Big Fork River Watershed Monitoring and Assessment Report

Minnesota Pollution Control Agency

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List of acronyms

AUID Assessment Unit Identification Determination

CCSI Channel Condition and Stability Index

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

E Eutrophic

EQuIS Environmental Quality Information System

EX Exceeds Criteria (Bacteria)

EXP Exceeds Criteria, Potential Impairment

EXS Exceeds Criteria, Potential Severe Impairment

FS Full Support

FWMC Flow Weighted Mean Concentration

H Hypereutrophic

HUC Hydrologic Unit Code

IBI Index of Biotic Integrity

IF Insufficient Information

K Potassium

LRVW Limited Resource Value Water

M Mesotrophic

MCES Metropolitan Council Environmental Services

MDA Minnesota Department of Agriculture

MDH Minnesota Department of Health

MDNR Minnesota Department of Natural Resources

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

USGS United States Geological Survey

WPLMN Water Pollutant Load Monitoring Network

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Executive summary

The Big Fork River Watershed is located in northern Minnesota, split between Itasca and Koochiching counties. The watershed drains over 1.3 million acres and contains many lakes, wetlands, and forests. Agricultural and urban land uses are not common; rather forestry and tourism are the dominant industries within the watershed. The major river in the watershed, the Big Fork River, starts at Dora Lake and winds its way north before flowing into the Rainy River. The river is an outstanding recreational resource offering fishing and canoeing opportunities for people seeking a northern Minnesota wilderness experience.

The Minnesota Pollution Control Agency (MPCA) began an Intensive Watershed Monitoring (IWM) program within the Big Fork River Watershed in 2010. The monitoring was comprehensive and included the collection of samples from lakes, streams and groundwater. Biological data was collected from rivers and streams to assess aquatic life and aquatic consumption. Water chemistry information was collected to assess surface waters for aquatic life and aquatic recreation as well as computing pollutant loads through the Major Watershed Load Monitoring Program (MWLMP). The work was carried out by staff from the MPCA as well as citizen volunteers. The results of this monitoring effort were used to assess the Big Fork River Watershed in 2012.

The assessment results for the Big Fork River Watershed indicate that the condition of the lakes and streams are good to very good, even though there were a few impairments found. The most widespread impairment found in both lakes and rivers is due to high mercury levels limiting the aquatic consumption of fish. The remaining impairments throughout the watershed consisted of low dissolved oxygen (DO), fish and macroinvertebrate, and nutrient impairments. Many of the aquatic life impairments were found to be the result of natural conditions within the Big Fork River Watershed.

Introduction

Water is one of Minnesota's most abundant and precious resources. The 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 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 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. This strategy provides an opportunity to more fully integrate MPCA water resource management efforts in cooperation with local government and stakeholders 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. A 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 Big Fork River Watershed beginning in the summer of 2010. This report provides a summary of all water quality assessment results in the Big Fork River Watershed and incorporates all data available for the assessment process including watershed monitoring, volunteer monitoring and monitoring conducted by local government units.

I. 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 81 major watersheds (Figure 1). 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).

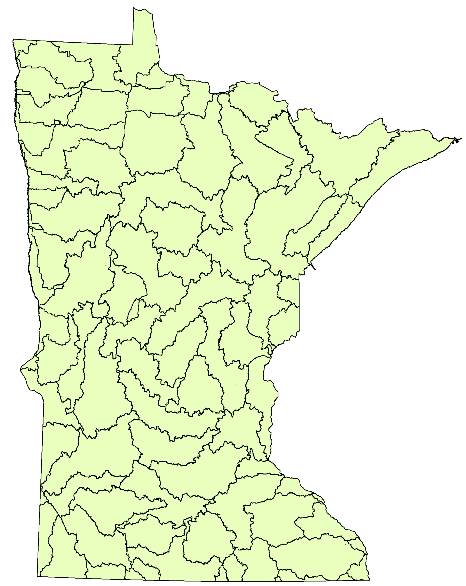

Figure 1. Major watersheds within Minnesota

Load monitoring network

Funded with appropriations from Minnesota's Clean Water Legacy Fund, the Major Watershed Load Monitoring Program (MWLMP) is a long-term program designed to measure and compare regional differences and long-term trends in water quality among Minnesota's major rivers including the Red, Rainy, St. Croix, Mississippi, and Minnesota, and the outlets of the major tributaries (8 digit HUC scale) draining to these rivers. Since the program's inception in 2007 the MWLMP has adopted a multi-agency monitoring design that combines site specific stream flow data from United States Geological Survey (USGS) and Minnesota Department of Natural Resources (MDNR) flow gaging stations with water quality data collected by the Metropolitan Council Environmental Services, local monitoring organizations, and MPCA major watershed load monitoring staff to compute annual pollutant loads at river monitoring sites across Minnesota. Data will also be used to assist with TMDL studies and implementation plans, watershed modeling efforts, and watershed research projects.

Intensive watershed monitoring

The IWM strategy utilizes a nested watershed design allowing the sampling of streams within watersheds from a coarse scale to a fine scale Figure 2. 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 81 major watersheds (8-HUC) within Minnesota. Using this approach many of the smaller headwaters and tributaries to the main stem river are sampled in a systematic way so that a more holistic assessment of the watershed can be conducted and problem areas identified without monitoring every stream reach. Each major watershed is the focus of attention for at least one year within the 10-year cycle.

River/stream sites are selected near the outlet of each of three watershed scales, 8-HUC, 11-HUC and 14-HUC (Figure 2). Within each scale, different water uses are assessed based on the opportunity for that use (i.e., fishing, swimming, supporting aquatic life such as fish and insects). The major river watershed is represented by the 8-HUC scale. The outlet of the major 8-HUC watershed (purple dot in Figure 3) 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 11-HUC is the next smaller watershed scale which generally consists of major tributary streams with drainage areas ranging from 75 to 150 mi^2. Each 11-HUC outlet (green triangles in Figure 3) is sampled for biology and water chemistry for the assessment of aquatic life and aquatic recreation use support.

Within each 11-HUC, 14-HUC, smaller watersheds (typically 10-20 mi^2), are sampled at each outlet that flows into the major 11-HUC tributaries. Each of these minor watershed outlets are sampled for biology to assess aquatic life use support (red dots in Figure 3).

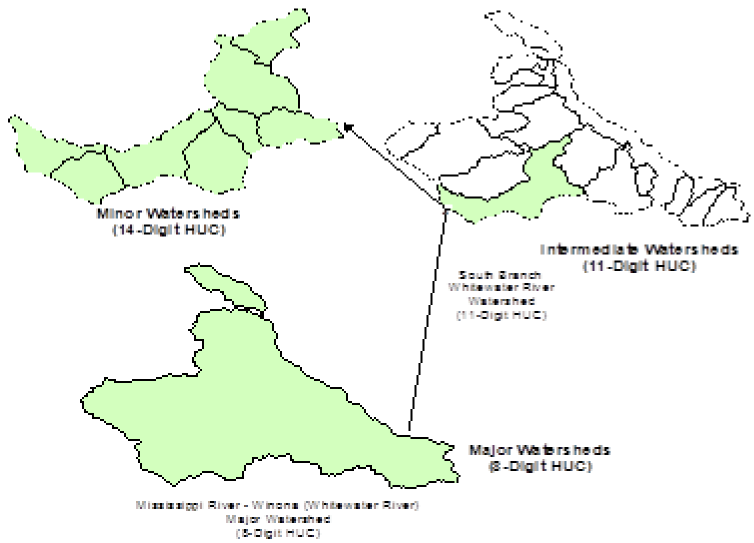

Figure 2. Example of nested HUCs from the Whitewater River Watershed

Within the IWM strategy, lakes are selected to represent the range of conditions and lake type (size and depth) found within the watershed. Lakes most heavily used for recreation (all those greater than 500 acres and at least 25% of lakes 100-499 acres) are monitored for water chemistry to determine if recreational uses, such as swimming and wading, are being supported. Lakes are sampled monthly from May-September for a two-year period. There is currently no tool that allows us to determine if lakes are supporting aquatic life; however, a method that includes monitoring fish and aquatic plant communities is in development.

Specific locations for sites sampled as part of the intensive monitoring effort in the Big Fork River Watershed are shown in Figure 3 and are listed in Appendix 2, Appendix 4.2, Appendix 4.3, Appendix 5.2 and Appendix 5.3.

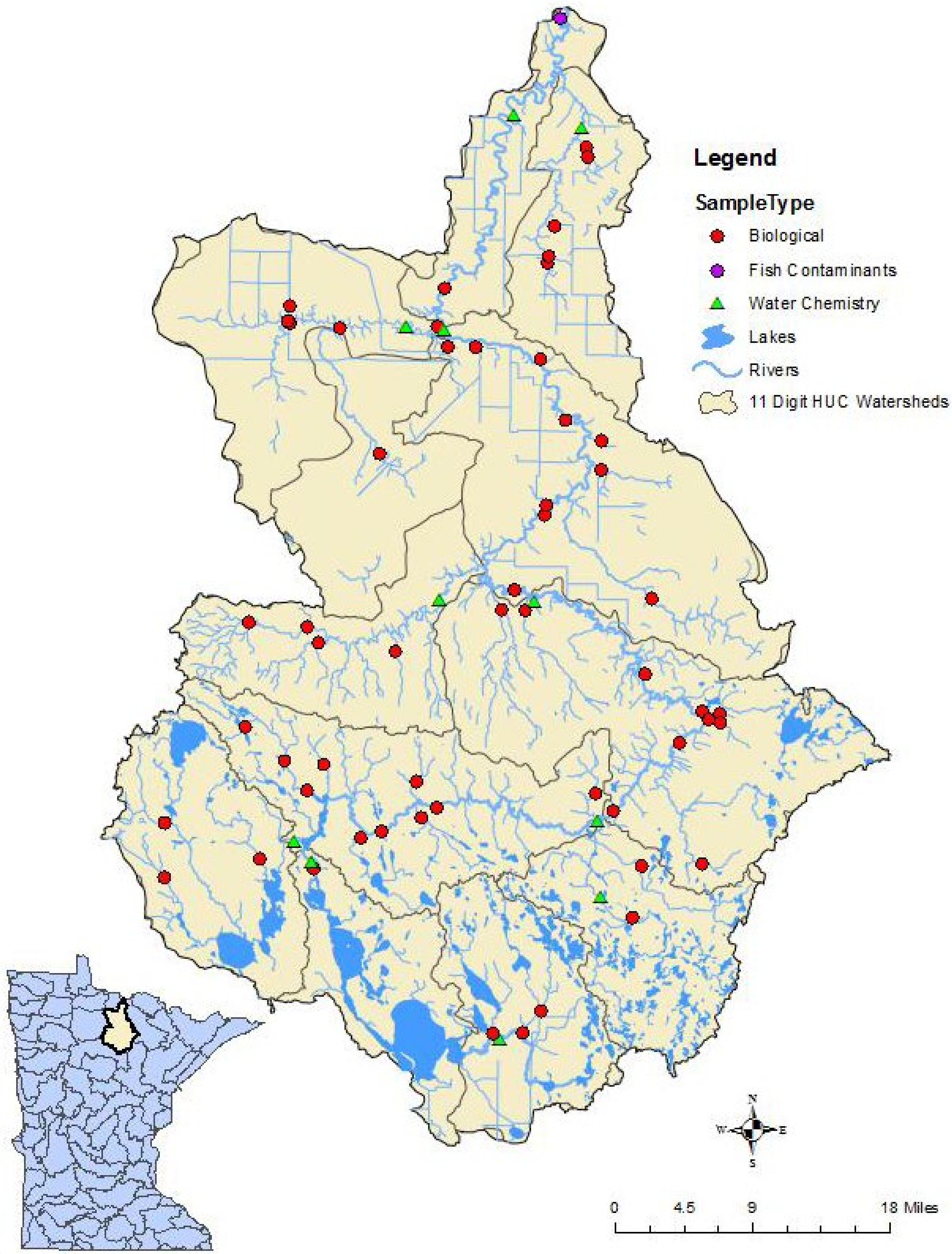

Figure 3. Intensive watershed monitoring sites for streams in the Big Fork River Watershed

Citizen and local monitoring

Citizen and local monitoring are important components of the watershed approach. The MPCA and its local partners jointly select the stream sites and lakes to be included in the IWM process. Funding passes from MPCA through Surface Water Assessment Grants (SWAGs) to local groups such as counties, soil and water conservation districts (SWCD), 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 data 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 4 provides an illustration of the locations where citizen monitoring data were used for assessment in the Big Fork River Watershed.

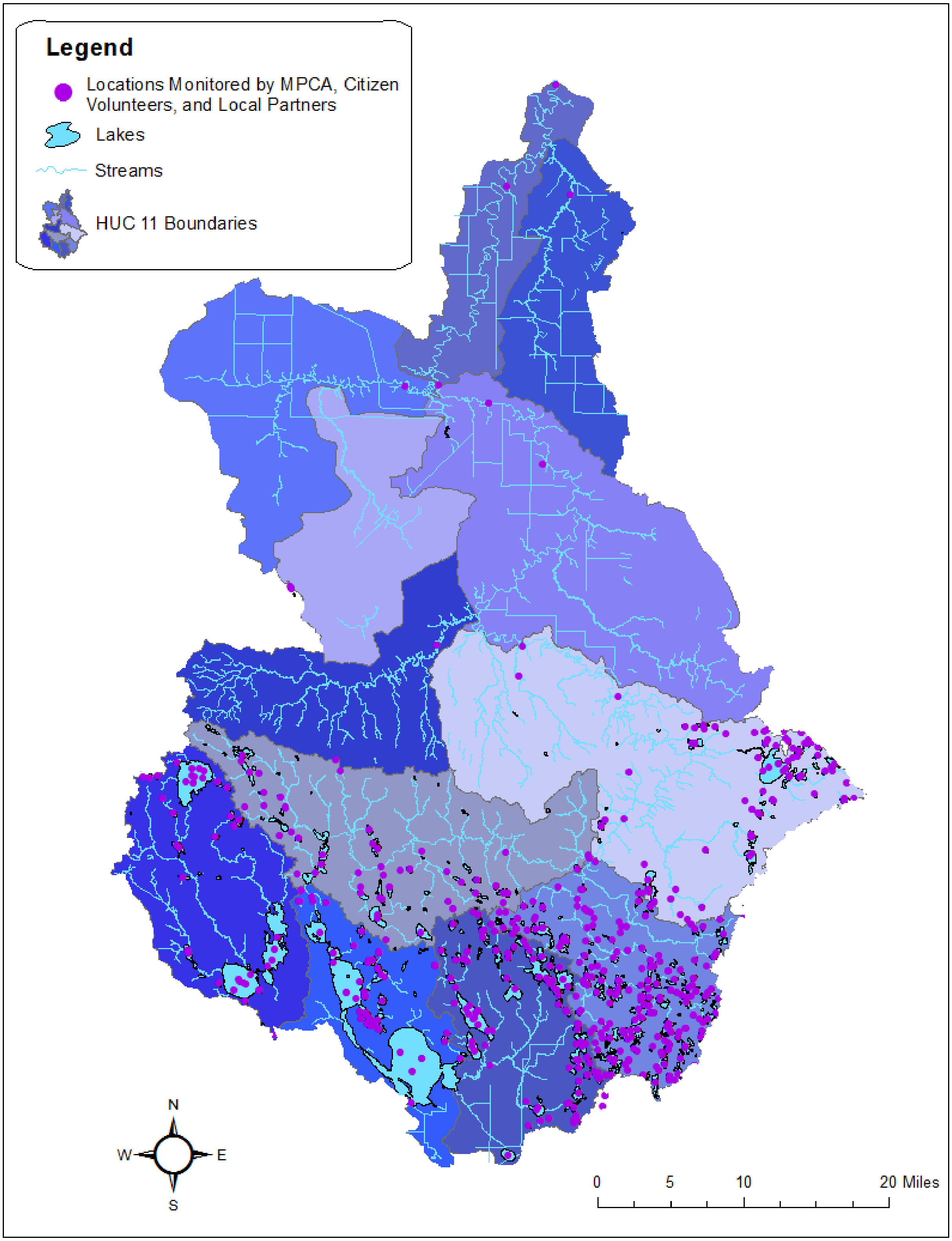

Figure 4. Locations of local groups', citizens' and the MPCA's lake monitoring in the Big Fork River Watershed

II. 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)*. http://www.pca.state.mn.us/index.php/view-document.html?gid=8601.

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 life means the maintenance of a healthy aquatic community, including fish, macroinvertebrates and plants. The sampling of aquatic organisms for assessment is called biological monitoring. Biological monitoring 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. Interpretations of narrative criteria for aquatic life in streams are based on multi-metric biological indices including the Fish Index of Biological Integrity (Fish IBI), which evaluates the health of the fish community, and the Macroinvertebrate Index of Biological Integrity (MIBI), which evaluates the health of the aquatic macroinvertebrate community. Additionally, chemical parameters are measured and assessed against numeric standards developed to be protective of aquatic life, including pH, DO, un-ionized ammonia nitrogen, chloride and turbidity.

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.

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

Assessment units

Assessments of use support in Minnesota are made for individual waterbodies. The waterbody unit used for river systems, lakes and wetlands is called the "assessment unit". A stream or river assessment unit usually extends from one significant tributary stream to another or from the headwaters to the first tributary. A stream "reach" may be further divided into two or more assessment reaches when there is a change in use classification (as defined in Minn. R. ch. 7050) or when there is a significant morphological feature, such as a dam or lake, within the reach. Therefore, a stream or river is often segmented into multiple assessment units that are variable in length. The MPCA is using the 1:24,000 scale high resolution National Hydrologic Dataset (NHD) to define and index stream, lake and wetland assessment units. Each river or stream reach is identified by a unique waterbody identifier (known as its AUID), comprised of the USGS eight digit hydrologic unit code (8-HUC) plus a three character code that is unique within each HUC. Lake and wetland identifiers are assigned by the MDNR. The Protected Waters Inventory (PWI) provides the identification numbers for lake, reservoirs and wetlands. These identification numbers serve as the AUID 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 5.

The first step in the aquatic life assessment process is a comparison of the monitoring data to water quality standards. This is largely an automated process performed by logic programmed into a database application and the results are referred to as 'Pre-Assessments'. 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 attenuating 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 2012) http://www.pca.state.mn.us/index.php/view-document.html?gid=16988 for guidelines and factors considered when making such determinations.

Any new impairment (i.e., waterbody not attaining its beneficial use) is first reviewed using GIS to determine if greater than 50% of the assessment unit is channelized. Currently, the MPCA is deferring any new impairments on channelized reaches until new aquatic life use standards have been developed as part of the Tiered Aquatic Life Use (TALU) framework. 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 However, in this report, channelized reaches with biological data are evaluated on a "good-fair-poor" system to help evaluate their condition (see Section IV and Appendix 5.1).

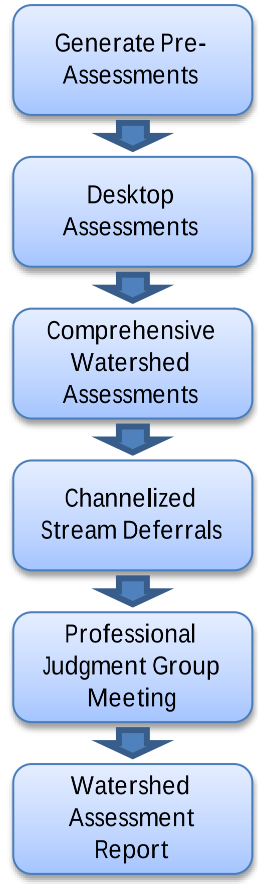

Figure 5. Flowchart of aquatic life use assessment process

The last step in the assessment process is the Professional Judgment Group meeting. At this meeting results are shared and discussed with entities outside of the MPCA that may have been involved in data collection or that might be responsible for local watershed reports and project planning. Information obtained during this meeting may be used to revise previous use attainment decisions (e.g., sampling events that may have been uncharacteristic due to annual climate or flow variation, local factors such as impoundments that do not represent the majority of conditions on the AUID). 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.

Data management

It is MPCA policy to use all credible and relevant monitoring data to assess surface waters. The MPCA relies on data it collects along with data from other sources, such as sister agencies, local governments and volunteers. The data must meet rigorous quality assurance protocols before being used. All monitoring data required or paid for by MPCA are entered into EQuIS (Environmental Quality Information System), MPCA's data system and are also uploaded to the U.S. Environmental Protection Agency's (EPA) data warehouse. Data for monitoring projects with federal or state funding are required to be stored in EQuIS (e.g., Clean Water Partnership, CWLA Surface Water Assessment Grants and TMDL program). Many local projects not funded by MPCA also choose to submit their data to the MPCA in an

EQuIS-ready format so that the monitoring data may be utilized in the assessment process. Prior to each assessment cycle, the MPCA sends out a request for monitoring data to local entities and partner organizations.

Period of record

The MPCA uses data collected over the most recent 10 year period for all water quality assessments. This time-frame provides a reasonable assurance that data will have been collected over a range of weather and flow conditions and that all seasons will be adequately represented; however, data for the entire period is not required to make an assessment. The goal is to use data that best represents current water quality conditions. Therefore, recent data for pollutant categories such as toxics, lake eutrophication and fish contaminants may be given more weight during assessment.

III. Watershed overview

Located in north-central Minnesota, the Big Fork River Watershed is highly comprised of lakes, wetlands, and forests. With only 25% of the land privately owned, most of the land is managed by federal, state, tribal, or county governments. The area has a rich history long before European settlers came to the Americas of the native people using these waterways as a main route of transportation. However in the early 1900s logging took a foothold on the area and the rivers then served as timber highways. Though the days of floating timber down the river are past, forestry continues today as one of the major land uses.

The Big Fork River Watershed has a drainage area greater than 1,300,000 acres. The southern 48.9% of the watershed is located in Itasca County, with the northern 51.1% located in Koochiching County (NRCS 2007). The Big Fork River starts at Dora Lake, about 45 miles northeast of Bemidji in Itasca County. The river winds its way northward for about 165 miles until it meets up with the Rainy River at the Minnesota/Ontario Border, approximately 15 miles southwest of International Falls, Minnesota.

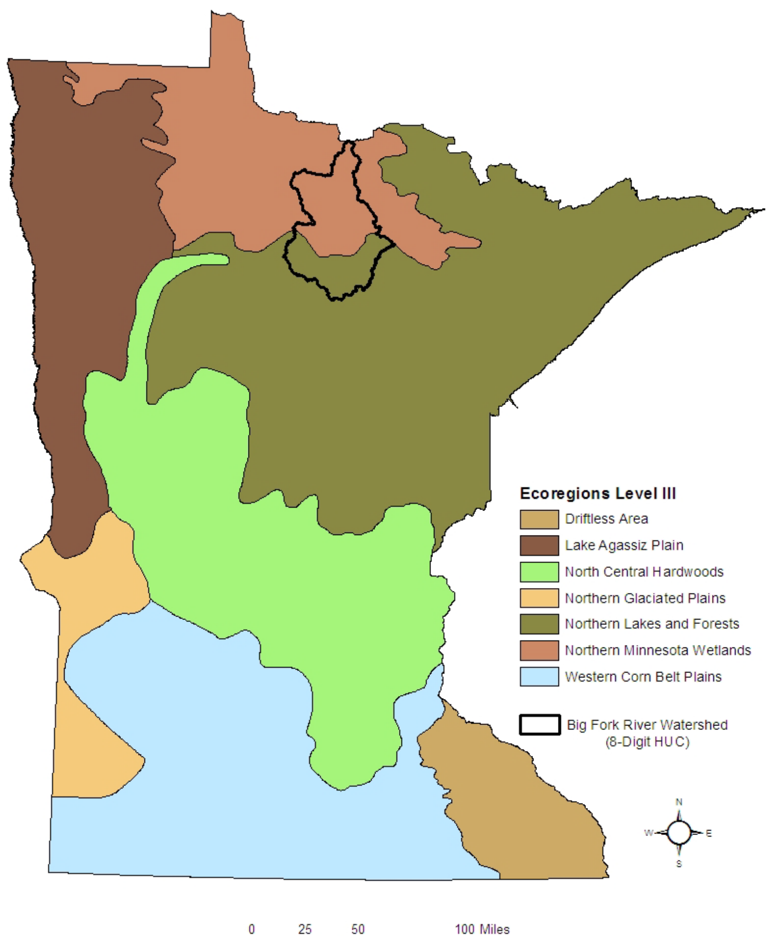

Figure 6. The Big Fork River Watershed within the Northern Minnesota Wetlands and Northern Lakes and Forests ecoregions of northern Minnesota

The watershed falls within two Omernick level III ecoregions (Figure 6). The Northern Minnesota Wetlands (NMW) Ecoregion comprises the northern section of the watershed and contains a larger percentage of the watershed. The area is sparsely populated by humans, with boreal forest vegetation and many wetlands. Large glacial lakes were once present following the last ice age and have left this region mostly flat with an abundance of standing water (Commission for Environmental,1997). The second ecoregion, the Northern Lakes and Forests (NLF) in the southern section of the watershed, comprises approximately one third of the watershed area. This region is best described by its coniferous and northern hardwood forests along with its many lakes that pepper the landscape. The soils in this region are mostly nutrient poor glacial soils; though they are deeper than the soils in the north, they still do not have the productivity seen in the soils found in more southern regions of Minnesota (Wiken et al, 2011).

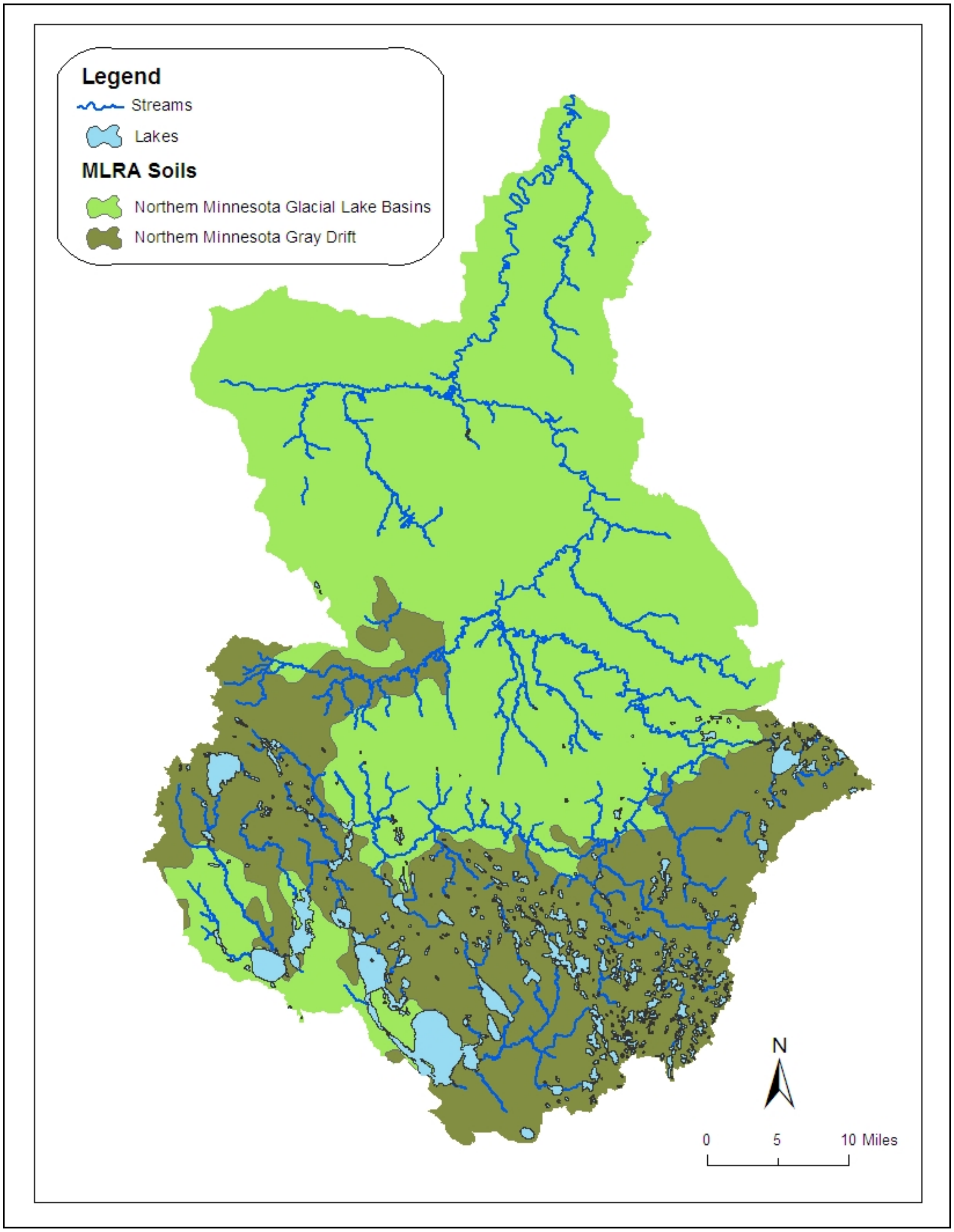

Figure 7. Major land resource areas (MLRA) in the Big Fork River Watershed

Land use summary

In the early 20th century, the Big Fork River Watershed started to see a large movement of European settlers into the area and with it changes to the landscape. One change was a push to turn this area into prime agriculture lands through the construction of drainage ditch networks. The efforts proved unsuccessful for reasons that included nutrient poor soils, high water saturation in soils, and a short growing season. Today there are only 257 farms in the watershed with an average size of 90 acres. Cattle make up 32% of the livestock population, with 55% of the livestock population categorized as other.

At the same time, forestry became another big driver of change for the area. As with typical logging practice, rivers would act as the major mode of transportation for hundreds of thousand logs on their way to mills to be processed. Massive logjams would span the river channels along with the banks and floodplains for many miles. Many of the harvested logs found their way to mills in International Falls, after flowing down the Bigfork River and sections of the Rainy River. Unlike farming, forestry has maintained a significant foothold and is still one of the major land uses today. However the rivers are no longer used to transport harvested logs.

With a population fewer than 5,500 people over a watershed of 1,326,975 acres, this area is indeed sparsely populated. About 60% of the land is state owned, 19.3% is privately owned, 5.9% is privately owned by corporations, 14.6% is owned by the United States federal government, 0.4% is tribal lands, 0.2% is county land, and less than 1% is other public lands (NRCS). With so much public land, hundreds of lakes, many miles of streams, and acres of forest land, this area calls to many outdoor enthusiasts making outdoor recreation a popular economic driver.

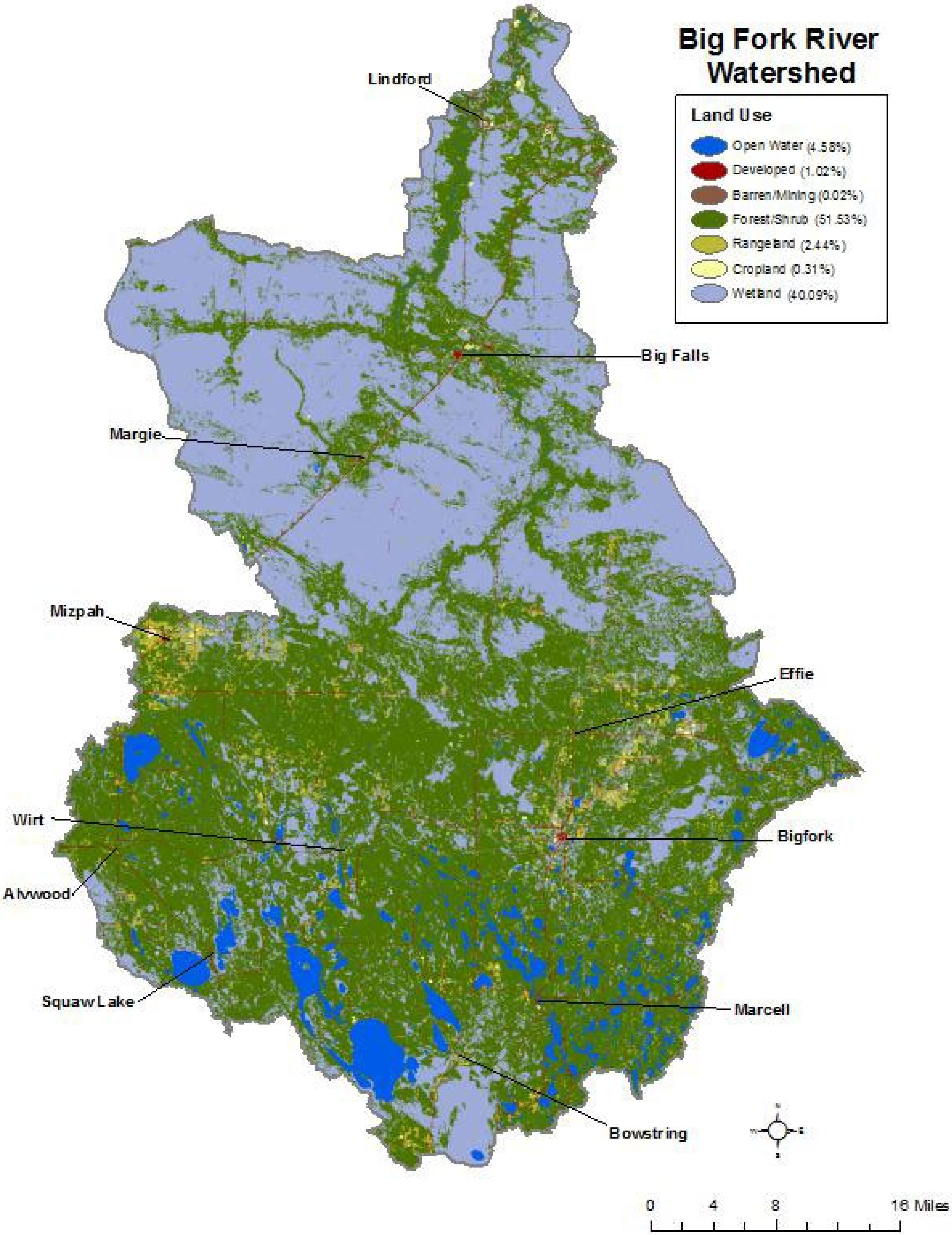

Figure 8. Land use in the Big Fork River Watershed

Surface water hydrology

Once the bottom of a portion of glacial Lake Agassiz, the land is now filled with forests, wetlands, lakes, and streams. Though many thousands of years have passed since the glaciers have melted away, this area's glacial history still impacts the hydrology of today's landscape. This area is flat and water rich, and due to these attributes the average stream gradient is 1.5 feet per mile. The gradient is so low that when the Rainy River is high enough the Big Fork River has been known to flow backwards for several miles. Lakes, bogs, and marshes which are all plentiful in this region are natural assets that tend to dampen hydrologic extremes, and slow water flow. However, the water emanating from wetlands is often low in DO leaving streams with naturally low DO.

The headwaters of the Big Fork River Watershed are northwest of Alvwood in the Popple River. The Popple River runs southeast into Round Lake and continues north through Natures Lake. It then runs 7 miles to the northeast where it enters Dora Lake. Both Moose Brook which flows southeast from Mizpah, and the Bowstring River which starts close to the city of Bowstring and hooks northwest through the Bowstring chain of lakes eventually flow into Dora Lake along with the Popple. The Big Fork River then flows out of the northern end of Dora Lake before going easterly until it reaches the city of Big Fork, where the Rice River and the Big Fork River converge before turning to the northeast. About 10 miles northeast of Big Fork and 6.5 miles east of Effie, the Deer River merges with the Big Fork River, and shortly after the Big Fork River then twists to the northwest. Caldwell Creek enters the Big Fork River 17 miles after Deer River, about 10 miles southeast of Margie. The Big Fork River makes another turn to the northeast before it hooks back to the west and runs through the city of Big Falls. The Big Fork River continues west 4 miles where it meets the Sturgeon River, flowing from the west. As the winding Big Fork River travels north it picks up flow from Bear Creek, and continues only 5 more miles until it reaches its final destination at the Rainy River, approximately 15 miles southwest of International Falls.

Climate and precipitation

Precipitation is the source of almost all water inputs to a watershed. Figure 9 shows two representations of precipitation for water year 2012 (October – September). On the left is total precipitation, which shows that the watershed received between 20 and 28 inches. The display on the right shows the amount that the precipitation levels in water year 2012 departed from normal. Within the Big Fork River Watershed precipitation was approximately two inches below normal. Most of Minnesota shows the effect of persistent drought for this period.

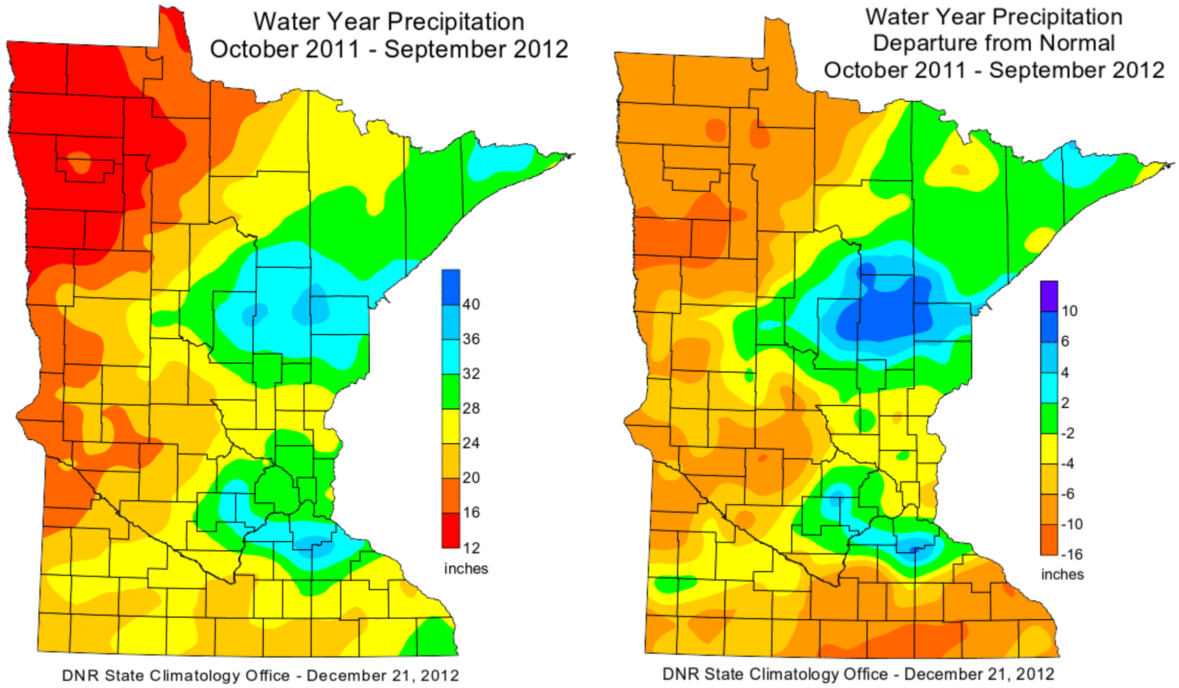

Figure 9. Statewide precipitation levels during the 2012 water year

Figure 10 displays the areal average representation of precipitation in north central Minnesota. An areal average is a spatial average of all the precipitation data collected within a certain area presented as a single dataset. This data is taken from the Western Regional Climate Center: http://www.wrcc.dri.edu/spi/divplot1map.html.

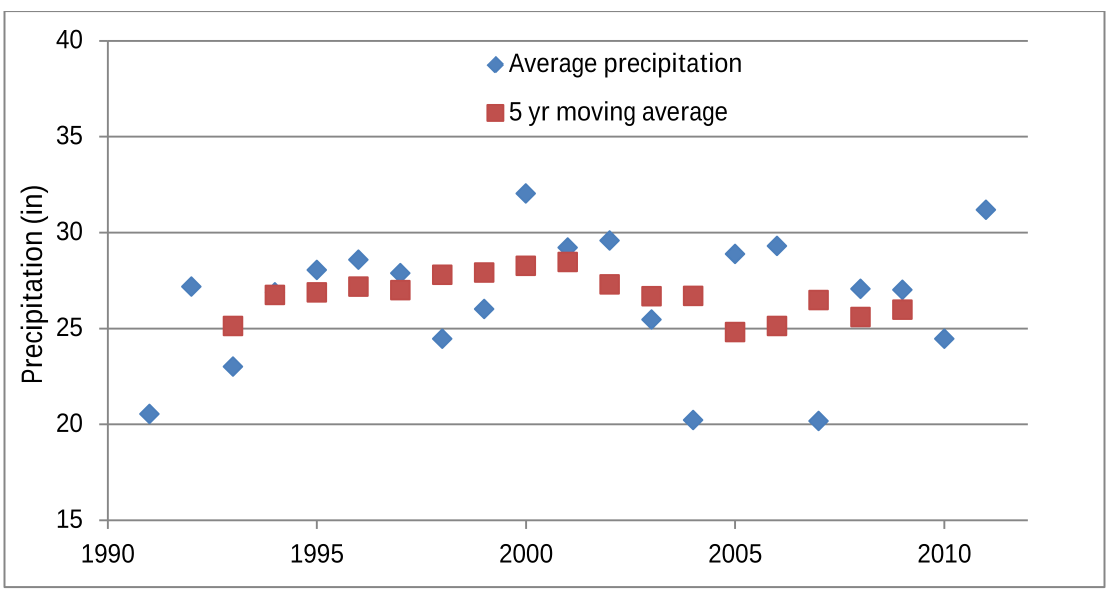

Figure 10. Precipitation trends in north-central Minnesota 1990 – 2011, with five year running average

Average yearly precipitation in the north central region displays no statistically significant trend over the last 20 years. Though rainfall can vary in intensity and time of year, it would appear that north central Minnesota precipitation has not changed dramatically over this time period.

Hydrogeology and groundwater quality

Hydrogeology encompasses the movement and distribution of groundwater in the subsurface, incorporating both the geology and its influence on the storage or movement of groundwater.

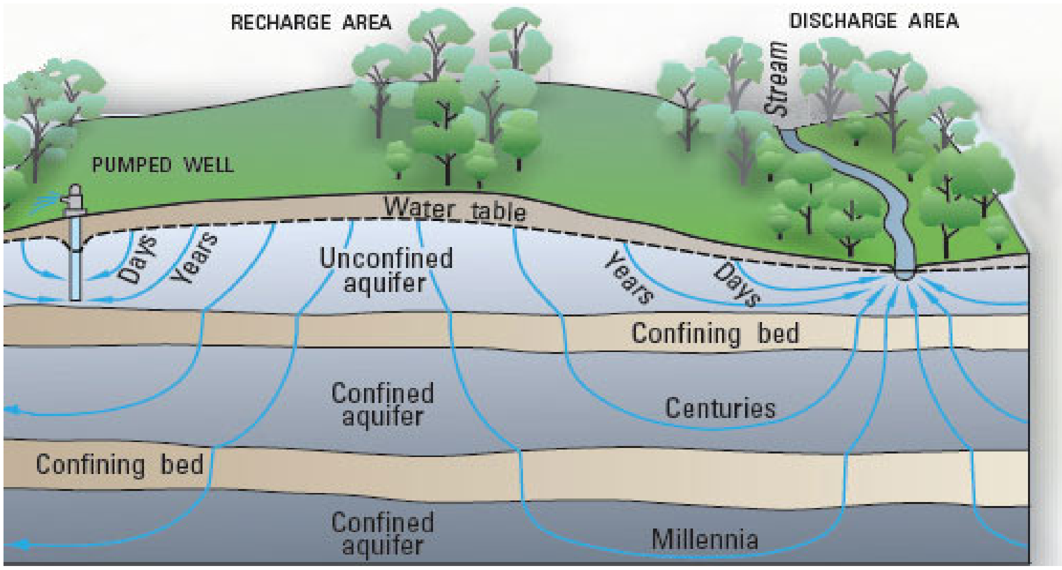

Figure 11. Depiction of groundwater flow adjacent to a river, with relative time of transit

High capacity withdrawals

The MDNR permits all high capacity water withdrawals where the pumped volume exceeds 10,000 gallons/day or one million gallons/year (See Figure 12 for locations of permitted groundwater and surface water withdrawals). Permit holders are required to track water use and report back to the MDNR yearly. Information on the program and the program database are found at: http://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/wateruse.html.

Displayed below are the locations of these permitted groundwater and surface water withdrawals in the Big Fork River Watershed, and neighboring area. Blue symbols are groundwater withdrawals and red are surface water, taken from lake, stream or other surface water feature.

The three largest permitted consumers of water in the state (in order) are municipalities, industry, and irrigation. The Big Fork River Watershed high-capacity withdrawals include the cities of Bigfork and Big Falls, several gravel pit operations, and a single golf course. The Big Fork River Watershed has very few withdrawals in comparison to other watersheds in the state.

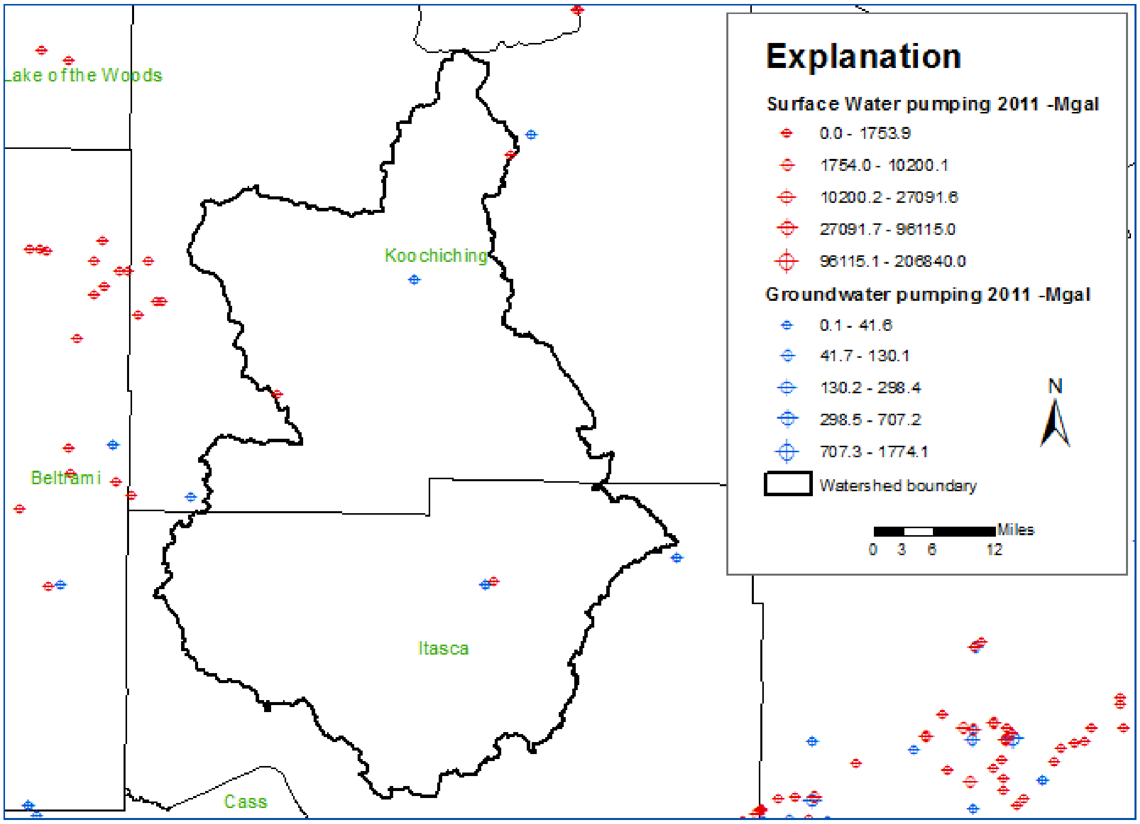

Figure 12. Locations of permitted groundwater withdrawals in the Big Fork River Watershed

Total surface water withdrawals for the watershed from 1988-2010 are displayed below in Figure 13, as red squares. Total groundwater withdrawals from the watershed are portrayed as blue diamonds. Groundwater withdrawals have shown no significant increase or decline during this time period. Surface water withdrawals have shown a statistically significant increase since 1988 ($p=0.001$).

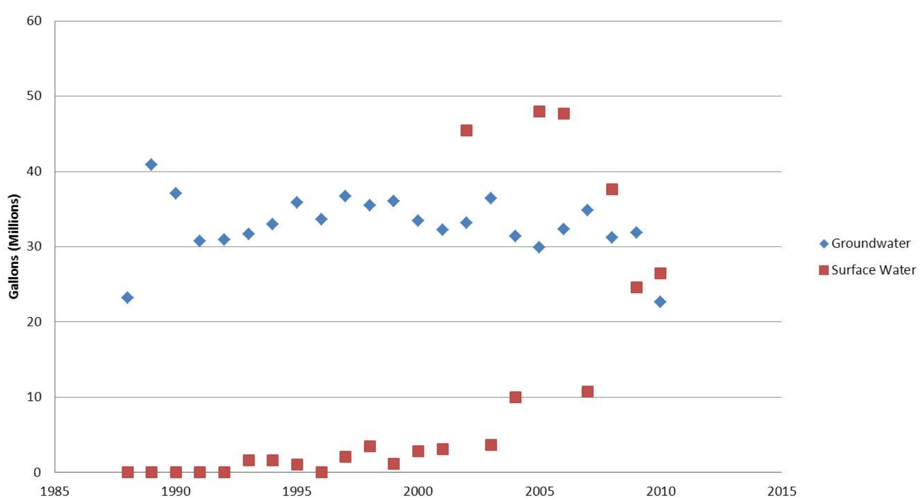

Figure 13. Total annual groundwater and surface water withdrawals in the Big Fork River Watershed (1990-2010)

IV. Watershed-wide data collection methodology

Load monitoring

Intensive water quality sampling occurs throughout the year at all Water Pollutant Load Monitoring Network (WPLMN) sites. Between 21and 36 mid-stream grab samples were collected per year at the Big Fork River on Highway 71, just north of the city of Big Falls, focusing the sampling frequency greatest during periods of moderate to high flow (Figure 14). Because correlations between concentration and flow exist for many of the monitored analytes, and because these relationships can shift between storms or with season, computation of accurate load estimates requires frequent sampling of all major runoff events. Low flow periods are also sampled and are well represented but sampling frequency tends to be less as concentrations are generally more stable when compared to periods of elevated flow. Despite discharge related differences in sample collection frequency, this staggered approach to sampling generally results in samples being well distributed over the entire range of flows.

Annual water quality and daily average discharge data are coupled in the "Flux32," pollutant load model, originally developed by Dr. Bill Walker and recently upgraded by the U.S. Army Corp of Engineers and the MPCA. Flux32 allows the user to create seasonal or discharge constrained concentration/flow regression equations to estimate pollutant concentrations and loads on days when samples were not collected. Primary outputs include annual and daily pollutant loads and flow weighted mean concentrations (pollutant load/total flow volume). Loads and flow weighted mean concentrations are calculated for total suspended solids (TSS), total phosphorus (TP), dissolved orthophosphate (DOP), and nitrate plus nitrite nitrogen (nitrate-N).

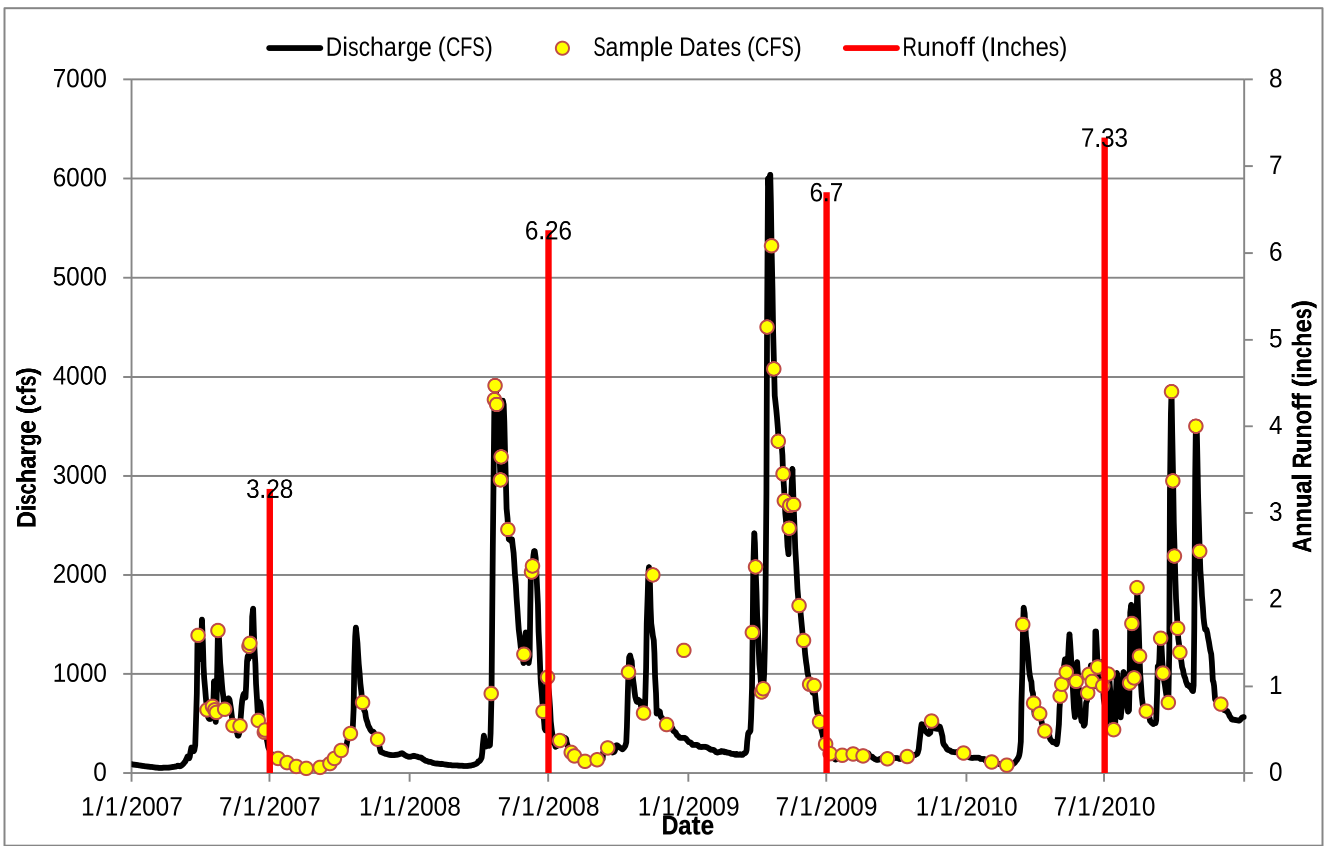

Figure 14. Hydrograph and annual runoff for the Big Fork River near Big Falls (2007-2010)

Stream water sampling

Big Fork River Watershed water chemistry stations were sampled from May through September in 2010, and again June thru August of 2011, to provide sufficient water chemistry data to assess all components of the Aquatic Life and Recreation Use Standards. Following the IWM design, water chemistry stations were placed at the outlet of each 11 HUC subwatershed that was >40 square miles in area (purple circles and green circles/triangles in Figure 12). All stations were co-located with the IWM design and water chemistry was collected by either the Itasca County or Koochiching County SWCD separating sites by their respective counties (See Appendix 2 for locations of stream water chemistry monitoring sites. See Appendix 1 for definitions of stream chemistry analytes monitored in this study).

Stream biological sampling

The biological monitoring component of the IWM in the Big Fork River Watershed was completed during the summer of 2010. A total of 42 sites were newly established across the watershed and sampled. These sites were located near the outlets of most minor HUC-14 watersheds. In addition, 14 existing biological monitoring stations within the watershed were revisited in 2010. These monitoring stations were initially established as part of a random Rainy River Basin wide survey in 2005. While data from the last 10 years contributed to the watershed assessments, the majority of data utilized for the 2012 assessment was collected in 2010. A total of 50 AUIDs were sampled for biology in the Big Fork River Watershed. Waterbody assessments to determine aquatic life use support were conducted for 33 AUIDs. Waterbody assessments were not conducted for 5 AUIDs because criteria for channelized reaches had not been developed prior to the assessments. Nonetheless, the 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. Qualitative ratings for non-assessed reaches area included in Appendix 5.1.

To measure the health of aquatic life at each biological monitoring station, indices of biological integrity (IBIs), specifically Fish and Invert 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 Invert 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 4.1). 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 Appendix 4 and Appendix 5.

Fish contaminants

Mercury was analyzed in fish tissue samples collected from the Big Fork River and 20 lakes in the watershed. Polychlorinated biphenyls (PCBs) were measured in fish from the Big Fork River and 9 lakes. MPCA biomonitoring staff collected the fish from the river in 2010 and MDNR fisheries staff collected all other fish.

Select fish species from Horseshoe and Round lakes were tested for perfluorochemicals (PFCs). The PFC that bioaccumulates in fish and is a known health concern for human consumption is perfluorooctane sulfonate (PFOS). Therefore, it is the only PFC concentration reported here for fish tissue. PFCs became a contaminant of emerging concern in 2004 when high concentrations of PFOS were measured in fish from the Mississippi River, Pool 2. Extensive statewide monitoring of lakes and rivers for PFCs in fish was continued through 2010. More focused monitoring for PFCs will continue in known contaminated waters, such as the Mississippi River, Fish Lake Flowage near Duluth, and Twin Lake in this watershed.

Captured fish were wrapped in aluminum foil and frozen until they were thawed, scaled, filleted, and ground. The homogenized fillets were placed in 125 mL glass jars with Teflon™ lids and frozen until thawed for mercury or PCBs analyses. The Minnesota Department of Agriculture laboratory performed all mercury and PCBs analyses of fish tissue.

For PFCs, the MPCA shipped whole fish to AXYS Analytical Services Ltd in Sidney, British Columbia, Canada. AXYS did the fish measurements and processing before analyzing the tissue samples for 13 PFCs. The one PFOS result for one bluegill sunfish (BGS) from Horseshoe Lake was analyzed by EPA Research Triangle Park Laboratory.

The MPCA has included waters impaired for contaminants in fish on the 303d Impaired Waters List since 1998. Impairment assessment for PCBs and PFCs in fish tissue is based on the fish consumption advisories prepared by the Minnesota Department of Health. If the consumption advice is to restrict consumption of a particular fish species to less than a meal per week because of PCBs or PFCs, the MPCA considers the lake or river impaired. The threshold concentration for impairment (consumption advice of one meal per month) is 0.22 mg/kg for PCBs and 0.200 mg/kg (200 ppb) for PFOS.

Prior to 2006, mercury concentrations in fish tissue were assessed for water quality impairment based on the Minnesota Department of Health's fish consumption advisory. An advisory more restrictive than a meal per week was classified as impaired for mercury in fish tissue. Since 2006, 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, which is one of Minnesota's water quality standards for mercury. At least five fish samples per species are required to make this assessment and only the last 10 years of data are used for statistical analysis. MPCA's Impaired Waters Inventory includes waterways that were assessed as impaired prior to 2006 as well as more recent impairments.

PCBs in fish have not been monitored as intensively as mercury in the last three decades due to monitoring completed in the 1970s and 1980s. These studies identified that high concentrations of PCBs were only a concern downstream of large urban areas in large rivers, such as the Mississippi River and in Lake Superior. Therefore, continued widespread frequent monitoring of smaller river systems was not necessary. However, limited PCB monitoring of forage fish was included in the watershed sampling design to confirm PCBs are not appearing in the smaller streams.

Lake water sampling

The amount of lake monitoring data in the Big Fork River Watershed is extensive. A total of 120 lakes have sufficient data for assessment (43% of all lakes greater than 10 acres within the watershed), and many more lakes have smaller sets of data collected in the last 10 years. Lake monitoring in the watershed was primarily conducted by local partners such as the Itasca County SWCD and Itasca Community College. Additionally there are many volunteers enrolled in the MPCA's CLMP that are conducting lake clarity monitoring within the watershed. MPCA staff sampled five of the assessed lakes from 2009-2011.

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.

Groundwater monitoring

Groundwater quantity is monitored by the MDNR through a network of observation wells. Figure 15 shows the locations of wells in the watershed and neighboring counties. There are currently no observation wells in operation within the Big Fork River Watershed, though there are several just to the south in the Mississippi River headwaters. Two monitoring wells within the watershed were actively measured from 1970 into the 1990s before the wells were abandoned.

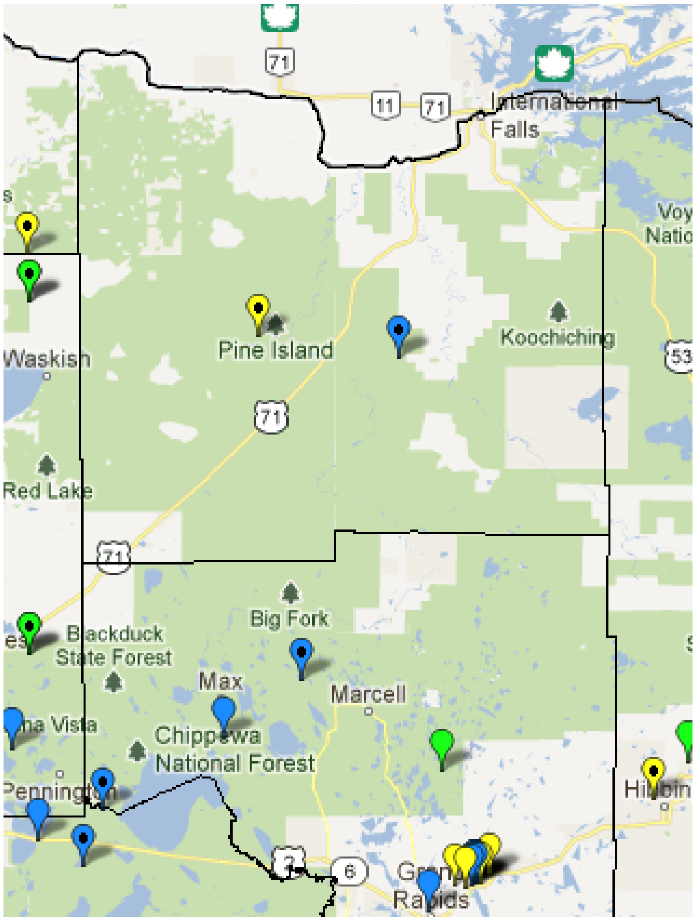

Figure 15. Locations of area MDNR observation wells

Groundwater quality is monitored by the MPCA through a smaller network of observation wells. The MPCA Ambient Network monitors trends in statewide groundwater quality by sampling for a comprehensive suite of chemicals including nutrients, metals, and volatile organic compounds.

Data collected from these wells indicates the presence of naturally-occurring constituents like iron, sulfate and manganese. Some of these may impact water aesthetically, creating need for treatment prior to household use. Chloride is also commonly detected and its source can either be from natural conditions or be an indicator of human impacts to groundwater.

Figure 16 shows the locations of the Ambient Groundwater Monitoring Program wells that surround the Big Fork River Watershed. There are no active observation wells in the watershed.

Regional assessments of groundwater availability and quality were prepared in 1976 and 1999. The first was a joint hydrogeologic atlas produced by the USGS and MDNR that concluded that groundwater chemistry, characterized by calcium or sodium carbonate, was determined by the chemical makeup of the surficial geology, residence time and location within the gradient of the watershed.

The second was published by the MPCA in the report, “Baseline Study of Minnesota’s Principal Aquifers – Northeast Region”. That study monitored wells within the Big Fork River Watershed. Like the earlier study, it found the water quality to be generally good with occasional detections of elements naturally occurring as a result of the region’s geology. MPCA report at:
http://www.pca.state.mn.us/index.php/view-document.html?gid=6291

Lindholm, G.F., J.O. Helgeson, and D.W. Ericson. 1974. *Water Resources of the Big Fork River Watershed, North-Central Minnesota*. Hydrologic Investigations Atlas. HA-549. United States Geological Survey. 2 plates.

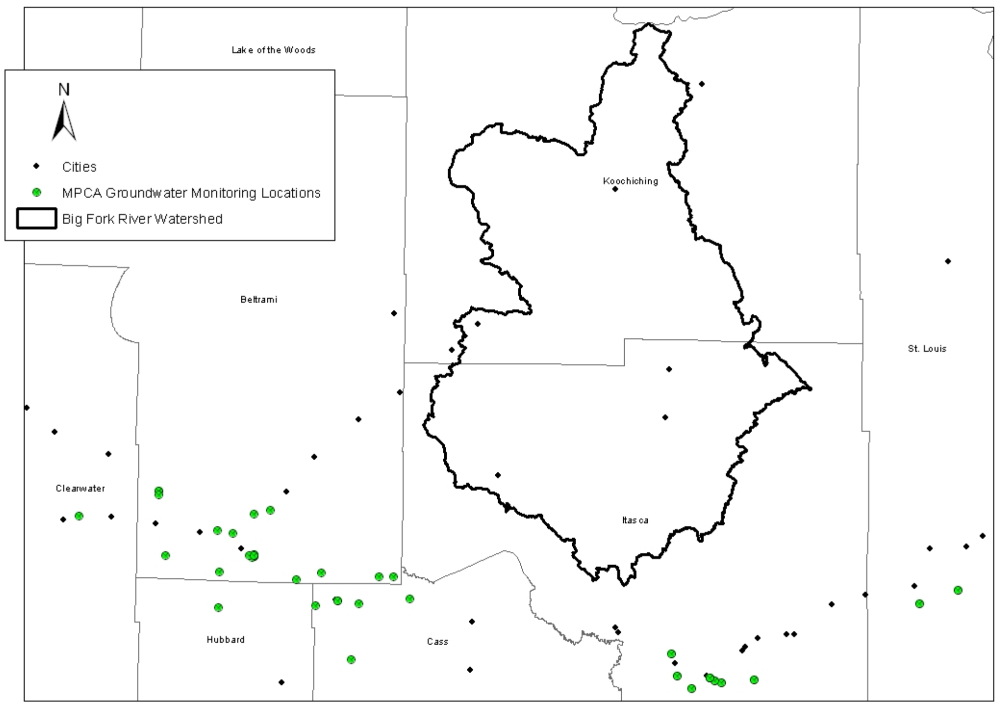

Figure 16. Locations of wells in the MPCA Ambient Groundwater Monitoring Program

Lake monitoring

The MPCA conducts and supports lake monitoring for a variety of objectives. Lake condition monitoring activities are focused on assessing the recreational use support of lakes, based on total phosphorus and chlorophyll concentrations, and identifying trends over time. The MPCA also assesses lakes for aquatic consumption use support, based on fish-tissue and water-column concentrations of toxic pollutants.

Within the IWM strategy, lakes are selected to represent the range of conditions and lake type (size and depth) found within the watershed. Lakes most heavily used for recreation (all those greater than 500 acres and at least 25% of lakes 100-499 acres) are monitored for water chemistry to determine if recreational uses, such as swimming and wading, are being supported. Lakes are sampled monthly from May-September for a two-year period. There is currently no tool that allows us to determine if lakes are supporting aquatic life; however, a method that includes monitoring fish and aquatic plant communities is in development.

V. Individual watershed results

HUC-11 watersheds

Assessment results for aquatic life and recreation use are presented for each HUC-11 watershed within the Big Fork River Watershed. The primary objective is to portray all the full support and impairment listings within an 11-HUC watershed resulting from the complex and multi-step assessment and listing process. (A summary table of assessment results for the entire 8-HUC watershed including aquatic consumption, and drinking water assessments (where applicable) is included in Appendix 3.) 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 HUC-11 watersheds contain the assessment results from the 2012 Assessment Cycle as well as any impairment listings from previous assessment cycles. Discussion of assessment results focuses primarily on the 2010 IWM effort, but also considers available data from the last 10 years.

The following pages provide an account of each HUC-11 watershed. Each account includes a brief description of the subwatershed and summary tables of the results for each of the following: a) stream aquatic life and aquatic recreation assessments, b) biological condition of channelized streams and ditches, c) stream habitat quality d) channel stability, e) water chemistry for the HUC-11 outlet, and f) lake aquatic recreation assessments. Following the tables is a narrative summary of the assessment results and pertinent water quality projects completed or planned for the 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 watershed (i.e., where sufficient information was available to make an assessment). Primarily, these tables reflect the results of the 2012 assessment process 2014 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); these determinations were made during the desktop phase of the assessment process (see Figure 5). Assessment of aquatic life is derived from the analysis of biological (fish and macroinvertebrate IBIs), DO, turbidity, chloride, pH and un-ionized ammonia (NH3) data, while the assessment of aquatic recreation in streams is based solely on bacteria (Escherichia coli or fecal coliform) data. Included in each table is the specific aquatic life use classification for each stream reach: cold water community (2A); cool or warm water community (2B); or indigenous aquatic community (2C). Stream reaches that do not have sufficient information for either an aquatic life or aquatic recreation assessment (from current or previous assessment cycles) are not included in these tables, but are included in Appendix 5.2 and Appendix 5.3. 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 HUC-11 as well as in the Watershed-Wide Results and Discussion section.

Channelized stream evaluations

Biological criteria have not been developed yet for channelized streams and ditches, therefore, assessment of fish and macroinvertebrate community data for aquatic life use support was not possible at some monitoring stations. A separate table provides a narrative rating of the condition of fish and macroinvertebrate communities at such stations based on IBI results. Evaluation criteria are based on aquatic life use assessment thresholds for each individual IBI class (see Appendix 5.1). IBI scores above this threshold are given a “good” rating, scores falling below this threshold by less than ~15 points (i.e., value varies slightly by IBI class) are given a “fair” rating, and scores falling below the threshold by more than ~15 points are given a “poor” rating. For more information regarding channelized stream evaluation criteria refer to Appendix 5.1.

Stream habitat results

Habitat information documented during each fish sampling visit is provided in each HUC-11 section. These tables 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 HUC-11 watershed.

Stream stability results

Stream channel stability information evaluated during each invert sampling visit is provided in each HUC-11 section. These tables display the results of the Channel Condition and Stability Index (CCSI) which rates the geomorphic stability of the stream reach sampled for biology. The CCSI rates three regions of the stream channel (upper banks, lower banks, and bottom) which may provide an indication of stream channel geomorphic changes and loss of habitat quality which may be related to changes in watershed hydrology, stream gradient, sediment supply, or sediment transport capacity. The CCSI was recently implemented in 2008, and is collected once at each biological station. Consequently, the CCSI ratings are only available for biological visits sampled in 2010 or later. The final row in each table displays the average CCSI scores and a rating for the HUC-11 watershed.

Watershed outlet water chemistry results

These summary tables display the water chemistry results for the monitoring station representing the outlet of the HUC-11 watershed. Data were collected in 2010 and 2011 by local government partners in the Itasca and Koochiching County SWCDs. These data along with other data collected within the last 10 years can provide valuable insight on water quality characteristics and potential parameters of concern within the watershed. Parameters included in these tables are those most closely related to the standards, proposed standards, or expectations used for assessing aquatic life and recreation. While not all of the water chemistry parameters of interest have established water quality standards, McCollor and Heiskary (1993) developed ecoregion expectations for a number of parameters that provide a basis for evaluating stream water quality data and estimating attainable conditions for an ecoregion. For comparative purposes, water chemistry results for the Big Fork River Watershed are compared to these expectations that were based on the 75th percentile of a long-term dataset of least impacted streams within the NLF and NWM ecoregions - dependent on the dominate landscape within each HUC11 watershed.

Table 1. Big Fork River HUC-11 watersheds

HUC-11 Units	Area (square miles)	Percent of HUC-8	Number of '10X' Water Chemistry Monitoring Sites
Upper Big Fork River	215	10.3	1
Popple River	162	7.8	1
Upper Bowstring River	142	6.8	1
Bowstring River	119	5.7	1
Gale Brook / Rice River	139	6.7	1
Middle Big Fork River	304	14.6	1
Caldwell Creek	146	7.1	1
Lower Middle Big Fork River	295	14.2	1
Dinner Creek	135	6.5	0
Sturgeon River	184	8.8	1
Lower Big Fork River	96	4.6	2
Bear River	137	6.5	1

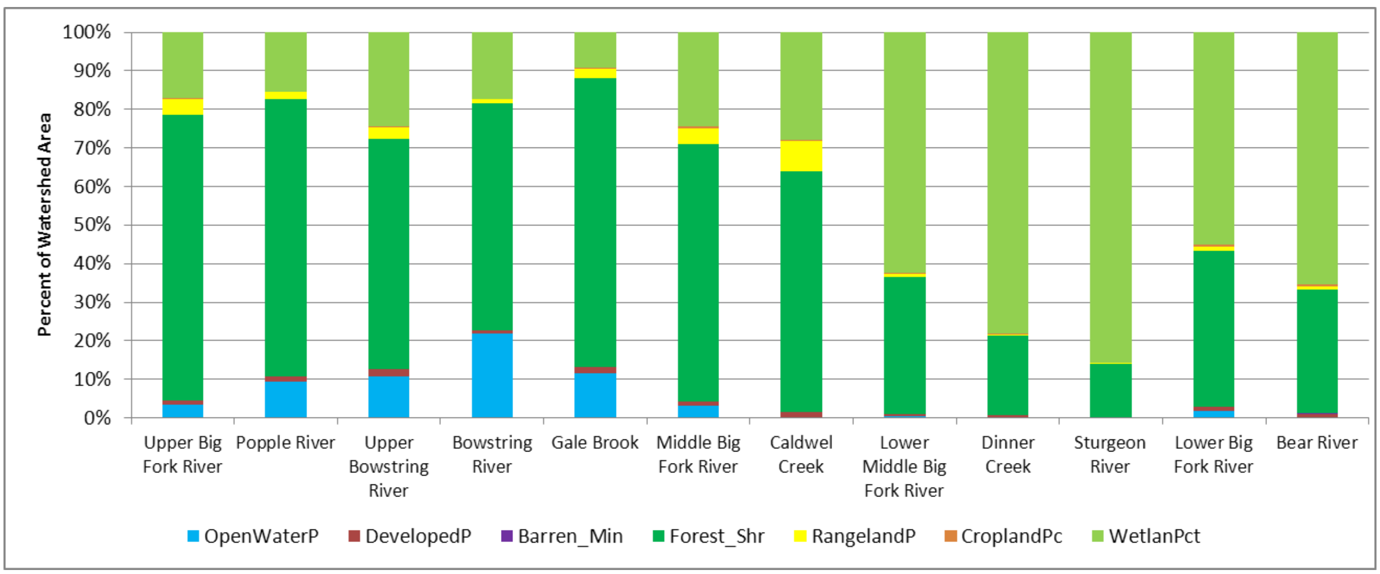

Figure 17. Land use within each HUC 11 Watershed

Lake assessments

Lakes are prominent and valued resources within the Big Fork River Watershed. Lake outflows make up a significant portion of sustaining flows in the Big Fork River and its principal headwater tributaries- the Popple and Bowstring Rivers. Nearly all the 278 lakes greater than 10 acres in size within the Big Fork River Watershed are in 6 headwater subwatersheds - the Upper Big Fork, Popple River, Upper and Lower Bowstring River, Gale Brook, and the Middle Big Fork River. No lakes are present in the lower subwatersheds of the Big Fork River, a landscape dominated by large tracts of peat and wetlands within the basin of Glacial Lake Agassiz.

Lake distribution and morphometry varies throughout these headwater subwatersheds. Distribution ranges from 107 lakes in the Gale Brook watershed to 17 in the Lower Bowstring watershed. Lakes within the Gale Brook and Middle Big Fork tend to be smaller and deeper; lakes in the Bowstring and Popple tend to be larger and shallower. The largest lake in the Big Fork River Watershed is Bowstring (8,900 acres or 3,601 hectares).

Table 2. Eutrophication standards by ecoregion and lake type (Heiskary and Wilson, 2005)

Ecoregion	TP	Chl-*a*	Secchi
	µg/L	µg/L	meters
NLF – Lake trout (Class 2A)	< 12	< 3	> 4.8
NLF – Stream trout (Class 2A)	< 20	< 6	> 2.5
NLF – Aquatic Rec. Use (Class 2B)	< 30	< 9	> 2.0
NCHF – Stream trout (Class 2a)	< 20	< 6	> 2.5
NCHF – Aquatic Rec. Use (Class 2b)	< 40	< 14	> 1.4
NCHF – Aquatic Rec. Use (Class 2b) - Shallow lakes	< 60	< 20	> 1.0
WCBP & NGP – Aquatic Rec. Use (Class 2b)	< 65	< 22	> 0.9
WCBP & NGP – Aquatic Rec. Use	< 90	< 30	> 0.7

Upper Big Fork River subwatershed HUC 9030006010

The Upper Big Fork River subwatershed includes the headwaters of the Big Fork River from Dora Lake to the town of Big Fork. It also includes the tributaries that flow south to Dora Lake including Moose Brook and Windigo Creek. The watershed covers 215 square miles and makes up 10.3% of the entire Big Fork River Watershed. Land cover in the subwatershed is dominated by forest (73.9 %) and wetlands (17.0 %). Much of the subwatershed is within the public lands of Big Fork State Forest and Chippewa National Forest. As with all subwatersheds within the Big Fork River, urban, developed, and agricultural land uses are low.

Table 3. Aquatic life and recreation assessments on stream reaches: Upper Big Fork River subwatershed. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name,*** *Reach Description*	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	**Aquatic Life**	**Aquatic Rec.**
09030006-599, Unnamed creek, Moose Lk to Big Calf Lk	0.21	2B, 3C	05RN185	4 mi. Downstream of CR 31, 7 mi. SE of Northome	--	MTS	--	--	--	--	--	--	--	FS	NA
09030006-511, Moose Brook, Headwaters (Big Calf Lk 31-0884-00) to Big Fork R	14.66	2B, 3C	05RN093 10RN029	1.5 mi. Downstream of CR 31, 10 mi. SE of Northhome, Upstream of CR 26, 2.5 mi. NW of Dora Lake	MTS	MTS	--	--	--	--	--	--	--	FS	NA
09030006-538, Hinken Creek, Lk Helen to Big Fork R	3.49	2B, 3C	10RN031	Upstream of CR 29, 2 mi. W of Wirt	MTS	MTS	--	--	--	--	--	--	--	FS	NA
09030006-505, Big Fork River, Moose Bk to Coon Cr	40.22	2B, 3C	10RN032 05RN175 10RN011 05RN106	Upstream of CR 31, 0.25 mi. N of Wirt, 1.5 mi. Upstream of CR 14, 11 mi. W of Bigfork, Upstream of Hwy 38, in Bigfork, Downstream of HWY 38, E of Big Fork	MTS	MTS	IF	MTS	--	MTS	MTS	--	MTS	FS	FS
09030006-508, Fletcher Creek, Unnamed cr (Dogfish Lk outlet) to Big Fork R	2.18	2B, 3C	10RN033	Downstream of CR 14, 2 mi. NE of Wirt	MTS	MTS	--	--	--	--	--	--	--	FS	NA
09030006-637, Harrison Creek, Headwaters to Big Fork R	6.26	2B, 3C	10RN034	Downstream of CR 150, 4 mi. NE of Wirt	IF	MTS	--	--	--	--	--	--	--	FS	NA

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.
Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

Table 4. Non-assessed biological stations on channelized AUIDs: 9030006010 11-HUC

AUID *Reach Name*, *Reach Description*	Reach length (miles)	Use Class	Biological Station ID	Location of Biological Station	Fish IBI	Invert IBI
09030006-613, Unnamed creek, Unnamed cr to Unnamed cr	3.46	2B, 3C	05RN019	Downstream of CR 236, 2 mi. N of Big Fork	Fair	Fair

= Good = Fair = Poor - See Appendix 5.1 for clarification on the good/fair/poor thresholds and Appendix 5.2 and Appendix 5.3 for IBI results.

Table 5. Minnesota Stream Habitat Assessment (MSHA): 9030006010 11-HUC

# 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
1	05RN185	Unnamed creek	5	12	19	13	18	67	Good
1	05RN093	Moose Brook	5	10	8	12	23	58	Fair
2	10RN029	Moose Brook	4.5	11	16.48	16.00	19.50	67.48	Good
1	10RN031	Hinken Creek	5	9	8	12	27	61	Fair
1	10RN032	Big Fork River	5	11	3	10	12	41	Poor
1	10RN034	Harrison Creek	5	10	4	13	24	56	Fair
1	05RN175	Big Fork River	5	12	23	15	26	81	Good
1	05RN019	Unnamed creek	3.5	8.5	7	12	13	44	Poor
1	10RN011	Big Fork River	2.3	10	12	11	31	66.3	Good
2	05RN106	Big Fork River	4.25	11.75	10.75	16.5	22	65.25	fair
Average Habitat Results: *9030006010 11 HUC*			**4.5**	**10.5**	**11.12**	**13.05**	**21.55**	**60.7**	**Fair**

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)

Table 6. Outlet water chemistry results: 9030006010 11-HUC

Station location:	Big Fork River at Highway 38 in Bigfork								
EQUIS ID:	S006-328								
Station #:	10RN011								
Parameter	TSS [5]	Turb. [4]	T-tube	D.O.	TP [5]	TKN	Chloro-phyll-a [5]	E. coli	pH
Units	mg/l	NTU	cm	mg/l	mg/l	mg/l	ug/l	#/100ml	SU
# samples	10	20	20	20	10	10	0	16	20
Min	4	1.9	47	2.4	0.032	0.92		16	7.14
Max	12	10.9	>100	10.2	0.098	1.73		203	8.4
Mean[1]	6.9	5.7	79	6.4	0.057	1.23		29	7.78
Median	6	4.9	88	6.7	0.048	1.19		24	7.84
WQ standard [5]	15	25	20	5	0.055		<10	126/1260	6.5-9.0
# WQ exceedances[2]	0	0	0	3	4			0	0
NLF 75th percentile[3]	5.6	4			0.05	0.18-0.73			7.9

1Geometric mean of all samples is provided for *E. coli* or fecal coliform.
2Represents exceedances of individual maximum standard for *E. coli* (1260/100ml) or fecal coliform (2000/100ml).
3Based on 1970-1992 summer data; see *Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions* (McCollor and Heiskary 1993). TKN range based on EPA Rivers and Streams in Nutrient Ecoregion VIII, NLF and NMW, EPA 822 B-01-015. 2001
[4] Combined data from 3 turbidity methods, each with slightly different standard methods
[5] Proposed TP, TSS and Chlorophyll-a standards for the North region of Minnesota, see http://www.pca.state.mn.us/index.php/view-document.html?gid=14947 http://www.pca.state.mn.us/index.php/view-document.html?gid=14922

**Data found in the above table was compiled using the results from data collected at the pour point monitoring station in the Upper Big Fork HUC 11 watershed, a component of the IWM work conducted in 2010 and 2011. This specific data does not necessarily reflect all data that was used to assess the AUID.

Table 7. Lake water aquatic recreation assessments: 9030006010 11-HUC

Name	DOW#	Area (ha)	Trophic Status	% Littoral	Max. Depth (F)	Avg. Depth (F)	CLMP Trend	Mean TP (µg/L)	Mean chl-a (µg/L)	Secchi Mean (F)	Support Status
Dora	31-0882	477	E	97	16	8.1	No Trend	41.1	10.3	2.8	IF
Gunderson	31-0782	172	O	32	42	17.6	No Trend	9.6	2.1	4.3	FS
Moose	31-0898	373	M	26.1	52	23.1	NA	14.8	2.8	4.6	FS
Lac a Roy	31-0802	89	O	79.2	30		NA	11.9	3.4	3.6	FS
Whitefish	31-0843	561	M	46.4	51	15.3	NA	12.8	3.2	2.9	FS
Holloway	31-0839	202	O	0	40	13	NA	10.5	2	4.5	FS
Arrowhead	31-0805	129	M	14	30		NA	15.7	5	3.8	FS
Trestle	31-0803	105	M	33.1	30	16.4	↑	14.8	3.8	4	FS
Bustic	31-0713	78	O	43	35		NA	10.4	2.6	3.5	FS
Holland	31-0804	24	O	39.2	45		NA	9.8	2	5.8	FS
Glove	31-0889	14	E	85.3	11		NA	31.3	13.4	1.1	IF
Clear	31-0845	137	M	43.6	29	13.6	NA	13	2.5	3.9	FS
Noma	31-0837	59	M	50.4	47		NA	13.7	4.3	4.1	FS
Eel	31-0886	38	M	0	40		NA	13.5	8.3	2.7	FS

Abbreviations: ↘ -- Decreasing/Declining Trend; ↗ -- Increasing/Improving Trends; NT – No Trend
O – Oligotrophic; **E** – Eutrophic; **M** – Mesotrophic
FS – Full Support; **NS** – Non-Support; **IF** – Insufficient Information

Summary

The Upper Big Fork River subwatershed had 6 assessable AUIDs containing 10 biological monitoring sites, 1 non-assessable AUID with one biological monitoring site, and 14 lakes assessed for aquatic recreation. All stream segments fully supported aquatic life and aquatic recreation based on water chemistry and biological assessment results. Given the low amount of watershed disturbance, it comes as no surprise that the subwatershed performs well. There were however, a number of sites that had poor MSHA habitat scores. The poor scores may be attributed to natural conditions stemming from wetlands. Wetland streams often lack coarse substrates and have relatively undefined channel morphology resulting in poorer MSHA scores. MSHA scores from 2 sites on the Big Fork River (10RN032 and 05RN175) illustrate the habitat differences typical of streams found in this subwatershed. 05RN175 occurs on a higher gradient section of the Big Fork River where the substrate is comprised of both coarse and fine material and the stream has the classic riffle-run-pool morphology. On the other hand, the next site upstream (10RN032) is a typical wetland influenced segment of the Big Fork River. The stream at this location lacks coarse substrate and is largely run channel morphology. Consequently, MSHA scores for both substrate and channel morphology are very low. This pattern persists throughout the Big Fork River Watershed with poor habitat scores primarily driven by the influence of naturally occurring riparian wetlands. In this subwatershed streams with larger drainage areas tended to perform better than those with small drainage areas. The Big Fork River was no exception as it had the highest drainage area along with some of the highest biological scores. In addition to having high IBI scores, the three Big Fork River sites' samples contained the lowest percentages of tolerant fish and macroinvertebrate species.

The one AUID that was non assessable due to channelization received a fair rating. The process of channelizing streams changes the physical structure of the stream bed as well as the hydrology of a river which can in turn influence substrate types, aquatic vegetation, habitat, and many other factors that influence biological communities. Channelized streams therefore often do not perform as well biologically as natural streams and so the expectations for these streams are lower. The MPCA does not currently compare altered streams to any IBI criteria, rather these streams are given a qualitative rating and are not assessed.

The water chemistry monitoring site for this subwatershed is station S006-328 on the Big Fork River at Minnesota Highway 38 in the town of Bigfork. Data indicate excellent water quality in this subwatershed, and full support for both aquatic life and aquatic recreational uses. Most parameters did not have any exceedances of water quality standards. Dissolved oxygen and phosphorus samples occasionally were not meeting standards, but these were collected during low flows when natural conditions, such as the decomposition of aquatic vegetation, can yield exceedances. The Big Fork River Board River Watch also collected data in this subwatershed. Their data, including fecal coliform bacteria data, corroborate the assessment-level data. In summary, concentrations of sediment, turbidity, nutrients, and bacteria were low and reflective of the forests and wetlands which dominate the land cover within the subwatershed.

The Upper Big Fork River subwatershed has a total of 35 lakes greater than 10 acres in size, including 14 lakes with sufficient data for assessment. In general, data indicate good water quality, reflective of the forests and wetland dominated landscape of Chippewa National Forest. Most lakes (12 of 14) are fully supporting recreational use (Table 7). On the remaining two lakes, Dora and Glove, it was determined that additional data were needed to make conclusive assessment decisions. These waters are very shallow, bog-stained, or drain large wetland dominated landscapes. Dora Lake covers 477 acres, and is located approximately five miles northeast of the community of Squaw Lake. The lake drains a very large watershed, (440 mi^2) including the Bowstring and Popple River subwatersheds. Dora Lake is shallow, and much of its riparian area is dominated by stands of wild rice by mid-summer. Dora Lake is riverine in nature; its residence time was estimated at just 7 days during average inflow conditions, and approximately 20 days during a once in 10 year drought condition. Dora Lake is a productive lake and is classified as eutrophic; however, conditions in the lake are likely highly influenced by natural conditions, such as aquatic vegetation growing throughout much of the lake's surface area. Long term Secchi monitoring data indicate stable transparencies, with no long term trends.

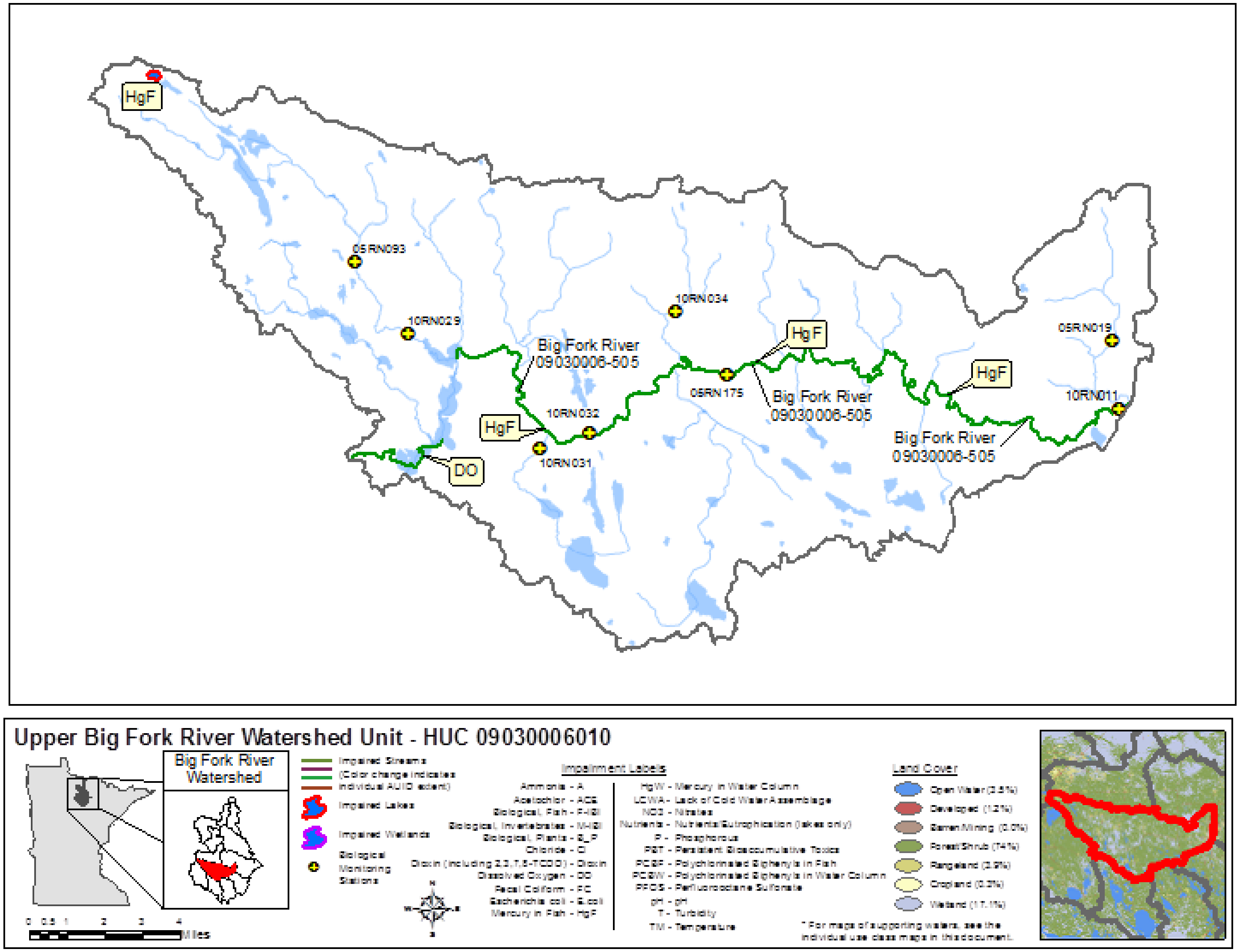

Figure 18. Currently listed impaired waters by parameter and land use characteristics in the Upper Big Fork River Watershed

Popple River subwatershed HUC 09030006020

The Popple River subwatershed includes the area from Island Lake (south of Northome) to its confluence with Dora Lake. The Popple River flows through several shallow, productive lakes such as Round and Natures, before reaching Dora Lake. The lower portions of the subwatershed are within the Leech Lake Reservation. Land cover is dominated by forest (71.8%), wetlands (15.3%) and open water/lakes (9.3%). The Popple River subwatershed covers 162 square miles and makes up 7.8% of the entire Big Fork River Watershed.

Table 8. Aquatic life and recreation assessments on stream reaches: Popple River watershed. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name,*** *Reach Description*	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	**Aquatic Life**	**Aquatic Rec.**
09030006-517, Popple River, Headwaters to Round Lk	24.21	2B, 3C	10RN001	Upstream of Hwy 46, 1 mi. N of Alvwood	EXS	MTS	--	--	--	--	--	--	--	NS*	NA
09030006-512, Popple River, Natures Lk to Dora Lk **	6.39	2B, 3C	10RN006	Upstream of CR 126, 6 mi. NE of Squaw Lake	--	--	EXS	MTS	--	MTS	MTS	--	MTS	NS	FS

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.
*** Non-supporting due to natural background conditions. ** This site is located on the border of 0903006010 and 09030006020, but is designated to assess the chemistry of 0903006020 so it is placed in the table the data is relevant to.**

Table 9. Minnesota Stream Habitat Assessment (MSHA): 09030006020 11-HUC

# 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
1	10RN001	Popple River	5	14	9	12	22	62	fair
1	10RN002	Dunbar Creek	5	11.5	4	12	21	53.5	fair
1	10RN004	Wagner Creek	5	11	9	8	15	48	fair
1	10RN006	Popple River	5	10.5	3	13	15	46.5	fair
Average Habitat Results: *09030006020 11 HUC*			**5**	**11.75**	**6.25**	**11.3**	**18.3**	**52.5**	**fair**

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)

Table 10. Outlet water chemistry results: 09030006020 11-HUC

Station location:	Popple River at County Road 126, 6 miles NE of Squaw Lake								
EQUIS ID:	S006-188								
Station #:	10RN006								
Parameter	TSS [5]	Turb. [4]	T-tube	D.O.	TP [5]	TKN	Chloro-phyll-a [5]	E. coli	pH
Units	mg/l	NTU	cm	mg/l	mg/l	mg/l	ug/l	#/100ml	SU
# samples	10	20	20	20	10	10	0	16	20
Min	1	<.1	>100	1.83	0.027	1.04		2	7.3
Max	4	3.3	>100	10.8	0.07	1.63		98	8.8
Mean[1]	2.2	0.8	>100	5.1	0.047	1.23		10	7.8
Median	2	0.8	>100	5	0.055	1.23		9	7.6
WQ standard [5]	15	25	20	5	0.055		<10	126/1260	6.5-9.0
# WQ exceedances[2]	0	0	0	9	5			0	0
NLF 75th percentile[3]	5.6	4			0.05	0.18-0.73			7.9

1Geometric mean of all samples is provided for *E. coli* or fecal coliform.
2Represents exceedances of individual maximum standard for *E. coli* (1260/100ml) or fecal coliform (2000/100ml).
3Based on 1970-1992 summer data; see *Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions* (McCollor and Heiskary 1993). TKN range based on EPA Rivers and Streams in Nutrient Ecoregion VIII, NLF and NMW, EPA 822 B-01-015. 2001
[4] Combined data from 3 turbidity methods, each with slightly different standard methods
[5] Proposed TP, TSS and Chlorophyll-a standards for the North region of Minnesota, see http://www.pca.state.mn.us/index.php/view-document.html?gid=14947 http://www.pca.state.mn.us/index.php/view-document.html?gid=14922

** Data found in the above table was compiled using the results from data collected at the pour point monitoring station in the Upper Big Fork HUC 11 watershed, a component of the IWM work conducted in 2010 and 2011. This specific data does not necessarily reflect all data that was used to assess the AUID.

Table 11. Lake water aquatic recreation assessments: 09030006020 11-HUC

Name	DOW#	Area (ha)	Trophic Status	percent Littoral	Max. Depth (F)	Avg. Depth (F)	CLMP Trend	Mean TP (µg/L)	Mean chl-a (µg/L)	Secchi Mean (F)	Support Status
Dunbar	31-0904	273	E	64	30	11.8	NA	33	2	5.7	IF
Round	31-0896	2959	E	69.6	24	12.1	No Trend	67.2	10	1.4	NS
Island	31-0913	2920	E	38.7	37	15.2	No Trend	37.1	20.7	1.8	NS
Shallow Pond	31-0910	222	E	100	10	4	NA	39.7	18.1	2.6	NS
Wagner	31-0912	63	M	0	60		NA	17.7	14.1	1.6	FS
Hamrey	31-0911	46	M	0	60		NA	14.1	6.7	2.3	FS

Abbreviations: ↘ -- Decreasing/Declining Trend
↗ -- Increasing/Improving Trends
NT – No Trend
O – Oligotrophic
E – Eutrophic
M – Mesotrophic
FS – Full Support
NS – Non-Support
IF – Insufficient Information

Summary

The Popple River subwatershed contained two assessed AUIDs - one assessable site for biology and the other for water chemistry only. Four biological sites were sampled, however only 10RN001 on the Popple River was assessable. The remaining three were non assessable due to wetland characteristics. Overall conditions in the Popple River subwatershed are rated fair to poor, it did not meet aquatic life standards for the two assessed AUIDs and three of the six assessable lakes do not support aquatic recreation. MSHA scores are all rated fair as a result of limited changes in channel morphology, fine sediments, and limited cover for fish. The majority of these issues are likely a result of being a naturally wetland dominated system, synonymous with slow flowing, homogeneous stream channels with fine sediments.

The water chemistry monitoring site for this subwatershed is station S006-188 on the Popple River at Itasca County Road 126, 6 miles northeast of Squaw Lake. The site is located only 2.5 miles downstream from the outlet of Natures Lake, so conditions there are likely influenced by the Lake/flowage. As such, DO levels were low, particularly during high flow conditions following late summer rain events, when organic material is flushed in the river and decomposes through natural processes. This was expected, given the low oxygen tolerant fish species that dominate in Natures Lake, and the low gradient wetland dominated landscape in the vicinity of the Popple River monitoring site. A total of 9 of 20 DO samples were below the 5 mg/L standard, and the minimum concentration was just 1.8 mg/L (Table 10), resulting in a non-support designation for protecting aquatic life.

Although the low DO concentrations are likely due in part to natural background conditions, potential influences from the anthropogenic portions of the subwatershed, such as shoreline development around Round Lake and the community of Squaw Lake, could not be ruled out as sources of pollution contributing to the downstream DO impairment. Bacteria levels in the Popple River are low and indicate full support for aquatic recreational use. Other parameters such as pH, conductivity, and TSS are in the expected range, and reflective of the subwatershed's land use and topography.

The Popple River subwatershed has a total of 20 lakes greater than 10 acres in size, including 6 lakes with sufficient data for assessment. Three lakes - Island, Round, and Shallow Pond - were assessed as non-supporting of aquatic recreation; two lakes- Wagner and Hamrey - were assessed as fully supporting; and one lake – Dunbar - was determined to have insufficient information to make an assessment (Table 11). The three impaired waterbodies are shallow flow-through lakes of the Popple River, and as such, have high productivity. Round Lake is representative of these conditions, and was selected for further description.

Round Lake (31-0896) is a large body of water, covering 2,959 acres located within both the Leech Lake Reservation and Chippewa National Forest. The lake drains a large forest and wetland dominated watershed of 104 mi^2, which is the majority of the Popple River subwatershed. The Popple River enters Round Lake along the northwest shore and exits on the northeast shore. The lake is moderately developed, including two resorts. The lake is fairly shallow, with a maximum and mean depth of 25 and 12 feet respectively, and is 70% littoral.

Round Lake was sampled in 2004-2006. In 2005 and 2006 all three eutrophication criteria were not meeting NLF standards. TP and Chl-a increased each year (Figure 19). These data indicate eutrophic conditions, and the lake was assessed as non-supporting of aquatic recreational use. Chl-a concentrations > 20 µg/L are typical of nuisance bloom conditions, and average concentrations in Round Lake over the assessment period exceeded this value. Recent aerial imagery indicates bloom conditions lake-wide in mid-summer (Figure 20). Chl-a concentrations averaged 20.8 µg/L over the assessment cycle (more than double the NLF Chl-a standard), but summer mean values were highly variable among years, ranging from 4 to 32 µg/L. The monthly maximum concentration was 57 µg/L in July 2006, a condition associated with severe nuisance bloom conditions. It is likely that the lake's shallow basin, large fetch, and large watershed are key contributing factors in its susceptibility to internal loading of P and subsequent high Chl-a concentrations. A review of profile data (temperature) indicates the lake is polymictic in mid-summer. MINLEAP modeling results indicate agreement between predicted and observed water quality. The model predicts a rapid residence time of 0.1 years, because the Popple River flows through the lake, and estimates a large total P load to the lake of 3,227 kg/yr. There are not enough data to determine trends in Secchi transparency. Values averaged 1.7 M (5.5 feet) over the assessment cycle, and ranged between 1.5 – 2.0 meters each year.

The restoration plans for impaired lakes within the watershed, including Round, will include detailed monitoring, modeling, and analysis of historical water quality, land use, climate, and geology data. Local partners involved in the Big Fork River Watershed assessment process in the spring 2012 requested further analysis exploring the factors that led to several shallow lakes being assessed as impaired due to exceedances of the MPCA's eutrophication criteria - such as polymictic conditions, internal loading, and naturally higher lake productivity that has been documented within lakes in the Chippewa Plains Ecological Subsection (MDNR letter to MPCA, dated April 23, 2012).

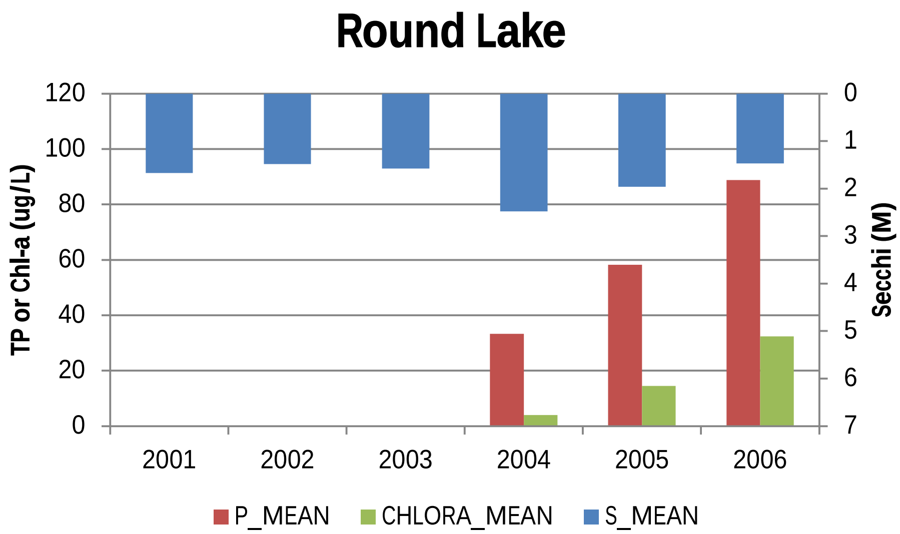

Figure 19. Annual average Round Lake TP, Chl-a, and Secchi data

Figure 20. Round Lake algae bloom, summer 2010; U.S. Department of Agriculture, Farm Service Agency. Water quality conditions in Round Lake likely have a significant effect in downstream water bodies, such as the adjacent Natures Lakes and lower reaches of the Popple River

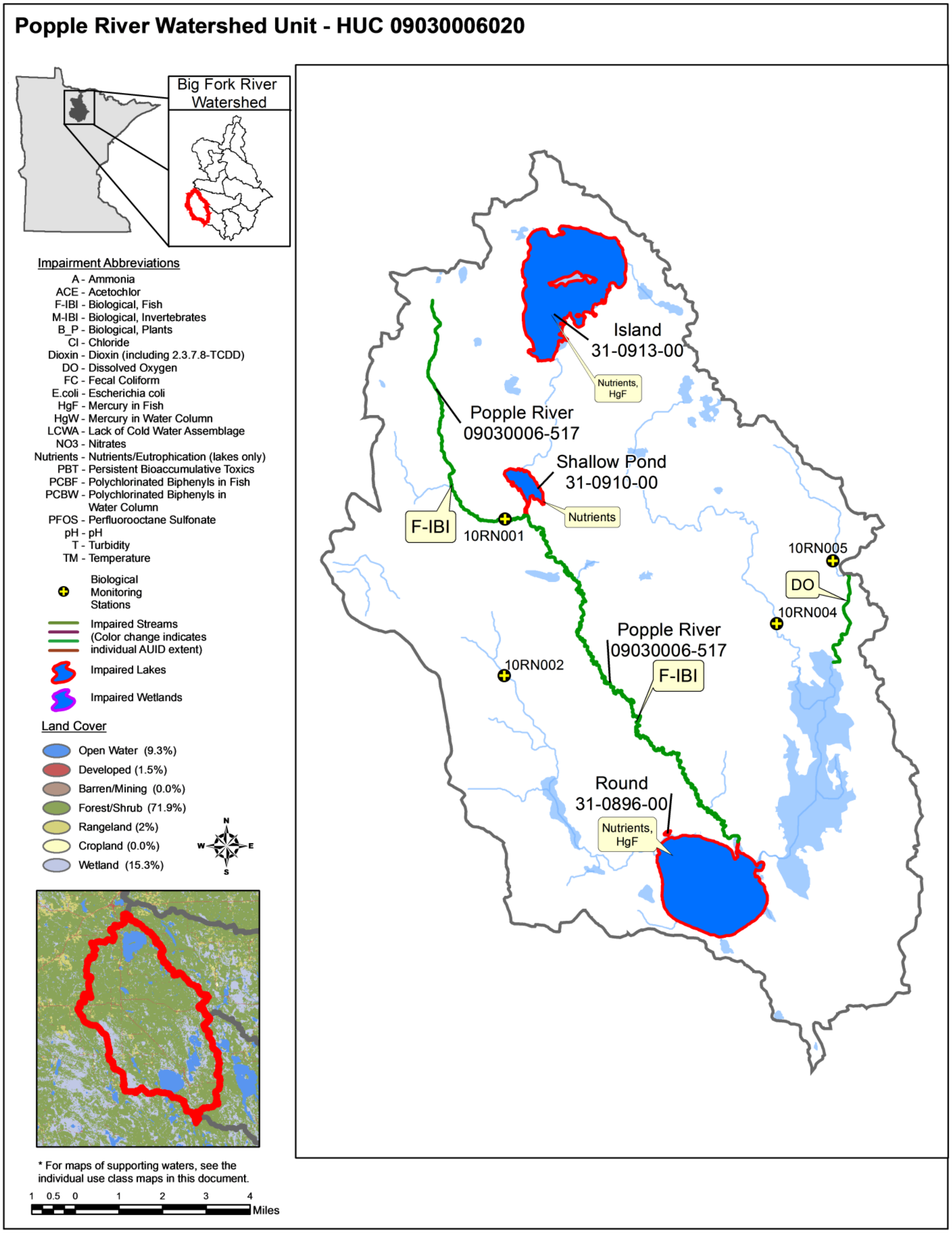

Figure 21. Currently listed impaired waters by parameter and land use characteristics in the Popple River Watershed

Upper Bowstring River subwatershed HUC 09030006030

The Upper Bowstring River subwatershed forms the southeastern border of the Big Fork River Watershed. It covers 142 square miles, and makes up 6.8% of the entire Big Fork River Watershed. It includes the headwaters of the Bowstring River to its confluence with Bowstring Lake. Several large and prominent lakes form the headwaters of this subwatershed. These lakes include Turtle, North Star, Graves, and Jessie, and they form the tributaries Turtle River, Potato Creek, and Jessie Brook. The northern portion of the subwatershed is principally lakes and upland forest; the lower reaches south of the Bowstring River drain a large wetland complex via the outlet of Rice Lake. Land use in the subwatershed is dominated by forest (59.6%), wetlands (24.3%), and open water/lakes (10.8%).

Table 12. Aquatic life and recreation assessments on stream reaches: Upper Bowstring River subwatershed. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name,*** *Reach Description*	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	**Aquatic Life**	**Aquatic Rec.**
09030006-582, Turtle River, Little Turtle Cr to Bowstring R	3.36	2B, 3C	99NF010	Little Turtle Cr to Bowstring R	MTS	MTS	--	--		--	--			FS	NA
09030006-576, Bowstring River, Unnamed ditch to Turtle R	1.79	2B, 3C	05RN047	1.5 mi. E of Hwy 6, 1.5 mi. E of Bowstring	MTS	MTS		--		--	--			FS	NA
09030006-575, Bowstring River, Turtle R to Jessie Bk	3.93	2B, 3C	10RN009	Upstream of Hwy 6, 0.5 mi. S of Bowstring	MTS		IF	MTS		MTS	MTS		MTS	NS*	FS
09030006-586, Jessie Brook, Jessie Lk to Bowstring R	2.61	2B, 3C	10RN010	Upstream of CR 133, 1 mi. N of Bowstring	MTS	MTS	--	--		--				FS	NA

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.
* Non-supporting due to natural background conditions resulting in low dissolved oxygen.

Table 13. Minnesota Stream Habitat Assessment (MSHA): 09030006030 11-HUC

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph.	MSHA Score (0-100)	MSHA Rating
1	99NF010	Turtle River	5	12	14	15	22	68	good
1	05RN047	Bowstring River	5	11	4	11	19	50	fair
1	10RN009	Bowstring River	3.75	10.5	9	15	22	60.25	fair
1	10RN010	Jessie Brook	5	11	10.5	8	15	49.5	fair
Average Habitat Results: *09030006030 11 HUC*			**4.69**	**11.13**	**9.38**	**12.25**	**19.50**	**56.94**	**fair**

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)

Table 14. Outlet water chemistry results: 09030006030 11-HUC

Station location:	Upper Bowstring River Upstream of Highway 6, 0.5 miles South of Bowstring								
EQUIS ID:	S006-212								
Station #:	10RN009								
Parameter	TSS [5]	Turb. [4]	T-tube	D.O.	TP [5]	TKN	Chloro-phyll-a [5]	E. coli	pH
Units	mg/l	NTU	cm	mg/l	mg/l	mg/l	ug/l	#/100ml	SU
# samples	10	20	20	20	10	10	0	16	20
Min	1	<.1	63	1.6	0.021	0.66		3.1	7
Max	8	4.8	>100	9.7	0.056	1.56		920	8.4
Mean[1]	3.7	1.9	>100	4.4	0.037	1.1		47	7.5
Median	3.5	1.3	>100	3.9	0.034	1.1		44	7.5
WQ standard [5]	15	25	20	5	0.055		<10	126/1260	6.5-9.0
# WQ exceedances[2]	0	0	0	12	1			0	0
NLF 75th percentile[3]	5.6	4			0.05	0.18-0.73			7.9

1Geometric mean of all samples is provided for *E. coli* or fecal coliform.
2Represents exceedances of individual maximum standard for *E. coli* (1260/100ml) or fecal coliform (2000/100ml).
3Based on 1970-1992 summer data; see *Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions* (McCollor and Heiskary 1993). TKN range based on EPA Rivers and Streams in Nutrient Ecoregion VIII, NLF and NMW, EPA 822 B-01-015. 2001
[4] Combined data from 3 turbidity methods, each with slightly different standard methods
[5] Proposed TP, TSS and Chlorophyll-a standards for the North region of Minnesota, see http://www.pca.state.mn.us/index.php/view-document.html?gid=14947 http://www.pca.state.mn.us/index.php/view-document.html?gid=14922

** Data found in the above table was compiled using the results from data collected at the pour point monitoring station in the Upper Big Fork HUC 11 watershed, a component of the IWM work conducted in 2010 and 2011. This specific data does not necessarily reflect all data that was used to assess the AUID.

Table 15. Lake water aquatic recreation assessments: 09030006030 11-HUC.

Name	DOW#	Area (ha)	Trophic Status	percent Littoral	Max. Depth (F)	Avg. Depth (F)	CLMP Trend	Mean TP (µg/L)	Mean chl-a (µg/L)	Secchi Mean (F)	Support Status
Jessie	31-0786	1782	E	26	42	22.5	No Trend	54.8	21.82	2.6	NS
Little Spring	31-0797	139	E	100	9	4.6	NA	50.25	22.63	1.69	NS
Turtle	31-0725	2066	O	27.1	137	32.4	↑	11	2.5	5.1	FS
North Star	31-0653	907	O	29.7	89	25.5	No Trend	10.91	2.37	3.85	FS
Little Jessie	31-0784	613	O	32.3	49	26.2	No Trend	9.8	3.05	4.6	FS
Grave	31-0624	538	O	60.8	39	13.6	↑	11.1	2.55	4.02	FS
Little Turtle	31-0779	470	M	47.6	30	13	↑	18.9	6.17	2.26	FS
Little Bowstring	31-0758	314	E	35.7	33		No Trend	27.17	10.45	2.42	FS
Big Too Much	31-0793	280	O	24.1	95	26.5	NA	9.8	1.83	4.06	FS
Hatch	31-0771	245	O	20	88	35.5	NA	5	1.53	4.04	FS
Caribou	31-0620	240	O	18.8	152	46.8	↑	6	1.43	10.56	FS
Maple	31-0773	235	O	33.6	39	17	NA	7.4	2.46	3.7	FS
Peterson	31-0791	180	M	72	55	10.9	NA	18	8.41	2.7	FS
La Croix	31-0788	137	O	0	80	15.5	NA	11	1.82	3.68	FS
Spring	31-0789	121	O	40	36	16	NA	10.91	2.76	3.38	FS
Grass	31-0727	116	M	83.8	54	6.1	NA	13.3	3	3.37	FS
Dead Horse	31-0622	96	M	60.6	36	12.5	NA	18.5	5.22	3	FS
East	31-0798	92	M	57	30	12	NA	16.7	4.48	3.54	FS
Crooked	31-0809	90	M	0	110		NA	13.5	1.75	4.84	FS
Elbow	31-0774	75	O	0	12		NA	11.2	2.2	1.69	FS
Little Too Much	31-0778	73	O	43	60		NA	10	2	3.95	FS
Little Dead Horse	31-0621	70	O	75.1	30		No Trend	9.9	1.36	4.43	FS
Unnamed	31-0666	53	M	0		24.8	NA	12.71		3.8	FS
Little North Star	31-0665	50	M	53.7	43		NA	13.09	3.07	2.96	FS
Little Ranier	31-0660	48	O	0	40		NA	11.73	1.58	4.89	FS
Boy	31-0623	26	M	37	40		↑	13.2	3.37	5.1	FS

Abbreviations: ↘ -- Decreasing/Declining Trend; ↗ -- Increasing/Improving Trends; NT – No Trend; **O** – Oligotrophic; **E** – Eutrophic; **M** – Mesotrophic; **FS** – Full Support; **NS** – Non-Support; **IF** – Insufficient Information

Summary

The Upper Bowstring River subwatershed contained four assessable AUIDs and 26 assessable lakes. Conditions in this watershed are fair. Nearly all of the streams and lakes are rated as meeting criteria and fully support aquatic life and aquatic recreation with the exception of the 10RN009 located on the Bowstring River. At this location, aquatic life is listed as non-supporting because of the borderline DO levels that were later determined to be due to natural background conditions. MSHA scores are rated as fair overall; sediment type and channel morphology are again the leading categories that drove scores down, similar to the Upper Big Fork River subwatershed.

The water chemistry monitoring site for this subwatershed is station S006-212 on the Bowstring River at Minnesota Highway 6, 0.5 miles south of the community of Bowstring. For most parameters, data indicated excellent water quality with minimal to no water quality exceedances. The exception was DO, with 12 of 20 samples below the 5 mg/L standard. The low DO conditions at the site are likely due to natural wetland characteristics at the site and in the low-gradient upstream watershed. The subwatershed has been classified as 5% disturbed; correspondingly 95% of the subwatershed's land-cover is classified as forest, wetland, and open water. Several samples that fell below the standard were collected during high flows, when water from surrounding wetlands can be released into the stream channel. Recent DO monitoring downstream of the river site, in Bowstring Lake, indicate DO levels are above the 5 mg/L standard. Bacteria levels, on average, are low in the subwatershed, and indicate full support for aquatic recreational use.

The Upper Bowstring River subwatershed has 46 lakes greater than 10 acres in size, including 26 lakes with sufficient data for assessment. A total of 24 lakes were assessed as fully supporting aquatic recreation, and two lakes (Jessie and Little Spring) were assessed as non-supporting (Table 15). In general, lake conditions in the subwatershed indicate good to excellent water quality. Most of the assessed lakes have low concentrations of phosphorus and chlorophyll-a, and high Secchi transparency. Conditions were reflective of the forest dominated landscape of the Chippewa National Forest. Headwater lakes such as Turtle and North Star, are deep, groundwater-dominated, and provide base flow to the Bowstring River. They also are popular recreational resources. The two impaired lakes, Jessie and Little Spring, are located along the western border of the subwatershed, and are relatively shallow. Jessie lake was assessed as non-supporting for aquatic recreation in 2004 due to high concentrations of TP and Chl-a, after completion of a Clean Water Partnership project in 2002. A TMDL study was initiated soon after this date, and was approved by the EPA in 2011. The TMDL study, completed by the Itasca County SWCD, private contractors, and the MPCA, provides much more detail on the lake, its watershed, water quality models, and restoration options. Further information can be found on these websites: http://www.itascaswcd.org/Programs/Jessie%20TMDL.html and http://www.pca.state.mn.us/tchy9dd

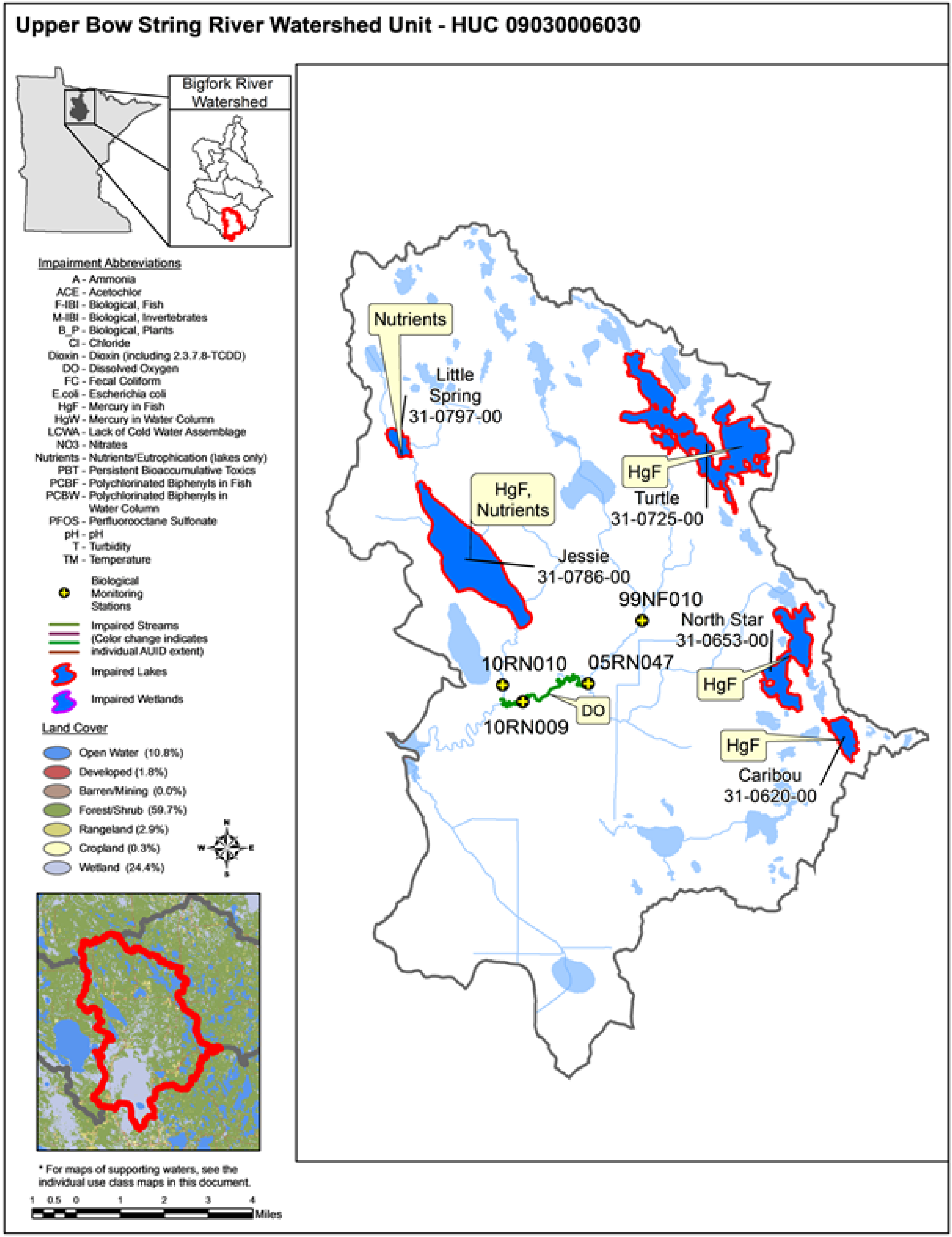

Figure 22. Currently listed impaired waters by parameter and land use characteristics in the Upper Bow String River subwatershed

Bowstring River subwatershed HUC 09030006040

The (Lower) Bowstring River subwatershed includes the area from Bowstring Lake to its confluence with Dora Lake. The subwatershed covers 119 square miles and makes up 5.7% of the entire Big Fork River Watershed. This is a lake-dominated landscape, and has the highest percentage of open water/lakes (21.8%) of any Big Fork River subwatershed. Large lakes in this subwatershed include Bowstring, Sand, and Rice. Other significant land uses are forest (58.8%) and wetlands (17.1%). Most of this watershed is within the Leech Lake Reservation.

Table 16. Aquatic life and recreation assessments on stream reaches: Bowstring subwatershed. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name***, *Reach Description*	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	**Aquatic Life**	**Aquatic Rec.**
09030006-555, Bowstring River, Unnamed lk (Schoolhouse) to Unnamed cr	1.25	2B, 3C	05RN082 10RN007	Upstream of CR 145, 23 mi. E of Black Duck, Downstream of CR 145, 6 mi. NE of Squaw Lake	MTS	MTS	MTS	MTS		MTS	MTS		MTS	FS	FS

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.

Table 17. Minnesota Stream Habitat Assessment (MSHA): 09030006040 11-HUC

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph.	MSHA Score	MSHA Rating
1	05RN082	Bowstring River	5	11	14	17	21	68	good
1	10RN007	Bowstring River	5	9.5	9	11	10	44.5	poor
	Average Habitat Results: *09030006040 11 HUC*		**5**	**10.3**	**11.5**	**14**	**15.5**	**56.3**	**fair**

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)

Table 18. Outlet water chemistry results: 09030006040 11-HUC

Station location:	Bowstring River at County Road 145, 6 miles NE of Squaw Lake								
EQUIS ID:	S001-965								
Station #:	10RN007								
Parameter	TSS [5]	Turb. [4]	T-tube	D.O.	TP [5]	TKN	Chloro-phyll-a [5]	E. coli	pH
Units	mg/l	NTU	cm	mg/l	mg/l	mg/l	ug/l	#/100ml	SU
# samples	10	20	20	20	10	10	0	16	20
Min	2	0	>100	3.4	0.018	0.68		1	7.4
Max	5	3.5	>100	10.9	0.053	1.09		63	8.7
Mean[1]	3.1	1.1	>100	6.9	0.03	0.91		4	7.9
Median	3	0.9	>100	6.8	0.029	0.9		3	7.9
WQ standard [5]	15	25	20	5	0.055		<10	126/1260	6.5-9.0
# WQ exceedances[2]	0	0	0	2	0			0	0
NLF 75th percentile[3]	5.6	4			0.05	0.18-0.73			7.9

1Geometric mean of all samples is provided for *E. coli* or fecal coliform.
2Represents exceedances of individual maximum standard for *E. coli* (1260/100ml) or fecal coliform (2000/100ml).
3Based on 1970-1992 summer data; see *Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions* (McCollor and Heiskary 1993). TKN range based on EPA Rivers and Streams in Nutrient Ecoregion VIII, NLF and NMW, EPA 822 B-01-015. 2001
4 Combined data from 3 turbidity methods, each with slightly different standard methods
5 Proposed TP, TSS and Chlorophyll-a standards for the North region of Minnesota, see http://www.pca.state.mn.us/index.php/view-document.html?gid=14947 http://www.pca.state.mn.us/index.php/view-document.html?gid=14922

** Data found in the above table was compiled using the results from data collected at the pour point monitoring station in the Upper Big Fork HUC 11 watershed, a component of the IWM work conducted in 2010 and 2011. This specific data does not necessarily reflect all data that was used to assess the AUID.

Table 19. Lake water aquatic recreation assessments: 09030006040 11-HUC

Name	DOW#	Area (ha)	Trophic Status	percent Littoral	Max. Depth (F)	Avg. Depth (F)	CLMP Trend	Mean TP (µg/L)	Mean chl-a (µg/L)	Secchi Mean (F)	Support Status
Bowstring	31-0813	8900	E	51.4	32	14.5	NA.	50.6	30.6	2.4	NS
Sand	31-0826	3785	M	44	70	17.2	No Trend	22.2	7.4	2.8	FS
Portage	31-0824	756	O	52	60		NA	10	3.8	3.3	FS
Rush Island	31-0832	294	M	30.7	29	19	No Trend	14.7	4.4	2.4	FS
Little Sand	31-0853	222	M	63.8	19	11	NA	18.5	4.5	1.9	FS
Cedar	31-0829	181	O	21	45	18.5	NA	10.8	2	3.8	FS
Little Whitefish	31-0836	154	O	100	15	6	NA	11.8	1.6	3.3	FS

Abbreviations: ↘ -- Decreasing/Declining Trend; ↗ -- Increasing/Improving Trends; NT – No Trend; **O** – Oligotrophic; **E** – Eutrophic; **M** – Mesotrophic; **FS** – Full Support; **NS** – Non-Support; **IF** – Insufficient Information

Summary

The Bowstring River subwatershed is in good condition. The subwatershed contains one assessable stream segment with two biological monitoring sites, and seven assessable lakes. Both sites on the Bowstring River met all aquatic life criteria and were fully supporting of both aquatic life and aquatic recreation. MSHA ratings varied between the two sites sampled within the stream segment, with a good rating given to the farthest upstream site and a poor rating given to the site farthest downstream. The downstream location 10RN007 was high in fine sediments and had poor channel morphology resulting in a low habitat score, even though the fish IBI score was 6 points higher at this downstream site than at 05RN082 with the higher habitat score. Of the seven assessable lakes, all but Bowstring were fully supporting aquatic recreational.

The water chemistry monitoring site for this subwatershed is station S001-965 on the Bowstring River at Itasca County Road 145, six miles northeast of Squaw Lake. Sediment, nutrient, and bacteria levels are low, water quality standards are being met, and data indicate full support for aquatic life and aquatic recreational uses.

The Bowstring River subwatershed has 17 lakes greater than 10 acres in size, including 7 lakes with sufficient data for assessment. A total of 6 lakes were assessed as fully supporting aquatic recreation, and one lake (Bowstring) was assessed as non-supporting (Table 19). Most of the assessed lakes in this subwatershed are shallow and hydrologically connected to each other. Bowstring Lake (31-0813), located 10 miles southeast of Squaw Lake, is the most prominent lake within the Bowstring River subwatershed, and it is the largest lake (8,900 acres) within the Big Fork River Watershed. The lake drains a large 200 mi^2 forest and wetland dominated watershed. The lake is shallow with a mean depth of 12.5 feet, and has a large fetch. Bowstring Lake is highly valued recreational resource, and includes several resorts. Overall lakeshore development is moderate and located primarily along the northern shores. The Bowstring River flows through the lake, entering on the east shore and exiting on the northwest shore.

Bowstring Lake was sampled in 2006 and 2010. Data indicate eutrophic conditions, and relatively poor water quality. All three eutrophication criteria are exceeding NLF standards, and the lake was assessed as non-supporting of aquatic recreational use. Water quality declined in 2010 compared to 2006, particularly Secchi transparency which declined from 4 to 1 M, and Chl-a concentrations which doubled. Average annual Chl-a concentrations were at levels associated with nuisance blooms, and individual samples had concentrations >50 µg/L, a level associated with very severe nuisance blooms. Conditions in Bowstring are likely similar to other large, shallow polymictic lakes that also are non-supporting of aquatic recreation, such as Round and Island. MINLEAP modeling results indicated predicted levels of TP and Chl-a were much lower than observed values. The higher than predicted P and Chl-a concentrations in the lake may be due to internal loading, which is not modeled by MINLEAP. The model predicts a residence time of 1.4 years, and estimates a large total P load to the lake of 6,300 kg/yr. There are not enough Secchi data to determine trends. During the Bowstring River TMDL study, comparisons will be made among lakes in the subwatershed to determine why Bowstring Lake has poor water quality compared to upstream and downstream lakes.

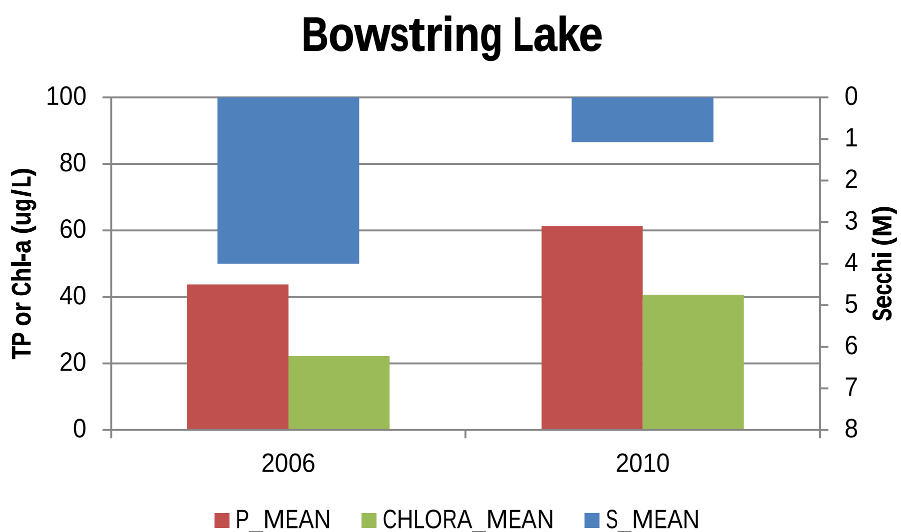

Figure 23. Annual average Bowstring Lake TP, Chl-a, and Secchi data

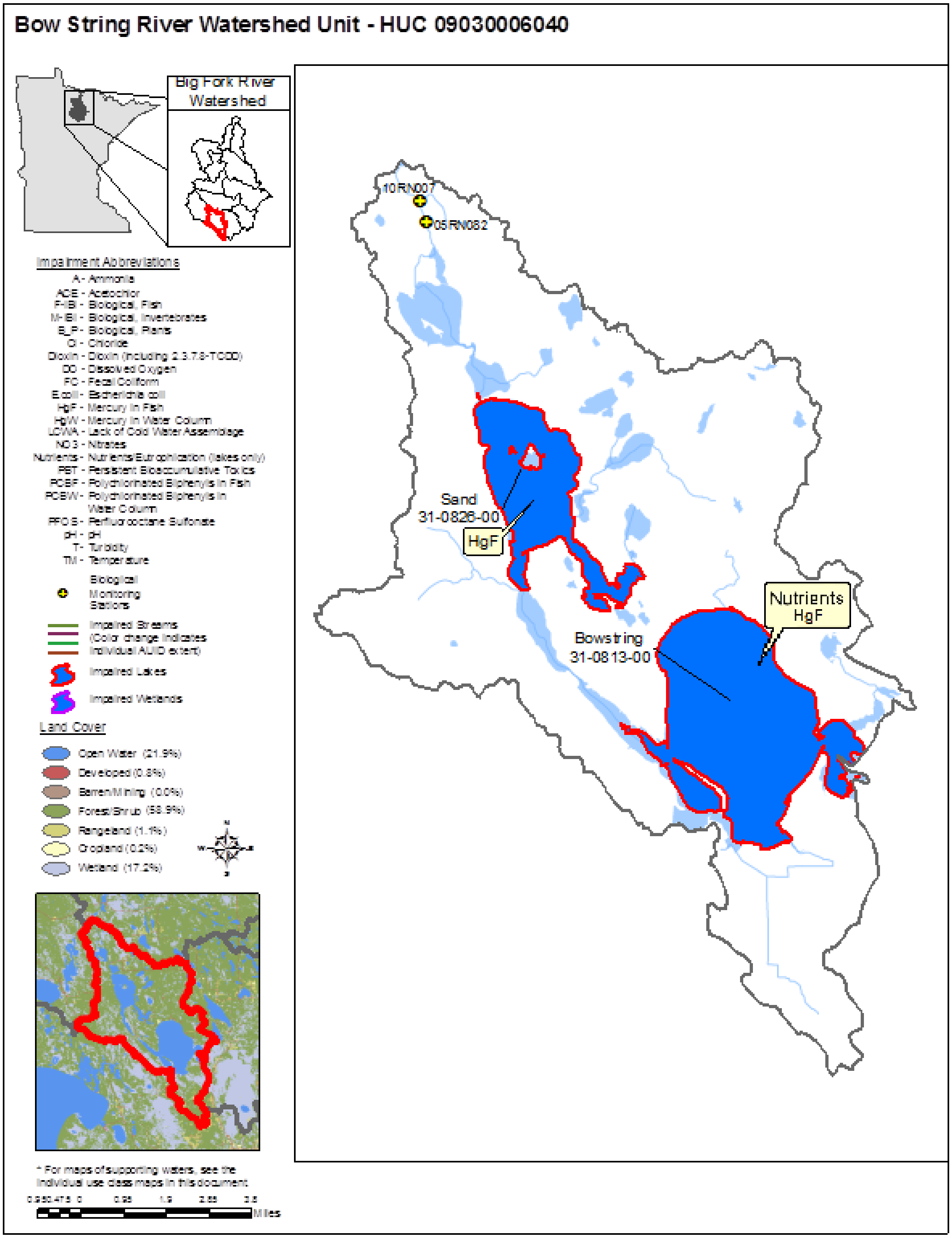

Figure 24. Currently listed impaired waters by parameter and land use characteristics in the Bowstring River subwatershed

Gale Brook subwatershed HUC 09030006050

The Gale Brook/Rice River subwatershed drains a low gradient, forest and lake dominated landscape within a remote part of Chippewa National Forest. It is in the southeastern portion of the Big Fork River Watershed, drains an area of 139 square miles, and makes up 6.7% of the entire Big Fork River Watershed area. The subwatershed is made up of 75% forested land, which is the highest percentage of forested land within any Big Fork River subwatershed. The Rice River/Gale Brook subwatershed contains 145 lakes greater than 10 acres in size. The Rice River flows into the Big Fork River at the town of Bigfork.

Table 20. Aquatic life and recreation assessments on stream reaches: Gale Brook subwatershed. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name***, *Reach Description*	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	**Aquatic Life**	**Aquatic Rec.**
09030006-644, Rice River, Headwaters (Cameron Lk 31-0544-00) to Batson Lk outlet	4.2	2B, 3C	10RN012	Downstream of Willis Lake Rd, 5 mi. SE of Bigfork	MTS	MTS	--	--		--				FS	NA
09030006-539, Rice River, Batson Lk outlet to Pelton Lk outlet	5.1	2B, 3C	10RN013	Upstream of CR 254, 4 mi. S of Bigfork	MTS	MTS	IF	MTS		MTS	MTS		MTS	NS*	FS
09030006-547, Gale Brook, Isaac Lk outlet to Aspen Lk	8.5	2B, 3C	10RN014	Upstream of CR 7, 3 mi. SE of Bigfork	MTS	EXP	NA	NA		NA				NS*	NA

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.
* Non-supporting due to natural background conditions resulting in low dissolved oxygen.

Table 21 Minnesota Stream Habitat Assessment (MSHA): 09030006050 11-HUC

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph.	MSHA Score	MSHA Rating
1	10RN012	Rice River	5	12	20	16	17	70	Good
1	10RN013	Rice River	5	11	9	12	18	55	fair
1	10RN014	Gale Brook	5	11	3	12	19	50	fair
Average Habitat Results: *09030006050 11 HUC*			**5**	**11.3**	**10.67**	**13.3**	**18**	**58.3**	**fair**

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)

Table 22. Outlet water chemistry results: 09030006050 11-HUC

Station location:	Rice River at County Road 254, 4 miles South of Bigfork								
EQUIS ID:	S006-208								
Station #:	10RN013								
Parameter	TSS [5]	Turb. [4]	T-tube	D.O.	TP [5]	TKN	Chloro-phyll-a [5]	E. coli	pH
Units	mg/l	NTU	cm	mg/l	mg/l	mg/l	ug/l	#/100ml	SU
# samples	10	20	20	20	10	10	0	16	20
Min	1	<.1	>100	2.9	0.009	0.3		8.6	7.5
Max	8	2.4	>100	10.8	0.025	0.58		723	8.3
Mean[1]	2.6	1.3	>100	5.7	0.016	0.42		47	7.7
Median	2	1.3	>100	5	0.016	0.41		37	7.6
WQ standard [5]	15	25	20	5	0.055		<10	126/1260	6.5-9.0
# WQ exceedances[2]	0	0	0	10	0			0	0
NLF 75th percentile[3]	5.6	4			0.05	0.18-0.73			7.9

1Geometric mean of all samples is provided for *E. coli* or fecal coliform.
2Represents exceedances of individual maximum standard for *E. coli* (1260/100ml) or fecal coliform (2000/100ml).
3Based on 1970-1992 summer data; see *Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions* (McCollor and Heiskary 1993). TKN range based on EPA Rivers and Streams in Nutrient Ecoregion VIII, NLF and NMW, EPA 822 B-01-015. 2001
[4] Combined data from 3 turbidity methods, each with slightly different standard methods
[5] Proposed TP, TSS and Chlorophyll-a standards for the North region of Minnesota, see http://www.pca.state.mn.us/index.php/view-document.html?gid=14947 http://www.pca.state.mn.us/index.php/view-document.html?gid=14922

** Data found in the above table was compiled using the results from data collected at the pour point monitoring station in the Upper Big Fork HUC 11 watershed, a component of the IWM work conducted in 2010 and 2011. This specific data does not necessarily reflect all data that was used to assess the AUID.

Table 23. Lake water aquatic recreation assessments: 09030006050 11-HUC

Name	DOW#	Area (ha)	Trophic Status	percent Littoral	Max. Depth (F)	Avg. Depth (F)	CLMP Trend	Mean TP (µg/L)	Mean chl-a (µg/L)	Secchi Mean (F)	Support Status
Fifth Chain	31-0497	89	M				No Trend	12.1	3.1	3.7	FS
Bello	31-0726	492	O	50.8	58	12.6	↓	10	2.5	3.2	FS
East Smith	31-0616	146	M	46.9	38	12.9	No Trend	13.6	2.2	3.8	FS
Gunn	31-0452	88	M		75		No Trend	12.5	3.3	4.1	FS
Jack The Horse (South)	31-0657	383	O		45	11.8	↓	10.1	2.5	3.7	FS
Clubhouse	31-0540	244	O	33.7	103	30.3	No Trend	10.2	2	4.5	FS
Big Dick	31-0656	234	O	61.4	25	11.6	↑	9.4	2.6	3.4	FS
Big Island	31-0671	220	O	85	42	8.8	No Trend	9.6	3	4.5	FS
East	31-0460	179	O	38	65	18.9	NA	9.1	1.7	3.6	FS
Ranier	31-0664	81	O		45		No Trend	8.2	1	5.7	FS
Mary	31-0473	197	O		45		NA	9.4	2.6	3.5	FS
Unnamed (Nickel)	31-0470	13	O	44.7	36.5		NA	8	1.6	4.8	FS
Black Island	31-0416	103	M	66.6	59	11.7	No Trend	13	3.2	2.9	FS
Mike	31-0706	101	M		20	3.9	NA	16.7	2.8	2.1	FS
Mink	31-0455	98	O		50		NA	8	2	4	FS
Lundeen	31-0705	75	M	48	30		NA	15.4	4.5	2.8	FS
Pine	31-0478	65	M		44		NA	14	5.6	2.9	FS
Bevo	31-0686	53	M	60	40		NA	13.1	1.8	3.5	FS
Marie	31-0507	49	M	84.9	35		NA	13.3	3.6	3	FS
La Barge	31-0522	39	M		30		NA	16.9	3.9	1.6	FS
Johnson	31-0687	288	O		50	23.5	↑	8.8	2.3	4	FS
Eagle	31-0454	261	M	75	35	15.4	No Trend	15	6.3	3	FS
Horseshoe	31-0466	123	O	35.1	58	19.4	NA	6.4	1.9	3.8	FS
Ruby	31-0422	271	O	37	88	31.9	No Trend	7.2	1.2	5.2	FS
Fox	31-0463	233	O	69.6	75	12.4	NA	9.5	2	3.3	FS
Elizabeth	31-0490	180	O	46.3	42	17.3	NA	11.3	2.8	3	FS

Slauson	31-0502	110	O	43	40	15.7	NA	9.8	2.5	3.7	FS
Smith	31-0650	351	M	56.1	32	12	NA	14	2.8	3.7	FS
Gunn	31-0480	347	O	41.5	39	15.1	NA	8.7	1.7	3.6	FS
Brush Shanty	31-0514	151	M	33	35	14.4	NA	14.2	2.5	2.9	FS
Long	31-0781	121	O	26.1	75	20.2	NA	10	3.2	3.9	FS
Jingo	31-0764	78	M	48	60		NA	14	2	4.8	FS
Gale	31-0513	73	O	51	50		NA	7.6	1.5	4.7	FS
Cameron	31-0544	73	O	59.8	37		NA	11.2	2.2	3.5	FS
Big Rose	31-0768	69	M	94.9	25		NA	14.8	4.9	2.9	FS
Lauchoh	31-0692	50	E	45	40		NA	24.6	3.6	2.9	FS
Lum	31-0487	48	M	86.5	24		NA	14.2	3.7	2.4	FS
Little Clubhouse	31-0479	27	M				NA	15.5	3.6	3.1	FS
Anderson	31-0350	284	M	25.9	100	13.5	NA	13.7	4.3	1.7	FS
Big Ole	31-0670	185	O		61	15.1	NA	7	1.1	5.5	FS
Burns	31-0654	171	O			40	NA	8.4	2.4	4.6	FS
Batson	31-0704	107	M	35	50	20	NA	13.4	3	2.8	FS
Crooked	31-0543	103	O	66	46	9.2	NA	9.8	2.2	4	FS
Nose	31-0417	102	O	50.9	47	15.3	NA	10.6	1.8	3.4	FS
Highland	31-0481	98	O	55.1	38	12.3	NA	10.4	2.1	3.5	FS
Little Dick	31-0658	85	M		20		NA	15.4	4.7	2.7	FS
Three Island	31-0451	66	M		28		NA	13.8	3	2.4	FS
Little East	31-0459	61	O		100		NA	10.1	1.8	4.4	FS
McDonald	31-0700	28	M				NA	16.1	18	1.7	FS
Little Round	31-0808	28	M		10		NA	21.4	6.8	2.3	FS
Oar	31-0464	27	O		60		NA	7	2	4.3	FS
Oak	31-0465	12	O		35	15.4	NA	8.1	2.9	3.7	FS

Abbreviations: ↘ -- Decreasing/Declining Trend; ↗ -- Increasing/Improving Trends; NT – No Trend

O – Oligotrophic; **E** – Eutrophic; **M** – Mesotrophic

FS – Full Support; **NS** – Non-Support; **IF** – Insufficient Information

Summary

The Gale Brook subwatershed contains three assessable stream segments and 52 assessable lakes. All three stream segments were found to meet fish indicator criteria, and all but Gale Brook met macroinvertebrate criteria. The stream segment on the Rice River associated with 10RN013 was listed as not meeting aquatic life standards because 10 of the 20 DO samples fell below the 5 mg/L standard. The lone Gale Brook AUID was listed as not meeting aquatic life criteria because it did not meet macroinvertebrate criteria. For both of these stream segments the failure to meet aquatic life standards was deemed natural due to wetland conditions. Anthropogenic impact is minimal in this remote portion of Chippewa National Forest, and there is a strong wetland influence in the stream and the adjacent riparian zone. The data and watershed characteristics strongly support a natural background cause for the aquatic life impairments. Similar to the biology and chemistry results, habitat is also strongly influenced by adjacent wetlands. The overall habitat conditions were fair to good. Fine substrates related to the prevailing wetland conditions of this subwatershed contributed to the lower scores at some sites.

The water chemistry monitoring site for this watershed is station S006-208 on the Rice River at Itasca County Road 254, 4 miles south of Bigfork. Gale Brook comes in downstream of the monitoring site but water chemistry samples were not taken from Gale Brook during IWM. The concentrations of water quality parameters such as nutrients, sediment, and turbidity and bacteria were low, with zero exceedances. In general, data indicate excellent water quality in the Rice River subwatershed, reflective of the forest and wetland dominated landscape.

The Gale Brook watershed is a lake-rich landscape within Chippewa National Forest, with 107 lakes greater than 10 acres. A total of 52 lakes have sufficient data for assessment, and all fully support aquatic recreational use. As expected, lake water quality is very good throughout the subwatershed. Most assessed lakes have seepage hydrology and as such, drain very small forested watersheds within isolated basins.

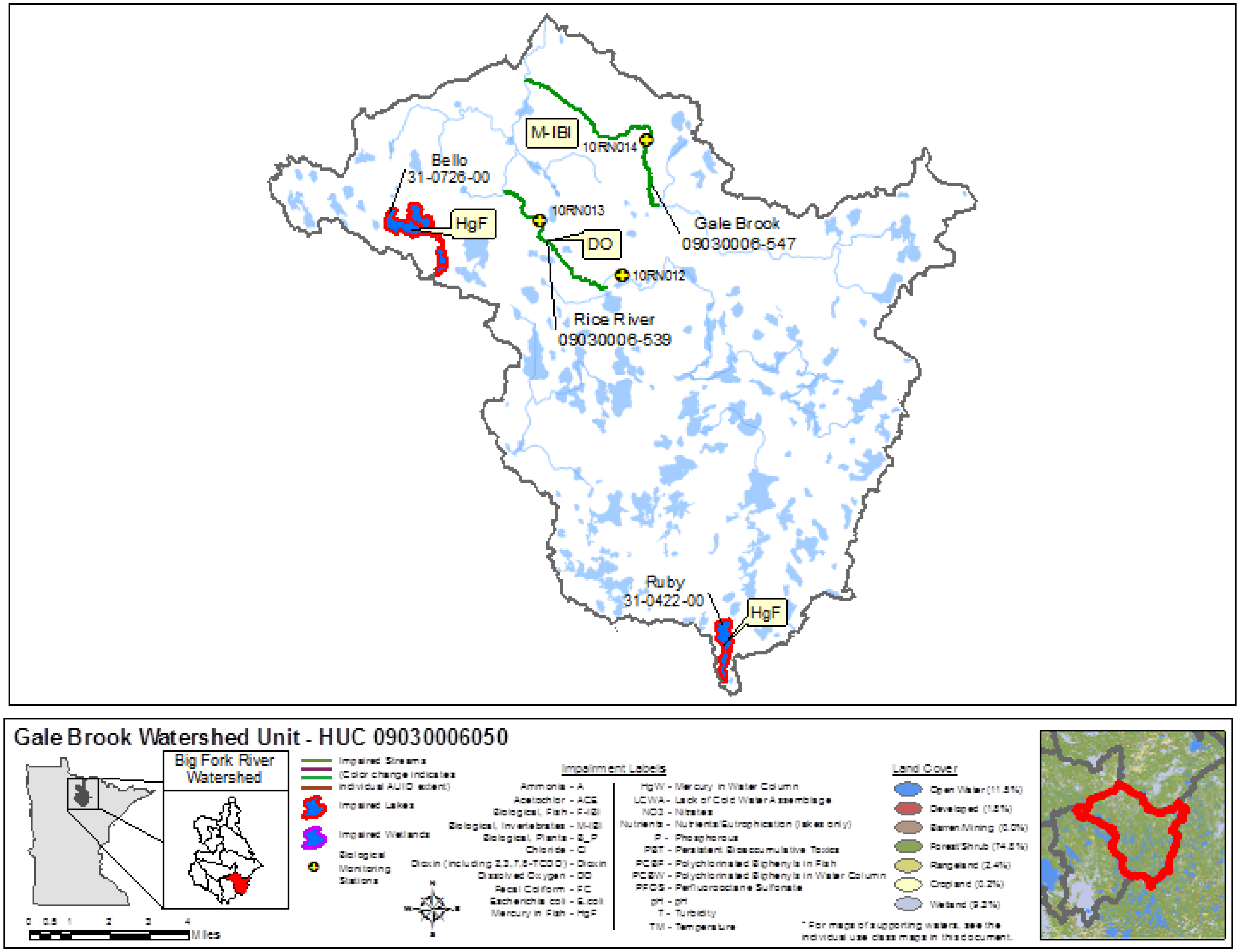

Figure 25. Currently listed impaired waters by parameter and land use characteristics in the Gale Brook subwatershed

Middle Big Fork River subwatershed — HUC 09030006060

The Middle Big Fork River subwatershed includes the reach of the Big Fork from the town of Bigfork to just upstream of the confluence with Caldwell Brook. This subwatershed also encompasses the drainages of Deer Creek, Bowerman Brook, and Beaver Brook, and includes the city of Effie and the community of Craigville. The subwatershed drains 304 square miles, a total of 14.6% of the entire Big Fork River Watershed. Land use in the subwatershed is dominated by forest (66.5%) and wetland (24.3%). Although most of the watershed is within the NMW Ecoregion, nearly all of the contributing drainage area upstream of the subwatershed is within the NLF Ecoregion. Most of this subwatershed is comprised of public lands within Koochiching and George Washington State Forests.

Table 24. Aquatic life and recreation assessments on stream reaches: Middle Big Fork River subwatershed. Reaches are organized upstream to downstream in the table.

AUID *Reach Name*, *Reach Description*	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	**Aquatic Life**	**Aquatic Rec.**
09030006-506, Big Fork River, Coon Cr to Deer Cr	5.89	2B, 3C	10EM025 10RN018	Downstream of CR 42, 7 mi. NE of Bigfork, Downstream of Hwy 1, 9 mi. NE of Bigfork	MTS	MTS	--	--		--				FS	NA
09030006-675, Unnamed creek, Headwaters to Big Fork R	3.67	2B, 3C	10RN020	Upstream of CR 42, 10 mi. NE of Bigfork	MTS	EXP	--	--		--				NS*	NA
09030006-514, Deer River, Headwaters (Deer Lk 31-0334-00) to Big Fork R	8.27	2B, 3C	10RN019	Upstream of CR 230, 10 mi. NE of Bigfork	MTS	MTS	--	--		--	--			FS	NA
09030006-504, Big Fork River, Deer Cr to Caldwell Bk	39.57	2B, 3C	05RN060 05RN046 10RN022 10EM137	1 m. Upstream of CR 40, 10 mi. NE of Big Fork, Downstream of CR 40 crossing, 1.5 mi. SE of Craigville, Upstream of Hwy 6, 7 mi. NW of Craigville, Downstream of Hwy 6, 15.5 mi. S of Big Falls	MTS	MTS	MTS	MTS		MTS	MTS		MTS	FS	FS
09030006-611, Bowerman Brook, Unnamed cr to Big Fork R	7.88	2B, 3C	10RN021	Upstream of Caldwell Rd, 8 mi. NW of Craigville	MTS	MTS	--	--		--				FS	NA
09030006-612, Plum Creek, Wade Bk to Big Fork R	4.34	2B, 3C	05RN092	Upstream of Caldwell Rd, 17 mi. S of Big Falls	MTS	MTS	--	--		--	--			FS	NA

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. * Non-supporting due to natural background conditions.

Table 25. Minnesota Stream Habitat Assessment (MSHA): 09030006060] 11-HUC.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph.	MSHA Score (0-100)	MSHA Rating
1	10EM137	Big Fork River	5	13.5	12	7	15	52.5	fair
1	10EM025	Big Fork River	4.5	14.5	12.15	4	27	62.15	fair
1	10RN020	Unnamed creek	3.5	14	17.9	16	23	74.4	good
1	10RN018	Big Fork River	5	15	21.7	15	29	85.7	good
1	10RN019	Deer River	3.5	11	20.2	14	27	75.7	good
1	05RN060	Big Fork River	5	9.5	20	17	30	81.5	good
1	05RN046	Big Fork River	5	10.5	20.7	13	30	79.2	good
1	10RN022	Big Fork River	5	12	15.9	12	22	66.9	good
1	10RN021	Bowerman Brook	5	14	14.8	17	19	69.8	good
2	05RN092	Plum Creek	5	13.5	17.1	14	27.5	77.1	good
	Average Habitat Results: *09030006060 11 HUC*		**4.65**	**12.75**	**17.24**	**12.9**	**24.95**	**72.5**	**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)

Table 26. Outlet water chemistry results: 09030006060 11-HUC

Station location:	Big Fork River at Highway 6, 7 Miles NW of Craigville
EQUIS ID:	S006-203
Station #:	10RN022

Parameter	TSS [5]	Turb. [4]	T-tube	D.O.	TP [5]	TKN	Chloro-phyll-a [5]	E. coli	pH
Units	mg/l	NTU	cm	mg/l	mg/l	mg/l	ug/l	#/100ml	SU
# samples	9	10	20	20	18	18	15	17	20
Min	1	3.5	22	6.5	0.021	0.6	<1	5	7.5
Max	20	31	>100	10.1	0.09	1.38	2	344	8.1
Mean[1]	9.5	10.6	NA	8.1	0.045	1	1	31	7.8
Median	9	8.4	56	7.7	0.043	0.96	1	31	7.9
WQ standard [5]	15	25	20	5	0.055		<10	126/1260	6.5-9.0
# WQ exceedances[2]	1	1	0	0	5			0	0
NLF 75^{th} percentile[3]	5.6	4			0.05	0.18-0.73			7.9

1Geometric mean of all samples is provided for *E. coli* or fecal coliform.
2Represents exceedances of individual maximum standard for *E. coli* (1260/100ml) or fecal coliform (2000/100ml).
3Based on 1970-1992 summer data; see *Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions* (McCollor and Heiskary 1993). TKN range based on EPA Rivers and Streams in Nutrient Ecoregion VIII, NLF and NMW, EPA 822 B-01-015. 2001
4 Combined data from 3 turbidity methods, each with slightly different standard methods
5 Proposed TP, TSS and Chlorophyll-a standards for the North region of Minnesota, see http://www.pca.state.mn.us/index.php/view-document.html?gid=14947 http://www.pca.state.mn.us/index.php/view-document.html?gid=14922

** Data found in the above table was compiled using the results from data collected at the pour point monitoring station in the Upper Big Fork HUC 11 watershed, a component of the IWM work conducted in 2010 and 2011. This specific data does not necessarily reflect all data that was used to assess the AUID.

Table 27. Lake water aquatic recreation assessments: 09030006060 11-HUC

Name	DOW#	Area (ha)	Trophic Status	percent Littoral	Max. Depth (F)	Avg. Depth (F)	CLMP Trend	Mean TP (µg/L)	Mean chl-a (µg/L)	Secchi Mean (F)	Support Status
Deer	31-0334	1891	M	1332	50	8.6	No Trend	14.8	4.84	2.94	FS
Coon	31-0318	310	M	194.4	30	9.3	NA	17.3	5.03	1.57	FS
Battle	31-0197	259	M	199	15	8.1	↓	14	3.97	2.57	FS
Busties	31-0530	237	M	0	45	12.4	NA	15.8	4.39	3.08	FS
Pickerel	31-0339	230	M	152.4	70	17	NA	14.4	4.49	3.01	FS
Five Island	31-0183	219	O	111	32	11.5	↓	12	3	3.63	FS
Larson	31-0317	190	O	51.5	177	42.9	NA	6.8	1.06	6.05	FS
Connors	31-0710	131	O	40.2	65	14.9	NA	10.78	1.92	3.83	FS
Bass	31-0316	112	O	35	45	24.3	No Trend	9.5	2.37	5.32	FS
Poplar	31-0196	110	O	26.8	50	27.8	NA	7.7	1.55	4.31	FS
Mirror	31-0160	102	O	48	44	17.9	NA	9.7	1.64	4.72	FS
Round	31-0528	52	M	0	60		NA	15.5	1.98	3.06	FS
Erickson	31-0512	30	O	0	70		NA	11.8	3.84	3.34	FS
Coon/Sandwick	31-0524	627	M	80	36	7.5	NA	15	6	3	FS

Abbreviations: ↘ -- Decreasing/Declining Trend
↗ -- Increasing/Improving Trends
NT – No Trend

O – Oligotrophic
E – Eutrophic
M – Mesotrophic

FS – Full Support
NS – Non-Support
IF – Insufficient Information

Summary

The Middle Big Fork River subwatershed has 10 assessable sites on 6 assessable AUIDs. Nearly all of the sites met the biological expectations indicating good water quality. One exception to this pattern was at site 10RN020, an unnamed creek on a small tributary to the Big Fork River where the macroinvertebrate assemblage was impaired. The impairment was likely due natural conditions created from vast amounts of wetlands and beaver dams upstream of the site. Within this subwatershed the Big Fork River contained the highest IBI scores for macroinvertebrates and fish. Smaller tributary sites had slightly lower scores but they still met the biological criteria. Habitat was uniformly in good condition except for two sites that rated fair, both on the Big Fork River. These sites scored lower due to more homogenous substrates and channel morphology, as well as poor fish cover.

The water chemistry monitoring site for this watershed is station S006-203 on the Big Fork River at Minnesota Highway 6, 7 miles northwest of Craigville. Data indicate good water quality. Sediment, nutrient, and bacteria levels are low and reflective of the forest and wetland dominated landscape. A total of 5 of 18 samples exceeded the proposed phosphorus standard for northern Minnesota (0.055 mg/L); however, most exceedances were minor, and were within the expected range of samples from streams within the NMW Ecoregion. Bacteria data collected by the Big Fork River Board River Watch program indicated support for aquatic recreation and corroborate the assessment-level data collected at the Highway 6 site.

The Middle Big Fork River subwatershed contains 52 lakes greater than 10 acres, and 15 of these lakes have sufficient data for assessment. All 15 lakes fully support aquatic recreational use. Most assessed lakes are located in a forested landscape within the public lands of George Washington State Forest. As such, lake resources in this subwatershed are of high quality. Most of the assessed lakes drain the Deer Creek subwatershed. Two additional high quality waters are Coon and Sandwick Lakes within Scenic State Park.

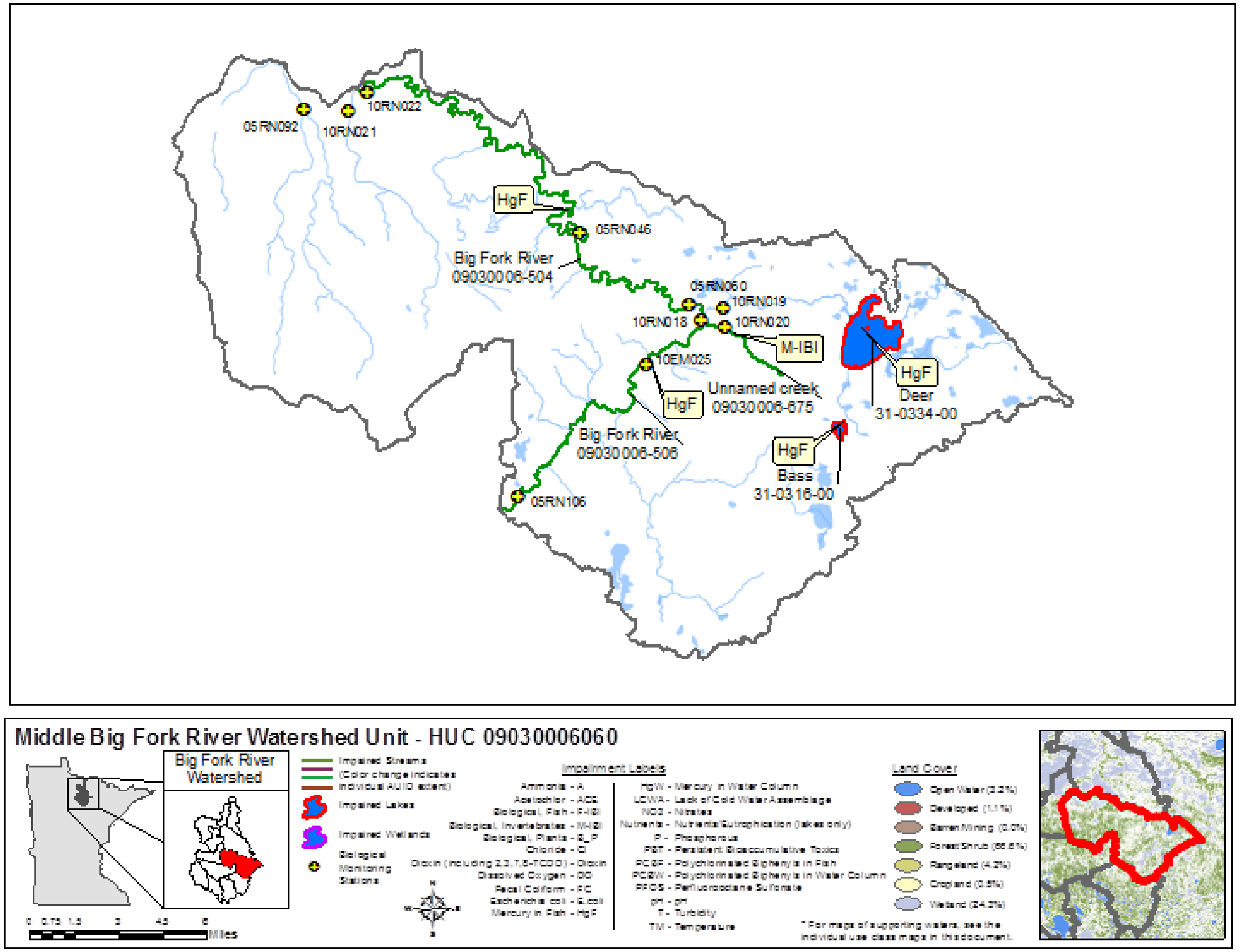

Figure 26. Currently listed impaired waters by parameter and land use characteristics in the Middle Big Fork Watershed

Caldwell Creek subwatershed HUC 09030006070

The Caldwell Creek subwatershed drains 146 square miles in southwest Koochiching County and represents 7.1% of the Big Fork River Watershed area. The headwaters of Caldwell Brook originate near the communities of Northome and Mizpah and eventually flow into the Big Fork River about 26 river miles downstream of Craigville. This subwatershed has the highest percentage of agricultural land use within the Big Fork River Watershed, with approximately 8% of the land in range or crop land, still a low percentage compared to other watersheds in Minnesota. The agricultural lands are primarily located near the headwaters of the subwatershed. The lower portions of the subwatershed are part of a large wetland complex within the Pine Island State Forest. Overall land cover in the subwatershed is dominated by forest (62.5%) and wetlands (27.8%).

Table 28. Aquatic life and recreation assessments on stream reaches: Caldwell Creek subwatershed. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name***, *Reach Description*	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	**Aquatic Life**	**Aquatic Rec.**
09030006-673, Unnamed creek, Headwaters to Caldwell Bk	5.53	2B, 3C	10RN026	Upstream of Twp Rd 17, 1 mi. NE of Wildwood		MTS	NA	NA		NA				FS	NA
09030006-510, Caldwell Brook, Headwaters to Big Fork R	49.83	2B, 3C	10RN024	Downstream of Caldwell Rd, 5 mi. NE of Wildwood	MTS	MTS	MTS	MTS		MTS	MTS		MTS	FS	FS

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.
Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

Table 29. Non-assessed biological stations on channelized AUIDs: 09030006070 11-HUC

AUID ***Reach Name,*** *Reach Description*	Reach length (miles)	Use Class	Biological Station ID	Location of Biological Station	Fish IBI	Invert IBI
09030006-608, Unnamed creek, Unnamed cr to Caldwell Bk	0.67	2B, 3C	05RN105	Downstream of CR 6, 2.5 miles E of Mizpah	Good	---
09030006-510, Caldwell Brook, Headwaters to Big Fork R	49.83	2B, 3C	05RN080	Upstream of CR 52, 4 mi. SE of Gemmell	Good	Poor
09030006-626, Pancake Creek, Unnamed cr to Caldwell Bk	1.73	2B, 3C	10RN027	Adjacent to CR 52, 5 miles SE of Gemmel	Good	Fair

= Good = Fair = Poor - See Appendix 5.1 for clarification on the good/fair/poor thresholds and Appendix 5.2 and Appendix 5.3 for IBI results.

Table 30. Minnesota Stream Habitat Assessment (MSHA): 09030006070 11-HUC

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph.	MSHA Score	MSHA Rating
2	05RN105	Unnamed creek	1	6	3.5	7.5	7	25	poor
1	05RN080	Caldwell Brook	5	11	9	12	1	38	poor
1	10RN027	Pancake Creek	2.5	5.5	20.8	13	21	62.8	fair
1	10RN024	Caldwell Brook	5	12	13.5	12	30	72.5	good
0	10RN026	Trib. to Caldwell Brook	-	-	-	-	-	-	NA
		Average Habitat Results: *09030006070 11 HUC*	**3.38**	**8.63**	**11.69**	**11.13**	**14.75**	**49.56**	**fair**

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)

Table 31. Outlet water chemistry results: 09030006070 11-HUC

Station location:	Caldwell Brook at Caldwell Road, 5 miles Northeast of Wildwood								
EQUIS ID:	S006-204								
Station #:	10RN024								
Parameter	TSS [5]	Turb. [4]	T-tube	D.O.	TP [5]	TKN	Chloro-phyll-a [5]	E. coli	pH
Units	mg/l	NTU	cm	mg/l	mg/l	mg/l	ug/l	#/100ml	SU
# samples	9	10	20	20	18	18	15	17	20
Min	6	5	32	5.9	0.038	0.69	<1	37	7.5
Max	20	15	>100	9.8	0.094	1.4	3	195	8.1
Mean[1]	10.3	10	52	7.2	0.066	1.1	1.5	95	7.8
Median	8	10	49	6.8	0.071	1.1	1.5	114	7.8
WQ standard [5]	15	25	20	5	0.055		<10	126/1260	6.5-9.0
# WQ exceedances[2]	1	0	0	0	11		0	0	0
NLF 75^{th} percentile[3]	20	12			0.09	0.18-0.73			8

1Geometric mean of all samples is provided for *E. coli* or fecal coliform.
2Represents exceedances of individual maximum standard for *E. coli* (1260/100ml) or fecal coliform (2000/100ml).
3Based on 1970-1992 summer data; see *Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions* (McCollor and Heiskary 1993). TKN range based on EPA Rivers and Streams in Nutrient Ecoregion VIII, NLF and NMW, EPA 822 B-01-015. 2001
[4] Combined data from 3 turbidity methods, each with slightly different standard methods
[5] Proposed TP, TSS and Chlorophyll-a standards for the North region of Minnesota, see http://www.pca.state.mn.us/index.php/view-document.html?gid=14947 http://www.pca.state.mn.us/index.php/view-document.html?gid=14922

** Data found in the above table was compiled using the results from data collected at the pour point monitoring station in the Upper Big Fork HUC 11 watershed, a component of the IWM work conducted in 2010 and 2011. This specific data does not necessarily reflect all data that was used to assess the AUID.

Summary

There were two assessable stream segments and three non-assessable stream segments in the Caldwell Brook subwatershed. The two natural reaches on Caldwell Brook and a tributary to Caldwell Brook both meet fish and macroinvertebrate thresholds. Also, all of the fish samples from the channelized streams were rated good in spite of generally poor habitat conditions at the channelized sites. In contrast to the fish results, macroinvertebrate communities at channelized sites were not good, with one receiving a fair and the other a poor rating. Channelized reaches had lower MSHA scores due to poor land use, riparian condition, substrate types, and channel morphology conditions.

The water chemistry monitoring site for this subwatershed is station S006-204 on Caldwell Brook at Caldwell Road, five miles northeast of Wildwood. Overall data indicate good water quality. Nutrient concentrations were higher here compared to most other subwatersheds, and most samples exceeded the draft phosphorus standard of 0.055 mg/L. However, exceedances were minor, and did not result high algal productivity (chlorophyll a concentrations were very low; Table 31), and conditions appeared representative of the wetland dominated landscape. The geometric mean of all bacteria samples was high relative to other subwatersheds, but within standards. Overall, data indicate full support for both aquatic life and aquatic recreational use.

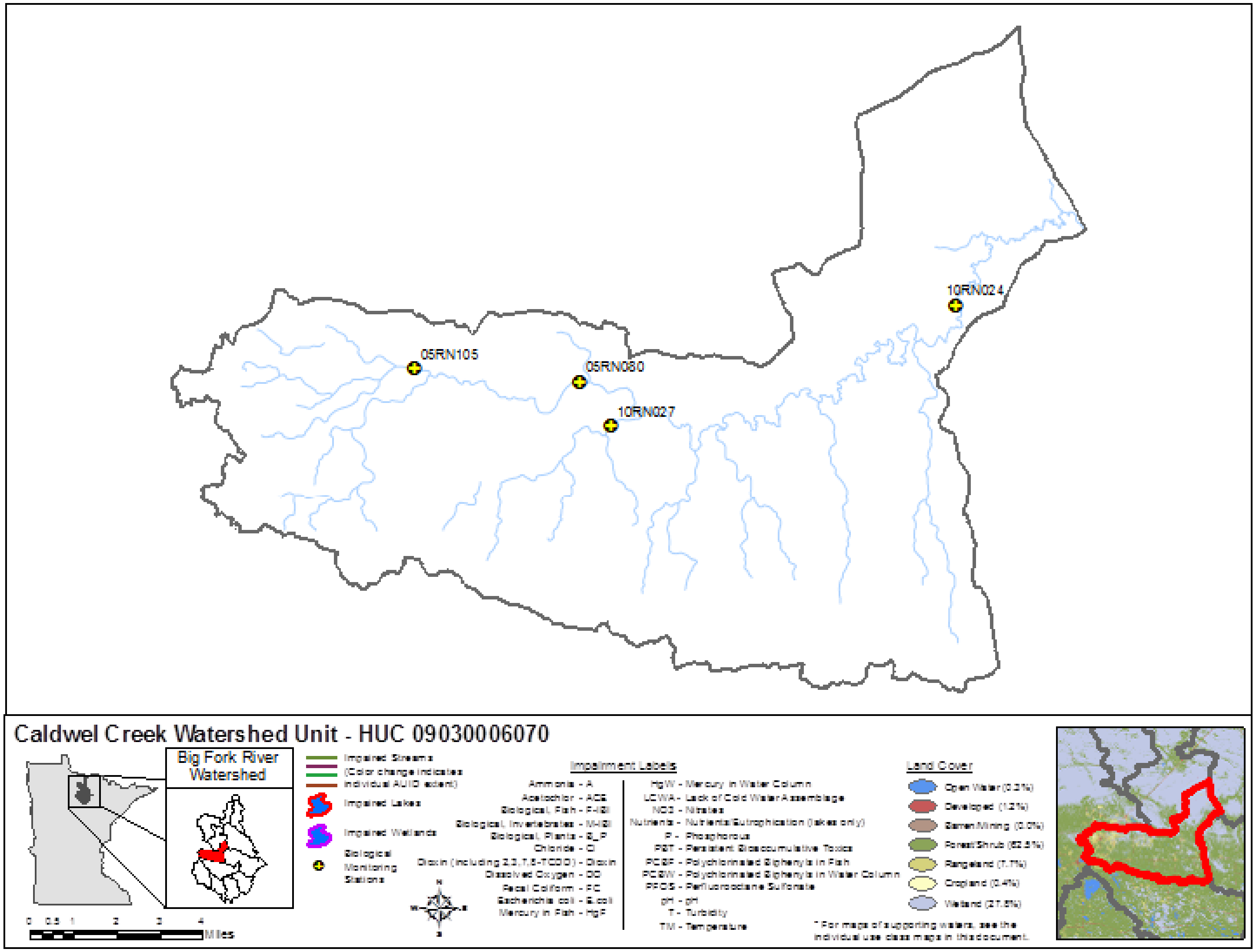

Figure 27. Currently listed impaired waters by parameter and land use characteristics in the Caldwell Brook Watershed

Lower Middle Big Fork River subwatershed HUC 09030006080

The Lower Middle Big Fork River subwatershed includes the reach of the Big Fork River from Caldwell Brook to the Sturgeon River downstream of the town of Big Falls, a distance of 36 miles. The subwatershed drains 295 square miles in central Koochiching County, and represents 14.2% of the Big Fork River subwatershed. This subwatershed also includes several small tributaries to the Big Fork River, including Reilly Brook and Reilly Creek. The subwatershed includes the city of Big Falls; however, most of the watershed is within a remote part of Koochiching and Pine Island State Forests. Wetlands (62.2%) and forests (35.4%) dominate land cover in the subwatershed.

Table 32. Aquatic life and recreation assessments on stream reaches: Lower Middle Big Fork River subwatershed. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name***, *Reach Description*	Reach Length (miles)	Use Class	Biological Station ID	Location of Biological Station	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	Aquatic Life	Aquatic Rec.
09030006-507, Big Fork River, Caldwell Bk to Reilly Bk	10.87	2B, 3C	10RN025	Upstream of Hwy 6, 10 mi. SE of Big Falls	MTS	MTS	--	--		--	--			FS	NA
09030006-683, Unnamed creek, Unnamed ditch to Big Fork R	1.36	2B, 3C	10RN057	Upstream of CR 6, 10 mi. SE of Big Falls	MTS	MTS	--	--		--	--			FS	NA
09030006-515, Reilly Brook, Headwaters to Big Fork R	39.29	2B, 3C	10RN045	Downstream of CR 62, 13 mi. NE of Wildwood	MTS	MTS	--	--		--	--			FS	NA
09030006-625, Reilly Creek, Unnamed cr to Big Fork R	1.83	2B, 3C	10RN046	Upstream of Dentaybow Rd, 9 mi. SE of Big Falls	MTS	MTS	--	--		--				FS	NA
09030006-682, Macaffee Brook, Headwaters to Big Fork R	2.5	2B, 3C	10RN052	Upstream of Dentaybow Rd, 6 mi. SE of Big Falls	MTS	MTS	--	--		--	--			FS	NA
09030006-620, Unnamed ditch, Unnamed ditch to Big Fork R	2.97	2B, 3C	10RN042	Upstream of CR 30, 1 mi. W of Big Falls	MTS	MTS	--	--		--				FS	NA
09030006-677, Unnamed creek, Unnamed cr to Sturgeon R	2.71	2B, 3C	10RN041	Upstream of CR 30, 3 mi. W of Big Falls	MTS	MTS	--	--		--				FS	NA
09030006-503, Big Fork River, Reilly Bk to Sturgeon R	24.85	2B, 3C	05RN081	2 mi. Downstream of CR 30, 4 mi. W of Bigfalls	MTS	MTS	MTS	MTS	MTS	MTS	MTS		MTS	FS	FS

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.
Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

Table 33. Minnesota Stream Habitat Assessment (MSHA): 09030006080 11-HUC

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph.	MSHA Score (0-100)	MSHA Rating
2	10RN025	Big Fork River	5	14.25	18.025	10	23.5	70.775	good
2	10RN057	Unnamed creek	5	14.5	20.3	14	31.5	85.3	good
1	10RN045	Reilly Brook	5	13	17.05	8	20	63.05	fair
1	10RN046	Reilly Creek	5	14	19.25	12	33	83.25	good
2	10RN052	Macaffee Brook	5	12.5	16	12.5	30.5	76.5	good
1	10RN058	Unnamed creek	5	15	21	16	36	93	good
1	10RN055	Unnamed creek (Trout	5	12.5	10.4	12	19	58.9	fair
1	10RN042	Unnamed ditch	4.5	13.5	20.7	12	28	78.7	good
1	10RN041	Unnamed creek	5	14	18.2	15	34	86.2	good
2	05RN081	Big Fork River	5	12.25	21.15	10.5	29	77.9	good
Average Habitat Results: *09030006080 11 HUC*			**4.95**	**13.55**	**17.64**	**11.73**	**27.23**	**75.10**	**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)

Table 34. Outlet water chemistry results: 09030006080 11-HUC

Station location:	Big Fork River at Sturgeon River Landing Road, 4 miles NW of Big Falls								
EQUIS ID:	S002-856								
Station #:	05RN081								
Parameter	TSS [5]	Turb. [4]	T-tube	D.O.	TP [5]	TKN	Chloro-phyll-a [5]	E. coli	pH
Units	mg/l	NTU	cm	mg/l	mg/l	mg/l	ug/l	#/100ml	SU
# samples	9	10	20	20	18	18	15	17	20
Min	4	1.6	22	7.4	0.021	0.49	<1	2	7.35
Max	13	25.9	>100	11	0.068	1.5	3	290	8.3
Mean[1]	8.1	7.1	NA	9	0.046	1.1	1.3	21	7.9
Median	9	3.55	NA	8.7	0.05	1.1	1	23	7.8
WQ standard [5]	15	25	20	5	0.055		<10	126/1260	6.5-9.0
# WQ exceedances[2]	0	1	0	0	7		0	0	0
NLF 75th percentile[3]	20	12			0.09	0.18-0.73			8

1Geometric mean of all samples is provided for *E. coli* or fecal coliform.
2Represents exceedances of individual maximum standard for *E. coli* (1260/100ml) or fecal coliform (2000/100ml).
3Based on 1970-1992 summer data; see *Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions* (McCollor and Heiskary 1993). TKN range based on EPA Rivers and Streams in Nutrient Ecoregion VIII, NLF and NMW, EPA 822 B-01-015. 2001
4 Combined data from 3 turbidity methods, each with slightly different standard methods
5 Proposed TP, TSS and Chlorophyll-a standards for the North region of Minnesota, see http://www.pca.state.mn.us/index.php/view-document.html?gid=14947 http://www.pca.state.mn.us/index.php/view-document.html?gid=14922

** Data found in the above table was compiled using the results from data collected at the pour point monitoring station in the Upper Big Fork HUC 11 watershed, a component of the IWM work conducted in 2010 and 2011. This specific data does not necessarily reflect all data that was used to assess the AUID.

Summary

The Lower Middle Big Fork River subwatershed encompasses eight assessable AUIDs and eight assessable sites. All eight met designated thresholds for both macroinvertebrates and fish indicating good water quality for these two biological indicators. Overall habitat scores were generally good indicating habitat conditions in this subwatershed are adequate to support healthy fish and macroinvertebrate communities. Habitat metrics related to land use, riparian condition, and channel morphology were particularly good in this subwatershed.

The water chemistry monitoring site for this subwatershed is station S002-856 on the Big Fork River at Sturgeon Landing Road, four miles northwest of Big Falls. The water quality in this subwatershed is excellent. Sediment, nutrient, and turbidity levels were low and indicative of the forest and wetland dominated landscape. Bacteria levels were also low and at expected levels given the overall lack of disturbance in the subwatershed. As seen in some upstream subwatersheds, periodic exceedances of the draft phosphorus standard occurred, a total 7 of 18 samples. These exceedances were minor and within the expected range of streams within the NMW Ecoregion. Overall, the data indicate full support for both aquatic life and aquatic recreational use. The Big Fork River Board River Watch program also collected data from this subwatershed. Their data, including fecal coliform bacteria data, corroborate assessment-level data collected at the Sturgeon Landing site.

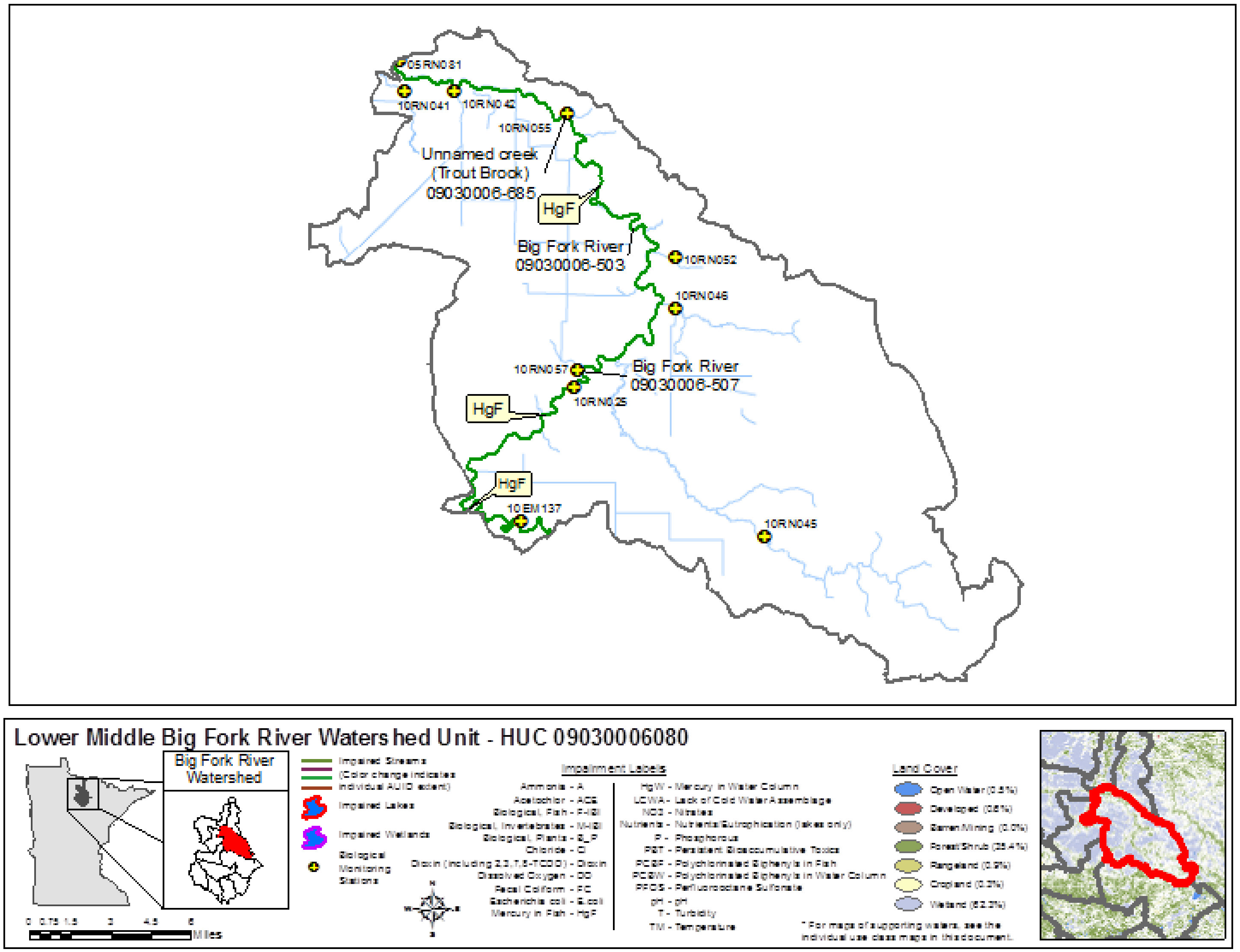

Figure 28. Currently listed impaired waters by parameter and land use characteristics in the Lower Middle Big Fork subwatershed

Dinner Creek Watershed HUC 09030006090

Located exclusively in Koochiching County and the Northern Minnesota Wetland ecoregion, the Dinner Creek subwatershed includes both Dinner Creek and the headwaters to the Sturgeon River. The Dinner Creek subwatershed is contained within the Pine Island state forest and has an area of 135 square miles, and represents 6.5% of the Big Fork River subwatershed. The two major land uses are wetlands (78.2%) and forests (20.6%).

Table 35. Aquatic life and recreation assessments on stream reaches: Dinner Creek subwatershed. Reaches are organized upstream to downstream in the table

AUID *Reach Name,* Reach Description	Reach Length (miles)	Use Class	Biological Station ID	Location of Biological Station	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	Aquatic Life	Aquatic Rec.
09030006-592, Dinner Creek, Headwaters to Sturgeon R	25.63	1B, 2A, 3B	10RN036 10RN060	Upstream of CR 61, 1.5 mi. W of Margie, 0.5 mi. S of CR 30, 15 mi SW of Big Falls	IF	IF	--	--		--	--			IF	NA

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.
Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

Table 36. Minnesota Stream Habitat Assessment (MSHA): 09030006090 11-HUC

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
2	10RN036	Dinner Creek	5	11.75	19.075	13	32.5	81.325	good
1	10RN060	Dinner Creek	5	12	17.8	12	20	66.8	good
		Average Habitat Results: *09030006090 11 HUC*	**5**	**11.88**	**18.44**	**12.50**	**26.25**	**74.06**	**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)

Summary

The Dinner Creek subwatershed had one assessable AUID with two biological sampling sites. Both macroinvertebrate and fish surveys were deemed to have inadequate information to accurately assign use classes, due to conflicting information on designation the creek as cold or warm water. The appropriate IBI threshold cannot be assigned until more data confirms the correct stream classification. Therefore aquatic life was not assessed in this subwatershed. MSHA scores indicated good habitat conditions at both sampling locations.

There was not a 10X stream chemistry monitoring site in this subwatershed due to limited access near the outlet.

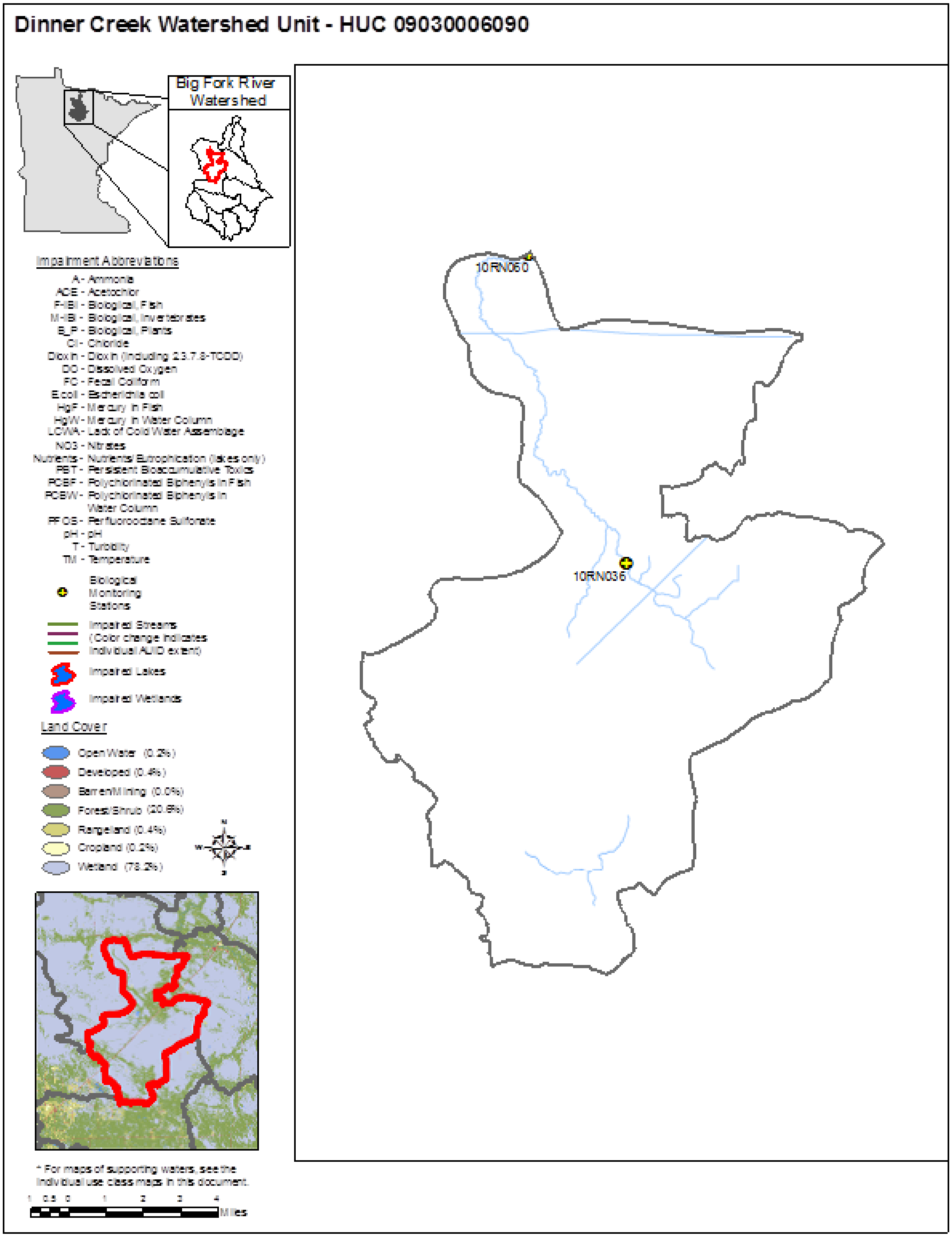

Figure 29. Currently listed impaired waters by parameter and land use characteristics in the Dinner Creek subwatershed

Sturgeon River subwatershed HUC 09030006100

The Sturgeon River drains a large, remote low gradient peatland landscape in west-central Koochiching County, and flows east to the Big Fork River northwest of Big Falls. Much of the headwaters of the Sturgeon River were ditched in the early 20th century in an unsuccessful attempt to drain the landscape for agriculture. The subwatershed includes Dinner Creek, the Sturgeon's principal tributary, as well as Hay Creek. This subwatershed drains a total of 301 square miles. Wetlands are the dominant land cover, making up over 80% of the subwatershed area.

Table 37. Aquatic life and recreation assessments on stream reaches: Sturgeon River subwatershed. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name***, *Reach Description*	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	**Aquatic Life**	**Aquatic Rec.**
09030006-610, Hay Creek, Unnamed cr to Sturgeon R	2.27	2B, 3C	05RN053	Downstream of Pine Island Rd, 14 mi. W of Big Falls	MTS	MTS	--	--		--	--			FS	NA
09030006-509, Sturgeon River, Headwaters to Big Fork R	26.2	2B, 3C	10RN039, 05RN002	Upstream of CR 30, 6 mi. W of Big Falls, 2 mi. downstream of CR 30, 4 mi. NW of Big Falls	MTS	MTS	IF	MTS		MTS	MTS		MTS	FS	FS

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.
Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

Table 38. Non-assessed biological stations on channelized AUIDs: 09030006100 11-HUC

AUID ***Reach Name***, *Reach Description*	**Reach length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Fish IBI**	**Invert IBI**
09030006-676, Unnamed creek, Unnamed ditch to Sturgeon R	2.45	2B, 3C	10RN053	Adjacent to Pine Island Rd, 13 mi. W of Big Falls	Poor	Poor
09030006-509, Sturgeon River, Headwaters to Big Fork R	26.2	2B, 3C	10RN035	Upstream of Pine Island Rd, 13 mi. W of Big Falls	---	Fair

= Good = Fair = Poor - See Appendix 5.1 for clarification on the good/fair/poor thresholds and Appendix 5.2 and Appendix 5.3 for IBI results.

Table 39. Minnesota Stream Habitat Assessment (MSHA): 09030006100 11-HUC

# 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**
1	05RN053	Hay Creek	5	13	12.25	15	14	59.25	fair
1	10RN053	Unnamed creek	5	10.5	9	15	18	57.5	fair
3	10RN039	Sturgeon River	5	14.2	21.2	9	20.7	70	good
2	05RN002	Sturgeon River	5	12	20.53	8	24	69.53	good
Average Habitat Results: *09030006100 11 HUC*			**5**	**12.4**	**15.75**	**11.75**	**19.2**	**64.08**	**fair**

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)

Table 40. Outlet water chemistry results: 09030006100 11-HUC

Station location:	Sturgeon River at County Road 30, 6 miles West of Big Falls
EQUIS ID:	S006-205
Station #:	10RN039

Parameter	TSS [5]	Turb. [4]	T-tube	D.O.	TP [5]	TKN	Chloro-phyll-a [5]	E. coli	pH
Units	mg/l	NTU	cm	mg/l	mg/l	mg/l	ug/l	#/100ml	SU
# samples	9	9	20	20	18	18	15	17	20
Min	3	3.7	26.5	5.84	0.023	1.1	<1	5.2	6.6
Max	30	5.6	>100	10.2	0.072	1.9	3	461	7.6
Mean[1]	10	4.7	48	7.3	0.049	1.5	1.3	24	7
Median	9	5.1	48	6.9	0.053	1.6	1	24	7
WQ standard [5]	15	25	20	5	0.055		<10	126/1260	6.5-9.0
# WQ exceedances[2]	2	0	0	0	6		0	0	0
NLF 75th percentile[3]	20	12			0.09	0.18-0.73			8

1Geometric mean of all samples is provided for *E. coli* or fecal coliform.
2Represents exceedances of individual maximum standard for *E. coli* (1260/100ml) or fecal coliform (2000/100ml).
3Based on 1970-1992 summer data; see *Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions* (McCollor and Heiskary 1993). TKN range based on EPA Rivers and Streams in Nutrient Ecoregion VIII, NLF and NMW, EPA 822 B-01-015. 2001
[4] Combined data from 3 turbidity methods, each with slightly different standard methods
[5] Proposed TP, TSS and Chlorophyll-a standards for the North region of Minnesota, see http://www.pca.state.mn.us/index.php/view-document.html?gid=14947 http://www.pca.state.mn.us/index.php/view-document.html?gid=14922

** Data found in the above table was compiled using the results from data collected at the pour point monitoring station in the Upper Big Fork HUC 11 watershed, a component of the IWM work conducted in 2010 and 2011. This specific data does not necessarily reflect all data that was used to assess the AUID.

Summary

The Sturgeon River subwatershed contains two assessable stream segments and two non-assessable stream segments. Assessable reaches were above the impairment thresholds for both macroinvertebrates and fish, indicating aquatic life use support. Non-assessable channelized sites ranged from fair to poor. Only the Macroinvertebrates were sampled from the Sturgeon River (10RN035), receiving a fair rating. The other channelized site (10RN053) received poor ratings for both fish and macroinvertebrates and had the lowest MSHA score within the Sturgeon River subwatershed. However, the overall MSHA rating for the site and for the subwatershed was still in the fair range.

The water chemistry monitoring site for this subwatershed is station S006-205 on the Sturgeon River at Koochiching County Road 30, 6 miles west of Big Falls. Data indicate good water quality, reflective of the low gradient, peatland landscape. Turbidity, bacteria, and nutrient levels are low and are at expected levels given the subwatershed's relatively remote location. Overall, data indicate full support for both aquatic life and aquatic recreational use.

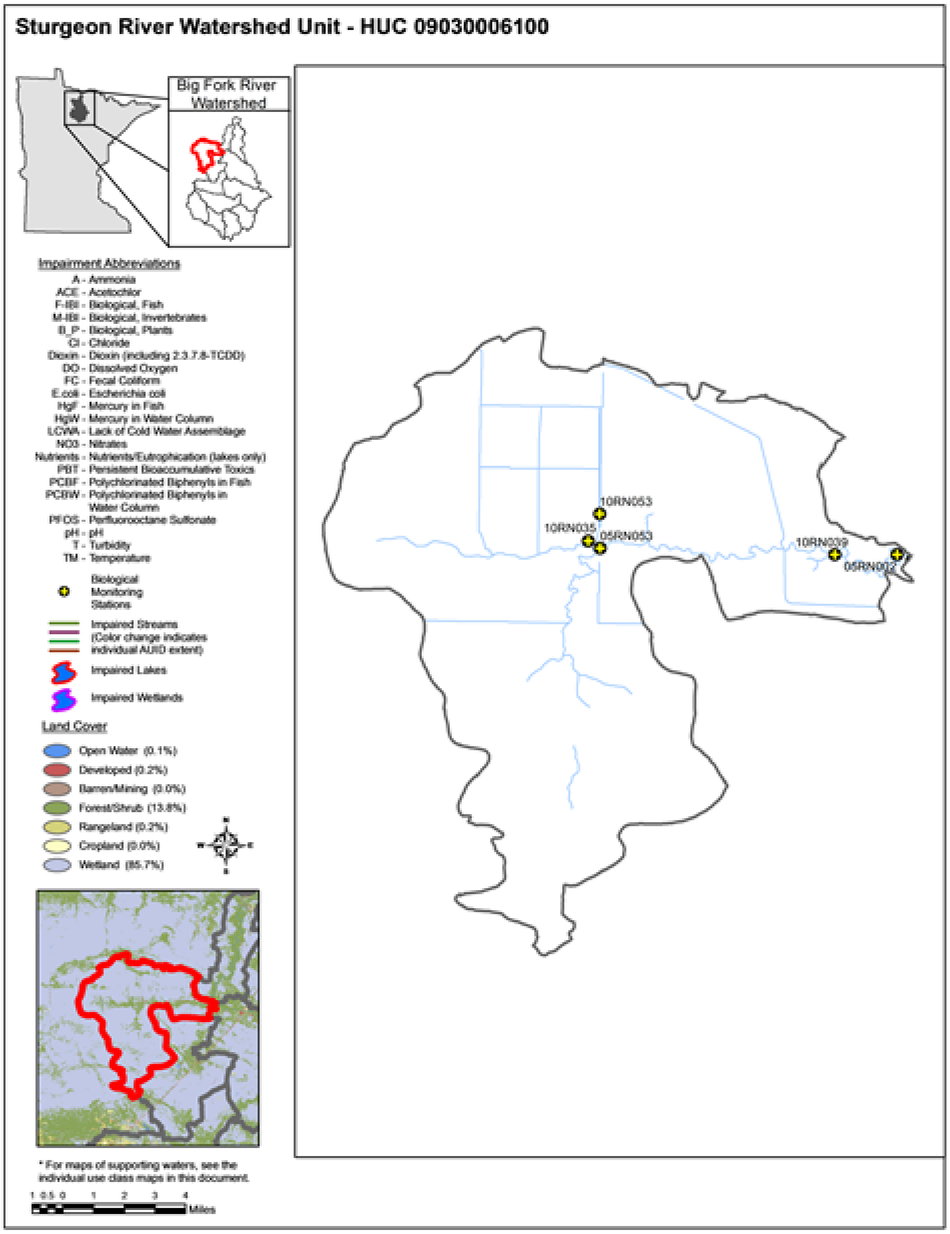

Figure 30. Currently listed impaired waters by parameter and land use characteristics in the Sturgeon River subwatershed

Lower Big Fork River subwatershed HUC 09030006110

The Lower Big Fork River subwatershed includes the reach of the Big Fork River from the Sturgeon River to the Rainy River, west of International Falls - a distance of 47 miles. The subwatershed drains 96 square miles, and represents just 4.6% of the entire Big Fork River Watershed. There are very few named tributaries to the Big Fork River in this subwatershed; the largest is the Bear River (discussed below as its own HUC 11 subwatershed). Most of the landscape is comprised of wetlands (54.9%) and forest (40.5%). There is a limited amount of agricultural land along the banks of the Big Fork River, in the area near the confluence with the Rainy River.

Table 41. Aquatic life and recreation assessments on stream reaches: Lower Big Fork River subwatershed. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name***, *Reach Description*	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	**Aquatic Life**	**Aquatic Rec.**
09030006-502, Big Fork River, Sturgeon R to Bear R	38.03	2B, 3C	10RN040, 10RN049	Upstream of Benn Lynn Rd, 5 mi. NW of Big Falls, Downstream of CR 1 In Lindford	MTS	MTS	MTS	MTS		MTS	MTS		MTS	FS	FS
09030006-501, Big Fork River, Bear R to Rainy R	9.26	2B, 3C	10RN050	Upstream of Hwy 11, 2 mi. W of Laurel	MTS	MTS	MTS	EXP	MTS	MTS	MTS		MTS	FS	FS

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.
Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

Table 42. Minnesota Stream Habitat Assessment (MSHA): 09030006110 11-HUC

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph.	MSHA Score (0-100)	MSHA Rating
1	10RN040	Big Fork River	5	14	19	13	14	65	fair
1	10RN049	Big Fork River	4	10.5	22	12	26	74.5	good
1	10RN050	Big Fork River	5	12.5	14	3	24	58.5	fair
Average Habitat Results: *09030006110 11 HUC*			4.7	12.3	18.3	9.3	21.3	66.0	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)

Table 43. Outlet water chemistry results: 09030006110 11-HUC

Station location:	Big Fork River at County Road 1 Bridge in Lindford (site is upstream of Laurel Pour Pt.)
EQUIS ID:	S002-855
Station #:	10RN049

Parameter	TSS [5]	Turb. [4]	T-tube	D.O.	TP [5]	TKN	Chloro-phyll-a [5]	E. coli	pH
Units	mg/l	NTU	cm	mg/l	mg/l	mg/l	ug/l	#/100ml	SU
# samples	10	9	20	20	19	19	17	18	20
Min	4	0.6	23	6.6	0.015	0.54	>1	3	7.4
Max	17	7	>100	10.4	0.071	1.96	3	214	8.3
Mean[1]	9	2.7	NA	8.4	0.041	1.2	1.7	19	7.8
Median	9.5	2.6	NA	8.2	0.041	1.29	1	18	7.7
WQ standard [5]	15	25	20	5	0.055		<10	126/1260	6.5-9.0
# WQ exceedances[2]	1	0	0	0	6		0	0	0
NLF 75th percentile[3]	20	12			0.09	0.18-0.73			8

1Geometric mean of all samples is provided for *E. coli* or fecal coliform.
2Represents exceedances of individual maximum standard for *E. coli* (1260/100ml) or fecal coliform (2000/100ml).
3Based on 1970-1992 summer data; see *Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions* (McCollor and Heiskary 1993). TKN range based on EPA Rivers and Streams in Nutrient Ecoregion VIII, NLF and NMW, EPA 822 B-01-015. 2001
4 Combined data from 3 turbidity methods, each with slightly different standard methods
5 Proposed TP, TSS and Chlorophyll-a standards for the North region of Minnesota, see http://www.pca.state.mn.us/index.php/view-document.html?gid=14947 http://www.pca.state.mn.us/index.php/view-document.html?gid=14922

** Data found in the above table was compiled using the results from data collected at the pour point monitoring station in the Upper Big Fork HUC 11 watershed, a component of the IWM work conducted in 2010 and 2011. This specific data does not necessarily reflect all data that was used to assess the AUID.

Summary

The Lower Big Fork River subwatershed has two assessable stream segments on the Big Fork River, both of which had good water quality. Fish IBI scores improved in a downstream direction. This subwatershed had some of the highest percentages of sensitive fish species ranging from 17.5 to 66.5% of the species found. The overall habitat quality rating was good. Contrary to the fish results, the lowest MSHA score was located at the farthest downstream reach. The lower MSHA score was due primarily to a lack of fish cover, receiving only 3 out of 17 possible points for the fish cover subcategory.

The water chemistry monitoring site for this subwatershed was on the Big Fork River at the County Road 1 Bridge in Lindford. The subwatershed's outlet location (the Big Fork's confluence with the Rainy River at the Minnesota Highway 11 Bridge) was not selected as the representative monitoring site because backwater effects from the Rainy River influence water quality conditions in the Big Fork. These conditions occur when there are low flows in the Big Fork and stagnant conditions are common, or when flow in the Rainy River are higher than those in the Big Fork.

Data at the Lindford site indicate excellent water quality; this site integrates conditions in nearly the entire watershed, draining 93% of the Big Fork subwatershed (except the Bear River). Turbidity, bacteria, and nutrient levels are low and are at expected levels given the watershed's characteristics. Phosphorus concentrations were occasionally above the draft standard, but still within the expected range for the NMW Ecoregion. Overall, the data indicate full support of both aquatic life and aquatic recreational use. Big Fork River Board River Watch data were also collected in this subwatershed. Their data, including fecal coliform bacteria data, corroborate assessment-level data collected at the Lindford site.

Data at the Lindford site were also compared to data collected from the Highway 11 confluence site. In general, data were similar among sites, except that higher turbidity and TSS levels were observed at Highway 11. This may indicate an influence from the Rainy River and its principal tributary, the Little Fork River which has a turbidity impairment.

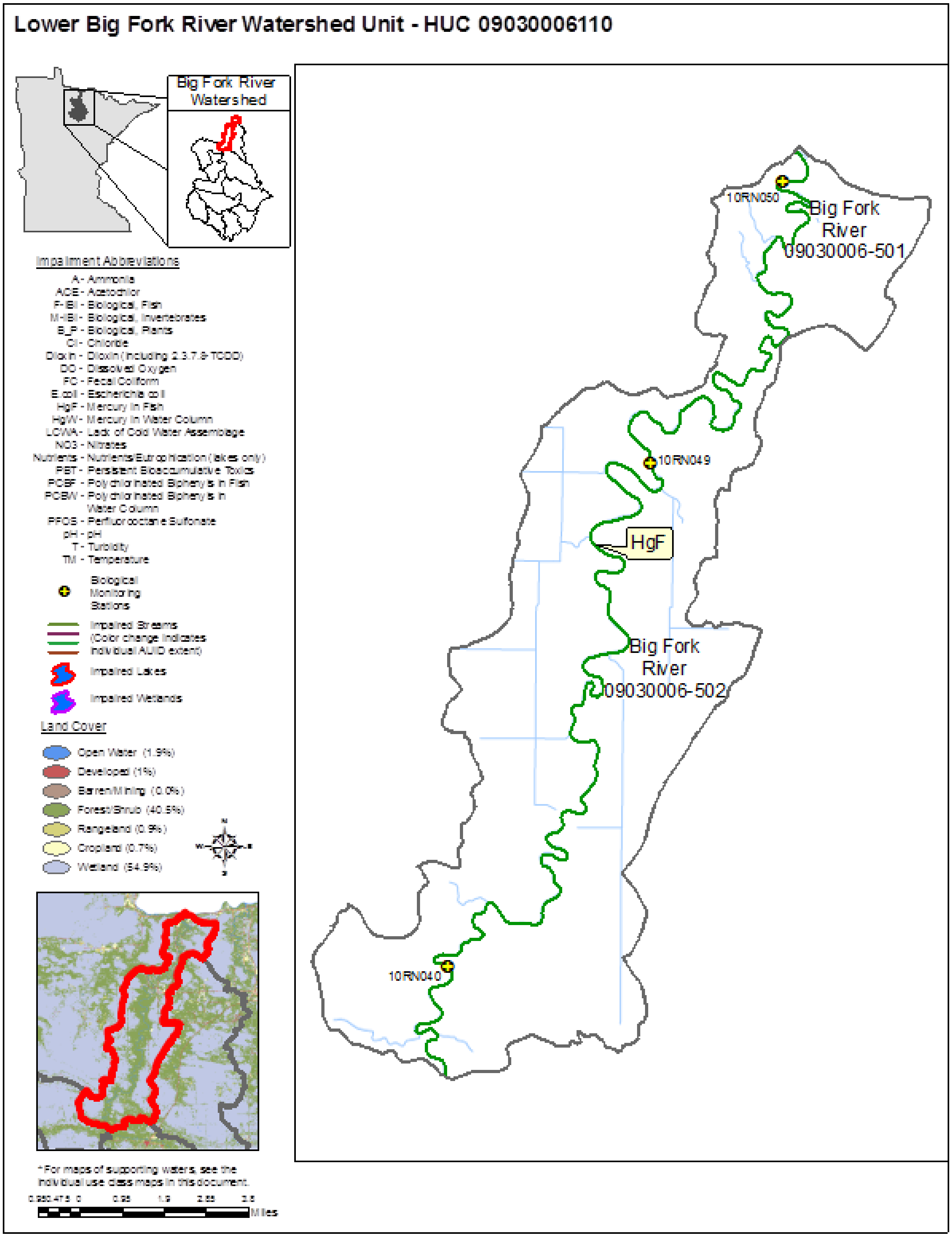

Figure 31. Currently listed impaired waters by parameter and land use characteristics in the Lower Big Fork River subwatershed

Bear River subwatershed HUC 09030006120

The Bear River subwatershed drains 137 square miles of wetland dominated land in north central Koochiching County. The area represents 6.5% of the Big Fork River Watershed's drainage area. The Bear River originates in a large wetland complex north of Big Falls within Koochiching State Forest. Portions of the headwaters were ditched historically. The river flows north, reaching the Big Fork River about 10 river miles downstream of Lindford. The Bear River subwatershed is dominated by wetlands making up 65.2% of the land area, followed only by 31.9% forest. There is some agricultural land in the lower stretches of the river at about 1.5% of the subwatershed, when range and cropland are combined.

Table 44. Aquatic life and recreation assessments on stream reaches: Bear River subwatershed. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name,*** *Reach Description*	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	**Aquatic Life**	**Aquatic Rec.**
09030006-679, Hay Creek, Unnamed ditch to Bear Cr	2.23	2B, 3C	10RN044	Upstream of Hwy 71, 6 mi. NE of Big Falls	EXS	EXS	--	--		--	--			IF**	NA
09030006-678, Unnamed creek, Unnamed cr to Unnamed cr	1.18	2B, 3C	10RN047	Downstream of CR 14, 6 mi. SW of Little Fork	MTS	MTS	--	--		--				FS	NA
09030006-609, Unnamed creek, Unnamed cr to Bear R	1.58	2B, 3C	05RN050	0.5 mi. Upstream of CR 78, 6 mi. W of Littlefork	MTS	MTS	--	--		--	--			FS	NA
09030006-516, Bear Creek, Headwaters to Big Fork R	34.52	2B, 3C	10RN048	Upstream of CR 1, 4 mi. E of Lindford	MTS	MTS	MTS	MTS		MTS	MTS		IF	FS	IF

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.
Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.
**Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized while the biological station occurred on a natural reach within the channelized AUID.

Table 45. Non-assessed biological stations on channelized AUIDs: 09030006120 11-HUC

AUID ***Reach Name***, *Reach Description*	Reach length (miles)	Use Class	Biological Station ID	Location of Biological Station	Fish IBI	Invert IBI
09030006-516, Bear Creek, Headwaters to Big Fork R	34.52	2B, 3C	10RN043	Upstream of Hwy 71, 5 mi. NE of Big Falls	Poor	Fair
09030006-681, Unnamed ditch, Headwaters to Bear Cr	3.83	2B, 3C	10RN056	Adjacent to Wisner State Forest Rd, 1.5 mi. W of Wisner	Poor	Poor

= Good = Fair = Poor - See Appendix 5.1 for clarification on the good/fair/poor thresholds and Appendix 5.2 and Appendix 5.3 for IBI results.

Table 46. Minnesota Stream Habitat Assessment (MSHA): 09030006120 11-HUC

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph.	MSHA Score (0-100)	MSHA Rating
1	10RN044	Hay Creek	5	14	8	12	23	62	fair
1	10RN047	Unnamed creek	4.5	15	19.85	11	28	78.35	good
1	10RN056	Unnamed ditch	5	10	10	10	7	42	poor
2	05RN050	Unnamed creek	5	11.5	13.2	7.5	27	64.2	fair
1	10RN048	Bear Creek	4.5	13.5	20	13	16	67	good
1	10RN043	Bear Creek	5	11.5	13	12	4	45.5	fair
Average Habitat Results: *09030006120 11 HUC*			**4.83**	**12.58**	**14.01**	**10.92**	**17.50**	**59.84**	**fair**

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)

Table 47. Outlet water chemistry results: 09030006120 11-HUC

Station location:	Bear River at County Road 1, 4 Miles East of Lindford								
EQUIS ID:	S001-150								
Station #:	10RN048								
Parameter	TSS [5]	Turb. [4]	T-tube	D.O.	TP [5]	TKN	Chloro-phyll-a [5]	E. coli	pH
Units	mg/l	NTU	cm	mg/l	mg/l	mg/l	ug/l	#/100ml	SU
# samples	10	9	20	20	19	19	17	18	20
Min	1	3.3	23	6.5	0.024	1.16	<1	24	7
Max	40	19	82	10.4	0.084	1.95	2	517	7.8
Mean[1]	11.6	8.7	44	7.8	0.053	1.53	<1	99	7.4
Median	6	7.6	42	7.5	0.05	1.52	<1	88	7.3
WQ standard [5]	15	25	20	5	0.055		<10	126/1260	6.5-9.0
# WQ exceedances[2]	2	0	0	0	6		0	0	0
NLF 75^{th} percentile[3]	20	12			0.09	0.18-0.73			8

1Geometric mean of all samples is provided for *E. coli* or fecal coliform.
2Represents exceedances of individual maximum standard for *E. coli* (1260/100ml) or fecal coliform (2000/100ml).
3Based on 1970-1992 summer data; see *Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions* (McCollor and Heiskary 1993). TKN range based on EPA Rivers and Streams in Nutrient Ecoregion VIII, NLF and NMW, EPA 822 B-01-015. 2001
4 Combined data from 3 turbidity methods, each with slightly different standard methods
5 Proposed TP, TSS and Chlorophyll-a standards for the North region of Minnesota, see http://www.pca.state.mn.us/index.php/view-document.html?gid=14947 http://www.pca.state.mn.us/index.php/view-document.html?gid=14922

** Data found in the above table was compiled using the results from data collected at the pour point monitoring station in the Upper Big Fork HUC 11 watershed, a component of the IWM work conducted in 2010 and 2011. This specific data does not necessarily reflect all data that was used to assess the AUID.

Table 48. Water Outlet water chemistry results: Big Fork River HUC 8 outlet

Station location:	Big Fork River at Minnesota Highway 11, 2 miles West of Laurel (HUC 8 Pour Point site; location is influenced by Rainy River backwater at high flows)								
EQUIS ID:	S000-173								
Station #:	Down Stream of 10RN050								
Parameter	TSS [5]	Turb. [4]	T-tube	D.O.	TP [5]	TKN	Chloro-phyll-a [5]	E. coli	pH
Units	mg/l	NTU	cm	mg/l	mg/l	mg/l	ug/l	#/100ml	SU
# samples	10	10	20	20	19	19	17	18	20
Min	4	1.2	21	6.3	0.015	0.51	<1	3.1	7.4
Max	22	31	78	10	0.075	1.54	3	139	8.2
Mean[1]	12.7	10.1	48	7.9	0.043	1.06	1.6	21	7.7
Median	12.5	7.4	43	7.8	0.045	1.1	<1	24	7.7
WQ standard [5]	15	25	20	5	0.055		<10	126/1260	6.5-9.0
# WQ exceedances[2]	4	1	0	0	5		0	0	0
NLF 75th percentile[3]	20	12			0.09	0.18-0.73			8

1Geometric mean of all samples is provided for *E. coli* or fecal coliform.
2Represents exceedances of individual maximum standard for *E. coli* (1260/100ml) or fecal coliform (2000/100ml).
3Based on 1970-1992 summer data; see *Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions* (McCollor and Heiskary 1993). TKN range based on EPA Rivers and Streams in Nutrient Ecoregion VIII, NLF and NMW, EPA 822 B-01-015. 2001
[4] Combined data from 3 turbidity methods, each with slightly different standard methods
[5] Proposed TP, TSS and Chlorophyll-a standards for the North region of Minnesota, see http://www.pca.state.mn.us/index.php/view-document.html?gid=14947 http://www.pca.state.mn.us/index.php/view-document.html?gid=14922

** Data found in the above table was compiled using the results from data collected at the pour point monitoring station in the Upper Big Fork HUC 11 watershed, a component of the IWM work conducted in 2010 and 2011. This specific data does not necessarily reflect all data that was used to assess the AUID.

Summary

There were three stream segments assessed in the Bear River subwatershed and one that was not assessed due to channelization. A largely channelized segment of Hay Creek (10RN044) did not meet either the fish or macroinvertebrate impairment thresholds. However, due to extensive channelization throughout the reach an overall assessment was not made. The remaining three assessable stream segments met biological standards for both fish and macroinvertebrates as well as the chemical standards. The two channelized AUIDs rated poorly for biology and had the lowest MSHA scores. Overall, the MSHA rating was fair, but had only natural channels been included in the average the overall MSHA rating would have been good.

The water chemistry monitoring site for this subwatershed was on the Bear River at the Koochiching County Highway 1 Bridge, four miles east of Lindford. In general, results indicate good water quality. Sediment and turbidity levels are low. Nutrient concentrations are within expected ranges, although they occasionally exceeded the draft standards during low or high flow conditions. The data indicated full support of aquatic life use, based on DO and turbidity data. Bacteria concentrations were higher here than most other upstream subwatersheds. One monthly geometric mean value exceeded the standard, but no individual samples exceeded the maximum standard of 1,260 counts/100 mL. Because the results were not conclusive there was not sufficient information to make an assessment decision regarding aquatic recreational use. Additional bacteria monitoring is suggested at this location to collect a more robust dataset.

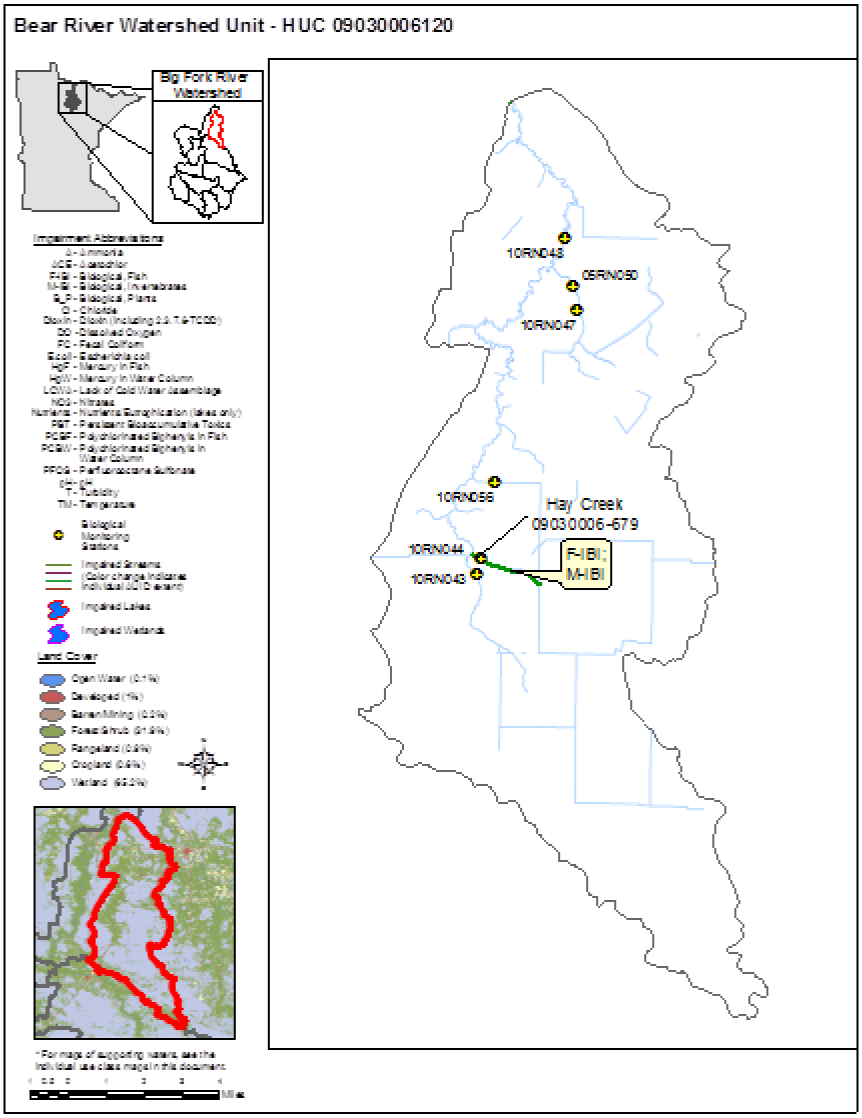

Figure 32. Currently listed impaired waters by parameter and land use characteristics in the Bear River subwatershed

VI. Watershed-wide results and discussion

Assessment results and data summaries are included below for the entire Big Fork River Watershed, grouped by sample type. Summaries are provided for load monitoring data results near the mouth of the river, aquatic life and recreation uses in streams and lakes throughout the watershed, and for aquatic consumption results at select river and lake locations within the watershed. Additionally, groundwater monitoring results and long-term monitoring trends 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 Big Fork River Watershed.

Pollutant load monitoring

The Big Fork River is monitored for pollutant loads at Hwy 77 near Big Falls. Many years of water quality data from throughout Minnesota combined with the previous analysis of Minnesota's ecoregion patterns resulted in the development of three "River Nutrient Regions" (RNR), each with unique nutrient standards (MPCA, 2008). Of the state's three RNRs (North, Central, South), the Big Fork River's monitoring station is located within the North RNR.

Annual flow weighed mean concentrations (FWMCs) were calculated and compared for years 2007-2010 (Figure 33, Figure 34, Figure 35, and Figure 36) and compared to the RNR standards (only TP and TSS draft standards are available for the North RNR). It should be noted that while a FWMC exceeding a given water quality standard is generally a good indicator that the water body is out of compliance with the RNR standard, the rule does not always hold true. Waters of the state are listed as impaired based on the percentage of individual samples exceeding the numeric standard, generally 10% and greater, over the most recent 10 year period and not based on comparisons with FWMCs (MPCA, 2012). A river with a FWMC above a water quality standard, for example, would not be listed as impaired if less than 10% of the individual samples collected over the assessment period were above the standard.

Pollutant sources affecting rivers are often diverse and can be quite variable from one watershed to the next depending on land use, climate, soils, slopes, and other watershed factors. However, as a general rule, elevated levels of TSS and nitrate-N are generally regarded as "non-point" source derived pollutants originating from many small diffuse sources such as urban or agricultural runoff. Excess TP and DOP can be attributed to both "non-point" as well as "point" or end of pipe sources such as industrial or waste water treatment plants. Major "non-point" sources of phosphorus include dissolved phosphorus from fertilizers and phosphorus adsorbed to and transported with sediment during runoff.

Within a given watershed, pollutant sources and source contributions can also be quite variable from one runoff event to the next depending on factors such as: canopy development, soil saturation level, and precipitation type and intensity. Surface erosion and in-stream sediment concentrations, for example, will typically be much higher following high intensity rain events prior to canopy development rather than after low intensity post-canopy events where less surface runoff and more infiltration occur. Precipitation type and intensity influence the major course of storm runoff, routing water through several potential pathways including overland, shallow and deep groundwater, and/or tile flow. Runoff pathways along with other factors determine the type and levels of pollutants transported in runoff to receiving waters and help explain between-storm and temporal differences in FWMCs and loads, barring differences in total runoff volume. During years when high intensity rain events provide the greatest proportion of total annual runoff, concentrations of TSS and TP tend to be higher and DOP and nitrate-N concentrations tend to be lower. In contrast, during years with high snow melt runoff and less intense rainfall events, TSS levels tend to be lower while TP, DOP, and nitrate-N levels tend to be elevated.

Total suspended solids

Water clarity refers to the transparency of water. Turbidity is a measure of the lack of transparency or the "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. By definition, turbidity is caused primarily by suspension of particles that are smaller than one micron in diameter in the water column.

Analysis has shown a strong correlation to exist between the measures of TSS and turbidity. The greater the level of TSS, the murkier the water appears and the higher the measured turbidity. High turbidity results in reduced light penetration that harms beneficial aquatic species and favors undesirable algae species (MPCA and MSUM 2009). An overabundance of algae can lead to increases in turbidity, further compounding the problem. Periods of high turbidity often occur when heavy rains fall on unprotected soils. Upon impact, raindrops dislodge soil particles and overland flow transports fine particles of silt and clay into rivers and streams (MPCA and MSUM 2009).

Currently, the state of Minnesota's TSS standards are in development and must be considered to be draft standards until complete approval. Within the North RNR, the TSS draft standard is 15 mg/L (MPCA 2010c); when greater than 10% of the individual samples exceed the draft standard, the river is out of compliance. Calculations from 2007 through 2010 show 4, 30, 13, and 18% of the individual TSS samples exceeded the 15 mg/L draft standard, respectively. In addition, of the computed annual FWMCs for the four sampling years, only 2008 exceeded the 15 mg/L draft standard while 2007, 2009 and 2010 were below the draft standard (Figure 24). In 2008, the sample with the highest measured TSS concentrations (150 mg/L) was collected on the peak of a spring melt and coincided with the highest discharge value of the year. All other values over 15 mg/L that year were collected during the same spring event within a one month timeframe. 2007 was characterized as a low flow year with only a few rain events; the highest recorded TSS value, 15 mg/L, was during a June storm event. 2009 had the highest flows for the four years during the spring melt, but during that period the highest concentrations only reached 32 mg/L. Although the data may not reflect long-term trends, both TSS FWMCs and annual loads showed a decline between 2008 and 2010 (Figure 33 and Table 49).

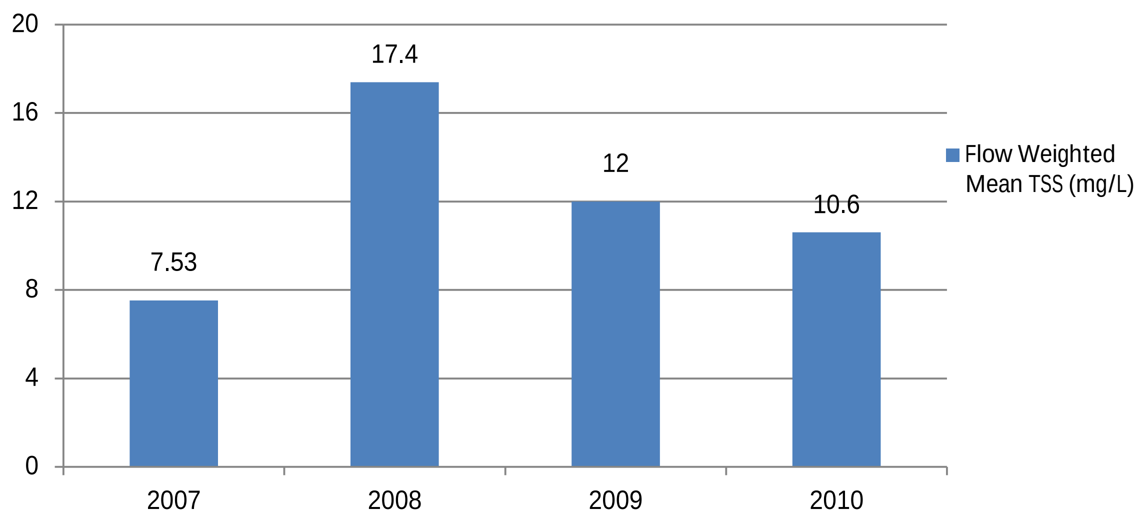

Figure 33. Total suspended solids (TSS) flow weighted mean concentrations in the Big Fork River Watershed

Table 49. Annual pollutant loads by parameter calculated for the Big Fork River

	2007	2008	2009	2010
Parameter	Mass (kg)	Mass (kg)	Mass (kg)	Mass (kg)
Total Suspended Solids	2,403,107	10,578,304	7,970,098	7,551,799
Total Phosphorus	17,702	32,802	25,270	36,465
Ortho Phosphorus	4,554	8,133	7,261	14,144
Nitrate + Nitrite Nitrogen	16,716	29,565	30,998	24,601

Total phosphorus

Nitrogen (N), phosphorus (P), and potassium (K) are essential macronutrients and are required for growth by all animals and plants. Lack of sufficient nutrient levels in surface water often restricts the growth of aquatic plant species (University of Missouri Extension 1999). In freshwaters such as lakes and streams, phosphorus is typically the nutrient limiting growth; increasing the amount of phosphorus entering a stream or lake will increase the growth of aquatic plants and other organisms. Although phosphorus is a necessary nutrient, excessive levels overstimulate aquatic growth in lakes and streams resulting in reduced water quality. The progressive deterioration of water quality from overstimulation of nutrients is called eutrophication where, as nutrient concentrations increase, the surface water quality is degraded (University of Missouri Extension 1999). Elevated levels of phosphorus in rivers and streams 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 (University of Missouri Extension 1999). In “non-point” source dominated watersheds, TP concentrations are strongly correlated with stream flow. During years of above average precipitation, TP loads are generally highest.

Total phosphorus standards for Minnesota’s rivers are also in development and must be considered draft standards until approved. Within the North RNR, the TP draft standard is 55 ug/L as a summer average. Summer average violations of one or more “response” variables (pH, biological oxygen demand (BOD), DO flux, chlorophyll-a) must also occur along with the numeric TP violation for the water to be listed as impaired. Concentrations from 2007, 2008, 2009 and 2010 show that 44, 24, 11, and 37% of the individual TP samples exceeded the 55 ug/L draft standard, respectively. Observation of Figure 34 shows that the FWMCs from 2007 to 2010 exceeded the draft standard in 2007 with FMMC’s at 56, 54, 39, and 51 ug/L, respectively.

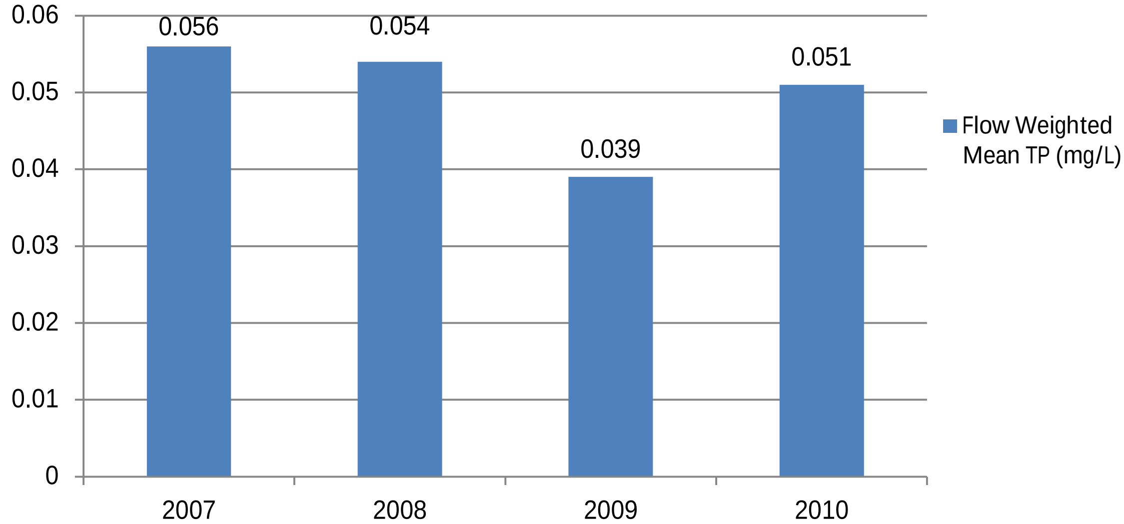

Figure 34. Total phosphorus (TP) flow weighted mean concentrations for the Big Fork River Watershed

Dissolved orthophosphate

Dissolved orthophosphate is a water soluble form of phosphorus that is readily available to algae (bioavailable) (MPCA and MSUM 2009). 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. The 2007 through 2010 FWMC ratio of DOP to TP shows that 24 to 39% of TP is in the orthophosphate form.

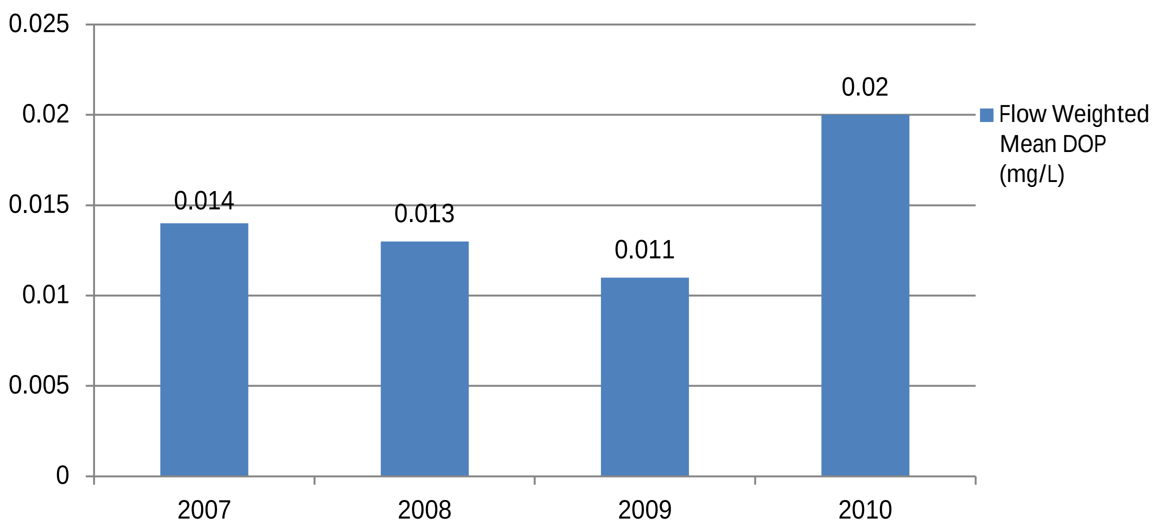

Figure 35. Dissolved orthophosphate (DOP) flow weighted mean concentrations for the Big Fork River Watershed

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, they too, like phosphorus, can stimulate excessive levels of some algae species in streams (MPCA, 2008). Because nitrate and nitrite-nitrogen are water soluble, transport to surface waters is enhanced through agricultural drainage. The ability of nitrite-N to be readily converted to nitrate-nitrogen is the basis for the combined laboratory analysis of nitrate plus nitrite-nitrogen, 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.

Nitrate-N can also be a common toxicant to aquatic organisms in Minnesota's surface waters with macroinvertebrates appearing to be the most sensitive to nitrate toxicity. Draft nitrate-N standards have been proposed for the protection of aquatic life in lakes and streams. The draft acute value (maximum standard) for all Class 2 surface waters is 41 mg/L nitrate-N for a 1-day duration, and the draft chronic value for Class 2B (warm water) surface waters is 4.9 mg/L nitrate-N for a 4-day duration. In addition, a draft chronic value of 3.1 mg/L nitrate- N (4-day duration) was determined for protection of Class 2A (cold water) surface waters (MPCA, 2010).

Nitrate-N FWMCs from 2007 through 2010 for the Big Fork River Watershed were 0.052, 0.049, 0.047, and 0.035 mg/L, respectively (Figure 36), well below all the standards and draft standards.

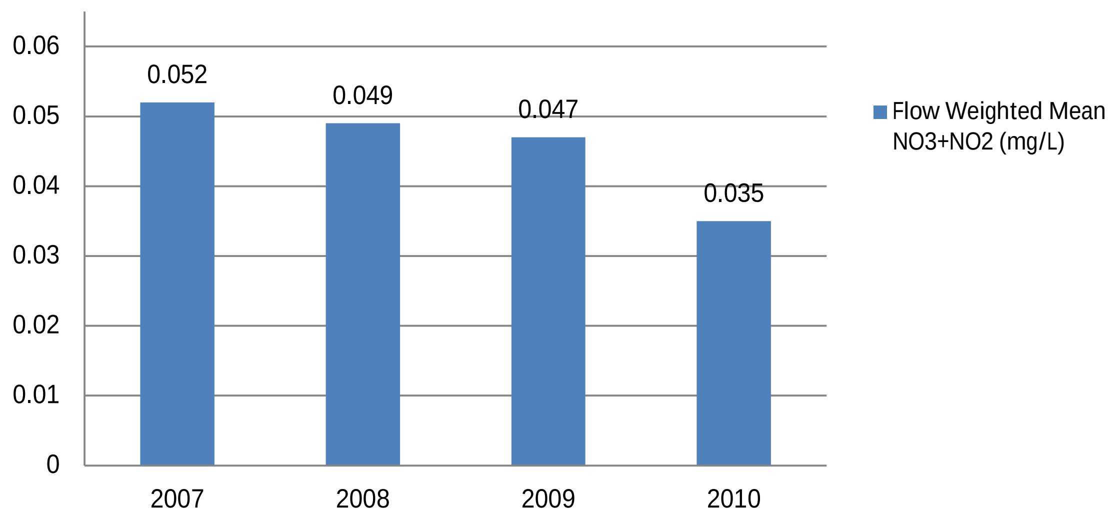

Figure 36. Nitrate + Nitrite Nitrogen (Nitrate-N) flow weighted mean concentrations for the Big Fork River Watershed

Stream and lake water quality

Forty one of the watershed's 193 stream segments were assessed (Table 50). Of the assessed streams, 33 streams fully support aquatic life, 6 streams did not support aquatic life, and 2 streams had insufficient data to make an assessment. All 11 stream segments assessed for aquatic recreation were fully supporting. There were 5 stream segments that were not assessed for aquatic biology because greater than 50% of the AUID is channelized or the biological station fell on a channelized stream reach on the AUID.

For the Big Fork River Watershed lakes see similar results to streams in that of the 117 lakes assessed 111 were found to be in full support with only 6 non-supporting lakes. When impairments were found for lakes they were either mercury or nutrient exceedances.

Table 50. Assessment summary for stream water quality in the Big Fork River Watershed

Watershed	Area (acres)	# 10X Water Chemistry Sites	# Total AUIDs	# Assessed AUIDs	Supporting: # Aquatic Life	Supporting: # Aquatic Recreation	Non-supporting: # Aquatic Life	Non-supporting: # Aquatic Recreation	Insufficient Data
09030006 **HUC 8**	137600	**12**	**193**	**41**	**33**	**11**	**6**	**0**	**2**
Upper Big Fork	103680	1	28	6	6	1	0	0	0
Popple River	90880	1	23	2	0	1	2	0	0
Upper Bowstring	76160	1	22	4	3	1	1	0	0
Bowstring River	88960	1	24	1	1	1	0	0	0
Gale Brook	194560	1	21	3	1	1	2	0	0
Middle Big Fork	93440	1	18	6	5	1	1	0	0
Caldwell Creek	188800	1	9	2	2	1	0	0	0
Lower Middle Big Fork	86400	1	16	8	8	1	0	0	0
Dinner Creek	117760	0	20	1	0	0	0	0	1
Sturgeon River	61440	1	4	2	2	1	0	0	0
Lower Big Fork	87680	2	2	2	2	2	0	0	0
Bear River	137600	1	6	4	3	0	0	0	1

Table 51. Assessment summary for lake water chemistry in the Big Fork River Watershed

Watershed	Area (acres)	Total Lakes or Reservoirs	Lakes >10 Acres	Lake <10 Acres	Full Support	Non-support	Insufficient Data
Big Fork River HUC 8	1326720	285	278	7	111	6	168
Upper Big Fork River	137600	36	35	1	12	0	24
Popple River	103680	20	20	0	2	3	15
Upper Bowstring River	90880	46	46	0	24	2	20
Bowstring River	76160	17	17	0	6	1	10
Gale Brook	88960	111	107	4	52	0	59
Middle Big Fork River	194560	54	52	2	15	0	39
Dinner Creek	86400	1	1	0	0	0	1

Biological monitoring

The Big Fork River Watershed drains over 1,300,000 acres through wetlands, forests, and lakes. The main stem Big Fork River is over 165 miles long, not including the many rivers and streams that meet up with it as it flows north emptying into the Rainy River. A total of 78 fish samples were collected from a total of 63 sampling locations. Forty-eight samples from 39 sites were assessable and there were 9 sites that were repeated during the 2010 field season to estimate sampling precision. Finally, there were 16 samples taken from 15 sites that were not assessed; most of these were on channelized reaches.

The most abundant fish species was not the most frequently captured (Table 52). The central mudminnow was the most frequently captured species, occurring in 84% of samples. The common shiner was the most abundant fish species with 2727 individuals collected but it was only captured in 70% of the samples. The top five largest discrepancies between number of individuals and frequency sampled were with the pumpkinseed, pearl dace, river darter, and common shiner. These discrepancies are created when a few sites contain the majority of the total number of individuals sampled.

Fish species may be grouped by their preference for a particular habitat or by a unique behavior or trait. Some of these classifications are helpful indicators of environmental stress. For example, species may be grouped by their tolerance to pollution. Fish species that are known to be intolerant of pollution are almost always a good sign that stream habitat, water chemistry, and connectivity have not been compromised. A preponderance of tolerant species indicates that the stream environment is harsh, a possible indication of poor water quality, habitat, or other natural or anthropogenic factor. Though there were many tolerant fish species captured throughout the watershed including bigmouth shiners, fathead minnows, and white suckers, their prevalence is more likely due to the naturally harsh conditions of these northern Minnesota streams. These harsh conditions are predominant in headwater streams, where streams are often transitioning from wetland to stream characteristics. On the other hand the long list of intolerant species highlighted in blue in Table 52 indicate that many streams in the Big Fork River Watershed offer stable, high quality habitat for species that are sensitive to environmental stress. These intolerant species are generally found in the larger streams and include the burbot and lake sturgeon. The most frequently captured intolerant species was the long nose dace found in 23% of the samples.

Table 52. Fish species captured within the Big Fork River Watershed between 2005 and 2011, indicating the number of fish collected and the percentage of samples each species was captured from out of 61 possible samples.

Common Name	# Fish Collected	% Sampled
bigmouth shiner	36	5.13
black bullhead	48	8.97
black crappie	168	15.38
blackchin shiner	44	5.13
blacknose dace	283	34.62
blacknose shiner	77	11.54
blackside darter	1390	62.82
bluegill	23	8.97
bowfin	3	2.56
brassy minnow	42	12.82
brook stickleback	964	41.03
brown bullhead	8	1.28
burbot	8	8.97
central mudminnow	1456	84.62
channel shiner	11	1.28

Common Name	# Fish Collected	% Sampled
common shiner	2727	70.51
creek chub	971	47.44
emerald shiner	4	2.56
fathead minnow	89	15.38
finescale dace	238	14.10
Gen: Percina	1	1.28
golden redhorse	1	1.28
golden shiner	144	20.51
hornyhead chub	1202	47.44
Iowa darter	21	7.69
johnny darter	570	55.13
lake sturgeon	2	1.28
lamprey ammocoete	203	16.67
largemouth bass	1143	37.18
logperch	76	7.69
longnose dace	262	23.08
mimic shiner	301	16.67
mottled sculpin	54	15.38
muskellunge	9	7.69
northern brook lamprey	12	7.69
northern pike	164	50.00
northern redbelly dace	279	20.51
pearl dace	860	21.79
pumpkinseed	518	7.69
river darter	201	5.13
rock bass	291	37.18
shorthead redhorse	61	24.36
silver lamprey	1	1.28
silver redhorse	68	19.23
smallmouth bass	23	8.97
spottail shiner	59	16.67
tadpole madtom	25	14.10
trout-perch	14	10.26
walleye	35	23.08
white sucker	987	82.05
yellow bullhead	15	5.13
yellow perch	982	43.59

Key for Cell Shading- = Pollution Intolerant fish species

Fish contaminant results

Fish species are identified by codes that are defined by their common and scientific names in Table 53. In this watershed, mercury has been measured in six fish species, PCBs in eight species, and PFCs in three species. A total of 780 fish were analyzed from the Big Fork River and 20 lakes in the watershed.

Table 54 shows which waterways are impaired for aquatic consumption (i.e., fish contaminants). Big Fork River and 12 (60%) of the lakes are impaired due to elevated levels of mercury (Hg) in fish tissue. Table 54 also shows the number of fish tested by waterway and species. Northern pike (NP) was the most commonly tested fish, followed by walleye (WE). Together they represent 57% of the tested fish.

Table 55 is a summary of contaminant concentrations by waterway, fish species, and year. The table shows which contaminants, species, and years were sampled within a given waterway. "Total Fish" and "Samples" are shown because most of the samples before 1990, and many of the panfish since then, were composite samples—multiple fish homogenized into a single sample. Sample years ranged from 1981 to 2011. Most of the samples were skin-on fillets (FILSK) or for fish without scales (catfish and bullheads), skin-off fillets (FILET). Yellow perch were homogenized as whole fish (WHORG) because of their small size.

Mercury was measured in 362 samples. All of the lakes (and the river) had at least one fish species with mean mercury concentrations exceeding the 0.2 mg/kg threshold, including those lakes not listed as impaired. The lakes not on the Impaired Waters List either have old data (before 1990) or the sample sizes for a given fish species were less than five. The highest mercury concentration was in a WE collected in 1985 from Big Fork River. No WE were collected from the river in 2010; NP collected from the river in 2010 had mercury concentrations ranging from 0.381 to 0.918 mg/kg, which are still quite high levels.

PCBs were measured in 35 fish samples. Total PCB concentrations were generally below the detection limit. The maximum total PCBs concentration was 0.067mg/kg in a WE collected in 1992 from Caribou Lake (31062000). The impairment threshold for PCBs is 0.22 mg/kg.

PFOS was measured in six fish from Round Lake (31089600) and one bluegill sunfish (BGS) from Horseshoe Lake (31069600). All PFOS concentrations were below the detection limit.

Overall, mercury in fish tissue remains a major concern in this watershed. PCBs and PFOS concentrations were mostly below the detection limits or at very low concentrations. Therefore, they are not a concern for the watershed.

Table 53. Summary statistics of mercury, PCBs, and PFOS, by waterway-species-year

SPEC	Common Name	*Scientific Name*
BGS	Bluegill sunfish	*Lepomis macrochirus*
BKS	Black crappie	*Pomoxis nigromaculatis*
BRB	Brown bullhead	*Ictalurus nebulosus*
CIS	Cisco (Lake Herring)	*Coregonus artedii*
LMB	Largemouth bass	*Micropterus salmoides*
LT	Lake trout	*Salvelinus Namaycush*
LWH	Lake whitefish	*Coregonus Clupeaformis*
NP	Northern pike	*Esox lucius*
RHS	Redhorse, unknown sp.	*Moxostoma sp.*
RKB	Rock bass	*Ambloplites Rupestris*
SF	Pumpkinseed sunfish	*Lepomis gibbosus*
SMB	Smallmouth bass	*Micropterus dolomieu*
SRD	Shorthead redhorse	*Moxostoma macrolepidotum*
WE	Walleye	*Sander vitreus*
WSU	White sucker	*Catostomus commersoni*
YP	Yellow perch	*Perca flavescens*

Table 54. Waterways having fish contaminant data, showing impairments caused by contaminants in fish tissue and number of fish tested by species

Waterway	AUID	Impaired	BGS	BKS	BRB	CIS	LMB	LRA	LT	LWH	NP	RHS	RKB	SF	SMB	SRD	WE	WSU	YP
BIG FORK R.	9030006	Hg									6					5	9	10	
ASPEN	31069000										5						3		3
BASS	31031600						6				26				19				
BELLO	31072600	Hg					9				26								3
BLACK ISLAND	31041600		15								43				11		1		
BOWSTRING	31081300	Hg									13						20		
CARIBOU	31062000	Hg							16		1		13		7		1	5	
DEER	31033400	Hg	14	1		3					9						22	9	
EAST	31046000							10			3								
ELIZABETH	31049000										10								
HORSESHOE	31069600		9												3				
ISLAND	31091300	Hg				7					10			10			10		
JESSIE	31078600	Hg		7		6					11			4			13		
NORTH STAR	31065300	Hg	4	7							6						7		
NOSE	31041700			20							21								
RANIER	31066400										16							6	
ROUND	31089600	Hg		2							27						27		
RUBY	31042200	Hg									25								10
SAND	31082600	Hg		2	1						7	3					30	12	36
TEUFER	36001900	Hg															8		
TURTLE	31072500	Hg	10	4		3				6	4				5		24		

Table 55. Summary statistics of mercury, PCBs, and PFOS, by waterway-species-year

Waterway	AUID	SPEC[1]	Year	Anat[2]	Total Fish	Samples	Length (in)			Mercury (mg/kg)				PCBs (mg/kg)				PFOS (µg/kg)		
							Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Max
BIG FORK R.	09030006 -505 -506 -504 -507 -503 -502 -501	NP	1985	FILSK	1	1	29.2	29	29	1	0.66	0.66	0.66	1	< 0.05					
			2010	FILSK	5	5	21.1	16	27	5	0.55	0.38	0.92	2		< 0.025	< 0.025			
		SRD	2010	FILSK	5	5	17.4	16	19	5	0.31	0.12	0.68	2		< 0.025	< 0.025			
		WE	1985	FILSK	9	5	18.7	13	27	5	0.81	0.27	1.36	5	< 0.05					
		WSU	1985	FILSK	10	2	15.8	15	16	2	0.28	0.25	0.3	2	< 0.05					
ASPEN	31069000	NP	1986	FILSK	5	2	24.3	22.3	26.3	2	0.81	0.8	0.82							
		WE	1986	FILSK	3	2	20	19.2	20.7	2	0.83	0.67	0.99							
		YP	1986	FILSK	3	1	11			1	0.42									
BASS	31031600	LMB	2007	FILSK	6	6	14.3	10.8	16.8	6	0.232	0.05	0.433							
		NP	1981	FILSK	3	1	22.5			1	0.32			1	< 0.025					
				WHORG	5	1	19.1			1	0.24									
			1984	FILSK	5	1	16.5			1	0.16									
			1987	FILSK	8	8	21.3	17.8	24	8	0.286	0.2	0.4							
		SMB	1981	WHORG	2	1	11.2			1	0.15									
			1984	FILSK	4	1	8.8			1	0.18									
			1987	FILSK	9	2	11.9	10.5	13.2	2	0.235	0.15	0.32							
BELLO	31072600	LMB	1985	FILSK	4	1	14.2			1	0.34									
			2007	FILSK	5	5	14.9	11.6	17.5	5	0.177	0.037	0.363							
		NP	1985	FILSK	8	2	20.3	19.2	21.4	2	0.505	0.4	0.61							
			2007	FILSK	18	18	21.2	16.6	27.5	18	0.22	0.068	0.515							
		YP	2007	WHORG	3	1	5.9			1	0.031									

BLACK ISLAND	31041600	BGS	1988	FILSK	15	3	6.4	6.3	6.5	3	0.167	0.15	0.18							
		NP	1982	FILSK	16	2	20.2	18.4	21.9	2	0.6	0.5	0.7							
			1985	FILSK	5	2	24.7	22.3	27	2	0.75	0.64	0.86							
			1988	FILSK	8	8	21.7	18.5	24.6	8	0.503	0.29	0.68							
		SMB	1982	FILSK	2	1	17.2			1	1.1									
			1985	FILSK	3	2	16.2	13.4	19	2	0.68	0.53	0.83							
			1988	FILSK	2	2	16.2	14.7	17.7	2	0.63	0.38	0.88							
		WE	1985	FILSK	1	1	24.5			1	0.92									
BOWSTRING	31081300	NP	1988	FILSK	6	2	20.7	19.7	21.6	2	0.27	0.26	0.28							
			2007	FILSK	7	7	18.9	17	21.3	7	0.121	0.078	0.19							
		WE	1988	FILSK	13	5	19	12.5	24.3	5	0.26	0.15	0.45	1	< 0.01					
			2007	FILSK	7	7	15.8	12.8	23	7	0.117	0.051	0.341							
CARIBOU	31062000	LT	1992	FILSK	16	4	20.8	9.5	30.3	4	0.207	0.033	0.39	2	0.054	0.044	0.064			
		NP	1992	FILSK	1	1	36.7			1	0.5			1	0.052					
		RKB	1992	FILSK	13	1	6.6			1	0.2									
		SMB	1992	FILSK	7	2	12.4	9.7	15.1	2	0.29	0.22	0.36							
		WE	1992	FILSK	1	1	25.1			1	0.89			1	0.067					
		WSU	1992	FILSK	5	1	18.7			1	0.13			1	0.015					
DEER	31033400	BGS	1992	FILSK	10	1	7.1			1	0.014									
			2010	FILSK	4	1	7.8			1	0.031									
		BKS	2010	FILSK	1	1	10.8			1	0.048									
		CIS	2010	FILSK	3	1	18.1			1	0.115									
		NP	2010	FILSK	9	9	21.3	17	25.8	9	0.245	0.112	0.401							
		WE	1992	FILSK	15	3	17.4	13.9	22.6	3	0.257	0.11	0.53	1	< 0.01					
			2010	FILSK	7	7	16.7	11.6	26	7	0.177	0.092	0.325							
		WSU	1992	FILSK	9	2	18.8	17.5	20	2	0.042	0.037	0.046	1	< 0.01					
EAST	31046000	NP	1988	FILSK	3	1	25.2	25.2	25.2	1	0.43			1	< 0.01					
ELIZABETH	31049000	NP	1987	FILSK	10	10	23.9	19.5	32.2	10	0.464	0.09	0.64							
HORSESHOE	31069600	BGS	2007	FILSK	9	1	6.6			1	0.063							1	< 0.98	

		SMB	2007	FILSK	3	3	14.8	13.8	16.2	3	0.246	0.09	0.422							
ISLAND	31091300	CIS	1997	FILSK	7	1	14.7			1	0.04	0.04	0.04	1	0.025					
		NP	1997	FILSK	10	10	27.9	19.1	33.5	10	0.227	0.06	0.44	2		< 0.01	< 0.01			
		SF	1997	FILSK	10	1	6.9			1	0.023									
		WE	1997	FILSK	10	10	22.8	19.4	26.6	10	0.229	0.1	0.54	2		< 0.01	0.02			
JESSIE	31078600	BKS	2004	FILSK	7	1	7.6			1	0.024									
		CIS	2004	FILSK	6	1	14.7			1	0.013									
		NP	1983	FILSK	11	4	25.6	18	32.6	4	0.408	0.17	0.64							
		SF	2007	FILSK	4	1	5.9			1	0.036									
		WE	1983	FILSK	5	1	19.5			1	0.3									
			2004	FILSK	8	8	17.6	15.5	23.2	8	0.119	0.055	0.202							
NORTH STAR	31065300	BGS	2009	FILSK	4	1	6.7			1	0.042	0.042	0.042							
		BKS	2009	FILSK	7	2	9.6	8.9	10.2	2	0.05	0.048	0.051							
		NP	2009	FILSK	6	6	26.2	20.9	32.7	6	0.395	0.243	0.74							
		WE	2009	FILSK	7	7	17.1	13.2	23.5	7	0.266	0.222	0.35							
NOSE	31041700	BKS	1985	FILSK	10	1	6.5			1	0.2									
		NP	1982	FILSK	7	2	25	23.4	26.6	2	0.38	0.24	0.52							
			1985	FILSK	5	1	22.5			1	0.38	0.38	0.38							
RANIER	31066400	NP	1987	FILSK	16	6	25.2	20.5	32.3	6	0.563	0.49	0.61							
		WSU	1987	FILSK	6	2	20.3	20.3	20.3	2	0.23	0.23	0.23	2	0.05					
ROUND	31089600	BKS	2009	FILSK	2	1	9.6			1	0.053							1	< 4.69	
		NP	1983	FILSK	14	4	25	18.1	32.5	4	0.308	0.18	0.56							
			2007	FILSK	13	13	20.3	17.5	22.6	13	0.168	0.078	0.276							
		WE	1983	FILSK	5	2	19.2	12.9	25.5	2	0.205	0.14	0.27							
			2007	FILSK	9	9	17.2	14.1	21.2	9	0.117	0.045	0.175							
			2009	FILSK	13	13	15.2	11.8	20.7	8	0.136	0.068	0.254					5	< 4.906	< 5.03
RUBY	31042200	NP	2006	FILSK	25	25	23.2	15.8	30.6	25	0.342	0.081	0.819							
		YP	2006	WHORG	10	4	7.1	5.6	8.5	4	0.128	0.09	0.202							
SAND	31082600	BKS	1992	FILSK	2	2	11.8	11.1	12.4	2	0.135	0.12	0.15							

		BRB	1992	FILET	1	1	10.7			1	0.041									
		NP	2011	FILSK	7	7	21.1	16.3	32.2	7	0.227	0.103	0.85							
		RHS	1992	FILSK	3	1	21.9			1	0.17			1	< 0.01					
		WE	1992	FILSK	21	6	18	12.8	22.2	6	0.208	0.13	0.28	2	< 0.01					
			2011	FILSK	9	9	16.5	12.8	19.5	9	0.107	0.078	0.16							
		WSU	1992	FILSK	9	5	19.6	17.1	23	5	0.123	0.034	0.26	1	0.027					
			2011	FILSK	3	1	18.2			1	0.101									
		YP	1992	FILSK	1	1	10.1			1	0.097									
				WHORG	11	1	7.2			1	0.052									
			2007	FILSK	16	1	8.7			1	0.061									
			2011	FILSK	8	2	10.3	9.7	10.9	2	0.064	0.057	0.071							
TEUFER	36001900	WE	2009	FILSK	8	8	17.1	12.3	20.6	8	0.275	0.158	0.419							
TURTLE	31072500	BGS	1995	FILSK	10	1	6			1	0.079									
		BKS	2010	FILSK	4	1	8.4			1	0.043									
		CIS	2010	FILSK	3	1	15.5			1	0.086									
		LWH	1995	FILSK	6	1	15.9			1	0.047			1	< 0.01					
		NP	2010	FILSK	4	4	23	20.4	27.9	4	0.37	0.303	0.44							
		SMB	2010	FILSK	5	5	14.5	11.1	16.1	5	0.262	0.137	0.361							
		WE	1995	FILSK	19	4	21.1	17.3	25.6	4	0.408	0.25	0.63	1	0.025					
			2010	FILSK	5	5	18.8	15.9	22.5	5	0.389	0.191	0.618							

1 Species codes are defined in Table 53
2 Anatomy codes: FILSK – fillet skin-on

Pollutant trends for the Big Fork River

Water quality trends at long-term monitoring stations

Water chemistry data were analyzed for trends (Table 56) for the long term period of record (1971-2010) and near term period of record (1995-2010). In general, the long term trends show decreases for all variables except those that no trend was available. Although the general long term trend for biochemical oxygen demand shows a decreasing trend, within the short term trends it is estimated to be on the rise.

Table 56. Trends in the Big Fork River Watershed

	Total Suspended Solids	Total Phosphorus	Nitrite/ Nitrate	Ammonia	Biochemical Oxygen Demand	Chloride
Big Fork River Bridge On Mn-11, 4 Miles E Of Loman (S000-173) (BF-0.5) (period of record 1971 - 2010)						
overall trend (1971–2010)	**decrease**	**decrease**	**no trend**	**decrease**	**decrease**	**no trend**
estimated average annual change	-1.5%	-1.6%		-1.5%	-0.7%	
estimated total change	**-46%**	**-47%**		**-36%**	**-26%**	
1995 – 2010	**no trend**	**no trend**	**no trend**	**no trend**	**increase**	little data
estimated average annual change					11.8%	
estimated total change					144%	
median concentrations first 10 years	13	0.07	0.03	0.08	1.6	2.6
median concentrations most recent 10 years	12	0.05	<0.03	<0.03	1.0	2.4

Analysis was performed using the Seasonal Kendall Test for Trends. Trends shown are significant at the 90% confidence level. Percentage changes are statistical estimates based on the available data. Actual changes could be higher or lower. A designation of "no trend" means that a statistically significant trend has not been found; this may simply be the result of insufficient data.

(Concentrations are median summer (Jun-Aug) values, except for chlorides, which are median year-round values. All concentrations are in mg/L.)

Water clarity trends at citizen monitoring sites

Citizen volunteer monitoring occurs at only 17 streams in the watershed, and only two have sufficient data to determine trends. Citizen lake monitoring occurs at 106 lakes within the Big Fork River Watershed. Most lakes, 75 of 106, have no trends in transparency; 8 lakes have declining transparency, while 23 have an increasing trend in transparency.

Table 57. Water clarity trends at citizen stream and lake monitoring sites.

Big Fork River Watershed, 09030006	Citizen Stream Monitoring Program	Citizen Lake Monitoring Program
Number of sites w/ increasing trend	0	23
Number of sites w/ decreasing trend	0	8
Number of sites w/ no trend	2 (15 sites have insufficient data)	75

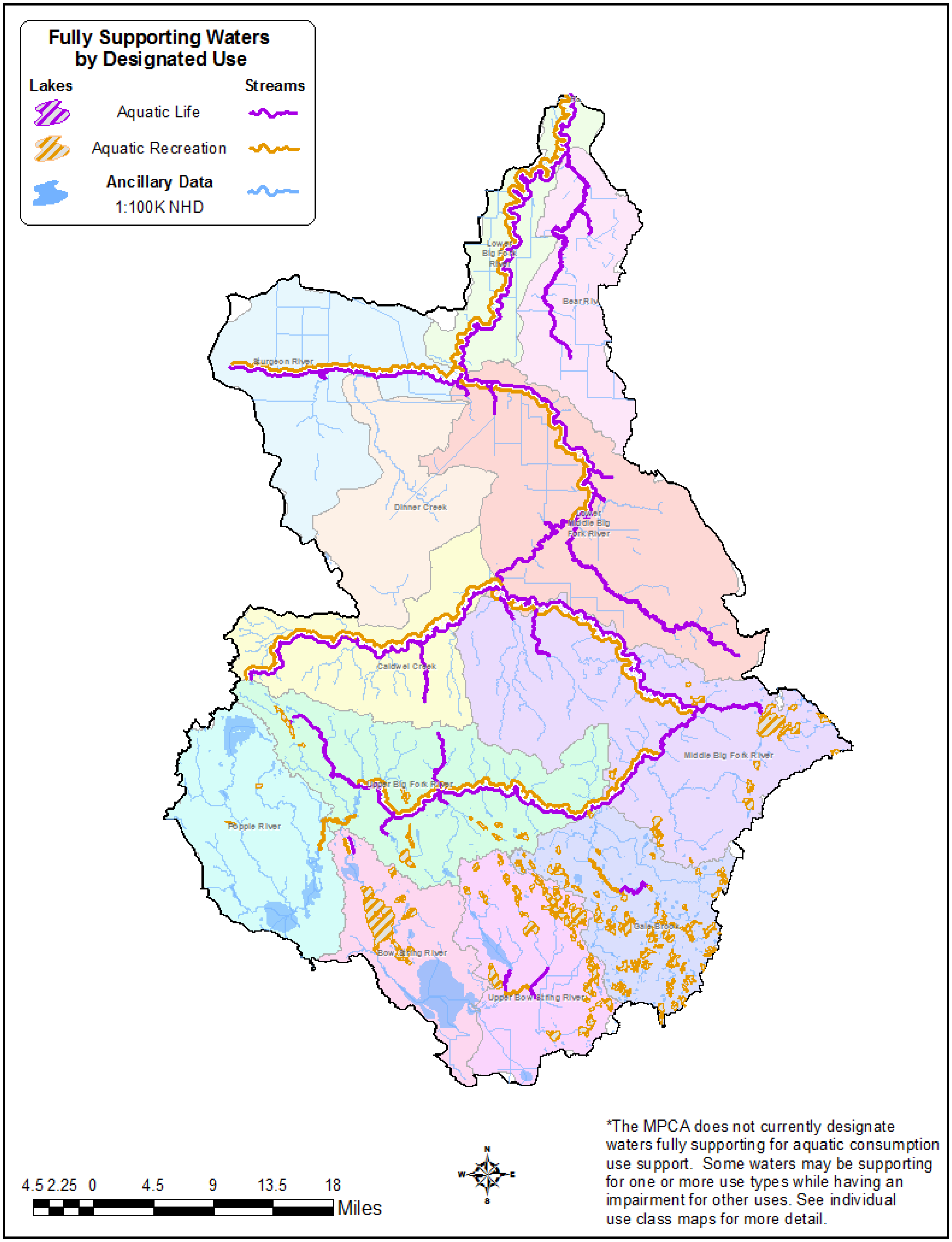

Figure 37. Fully supporting waters by designated use in the Big Fork River Watershed

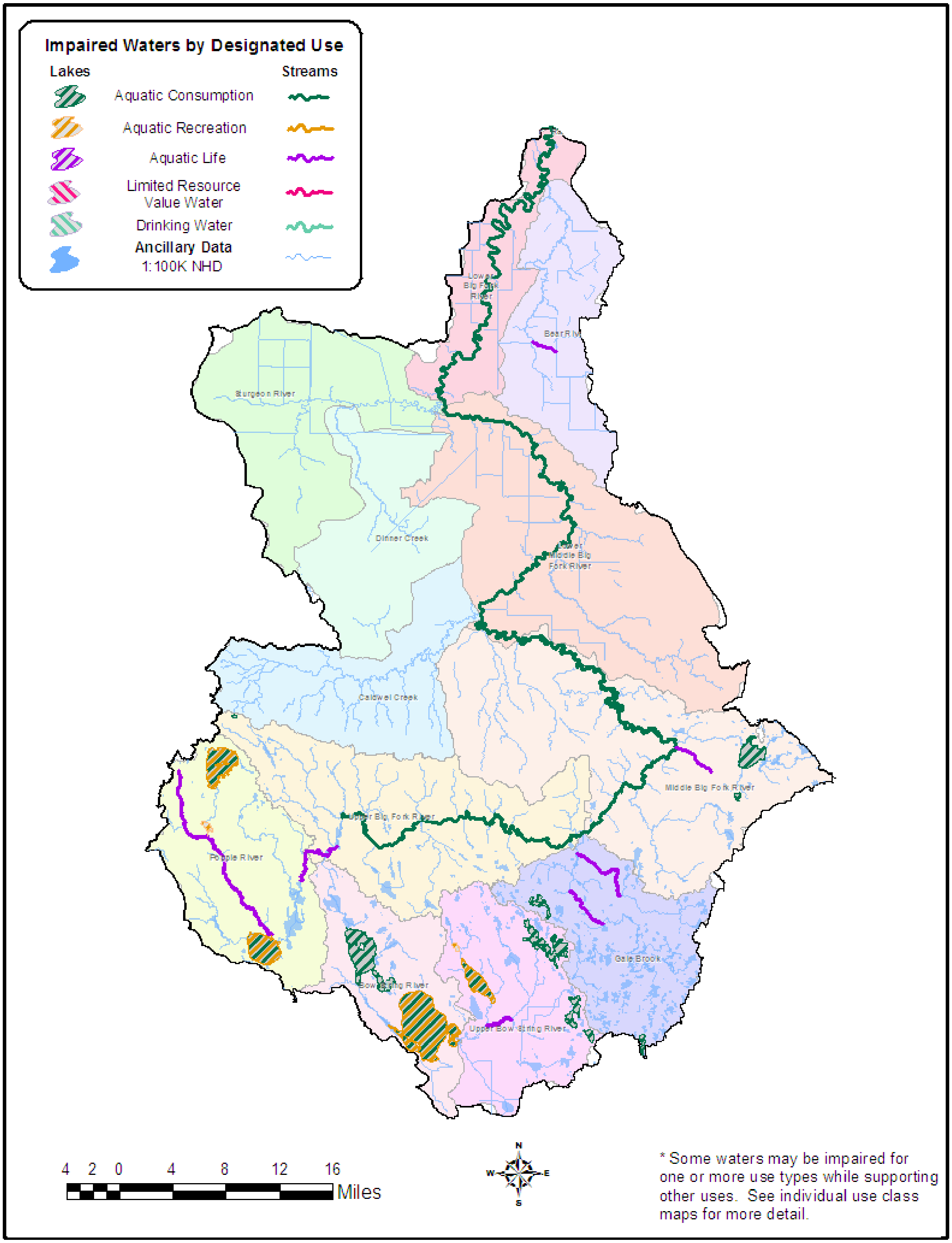

Figure 38. Impaired waters by designated use in the Big Fork River Watershed

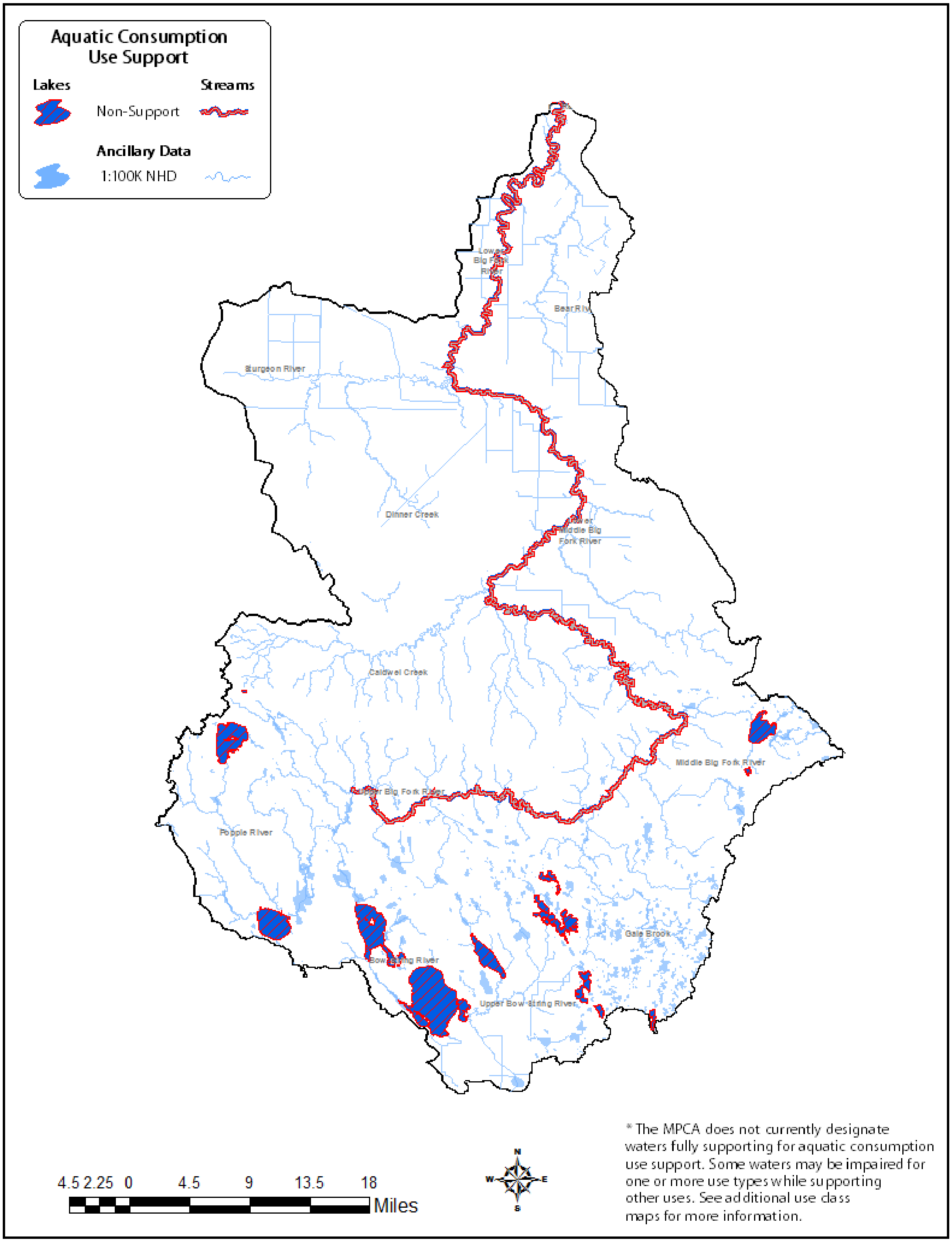

Figure 39. Aquatic consumption use support in the Big Fork River Watershed

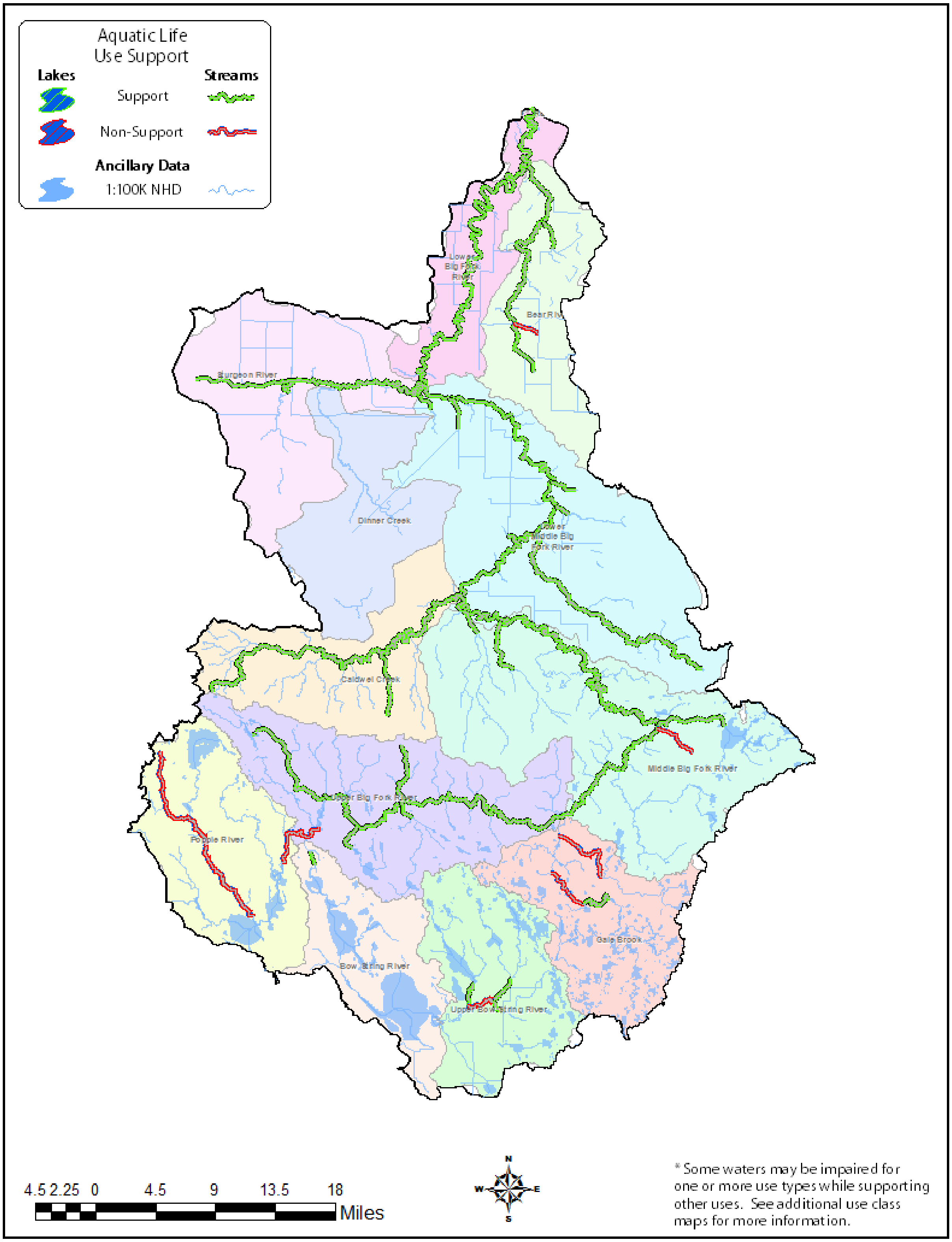

Figure 40. Aquatic life use support in the Big Fork River Watershed

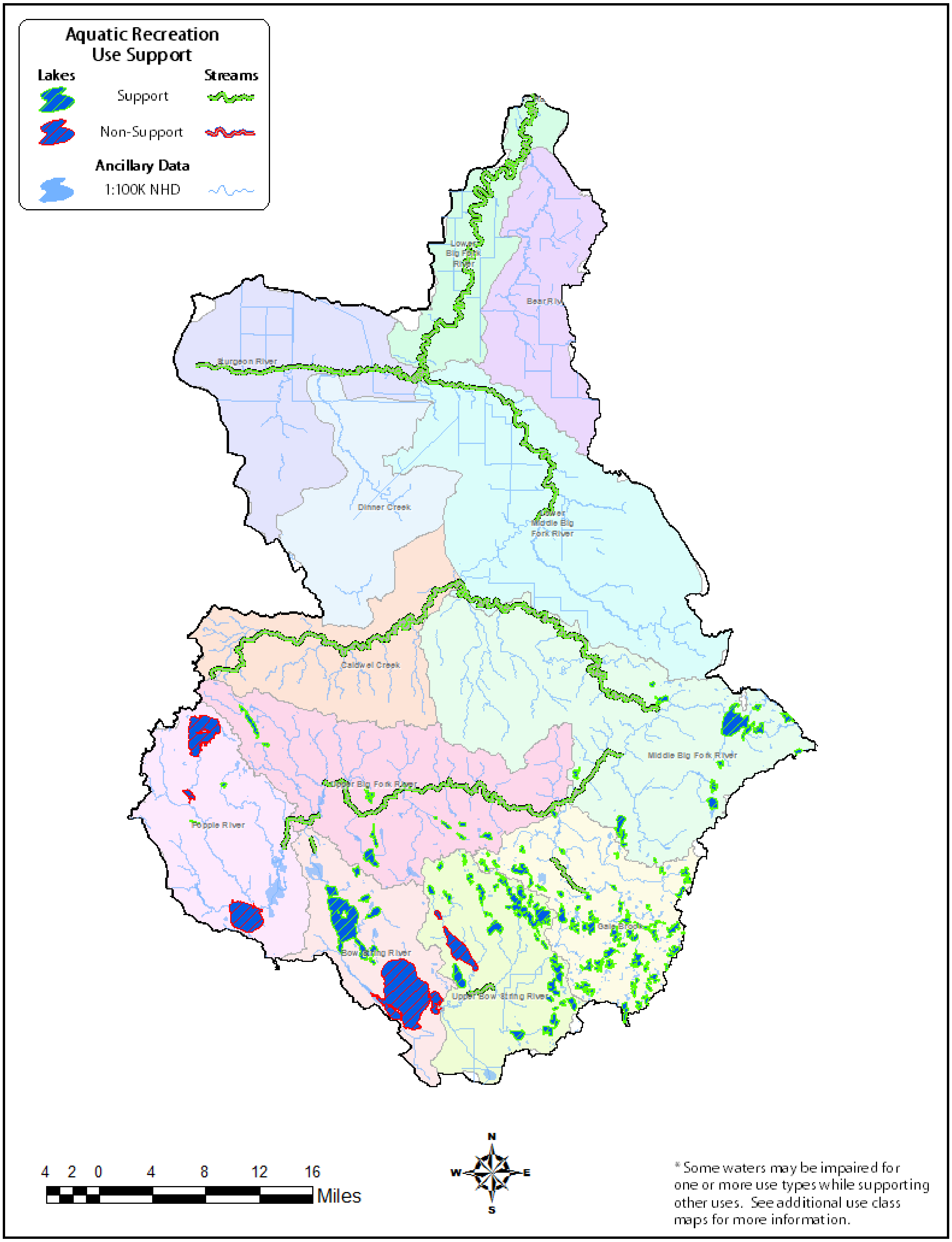

Figure 41. Aquatic recreation use support in the Big Fork River Watershed

VII. Summaries and recommendations

The Big Fork River Watershed is comprised of vast acreages of wetlands and forests. The forested landscape with its many lakes and streams are well defined characteristics that come to mind when people envision the classic north woods of Minnesota. This scenic watershed is only 25% privately owned leaving the majority of the land undeveloped. The undeveloped nature of this watershed is undoubtedly a key reason for the high water quality found throughout the Big Fork River Watershed.

Biological monitoring results identified a number of sensitive fish species within the Big Fork River Watershed. The majority of assessable stream segments met the biological criteria for both fish and macroinvertebrates. Though many of the natural reaches were found to be in good biological standing, the channelized reaches did not score as well. The fish communities were poor for four of the eight channelized reaches and only two were considered good. Channelized reaches scored marginally better for macroinvertebrates with the majority being in fair condition. Habitat as indicated by the MSHA scores, ranged from fair to good, except once again for channelized streams where habitat scores were generally poor.

Lake water quality is generally good. Of the 120 assessable lakes only six did not meet the eutrophication standards.

Big Fork River Watershed impairments found in lakes and streams are likely a function of both natural and anthropogenic causes. Streams flowing through wetland areas often have low DO and buildup of fine sediments. These conditions are natural but may result in stressful condition for biota. Aquatic consumption mercury impairments, caused primarily by atmospheric deposition of mercury from the global burning of fossil fuels, are one of the widest spread impairments in the watershed, including many lakes and the Big Fork River. Nutrient impairments are infrequent and commonly found in shallow lakes with frequent summer mixing intensified by their larger fetch. Often these lakes have development on shore. Even with these impairments, overall conditions are good throughout the watershed.

The Big Fork River system has the benefit of little developmental pressure, but like many northern Minnesota aquatic systems the streams and lakes in the watershed are highly sensitive to even small anthropogenic sources of stress. For this reason continued vigilance is necessary to monitor in areas where developmental pressures are, or will be expected to occur. With few point sources present within the watershed, an emphasis on maintaining a natural vegetative buffer area along shore lines to prevent overland runoff and reduce erosion potential should be considered a key protection strategy to maintain the existing high quality of lakes, rivers and streams in this watershed.

Literature cited

Commission for Environmental Cooperation. Ecological Regions of North America: Toward a Common Perspective. Montréal: Commission for Environmental Cooperation 1997.

McCollor, S., and S. Heiskary. 1993. Selected Water Quality Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoregions. Addendum to Fandrei, G., S. Heiskary, and S. McCollor. 1988. Descriptive Characteristics of the Seven Ecoregions in Minnesota. Division of Water Quality, Program Development Section, Minnesota Pollution Control Agency, St. Paul, Minnesota. 140 p.

Minnesota Conservation Department (MCD). 1959. Hydrologic Atlas of Minnesota. Division of Waters, Minnesota Conservation Department, St. Paul, Minnesota.

Minnesota Pollution Control Agency (MPCA). 2007a. Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment 305(b) Report and 303(d) List. Environmental Outcomes Division, Minnesota Pollution Control Agency, St. Paul, Minnesota.

Minnesota Pollution Control Agency (MPCA). 2007b. Minnesota Statewide Mercury Total Maximum Daily Load. Minnesota Pollution Control Agency, St. Paul, Minnesota.

Minnesota Pollution Control Agency (MPCA). 2008a. Watershed Approach to Condition Monitoring and Assessment. Appendix 7 *in* Biennial Report of the Clean Water Council. Minnesota Pollution Control Agency, St. Paul, Minnesota.

Minnesota Pollution Control Agency (MPCA). 2010a. Aquatic Life Water Quality Standards Draft Technical Support Document for Total Suspended Solids (Turbidity). http://www.pca.state.mn.us/index.php/view-document.html?gid=14922.

Minnesota Pollution Control Agency (MPCA). 2010c. Guidance Manual for Assessing the Quality of Minnesota Surface Water for the Determination of Impairment: 305(b) Report and 303(d) List. Environmental Outcomes Division, Minnesota Pollution Control Agency, St. Paul, Minnesota.

Minnesota Pollution Control Agency (MPCA). 2010d. Minnesota Milestone River Monitoring Report. http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/streams-and-rivers/minnesota-milestone-river-monitoring-program.html.

Minnesota Pollution Control Agency (MPCA). 2010e. Regionalization of Minnesota's Rivers for Application of River Nutrient Criteria. http://www.pca.state.mn.us/index.php/view-document.html?gid=6072.

Minnesota Rules Chapter 7050. 2008. Standards for the Protection of the Quality and Purity of the Waters of the State. Revisor of Statutes and Minnesota Pollution Control Agency, St. Paul, Minnesota.

National Resource Conservation Service (NRCS). 2007. Rapid Watershed Assessment: Big Fork (MN) HUC: 09030006. NRCS. USDA. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_022518.pdf.

Omernik, J.M. and A.L. Gallant. 1988. Ecoregions of the Upper Midwest States. EPA/600/3-88/037. Corvallis, OR: United States Environmental Protection Agency. 56 p.

State Climatology Office- MDNR Division of Ecological and Water Resources. 2010. http://www.climate.umn.edu/doc/hydro_yr_pre_maps.htm.

Waters, T.F. 1977. The Rivers and Streams of Minnesota. University of Minnesota Press, Minneapolis, Minnesota.

Wiken, Ed, Francisco Jiménez Nava, and Glenn Griffith. 2011. North American Terrestrial Ecoregions—Level III. Commission for Environmental Cooperation, Montreal, Canada.

University of Missouri Extension. 1999. Agricultural Phosphorus and Water Quality. Pub. G9181. http://extension.missouri.edu/publications/DisplayPub.aspx?P=G9181.

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-N) - 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-N, with nitrite-nitrogen typically making up a small proportion of the combined total concentration. These and other forms of nitrogen exist naturally in aquatic environments; however concentrations can vary drastically depending on season, biological activity, and anthropogenic inputs.

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

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

Specific conductance - The amount of ionic material dissolved in water. Specific conductance is influenced by the conductivity of rainwater, evaporation and by road salt and fertilizer application.

Temperature - Water temperature in streams varies over the course of the day similar to diurnal air temperature variation. Daily maximum temperature is typically several hours after noon, and the minimum is near sunrise. Water temperature also varies by season as does air temperature.

Total Kjehldahl 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.

Total suspended volatile solids (TSVS) - Volatile solids are solids lost during ignition (heating to 500 degrees C.) They provide an approximation of the amount of organic matter that was present in the water sample. ‘‘Fixed solids’’ is the term applied to the residue of total, suspended, or dissolved solids after heating to dryness for a specified time at a specified temperature. The weight loss on ignition is called ‘‘volatile solids.’’

Unnionized 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 - Intensive watershed monitoring water chemistry stations in the Big Fork River Watershed

Biological Station ID	STORET/ EQuIS ID	Waterbody Name	Location	11-digit HUC
10RN011	S006-328	Big Fork River	Upstream of Hwy 38, in Bigfork	9030006010
10RN006	S006-188	Popple River	Upstream of CR 126, 6 mi. NE of Squaw Lake	9030006010/20
10RN009	S006-212	Bowstring River	Upstream of Hwy 6, 0.5 mi. S of Bowstring	9030006030
10RN007	S006-219	Bowstring River	Downstream of CR 145, 6 mi. NE of Squaw Lake	9030006040
10RN013	S006-208	Rice River	Upstream of CR 254, 4 mi. S of Bigfork	9030006050
10RN022	S002-203	Big Fork River	Upstream of Hwy 6, 7 mi. NW of Craigville	9030006060
10RN024	S006-204	Caldwell Brook	Downstream of Caldwell Rd, 5 mi. NE of Wildwood	9030006070
05RN081	S002-856	Big Fork River	2 mi. Downstream of CR 30, 4 mi. W of Bigfalls	9030006080
10RN039	S006-205	Sturgeon River	Upstream of CR 30, 6 mi. W of Big Falls	9030006100
10RN049	S002-855	Big Fork River	Downstream of CR 1 In Lindford	9030006110
10RN050	S000-173	Big Fork River	Minnesota Highway 11, 2 miles West of Laurel	9030006110
10RN048	S001-150	Bear River	Upstream of CR 1, 4 mi. E of Lindford	9030006120

Appendix 3.1 - AUID table of stream assessment results (by parameter and beneficial use)

AUID Descriptions				Uses				Biological Criteria		Water Quality Standards									Ecoregion Expectations				
National Hydrography Dataset (NHD) Assessment Segment AUID	Stream Segment Name	Segment Description	NHD Length (Miles)	Use Class	Aquatic Life	Aquatic Recreation	Aquatic Consumption	Fish	Macroinvertebrates	Acetochlor	Alachlor	Atrazine	Chloride	Bacteria (Aquatic Recreation)	Metolachlor	Dissolved Oxygen	pH	Turbidity	Un-ionized ammonia	Oxygen Demand (BOD)	Nitrite/Nitrate	Total Phosphorous	Suspended Solids
HUC 11: 9030006010 Upper Big Fork River																							
09030006-599	Unnamed creek	Moose Lk to Big Calf Lk	0.21	2B, 3C	FS	NA			MTS							--	--	--					
09030006-511	Moose Brook	Headwaters (Big Calf Lk 31-0884-00) to Big Fork R	14.66	2B, 3C	FS	NA		MTS	MTS							--	--	--					
09030006-538	Hinken Creek	Lk Helen to Big Fork R	3.49	2B, 3C	FS	NA		MTS	MTS							--	--	--	--				
09030006-505	Big Fork River	Moose Bk to Coon Cr	40.22	2B, 3C	FS	FS	NS	MTS	MTS					MTS		IF	MTS	MTS	MTS	MT		EX	EX
09030006-508	Fletcher Creek	Unnamed cr (Dogfish Lk outlet) to Big Fork R	2.18	2B, 3C	FS	NA			MTS							--	--	--	--				
09030006-637	Harrison Creek	Headwaters to Big Fork R	6.26	2B, 3C	FS	NA		IF	MTS							--	--	--	--				
HUC 11: 9030006020 Popple River																							
09030006-517	Popple River	Headwaters to Round Lk	24.21	2B, 3C	NS	NA		EXS	MTS							--	--	--	--				
09030006-512	Popple River	Natures Lk to Dora Lk	6.39	2B, 3C	NS	FS								MTS		EXS	MTS	MTS	MTS	MT		MT	MT

HUC 11: 9030006030 Upper Bowstring River																							
09030006-582	Turtle River	Little Turtle Cr to Bowstring R	3.36	2B, 3C	FS	NA		MTS	MTS							--	--	--	--				
09030006-576	Bowstring River	Unnamed ditch to Turtle R	1.79	2B, 3C	FS	NA		MTS	MTS								--	--	--				
09030006-575	Bowstring River	Turtle R to Jessie Bk	3.93	2B, 3C	NS	FS		MTS						MTS		IF	MTS	MTS	MTS	MT		EX	EX
09030006-586	Jessie Brook	Jessie Lk to Bowstring R	2.61	2B, 3C	FS	NA		MTS	MTS							--	--	--					
09030006-541	Rice River	Pelton Lk outlet to Lauchoh Lk outlet	1.4	2B, 3C	IF	NA												IF					
HUC 11: 9030006040 Bowstring River																							
09030006-555	Bowstring River	Unnamed lk (Schoolhouse) to Unnamed cr	1.25	2B, 3C	FS	FS		MTS	MTS					MTS		MTS	MTS	MTS	MTS	MT		MT	MT
HUC 11: 9030006050 Gale Brook																							
09030006-644	Rice River	Headwaters (Cameron Lk 31-0544-00) to Batson Lk outlet	4.19	2B, 3C	FS	NA		MTS	MTS							--	--	--					
09030006-539	Rice River	Batson Lk outlet to Pelton Lk outlet	5.11	2B, 3C	NS*	FS		MTS	MTS					MTS		IF	MTS	MTS	MTS	MT		MT	MT
09030006-547	Gale Brook	Isaac Lk outlet to Aspen Lk	8.46	2B, 3C	NS*	NA		MTS	EXP							NA	NA	NA					
09030006-541	Rice River	Pelton Lk outlet to Lauchoh Lk outlet	1.4	2B, 3C	IF	NA												IF					

HUC 11: 9030006060 Middle Big Fork River																							
09030006-506	Big Fork River	Coon Cr to Deer Cr	5.89	2B, 3C	FS	NA		MTS	MTS							--	--	--					
09030006-675	Unnamed creek	Headwaters to Big Fork R	3.67	2B, 3C	NS*	NA		MTS	EXP							--	--	--					
09030006-514	Deer River	Headwaters (Deer Lk 31-0334-00) to Big Fork R	8.27	2B, 3C	FS	NA		MTS	MTS							--	--	--	--				
09030006-504	Big Fork River	Deer Cr to Caldwell Bk	39.57	2B, 3C	FS	FS		MTS	MTS					MTS		MTS	MTS	MTS	MTS	MT		MT	EX
09030006-611	Bowerman Brook	Unnamed cr to Big Fork R	7.88	2B, 3C	FS	NA		MTS	MTS							--	--	--					
09030006-612	Plum Creek	Wade Bk to Big Fork R	4.34	2B, 3C	FS	NA		MTS	MTS							--	--	--	--				
HUC 11: 9030006070 Caldwell Creek																							
09030006-673	Unnamed creek	Headwaters to Caldwell Bk	5.53	2B, 3C	FS	NA			MTS							NA	NA	NA					
09030006-510	Caldwell Brook	Headwaters to Big Fork R	49.83	2B, 3C	FS	FS		MTS	MTS					MTS		MTS	MTS	MTS	MTS	MT	MT		EX
HUC 11: 9030006080 Lower Middle Big Fork River																							
09030006-507	Big Fork River	Caldwell Bk to Reilly Bk	10.87	2B, 3C	FS	NA		MTS	MTS							--	--	--	--				
09030006-683	Unnamed creek	Unnamed ditch to Big Fork R	1.36	2B, 3C	FS	NA		MTS	MTS							--	--	--	--				
09030006-515	Reilly Brook	Headwaters to Big Fork R	39.29	2B, 3C	FS	NA		MTS	MTS							--	--	--	--				
09030006-625	Reilly Creek	Unnamed cr to Big Fork R	1.83	2B, 3C	FS	NA		MTS	MTS							--	--	--					
09030006-682	Macaffee Brook	Headwaters to Big Fork R	2.5	2B, 3C	FS	NA		MTS	MTS							--	--	--	--				
09030006-620	Unnamed ditch	Unnamed ditch to Big Fork R	2.97	2B, 3C	FS	NA		MTS	MTS							--	--	--					
09030006-677	Unnamed creek	Unnamed cr to Sturgeon R	2.71	2B, 3C	FS	NA		MTS								--	--	--					
09030006-503	Big Fork River	Reilly Bk to Sturgeon R	24.85	2B, 3C	FS	FS		MTS	MTS	MTS	NA	MTS	MTS	MTS	MTS	MTS	MTS	MTS	MTS	MT	MT		MT

HUC 11: 9030006090 Dinner Creek																							
09030006-592	Dinner Creek	Headwaters to Sturgeon R	25.63	1B, 2A, 3B	IF	NA		IF	IF							--	--	--	--				
HUC 11: 9030006100 Sturgeon River																							
09030006-610	Hay Creek	Unnamed cr to Sturgeon R	2.27	2B, 3C	FS	NA		MTS	MTS							--	--	--	--				
09030006-509	Sturgeon River	Headwaters to Big Fork R	26.2	2B, 3C	FS	FS		MTS	MTS					MTS		IF	MTS	MTS	MTS	MT	MT	MT	
HUC 11: 9030006110 Lower Big Fork River																							
09030006-501	Big Fork River	Bear R to Rainy R	9.26	2B, 3C	FS	FS		MTS	MTS				MTS	MTS		MTS	MTS	EXP	MTS				
09030006-502	Big Fork River	Sturgeon R to Bear R	38.03	2B, 3C	FS	FS		MTS	MTS					MTS		MTS	MTS	MTS	MTS	MT	MT	MT	
HUC 11: 9030006120 Bear River																							
09030006-516	Bear Creek	Headwaters to Big Fork R	34.52	2B, 3C	FS	IF		MTS	MTS					IF		MTS	MTS	MTS	MTS	MT		MT	MT
09030006-609	Unnamed creek	Unnamed cr to Bear R	1.58	2B, 3C	FS	NA		MTS	MTS							--	--	--	--				
09030006-678	Unnamed creek	Unnamed cr to Unnamed cr	1.18	2B, 3C	FS	NA		MTS	MTS							--	--	--					
09030006-679	Hay Creek	Unnamed ditch to Bear Cr	2.23	2B, 3C	IF	NA		EXS	EXS							--	--	--	--				

Full Support (FS); Not Supporting (NS); Insufficient Data (IF); Not Assessed (NA); Meets standards or ecoregion expectations (MT/MTS), Potential Exceedence (EXP), Exceeds standards or ecoregion expectations (EX/EXS).
Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use. *Trib. to Caldwell Brook
Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.
*Non-supporting due to natural background conditions resulting in low dissolved oxygen.
**Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

Appendix 3.2 - Assessment results for lakes in the Big Fork River Watershed

Lake ID	Lake Name	County	HUC-11	Ecoregion	Lake Area (ha)	Max Depth (m)	Watershed Area (ha)	% Littoral	Mean depth (m)	Support Status
31-0889-00	Glove	Itasca	9030006010	NLF	14	11	0.14	85.3		IF
31-0882-00	Dora	Itasca	9030006010	NLF	477	16	440	97	8.1	IF
31-0843-00	Whitefish	Itasca	9030006010	NLF	561	51	15.1	46.4	15.3	FS
31-0898-00	Moose	Itasca	9030006010	NLF	373	52	8.8	26.1	23.1	FS
31-0839-00	Holloway	Itasca	9030006010	NLF	202	40	1.29	0	13	FS
31-0782-00	Gunderson	Itasca	9030006010	NLF	172	42	1.16	32	17.6	FS
31-0845-00	Clear	Itasca	9030006010	NMW	137	29	0.42	43.6	13.6	FS
31-0805-00	Arrowhead	Itasca	9030006010	NLF	129	30	1.21	14		FS
31-0803-00	Trestle	Itasca	9030006010	NLF	105	30	1.22	33.1	16.4	FS
31-0802-00	Lac a Roy	Itasca	9030006010	NLF	89	30	0.8	79.2		FS
31-0713-00	Bustic	Itasca	9030006010	NLF	78	35	0.36	43		FS
31-0837-00	Noma	Itasca	9030006010	NMW	59	47	0.15	50.4		FS
31-0886-00	Eel	Itasca	9030006010	NLF	38	40	2.49	0		FS
31-0804-00	Holland	Itasca	9030006010	NLF	24	45	1.63	39.2		FS
31-0904-00	Dunbar	Itasca	9030006020	NLF	273	30	25.4	64	11.8	IF
31-0896-00	Round	Itasca	9030006020	NLF	2959	24	104	69.6	12.1	NS
31-0913-00	Island	Itasca	9030006020	NLF	2920	37	16.5	38.7	15.2	NS
31-0910-00	Shallow Pond	Itasca	9030006020	NLF	222	10	26	100	4	NS
31-0912-00	Wagner	Itasca	9030006020	NLF	63	60	5.95	0		FS
31-0911-00	Hamrey	Itasca	9030006020	NLF	46	60	1.55	0		FS

Lake ID	Lake Name	County	HUC-11	Ecoregion	Lake Area (ha)	Max Depth (m)	Watershed Area (ha)	% Littoral	Mean depth (m)	Support Status
31-0786-00	Jessie	Itasca	9030006030	NLF	1782	42	32.6	26	22.5	NS
31-0797-00	Little Spring	Itasca	9030006030	NLF	139	9	12.9	100	4.6	NS
31-0725-00	Turtle	Itasca	9030006030	NLF	2066	137	23.2	27.1	32.4	FS
31-0653-00	North Star	Itasca	9030006030	NLF	907	89	4.91	29.7	25.5	FS
31-0784-00	Little Jessie	Itasca	9030006030	NLF	613	49	3.07	32.3	26.2	FS
31-0624-00	Grave	Itasca	9030006030	NLF	538	39	6.19	60.8	13.6	FS
31-0779-00	Little Turtle	Itasca	9030006030	NLF	470	30	12.7	47.6	13	FS
31-0758-00	Little Bowstring	Itasca	9030006030	NLF	314	33	10.5	35.7		FS
31-0793-00	Big Too Much	Itasca	9030006030	NLF	280	95	7.58	24.1	26.5	FS
31-0771-00	Hatch	Itasca	9030006030	NLF	245	88	3.82	20	35.5	FS
31-0620-00	Caribou	Itasca	9030006030	NLF	240	152	1.31	18.8	46.8	FS
31-0773-00	Maple	Itasca	9030006030	NLF	235	39	7.95	33.6	17	FS
31-0791-00	Peterson	Itasca	9030006030	NLF	180	55	2.44	72	10.9	FS
31-0788-00	La Croix	Itasca	9030006030	NLF	137	80	4.7	0	15.5	FS
31-0789-00	Spring	Itasca	9030006030	NLF	121	36	5.4	40	16	FS
31-0727-00	Grass	Itasca	9030006030	NLF	116	54	0.87	83.8	6.1	FS
31-0622-00	Dead Horse	Itasca	9030006030	NLF	96	36	4.07	60.6	12.5	FS
31-0798-00	East	Itasca	9030006030	NLF	92	30	1.49	57	12	FS
31-0809-00	Crooked	Itasca	9030006030	NLF	90	110	1.77	0		FS
31-0774-00	Elbow	Itasca	9030006030	NLF	75	12	0.3	0		FS
31-0778-00	Little Too Much	Itasca	9030006030	NLF	73	60	8.6	43		FS

Lake ID	Lake Name	County	HUC-11	Ecoregion	Lake Area (ha)	Max Depth (m)	Watershed Area (ha)	% Littoral	Mean depth (m)	Support Status
31-0621-00	Little Dead Horse	Itasca	9030006030	NLF	70	30	2.07	75.1		FS
31-0666-00	Unnamed	Itasca	9030006030	NLF	53		N/A	0	24.8	FS
31-0665-00	Little North Star	Itasca	9030006030	NLF	50	43	0.5	53.7		FS
31-0660-00	Little Ranier	Itasca	9030006030	NLF	48	40	0.39	0		FS
31-0623-00	Boy	Itasca	9030006030	NLF	26	40	0.3	37		FS
31-0813-00	Bowstring	Itasca	9030006040	NLF	8900	32	200	51.4	14.5	NS
31-0826-00	Sand	Itasca	9030006040	NLF	3785	70	243	44	17.2	FS
31-0824-00	Portage	Itasca	9030006040	NLF	756	60	243	52		FS
31-0832-00	Rush Island	Itasca	9030006040	NLF	294	29	8.5	30.7	19	FS
31-0853-00	Little Sand	Itasca	9030006040	NLF	222	19	248	63.8	11	FS
31-0829-00	Cedar	Itasca	9030006040	NLF	181	45	3	21	18.5	FS
31-0836-00	Little Whitefish	Itasca	9030006040	NLF	154	15	0.67	100	6	FS
31-0726-00	Bello	Itasca	9030006050	NLF	492	58	4.7	50.8	12.6	FS
31-0650-00	Smith	Itasca	9030006050	NLF	351	32	3.96	56.1	12	FS
31-0480-00	Gunn	Itasca	9030006050	NLF	347	39	16.7	41.5	15.1	FS
31-0687-00	Johnson	Itasca	9030006050	NLF	288	50	17.5	0	23.5	FS
31-0350-00	Anderson	Itasca	9030006050	NLF	284	100	4.5	25.9	13.5	FS
31-0422-00	Ruby	Itasca	9030006050	NLF	271	88	1.16	37	31.9	FS
31-0454-00	Eagle	Itasca	9030006050	NLF	261	35	3.1	75	15.4	FS
31-0540-00	Clubhouse	Itasca	9030006050	NLF	244	103	27.6	33.7	30.3	FS
31-0656-00	Big Dick	Itasca	9030006050	NLF	234	25	1.7	61.4	11.6	FS

Lake ID	Lake Name	County	HUC-11	Ecoregion	Lake Area (ha)	Max Depth (m)	Watershed Area (ha)	% Littoral	Mean depth (m)	Support Status
31-0463-00	Fox	Itasca	9030006050	NLF	233	75	20.1	69.6	12.4	FS
31-0671-00	Big Island	Itasca	9030006050	NLF	220	42	1.4	85	8.8	FS
31-0473-00	Mary	Itasca	9030006050	NLF	197	45	1.5	0		FS
31-0670-00	Big Ole	Itasca	9030006050	NLF	185	61	6.6	0	15.1	FS
31-0490-00	Elizabeth	Itasca	9030006050	NLF	180	42	3.1	46.3	17.3	FS
31-0460-00	East	Itasca	9030006050	NLF	179	65	15.1	38	18.9	FS
31-0654-00	Burns	Itasca	9030006050	NLF	171		2.5	0	40	FS
31-0514-00	Brush Shanty	Itasca	9030006050	NLF	151	35	2.18	33	14.4	FS
31-0616-00	East Smith	Itasca	9030006050	NLF	146	38	2	46.9	12.9	FS
31-0466-00	Horseshoe	Itasca	9030006050	NLF	123	58	7.8	35.1	19.4	FS
31-0781-00	Long	Itasca	9030006050	NLF	121	75	1.6	26.1	20.2	FS
31-0502-00	Slauson	Itasca	9030006050	NLF	110	40	49.8	43	15.7	FS
31-0704-00	Batson	Itasca	9030006050	NLF	107	50	22.6	35	20	FS
31-0416-00	Black Island	Itasca	9030006050	NLF	103	59	2.1	66.6	11.7	FS
31-0543-00	Crooked	Itasca	9030006050	NLF	103	46	3.6	66	9.2	FS
31-0417-00	Nose	Itasca	9030006050	NLF	102	47	1.4	50.9	15.3	FS
31-0706-00	Mike	Itasca	9030006050	NLF	101	20	1.86	0	3.9	FS
31-0455-00	Mink	Itasca	9030006050	NLF	98	50	9.7	0		FS
31-0481-00	Highland	Itasca	9030006050	NLF	98	38	3.99	55.1	12.3	FS
31-0497-00	Fifth Chain	Itasca	9030006050	NLF	89		N/A	0		FS
31-0452-00	Gunn	Itasca	9030006050	NLF	88	75	10.5	0		FS

Lake ID	Lake Name	County	HUC-11	Ecoregion	Lake Area (ha)	Max Depth (m)	Watershed Area (ha)	% Littoral	Mean depth (m)	Support Status
31-0658-00	Little Dick	Itasca	9030006050	NLF	85	20	1.35	0		FS
31-0664-00	Ranier	Itasca	9030006050	NLF	81	45	0.4	0		FS
31-0764-00	Jingo	Itasca	9030006050	NLF	78	60	0.46	48		FS
31-0705-00	Lundeen	Itasca	9030006050	NLF	75	30	19.3	48		FS
31-0513-00	Gale	Itasca	9030006050	NLF	73	50	0.7	51		FS
31-0544-00	Cameron	Itasca	9030006050	NLF	73	37	51.6	59.8		FS
31-0768-00	Big Rose	Itasca	9030006050	NLF	69	25	0.3	94.9		FS
31-0451-00	Three Island	Itasca	9030006050	NLF	66	28	0.52	0		FS
31-0478-00	Pine	Itasca	9030006050	NLF	65	44	0.85	0		FS
31-0459-00	Little East	Itasca	9030006050	NLF	61	100	0.52	0		FS
31-0686-00	Bevo	Itasca	9030006050	NLF	53	40	0.21	60		FS
31-0692-00	Lauchoh	Itasca	9030006050	NLF	50	40	5.82	45		FS
31-0507-00	Marie	Itasca	9030006050	NLF	49	35	0.4	84.9		FS
31-0487-00	Lum	Itasca	9030006050	NLF	48	24	0.31	86.5		FS
31-0522-00	La Barge	Itasca	9030006050	NLF	39	30	13	0		FS
31-0700-00	McDonald	Itasca	9030006050	NLF	28		N/A	0		FS
31-0808-00	Little Round	Itasca	9030006050	NLF	28	10	0.4	0		FS
31-0464-00	Oar	Itasca	9030006050	NLF	27	60	8.16	0		FS
31-0479-00	Little Clubhouse	Itasca	9030006050	NLF	27		20.5	0		FS
31-0470-00	Unnamed (Nickel)	Itasca	9030006050	NLF	13	36.5	0.1	44.7		FS
31-0465-00	Oak	Itasca	9030006050	NLF	12		7.8	0		FS

Lake ID	Lake Name	County	HUC-11	Ecoregion	Lake Area (ha)	Max Depth (m)	Watershed Area (ha)	% Littoral	Mean depth (m)	Support Status
31-0657-02	Jack the Horse (S)	Itasca	9030006050	NLF	383	45	3.48	0	11.8	FS
31-0334-00	Deer	Itasca	9030006060	NLF	1891	50	38.4	76.2	8.6	FS
31-0318-00	Coon	Itasca	9030006060	NLF	310	30	3.07	60	9.3	FS
31-0197-00	Battle	Itasca	9030006060	NLF	259	15	7.95	100	8.1	FS
31-0530-00	Busties	Itasca	9030006060	NLF	237	45	2.25	0	12.4	FS
31-0339-00	Pickerel	Itasca	9030006060	NLF	230	70	18.4	52	17	FS
31-0183-00	Five Island	Itasca	9030006060	NLF	219	32	1.47	63.4	11.5	FS
31-0317-00	Larson	Itasca	9030006060	NLF	190	177	1.63	26	42.9	FS
31-0710-00	Connors	Itasca	9030006060	NMW	131	65	1	29.8	14.9	FS
31-0316-00	Bass	Itasca	9030006060	NLF	112	45	0.4	28	24.3	FS
31-0196-00	Poplar	Itasca	9030006060	NLF	110	50	3.66	25	27.8	FS
31-0160-00	Mirror	Itasca	9030006060	NLF	102	44	0.63	45.7	17.9	FS
31-0528-00	Round	Itasca	9030006060	NLF	52	60	0.62	0		FS
31-0512-00	Erickson	Itasca	9030006060	NLF	30	70	0.44	0		FS
31-0524-01	Coon-Sandwick (Coon Lk)	Itasca	9030006060	NLF	0	36	2.84	0	9	FS
31-0524-02	CoonSandwick (Sandwick Lk)	Itasca	9030006060	NLF	0	36	2.84	0	6	FS

Abbreviations: **FS** – Full Support
NS – Non-Support
IF – Insufficient Information
N/A – Not Assessed

Key for Cell Shading: impairment, full support of designated use.
*These depths were created by MPCA Staff.

Appendix 4.1 - Minnesota statewide IBI thresholds and confidence limits

Class #	Class Name	Use Class	Threshold	Confidence Limit	Upper	Lower
Fish						
1	Southern Rivers	2B, 2C	39	±11	50	28
2	Southern Streams	2B, 2C	45	±9	54	36
3	Southern Headwaters	2B, 2C	51	±7	58	44
10	Southern Coldwater	2A	45	±9	58	32
4	Northern Rivers	2B, 2C	35	±9	44	26
5	Northern Streams	2B, 2C	50	±9	59	41
6	Northern Headwaters	2B, 2C	40	±16	56	24
7	Low Gradient	2B, 2C	40	±10	50	30
11	Northern Coldwater	2A	37	±10	47	27
Macroinvertebrates						
1	Northern Forest Rivers	2B, 2C	51.3	±10.8	62.1	40.5
2	Prairie Forest Rivers	2B, 2C	30.7	±10.8	41.5	19.9
3	Northern Forest Streams RR	2B, 2C	50.3	±12.6	62.9	37.7
4	Northern Forest Streams GP	2B, 2C	52.4	±13.6	66	38.8
5	Southern Streams RR	2B, 2C	35.9	±12.6	48.5	23.3
6	Southern Forest Streams GP	2B, 2C	46.8	±13.6	60.4	33.2
7	Prairie Streams GP	2B, 2C	38.3	±13.6	51.9	24.7
8	Northern Coldwater	2A	26	±12.4	38.4	13.6
9	Southern Coldwater	2A	46.1	±13.8	59.9	32.3

Appendix 4.2 - Biological monitoring results – fish IBI (assessable reaches)

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Threshold	FIBI	Visit Date
HUC 11: 09030006010 Upper Big Fork River Watershed							
09030006-505	05RN106	Big Fork River	772.08	4	35	51	28-Sep-05
09030006-505	05RN106	Big Fork River	772.08	4	35	64	24-Aug-05
09030006-505	05RN175	Big Fork River	567.33	4	35	68	12-Jul-05
09030006-505	10RN011	Big Fork River	622.88	4	35	69	9-Sep-10
09030006-505	10RN032	Big Fork River	529.42	4	35	54	10-Aug-10
09030006-508	10RN033	Fletcher Creek	16.21	7	40	44	7-Jul-12
09030006-511	05RN093	Moose Brook	24.61	7	40	49	11-Jul-05
09030006-511	10RN029	Moose Brook	27.45	7	40	58	10-Aug-10
09030006-511	10RN029	Moose Brook	27.45	7	40	50	28-Jun-10
09030006-538	10RN031	Hinken Creek	22.28	7	40	45	21-Jun-10
09030006-599	05RN185	Unnamed creek	8.77	6	56	72	2-Aug-06
09030006-637	10RN034	Harrison Creek	8.01	7	40	28	21-Jun-10
HUC 11: 09030006020 Popple River Watershed							
09030006-512	10RN006	Popple River	159.51	5	59	18	10-Aug-10
09030006-517	10RN001	Popple River	13.76	7	40	0	22-Jun-10
09030006-535	10RN004	Wagner Creek	18.59	7	40	0	22-Jun-10
09030006-638	10RN002	Dunbar Creek	9.44	7	40	21	22-Jun-10
HUC 11: 09030006030 Upper Bowstring River Watershed							
09030006-575	10RN009	Bowstring River	90.64	5	59	59	12-Jul-10
09030006-576	05RN047	Bowstring River	40.39	7	40	57	24-Aug-05
09030006-582	99NF010	Turtle River	45.57	7	40	50	12-Jul-10
09030006-586	10RN010	Jessie Brook	36.78	7	40	45	14-Jun-10
HUC 11: 09030006040 Bowstring River Watershed							
09030006-555	05RN082	Bowstring River	255.14	5	59	59	28-Sep-05
09030006-555	10RN007	Bowstring River	255.64	5	59	65	31-Aug-10

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Threshold	FIBI	Visit Date
HUC 11: 09030006050 Gale Brook Watershed							
09030006-539	10RN013	Rice River	80.76	5	59	70	30-Aug-10
09030006-547	10RN014	Gale Brook	21.42	7	40	61	28-Jun-10
09030006-644	10RN012	Rice River	53.83	5	59	75	29-Jun-10
HUC 11: 09030006060 Middle Big Fork River							
09030006-504	05RN046	Big Fork River	942.59	4	35	81	25-Aug-05
09030006-504	05RN060	Big Fork River	932.1	4	35	68	21-Jul-05
09030006-504	10EM137	Big Fork River	1014.59	4	35	70	21-Sep-10
09030006-504	10RN022	Big Fork River	985.84	4	35	73	9-Sep-10
09030006-506	10EM025	Big Fork River	862.34	4	35	72	20-Sep-11
09030006-506	10EM025	Big Fork River	862.34	4	35	78	20-Sep-10
09030006-506	10RN018	Big Fork River	870.63	4	35	67	26-Jul-11
09030006-506	10RN018	Big Fork River	870.63	4	35	86	30-Aug-10
09030006-514	10RN019	Deer River	54.43	5	59	50	29-Jun-10
09030006-611	10RN021	Bowerman Brook	24.94	6	56	63	30-Jun-10
09030006-612	05RN092	Plum Creek	39.54	6	56	80	1-Jul-10
09030006-612	05RN092	Plum Creek	39.54	6	56	44	6-Jul-05
09030006-674	10RN016	Unnamed creek	10.87	7	40	0	8-Sep-10
09030006-675	10RN020	Unnamed creek	5.55	6	56	48	15-Jun-10
HUC 11: 09030006070 Caldwell Creek Watershed							
09030006-510	10RN024	Caldwell Brook	122.06	5	59	64	28-Jul-10
HUC 11: 09030006080 Lower Middle Big Fork River Watershed							
09030006-503	05RN081	Big Fork River	1529.05	4	35	77	1-Sep-10
09030006-503	05RN081	Big Fork River	1529.05	4	35	84	26-Jul-11
09030006-503	05RN081	Big Fork River	1529.05	4	35	85	3-Aug-05
09030006-507	10RN025	Big Fork River	1288.11	4	35	80	31-Aug-10
09030006-507	10RN025	Big Fork River	1288.11	4	35	72	2-Aug-10
09030006-515	10RN045	Reilly Brook	35.9	6	56	83	24-Aug-10
09030006-620	10RN042	Unnamed ditch	23.67	6	56	75	13-Jul-10
09030006-625	10RN046	Reilly Creek	62.26	5	59	41	13-Jul-10

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Threshold	FIBI	Visit Date
HUC 11: 09030006080 Lower Middle Big Fork River Watershed Continued							
09030006-677	10RN041	Unnamed creek	8.84	6	56	66	3-Aug-10
09030006-682	10RN052	Macaffee Brook	8.44	6	56	57	4-Aug-10
09030006-682	10RN052	Macaffee Brook	8.44	6	56	64	23-Jun-10
09030006-683	10RN057	Unnamed creek	12.13	6	56	54	11-Aug-10
09030006-683	10RN057	Unnamed creek	12.13	6	56	69	23-Jun-10
09030006-685	10RN055	Unnamed creek (Trout Brook)	0.67	11	37	63	8-Sep-10
09030006-686	10RN058	Unnamed creek	12.12	6	56	0	11-Aug-10
HUC 11: 09030006090 Dinner Creek Watershed							
09030006-592	10RN036	Dinner Creek	36.26	11	37	46	10-Aug-10
09030006-592	10RN036	Dinner Creek	36.26	11	37	36	29-Jul-10
09030006-592	10RN060	Dinner Creek	111.71	11	37	29	25-Aug-10
HUC 11: 09030006100 Sturgeon River Watershed							
09030006-509	05RN002	Sturgeon River	300.15	5	59	76	25-Aug-10
09030006-509	05RN002	Sturgeon River	300.15	5	59	83	3-Aug-05
09030006-509	10RN039	Sturgeon River	285.79	5	59	70	27-Jul-11
09030006-610	05RN053	Hay Creek	68.61	5	59	65	4-Aug-05
HUC 11: 09030006110 Lower Big Fork River Watershed							
09030006-501	10RN050	Big Fork River	2055.64	4	35	91	8-Sep-10
09030006-502	10RN040	Big Fork River	1843.73	4	35	51	2-Sep-10
09030006-502	10RN049	Big Fork River	1906.07	4	35	85	27-Jul-11
09030006-502	10RN049	Big Fork River	1906.07	4	35	87	1-Sep-10
HUC 11: 09030006120 Bear River Watershed							
09030006-516	10RN048	Bear Creek	97.41	5	59	57	13-Jul-10
09030006-609	05RN050	Unnamed creek	13.25	6	56	54	15-Aug-05
09030006-609	05RN050	Unnamed creek	13.25	6	56	56	7-Jul-05
09030006-678	10RN047	Unnamed creek	11.34	6	56	67	4-Aug-10
09030006-679	10RN044	Hay Creek	12.89	7	40	0	4-Aug-10

Appendix 4.3 - Biological monitoring results-macroinvertebrate IBI (assessable reaches)

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Invert Class	Threshold	MIBI	Visit Date
HUC 11: 09030006010 Upper Big Fork River Watershed							
09030006-505	05RN175	Big Fork River	567.33	1	51.3	51.79	29-Aug-05
09030006-505	10RN032	Big Fork River	529.42	1	51.3	53.79	3-Aug-11
09030006-505	05RN106	Big Fork River	772.08	1	51.3	62.58	18-Aug-05
09030006-508	10RN033	Fletcher Creek	16.21	4	52.4	66.49	3-Aug-11
09030006-511	05RN093	Moose Brook	24.61	4	52.4	61.33	16-Aug-05
09030006-511	10RN029	Moose Brook	27.45	4	52.4	69.23	3-Aug-11
09030006-512	10RN006	Popple River	159.51	4	52.4	38.81	22-Sep-10
09030006-530	05RN041	Windigo Creek	4.81	4	52.4	39.15	16-Aug-05
09030006-533	10EM117	Unnamed creek	13.18	4	52.4	21.55	21-Sep-10
09030006-538	10RN031	Hinken Creek	22.28	4	52.4	63.29	3-Aug-11
09030006-599	05RN185	Unnamed creek	8.77	4	52.4	52.15	14-Aug-06
09030006-613	05RN019	Unnamed creek	10.65	4	52.4	40.99	15-Aug-05
09030006-637	10RN034	Harrison Creek	8.01	4	52.4	52.73	3-Aug-11
HUC 11: 09030006020 Popple River Watershed							
09030006-517	10RN001	Popple River	13.76	4	52.4	58.88	3-Aug-11
09030006-638	10RN002	Dunbar Creek	9.44	4	52.4	33.74	3-Aug-11
HUC 11: 09030006030 Upper Bowstring River Watershed							
09030006-576	05RN047	Bowstring River	40.39	4	52.4	63.36	29-Aug-05
09030006-582	99NF010	Turtle River	45.57	4	52.4	67.61	1-Aug-11
09030006-586	10RN010	Jessie Brook	36.78	4	52.4	59.15	1-Aug-11
HUC 11: 09030006040 Bowstring River Watershed							
09030006-555	10RN007	Bowstring River	255.64	4	52.4	32.93	31-Aug-10
09030006-555	05RN082	Bowstring River	255.14	4	52.4	50.49	15-Aug-05
HUC 11: 09030006050 Gale Brook Watershed							
09030006-539	10RN013	Rice River	80.76	4	52.4	53.45	1-Aug-11
09030006-547	10RN014	Gale Brook	21.42	4	52.4	26.13	21-Sep-10
09030006-644	10RN012	Rice River	53.83	4	52.4	81.26	8-Sep-10

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Invert Class	Threshold	MIBI	Visit Date
HUC 11: 09030006060 Middle Big Fork River Watershed							
09030006-504	10EM137	Big Fork River	1014.59	1	51.3	42.79	21-Sep-10
09030006-504	10RN022	Big Fork River	985.84	1	51.3	76.97	2-Aug-11
09030006-504	05RN046	Big Fork River	942.59	1	51.3	78.16	24-Aug-05
09030006-504	05RN060	Big Fork River	932.1	1	51.3	86.53	24-Aug-05
09030006-506	10EM025	Big Fork River	862.34	1	51.3	42	20-Sep-10
09030006-506	10EM025	Big Fork River	862.34	1	51.3	45.38	20-Sep-11
09030006-506	10RN018	Big Fork River	870.63	1	51.3	46.97	30-Aug-10
09030006-514	10RN019	Deer River	54.43	3	50.3	62	31-Aug-10
09030006-611	10RN021	Bowerman Brook	24.94	4	52.4	52.53	2-Aug-10
09030006-612	05RN092	Plum Creek	39.54	4	52.4	59.2	2-Aug-10
09030006-612	05RN092	Plum Creek	39.54	4	52.4	64.7	17-Aug-05
09030006-674	10RN016	Unnamed creek	10.87	4	52.4	28.33	8-Sep-10
09030006-675	10RN020	Unnamed creek	5.55	4	52.4	30.51	31-Aug-10
HUC 11: 09030006070 Caldwell Creek Watershed							
09030006-510	05RN080	Caldwell Brook	34.17	4	52.4	32.62	16-Aug-05
09030006-510	05RN080	Caldwell Brook	34.17	4	52.4	41.59	30-Aug-05
09030006-510	10RN024	Caldwell Brook	122.06	4	52.4	66.72	24-Aug-10
09030006-626	10RN027	Pancake Creek	19.18	4	52.4	44.33	4-Aug-10
09030006-673	10RN026	Unnamed creek	4.76	4	52.4	57.84	2-Aug-11
HUC 11: 09030006080 Lower Middle Big Fork River Watershed							
09030006-503	05RN081	Big Fork River	1529.05	1	51.3	61.52	1-Sep-10
09030006-503	05RN081	Big Fork River	1529.05	1	51.3	75.12	30-Aug-05
09030006-503	05RN081	Big Fork River	1529.05	1	51.3	75.72	16-Aug-05
09030006-507	10RN025	Big Fork River	1288.11	1	51.3	64.93	31-Aug-10

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Invert Class	Threshold	MIBI	Visit Date
HUC 11: 09030006080 Lower Middle Big Fork River Watershed Continued							
09030006-515	10RN045	Reilly Brook	35.9	4	52.4	62.98	3-Aug-10
09030006-620	10RN042	Unnamed ditch	23.67	3	50.3	53.68	3-Aug-10
09030006-625	10RN046	Reilly Creek	62.26	4	52.4	71.04	3-Aug-10
09030006-682	10RN052	Macaffee Brook	8.44	4	52.4	59.01	3-Aug-10
09030006-683	10RN057	Unnamed creek	12.13	3	50.3	48.93	25-Aug-10
09030006-686	10RN058	Unnamed creek	12.12	3	50.3	42.18	25-Aug-10
HUC 11: 09030006090 Dinner Creek River Watershed							
09030006-592	10RN036	Dinner Creek	36.26	8	26	15.27	4-Aug-10
09030006-592	10RN060	Dinner Creek	111.71	8	26	34.62	2-Aug-11
09030006-592	10RN060	Dinner Creek	111.71	8	26	36.58	2-Aug-11
HUC 11: 09030006100 Sturgeon River Watershed							
09030006-509	10RN035	Sturgeon River	58.59	4	52.4	45.91	4-Aug-10
09030006-509	05RN002	Sturgeon River	300.15	3	50.3	61.47	2-Aug-11
09030006-509	10RN039	Sturgeon River	285.79	4	52.4	79.74	3-Aug-10
09030006-509	05RN002	Sturgeon River	300.15	3	50.3	83.03	16-Aug-05
09030006-610	05RN053	Hay Creek	68.61	4	52.4	85.63	16-Aug-05
09030006-676	10RN053	Unnamed creek	8.05	4	52.4	27.05	24-Aug-10
HUC 11: 09030006110 Lower Big Fork River Watershed							
09030006-501	10RN050	Big Fork River	2055.64	1	51.3	74.39	8-Sep-10
09030006-502	10RN049	Big Fork River	1906.07	1	51.3	69.69	1-Sep-10
HUC 11: 09030006120 Bear River Watershed							
09030006-516	10RN043	Bear Creek	40.08	4	52.4	51.83	4-Aug-10
09030006-516	10RN048	Bear Creek	97.41	4	52.4	76.9	3-Aug-10
09030006-609	05RN050	Unnamed creek	13.25	4	52.4	79.64	17-Aug-05
09030006-678	10RN047	Unnamed creek	11.34	4	52.4	74.94	5-Aug-10
09030006-679	10RN044	Hay Creek	12.89	4	52.4	13.17	5-Aug-10
09030006-681	10RN056	Unnamed ditch	2.64	4	52.4	31.31	2-Aug-11

Appendix 5.1 - Good/fair/poor thresholds for biological stations on non-assessed channelized AUIDs

Ratings of **Good** for channelized streams are based on Minnesota's general use threshold for aquatic life (Appendix 4.1). Stations with IBIs that score above this general use threshold would be given a rating of **Good**. The **Fair** rating is calculated as a 15 point drop from the general use threshold. Stations with IBI scores below the general use threshold, but above the **Fair** threshold would be given a rating of **Fair**. Stations scoring below the Fair threshold would be considered **Poor**.

Class #	Class Name	Good	Fair	Poor
Fish				
1	Southern Rivers	>38	38-24	<24
2	Southern Streams	>44	44-30	<30
3	Southern Headwaters	>50	50-36	<36
4	Northern Rivers	>34	34-20	<20
5	Northern Streams	>49	49-35	<35
6	Northern Headwaters	>39	39-25	<25
7	Low Gradient Streams	>39	39-25	<25
Macroinvertebrates				
1	Northern Forest Rivers	>51	52-36	<36
2	Prairie Forest Rivers	>31	31-16	<16
3	Northern Forest Streams RR	>50	50-35	<35
4	Northern Forest Streams GP	>52	52-37	<37
5	Southern Streams RR	>36	36-21	<21
6	Southern Forest Streams GP	>47	47-32	<32
7	Prairie Streams GP	>38	38-23	<23

Appendix 5.2 - Channelized stream reach and AUID IBI scores-FISH (non-assessed)

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Good	Fair	Poor	FIBI	Visit Date
HUC 11: 09030006010 (Upper Big Fork River Watershed)									
09030006-613	05RN019	Unnamed creek	10.65	7	100-51	50-36	35-0	37	8-Jul-05
HUC 11: 09030006070 (Caldwell Creek Watershed)									
09030006-510	05RN080	Caldwell Brook	34.17	7	100-51	50-36	35-0	47	11-Aug-05
09030006-608	05RN105	Unnamed creek	12.75	7	100-51	50-36	35-0	22	22-Jun-10
09030006-608	05RN105	Unnamed creek	12.75	7	100-51	50-36	35-0	53	29-Jun-05
09030006-626	10RN027	Pancake Creek	19.18	6	100-51	50-36	35-0	57	22-Jun-10
HUC 11: 09030006100 (Sturgeon River Watershed)									
09030006-676	10RN053	Unnamed creek	8.05	7	100-51	50-36	35-0	0	23-Jun-10
HUC 11: 09030006120 (Bear River Watershed)									
09030006-516	10RN043	Bear Creek	40.08	6	100-51	50-36	35-0	0	3-Aug-10
09030006-681	10RN056	Unnamed ditch	2.64	7	100-51	50-36	35-0	0	23-Jun-10

Appendix 5.3 - Channelized stream reach and AUID IBI scores-macroinverbrates (non-unassessed)

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi²	Invert Class	Good	Fair	Poor	MIBI	Visit Date
HUC 11: 09030006010 (Upper Big Fork River Watershed)									
09030006-613	05RN019	Unnamed creek	10.65	4	100-48	47-32	31-0	40.99	15-Aug-05
HUC 11: 09030006070 (Caldwell Creek Watershed)									
09030006-510	05RN080	Caldwell Brook	34.17	4	100-48	47-32	31-0	32.6	16-Aug-05
09030006-510	05RN080	Caldwell Brook	34.17	4	100-48	47-32	31-0	41.6	30-Aug-05
09030006-626	10RN027	Pancake Creek	19.18	4	100-48	47-32	31-0	44.3	4-Aug-10
HUC 11: 09030006100 (Sturgeon River Watershed)									
09030006-509	10RN035	Sturgeon River	58.59	4	100-48	47-32	31-0	45.9	4-Aug-10
09030006-676	10RN053	Unnamed creek	8.05	4	100-48	47-32	31-0	27.1	24-Aug-10
HUC 11: 09030006120 (Bear River Watershed)									
09030006-516	10RN043	Bear Creek	40.08	4	100-48	47-32	31-0	51.8	4-Aug-10
09030006-681	10RN056	Unnamed ditch	2.64	4	100-48	47-32	31-0	31.3	2-Aug-11

Appendix 6.1 - Minnesota's ecoregion-based lake eutrophication standards

Ecoregion	TP µg/L	Chl-a µg/L	Secchi meters
NLF – Lake Trout (Class 2A)	< 12	< 3	> 4.8
NLF – Stream trout (Class 2A)	< 20	< 6	> 2.5
NLF – Aquatic Rec. Use (Class 2B)	< 30	< 9	> 2.0
NCHF – Stream trout (Class 2A)	< 20	< 6	> 2.5
NCHF – Aquatic Rec. Use (Class 2B)	< 40	< 14	> 1.4
NCHF – Aquatic Rec. Use (Class 2B) Shallow lakes	< 60	< 20	> 1.0
WCBP & NGP – Aquatic Rec. Use (Class 2B)	< 65	< 22	> 0.9
WCBP & NGP – Aquatic Rec. Use (Class 2B) Shallow lakes	< 90	< 30	> 0.7

Appendix 6.2 - MINLEAP model estimates of phosphorus loads for lakes in the Big Fork River Watershed

Lake ID	Lake Name	Obs TP (µg/L)	MINLEAP TP (µg/L)	Obs Chl-a (µg/L)	MINLEAP Chl-a (µg/L)	Obs Secchi (m)	MINLEAP Secchi (m)	Avg. TP Inflow (µg/L)	TP Load (kg/yr)	Background TP (µg/L)	%P Retention	Outflow (hm3/yr)	Residence Time (yrs)	Areal Load (m/yr)	Trophic Status
31-0882	Dora	41	47	10	18	2.8	1.4	52	13641	26	10	262	< 0.1	135	M / E
31-0898	Moose	15	22	3	6	4.6	2.7	54	277	22	60	5.1	2.1	3.3	M
31-0782	Gunderson	10	16	2	4	4.3	3.5	61	38	18	74	0.6	6	0.9	M
31-0896	Round	67	42	21	16	1.8	1.5	52	3227	23	19	61.8	0.1	51.8	E
31-0913	Island	37	16	18	4	2.6	3.5	63	547	21	75	8.6	6.3	0.7	M / E
31-0786	Jessie	55	20	22	5	2.6	2.9	55	1032	19	63	18.7	2.6	2.6	E
31-0725	Turtle	11	15	3	3	5.1	3.7	57	744	18	74	12.9	6.3	1.5	O / M
31-0653	North Star	11	13	2	3	3.9	4.3	64	163	19	80	2.5	11.2	0.7	O / M
31-0758	Little Bowstring	27	25	11	7	2.4	2.4	54	329	21	53	6.1	1.3	4.8	M
31-0813	Bowstring	51	25	31	7	2.4	2.4	55	6307	21	55	116	1.4	3.2	E
31-0826	Sand	22	31	7	10	2.8	2	53	7577	21	42	143	0.6	9.3	M / E
31-0726	Bello	10	20	3	5	3.2	2.9	58	152	20	65	2.6	2.9	1.3	M
31-0540	Clubhouse	10	30	2	10	4.5	2	52	858	17	42	16.3	0.6	16.5	O / M
31-0657	Jack the Horse	10	20	3	5	3.7	2.9	59	113	25	65	1.9	2.9	1.2	M
31-0334	Deer	15	28	5	9	2.9	2.2	55	1213	26	49	22.1	0.9	2.9	M
31-0183	Five Island	12	19	3	5	3.6	3.1	61	48	23	69	0.7	3.9	0.9	M
31-0524	Coon / Sandwick	15	20	6	5	3	2.9	67	96	21	70	1.4	4.1	0.57	M

Abbreviations: **H** – Hypereutrophic; **E** – Eutrophic; **M** – Mesotrophic; **O** – Oligotrophic; --- No data