinae	1	6
Gammarus	1	1
Gerridae	3	3
Glossosoma	9	67
Glossosomatidae	12	57
Glyphopsyche	1	2
Glyphopsyche irrorata	1	1
Glyptotendipes	4	10
Goera	1	1
Gomphidae	7	7
Gomphus	2	4
Gyraulus	8	95
Gyrinus	8	12
Hagenius brevistylus	6	8
Haliplidae	2	3
Haliplus	12	34
Helichus	4	4
Helicopsyche	1	12
Helicopsyche borealis	22	196
Helisoma	1	52

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
Helisoma anceps	2	4
Helopelopia	1	1
Helophorus	1	1
Hemerodromia	37	142
Heptageniidae	20	134
Hetaerina	1	3
Heterocloeon	3	3
Heterotrissocladius	1	2
Hexagenia	1	1
Hexatoma	6	10
Hirudinea	23	64
Hyalella	44	1283
Hydaticus	1	1
Hydatophylax	1	5
Hydatophylax argus	8	25
Hydra	1	1
Hydraena	8	13
Hydrobaenus	1	2
Hydrobiidae	18	403
Hydrochara	1	1
Hydrochus	1	1
Hydrophilidae	3	4
Hydroporinae	2	4
Hydropsyche	16	114
Hydropsyche betteni	28	468
Hydropsyche dicantha	6	67
Hydropsyche phalerata	1	2
Hydropsyche placoda	2	2
Hydropsyche simulans	4	26
Hydropsychidae	28	437
Hydroptila	18	64
Hydroptilidae	6	11
Hygrotus	2	2
Ilybius	1	1
Isonychia	9	17
Isoperla	5	13
Iswaeon	21	182
Kribiodorum perpulchrum	1	1
Labiobaetis	2	5
Labiobaetis frondalis	1	3
Labiobaetis propinquus	32	312
Labrundinia	33	96

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
Laccobius	1	1
Laccophilus	2	2
Larsia	1	1
Lauterborniella agrayloides	2	2
Lepidostoma	19	200
Leptoceridae	5	9
Leptocerus americanus	1	2
Leptophlebia	1	33
Leptophlebiidae	41	560
Lethocerus	3	3
Leucorrhinia frigida	1	1
Leucotrichia pictipes	1	1
Leucrocuta	19	103
Libellulidae	2	2
Limnephilidae	13	49
Limnephilus	2	8
Limnophila	3	6
Limnophyes	7	20
Liodessus	9	46
Lopescladius	3	5
Lymnaeidae	2	3
Lype	1	4
Lype diversa	10	45
Maccaffertium	40	457
Maccaffertium exiguum	1	1
Maccaffertium mediopunctatum	1	5
Maccaffertium mexicanum	1	1
Maccaffertium terminatum	3	6
Maccaffertium vicarium	15	52
Macromia illinoiensis	6	9
Macromiidae	1	1
Macronychus glabratus	33	225
Macrostemum zebratum	1	1
Mayatrichia ayama	4	5
Metretopodidae	1	1
Micrasema	3	4
Micrasema rusticum	8	46
Micrasema sprulesi	1	1
Micropsectra	37	233
Microtendipes	47	243
Microvelia	4	7
Molanna	2	3

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
Mystacides	2	2
Nanocladius	14	21
Natarsia	3	3
Nectopsyche	1	4
Nectopsyche diarina	2	2
Nectopsyche exquisita	1	1
Nemata	8	13
Nematoda	1	1
Neoperla	3	5
Neophylax	3	9
Neophylax concinnus	3	4
Neophylax fuscus	1	2
Neophylax oligius	4	17
Neoplasta	6	9
Neoplea	1	1
Neoplea striola	8	40
Neoporus	1	1
Neostempellina reissi	1	1
Neureclipsis	12	75
Neurocordulia	1	1
Nigronia	15	31
Nilotanypus	13	18
Nilothauma	12	12
Notonecta	2	2
Nyctiophylax	6	9
Odontomesa	1	2
Oecetis	2	8
Oecetis avara	4	9
Oecetis furva	4	14
Oecetis persimilis	1	4
Oecetis testacea	23	94
Oligochaeta	51	347
Ophiogomphus	5	7
Ophiogomphus rupinsulensis	4	14
Optioservus	38	474
Orconectes	26	27
Orthocladiinae	12	13
Orthocladius	13	22
Orthocladius (Symposiocladius)	9	9
Oxyethira	11	23
Pagastia	1	2
Pagastiella	1	1

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
Parachaetocladius	1	6
Parachironomus	3	8
Paracladopelma	1	2
Paracloeodes minutus	1	3
Paragnetina media	21	75
Parakiefferiella	6	9
Paralauterborniella	1	5
Paralauterborniella nigrohalterale	1	1
Paraleptophlebia	3	38
Paramerina	2	25
Parametriocnemus	30	127
Parapoynx	1	1
Paratanytarsus	38	308
Paratendipes	6	58
Peltodytes	2	2
Pentaneura	8	15
Perlesta	4	5
Perlidae	8	10
Perlinella dryma	1	1
Perlodidae	2	11
Petrophila	1	1
Phaenopsectra	34	88
Phryganeidae	2	7
Phylocentropus	4	9
Physa	7	26
Physella	30	239
Pisidiidae	53	450
Planorbella	5	14
Planorbidae	11	116
Planorbula	1	2
Platycentropus	1	1
Plauditus	5	67
Polycentropodidae	14	56
Polycentropus	11	23
Polypedilum	61	1622
Potthastia	8	16
Procladius	14	29
Procloeon	11	26
Protoptila	10	51
Psectrocladius	4	6
Pseudocentroptiloides usa	1	1
Pseudochironomus	1	1

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
Pseudocloeon	2	5
Pseudorthocladius	2	3
Pseudosmittia	1	1
Psilotreta indecisa	1	1
Psychoda	1	2
Psychomyia flavida	9	16
Pteronarcys	8	10
Ptilostomis	10	29
Pycnopsyche	15	42
Rhagovelia	4	11
Rheocricotopus	30	123
Rheopelopia	1	1
Rheosmittia	1	1
Rheotanytarsus	56	1234
Rheumatobates	1	1
Rhithrogena	1	1
Rhyacophila	1	1
Roederiodes	1	1
Scirtidae	1	1
Sialis	18	26
Sigara	2	2
Simulium	55	2475
Smittia	1	1
Somatochlora	1	1
Sperchopsis tessellata	1	1
Stagnicola	2	3
Stempellina	8	17
Stempellinella	36	168
Stenacron	7	22
Stenelmis	37	354
Stenochironomus	26	82
Stictochironomus	2	14
Stictotarsus	1	1
Sublettea coffmani	1	7
Synorthocladius	1	3
Tabanidae	7	8
Taeniopteryx	3	6
Tanypodinae	27	44
Tanypus	1	1
Tanytarsini	17	32
Tanytarsus	53	626
Teloganopsis deficiens	3	8

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
Telopelopia okoboji	1	1
Thienemanniella	33	90
Thienemannimyia	3	8
Thienemannimyia Gr.	52	404
Tipula	14	52
Trepaxonemata	15	65
Triaenodes	16	47
Tribelos	17	57
Trichocorixa	1	3
Trichoptera	6	6
Tricorythodes	32	292
Trissopelopia	1	1
Trissopelopia ogemawi	2	2
Tropisternus	3	3
Turbellaria	1	1
Tvetenia	25	62
Uenoidae	5	10
Valvata	1	1
Viviparus	1	1
Xenochironomus xenolabis	3	4
Xylotopus par	6	9
Zavrelimyia	12	41

Appendix 5-Minnesota Stream Habitat Assessment results

Habitat information documented during each fish sampling visit is provided. This table convey 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
4	16SC043	Kettle River	4.63	10.88	10.5	9.25	8.8	44	Poor
2	16SC035	Kettle River, West Branch	2.5	11.75	14.72	16	17	61.98	Fair
2	16SC042	Kettle River	4.63	13	23.3	13.5	29	83.42	Good
2	16SC039	Unnamed Creek	4	8	8	11	8.5	39.5	Poor
2	16SC036	Heikkila Creek	4.5	10	18.05	10.5	7	50.05	Fair
Average Habitat Results: *Upper Kettle River Aggregated 12 HUC*			**4.15**	**10.75**	**14.18**	**11.6**	**13**	**53.83**	**Fair**
2	16SC030	Gillespie Brook	4.13	12.5	18.65	15.5	19	69.78	Good
1	92SC018	Kettle River	5	12	22.9	16	24	79.9	Good
2	96SC040	Kettle River	5	14	24.45	12	25	80.45	Good
2	16SC033	Dead Moose River	4.38	13	24.7	13	25	79.58	Good
5	10EM024	Kettle River	5	13.2	22.5	12	21	73.5	Good
2	16SC050	Silver Creek	3.75	11.5	21.3	14	26	76.05	Good
Average Habitat Results: *Middle Kettle River Aggregated 12 HUC*			**4.61**	**12.86**	**22.4**	**13.2**	**23**	**75.65**	**Good**
2	16SC026	Split Rock River	5	11.75	8.6	12.5	10	47.85	Fair
2	16SC028	Split Rock River	4.13	12.25	25.98	9.5	29	80.35	Good
2	16SC077	Split Rock River	2.5	12.25	22.18	13	21	70.42	Good
Average Habitat Results: *Split Rock River Aggregated 12 HUC*			**3.88**	**12.08**	**18.92**	**11.7**	**20**	**66.21**	**Good**
2	15EM055	Birch Creek	5	12	24	13.5	28	82.5	Good
2	96SC074	Birch Creek	5	11.5	18.05	12.5	24	70.55	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
Average Habitat Results: *Birch Creek Aggregated 12 HUC*			**5**	**11.75**	**21.03**	**13**	**26**	**76.52**	**Good**
2	16SC032	Moose Horn River	3	9.25	18.78	10.5	20	61.52	Fair
4	16SC024	Moose Horn River	4.75	11.75	14.71	13.3	12	56.46	Fair
2	16SC031	Moose Horn River	4.63	12.5	24.7	14.5	25	81.33	Good
2	16SC055	Moose Horn River	4.5	11.75	19.22	12	20	67.48	Good
2	16SC046	King Creek	4.38	13	23.4	13	21	74.28	Good
2	16SC034	Moose Horn River, West Fork	3.25	12.25	22.52	12.5	25	75.03	Good
2	16SC056	Moose Horn River	5	10.75	10.65	14.5	19	59.9	Fair
2	16SC048	Moose Horn River	3.75	11	19.8	15.5	22	72.05	Good
Average Habitat Results: *Moose Horn River Aggregated 12 HUC*			**4.22**	**11.56**	**18.72**	**13.2**	**19**	**67.17**	**Good**
3	16SC068	Larsons Creek	4.75	12.5	18.17	15	19	69.75	Good
2	16SC020	Little Willow River	5	13.25	21.65	12.5	20	72.4	Good
4	16SC023	Hay Creek	5	11.5	16.78	11.5	19	63.77	Fair
3	16SC069	Willow River	4.17	10	17.33	12	24	67.5	Good
2	16SC072	Willow River	5	11.75	20.05	12	15	63.8	Fair
2	16SC073	Willow River	4.38	11.5	19.95	12	23	70.33	Good
2	16SC074	Willow River	5	11.5	20.55	10	18	65.05	Fair
Average Habitat Results: *Willow River Aggregated 12 HUC*			**4.75**	**11.64**	**18.78**	**12.2**	**20**	**67.22**	**Good**
2	16SC010	Little Pine Creek	4.5	10.5	20	13.5	20	68.5	Good
2	16SC017	Bremen Creek	4.25	10.25	18.35	11.5	19	63.35	Fair
2	16SC059	Rhine Creek	3.75	10.25	20.4	13.5	18	65.9	Fair
2	16SC016	Bremen Creek	4.13	11.75	24.15	12.5	29	81.53	Good
2	16SC011	Pine River	1.25	13	17.5	12.5	16	60.25	Fair
2	16SC015	Pine River	3.75	11.5	20.7	15.5	26	77.45	Good
3	10EM072	Pine River	5	12.67	20.98	16.3	28	83.32	Good
2	16SC062	Pine River	4.5	10.5	17.48	14	18	64.47	Fair
2	98SC021	Pine River	3.75	12.25	20.52	13.5	25	74.53	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
Average Habitat Results: Pine River *Aggregated 12 HUC*			**3.93**	**11.47**	**20.06**	**13.8**	**22**	**71.68**	**Good**
2	16SC001	Grindstone River	3.13	11.75	20.6	15.5	24	74.97	Good
3	98SC009	Grindstone River	3.25	12.17	21.75	12	22	71.5	Good
2	16SC076	Grindstone River, South Branch	3.75	10	17.7	13	26	69.95	Good
2	16SC086	Grindstone River, South Branch	2.75	10.25	16.15	12	16	56.65	Fair
4	96SC063	Grindstone River, South Branch	3.19	10.13	17.93	14.8	20	65.74	Fair
2	16SC081	Grindstone River, North Branch	5	13.75	21.05	13.5	19	72.3	Good
2	16SC082	Grindstone River, North Branch	3.75	13.75	21.3	14	25	77.3	Good
3	10SC001	Spring Creek	3	12.33	11.85	9.67	18	54.85	Fair
Average Habitat Results: *Grindstone River Aggregated 12 HUC*			**3.41**	**11.65**	**18.31**	**13**	**21**	**67.22**	**Good**
2	16SC002	Kettle River	5	12.75	10.5	10.5	19	57.75	Fair
2	96SC033	Kettle River	5	11.5	24.95	12.5	28	81.45	Good
4	06SC020	Kettle River	4.44	12	19.7	13	20	68.89	Good
2	16SC063	Kettle River	4.5	10.5	16.15	13	19	63.15	Fair
1	92SC017	Kettle River	4	13	18.1	12	18	65.1	Fair
2	16SC012	Cane Creek	5	13.5	20.6	13.5	28	80.1	Good
1	16SC083	Kettle River	5	13.5	18.6	7	14	58.1	Fair
2	92SC011	Kettle River	5	13	15.2	12.5	17	62.7	Fair
2	16SC006	Friesland Ditch	5	10.25	14.35	11	18	58.1	Fair
4	16SC007	Skunk Creek	4.63	11.75	19.1	14.5	27	76.98	Good
Average Habitat Results: Lower Kettle River *Aggregated 12 HUC*			**4.76**	**12.18**	**17.73**	**11.95**	**20.63**	**67.23**	**Good**

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
09-0034-00	**Bear**	25.6	No evidence of trend	44%	7	**A**
09-0035-00	**Little Hanging Horn**	17.2	Improving trend	15%	5	**A**
09-0039-00	**Eddy**	22.3	Declining trend	10%	121	**A**
58-0048-00	**Oak**	32.8	No evidence of trend	12%	24	**A**
58-0062-00	**Island**	31.5	No evidence of trend	22%	39	**A**
58-0067-00	**Sturgeon**	14.0	No evidence of trend	17%	27	**A**
58-0073-00	**Dago**	16.1	Improving trend	21%	3	**A**
58-0081-00	**Sand**	17.9	No evidence of trend	20%	35	**A**
58-0136-00	**Rhine**	62.0	Declining trend	6%	31	**A**
58-0137-00	**Bass**	16.7	Insufficient data	16%	4	**A**
09-0029-00	**Park**	16.5	No evidence of trend	4%	8	**B**
09-0041-00	**Moosehead**	35.9	Declining trend	61%	378	**B**
09-0043-00	**Moose**	24.0	No data provided	7%	8	**B**
09-0044-00	**Echo**	16.0	No data provided	13%	5	**B**
09-0045-00	**Coffee**	19.9	Insufficient data	28%	30	**B**
09-0058-00	**Merwin**	39.3	No data provided	9%	7	**B**
33-0001-00	**Eleven**	38.9	Insufficient data	10%	22	**B**
58-0068-00	**Eleven**	24.6	No evidence of trend	8%	3	**B**
58-0076-00	**Passenger**	12.3	No data provided	11%	1	**B**
58-0083-00	**Second**	28.0	Insufficient data	12%	2	**B**
58-0089-00	**Cedar**	38.0	Insufficient data	8%	11	**B**
58-0099-00	**First**	39.0	Insufficient data	27%	30	**B**

58-0107-00	**Long**	29.6	Insufficient data	13%	10	**B**
58-0126-00	**Elbow**	40.9	Insufficient data	13%	23	**B**
58-0127-00	**Little Bass**	35.1	No evidence of trend	15%	1	**B**
58-0135-00	**Miller**	35.5	Insufficient data	11%	7	**B**
09-0022-00	**Twentynine**	53.4	No data provided	11%	8	**C**
09-0026-00	**Bob**	17.6	Insufficient data	4%	9	**C**
09-0038-00	**Hanging Horn**	25.5	No evidence of trend	10%	276	**C**
09-0049-00	**Kettle**	28.9	Insufficient data	1%	53	**C**
33-0003-00	**Five**	24.3	Insufficient data	5%	2	**C**
58-0058-00	**McCormick**	34.5	Insufficient data	9%	21	**C**
58-0102-00	**Fox**	52.1	Insufficient data	7%	52	**C**
58-0103-00	**Mud**	80.0	Insufficient data	3%	15	**C**
58-0106-00	**Little Mud**	54.5	No data provided	3%	8	**C**
58-0111-00	**Stanton**	41.0	No data provided	27%	394	**C**
58-0128-00	**Bass**	23.5	No evidence of trend	7%	1	**C**
58-0129-00	**Little Pine**	67.0	Insufficient data	11%	118	**C**
58-0130-00	**Upper Pine**	24.2	No evidence of trend	7%	43	**C**
58-0131-00	**Fish**	69.0	Insufficient data	18%	23	**C**
58-0132-00	**Indian**	27.0	Insufficient data	9%	14	**C**

Appendix 7-Stream protection and prioritization results

WID	Stream Name	TALU	Cold/Warm	Community Nearly Impaired	Riparian Risk	Watershed Risk	Current Protection Level	Protection Priority Class
07030003-560	**Little Pine Creek**	Exceptional	warm	both	high	med/high	low	**A**
07030003-628	**Moose Horn River, West Branch**	Exceptional	warm	one	med/high	medium	med/low	**A**
07030003-624	**Pine River**	Exceptional	warm	one	medium	medium	med/low	**A**
07030003-505	**Kettle River**	Exceptional	warm	one	medium	medium	medium	**B**
07030003-503	**Kettle River**	Exceptional	warm	neither	med/high	medium	med/low	**B**
07030003-629	**Moose Horn River**	Exceptional	warm	neither	med/high	med/high	medium	**B**
07030003-622	**Willow River**	Exceptional	warm	neither	med/high	medium	medium	**B**
07030003-501	**Grindstone River**	General	warm	one	high	med/high	med/low	**A**
07030003-521	**Moose Horn River**	General	warm	one	high	med/high	med/low	**A**
07030003-548	**Larsons Creek**	General	cold	both	low	low	medium	**A**
07030003-547	**King Creek**	General	cold	one	med/low	medium	low	**A**
07030003-615	**Unnamed ditch**	General	warm	one	med/low	medium	medium	**B**
07030003-609	**Rhine Creek**	General	warm	neither	high	medium	med/low	**B**
07030003-502	**Kettle River**	General	warm	one	low	medium	medium	**B**
07030003-529	**Kettle River**	General	warm	neither	med/high	medium	med/low	**B**
07030003-620	**Bremen Creek**	General	warm	one	med/low	low	med/high	**B**
07030003-531	**Moose Horn River**	General	warm	neither	medium	med/high	medium	**B**
07030003-544	**Grindstone River, North Branch**	General	warm	neither	medium	medium	med/low	**B**
07030003-575	**Little Willow River**	General	warm	neither	med/low	medium	low	**B**
07030003-630	**Moose Horn River**	General	warm	neither	medium	med/high	medium	**B**
07030003-509	**Gillespie Brook**	General	warm	neither	med/low	medium	med/low	**B**
07030003-510	**Kettle River**	General	warm	neither	medium	medium	medium	**B**
07030003-513	**Split Rock River**	General	warm	neither	medium	medium	medium	**B**
07030003-514	**Birch Creek**	General	warm	neither	medium	medium	medium	**B**

07030003-568	**Bremen Creek**	General	warm	neither	med/high	med/low	medium	**B**
07030003-592	**Silver Creek**	General	warm	neither	med/low	medium	med/low	**B**
07030003-512	**Kettle River, West Branch**	General	warm	neither	medium	med/low	medium	**C**
07030003-528	**Kettle River**	General	warm	neither	medium	medium	med/high	**C**
07030003-535	**Moose Horn River**	General	cold	neither	med/low	medium	medium	**C**
07030003-537	**Dead Moose River**	General	warm	neither	med/low	medium	medium	**C**
07030003-552	**Kettle River**	General	warm	neither	med/low	medium	medium	**C**
07030003-621	**Willow River**	General	warm	neither	low	medium	medium	**C**