Thief River Watershed Monitoring and Assessment Report

Minnesota Pollution Control Agency

July 2014

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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

HGM Hydrogeomorphic

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

NWI National Wetland Inventory

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

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 Thief River Watershed (HUC-09020304), located in the Red River Basin, drains 624,422 acres in northwestern Minnesota. The watershed is almost entirely within Marshall and Beltrami counties (97.8%); the remaining 2% are within Pennington, Roseau, and Lake of the Woods counties. The Thief River starts at Thief Lake and flows 39 miles to its confluence with the Red Lake River in Thief River Falls. Agassiz National Wildlife Refuge (NWR) makes up much of the watershed's western boundary and continues to be a popular tourist destination for people seeking recreational activities. Aside from the refuge, land in the watershed is primarily used for agricultural purposes. Stream channelization is extensive, and because of the low gradient nature of the watershed, flooding and wind erosion is a major concern.

In 2011 the Minnesota Pollution Control Agency (MPCA) began an intensive watershed monitoring (IWM) effort of surface waters within the Thief River Watershed. Thirty-five sites were sampled for biology at the outlet of variable sized subwatersheds. In 2013, the surface water bodies within the watershed were assessed for aquatic life, aquatic recreation, and aquatic consumption use support. Seven stream segments (AUIDs) and one lake were assessed. Twenty stream segments were not assessed due to insufficient data, modified channel condition, or their status as limited resource waters. Also, numerous lakes were not assessed due to insufficient data.

The assessment results for the Thief River Watershed indicated that surface waters were in poor condition. Every stream segment assessed within the watershed failed to fully support aquatic life. Most of the aquatic life impairments were the result of low dissolved oxygen (DO) and/or high levels of turbidity. No impairments were the result of poor fish and macroinvertebrate communities; however, impairment decisions on the majority of streams in the watershed were deferred pending the adoption of tiered aquatic life uses. A less robust indicator of the overall condition of channelized streams using the fish and macroinvertebrate indices of biological integrity and habitat scores suggests that these streams are also in poor condition.

Of the seven stream segments assessed for aquatic recreation, five showed full support. The remaining two are impaired due to elevated levels of bacteria. The only lake in the watershed with assessment level data is Thief Lake, which fully supports aquatic recreation.

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. The 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 (TMDL). 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 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 identify waters in need of protection. The benefit of this 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 Thief River Watershed beginning in the summer of 2011. This report provides a summary of all water quality assessment results in the Thief 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 at 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).

Load monitoring network

Funded with appropriations from Minnesota's Clean Water Legacy Fund, the Watershed Pollutant Load Monitoring Network (WPLMN) 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 WPLMN 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 (MCES), local monitoring organizations, and Minnesota Pollution Control Agency WPLMN staff to compute annual pollutant loads at 79 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.

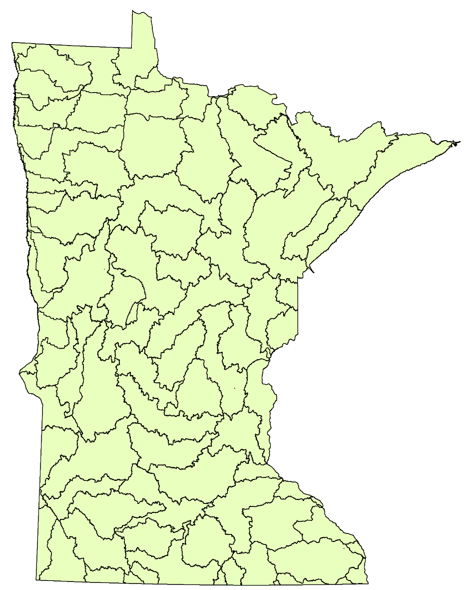


Figure 1. Major watersheds within Minnesota

Intensive watershed monitoring

The IWM strategy utilizes a nested watershed design allowing the sampling of streams within watersheds from a coarse 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 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. 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, 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 dots 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, 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 is sampled for biology (fish and macroinvertebrates) to assess aquatic life use support (red dots in Figure 3).

Within theIWM 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, but 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 Thief River Watershed are shown in Figure 3 and are listed in Appendix 4.2, Appendix 4.3, Appedix 5.2 and Appendix 5.3.

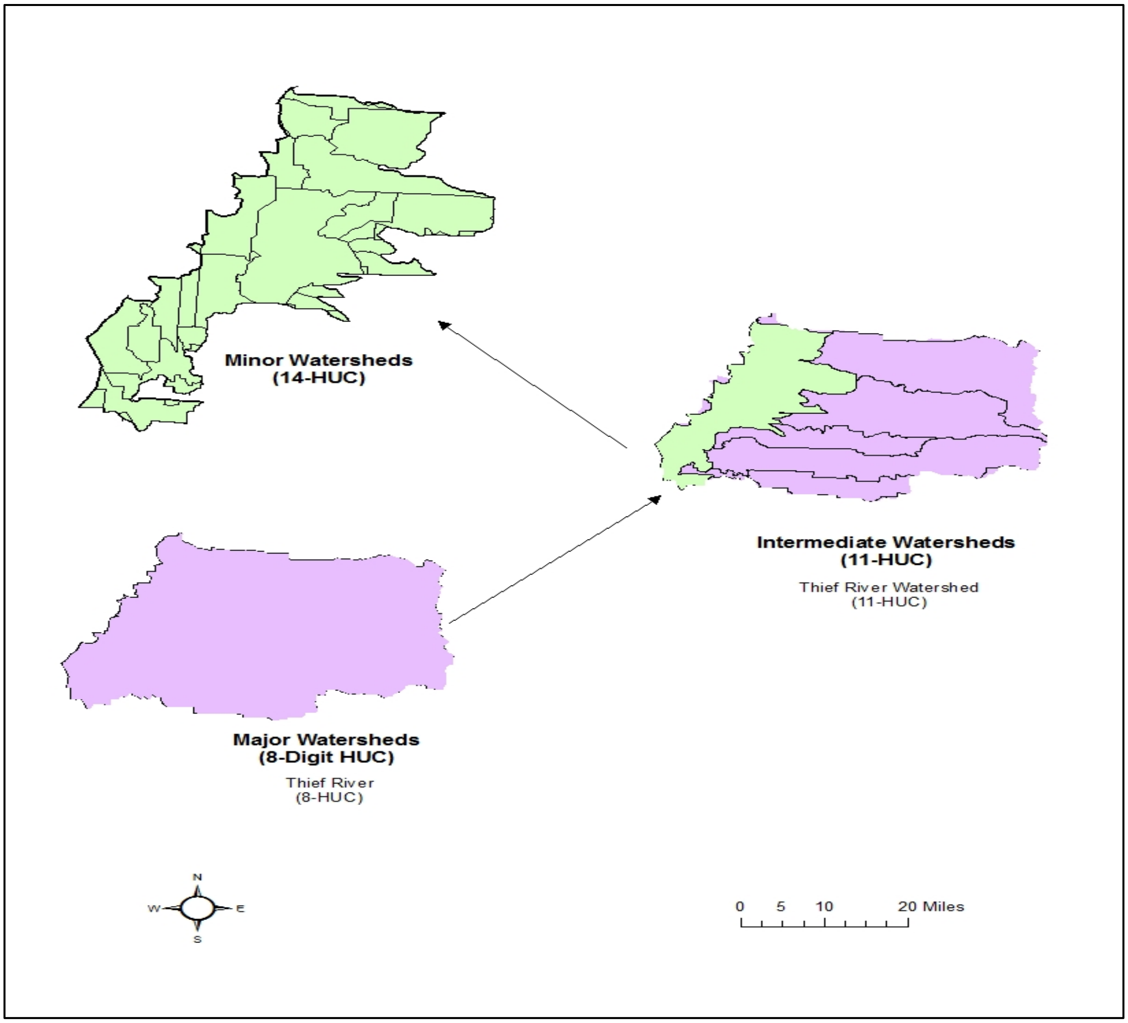


Figure 2. Intensive watershed monitoring design

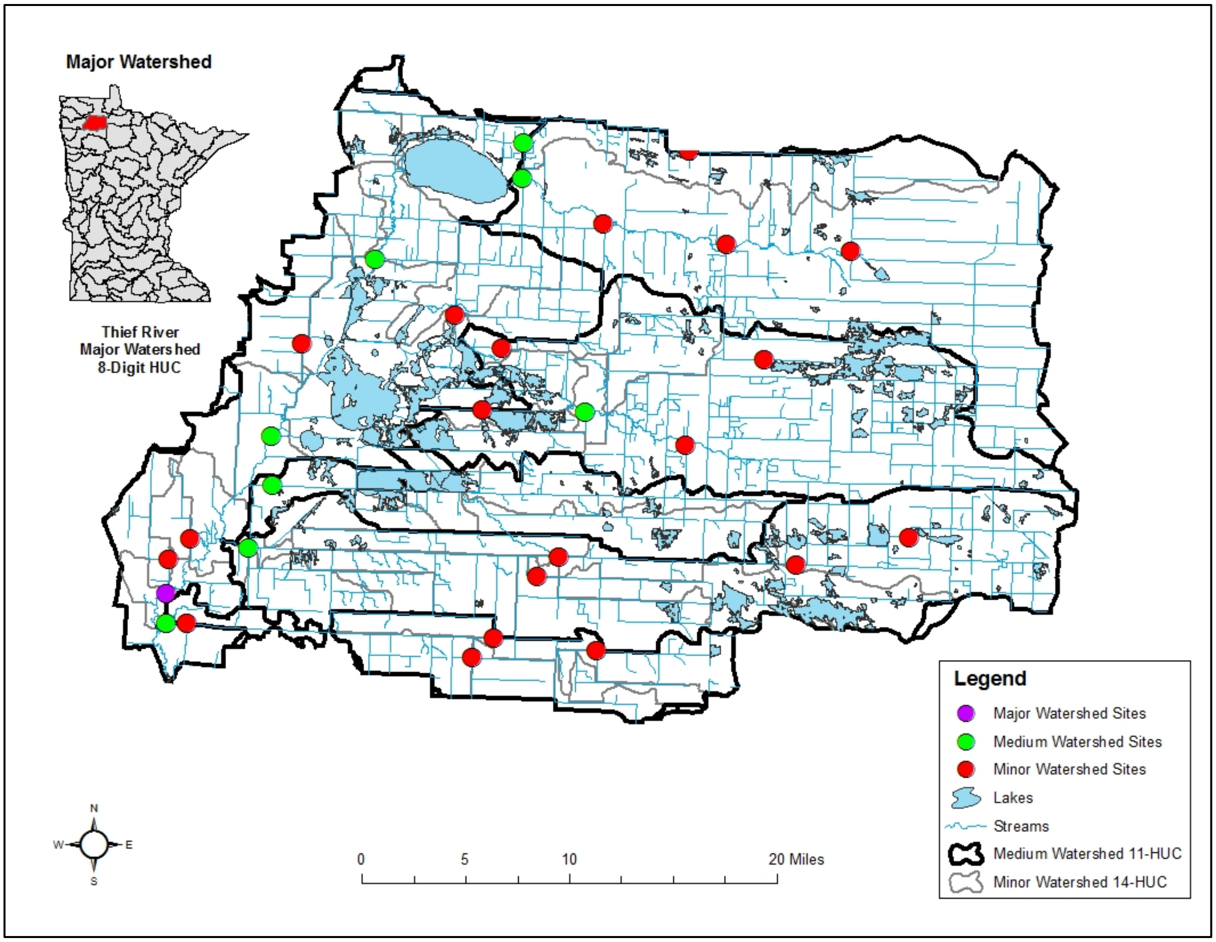


Figure 3. Intensive watershed monitoring sites for streams in the Thief River Watershed

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 (SWCDs), watershed districts, nonprofits, and educational institutions to support lake and stream water chemistry monitoring. Local partners use the same monitoring protocols as the MPCA, and all monitoring data from SWAG projects are combined with the MPCA's to assess the condition of Minnesota lakes and streams. Preplanning and coordination of sampling with local citizens and governments helps focus monitoring where it will be most effective for assessment and observing long-term trends. This allows citizens/governments the ability to see how their efforts are used to inform water quality decisions and track how management efforts affect change. Many SWAG grantees invite citizen participation in their monitoring projects, and their combined participation greatly expand our overall capacity to conduct sampling.

The MPCA also coordinates two programs aimed at encouraging long-term citizen surface water monitoring: the Citizen Lake Monitoring Program (CLMP) and the Citizen Stream Monitoring Program (CSMP). Like the permanent load monitoring network, having citizen volunteers monitor a given lake or stream site monthly and from year to year can provide the long-term picture needed to help evaluate current status and trends. Citizen monitoring is especially effective at helping to track water quality changes which occur in the years between intensive monitoring years. Figure 4 provides an illustration of the locations where MPCA, local partners, and citizen monitoring data were used for assessment in the Thief River Watershed.

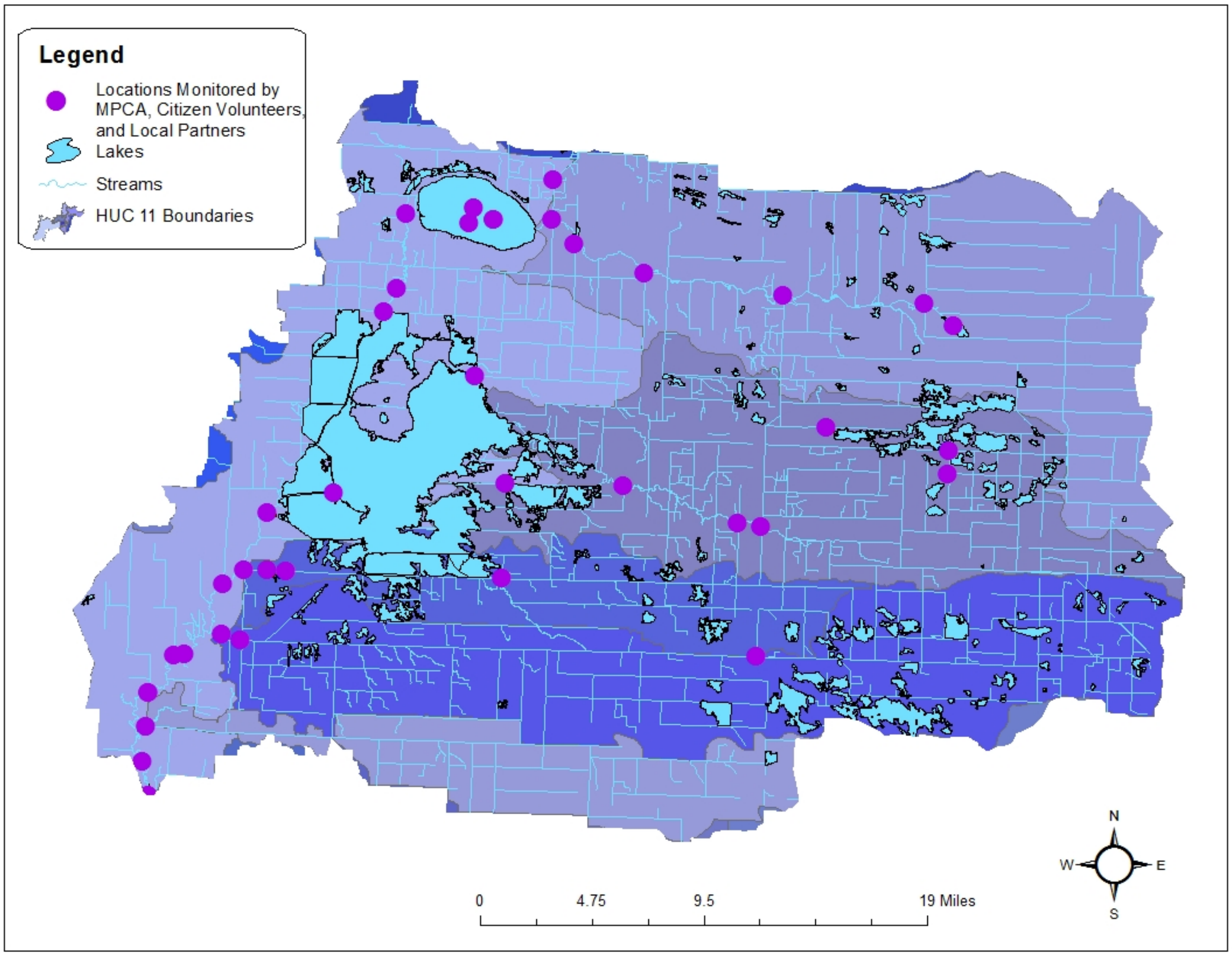


Figure 4. Monitoring locations of local groups, citizens, and the MPCA lake monitoring staff in the Thief River Watershed

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 which 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 methodology, 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=16988.

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, invertebrates, 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 (F-IBI), which evaluates the health of the fish community, and the Macroinvertebrate Index of Biological Integrity (M-IBI), which evaluates the health of the aquatic invertebrate 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 which 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 which 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 Class 7 limited resource value waters (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, aesthetics and 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 water body 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 which 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 water body identifier (known as its AUID), comprised of the USGS eight digit 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 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 water body 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, 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 water body. 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.

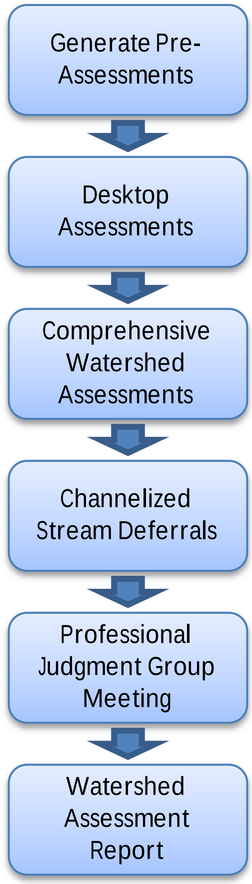


Figure 5. Flowchart of aquatic life use assessment process

Any new impairment (i.e., water body 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 watershed-wide results and discussion).

The last step in the assessment process is the Professional Judgement 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

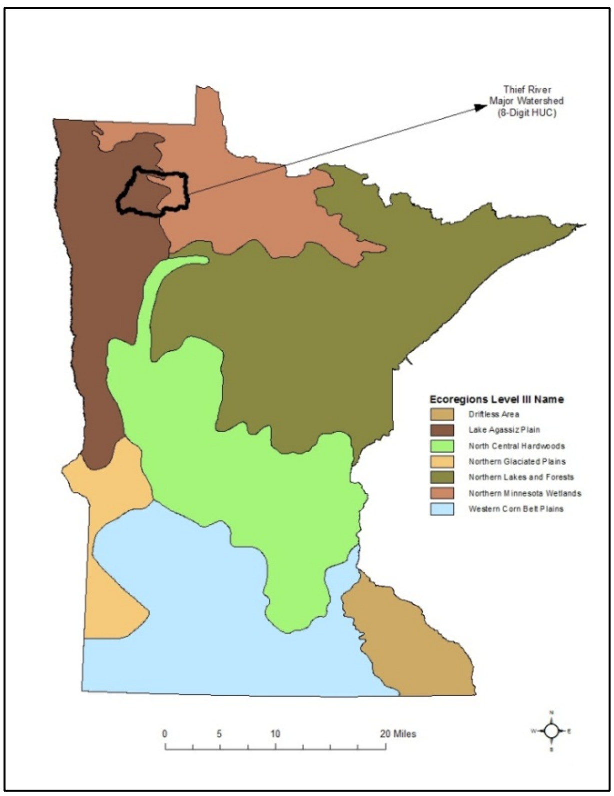
It is MPCA policy to use all credible and relevant monitoring data, collected during the most recent 10-year period, to assess surface waters. The MPCA relies on data it collects along with data from other sources, such as sister agencies, local governments, and volunteers. The data must meet rigorous quality assurance protocols before being used. All monitoring data required or paid for by MPCA iare entered into EQuIS (Environmental Quality Information System), MPCA's data system, and also uploaded to the U.S. Enivornmental Protection Agency's (EPA) data warehouse. Monitoring projects with federal or state funding are required to store data in EQuIS (e.g., Clean Water Partnership, CWLA Surface Water Assessment Grants, 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

The Thief River Watershed, HUC-09020304, is located in far northwestern Minnesota and is part of the Red River Basin. From its source at Thief Lake, the Thief River flows southwesterly 39 miles to its confluence with the Red Lake River in Thief River Falls. This section of the Red Lake River provides drinking water for the towns of Thief River Falls, East Grand Forks and Grand Forks. Draining 624,422 acres, the watershed is almost entirely within Marshall and Beltrami counties (97.8% of the watershed). The remaining 3% are within Pennington, Roseau, and Lake of the Woods counties (NRCS, 2007).



The Thief River Watershed lies in both the Lake Agassiz Plain (LAP) and Northern Minnesota Wetlands (NMW) level III ecoregions (Figure 6). The LAP is dominated by glacial sediments and glacial landforms deposited from the Des Moines Lobe of Wisconsin Glaciation approximately 14,000 year ago. These sediments consist of fine textured till containing Paleozoic limestone and cretaceous shale. As the NMW ecoregion name implies, this region is dominated by marshes and wetlands which consist of clays and silts deposited while Lake Agassiz existed. Formerly inundated by broad glacial lakes, most of the flat terrain in this ecoregion is still covered by standing water (Omernik et al.1988).

There are two Major Land Resource Areas in the Thief River Watershed. Making up much of the watersheds western half is the Red River Valley of the North; this area can be characterized by lake plain with remnants of gravelly beaches left behind from glacial Lake Agassiz. The far eastern edge of the watershed is the Northern Minnesota Glacial Lake Basins. Consisting of a nearly flat landscape, this area is dominated by lake washed till and organic soil matter (NCS 2007) (Figure 7).

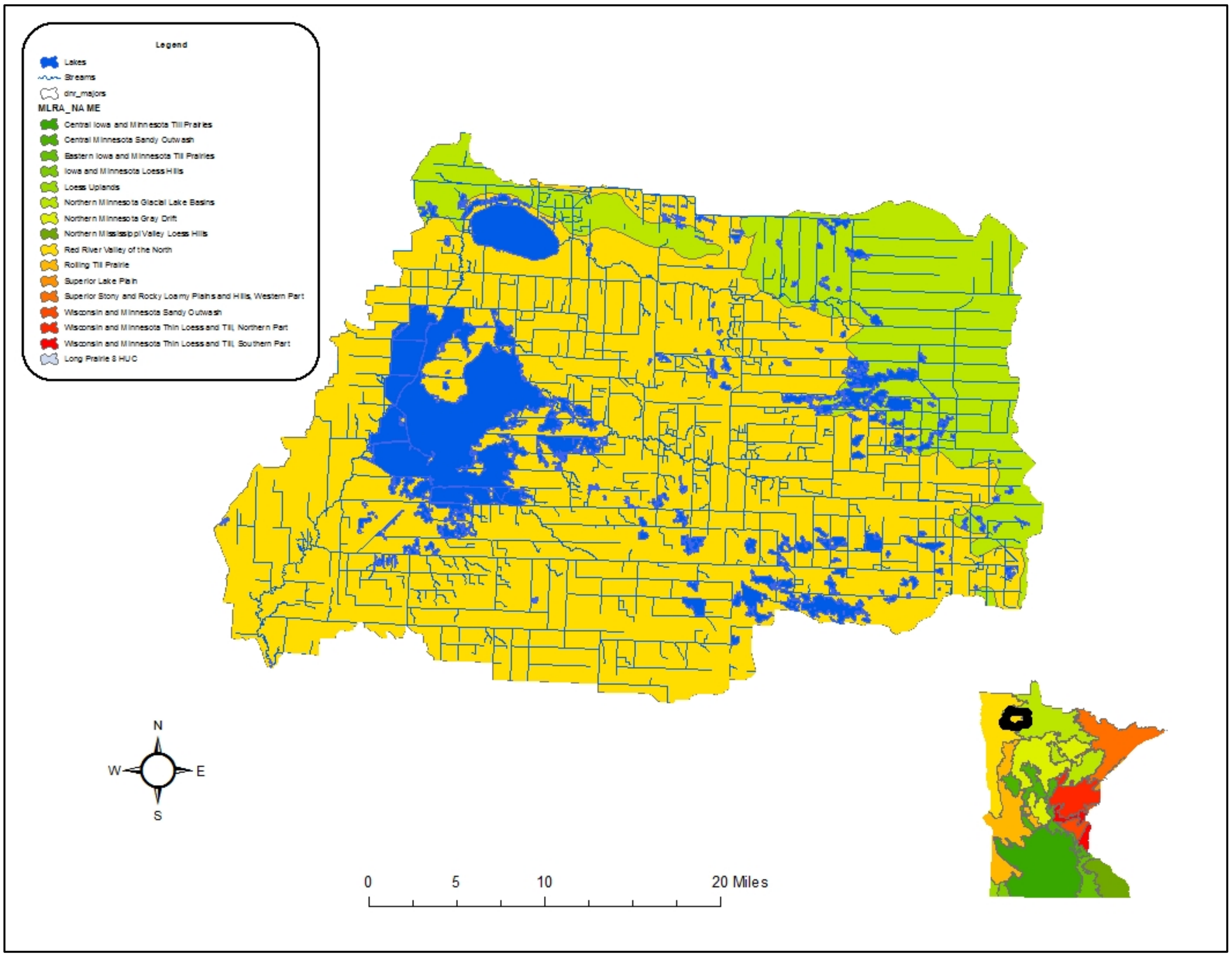


Figure 7. Major Land Resource Areas in the Thief River Watershed

Land use summary

Prior to western settlement, the Thief River Watershed was dominated by vast areas of tall grass prairie and low lying wetlands. Around the turn of the century, agricultural demands increased and many of the watersheds natural prairies and wetlands were altered or removed for crop production. Due to the flat topography and silt-clayey lake washed till, most of the watershed is classified as poorly drained and prone to severe flooding. To increase drainage potential for agricultural purposes, most of the rivers and streams in the watershed were channelized.

In the early 1900s, much of the watershed was thriving from agriculture. In an attempt to drain the Mud Lake area for farming, a multi-million dollar project was approved by Marshall County to improve drainage. After the project proved to be unsuccessful, the state Legislature protected the county from bankruptcy by approving a land transfer to the NWR System. Today, this area is home to the 61,500 acre Agassiz NWR. Originally named the Mud Lake Migratory Waterfowl Refuge, the primary goal for the refuge is waterfall production and maintenance. The refuge receives more than 20,000 visitors annually and is comprised of over 37,400 acres of wetlands, 9,900 acres of forestland, 1,710 acres of grassland, and 150 acres of cropland. (http://www.fws.gov/refuges/profiles/History.cfm?ID=32510).

Currently, land use in the Thief River Watershed is dominated by cropland (36.0%) and wetlands (44.9%). The remaining land cover distribution in the watershed is as follows: 7.8% range (52,288 acres), 6.7% forest (44,840 acres), 2.8% developed (18,981 acres), 1.7% open water (11,387 acres) and 0.6% barren/mining (421 acres) (Figure 8).

Land ownership in the Thief River Watershed is dominated by private land (309,530 acres) and state land (245,000 acres). The remaining land ownership within this watershed consists of federal (61,628 acres), tribal (8,061), corporate (120 acres), county (40 acres), and miscellaneous public land (40 acres) (NRCS, 2007).

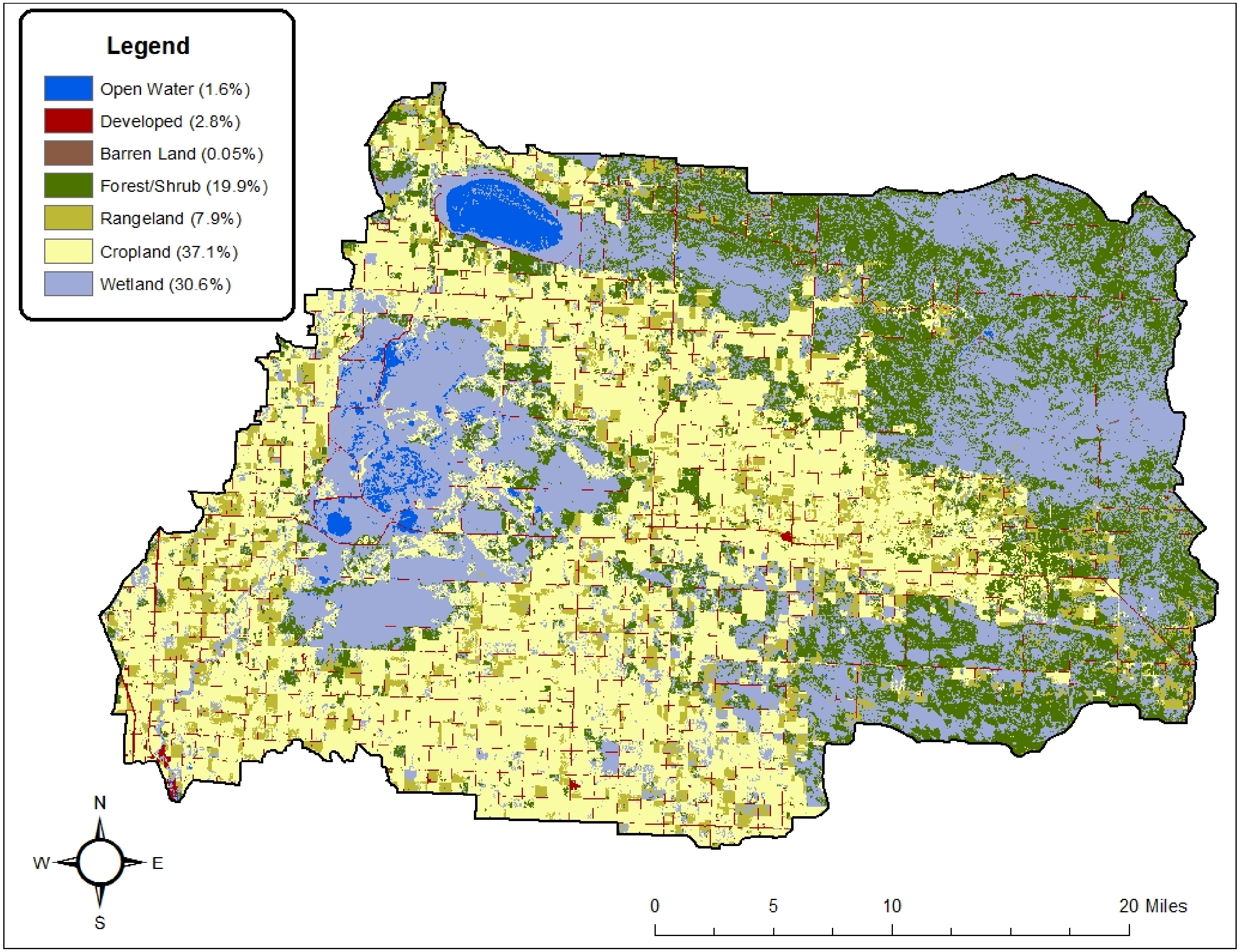


Figure 8. Land use in the Thief River Watershed

Surface water hydrology

From its headwaters at Thief Lake, the Thief River flows approximately 39 miles to its confluence with the Red Lake River, in Thief River Falls. Like much of the watershed's streams, most of the main stem Thief River has been historically channelized. Beginning as a natural channel, the river flows eight miles south before entering Agassiz NWR. Throughout the refuge, the river is channelized and takes on water from an extensive ditch network which is used to regulate water levels in the refuge pools.

There are two major tributaries that indirectly flow into the Thief River - the Moose River and the Mud River. From its headwaters, the Moose River flows east to west 23.4 miles to its outlet at Thief Lake. Along its course, the river is almost entirely contained within the Thief Lake and Wapiti Wildlife Management Areas (WMA). The Mud River begins two miles southwest of Grygla and flows northwesterly 20 miles to its confluence with the Agassiz Pool at Agassiz NWR. From there, the river channel becomes less defined as it flows through a large series of open pools. The river eventually dumps into the Thief River at the southwestern edge of the Agassiz Pool, 30.7 miles from its headwaters. Other named tributaries to the Thief River include County Ditch 20 and Judicial Ditch 18.

According to the Altered Water Course Project (http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/streams-and-rivers/minnesota-statewide-altered-watercourse-project.html) conducted by the MPCA, 1,243.8 of the 1,298.9 stream miles (95.8%) within the watershed are considered altered. The remaining stream miles are either natural or impounded (Figure 9). The Thief River Watershed has the third highest percentage of altered streams among the 81 major watersheds in the state of Minnesota, behind only the Upper Wapsipinicon River and Winnebago River.

There are 21 dams located in the Thief River Watershed, 19 of which are located within the Agassiz National Wildlife Refuge. Three of the dams, including the Thief Lake Dam, the Pool 8 Dam, and the Pool 10 Dam, are situated on the mainstem Thief River (USCOE, 2013). Each of these structures has the potential to limit connectivity. Also, the Thief River Falls dam located on the Red Lake River immediately downstream of the Thief River is a known barrier to fish passage (Groshens, 2005) and is likely affecting the fish community of the watershed.

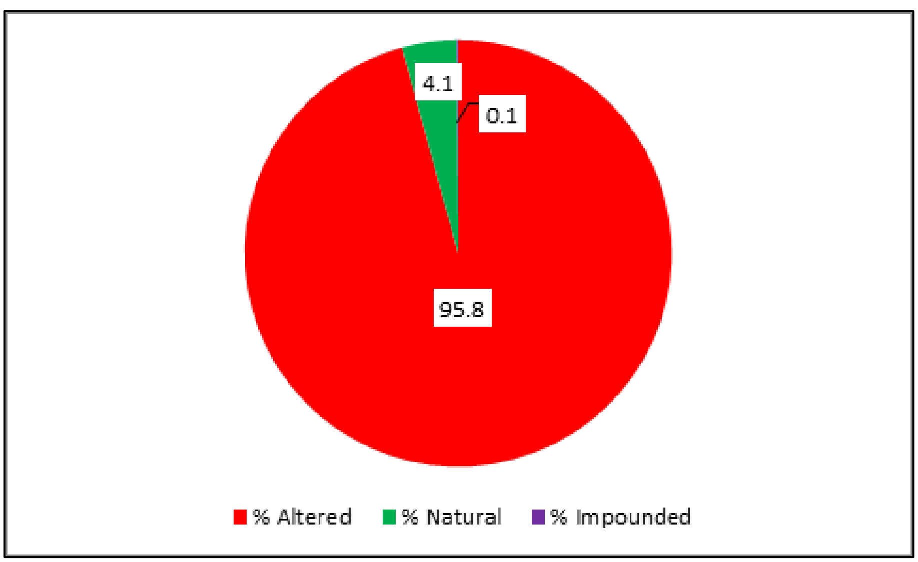


Figure 9. Status of rivers and streams within the Thief River Watershed based on the MPCA's altered watercourse project

Climate and precipitation

The Thief River Watershed has a continental climate, marked by warm summers and cold winters. The mean annual temperature for Minnesota is 4.5˚C; the mean summer temperature for the Thief River Watershed is 17.8˚C; and the mean winter temperature is -14.4˚ C (Minnesota State Climatologists Office, 2003).

The Thief River Watershed received approximately 20-24 inches of precipitation in 2011, which was 2 to 4 inches lower than normal. In 2012, the watershed received 16 inches, with precipitation deviating 6 to 10 inches below normal (Figure 10)

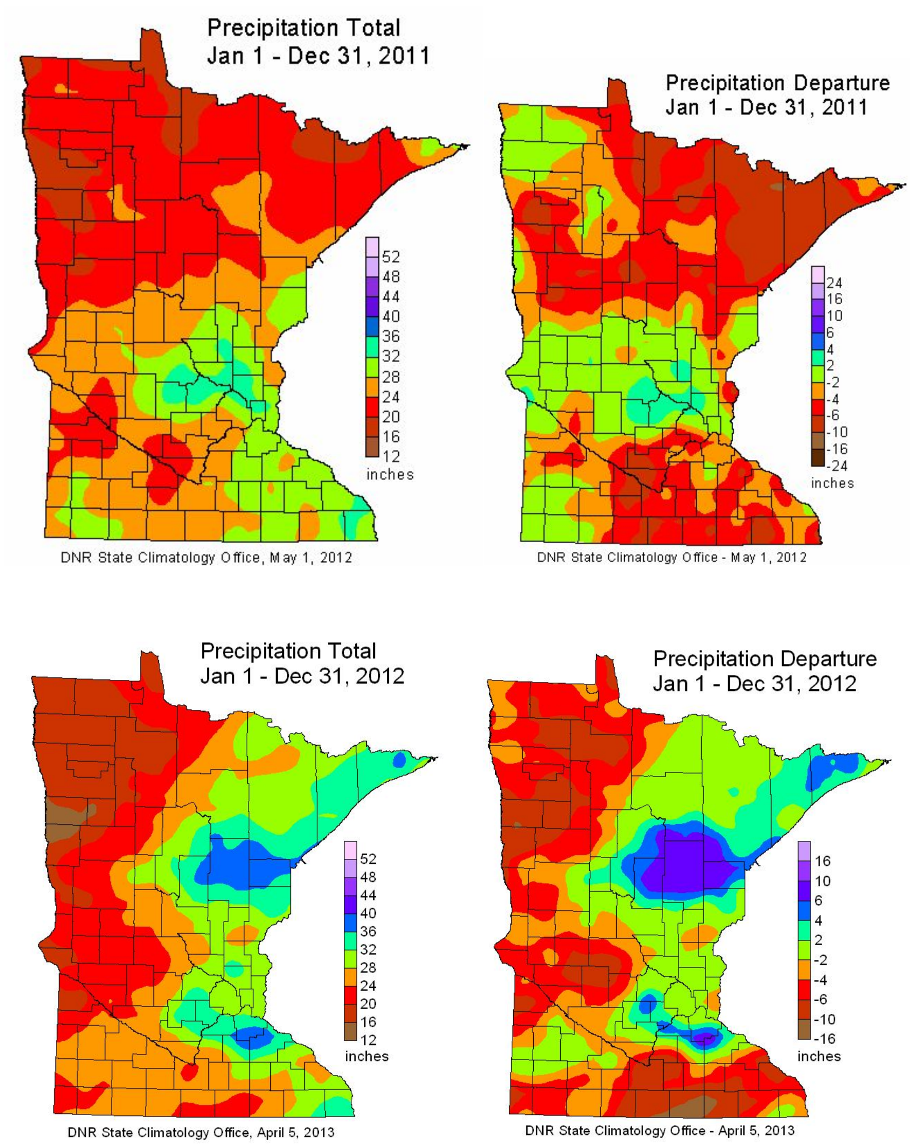


Figure 10. State-wide precipitation levels during the 2011 and 2012 water years

Rainfall in the northwest region displays no significant trend over the last 20 years (Figure 11). Though rainfall can vary in intensity and time of year, it would appear that northwest Minnesota precipitation has not changed dramatically over this time period. This data is taken from the Western Regional Climate Center, available as a link to the University of Minnesota Climate website: http://www.wrcc.dri.edu/spi/divplot1map.html.

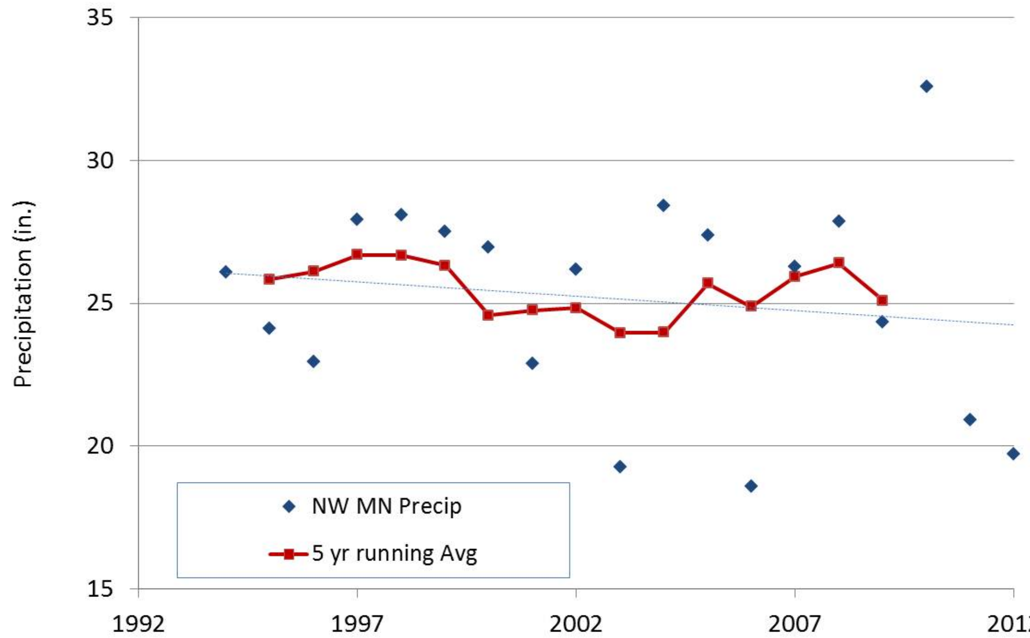


Figure 11. Precipitation trends in northwest Minnesota (1992-2012) with five year running average

Precipitation in northwest Minnesota exhibits a statistically significant rising trend over the past 100 years, p=0.001. This is a strong trend and matches similar trends throughout Minnesota.

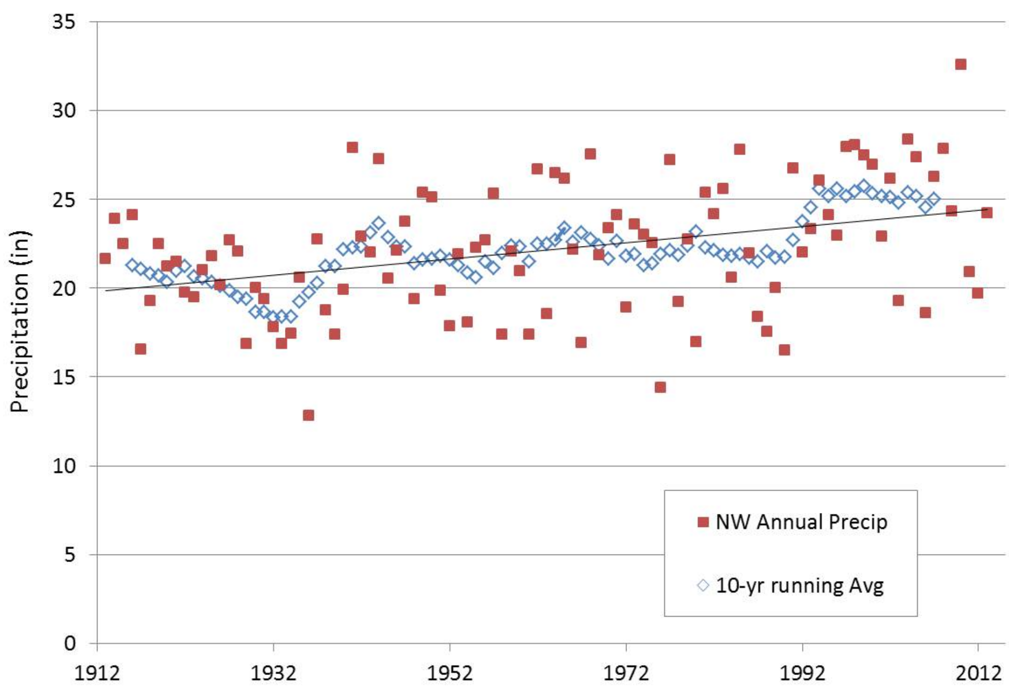


Figure 12. Precipitation trends in northwest Minnesota (1913-2013) with ten year running average

Hydrogeology

The Thief River Watershed is located in the Western Groundwater Province of Minnesota as defined by the MDNR and described geologically as "clayey glacial drift overlying Cretaceous and Precambrian bedrock." More specifically, the watershed's location is part of a physiographic region of the Red River Valley known as the Lake-Washed Till Plain. This region was formed by glacial Lake Agassiz and is characterized by glacially-deposited, clay-rich sediments, poorly drained organic soils, peat and open and wooded wetlands (Lorenz, Stoner 1996).

Groundwater is available primarily through surficial sand and gravel aquifers, buried sand and gravel aquifers, and deeper cretaceous aquifers. Recharge of these aquifers is limited to areas located at topographic highs, areas with surficial sand and gravel deposits, and those along the bedrock/surficial deposit interface. Typically, recharge rates in unconfined aquifers are estimated at 20 to 25% of precipitation received, but can be less than 10% of precipitation where glacial clays or till are present (USGS, 2007). For the Thief River Watershed, the average annual recharge rate to surficial materials is two to four inches per year in the western portion of the watershed, and four to six inches per year in the eastern reaches (Figure 13).

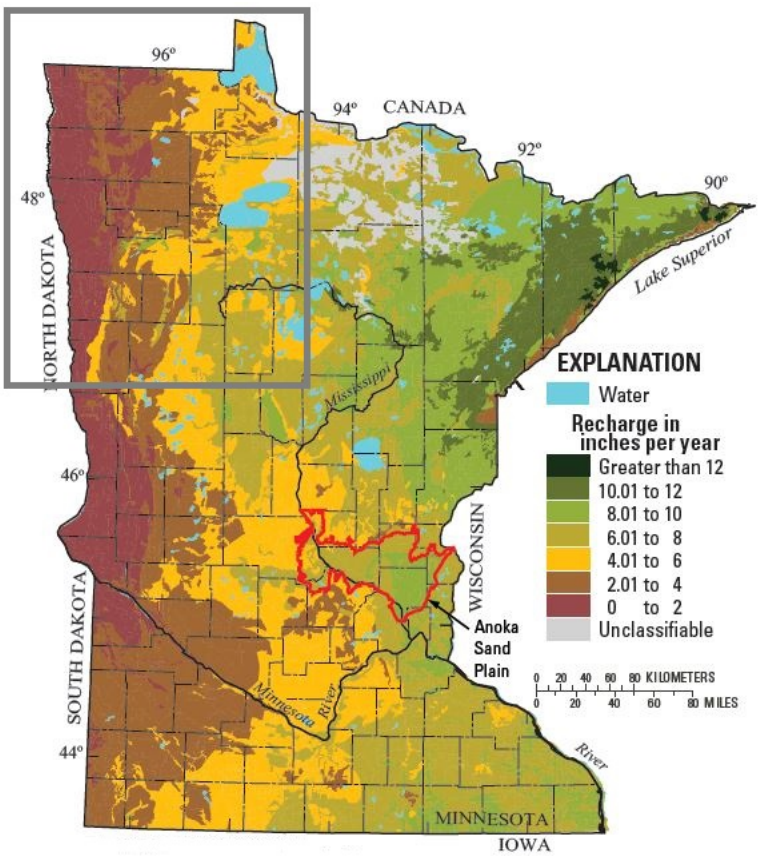


Figure 13. Average annual recharge rate to surficial materials in Minnesota (1971-2000) (Source: USGS, 2007)

Wetlands

Wetlands are a prominent feature in the Thief River Watershed. The National Wetlands Inventory (NWI) estimates that there are 330,223 acres of wetlands—which is approximately half (49%) of the watershed area (Figure 14). This coverage far exceeds the state wetland coverage rate of 19% (Kloiber and Norris 2013). The majority of the wetlands are fairly evenly split between three general cover types: emergent (i.e., dominated by grasses, sedges, bulrushes, and/or cattails), scrub-shrub, and forested (Figure 14). Wetlands are not distributed evenly throughout watershed as there is a distinct difference in wetland coverage that roughly corresponds to the level II ecoregion boundry (Figure 14). Wetland acreage exceeds upland acreage in the Mixed Wood Shield Ecoregion portion of the watershed, and vice versa in the Temperate Prairies Ecoregion. There are two large shallow open water/emergent marsh complexes in the watershed: Mud Lake-Agassiz National Wildlife Refuge and Thief Lake. National Wetlands Inventory may actually be under-estimating wetlands in the watershed due to Thief Lake being classified as a deepwater habitat—the maximum depth of Thief Lake is 4 feet at normal pool elevation and mixed patches of emergent wetland vegetation are present.

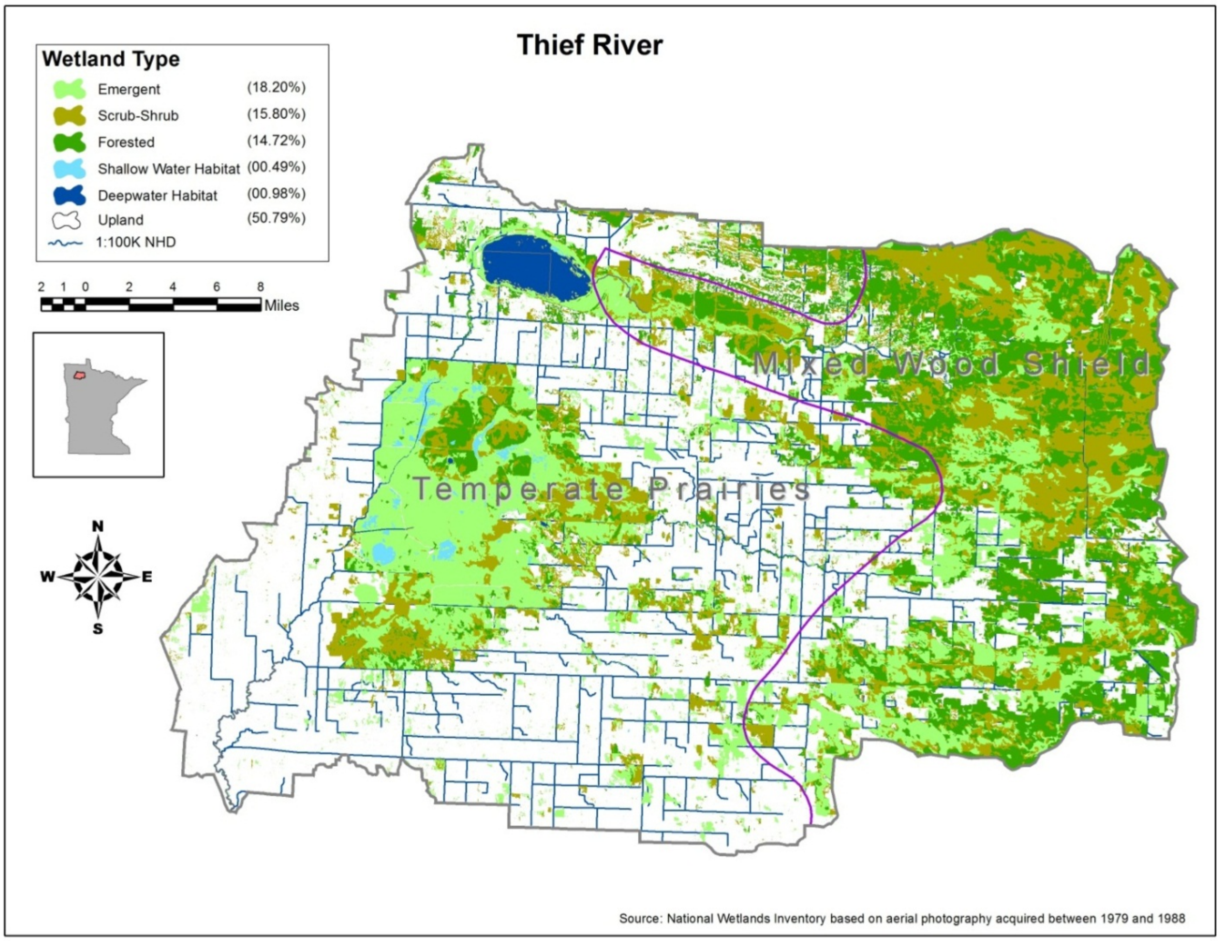


Figure 14. Wetlands and surface water in the Thief River Watershed. Wetland data is from the National Wetlands Inventory. The level II ecoregion boundary has been included

Historically, wetlands were more prevalent in Thief River Watershed than today. A network of drainage ditches has long been established—primarily in the Temperate Prairies ecoregion portion of the watershed—to drain wetlands and improve the land for agriculture. This included at least partial drainage of both Mud and Thief Lakes (which were subsequently restored). Digital soil survey data is available for the entire watershed and can be used to approximate the historical wetland extent by totaling the mapped hydric soils present—which form under wetland conditions and can persist after drainage. Soil map units designated as "all hydric" total 529,794 acres or 79% of watershed. Based on this estimate and the current wetland extent estimate from NWI—the Thief River Watershed has lost approximately 38% of its wetlands.

The prevalence of wetlands in the watershed is due to the glacial lake plain landform and climate patterns of the region. The plain was formed from sediment deposition in Glacial Lake Agassiz that covered the region approximately 11,000 years ago (MNGS 1997). The extremely flat landscape that remained following drainage of the lake had little capacity to drain surface water—promoting saturated soil conditions over expansive areas. Deep organic (peat) soils subsequently developed over the fine mineral lake sediments where constant saturated conditions existed at the surface and plant decay was inhibited (Wright et al. 1992). Mineral soil flat wetlands formed where saturated conditions were less permanent or seasonal. There is a climate-moisture gradient from west-east in the watershed that corresponds with the ecoregions. Relatively warmer/dryer conditions in the Temperate Prairies portion of the watershed promoted a larger share of uplands and mineral soil flat wetlands (prior to agricultural drainage). The cooler/wetter Mixed Wood Shield promoted the generation of the extensive peatland complexes that occupy north-central Minnesota. The Mud Lake/Agassiz NWR wetland complex appears to be an outlying western extension of the large peat lands in Minnesota.

The predominant water source for hydrogeomorphically flat type wetlands (both with mineral or organic soils) is precipitation, and the primary loss is by evapotranspiration and saturation-overland flow (Smith et al 1995). Wetland saturation/overland water—particularly from organic flat wetlands—can influence stream water quality by delivering high dissolved organic matter/low DO water as it very slowly drains from the surface of the wetland to the stream (Acreman and Holden 2013). In the Thief River Watershed wetland saturation/overland flow likely provides most of the source waters for the streams and ditches above Mud and Thief Lakes.

IV. Watershed-wide data collection methodology

Watershed pollutant load monitoring

Intensive water quality sampling occurs throughout the year at all WPLMN sites. Between 33 and 40 mid-stream grab samples were collected per year at the Thief River near Thief River Falls, 140th Avenue NE. (Figure 15). 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 (NO_3 + NO_2-N).

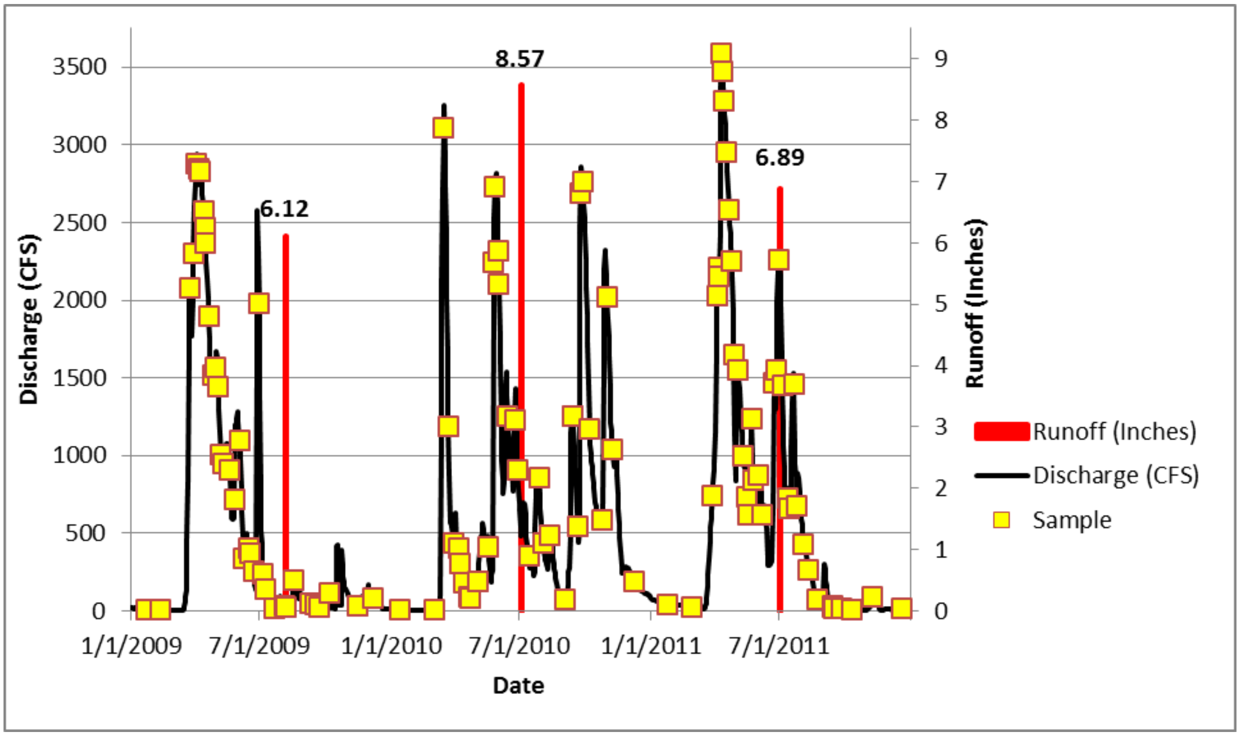


Figure 15. 2009-2011 Hydrograph, sampling regime and annual runoff for the Thief River near Thief River Falls

Stream water sampling

Nine water chemistry stations were sampled from May through September in 2011, and again during June through August of 2012, to provide sufficient water chemistry data to assess all components of aquatic life and recreation uses. Following the IWM design, water chemistry stations were placed at the outlet of each HUC-11 subwatershed which was greater than 40 square miles in area (purple and green circles in (Figure 3). The MPCA awarded a SWAG to the Red Lake Watershed District (RLWD) to collect water chemistry samples at all nine of the stations (See Appendix 2 for locations of stream water chemistry monitoring sites. See Appendix 1 for definitions of stream chemistry analytes monitored in this study). Currently there are two volunteers enrolled in the MPCA's CSMP conducting stream monitoring on the Thief River. Sampling methods are similar among monitoring groups and are described in the document entitled "Standard Operating Procedures Intensive Watershed Monitoring – Stream Water Quality Component" found at http://www.pca.state.mn.us/index.php/view-document.html?gid=16141.

Stream biological sampling

The biological monitoring component of the IWM in the Thief River Watershed was completed during the summer of 2011. A total of 28 new sites were established across the watershed. These sites were located near the outlets of most minor HUC-14 watersheds. In addition, one existing biological monitoring station was revisited in 2011. This station was initially established as part of a 2007 survey which investigated the quality of channelized streams with intact riparian zones. While data from the last 10 years contributed to the watershed assessments, the majority of data utilized for the 2013 assessment was collected in 2011. A total of 24 AUIDs were sampled for biology but water body assessments to determine aquatic life use support were conducted for only one AUID. Water body assessments were not conducted for 23 AUIDs because they were primarily channelized reaches and 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 are included in Appendix 5.2 and Appendix 5.3.

To measure the health of aquatic life at each biological monitoring station, indices of biological integrity (IBIs), specifically fish and macroinvertebrate IBIs, were calculated based on monitoring data collected for each of these communities. A fish and macroinvertebrate classification framework was developed to account for natural variation in community structure which is attributed to geographic region, watershed drainage area, water temperature and stream gradient. As a result, Minnesota's streams and rivers were divided into seven distinct warm water classes and two cold water classes, with each class having its own unique fish IBI and macroinvertebrate IBI. Each IBI class uses a unique suite of metrics, scoring functions, impairment thresholds, and confidence intervals (CIs). For IBI classes, thresholds and CIs, see Appendix 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 Appendices 4 and 5.

Fish contaminants

Mercury was analyzed in fish tissue samples collected from the Thief River and the Red Lake River Reservoir in Thief River Falls. Polychlorinated biphenyls (PCBs) were measured in three fish species collected by MPCA biomonitoring staff from the river in 2011. The MDNR fisheries staff collected fish from Red Lake River Reservoir.

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.

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

Prior to 2006, mercury concentrations in fish tissue were assessed for water quality impairment based on the MDH'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 water body 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 List 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 earlier 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. The current watershed monitoring approach includes screening for PCBs in representative predator and forage fish collected at the pour point stations in each major watershed.

Lake water sampling

There are nine natural lakes greater than 10 acres in the watershed but only one, Thief Lake, had assessment level data. Most of the lakes are located within Agassiz National Wildlife Refuge and have no public access; as a result, little or no historical water quality data has been collected. Currently there are no volunteers enrolled in the MPCA's CLMP that are conducting lake monitoring within the watershed. Procedures for monitoring water quality in lakes 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 quality

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

Groundwater/surface water withdrawals

The MDNR permits all high capacity water withdrawals where the pumped volume exceeds 10,000 gallons/day or one million gallons/year. 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

The changes in withdrawal volume detailed in this report are a representation of water use and demand in the watershed, and are taken into consideration when the MDNR issues permits for water withdrawals. Other factors not discussed in this report but considered when issuing permits include: interactions between individual withdrawal locations, cumulative effects of withdrawals from individual aquifers, and potential interactions between aquifers. This holistic approach to water allocations is necessary to ensure the sustainability of Minnesota's groundwater resources.

Groundwater quantity

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

Stream flow

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

Wetland monitoring

The MPCA is actively developing methods and building capacity to conduct wetland quality monitoring and assessment. Currently, the MPCA does not monitor wetlands systematically by watershed. Our primary approach is to track changes in biological communities using statewide and ecoregional probabalistic surveys—where results from a small sample can be extrapolated to a larger population. The MPCA has developed macroinvertebrate and vegetation IBIs for depressional wetlands (i.e., wetlands occurring within a depression in the landscape that has marsh vegetation and semi-permanent to permanent open water), and has a completed an initial baseline estimate of depressional wetland quality for Minnesota (MPCA 2012).

Unfortunately, as the landform is predominantly flat and few wetlands meet the MPCA depressional definition (no depressional wetland monitoring sites have been established in the watershed) the depressional wetland quality monitoring results are not readily applicable in the Thief River Watershed. We do know that there have been significant changes in the surface hydrology in the watershed. In addition to drainage, a series of water control structures have been established to manipulate water levels to promote wildlife habitat and provide flood control (primarily at Mud and Thief Lakes). Extensive drainage is an obvious impact to wetlands but hydrological alterations that inundate and/or disrupt the natural water dynamics—while providing wildlife and flood retention benefits—can also negatively impact natural wetland biology conditions. Vegetation quality in particular can be susceptible as hydrological alterations often promote the replacement of native species with more tolerant non-natives. The MPCA has conducted the field sampling and is in the process of compiling results for an expanded statewide random wetland quality survey that includes all wetland types. These results should be more applicable for documenting wetland condition in the Thief River Watershed when they become available. For more information visit: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/wetlands/wetland-monitoring-and-assessment.html.

V. Individual subwatershed results

HUC-11 watershed units

Assessment results for aquatic life and recreation uses are presented for each HUC-11 watershed unit within the Thief River Watershed. The primary objective is to portray all the assessment results (i.e. waters that support and do not support their designated uses) within an 11-HUC watershed unit 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 3.1. 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 watershed units contain the assessment results from the 2013 assessment cycle as well as any impairment listings from previous assessment cycles. Discussion of assessment results focuses primarily on the 2011 IWM effort, but also considers available data from the last 10 years.

The proceeding 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, and where applicable 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. 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 subwatershed (i.e., where sufficient information was available to make an assessment). Primarily, these tables reflect the results of the 2011 assessment process (2012 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 invertebrate IBIs), DO, turbidity, chloride, pH and un-ionized ammonia (NH_3) 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 Appendices 5.2 and 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 subwatershed 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 is not yet possible for channelized streams in Minnesota. Though not an official assessment of aquatic life, a separate table within each HUC-11 summary provides a narrative rating of the condition of fish and macroinvertebrate communities at channelized streams based on the IBI results. The narrative ratings 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 habitat at 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 subwatershed.

Stream stability results

Stream channel stability information evaluated during each macroinvertebrate sampling visit is provided in each HUC-11 subwatershed 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 implemented in 2008, and is collected once at each biological station. Consequently, the CCSI ratings are only available for the 2009 biological visits. 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. This data along with other data collected within the 10 year assessment window 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 or expectations used for assessing aquatic life and recreation.

Lake assessments

A summary of lake water quality is provided in the HUC-11 sections where available data exists. For lakes with sufficient data, basic modeling was completed. Assessment results for all lakes in the watershed are available in Appendix 3.2. Lake models and corresponding morphometric inputs can be found in Appendix 6.2.

Moose River Subwatershed HUC 09020304010

Encompassing 260 square miles, the Moose River Subwatershed is located in northeastern Marshall and northwestern Beltrami counties. From its headwaters, the Moose River flows westerly 23 miles to its confluence with Thief Lake; the river does not receive drainage from any major tributaries, however it does receive water from a number of small unnamed drainage ditches. Development in this subwatershed is sparse; land use predominately consists of forest (38.7%) and wetland (48.3%). Cropland is minimal (7.9%) and is generally concentrated in the southwest portion of the subwatershed. This is the only subwatershed within the Thief River HUC-8 Watershed that contains less than 35% cropland. The remaining land use consists of range (3.5%), developed (1.5%) and barren (0.1%). The water chemistry monitoring stations (11RD067, 11RD068) on the Moose River were located off 300th Ave NE, one mile upstream of Thief Lake and upstream of CR 48, 7 mi. SW of Torfin (Figure 16).

Table 1. Aquatic life and recreation assessments in stream reaches in the Moose River Subwatershed. Reaches are organized downstream to upstream 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.
09020304-505 ***Moose River*** Headwaters to Thief Lk	23.35	2B	11RD067 11RD064 11RD062 11RD063 05RD096 05RD104	Downstream of 300th Ave NE, 4.5 mi NW of Gatzke Downstream of Hwy 89, 11 mi. NW of Grygla Upstream of CSAH 54, 9 mi. NE of Gatzke Adjacent to CR 706, 11 mi. NE of Grygla Upstream of CR 127 (310th Ave NE), 14 mi. NW of Grygla Adjacent to CR 706 (Moose River Rd), 9 mi. N of Grygla	NA*	NA*	EXS	MTS		MTS	MTS		MTS	NS	FS
09020304-555 ***Unnamed Ditch*** *Unnamed Ditch to Moose R*	1.7	2B	11RD068	Upstream of CR 48, 7 mi. SW of Torfin	NA*	NA*	IF	MTS		MTS	MTS		EX	IF	NS

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 assessments on channelized streams made prior to the decision to defer them due to TALU remain in effect.

Table 2. Non-assessed biological stations on channelized AUIDs in the Moose River Subwatershed.

AUID *Reach Name*, *Reach Description*	Reach length (miles)	Use Class	Biological Station ID	Location of Biological Station	Fish IBI	Invert IBI
09020304-505 ***Moose River*** *Headwaters to Thief Lk*	23.35	2B	11RD067	Downstream of 300th Ave NE, 4.5 mi NW of Gatzke	Fair	Good
			11RD064	Downstream of Hwy 89, 11 mi. NW of Grygla	Fair	Fair
			11RD062	Upstream of CSAH 54, 9 mi. NE of Gatzke	Fair	Good
			11RD063	Adjacent to CR 706, 11 mi. NE of Grygla	Fair	Good
			05RD096	Upstream of CR 127 (310th Ave NE), 14 mi. NW of Grygla	Poor	Poor
			05RD104	Adjacent to CR 706 (Moose River Rd), 9 mi. N of Grygla	Fair	Fair
09020304-555 ***Unnamed Ditch*** *Unnamed Ditch to Moose R*	1.7	2B	11RD068	Upstream of CR 48, 7 mi. SW of Torfin	Good	Good
09020304-557 ***Unnamed Ditch*** *Unnamed Ditch to Unnamed Ditch*	6.97	2B	11RD069	Adjacent to CR 134, 3 mi. SE of Skime	Good	Fair

See Appendix 5.1 for clarification on the good/fair/poor thresholds and Appendix 4.3 for IBI results.

Table 3. Minnesota Stream Habitat Assessment (MSHA) for the Moose River Subwatershed.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	05RD096	Moose River	5	12.5	4	11	9	41.5	Poor
1	05RD104	Moose River	2.5	7	15.85	7	14	46.35	Fair
1	11RD062	Moose River	2.5	6	13	10	1	32.5	Poor
1	11RD063	Moose River	5	13	18	15	8	59	Fair
1	11RD064	Moose River	3.75	15	9	15	4	46.75	Fair
1	11RD067	Moose River	5	11	9	6	7	38	Poor
1	11RD068	Trib. to Moose River	0	8.5	20.4	11	11	50.9	Fair
1	11RD069	Trib. to Moose River	5	9	9	12	8	43	Poor
Average Habitat Results: *Moose River Subwatershed*			**3.59**	**10.25**	**12.28**	**10.87**	**7.75**	**44.75**	**Poor**

Qualitative habitat ratings

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

Table 4. Channel Condition and Stability Assessment (CCSI) for the Moose River Subwatershed.

# Visits	Biological Station ID	Stream Name	Stream Type	Upper Banks (43-4)	Lower Banks (46-5)	Substrate (37-3)	Channel Evolution (11-1)	CCSI Score (137-13)	CCSI Rating
1	11RD063	Moose River	LGL	25	8	16	2	51	moderately unstable
		Average Stream Stability Results: *Moose River Subwatershed*		**25**	**8**	**16**	**2**	**51**	**moderately unstable**

Qualitative channel stability ratings
= Stable: CCSI < 27 = Fairly stable: 27 < CCSI < 45 = Moderately unstable: 45 < CCSI < 80 = Severely unstable: 80 < CCSI < 115 = Extremely unstable: CCSI > 115

Table 5. Outlet water chemistry results for Moose River Subwatershed (1).

Station location	Upstream of CR 48, 7 mi. southwest of Torfin						
STORET/EQuIS ID	S006-540						
Station #	11RD068						
Parameter	Units	# of Samples	Minimum	Maximum	Mean	WQ Standard[1]	# of WQ Exceedances[2]
Ammonia-nitrogen	mg/L	20	0.0001	0.003	0.0015	0.04	
Dissolved Oxygen (DO)	mg/L	34	5.6	16.7	10.0	5	
pH		35	7.1	8.7	8.0	6.5 - 9	
Secchi tube/Transparency Tube	100 cm	19	10	100	69	>20	1
Turbidity	FNU	32	0.1	101.0	6.4	25	1
Escherichia coli (geometric mean)	MPN/100ml	21	19	189	-	126	2
Escherichia coli	MPN/100ml	21	8.6	1986.3	214.5	1260	2
Inorganic nitrogen (nitrate and nitrite)	mg/L	20	0.0	1.5	0.1		
Kjeldahl nitrogen	mg/L	20	0.0	1.4	0.8		
Orthophosphate	ug/L	10	0.006	0.016	0.011		
Phosphorus	ug/L	20	9	112	30		
Specific Conductance	uS/cm	34	278	518	409		
Temperature, water	deg °C	35	2.3	24.9	16.5		
Total suspended solids	mg/L	20	1	48	5		
Total volatile solids	mg/L	11	48	88	70		

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Moose River Subwatershed, a component of the IWM work conducted between May and September in 2011 and 2012. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Table 6. Outlet water chemistry results for Moose River Subwatershed (2).

Station location	**Moose River at 300th Ave. NE, 4.5 miles northwest of Gatzke**
STORET/EQuIS ID	**S006-539**
Station #	**11RD067**

Parameter	Units	# of Samples	Minimum	Maximum	Mean	WQ Standard[1]	# of WQ Exceedances[2]
Ammonia-nitrogen	mg/L	11	0.0001	0.0023	0.001	0.04	
Dissolved Oxygen (DO)	mg/L	19	1.25	8.73	5.97	5	14
pH		19	7.5	8.2	7.8	6.5 - 9	
Secchi tube/Transparency Tube	100 cm	19	36	100	68	>20	
Turbidity	FNU	19	2	18	5	25	
Escherichia coli (geometric mean)	MPN/100ml	19	3.9	44.5	-	126	
Escherichia coli	MPN/100ml	19	5.2	686.7	58.7	1260	
Inorganic nitrogen (nitrate and nitrite)	mg/L	11	0.0	0.5	0.1		
Kjeldahl nitrogen	mg/L	11	0.78	1.43	1.05		
Orthophosphate	ug/L	1	0.007	0.007	0.007		
Phosphorus	ug/L	11	25	98	54		
Specific Conductance	uS/cm	19	298	603	396		
Temperature, water	deg °C	19	13.0	24.4	18.9		
Total suspended solids	mg/L	11	2	23	6		
Total volatile solids	mg/L	11	56	92	76		

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Moose River Subwatershed, a component of the IWM work conducted between May and September from 2011 and 2012 This specific data does not necessarily reflect all data that was used to assess the AUID.**

Summary

Eight biological monitoring stations on three AUIDs were sampled in the Moose River Subwatershed. All eight stations were on channelized reaches and therefore were not used to assess aquatic life. Fish and macroinvertebrate data indicate biological conditions on the mainstem Moose River are somewhat variable, ranging from poor to good. Two tributary streams were sampled for biology and yielded good scores for fish and fair to good scores for macroinvertebrates.

Fish species that can tolerate low levels of oxygen, such as fathead minnow, central mudminnow, and brook stickleback, dominated the fish communities at the majority of the stations along the Moose River. A combined 4,500 fathead minnows were sampled at the six Moose River stations; one station (11RD062) had over 2,500 fathead minnows collected within a 150 meter reach. In early spring, pioneering species (e.g., fathead minnow) likely use the Moose River's small, intermittent tributary streams for spawning. Throughout the summer, as water levels decrease, fathead minnows will retreat downstream into areas with more water (I.e. main stem reaches) contributing to the extremely high numbers of fathead minnows that were observed in the Moose River. While no stations along the main stem Moose River had fish communities representative of excellent water quality, sites with better MSHA substrate scores (>10) generally scored better on the F-IBI than sites with poor substrate scores (<10) (Table 3). In addition to the main stem, two tributary streams were sampled for biology and yielded good scores for fish and fair to good scores for macroinvertebrates. Excellent substrate composition in tributary streams like station 11RD068 (Table 3) was also associated with better biological communities.

Water quality data were available on the Unnamed Tributary to the Moose River (11RD067) and on the Moose River from its headwaters to Thief Lake (11RD068). The tributary to the Moose River was found to have high levels of bacteria and does not support aquatic recreation. No bacterial impairments were found in the Moose River itself, and therefore it fully supports aquatic recreation. An existing DO impairment remains along the entire Moose River after new data indicated that DO dipped as low as 1.8 mg/L during the summer of 2011. More early morning (pre 9:00 am) DO data is needed to see if current conditions are meeting DO standards. No lakes were sampled or assessed within this watershed.

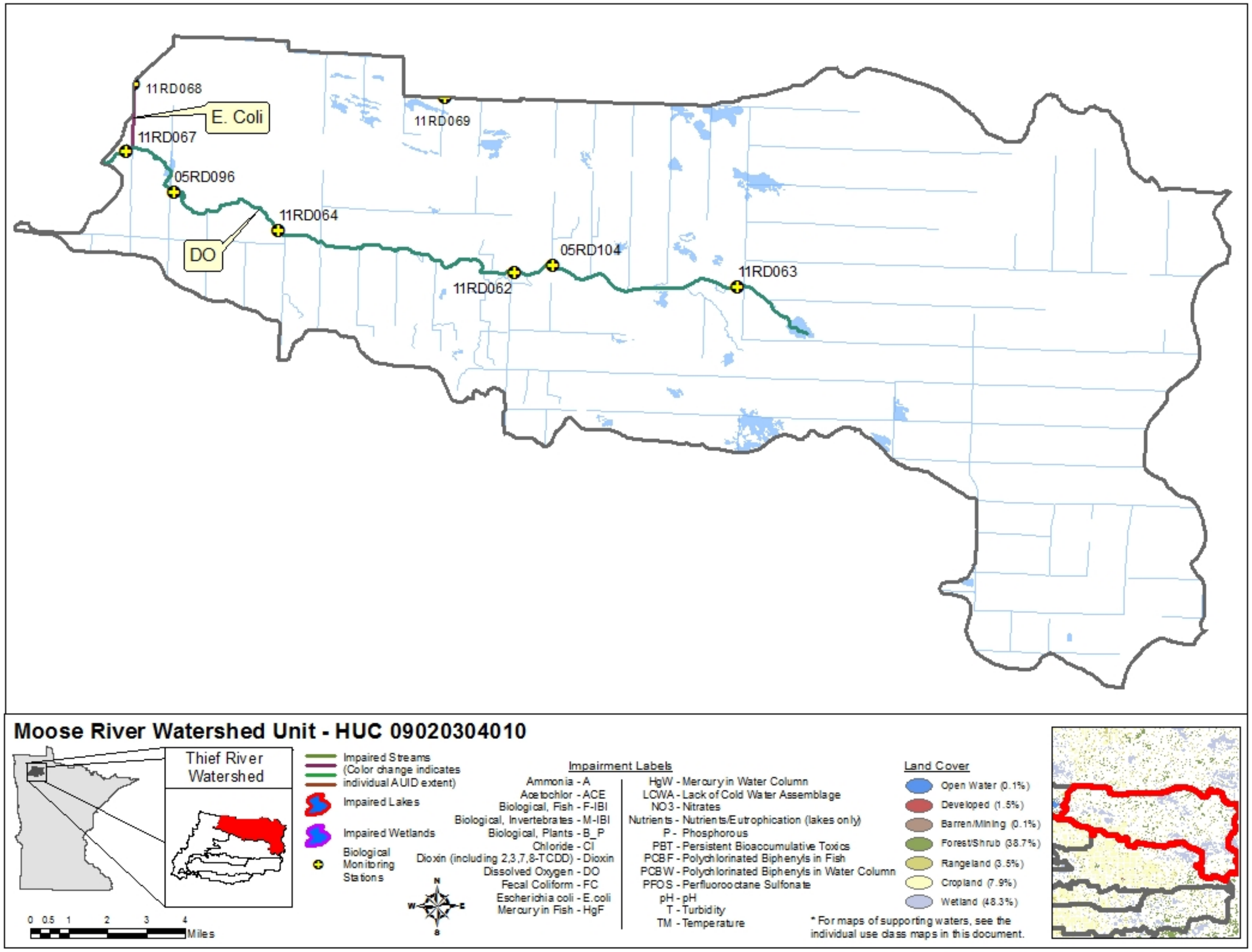


Figure 16. Currently listed impaired waters by parameter and land use characteristics in the Moose River Subwatershed

Thief River Subwatershed HUC 09020304020

The Thief River Subwatershed is located in eastern Marshall and north-central Pennington counties. Draining 261 square miles, this is the largest subwatershed in the Thief River HUC-8 Watershed. As the name implies, this subwatershed contains the entire main stem Thief River. Beginning at Thief Lake, the Thief River travels eight miles southwest before entering a 10,000 acre pool (Agassiz Pool) at Agassiz NWR. Half way through the pool the Thief River takes on its largest tributary, the Mud River, which drains the Mud and Lost River Subwatershed. After the Mud River confluence, the Thief River flows 25 miles south to its confluence with the Red Lake River in Thief River Falls.

Land use within the Thief River Subwatershed is predominately cropland (45.6%) and wetland (29.0%). Most of the wetlands are concentrated in and around Agassiz NWR. The remaining land use is comprised of range (8.1%), forest (7.1%), open water (6.3%) and developed (3.9%). Thief Lake is the only lake within the subwatershed. The water chemistry monitoring station (11RD031) on the Thief River is located upstream of the 140th Avenue NE bridge crossing, one mile northeast of Thief River Falls (Figure 17).

Table 7. Aquatic life and recreation assessments on stream reaches in the Thief River Subwatershed. Reaches are organized downstream to upstream 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.**
09020304-501 ***Thief River*** *Agassiz Pool to Red Lake R.*	21.96	2B	11RD031 11RD040**	Upstream of 140th Ave. NE, 1 mi. N of Thief River Falls Downstream of CSAH 7, 6 mi. E of Holt	MTS	MTS	MTS	EXS	MTS	MTS	MTS	--	MTS	NS	FS
09020304-504 ***Thief River*** *Thief Lake to Agassiz Pool*	7.9	2B	11RD042	Downstream of 380th St. NE, 9.5 mi. E of Middle River	NA*	NA*	IF	MTS	--	MTS	MTS	--	MTS	IF*	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. Aquatic life assessments on channelized streams made prior to the decision to defer them due to TALU remain in effect.
** Aquatic Life assessment and/or impairments for this station have been deferred until the adoption of Tiered Aquatic Life Uses due to the site being predominantly (>50%) channelized.

Table 8. Non-assessed biological stations on channelized AUIDs in the Thief River Subwatershed.

AUID ***Reach Name,*** *Reach Description*	Reach length (miles)	Use Class	Biological Station ID	Location of Biological Station	Fish IBI	Invert IBI
09020304-501 ***Thief River*** *Agassiz Pool to Red Lake R.*	21.96	2B	11RD040	Downstream of CSAH 7, 6 mi. E of Holt	Good	--
09020304-504 ***Thief River*** *Thief Lake to Agassiz Pool*	7.9	2B	11RD042	Downstream of 380th St. NE, 9.5 mi. E of Middle River	Fair	Good
09020304-543 **Unnamed Ditch** *Unnamed Ditch to Unnamed Ditch*	1.98	2B	11RD045	Upstream of Northgate Rd, 5 mi. SW of Gatzke	Good	--
09020304-550 **Unnamed Ditch** *Headwaters to Thief River*	5.78	2B	11RD034	Upstream of 240th St NE, 6.5 mi. N of Thief River Falls	Poor	--
09020304-551 **Unnamed Ditch** *Unnamed Ditch to Thief River*	4.56	2B	11RD033	Upstream of 140th Ave NE, 5 mi. N of Thief River Falls	Poor	Poor
09020304-558 **Unnamed Ditch** *Unnamed Ditch to Thief River*	2.33	2B	11RD041	Adjacent to 200th Ave NE, 7.5 mi. SE of Middle River	Poor	--

See Appendix 5.1 for clarification on the good/fair/poor thresholds and Appendix 4.3 for IBI results.

Table 9. Minnesota Stream Habitat Assessment (MSHA) for the Thief River Subwatershed.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
2	11RD031	Thief River	0.75	9.5	19.75	9.5	26.5	66	Good
1	11RD033	Trib. to Thief River	0	7	7	12	7	33	Poor
1	11RD034	Trib. to Thief River	0.75	7.5	9	1	4	22.25	Poor
1	11RD040	Thief River	1.5	8	18	6	8	41.5	Poor
1	11RD041	Unnamed Ditch	2.5	7.5	7	12	7	36	Poor
1	11RD042	Thief River	2.5	12	15	8	14	51.5	Fair
1	11RD045	Judicial Ditch 11	5	12	16	12	7	52	Fair
Average Habitat Results: *Thief River Subwatershed*			**2**	**8.83**	**13.08**	**8.83**	**9.72**	**42.47**	**Poor**

Qualitative habitat ratings

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

Table 10. Channel Condition and Stability Assessment (CCSI) for the Thief River Subwatershed.

# Visits	Biological Station ID	Stream Name	Stream Type	Upper Banks (43-4)	Lower Banks (46-5)	Substrate (37-3)	Channel Evolution (11-1)	CCSI Score (137-13)	CCSI Rating
1	11RD031	Thief River	MHL	19	27	11	2	59	moderately unstable
Average Stream Stability Results: *Thief River Subwatershed*				**19**	**27**	**11**	**2**	**59**	**moderately unstable**

Qualitative channel stability ratings

= Stable: CCSI < 27 = Fairly stable: 27 < CCSI < 45 = Moderately unstable: 45 < CCSI < 80 = Severely unstable: 80 < CCSI < 115 = Extremely unstable: CCSI > 115

Table 11. Outlet water chemistry results Thief River Subwatershed (1).

Station location	Downstream of 380th St. NE, 9.5 mi. E of Middle River						
STORET/EQuIS ID	S004-055						
Station #	11RD042						
Parameter	Units	# of Samples	Minimum	Maximum	Mean	WQ Standard[1]	# of WQ Exceedances[2]
Ammonia-nitrogen	mg/L	17	0.0003	0.0088	0.0029	0.04	
Dissolved Oxygen (DO)	mg/L	33	6.1	14.0	9.3	5	
pH		33	7.1	8.8	8.1	6.5 - 9	
Secchi tube/Transparency Tube	100 cm	18	31	100	64	>20	
Turbidity	FNU	33	0.1	32.5	7.6	25	1
Escherichia coli (geometric mean)	MPN/100ml	24	26.4	99.5	-	126	
Escherichia coli	MPN/100ml	24	2	2420	172	1260	1
Inorganic nitrogen (nitrate and nitrite)	mg/L	17	0.0	9.1	0.6		
Kjeldahl nitrogen	mg/L	17	0.7	2.2	1.1		
Orthophosphate	ug/L	17	0.003	0.369	0.033		
Phosphorus	ug/L	17	17	424	60		
Specific Conductance	uS/cm	33	283	590	352		
Temperature, water	deg °C	33	8.7	26.0	18.9		
Total suspended solids	mg/L	18	1	24	8		
Total volatile solids	mg/L	11	55	184	87		

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Thief River Subwatershed, a component of the IWM work conducted in 2011 and 2012. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Table 12. Outlet water chemistry results Thief River Subwatershed (2).

Station location	Downstream of CSAH 7, 6 mi. E of Holt						
STORET/EQuIS ID	S002-088						
Station #	11RD040						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	17	0.0003	0.0148	0.0029	0.04	
Dissolved Oxygen (DO)	mg/L	36	4.2	13.3	9.2	5	2
pH		37	7.4	9.1	8.2	6.5 - 9	
Secchi tube/Transparency Tube	100 cm	25	11	100	44	>20	4
Turbidity	FNU	37	0.1	81.7	21.1	25	11
Escherichia coli (geometric mean)	MPN/100ml	22	49	100	-	126	
Escherichia coli	MPN/100ml	22	3	2420	334	1260	2
Inorganic nitrogen (nitrate and nitrite)	mg/L	26	0.0	3.7	0.2		
Kjeldahl nitrogen	mg/L	26	0.9	2.7	1.5		
Orthophosphate	ug/L	26	0.003	0.276	0.021		
Phosphorus	ug/L	26	23	466	68		
Specific Conductance	uS/cm	37	335	788	447		
Temperature, water	deg °C	37	0.3	28.6	18.5		
Total suspended solids	mg/L	26	3	53	19		
Total volatile solids	mg/L	20	1	120	51		

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Thief River Subwatershed, a component of the IWM work conducted between May and September from 2011 and 2012. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Table 13. Outlet water chemistry results Thief River Subwatershed (3).

Station location	Upstream of 140th Ave. NE, 1 mi. N of Thief River Falls						
STORET/EQuIS ID	S002-079						
Station #	11RD031						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	21	0.0002	0.013	0.0026	0.04	
Chloride	mg/L	1	8.05	8.05	8.05	230	
Dissolved Oxygen (DO)	mg/L	89	1.9	15.9	8.8	5	4
pH		89	7.0	9.0	8.0	6.5 - 9	
Secchi tube/Transparency Tube	100 cm	62	11	100	56	>20	4
Turbidity	FNU	86	0.1	57.5	11.0	25	8
Escherichia coli (geometric mean)	MPN/100ml	29	49	100	-	126	
Escherichia coli	MPN/100ml	29	3	2420	163	1260	1
Inorganic nitrogen (nitrate and nitrite)	mg/L	55	0.0	2.8	0.2		
Kjeldahl nitrogen	mg/L	55	0.8	4.6	1.5		
Orthophosphate	ug/L	55	0.003	0.366	0.019		
Phosphorus	ug/L	55	17	447	55		
Specific Conductance	uS/cm	89	357	1827	553		
Temperature, water	deg °C	89	-0.06	28.5	16.7		
Total suspended solids	mg/L	54	1	60	13		
Total volatile solids	mg/L	43	1	144	26		

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Thief River Subwatershed, a component of the IWM work conducted between May and September from 2011 and 2012. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Table 14. Lake water aquatic recreation assessments: Thief River Subwatershed.

Name	DNR Lake ID	Area (acres)	Trophic Status	percent Littoral	Max. Depth (m)	Avg. Depth (m)	CLMP Trend	Mean TP (µg/L)	Mean chl-a (µg/L)	Secchi Mean (m)	Support Status
Thief	45-0001-00	6512.9	E	100	1.4	0.9	-	35	10.5	0.9	FS

Abbreviations:
D -- Decreasing/Declining Trend
I -- Increasing/Improving Trends
NT – No Trend
H – Hypereutrophic
E – Eutrophic
M – Mesotrophic
FS – Full Support
NS – Non-Support
IF – Insufficient

Summary

Eight biological monitoring stations on six AUIDs were sampled along the Thief River and its tributary streams in this subwatershed. Only one AUID was assessed for aquatic life; the other assessments were deferred because the stream segment was channelized. The Agassiz NWR is within this watershed. Many of the biological stations on the Thief River lie within, or on the edge of, the refuge boundaries.

Biological conditions along the Thief River and its tributaries were variable and associated with differences in habitat among sites. In-stream substrates at sites with poor F-IBIs were dominated by fine sediments (silt, sand, clay). Also, fish cover at these sites was limited to extensive emergent and/or submerged vegetation. In contrast, sites scoring better on the F-IBI had coarse substrates and less dense macrophytes.

The lone assessed stream segment along the Thief River (AUID 09020304-501) had one biological station (11RD031); the biological community met its standards for both F-IBI and M-IBI. Several sensitive fish species were sampled including smallmouth bass, golden redhorse and horneyhead chub. The habitat at this site was good with coarse substrates, excellent depth variability, woody debris, and good channel development that consisted of riffles, runs and pools (Table 9).

Water quality data were available from three stations along the Thief River. The segment from the headwaters to the Agassiz Pool (AUID 09020304-504) has been proposed for delisting for bacteria and ammonia as both parameters are currently meeting their respective standards. The stations that resulted in this segment being listed previously were not representative of the reach since they were too close to the Agassiz Pool and heavily impacted by waterfowl communities. Moving further downstream, from the Agassiz Pool to the Red Lake River (AUID 090203040-501), the Thief River supports aquatic recreation with low bacteria levels. In addition, DO levels have improved significantly from the 2006 listing and have been proposed to be delisted. Thief Lake is the only lake assessed in the Thief River HUC-8, and met all of its water quality standards (Table 14).

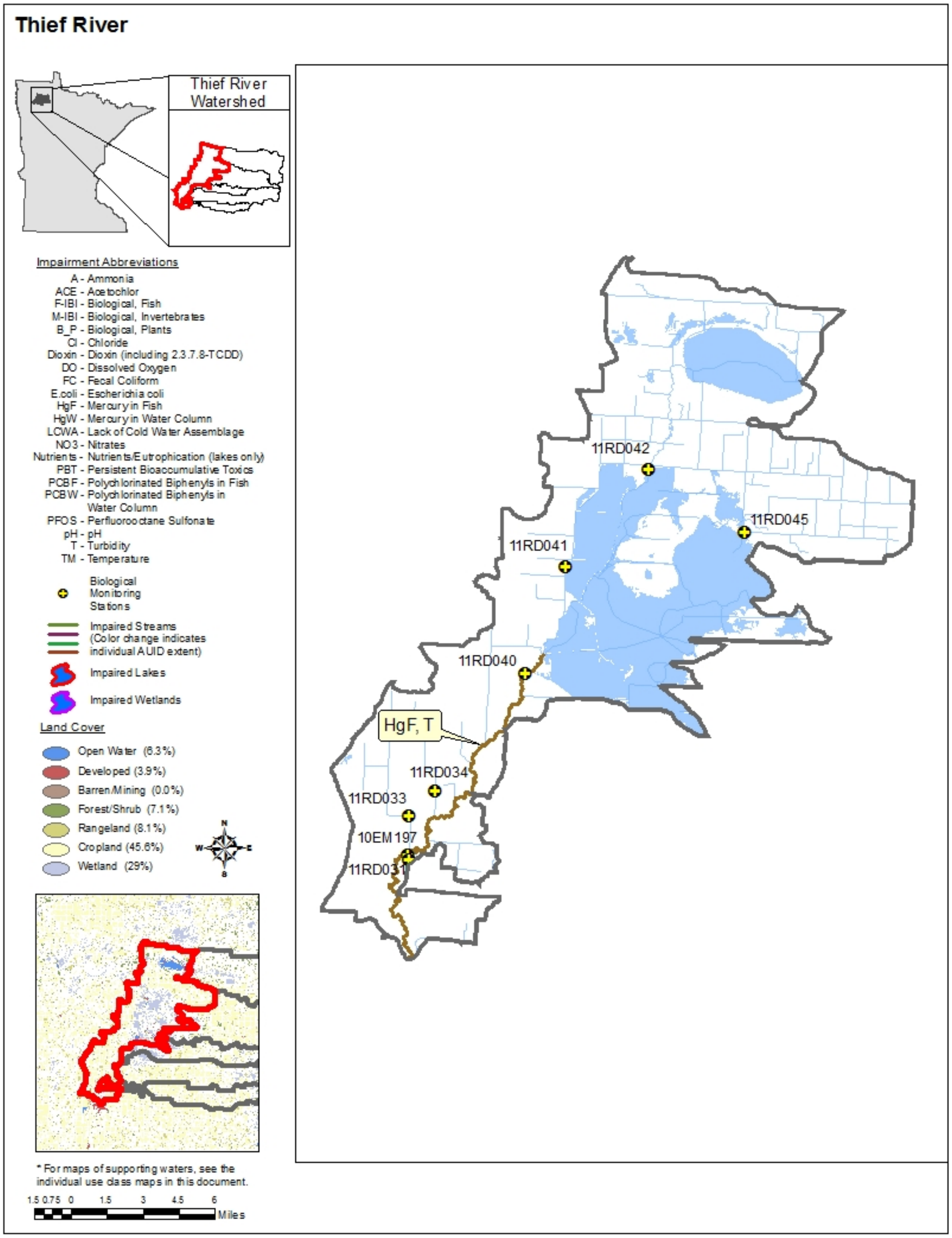


Figure 17. Currently listed impaired waters by parameter and land use characteristics in the Thief River Subwatershed

Mud and Lost River Subwatershed HUC 09020304030

The Mud River Subwatershed, located in eastern Marshall and western Beltrami counties, drains 195 square miles. The Mud River originates two miles southwest of Grygla, and flows 20 miles northwest to its confluence with Agassiz Pool at Agassiz NWR. There are no named tributaries to the Mud River. Land use within this subwatershed is predominately cropland (45.8%), wetlands (23.2%), and forest (18.6%). The remaining land use consists of range (9.4%) and developed (2.9%). Grygla is the only city within the subwatershed boundaries. The water chemistry monitoring station (11RD061) on the Mud River is located off the Highway 89 bridge, six miles northeast of Grygla (Figure 18). There are no lakes within this watershed.

Table 15. Aquatic life and recreation assessments on streams reaches in the Mud River Subwatershed. Reaches are organized downstream to upstream 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.**
09020304-507 ***Mud River*** *Headwaters to Agassiz Pool*	20.01	2B	05RD097 11RD060** 11RD061**	Downstream of 360th Ave NE, 4 mi. NW of Grygla Upstream of 390th Ave NE, 1 mi. W of Grygla Downstream of Hwy 89, 6 mi. NE of Grygla	NA	MTS	EXS	MTS	--	MTS	MTS	--	EX	NS	NS

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 assessments on channelized streams made prior to the decision to defer them due to TALU remain in effect.

** Aquatic Life assessment and/or impairments for this site have been deferred until the adoption of Tiered Aquatic Life Uses due to the site being predominantly (>50%) channelized

Table 16. Non-assessed biological stations on channelized AUIDs in the Mud River Subwatershed.

AUID *Reach Name*, *Reach Description*	Reach length (miles)	Use Class	Biological Station ID	Location of Biological Station	Fish IBI	Invert IBI
09020304-507 ***Mud River*** *Headwaters to Agassiz Pool*	20.06	2B	11RD060	Upstream of 390th Ave NE, 1 mi. W of Grygla	Fair	Poor
			11RD061	Downstream of Hwy 89, 6 mi. NE of Grygla	Good	Fair
09020304-527 ***Unnamed Ditch*** *Unnamed Ditch to Unnamed Ditch*	7.86	2B	11RD059	Upstream of CR 701, 5.5 mi. NE of Grygla	Good	--
09020304-559 **Unnamed Ditch** *Headwaters to Mud Lk.*	6.29	2B	11RD046	Adjacent to 340th St NE, 5 mi. SW of Gatzke	Good	Poor
09020304-536 **Judicial Ditch 11** *Unnamed Ditch to Thief River*	9.67	2B	11RD047	Downstream of 290th Ave NE, 7.5 mi. SW of Gatzke	Good	Fair

See Appendix 5.1 for clarification on the good/fair/poor thresholds and Appendix 4.3 for IBI results.

Table 17. Minnesota Stream Habitat Assessment (MSHA) for the Mud River Subwatershed.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	05RD097	Mud River	2.5	11.5	16	7	16	53	Fair
1	11RD046	Trib. to Mud Lake	2.5	5	12	1	4	24.5	Poor
1	11RD059	Trib. to Mud River	1.25	9	8	13	14	45.25	Fair
1	11RD060	Mud River	3.75	8	18.2	10	15	54.95	Poor
1	11RD061	Mud River	0	5.5	7.4	10	18	40.9	Poor
1	11RD047	Judicial Ditch 11	5	8	8	12	4	37	Poor
Average Habitat Results: *Mud River Subwatershed.*			**2.5**	**8.50**	**12.93**	**8.83**	**12.33**	**45.10**	**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. Channel Condition and Stability Assessment (CCSI) for the Mud River Subwatershed.

# Visits	Biological Station ID	Stream Name	Stream Type	Upper Banks (43-4)	Lower Banks (46-5)	Substrate (37-3)	Channel Evolution (11-1)	CCSI Score (137-13)	CCSI Rating
1	11RD060	Mud River	TCM	18	23	12	2	55	moderately unstable
Average Stream Stability Results: *Mud River Subwatershed*				**18**	**23**	**12**	**2**	**55**	**moderately unstable**

Qualitative channel stability ratings
= Stable: CCSI < 27 = Fairly stable: 27 < CCSI < 45 = Moderately unstable: 45 < CCSI < 80 = Severely unstable: 80 < CCSI < 115 = Extremely unstable: CCSI > 115

Table 19. Outlet water chemistry results for the Mud River Subwatershed.

Station location	**Mud River, on MN-89 bridge, 6 miles northwest of Grygla, MN**
STORET/EQuIS ID	**Downstream of Hwy 89, 6 mi. NE of Grygla**
Station #	**11RD061**

Parameter	Units	# of Samples	Minimum	Maximum	Mean	WQ Standard[1]	# of WQ Exceedances[2]
Ammonia-nitrogen	mg/L	23	0.0002	0.0143	0.0046	0.04	
Dissolved Oxygen (DO)	mg/L	47	5.0	17.4	10.5	5	
pH		47	7.4	8.8	8.1	6.5 - 9	
Secchi tube/Transparency Tube	100 cm	31	13	100	71	>20	1
Turbidity	FNU	45	0.1	47.6	5.9	25	2
Escherichia coli (geometric mean)	MPN/100ml	26	17.1	179.4	-	126	2
Escherichia coli	MPN/100ml	26	5.2	2419.6	244.7	1260	2
Inorganic nitrogen (nitrate and nitrite)	mg/L	37	0.0	4.6	0.8		
Kjeldahl nitrogen	mg/L	37	0.7	2.6	1.2		
Orthophosphate	ug/L	28	0.003	0.161	0.023		
Phosphorus	ug/L	37	21	282	61		
Specific Conductance	uS/cm	47	226	993	513		
Temperature, water	deg °C	47	0.1	29.2	18.7		
Total suspended solids	mg/L	37	1	51	7		
Total volatile solids	mg/L	23	1	156	42		

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Mud River Subwatershed, a component of the IWM work conducted between May and September in 2011 and 2012. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Summary

Six biological monitoring stations were sampled within the Mud and Lost River Subwatershed. Only one station was assessed. The M-IBI score at this station (05RD097) was 34 points above its respective threshold, indicating good conditions. Three types of habitat were sampled to collect the macroinvertebrates including rock, aquatic macrophytes, and overhanging vegetation. The sample included several sensitive taxa, namely stoneflies from the genera *Acroneuria* and *Pteronarcys*, caddisflies from the genera *Ceraclea*, *Helicopsyche* and *Oecetis*, and mayflies from the genera *Leptophlebia* and *Procloeon*. This station was also sampled for fish but it was not assessed because the sampling effort was insufficient. Fish communities in the non-assessed channelized reaches were generally good, and invertebrates were fair to poor.

Water quality data along the Mud River was available from its headwaters to the Agassiz Pool in Agassiz NWR. Mud River was found to have high bacteria levels this assessment cycle and does not support aquatic recreation. The reach was listed as impaired due to low DO in 2008. There were no additional exceedances of the DO standard during this assessment cycle but there was not sufficient evidence to delist the reach. For the most part, turbidity is relatively low with a mean reading of 5.9 FNU and only a couple samples exceeding the standard of 25 FNU over the most recent two year data window.

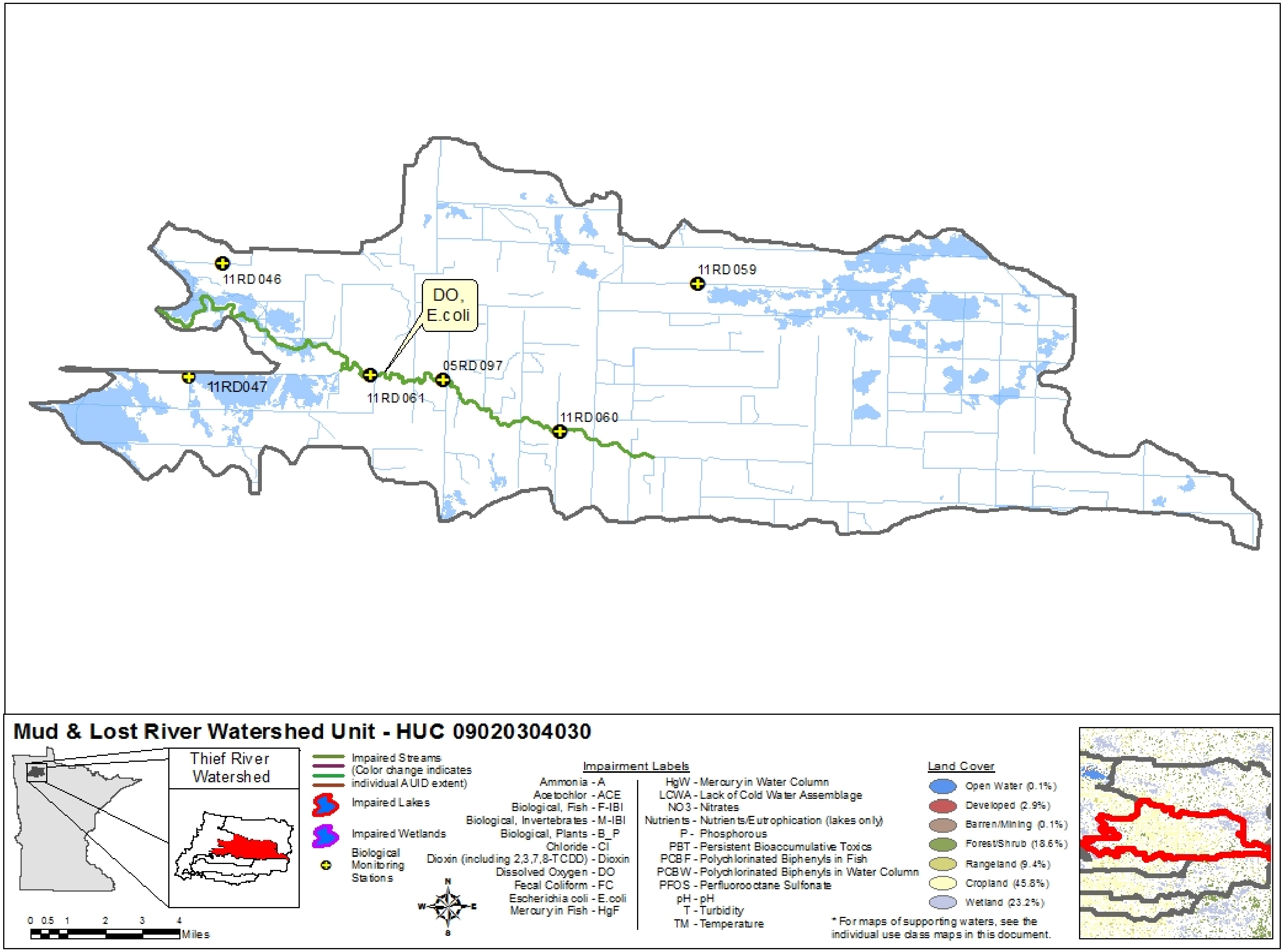


Figure 18. Currently listed impaired waters by parameter and land use characteristics in the Mud and Lost River Subwatershed

Branch 200 of Judicial Ditch 11 Subwatershed HUC 09020304040

The Branch 200 of Judicial Ditch 11 (JD 11) Subwatershed, located in western Beltrami and eastern Marshall counties, drains 77.6 square miles. Beginning 2.5 miles south of Grygla, JD 11 flows 20.5 miles before its confluence with the Red Lake River. Along its course, JD 11 takes on water from the Lost River and a number of unnamed drainage ditches. Land use within this subwatershed is predominantly cropland (42.4%) and wetland (32.8%). There is also a fair amount of forest (13.4%) and range (8.9%). The remaining land use consists of developed (2.3%) and open water (0.2%). There are no towns within the subwatershed boundaries. The water chemistry monitoring station on JD 11 is located upstream of 190th Ave. NE, 10 miles NE of Thief River Falls (Figure 21).

Table 20. Aquatic life and recreation assessments on stream reaches in the Branch 200 of Judicial Ditch 11 Subwatershed. Reaches are organized downstream to upstream 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.**
09020304-511 ***Unnamed Ditch (Ditch 200)*** *Unnamed Ditch to Unnamed Ditch*	5	2B	11RD038	Upstream of 190th Ave NE, 10 mi. NE of Thief River Falls	NA*	NA*	EXP	MTS	--	MTS	MTS	--	MTS	IF*	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. Aquatic life assessments on channelized streams made prior to the decision to defer them due to TALU remain in effect.

Table 21. Non-assessed biological stations on channelized AUIDs in the Branch 200 of Judicial Ditch 11 Subwatershed.

AUID *Reach Name,* *Reach Description*	Reach length (miles)	Use Class	Biological Station ID	Location of Biological Station	Fish IBI	Invert IBI
09020304-511 ***Unnamed Ditch (Ditch 200)*** *Unnamed Ditch to Unnamed Ditch*	5	2B	11RD038	Upstream of 190th Ave NE, 10 mi. NE of Thief River Falls	Poor	Fair

See Appendix 5.1 for clarification on the good/fair/poor thresholds and Appendix 4.3 for IBI results.

Table 22. Minnesota Stream Habitat Assessment (MSHA) for the Branch 200 of Judicial Ditch 11 Subwatershed.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	11RD038	Judicial Ditch 11	3	6.5	12	12	1	34.5	Poor
Average Habitat Results: *Branch 200 of Judicial Ditch 11 Subwatershed*			**3**	**6.5**	**12**	**12**	**1**	**34.5**	Poor

Qualitative habitat ratings

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

Table 23. Outlet water chemistry results for Branch 200 of Judicial Ditch 11 Subwatershed.

Station location	**Upstream of 190th Ave NE, 10 mi. NE of Thief River Falls**						
STORET/EQuIS ID	**S004-493**						
Station #	**11RD038**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	13	0.0002	0.0041	0.0011	0.04	
Dissolved Oxygen (DO)	mg/L	27	2.5	15.8	9.8	5	1
pH		28	7.0	8.7	7.8	6.5 - 9	
Secchi tube/Transparency Tube	100 cm	19	60	100	73	>20	
Turbidity	FNU	28	0.1	15.2	2.7	25	
Escherichia coli (geometric mean)	MPN/100ml	19	10	44	-	126	
Escherichia coli	MPN/100ml	19	3	308	83	1260	
Inorganic nitrogen (nitrate and nitrite)	mg/L	13	0.0	0.13	0.04		
Kjeldahl nitrogen	mg/L	13	0.3	1.7	1.1		
Orthophosphate	ug/L	14	0.003	0.054	0.022		
Phosphorus	ug/L	13	21	95	48		
Specific Conductance	uS/cm	28	294	999	607		
Temperature, water	deg °C	28	11.9	28.3	20.4		
Total suspended solids	mg/L	13	1	11	4		
Total volatile solids	mg/L	11	72	152	114		

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Branch 200 of Judicial Ditch 11 Subwatershed, a component of the IWM work conducted between May and September in 2011 and 2012. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Summary

One biological monitoring station (11RD038) was located in the Branch 200 of the JD 11 Subwatershed. This station is predominately channelized and therefore was not assessed for aquatic life. The biological conditions of this stream were in fair to poor condition. The most abundant fish species sampled was fathead minnow, which is a very tolerant species. The invertebrate community was rated fair, yet 92% of the sample was made up of highly tolerant species. Habitat conditions were very poor and are likely limiting the survival of many sensitive fish and macroinvertebrates (Table 22). Extremely dense macrophytes, filamentous algae, and deep fine sediments persist throughout the stream channel (See Figure 20). The channel morphology component of the MSHA was extremely low (1 out of a possible 36 points) indicating that this stream has little to no depth variability, no channel development, low channel stability and low flows.

Water quality data available at 11RD038 indicate this stream segment is meeting water quality standards for bacteria and supports aquatic recreation. Aquatic life was not assessed because the sampling location was close to a water control structure and low flow conditions were present in 2012. Additional sampling during the critical early morning time period would help to determine if low DO levels are compromising aquatic life in this reach.

Figure 20. Image of extensive in-stream vegetation at biological monitoring station 11RD038 on Judicial Ditch 11

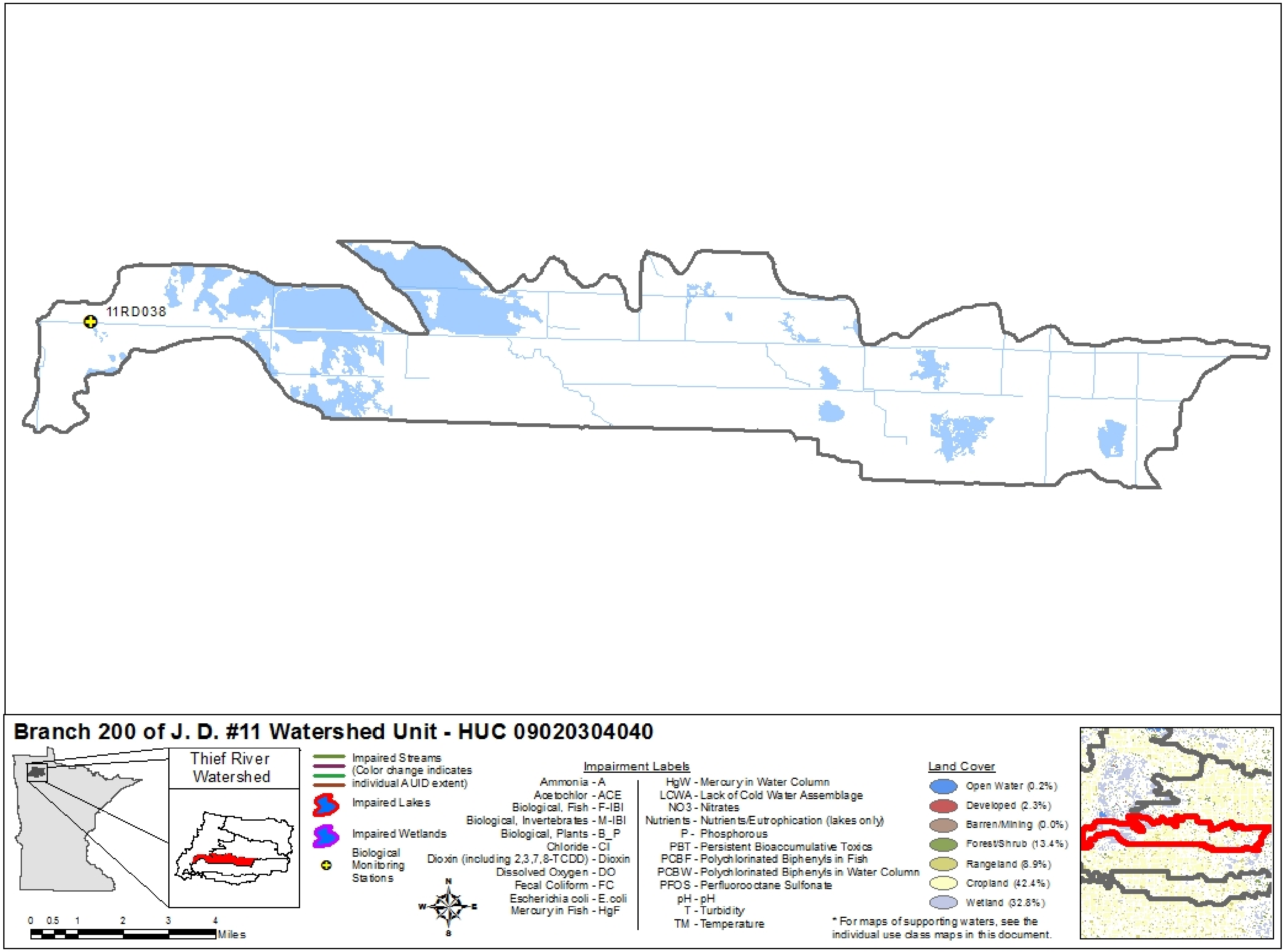


Figure 21. Currently listed impaired waters by parameter and land use characteristics in the Branch 200 of Judicial Ditch 11 Subwatershed

County Ditch 120 Subwatershed HUC 09020304050

Draining 201.8 square miles, the County Ditch (CD) 120 Subwatershed is located in Marshall, Pennington, and Beltrami counties. CD 20 starts in the eastern portion of the subwatershed and flows west 36 miles to its confluence with the Red Lake River. CD 20 takes on water from many small tributaries, with the majority being unnamed drainage ditches. Land use within the subwatershed is a mixture of cropland (35.6%), wetlands (29.0%), and forest (23.5%). The remaining land use consists of range (9.3%) and developed (2.5%). There are no towns or lakes within this subwatershed. The water chemistry monitoring station on CD 20 (11RD036) is located upstream of 180th Avenue, eight miles NE of Thief River Falls (Figure 22).

Table 24. Aquatic life and recreation assessments on streams reaches in the County Ditch 120 Subwatershed. Reaches are organized downstream to upstream 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.**
09020304-519 ***County Ditch 20*** *Unnamed Ditch to Unnamed Ditch*	1	2B	11RD036	Upstream of 180th Ave, 8 mi. NE of Thief River Falls	NA*	NA*	IF	MTS	--	MTS	MTS	--	MTS	IF*	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. Aquatic life assessments on channelized streams made prior to the decision to defer them due to TALU remain in effect.

Table 25. Non-assessed biological stations on channelized AUIDs in the County Ditch 120 Subwatershed.

AUID ***Reach Name,*** *Reach Description*	**Reach length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Fish IBI**	**Invert IBI**
09020304-513 ***County Ditch 20*** *Unnamed Ditch to CD 32*	8.44	2B	11RD051	Downstream of 330th Ave NE, 5.5 mi. NE of Goodridge	Good	Good
09020304-519 ***County Ditch 20*** *Unnamed Ditch to Unnamed Ditch*	1	2B	11RD036	Upstream of 180th Ave, 8 mi. NE of Thief River Falls	Fair	Good Fair

09020304-548 **County Ditch 20** *Unnamed Ditch to Unnamed Ditch*	5.43	2B	11RD056	Adjacent to CR 710, 7 mi. SE of Grygla	Poor	Fair (2)
09020304-549 **Unnamed Ditch** *Unnamed Ditch to CD 30*	3.97	2B	11RD057	Upstream of CR 707, 1 mi. N of Jelle	Good	--
09020304-552 **County Ditch 27** *Unnamed Ditch to Unnamed Ditch*	3.98	2B	11RD037	At end of 250th St NE, 9.5 mi. NE of Thief River Falls	Poor	Fair
09020304-554 **County Ditch 32** *Unnamed Ditch to County Ditch 20*	2.47	2B	11RD052	Adjacent to 230th St NE, 4.5 mi. N of Goodridge	Poor	Poor (2)

See Appendix 5.1 for clarification on the good/fair/poor thresholds and Appendix 4.3 for IBI results.

Table 26. Minnesota Stream Habitat Assessment (MSHA) for the County Ditch 120 Subwatershed.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	11RD056	County Ditch 20	2.5	9	18	10	7	46.5	Fair
1	11RD057	Trib. to County Ditch 20	5	9	9	12	4	39	Poor
1	11RD052	County Ditch 32	4	12	16	12	7	51	Fair
1	11RD037	Trib. to County Ditch 20	5	10.5	3	12	7	37.5	Poor
1	11RD036	County Ditch 20	2.5	6	14	7	5	34.5	Poor
1	11RD051	County Ditch 20	2.75	10.5	18	10	8	49.25	Fair
Average Habitat Results: *County Ditch 120 Subwatershed*			**3.6**	**9.5**	**13**	**10.5**	**6.3**	**43.0**	**Poor**

Qualitative habitat ratings

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

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

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

Table 27. Outlet water chemistry results for the County Ditch 120 Subwatershed.

Station location	Upstream of 180th Ave, 8 mi. NE of Thief River Falls						
STORET/EQuIS ID	S004-494						
Station #	11RD036						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	17	0.0001	0.0257	0.0039	0.04	
Dissolved Oxygen (DO)	mg/L	37	4.2	13.8	10.0	5	3
pH		37	7.3	9.3	8.2	6.5 - 9	
Secchi tube/Transparency Tube	100 cm	19	20	120	67	>20	1
Turbidity	FNU	37	0.1	34.4	9.0	25	3
Escherichia coli (geometric mean)	MPN/100ml	26	5.2	78.6	-	126	
Escherichia coli	MPN/100ml	26	5.2	547.5	103.2	1260	
Chlorophyll-a, Corrected	ug/L	2	1	4	3		
Inorganic nitrogen (nitrate and nitrite)	mg/L	17	0.03	1.37	0.16		
Kjeldahl nitrogen	mg/L	17	1.0	2.0	1.3		
Orthophosphate	ug/L	17	0.003	0.101	0.026		
Pheophytin-a	ug/L	2	1	2	2		
Phosphorus	ug/L	17	21	159	60		
Specific Conductance	uS/cm	37	173	865	544		
Temperature, water	deg °C	37	10.2	29.7	21.1		
Total suspended solids	mg/L	17	1	22	7		
Total volatile solids	mg/L	10	62	144	106		

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the County Ditch 120 Subwatershed, a component of the IWM work conducted between May and September in 2011 and 2012. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Summary

Seven biological monitoring stations were sampled on seven AUIDs in the CD 120 Subwatershed; all stations were channelized and aquatic life assessments were thus deferred. Biological conditions along CD 20 improved from upstream to downstream. Near the headwaters of CD 20 at station 11RD056, the F-IBI score was poor and the species composition consisted of only four species, two being highly tolerant (i.e central mudminnow and brook stickleback). The F-IBI score at the next downstream site (11RD051) was fair with four species present. The F-IBI at the most downstream site (11RD036) was good. Seventeen species of fish were sampled at this site, including several game fish and sensitive species (e.g., walleye, shorthead redhorse, and emerald shiner). Macroinvertebrate scores were highly variable with scores ranging from poor to good. There was little association between the habitat and the fish or macroinvertebrate communities throughout this subwatershed. Hydrology may be a larger factor in this heavily drained watershed where water levels tend to be flashy, specifically in the headwaters where the stream is smaller and more susceptible to extreme flow conditions. The rapid changes in water levels can alter habitat, increase bank erosion and alter stream morphology, which can be detrimental to sensitive biota.

Water chemistry data was available for a one mile stretch of CD 20 as it crosses 180th Avenue NE, just upstream of its outlet to the Thief River. This stream segment is meeting the water quality standards for E-coli and supports aquatic recreation. Turbidity values exceeded the standard on three occasions, but overall the data were still below the required 10% exceedance level to list the reach as impaired.

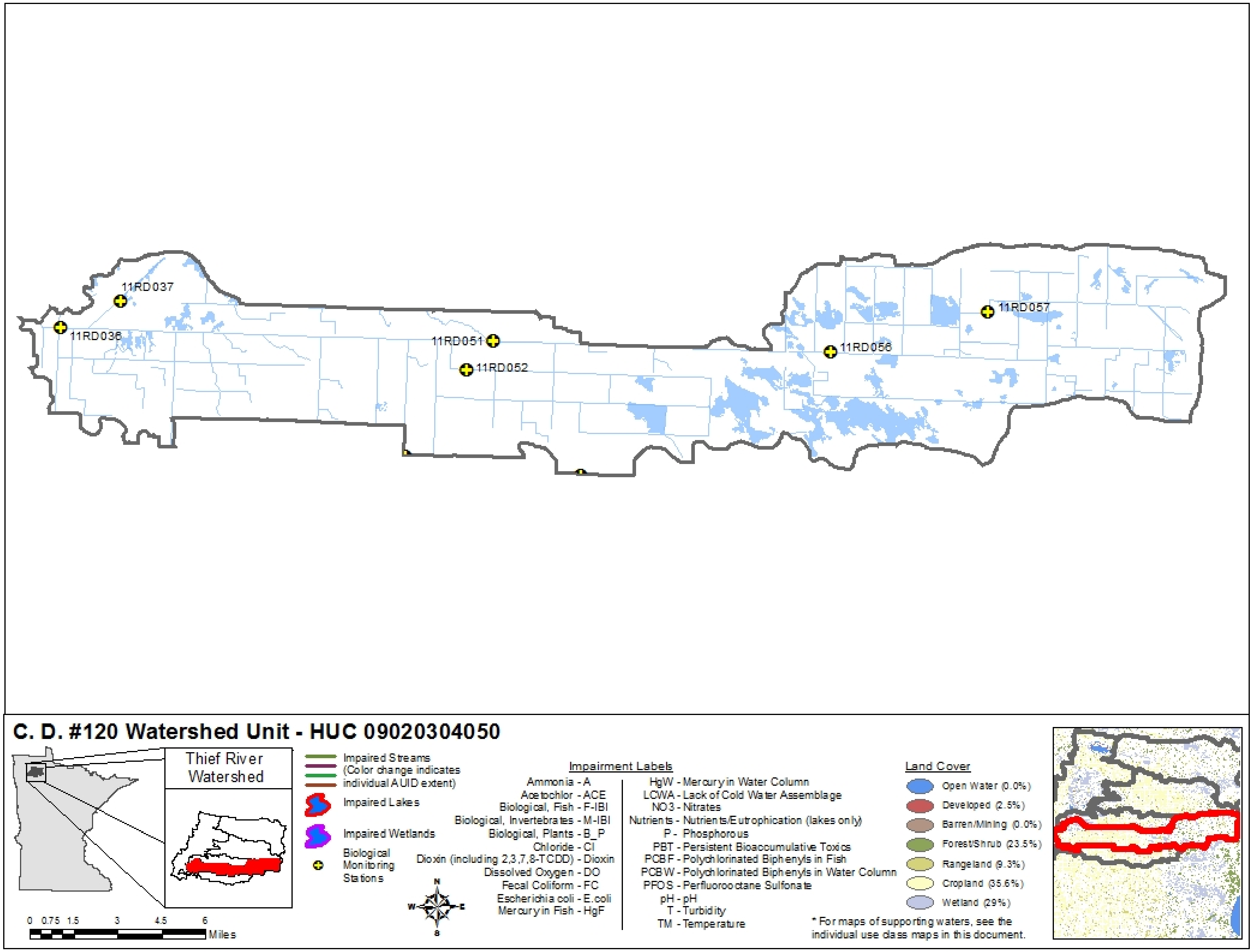


Figure 22. Currently listed impaired waters by parameter and land use characteristics in the County Ditch 120 Subwatershed

Goodrich Subwatershed — HUC 09020304060

Draining 80 square miles, the Goodrich Subwatershed is located in Marshall, Pennington, and Beltrami counties. The subwatershed consists of mainly channelized waterways which include Judicial Ditch (JD) 18 and JD 13. JD 18 starts near the town of Goodrich and flows northwesterly six miles before its confluence with JD 13. After this confluence, JD 18 flows west 21 miles to its confluence with the Thief River. This is the furthest downstream tributary to the Thief River before its confluence with the Red Lake River. Land use in this subwatershed is predominately cropland (65%). Additionally, there is a fair amount of wetlands (12.2%), range (10.1%) and forest (8.8%). The remaining land use is developed land (3.9%) which is concentrated around the town of Goodrich; this is the only town within the watershed. The water chemistry monitoring station for this watershed (11RD032) is located at the County Road 77 Bridge, three miles north of Thief River Falls (Figure 23).

Table 28. Non-assessed biological stations on channelized AUIDs in the Goodrich Subwatershed.

AUID ***Reach Name***, *Reach Description*	Reach length (miles)	Use Class	Biological Station ID	Location of Biological Station	Fish IBI	Invert IBI
09020304-509 ***Unnamed Ditch (Judicial Ditch 18)*** *T154 R42W S14, east line to Thief River*	8.45	7	11RD032	Upstream of CR 18, 2.5 mi. NE of Thief River Fall	Poor	--
09020304-537 ***Unnamed Ditch*** *Unnamed Ditch to JD 13*	3.42	2B	07RD019 11RD053	South of CR 64, 5.5 mi. E of Goodridge Downstream of CR 95, 4 mi. NE of Goodridge	Poor Poor	Poor --
09020304-540 **Judicial Ditch 13** *T154 R40W S16, east line to JD 18*	3.01	7	07RD020	Upstream of 300th Ave, 1.5 mi. NW of Goodrich	Poor (2)	Good
09020304-541 ***Judicial Ditch 18*** *T154 R40W S27, midpoint to T154 R42W S13, west line*	12.5	7	11RD055	Downstream of CR 64, 2 mi. W of Goodridge	Fair	--

See Appendix 5.1 for clarification on the good/fair/poor thresholds and Appendix 4.3 for IBI results.

Table 29. Minnesota Stream Habitat Assessment (MSHA) for the Goodrich Subwatershed.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
	11RD032	Judicial Ditch 18	0	8	18	7	10	43	Poor
1	07RD019	Trib. to Judicial Ditch 13	3.5	8	12	12	7	42.5	Poor
2	07RD020	Judicial Ditch 13	1	8.5	16	13	12	50.5	Fair
1	11RD053	Trib. to Judicial Ditch 13	3	8	9	9	7	36	Poor
1	11RD055	Judicial Ditch 18	2.5	7.5	7	12	7	36	Poor
Average Habitat Results: *Goodrich Subwatershed*			**2.8**	**8.5**	**11.2**	**11.6**	**8**	**42.1**	**Poor**

Qualitative habitat ratings

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

Table 30. Outlet water chemistry results for the Goodrich Subwatershed.

Station location	Upstream of CR 18, 2.5 mi. NE of Thief River Falls						
STORET/EQuIS ID	S004-966						
Station #	11RD032						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	22	0.0002	0.012	0.0044		
Dissolved Oxygen (DO)	mg/L	39	6.2	17.1	10.4	<1	
pH		39	7.5	8.9	8.2	6-9	
Secchi tube/Transparency Tube	100 cm	26	8	120	81		
Turbidity	FNU	36	1.3	47.0	6.5		
Escherichia coli (geometric mean)	MPN/100ml	22	24	60	-	630	
Escherichia coli	MPN/100ml	22	3	411	105	1260	
Chlorophyll-a, Corrected	ug/L	2	1	2	2		
Inorganic nitrogen (nitrate and nitrite)	mg/L	22	0.0	0.38	0.07		
Kjeldahl nitrogen	mg/L	22	0.6	1.6	1.0		
Orthophosphate	ug/L	14	0.003	0.040	0.011		
Pheophytin-a	ug/L	2	1	1	1		
Phosphorus	ug/L	22	22	195	61		
Specific Conductance	uS/cm	39	8	1831	743		
Temperature, water	deg °C	39	5.1	29.3	20.4		
Total suspended solids	mg/L	22	1	48	7		
Total volatile solids	mg/L	11	3	156	108		

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.

****Data found in the table above was compiled using the results from data collected at the outlet monitoring station in the Goodrich Subwatershed, a component of the IWM work conducted between May and September in 2011 and 2012. This specific data does not necessarily reflect all data that was used to assess the AUID.**

Summary

Five biological monitoring stations were sampled on four AUIDs in the Goodrich Subwatershed; all stations were channelized and therefore aquatic life assessments were deferred. The fish and macroinvertebrate communities in these streams were generally poor, coinciding with poor habitat conditions (Table 29), and specifically poor substrate and channel morphology. F-IBI scores were low and reflected a fish community that lacks abundance and diversity. No gravel spawning fish species (lithiphilic spawners) were sampled at any of the sampling locations, and no site had greater than four species, all of which were highly tolerant. Low flows prevented the collection of macroinvertebrates at three of the five biological stations and may have had an adverse effect on the overall condition of both macroinvertebrates and fish. However, one stream in the watershed (JD 13) had a macroinvertebrate community that was in good condition. In contrast to the other channelized streams in this watershed, the macroinvertebrate community in JD 13 (07RD020) had a few moderately sensitive taxa; namely, mayflies from the genera *Acerpenna* and *Procloeon,* and caddisflies from the genera *Brachycentrus* and *Oecetis.*

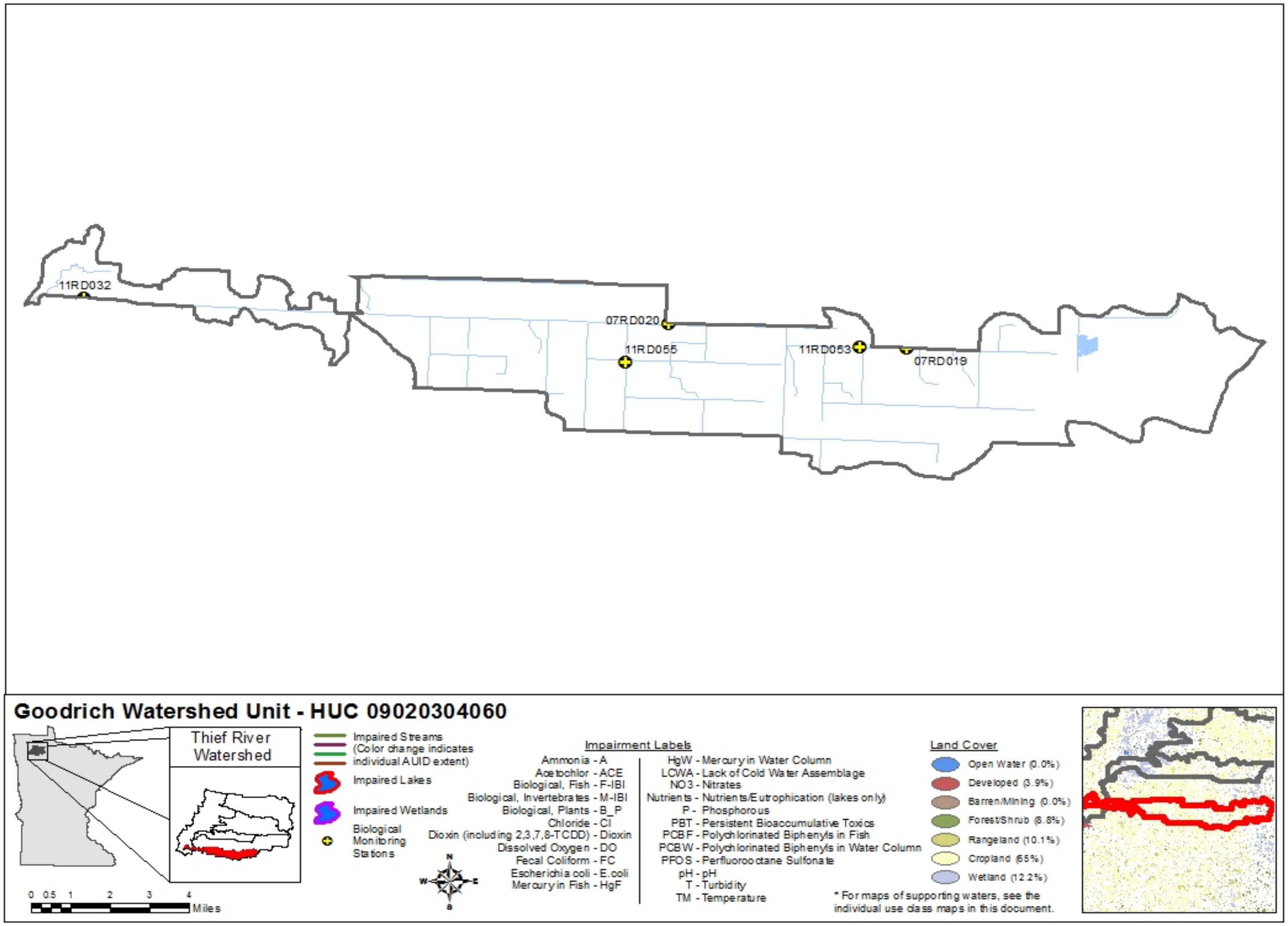


Figure 23. Currently listed impaired waters by parameter and land use characteristics in the Goodrich Subwatershed

VI. Watershed-wide results and discussion

Assessment results and data summaries are included below for the entire HUC-8 watershed unit of the Thief River, 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 along 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 Thief River Watershed.

Watershed pollutant load monitoring network

The Thief River is monitored at 140 Avenue NE near Thief River Falls, approximately six river miles above the confluence with the Red Lake River. 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 Thief's monitoring station is located within the Central RNR.

Annual flow weighted mean concentrations (FWMCs) were calculated and compared for years 2009-2011 (Figure 24-27) and compared to the RNR standards (only TP and TSS draft standards are available for the Central 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 plus nitrite-nitrogen (NO_3 + NO_2-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 NO_3 +

NO_2-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 $NO_3 + NO_2$-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 "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 Total Suspended Solids (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).

At the time of this monitoring study, the state of Minnesota's TSS standards were in development and must be considered to be draft standards until approved. Within the Central RNR, the river would be considered impaired when greater than 10% of the individual samples exceed the TSS draft standard of 30 mg/L (MPCA, 2011). From 2009-2011, 11%, 62%, and 30% of the samples exceeded the 30 mg/L draft standard, respectively (Figure 24). Table 31 displays the total annual loads, indicating TSS loads to be highest in 2010 which also had the highest FWMC for the three years. Often, there is a strong correlation between pollutant loads and annual runoff volume; the differences may be due strictly to differences in annual runoff volume (Figure 15).

Table 31. Annual pollutant loads by parameter calculated for the Thief River near Thief River Falls (2009-2011).

	2009		2010		2011	
Parameter	**Mass (kg)**	**FWM (mg/L)**	**Mass (kg)**	**FWM (mg/L)**	**Mass (kg)**	**FWM (mg/L)**
Total Suspended Solids	8225180	21.1	19360523	35.5	11897080	27.1
Total Phosphorus	38093	0.097	46457	0.085	32923	0.075
Ortho Phosphate	17606	0.045	25960	0.048	11730	0.027
Nitrate + Nitrite Nitrogen	48632	0.125	79390	0.146	97068	0.221

Figure 24. Total Suspended Solids (TSS) flow weighted mean concentrations in the Thief River near Thief River Falls 2009-2011

Total Phosphorus

Nitrogen, phosphorus, and potassium 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, total phosphorus (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 Central RNR, the TP draft standard is 0.100 mg/L as a summer average. Summer average violations of one or more "response" variables (pH, biological oxygen demand, DO flux, chlorophyll-a) must also occur along with the numeric TP violation for the water to be listed. A comparison of the data collected from June through September from 2009 to 2011, showed TP exceedances occurred 7, 16 and 10% of the time, respectively. Although there were a few exceedances to the draft standard, none of the summer averages for 2009-2011 were greater than the draft standard. Figure 25 illustrates FWMCs less than the draft standard, although this includes all data throughout the year (not just summer values). Table 31 shows annual loads, with 2010 exhibiting the highest load. The highest daily total flow volume also occurred in 2010.

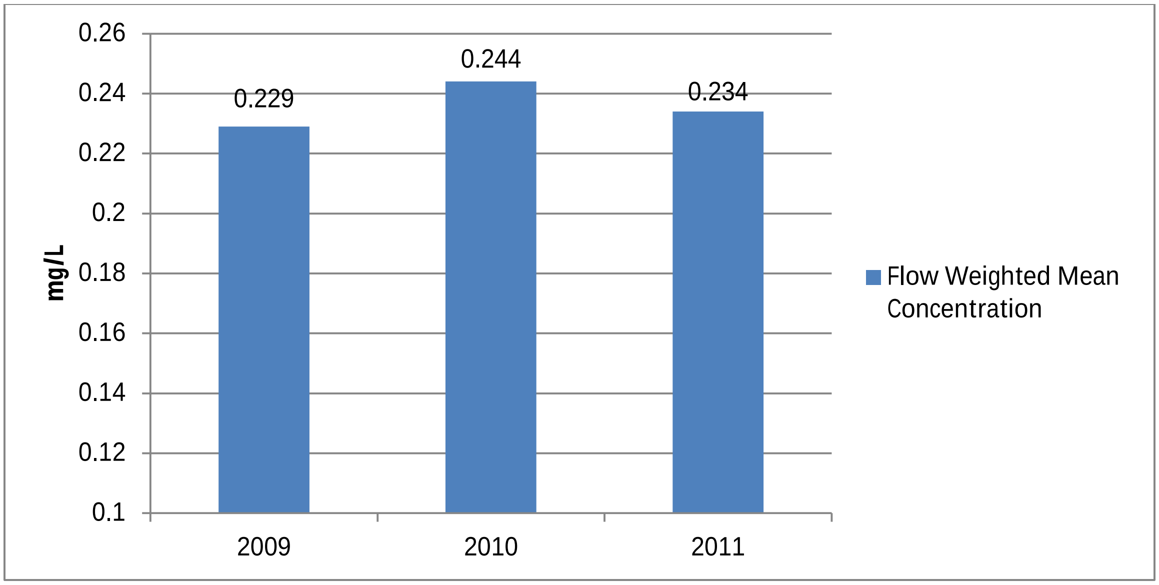


Figure 25. Total Phosphorus (TP) flow weighted mean concentrations for the Thief River near Thief River Falls 2009-2011

Dissolved Orthophosphate

Dissolved Orthophosphate (DOP) is a water soluble form of phosphorus that is readily available for plant uptake (MPCA and MSUM, 2009). While orthophosphates occur naturally in the environment, river and stream concentrations may become elevated with additional inputs from waste water treatment plants, noncompliant septic systems, and fertilizers in urban and agricultural runoff. The DOP:TP ratio of FWMCs from the three years were 36%, 21% and 56%, respectively. Figure 26 and Table 31 show similar trends between years as seen with TP. This is not uncommon due to the relationship between DOP and TP.

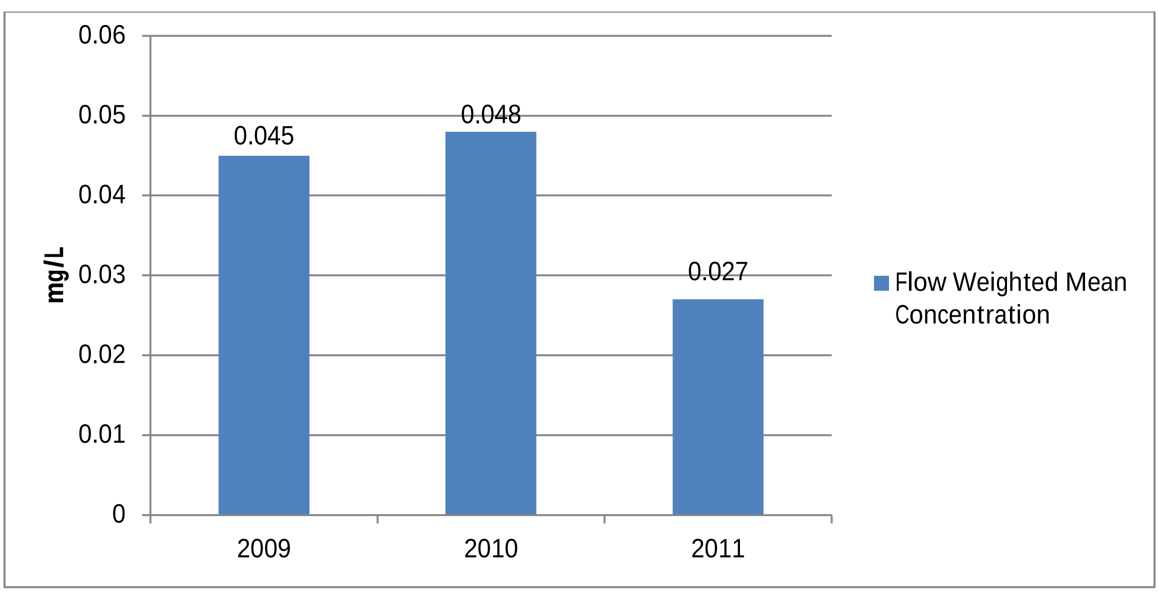


Figure 26. Dissolved Orthophosphate (DOP) flow weighted mean concentrations for the Thief River near Thief River Falls, 2009-2011

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 invertebrates 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).

Figure 27 shows the $NO_3 + NO_2$-N FWMCs over the three-year period for the Thief River monitoring site. The FWMC for all three years were below the draft acute and chronic nitrate-N standards. Between 2009 and 2011, there were no exceedances of the draft acute standard and no exceedances of the draft chronic 4-day duration standard. Table 31 displays the annual loads which increased over the three year period corresponding to the increase in FWMCs.

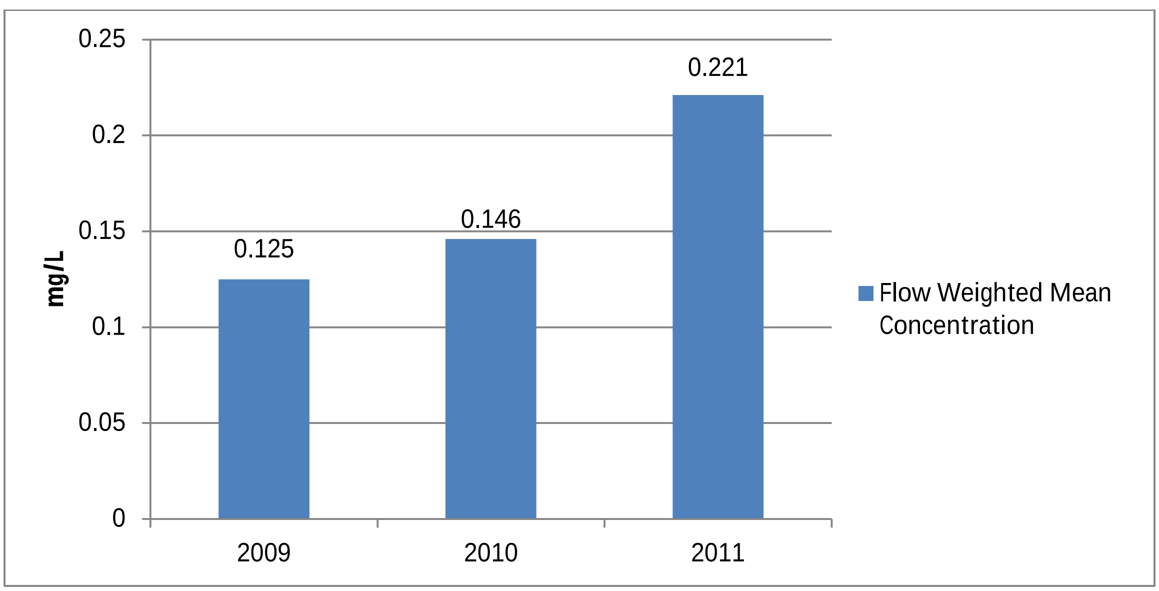


Figure 27. Nitrate + Nitrite Nitrogen (Nitrate-N) flow weighted mean concentrations for the Thief River near Thief River Falls, 2009-2011Stream water quality

For this assessment, twenty-seven stream AUIDs of the 58 unique stream reaches assigned AUIDs were reviewed. Of the 27 reviewed stream reaches, 13 were assessed for aquatic life and/or aquatic recreation uses, and of those 13, only 7 had sufficient data to make a determination (Table 32). Of the stream reaches with sufficient data, none were found to fully support aquatic life and five fully support aquatic recreation.

Twenty-three AUIDS were not assessed for aquatic biology because greater than 50% of the AUID was channelized or the biological station fell on a channelized stream reach on the AUID.

Three AUIDs did not fully support aquatic life, 2 did not fully support aquatic recreation and 9 AUIDs had insufficient data to make a determination. Three AUIDs with prior listings are now proposed to be delisted.

Table 32. Assessment summary for stream water quality in the Thief River Watershed.

				Supporting		Non-supporting			
Watershed	**Area (acres)**	**# Total AUIDs**	**# Assessed AUIDs**	**# Aquatic Life**	**# Aquatic Recreation**	**# Aquatic Life**	**# Aquatic Recreation**	**Insufficient Data**	**# Delistings**
Thief River **09020304**	**671,021**	**58**	**13**	**0**	**5**	**3**	**2**	**9**	**3**
09020304010	260	3	2	0	1	1	1	1	0
09020304020	262	8	2	0	2	1	0	2	3
09020304030	195	14	3	0	0	1	1	2	0
09020304040	78	6	2	0	1	0	0	2	0
09020304050	202	14	2	0	1	0	0	2	0
09020304060	80	6	0	0	0	0	0	0	0

Lake water quality

Of the nine natural lakes greater than 10 acres in the watershed, only one, Thief Lake, had water quality data. Thief Lake drains land from the NMW and Red River Valley Ecoregions; neither has dedicated lake water quality standards. Standards from the North Central Hardwood Forest (NCHF) ecoregion are commonly applied to lakes and reservoirs in the Red River Valley. Thief Lake was assessed relative to the NCHF Class 2B shallow lake eutrophication standards. Thief Lake was the only lake greater than 10 acres assessed in the watershed and was found to fully support aquatic recreation. The Thief River Watershed is an almost even mix of agriculture and wetlands, characterized by extensive drainage; most of the remaining natural lakes are shallow, located within wildlife preserves, have no public access, and as a result, little or no historical water quality data has been collected. Primary uses of these lakes are waterfowl hunting and viewing, and as they are shallow lakes, most uses are severely impacted by drought (Table 33).

Table 33. Assessment summary for lake water chemistry in the Thief River Watershed.

			Supporting		Non-supporting			
Watershed	**Area (acres)**	**Lakes >10 Acres**	**# Aquatic Life**	**# Aquatic Recreation**	**# Aquatic Life**	**# Aquatic Recreation**	**Insufficient Data**	**# Delistings**
Thief River **09020304**	**671,021**	**9**	**0**	**1**	**0**	**0**	**1**	**0**
09020304010	260	0	0	0	0	0	0	0
09020304020	262	5	0	1	0	0	1	0
09020304030	195	2	0	0	0	0	0	0
09020304040	78	2	0	0	0	0	0	0
09020304050	202	0	0	0	0	0	0	0
09020304060	80	0	0	0	0	0	0	0

Biological monitoring

Fish

The Minnesota portion of the Red River Basin encompasses approximately 37,100 square miles and lies in 21 counties. The Thief River Watershed makes up about 7% of this area (2,715 square miles). Historically, 86 different species of fish have been sampled in the Red River Basin. Thirty of these species were found during this survey. The dam at Thief River Falls could be preventing some species from migrating into the watershed, including the lake sturgeon, smallmouth bass, and channel catfish. This watershed does not have any endangered fish species or species of special concern. No known invasive fish or aquatic plant species are known to exist in this watershed, with the exception of the exotic common carp.

In general, most stations within the watershed were dominated by tolerant species. The most common species was the central mudminnow which was sampled at all but one station (11RD040). The next two commonly occurring species were the brook stickleback (28 sites) and fathead minnow (26 sites). Eleven different species were only found at one station; most notably smallmouth bass, horneyhead chub and golden redhorse, all of which are relatively sensitive species that were only found at 11RD031. This station also received the highest F-IBI scores in the entire watershed which can be attributed to excellent in-stream habitat (Table 9). In total, 26293 individual fish specimens were collected in just under 18 hours of electrofishing (64,065 seconds).

Invertebrates

Seventy percent of the habitats sampled during macroinvertebrate surveys consisted of aquatic macrophytes and undercut banks/overhanging vegetation. Coarse substrates comprised approximately 12% of the habitats sampled, with woody debris contributing roughly 18% of the samples. Approximately 96% of the streams in the Thief River Watershed have been hydrologically modified. The lack of coarse substrate due to unnatural stream alterations and sedimentation can significantly impact macroinvertebrate taxonomic diversity. Coarse substrates are often a productive habitat for macroinvertebrates and the covering of these habitats with fine sediments or their excavation may significantly impact macroinvertebrate communities. Therefore, it is no surprise that the most common macroinvertebrates found within streams in this watershed represent tolerant taxa. The most frequently encountered macroinvertebrate taxa were midges from the genera *Dicrotendipes, Polypedilum, Paratanytarsus* and *Cricotopus;* mayflies from the genus *Caenidae*; segmented worms (*Oligochaeta*); leeches and snails from the genus *Physa*.

There are two biological monitoring stations on natural stream channels within the Thief River Watershed, and one of these stations provides evidence of the potential for macroinvertebrate communities within the watershed. In particular, the middle station on the Mud River (05RD097), which was sampled in 2005 as part of a probabalistic survey, contained several sensitive taxa; namely stoneflies from the genera *Acroneuria* and *Pteronarcys*, caddisflies from the genera *Ceraclea*, *Helicopsyche* and *Oecetis*, and mayflies from the genera *Leptophlebia* and *Procloeon*. Given the close proximity of many of these streams to source populations that contain sensitive macroinvertebrate taxa (such as 05RD097), it is plausible that if habitats are restored to natural conditions, or in the instance of the manufactured systems coarse substrates are added and the streams are left to recover, many of these macroinvertebrates would return. However, many of the intolerant macroinvertebrate species are also sensitive to nutrient concentrations and the elevated concentrations seen within many streams in the watershed could explain the absence of many of these taxa.

Fish contaminant results

Eight fish species from the Thief River and Red Lake River Reservoir (Lake ID 57-0051) were tested for mercury and/or PCBs. A total of 24 fish were tested from the Thief River and 34 fish from Red Lake River Reservoir in 2011 and 2009, respectively. Fish species are identified by codes that are defined by their common and scientific names in Table 34.

Table 35 is a summary of contaminant concentrations by waterway, fish species, and year. The table shows which contaminants, species, and years were sampled. "No. Fish" indicates the total number of fish analyzed and "N" indicates the number of samples. The number of fish exceeds the number of samples when fish are combined into a composite sample. This was typically done for panfish, such as bluegill sunfish (BGS) and yellow perch (YP). Since 1989, most of the samples have been skin-on fillets (FILSK) or for fish without scales (catfish and bullheads), skin-off fillets (FILET).

Of the five fish species collected from the Red Lake River Reservoir in 2009, all were tested for mercury and two species were tested for PCBs. Ten rock bass (RKB) were composited into one sample, which had a mercury concentration of 0.135, below the state water quality standard for mercury in fish tissue (0.2 mg/kg). Similarly, five white sucker (WSU) and five yellow perch (YP) were composited into one sample for each species and their mercury concentrations were below the standard. Eight northern pike (NP) and six walleye (WE) were tested individually and all but one of each species exceeded the 0.2 mg/kg mercury standard. Furthermore, the 90th percentile mercury concentration of both species exceeded the 0.572 mg/kg threshold for inclusion in the Minnesota Statewide Mercury TMDL; consequently, the Red Lake River Reservoir was listed in 2012 as impaired due to mercury in fish tissue and is classified as needing a separate TMDL.

Seven fish species from the Thief River were tested for mercury. All fish were tested individually (i.e., not composited). The two golden redhorse (GRH), one shorthead redhorse (SRD), and six of the seven white suckers (WSU) were below the state water quality standard for mercury in fish tissue (0.2 mg/kg). All six northern pike (NP), four rock bass (RKB), one smallmouth bass, and three walleye (WE) from the Thief River exceeded the mercury standard. Because of these high mercury concentrations in several species, the Thief River was recommended for listing as impaired due to mercury in fish tissue in the 2014 Draft Impaired Waters List.

Table 34. Fish species codes, common names, and scientific names

CODE	COMMON NAME	SCIENTIFIC NAME
GRH	Golden redhorse	*Moxostoma erythrurum*
NP	Northern pike	*Esox lucius*
RKB	Rock bass	*Ambloplites rupestris*
SMB	Smallmouth bass	*Micropterus dolomieue*
SRD	Shorthead redhorse	*Moxostoma macrolepidotum*
WE	Walleye	*Sander vitreus*
WHS	White crappie	*Pomoxis annularis*
YP	Yellow perch	*Perca flavescens*

Table 35. Summary statistics of mercury and PCBs, by waterway-species-year.

WATERWAY	AUID	LOCATION	SPECIES[1]	YEAR	ANAT-OMY[2]	No. fish	Length (in)			Mercury (mg/kg)				PCBs (mg/kg)		
							Mean	Min	Max	N	Mean	Min	Max	N	Mean	Max
Thief River**	09020304-501	11RD031, UPSTREAM OF 140	GRH	2011	FILSK	2	12.1	10.8	13.3	2	0.067	0.054	0.079			
			NP	2011	FILSK	6	16.6	14.3	18.8	6	0.289	0.217	0.387	2	< 0.025	< 0.025
			RKB	2011	FILSK	4	9.1	8.4	10.0	4	0.256	0.203	0.315			
			SMB	2011	FILSK	1	12.3			1	0.252					
			SRD	2011	FILSK	1	14.3			1	0.161					
			WE	2011	FILSK	3	14.4	14.0	14.6	3	0.228	0.218	0.237			
			WSU	2011	FILSK	7	15.7	14.8	18.1	7	0.137	0.076	0.244	2	< 0.025	< 0.025
Red Lake River Reservoir*	57005100		NP	2009	FILSK	8	20.1	15.5	31.8	8	0.320	0.200	0.782			
			RKB	2009	FILSK	10	6.8	6.8	6.8	1	0.135					
			WE	2009	FILSK	6	18.1	13.7	26.3	6	0.310	0.188	0.755			
			WSU	2009	FILSK	5	17.3	17.3	17.3	1	0.179					
			YP	2009	FILSK	5	8.8	8.8	8.8	1	0.121					

****** Recommended for 2014 Draft Impaired Waters List for Mercury in Fish Tissue.

***** Impaired for mercury in fish tissue as of 2012 Draft Impaired Waters List and categorized as EPA Class 5 (requires TMDL).

1 Species codes are defined in Table BM1

2 Anatomy codes: FILSK – edible fillet

Groundwater monitoring

Groundwater quality

A baseline study conducted by the MPCA found that the median concentrations of most analytes in the sand and gravel aquifers in this region were slightly higher, while iron and sulfate concentrations were much higher when compared to similar aquifers statewide (MPCA, 1998).

The results of this study also identified exceedances of drinking water criteria in the three different aquifers – cretaceous, surficial and buried sand and gravel. The two factors that most heavily influence water quality were determined to be the presence of cretaceous bedrock and location. While water quality in cretaceous bedrock is typically poor, the location can dictate higher levels of contamination, such as higher arsenic concentrations in buried sand and gravel aquifers along stagnation moraines.

Another source of information on groundwater quality comes from the MDH. Mandatory testing for arsenic of all newly constructed wells has found that 10.4% of all wells installed from 2008 to 2013 have arsenic levels above the MCL for drinking water of 10 micrograms per liter. In northwest Minnesota, the majority of new wells are within the water quality standards for arsenic levels, but there are some exceedances (Figure 28)

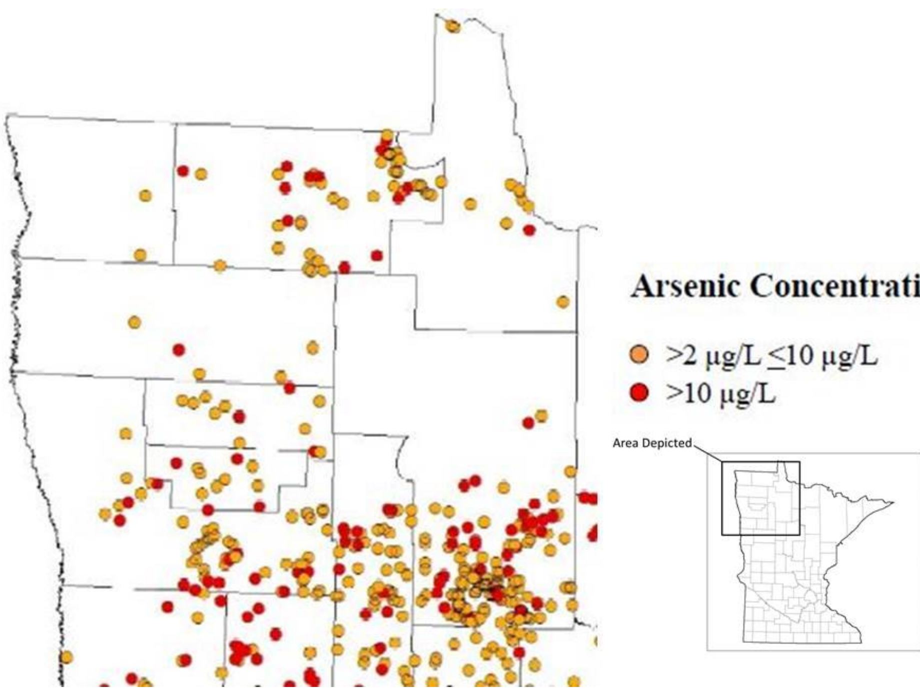


Figure 28. Locations of permitted withdrawals within the Thief River Watershed

Groundwater/surface water withdrawals

The three largest permitted consumers of water in the state (in order) are municipalities, industry and irrigation. The withdrawals within the Thief River Watershed are mostly for municipal use and water level maintenance.

From 1991-2011 surface water withdrawals in the Thief River Watershed (Figure 29) exhibit a significant rising trend (p=0.01, Figure 30). High capacity groundwater withdrawals (Figure 29) have also risen, statistically, but with only four data points, determining any trend in groundwater withdrawals is premature.

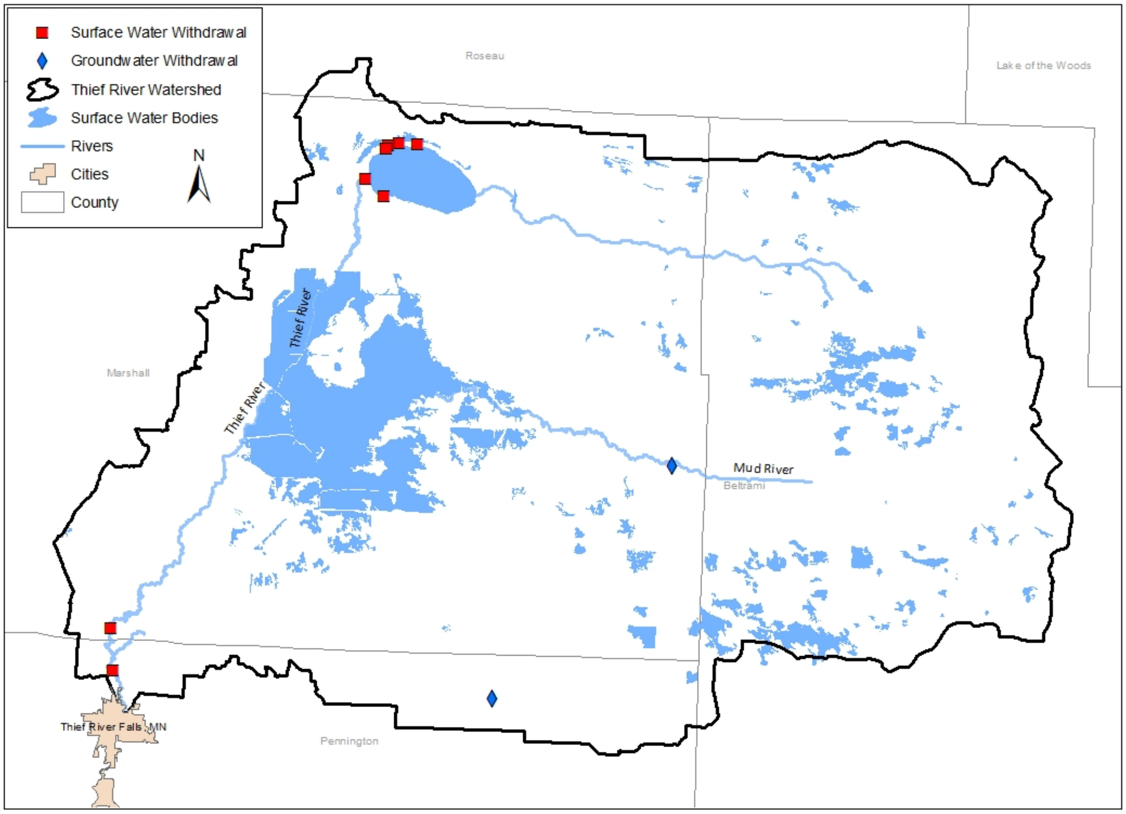


Figure 29. Locations of permitted groundwater withdrawals in the Thief River Watershed

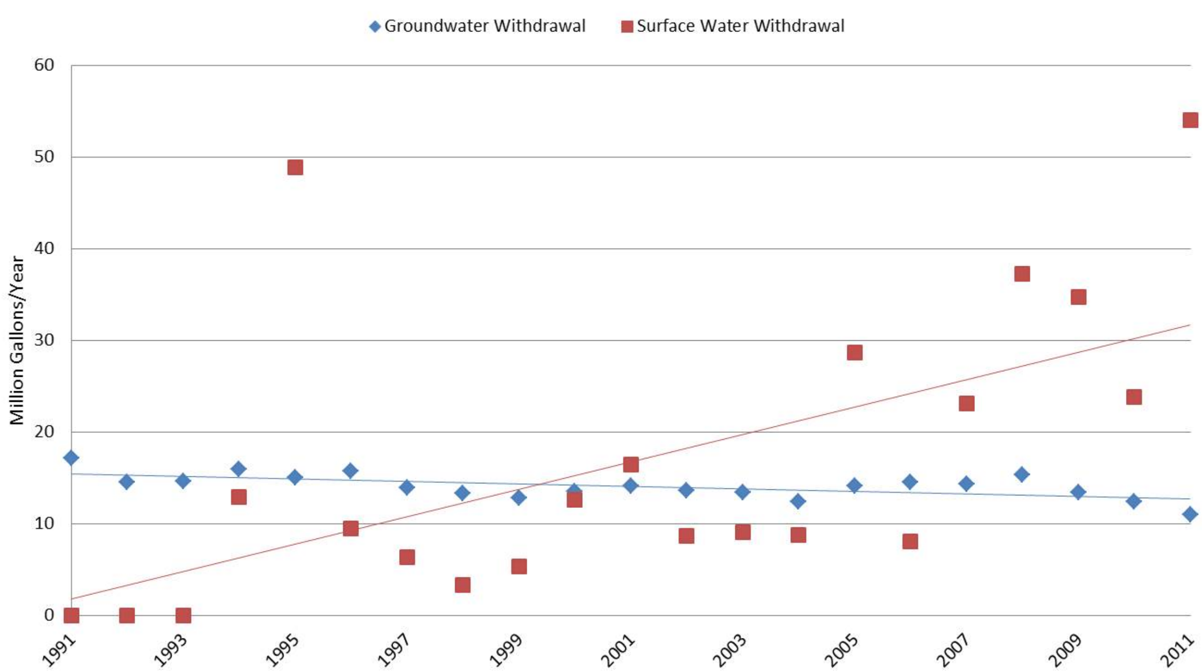


Figure 30. Total annual groundwater and surface water withdrawals in the Thief River Watershed (1991-2011).

Stream flow

Figure 31 is a display of the annual mean discharge for Thief River near Thief River Falls from 1992 to 2012. The data shows that there is an increase in stream flow over time, but there is no statistically significant trend. Figure 32 displays July and August mean flows for the last 20 years for the same water body. Both months show a decreasing flow trend, but the level of significance is not high. By way of comparison, summer month flows have declined at a statistically significant rate at a majority of streams selected randomly for a study of statewide trends.

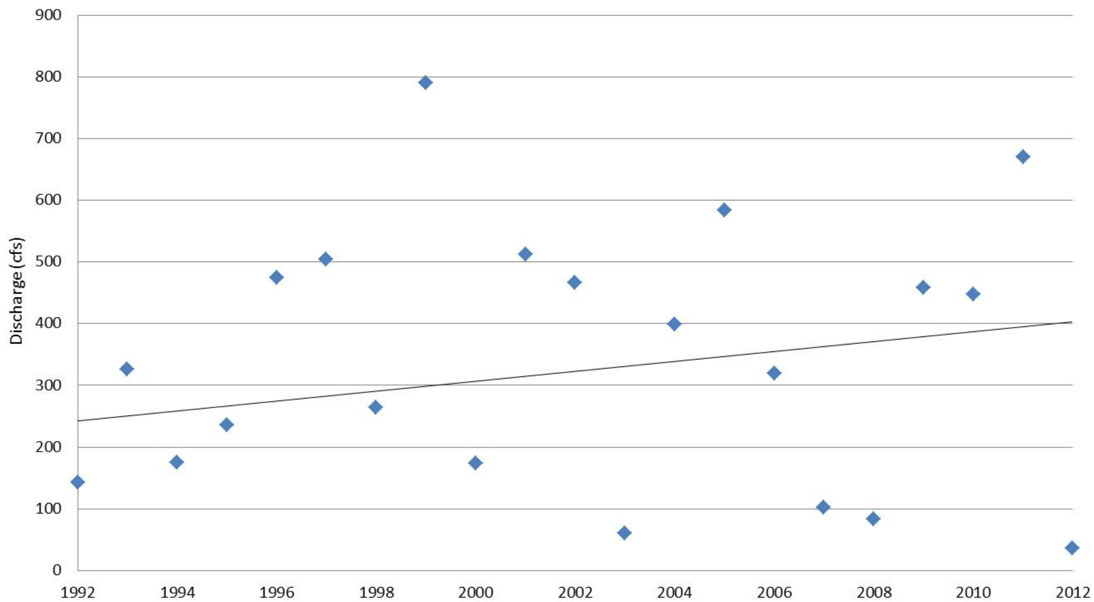


Figure 31. Annual mean discharge for Thief River near Thief River Falls (1992-2012)

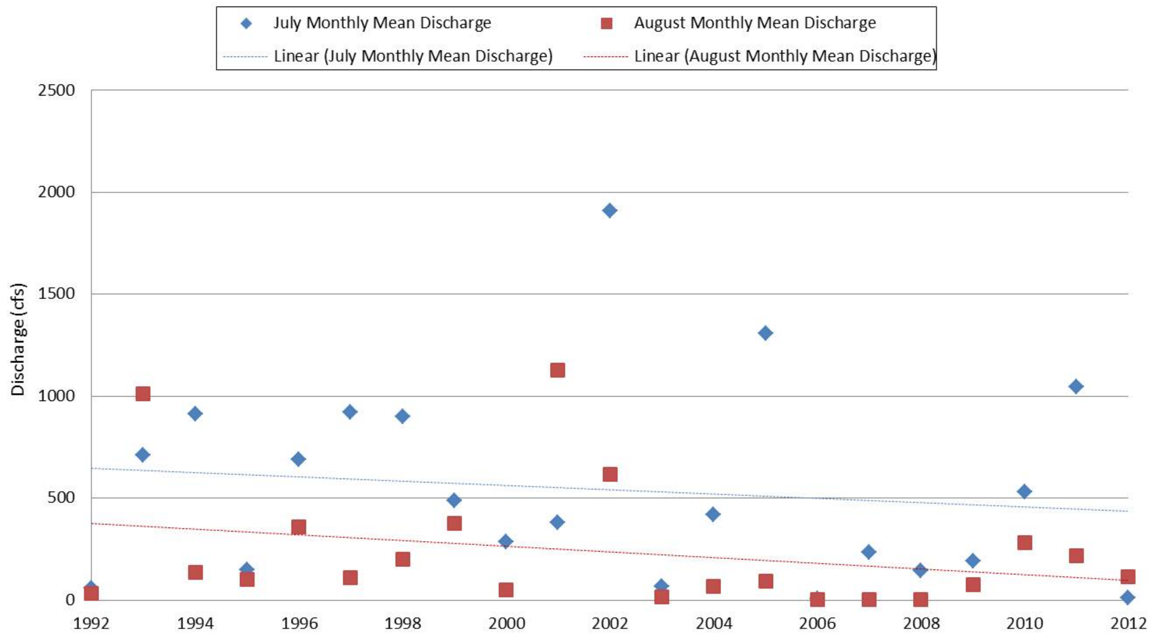


Figure 32. Mean monthly discharge measurements for July and August flows for Thief River near Thief River Falls (1992-2012)

Stressor identification

Stressor identification (SI) is a formal and rigorous methodology for determining the causes, or "stressors", that are likely contributing to the biological impairment of aquatic ecosystems (EPA, 2000). The SI process is prompted by the assessment of biological monitoring data indicating that an impairment has occurred. The biological monitoring data for the Thief River Watershed were assessed as part of the development of this report. The one assessable stream reach in the watershed was determined to be fully supporting aquatic life. The assessment of the data for the remaining reaches was deferred, primarily due to channelization, pending the implementation of the MPCA's proposed Tiered Aquatic Life Use (TALU) standards. As a result, there are no biological impairments to prompt the preparation of a SI report for the watershed. However, based upon a review of the biological data for the watershed, there are several stream reaches with extremely low IBI scores that are likely to be identified as impaired once the TALU standards are enacted.

To guide future SI efforts, MPCA staff developed a list of potential stressors that may be adversely affecting the aquatic ecosystems of the watershed. The stressors were identified through a comprehensive review of available information for the watershed, including water quality and quantity data, as well as existing plans and reports including this report, the *Red River Basin Stream Survey Report: Red Lake River Watershed* (Groshens, 2005), the *Thief River Watershed Sediment Investigation Final Report* (Hanson, 2010), the *Red River Valley Biotic Impairment Assessment* (MPCA, 2009), the *Assessment of Nutrients and Suspended Sediment Conditions in and near the Agassiz National Wildlife Refuge, Northwest Minnesota, 2008-2010* (Nustad and Galloway, 2012), the *Red Lake Watershed District's (RLWD's) 10-Year Comprehensive Plan* (RLWD, 2006), and *Thief River SWAT Modeling, Thief River Watershed, Minnesota: Numerical Modeling and Evaluation of Management Scenarios* (RLWD, 2010). A summary of the potential stressors for the Thief River Watershed is provided below:

Loss of connectivity

Connectivity in aquatic ecosystems refers to how waterbodies and waterways are linked to each other on the landscape, and how matter, energy, and organisms move throughout the system (Pringle, 2003). Dams and other water control structures alter stream flow, water temperature regime, and sediment transport processes - each of which can cause changes in fish and macroinvertebrate assemblages (Cummins, 1979; Waters, 1995). These structures alter hydrologic (longitudinal) connectivity, often obstructing the movement of migratory fish and causing a change in the population and community structure (Brooker, 1981; Tiemann et al., 2004).

Figure 33. Thief River Falls Dam. Photo courtesy of Corey Hanson, RLWD

According to the U.S. Army Corps of Engineers (2013), there are 21 dams located in the Thief River Watershed; 19 of which are located within the Agassiz National Wildlife Refuge (NWR). Three of the dams, including the Thief Lake Dam, the Pool 8 Dam, and the Pool 10 Dam, are situated on the mainstem of the Thief River. Each of these structures has the potential to limit connectivity. Also, the Thief River Falls dam (Figure 33), located on the Red Lake River immediately downstream of the Thief River, is a known barrier to fish passage (Groshens, 2005) and is likely affecting the fish community of the watershed.

Flow regime alteration

According to Mitch and Gosselink (2007), drainage practices can upset the natural flow regime of streams, resulting in increased and quicker peak discharges following rain events and reduced baseflows during dry periods. High flows can result in the direct displacement of fish and macroinvertebrates downstream if they are unable to move into tributaries or refuges along the margins of the river, or if refuges are not available. The intensification of channel shear stresses associated with increased flows may cause the mobilization of sediment, woody debris, and plant materials, as well as increased channel scouring and bank destabilization. Diminished baseflows result in decreased wetted width, cross sectional area, and water volume. Aquatic organisms require adequate living space, and when flows are reduced beyond normal baseflow, habitat can be scarce and the competition for resources increases.

Figure 34. Ditch upstream of the Mud River Pool, Agassiz NWR. Photo courtesy of Ed Dobrowolski, USGS

The surficial hydrology of the Thief River Watershed has been highly altered for agricultural, flood control, and wildlife management purposes. According to the Statewide Altered Watercourse Project dataset, the hydrologic regime of 96% of the waterways in the watershed has been altered by ditching and/or channelization. Figure 34 displays an example of the extensive network of altered waterways in the watershed. In addition, there are more than 30 impoundments located throughout the watershed (Hanson, 2010). As a result of these hydrologic alterations, streams in the watershed can be described as "flashy", where multiple peak flows occur, along with periods of very low discharge (Groshens, 2005).

Lack of In-stream habitat

Habitat is a broad term encompassing all aspects of the physical, chemical, and biological conditions needed to support a biological community (EPA, 2012). Healthy aquatic biotic communities often have access to diverse in-stream habitat, enabling fish and macroinvertebrate habitat specialists to prosper. In-stream habitat is primarily a function of channel geomorphology (Rosgen, 1996) and flow (Bovee, 1986). Biotic population changes can result from decreases in the availability or quality of habitat by way of altered behavior, increased mortality, or decreased reproductive success (EPA, 2012).

The MPCA's Stream Habitat Assessment (MSHA) was used to evaluate the quality of habitat present at each of the biological monitoring sites in the Thief River Watershed. A majority of sites in the watershed (19) received a "Poor" rating, while 16 sites were rated "Fair", and one site was rated "Good". Many of the sites had extremely low scores in the in-stream Zone Substrate and Channel Morphology assessment categories. Channelization and ongoing ditch maintenance are contributing factors to the overall lack of in-stream habitat in the watershed (C. Hanson, personal communication, 2013). According to Groshens (2005), streams in the watershed have the potential to provide quality in-stream habitat; however, channel instability and high sediment loads are reducing both habitat quality and quantity.

Excess suspended sediment

Turbidity and TSS are measurements of the amount of sediment suspended in the water, whether mineral (e.g., soil particles) or organic (e.g., algae). Although sediment delivery and transport are important natural processes for all stream systems, sediment imbalance (either excess sediment or lack of sediment) can result in the loss of habitat, as well as direct harm to aquatic organisms. As described by Waters (1995), excess suspended sediment can cause harm to fish and macroinvertebrates through two major pathways: 1) direct, physical effects (e.g., abrasion of gills and avoidance behaviors) and 2) indirect effects (e.g., loss of visibility and increase in sediment oxygen demand). Excess fine sediment deposition on benthic habitat has been proven to adversely impact fish and macroinvertebrate species that depend on clean, coarse stream substrates for feeding, refugia, and/or reproduction (Newcombe and MacDonald. 1991). Elevated levels of turbidity and TSS can also reduce the penetration of sunlight and thus impede photosynthetic activity and limit primary production (Munavar et al., 1991; Murphy et al., 1981).

Figure 35. Confluence of the Thief River and the Red Lake River. Image courtesy of Bing Maps.

The 2012 Impaired Waters List included a reach of the Thief River (Agassiz Pool to Red Lake River/AUID #09020304-501) due to turbidity affecting aquatic life. Figure 35 provides a contrasting view of the confluence of this impaired reach and the Red Lake River, which is not impaired by turbidity. According to the *Erosion, Sediment, Sediment Yield Report, Thief and Red Lake River Basin, Minnesota* (U.S. Department of Agriculture, 1996), 63% of sediment yielded to streams in the Thief River Watershed is derived from stream and ditch bank erosion. However, Schottler and Engstrom (unpublished data, 2012) concluded that erosion from agricultural fields is the dominant source of sediment to the Agassiz Pool, which receives water from 58% of the watershed. Fluvial geomorphology data collected by the MDNR in that portion of the watershed lends support the findings of Schottler and Engstrom (D. Friedl, personal communication, 2014).

Low dissolved oxygen

The concentration of DO changes seasonally and daily in response to shifts in ambient air and water temperature, along with various chemical, physical, and biological processes within the water column. If DO becomes limited or fluctuates dramatically, aerobic aquatic life can experience reduced growth or fatality (Allan, 1995; Davis, 1975; Nebeker et al., 1991). Hieskary et al. (2010) observed several strong negative relationships between fish and macroinvertebrate metrics and DO flux. In most streams and rivers, the critical conditions for DO usually occur during the late summer, when water temperatures are high and stream flows are reduced to baseflow. As the temperature of water increases, the saturation level of DO decreases. High water temperatures also raise the DO needs for many species of fish (Raleigh et al., 1986). Low DO can be an issue in streams with slow currents, excessive temperatures, high biological oxygen demand, and/or high groundwater seepage (Hansen, 1975).

Figure 36. Dead fish along Judicial Ditch 21 after a winterkill. Photo courtesy of Corey Hanson, RLWD

The 2012 Impaired Waters List included three reaches in the Thief River Watershed that are impaired by low DO affecting aquatic life. These reaches include the Thief River (Agassiz Pool to Red Lake River/AUID #09020304-501), the Moose River (Headwaters to Thief Lake/AUID #09020304-505), and the Mud River (Headwaters to Agassiz Pool/AUID #09020304-507). However, the impairment associated with the Thief River reach is proposed to be delisted in the draft 2014 Impaired Waters List based upon new and more comprehensive data indicating that the reach meets the state DO standard. According to C. Hanson (personal communication, 2013), these rivers and their tributaries often experience low DO concentrations during the winter months, which can result in the winterkill of fish (Figure 36).

Elevated ammonia

Ammonia is a common toxicant derived from wastes, fertilizers, and natural processes. Ammonia includes both the ionized form (ammonium) and the un-ionized form (ammonia). An increase in pH favors the formation of the more toxic ammonia form, while a decrease favors the ammonium form. Temperature also affects the toxicity of ammonia. Elevated ammonia concentrations can alter fish growth, gill condition, organ weights, and hematocrit, as well as cause fish kills (Milne et al. 2000). Exposure duration and frequency strongly influence the severity of these effects (Milne et al. 2000).

The 2012 Impaired Waters List included a reach of the Thief River (Thief Lake to Agassiz Pool/AUID #09020304-504) for un-ionized ammonia affecting aquatic life. However, this impairment is proposed to be delisted in the draft 2014 Impaired Waters List based new and more comprehensive data indicating that the reach meets the state ammonia standard.

Pesticide toxicity

A pesticide is defined by the EPA (2012) as "any substance intended for preventing, destroying, repelling or mitigating any pest". Pesticides (e.g., herbicides, insecticides, and fungicides) are commonly used in the agricultural industry and may cause biological impairment if they are present in water or sediment at sufficient concentrations. The most common pathway for pesticides to enter surface water is through runoff or leaching.

The Minnesota Department of Agriculture (MDA) routinely collects and analyzes water samples from selected locations throughout the state to determine the identity, concentration, and frequency of detections of pesticides in Minnesota's ground and surface water resources. In 2011, the MDA sampled the Thief River and detected the presence of 2,4-D and MPCA, both of which are common agricultural herbicides.

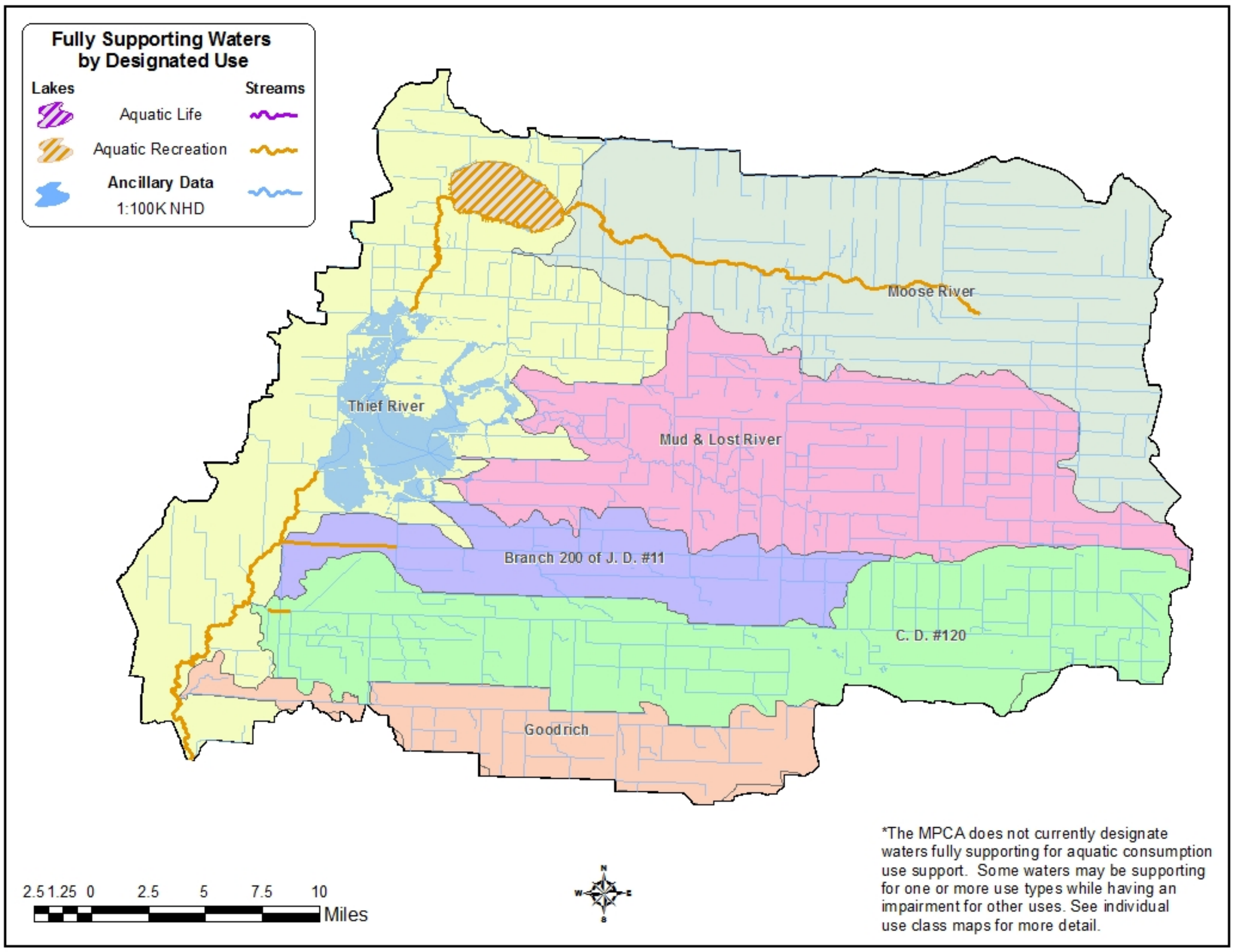


Figure 37. Fully supporting waters by designated use in the Thief River Watershed

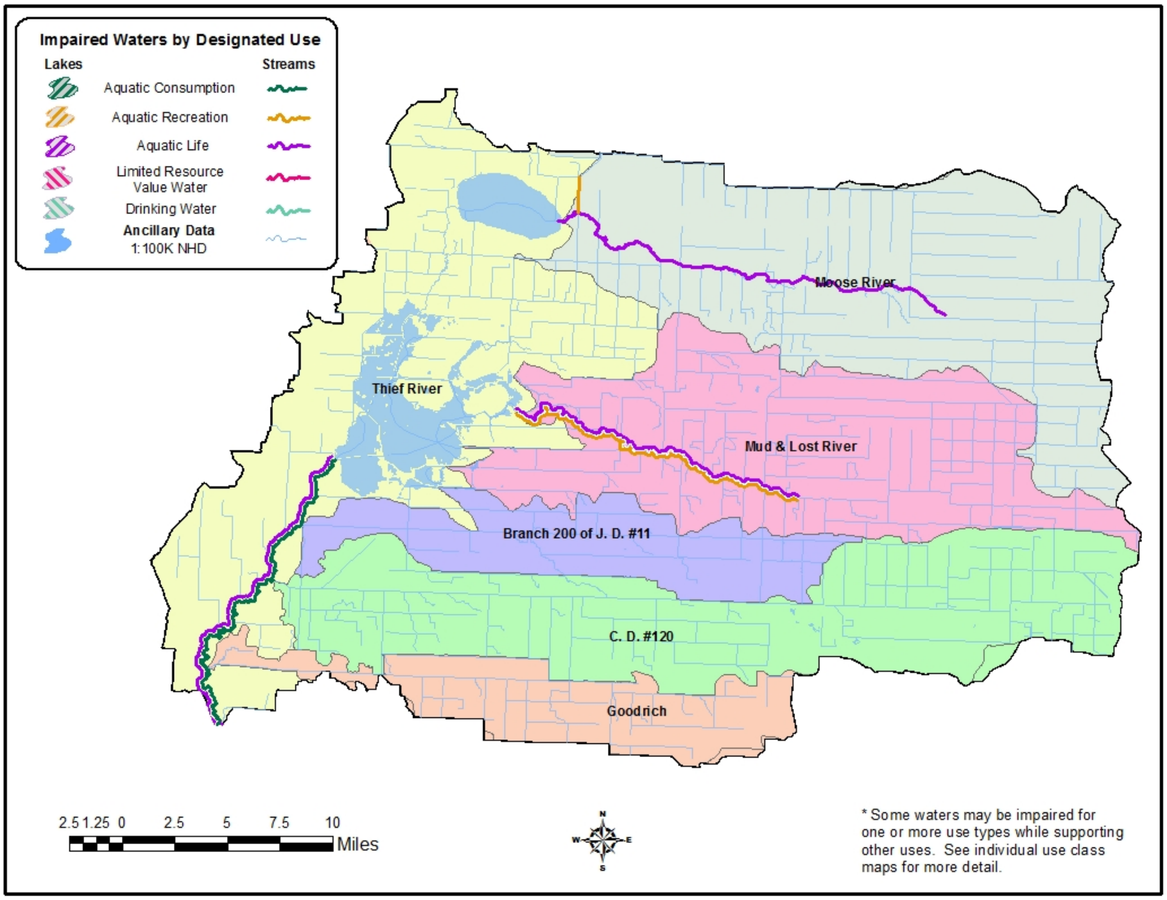


Figure 38. Impaired waters by designated use in the Thief River Watershed.

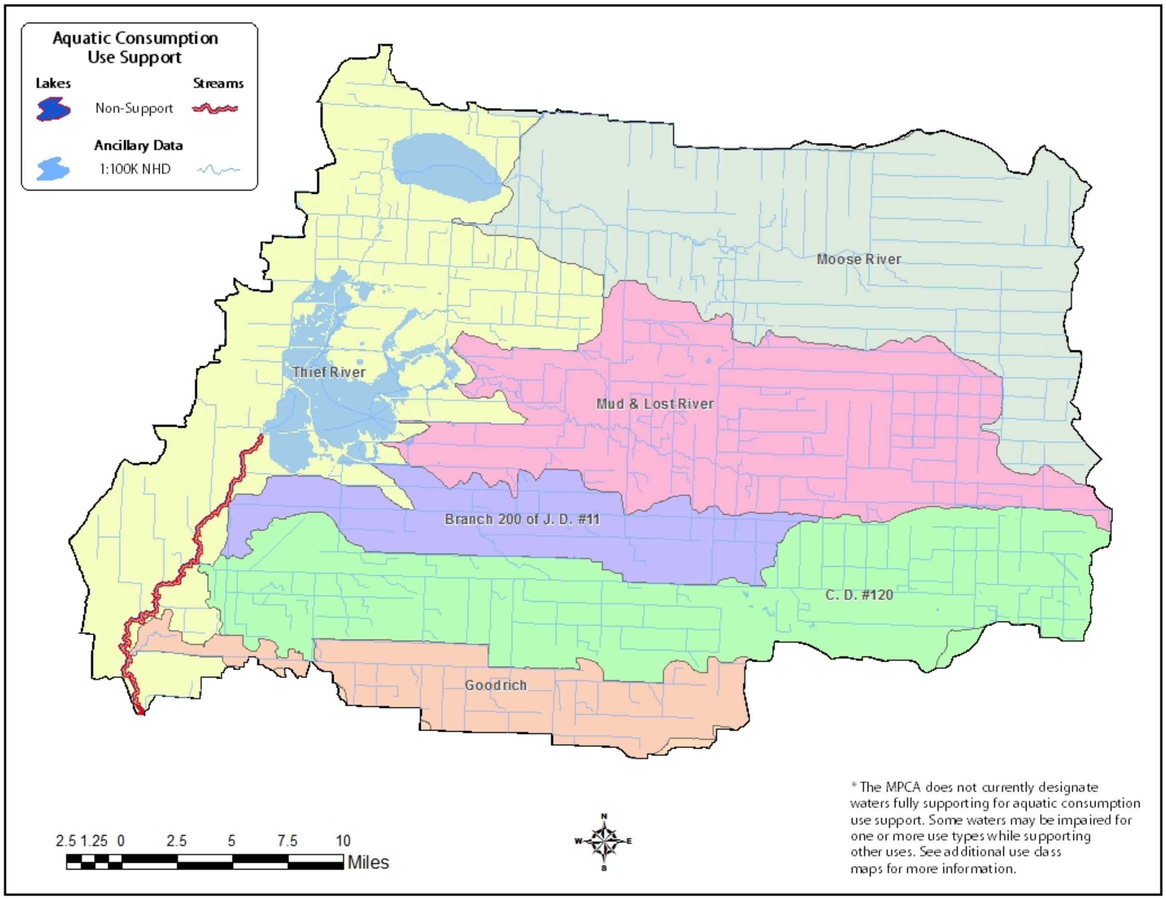


Figure 39. Aquatic consumption use support in the Thief River Watershed

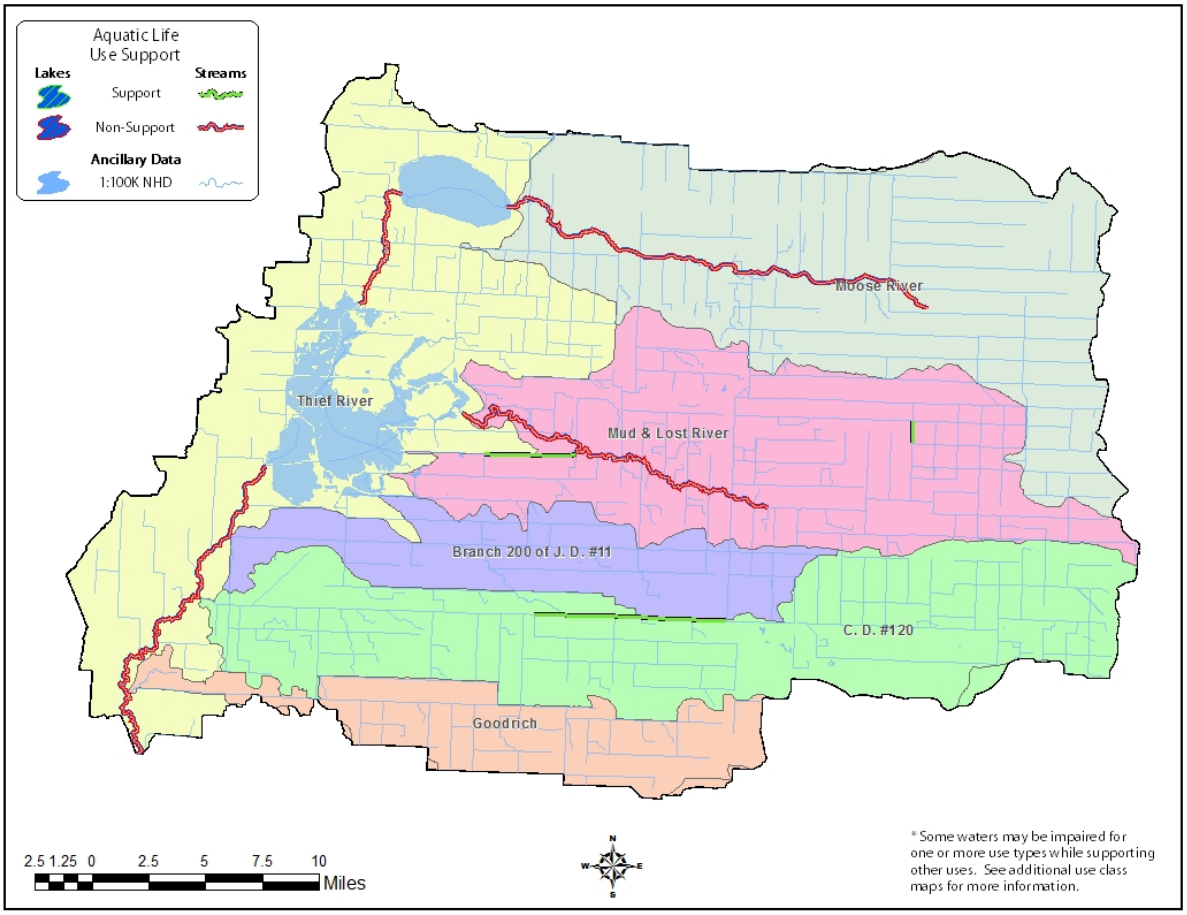


Figure 40. Aquatic life use support in the Thief River Watershed

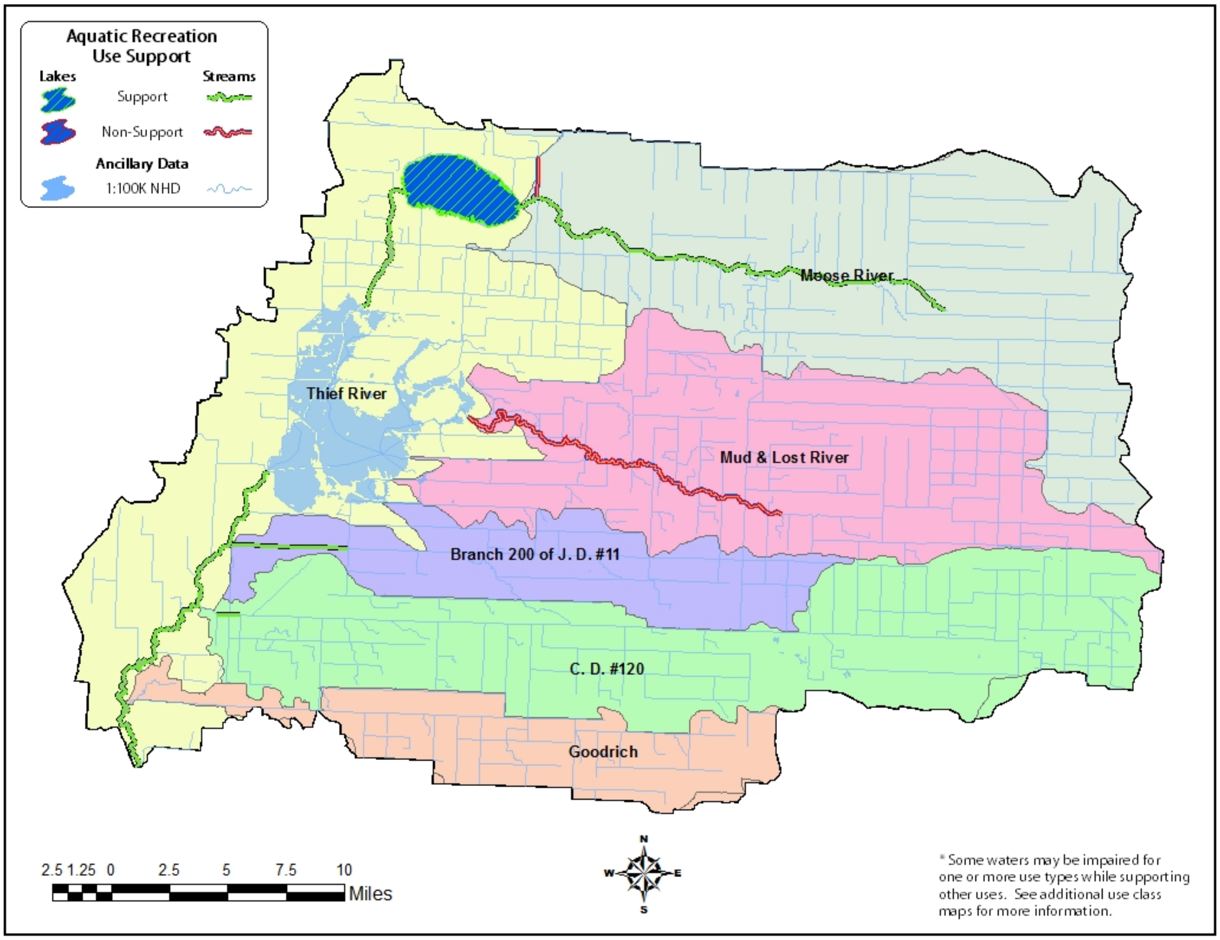


Figure 41. Aquatic recreation use support in the Thief River Watershed

VII. Summaries and recommendations

Once dominated by vast wetlands and free flowing rivers, direct alteration of surface water through ditching, stream channelization, tiling, and the creation of dams, along with poor land use practices throughout the watershed have had a cumulative effect on the quality of lakes and streams in the watershed. Today, 96% of the stream miles within the watershed have been altered. These alterations have reduced the water storage capacity of the watershed, which has made rivers and streams "flashy" with high peak flows during rain events and severely low flows during drought.

All but one biological station in the Thief River Watershed were not able to be assessed for aquatic life because of channelization, however their data suggest that a lack of in-stream habitat is limiting biological communities. In-stream habitat is primarily a function of channel geomorphology (Rosgen, 1996) and flow (Bovee, 1986); with the fluctuating water levels, much of the remaining habitat is either inaccessible during high flows or unavailable during low flows. Only one station in the watershed was sampled on a natural stream segment (11RD031); this station had good habitat (high MSHA score) and also scored well above its respective F-IBI threshold. Habitat at this station displayed good channel development, moderately stable banks, and available substrates for lithiphilic spawners (clean boulder, coble, gravel). In contrast, all of the other biological stations in the watershed were located on channelized reaches and scored fair to poor for the MSHA. Fish communities at these stations were dominated by tolerant individuals that can survive highly degraded environments with little to no habitat. While not all streams in this region are capable of providing certain habitats (riffle, woody debris), channel alterations throughout the watershed have led to channel instability, which is increasing sediment load and decreasing habitat quality and quantity.

The surficial geology of the Red River Valley is such that conditions for groundwater recharge are ideal in only a few areas around topographic highs and in the presence of surficial sand and gravel deposits. Preservation of these areas is critical to maintaining sufficient groundwater availability for consumptive use.

Only one lake, Thief Lake, was assessed for aquatic recreation and is meeting its standards. The lake was sampled for chloride and met it standards, however a policy decision was made to assess the lake as "Insufficient Information", as no biological data is available to determine if the lake is supporting aquatic life use at this time.

Excess sedimentation has contributed to a turbidity impairment along the Thief River from the Agassiz Pool to its confluence with the Red Lake River. Soil erosion coming from agricultural fields and/or streams banks appears to be the likely cause. In addition, this reach is impaired by low DO, however the impairment is proposed to be delisted in the draft 2014 Impaired Waters List based upon new comprehensive data indicating that the reach meets the state DO standard. Dissolved oxygen impairments will remain along the entire Moose River and Mud River. These impairments can be attributed to a multitude of factors including stream channelization, poor land use management, and nutrients input. Excessive nutrients, such as nitrogen and phosphorus, can increase algae and macrophyte production in streams which leads to low levels of DO, larger diel DO fluctuations, and increased turbidity. Streams in this region are susceptible to excessive nutrients because they are low gradient and often channelized with a limited riparian zone. In healthy streams, excess nutrients can be utilized by macrophytes, invertebrate and vertebrate biomass, and deposited in the riparian zone during flood events (Rankin *et al*. 1999).

Overall, rivers and streams in the Thief River Watershed are in poor condition. With the large number of altered streams, it is important to provide riparian buffers to prevent runoff of excess nutrients and sediment. Good land management practices can substantially reduce overland runoff of pollutants to streams and ditches in the watershed, resulting in water quality improvements. Throughout much of the watershed, hydrologic alterations by means of agricultural drainage, dams, and stream channelization appear to be affecting necessary habitats to support healthy biological communities.

Additional monitoring may be needed to determine the extent and nature of new and existing impairments and the effects of Best Management Practices (BMPs) implementation. While improvements have been made to increase water quality, additional monitoring and BMP implementation must be continued on a watershed wide scale.

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Appendix 1 - Water chemistry definitions

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

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

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

Orthophosphate - Orthophosphate (OP) is a water soluble form of phosphorus that is readily available to algae (bioavailable). While orthophosphates occur naturally in the environment, river and stream concentrations may become elevated with additional inputs from 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 doe’s 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 Thief River Watershed

Biological Station ID	STORET/ EQuIS ID	Water body Name	Location	11-digit HUC
11RD031	S002-079	Thief River	At 140th Ave NE, 4 mi. N of Thief River Falls	09020304020
11RD032	S004-966	Judicial Ditch 18	At 140th Ave NE, 3 mi. N of Thief River Falls	09020304060
11RD036	S004-494	County Ditch 20	At 180th Ave, 7 mi. NE of Thief River Falls	09020304050
11RD038	S004-493	Judicial Ditch 11	At 190th Ave, 10 mi. NE of Thief River Falls	09020304040
11RD040	S002-088	Thief River	At CR 7, 6 mi. E of Holt	09020304020
11RD042	S004-055	Thief River	At 380th St. NE, 9.5 mi. E of Middle River	09020304020
11RD061	S002-078	Mud River	At Hwy 89, 6 mi. NE of Grygla	09020304030
11RD067	S006-539	Moose River	At 300th Ave NE, CR 131, in Thief Lake	09020304010
11RD068	S006-540	Judicial Ditch 21	At CR 48, 7 mi. SW of Torfin	09020304010

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

AUID DESCRIPTIONS				USES							BIOLOGICAL CRITERIA		WATER QUALITY STANDARDS							
Assessment Unit ID (AUID)	Stream Reach Name	Reach Description	Reach Length (Miles)	Use Class	Aquatic Life	Aquatic Recreation	Aquatic Consumption	Drinking Water	303d listed impairments 2012		Fish	Macroinvertebrates	Dissolved Oxygen	Turbidity	Chloride	pH	NH3	Pesticides	Bacteria (Aquatic Recreation)
HUC 12: *09020304010 (Moose River)*																			
09020304-505	Moose River	Headwaters to Thief Lake	23.35	2B	NS	FS					NA	NA	EXS	MTS			MTS		MTS
09020304-555	Unnamed Ditch	Unnamed Ditch to Moose River	1.7	2B	IF	NS					NA	NA	IF	MTS			MTS		EX
09020304-557	Unnamed Ditch	Unnamed Ditch to Unnamed Ditch	6.67	2B	NA	NA					NA	NA							
HUC 12: *09020304020 (Thief River)*																			
09020304-501	Thief River	Agassiz Pool to Red Lake River	21.96	2B	NS	FS					MTS	MTS	MTS	EXS		MTS	MTS		MTS
09020304-504	Thief River	Thief Lake to Agassiz Pool	7.9	2B	IF	FS					NA	NA	IF			MTS	MTS		MTS
09020304-509	Unnamed Ditch (Judicial Ditch 18)	T154 R42W S14, east line to Thief River	8.45	7	NA	NA					NA	--	IF			MTS			MTS
09020304-536	Judicial Ditch 11	Unnamed Ditch to Thief River	9.67	2B	IF	NA					NA	NA	IF			MTS	IF		
09020304-543	Unnamed Ditch	Unnamed Ditch to Unnamed Ditch	1.98	2B	NA	NA					NA	--							
09020304-550	Unnamed Ditch	Headwaters to Thief River	5.78	2B	NA	NA					NA	NA							
09020304-551	Unnamed Ditch	Unnamed Ditch to Thief River	4.56	2B	NA	NA					NA	NA							
09020304-558	Unnamed Ditch	Unnamed Ditch to Thief River	-	2B	NA	NA					NA	--							
HUC 12: *09020304030 (Mud River)*																			
09020304-507	Mud River	Headwaters to Agassiz Pool	20.01	2B	NS	NS					NA	MTS	EXS	MTS		MTS	MTS		EX
09020304-521	Unnamed Ditch	Unnamed Ditch to Unnamed Ditch	0.98	2B	IF	NA					--	--	IF	MTS		MTS			
09020304-527	Unnamed Ditch	Unnamed Ditch to Unnamed Ditch	7.86	2B	NA	NA					NA	--							
09020304-535	Judicial Ditch 11	Unnamed Ditch to Unnamed Ditch	4.03	2B	IF	NA					--	--	IF	MTS		MTS			
09020304-559	Unnamed Ditch	Headwaters to Mud Lake	6.29	2B	NA	NA					NA	NA							
HUC 12: *09020304040 (Branch 200 of Judicial Ditch 11)*																			
09020304-511	Unnamed Ditch (Ditch 200)	Unnamed Ditch to Unnamed Ditch	5.0	2B	IF	FS					NA	NA	EXP	MTS		MTS			MTS
09020304-534	Unnamed Ditch	Unnamed Ditch to Unnamed Ditch	2.0	2B	IF	NA					--	--	EXP	MTS		MTS			

Appendix 3.1 (Cont.)

AUID DESCRIPTIONS				USES						BIOLOGICAL CRITERIA		WATER QUALITY STANDARDS						
Assessment Unit ID (AUID)	Stream Reach Name	Reach Description	Reach Length (Miles)	Use Class	Aquatic Life	Aquatic Recreation	Aquatic Consumption	Drinking Water	303d listed impairments 2012	Fish	Macroinvertebrates	Dissolved Oxygen	Turbidity	Chloride	pH	NH3	Pesticides	Bacteria (Aquatic Recreation)
HUC 12: ***09020304050 (County Ditch 120)***																		
09020304-513	County Ditch 20	Unnamed Ditch to CD 32	8.44	2B	IF	NA				NA	NA	IF	MTS		MTS			
09020304-519	County Ditch 20	Unnamed Ditch to Unnamed Ditch	1.0	2B	IF	FS				NA	NA	IF	MTS		MTS	MTS		MTS
09020304-548	County Ditch 20	Unnamed Ditch to Unnamed Ditch	5.43	2B	NA	NA				NA	NA							
09080304-549	Unnamed Ditch	Unnamed Ditch to CD 30	3.97	2B	NA	NA				NA	--							
09020304-552	County Ditch 27	Unnamed Ditch to Unnamed Ditch	3.98	2B	NA	NA				NA	NA							
09020304-554	County Ditch 32	Unnamed Ditch to CD 20	2.47	2B	NA	NA				NA	NA							
HUC 12: ***09020304060 (Goodrich)***																		
09020304-537	Unnamed Ditch	Unnamed ditch to JD 13	3.42	2B	NA	NA				NA	NA							
09020304-540	Judicial Ditch 13	T154 R40W S16, east line to JD 18	3.01	7	NA	NA				NA	NA							
09020304-541	Judicial Ditch 18	T154 R40W S27, midpoint to T154 R42W S13, west line	12.5	7	NA	NA				NA	--							

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. *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 Thief River Watershed

Lake ID	Lake Name	County	HUC-11	Ecoregion	Lake Area (acres)	Max Depth (m)	Watershed Area (acres)	% Littoral	Mean depth (m)	Support Status
04-0615-00	Unnamed	Beltrami	09020304030	NMW	18	1.4				NA
45-0001-00	Thief	Marshall	09020304020	RRV	6513	1.4	146547	100	0.9	FS
45-0002-00	Mud	Marshall	09020304020	RRV	2747					NA
45-0003-00	Kuriko	Marshall	09020304020	RRV	38					NA
45-0004-00	Webster	Marshall	09020304020	RRV	18					NA
45-0005-00	Whiskey	Marshall	09020304020	RRV	19					NA
45-0008-00	Unnamed	Marshall	09020304030	RRV	19					NA
45-0012-00	Elm Lake WMA	Marshall	09020304040	RRV	44					NA
45-0053-00	Elm Lake WMA	Marshall	09020304040	RRV	11					NA

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

Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new 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
Invertebrates						
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: 09020304020 (Thief River Watershed)							
09020304-501	11RD031	Thief River	963.82	4	35	71	24-Aug-11

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: 09020304020 (Thief River Watershed)							
09020304-501	11RD031	Thief River	963.82	2	30.7	31.44	30-Aug-11
HUC 11: 09020304030 (Mud River Watershed)							
09020304-507	05RD097	Mud River	157.41	7	38.3	65.78	28-Sep-05

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
Invertebrates				
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 (unassessed)

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: 09020301010 (Moose River)									
09020304-505	05RD096	Moose River	142.36	5	100 - 50	49 - 35	34 - 0	34	30-Aug-06
09020304-505	05RD104	Moose River	83.33	5	100 - 50	49 - 35	34 - 0	42	23-Aug-05
09020304-505	11RD062	Moose River	105.37	5	100 - 50	49 - 35	34 - 0	35	04-Aug-11
09020304-505	11RD063	Moose River	66.42	5	100 - 50	49 - 35	34 - 0	39	08-Sep-11
09020304-505	11RD064	Moose River	135.76	5	100 - 50	49 - 35	34 - 0	36	13-Sep-11
09020304-505	11RD067	Moose River	198.56	5	100 - 50	49 - 35	34 - 0	37	15-Sep-11
09020304-555	11RD068	Unnamed Ditch	47.09	7	100 - 40	39 - 35	24 - 0	49	21-Jun-11
09020304-557	11RD069	Unnamed Ditch	30.54	7	100 - 40	39 - 35	24 - 0	48	21-Jun-11
HUC 11: 09020304020 (Thief River)									
09020304-504	11RD042	Thief River	274.61	5	100 - 50	49 - 35	34 - 0	39	25-Aug-11
09020304-509	11RD032	Unnamed Ditch (Judicial Ditch 18)	65.68	5	100 - 50	49 - 35	34 - 0	9	13-Jun-11
09020304-536	11RD047	Judicial Ditch 11	196.76	5	100 - 50	49 - 35	34 - 0	52	07-Sep-11
09020304-543	11RD045	Unnamed Ditch	18.97	7	100 - 40	39 - 35	24 - 0	47	14-Jun-11
09020304-550	11RD034	Unnamed Ditch	4.18	6	100 - 40	39 - 35	24 - 0	22	01-Aug-11
09020304-551	11RD033	Unnamed Ditch	11.15	6	100 - 40	39 - 35	24 - 0	21	13-Jun-11
09020304-558	11RD041	Unnamed Ditch	14.90	7	100 - 40	39 - 35	24 - 0	23	14-Jun-11
HUC 11: 09020304030 (Mud River)									
09020304-507	11RD060	Mud River	135.85	5	100 - 50	49 - 35	34 - 0	50	07-Sep-11
09020304-507	11RD061	Mud River	185.48	5	100 - 50	49 - 35	34 - 0	39	06-Sep-11
09020304-527	11RD059	Unnamed Ditch	2.65	6	100 - 40	39 - 35	24 - 0	69	20-Jun-11
09020304-559	11RD046	Unnamed Ditch	7.05	7	100 - 40	39 - 35	24 - 0	54	01-Aug-11
HUC 11: 09020304040 (Branch 200 of Judicial Ditch 11)									
09020304-511	11RD038	Unnamed Ditch (Ditch 200)	61.02	5	100 - 50	49 - 35	34 - 0	34	24-Aug-11

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: 09020304050 (County Ditch 120)									
09020304-513	11RD051	County Ditch 20	92.71	5	100 - 50	49 - 35	34 - 0	53	15-Jun-11
09020304-519	11RD036	County Ditch 20	195.78	5	100 - 50	49 - 35	34 - 0	47	24-Aug-11
09020304-548	11RD056	County Ditch 20	62.66	5	100 - 50	49 - 35	34 - 0	9	16-Jun-11
09020304-549	11RD057	Unnamed Ditch	1.12	7	100 - 40	39 - 35	24 - 0	43	08-Sep-11
09020304-552	11RD037	County Ditch 27	14.80	7	100 - 40	39 - 35	24 - 0	23	14-Jun-11
09020304-554	11RD052	County Ditch 32	7.96	7	100 - 40	39 - 35	24 - 0	15	15-Jun-11
HUC 11: 09020304060 (Goodrich)									
09020304-537	07RD019	Unnamed Ditch	11.05	7	100 - 40	39 - 35	24 - 0	39	08-Aug-07
09020304-537	11RD053	Unnamed Ditch	18.48	7	100 - 40	39 - 35	24 - 0	9	15-Jun-11
09020304-540	07RD020	Judicial Ditch 13	34.30	7	100 - 40	39 - 35	24 - 0	0	08-Aug-07
09020304-540	07RD020	Judicial Ditch 13	34.30	7	100 - 40	39 - 35	24 - 0	18	20-Jun-11
09020304-541	11RD055	Judicial Ditch 18	5.60	6	100 - 40	39 - 35	24 - 0	47	14-Jun-11

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

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Invert Class	Good	Fair	Poor	MIBI	Visit Date
HUC 11: 09020301010 (Moose River)									
09020304-505	05RD096	Moose River	142.36	7	100 - 39	38 - 23	22 - 0	24.36	11-Oct-05
09020304-505	05RD104	Moose River	83.33	7	100 - 39	38 - 23	22 - 0	36.83	11-Oct-05
09020304-505	11RD062	Moose River	105.37	7	100 - 39	38 - 23	22 - 0	40.35	02-Aug-11
09020304-505	11RD063	Moose River	66.42	4	100 - 53	52 - 37	36 - 0	58.23	02-Aug-11
09020304-505	11RD064	Moose River	135.76	7	100 - 39	38 - 23	22 - 0	37.83	13-Sep-11
09020304-505	11RD067	Moose River	198.56	7	100 - 39	38 - 23	22 - 0	54.06	15-Sep-11
09020304-555	11RD068	Unnamed Ditch	47.09	7	100 - 39	38 - 23	22 - 0	59.51	31-Aug-11
09020304-557	11RD069	Unnamed Ditch	30.54	7	100 - 39	38 - 23	22 - 0	36.58	11-Aug-11

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Invert Class	Good	Fair	Poor	MIBI	Visit Date
HUC 11: 09020304020 (Thief River)									
09020304-504	11RD042	Thief River	274.61	7	100 - 39	38 - 23	22 - 0	40.45	25-Aug-11
09020304-536	11RD047	Judicial Ditch 11	196.76	7	100 - 39	38 - 23	22 - 0	31.91	11-Aug-11
09020304-550	11RD034	Unnamed Ditch	4.18	7	100 - 39	38 - 23	22 - 0	12.61	01-Aug-11
09020304-551	11RD033	Unnamed Ditch	11.15	7	100 - 39	38 - 23	22 - 0	3.43	02-Aug-11
HUC 11: 09020304030 (Mud River)									
09020304-507	11RD060	Mud River	135.85	7	100 - 39	38 - 23	22 - 0	21.54	31-Aug-11
09020304-507	11RD061	Mud River	185.48	7	100 - 39	38 - 23	22 - 0	36.73	31-Aug-11
09020304-559	11RD046	Unnamed Ditch	7.05	7	100 - 39	38 - 23	22 - 0	9.39	01-Aug-11
HUC 11: 09020304040 (Branch 200 of Judicial Ditch 11)									
09020304-507	11RD038	Unnamed Ditch (Ditch 200)	61.02	7	100 - 39	38 - 23	22 - 0	20.78	10-Aug-11
HUC 11: 09020304050 (County Ditch 120)									
09020304-513	11RD051	County Ditch 20	92.71	5	100 - 37	36 - 21	20 - 0	44.13	10-Aug-11
09020304-519	11RD036	County Ditch 20	195.78	5	100 - 37	36 - 21	20 - 0	35.19	10-Aug-11
09020304-519	11RD036	County Ditch 20	195.78	5	100 - 37	36 - 21	20 - 0	49.29	24-Aug-11
09020304-548	11RD056	County Ditch 20	62.66	4	100 - 53	52 - 37	36 - 0	50.16	31-Aug-11
09020304-552	11RD037	County Ditch 27	14.80	7	100 - 39	38 - 23	22 - 0	23.86	10-Aug-11
09020304-554	11RD052	County Ditch 32	7.96	7	100 - 39	38 - 23	22 - 0	14.78	10-Aug-11
HUC 11: 09020304060 (County Ditch 120)									
09020304-537	07RD019	Unnamed Ditch	11.05	7	100 - 37	36 - 21	20 - 0	17.64	14-Aug-07
09020304-540	07RD020	Judicial Ditch 13	34.30	7	100 - 37	36 - 21	20 - 0	39.95	14-Aug-07

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 Thief 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
45-0001-00	Thief	35	84	10.5	43	0.9	0.8	156	12201	39.9	0.46	78.15	0.3	2.97	E

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

Appendix 7 - Fish species found during biological monitoring surveys

Common Name	Quantity of Stations Where Present	Quantity of Individuals Collected
bigmouth shiner	2	199
black bullhead	1	1
black crappie	1	1
blackside darter	10	482
bluegill	1	1
brassy minnow	11	734
brook stickleback	28	2543
brown bullhead	1	2
central mudminnow	31	2677
common shiner	4	47
creek chub	1	1
emerald shiner	3	76
fathead minnow	26	9663
finescale dace	20	2135
Gen: Phoxinus	1	25
Gen: redhorses	1	2
golden redhorse	1	3
hornyhead chub	1	1
Iowa darter	14	431
johnny darter	10	404
northern pike	10	118
northern redbelly dace	20	2840
pearl dace	18	2310
rock bass	1	4
shorthead redhorse	3	31
smallmouth bass	1	1

Appendix 8 - Macroinvertebrate species found during biological monitoring surveys

Taxonomic Name	Number of Stations Where Present	Quantity of Individuals Collected
Acari		
Acari	17	234
Amphipoda		
Gammarus	1	1
Hyalella	16	345
Coleoptera		
Acilius	2	3
Agabus	1	1
Anacaena	3	3
Berosus	3	5
Colymbetes	1	1
Coptotomus	1	
Desmopachria	1	1
Dubiraphia	15	176
Dytiscidae	3	12
Gyrinidae	1	1
Gyrinus	3	10
Haliplus	14	65
Helichus	1	1
Helophorus	1	1
Hydraena	5	9
Hydrobius	1	1
Hydrochus	1	1
Hydrophilidae	3	4
Hydroporus	1	1
Hygrotus	1	2
Ilybius	1	
Laccophilus	5	19
Liodessus	10	120
Neoporus	1	3
Optioservus	3	6
Paracymus	1	1
Peltodytes	5	22
Stenelmis	3	14
Tropisternus	3	2

Crustacea		
Crambidae	2	9
Orconectes	7	1
Diptera		
Ablabesmyia	11	29
Anopheles	1	1
Atrichopogon	1	1
Bezzia	1	1
Bezzia/Palpomyia	3	3
Brillia	3	10
Ceratopogonidae	3	3
Ceratopogoninae	3	7
Chironomini	3	4
Chironomus	5	10
Chrysops	2	2
Cladotanytarsus	10	58
Coenagrionidae	10	83
Conchapelopia	3	3
Corynoneura	6	19
Cricotopus	21	388
Cryptochironomus	7	18
Cryptotendipes	2	2
Culicidae	2	2
Dasyhelea	2	2
Dicrotendipes	23	238
Empididae	2	2
Enallagma	6	36
Endochironomus	5	73
Ephydridae	5	9
Eukiefferiella	2	7
Glyptotendipes	5	8
Hemerodromia	2	7
Hexatoma	1	1
Labrundinia	12	26
Limnophyes	2	4
Micropsectra	12	92
Microtendipes	8	15
Nanocladius	9	23
Neoplasta	1	1
Nilotanypus	2	2
Orthocladiinae	4	4
Orthocladius	7	11
Parachironomus	6	8
Parakiefferiella	8	38

Paramerina	3	7
Parametriocnemus	1	1
Paratanytarsus	21	198
Paratendipes	2	17
Pentaneura	1	3
Phaenopsectra	6	11
Polypedilum	22	473
Potthastia	3	3
Probezzia	1	1
Procladius	5	9
Pseudochironomus	1	1
Rheocricotopus	5	6
Rheotanytarsus	14	458
Saetheria	3	10
Sciomyzidae	1	2
Simulium	11	279
Stempellina	2	3
Stempellinella	8	19
Stenochironomus	4	12
Stictochironomus	1	7
Tanypodinae	11	16
Tanytarsini	9	87
Tanytarsus	19	209
Thienemanniella	11	123
Thienemannimyia Gr.	16	75
Tipula	5	17
Tribelos	1	9
Tvetenia	3	6
Xenochironomus xenolabis	2	3
Zavreliella marmorata	1	1
Zavrelimyia	1	9
Ephemeroptera		
Acentrella	2	3
Acentrella parvula	2	16
Acerpenna	3	4
Baetidae	4	7
Baetis	1	1
Baetis brunneicolor	1	2
Baetis intercalaris	1	8
Baetisca	2	6
Caenis	20	268
Caenis youngi	8	51
Caenis tardata	3	5
Callibaetis	1	1

Ephoron	2	2
Ephoron album	1	2
Eurylophella	1	4
Heptagenia	4	12
Heptageniidae	3	12
Hexagenia	3	2
Hexagenia limbata	1	1
Iswaeon	5	206
Labiobaetis	1	1
Labiobaetis propinquus	5	21
Leptophlebia	2	24
Leucrocuta	3	8
Maccaffertium	2	5
Maccaffertium luteum	1	1
Maccaffertium mediopunctatum	1	1
Paraleptophlebia	1	3
Plauditus	1	2
Procloeon	12	42
Pseudocloeon	2	3
Stenacron	3	10
Stenacron interpunctatum	1	8
Stenacron minnetonka	1	3
Stenonema	1	1
Tricorythodes	7	26
Gastropoda		
Amnicola	1	15
Ferrissia	16	369
Fossaria	1	2
Gyraulus	11	313
Helisoma	2	3
Helisoma anceps	2	3
Hydrobiidae	3	79
Lymnaea stagnalis	2	1
Lymnaeidae	6	50
Physa	18	519
Planorbella	4	13
Planorbidae	7	177
Promenetus	1	1
Pseudosuccinea	1	
Stagnicola	14	107
Valvata	4	25
Hemiptera		
Belostoma	4	7
Belostoma flumineum	6	6

Corixidae	6	23
Gerridae	1	1
Hesperocorixa	4	9
Lethocerus	1	
Mesovelia	1	1
Metrobates	1	1
Neoplea striola	2	6
Notonecta	3	2
Ranatra	2	0
Sigara	7	192
Trichocorixa	5	25
Hirudinea		
Hirudinea	19	44
Hydrozoa		
Hydra	1	1
Hydrozoa	4	6
Nematoda		
Nematoda	1	1
Odonata		
Anax	2	3
Anax junius	1	0
Calopterygidae	3	6
Calopteryx	4	6
Calopteryx aequabilis	1	2
Gomphidae	1	2
Libellulidae	3	11
Ophiogomphus carolus	1	0
Somatochlora	1	
Somatochlora minor	1	0
Sympetrum	1	1
Oligochaeta		
Oligochaeta	20	472
Plecoptera		
Acroneuria	1	
Perlidae	1	2
Pteronarcys	3	6
Trichoptera		
Brachycentrus	1	1
Brachycentrus numerosus	3	8
Ceraclea	5	23
Ceratopsyche	2	11
Ceratopsyche bronta	1	10
Ceratopsyche morosa	1	2
Ceratopsyche slossonae	1	3

Cheumatopsyche	7	49
Glyphopsyche irrorata	1	1
Helicopsyche	1	5
Helicopsyche borealis	4	27
Hydropsyche	3	17
Hydropsyche betteni	2	10
Hydropsyche simulans	2	13
Hydropsychidae	4	52
Hydroptila	5	37
Hydroptilidae	2	5
Leptoceridae	4	5
Limnephilidae	1	10
Mystacides	5	5
Nectopsyche	3	4
Nectopsyche candida	1	1
Nectopsyche diarina	8	37
Nemotaulius hostilis	1	1
Neotrichia	1	2
Oecetis	5	17
Oecetis avara	3	6
Oxyethira	1	38
Phryganea	1	1
Ptilostomis	5	9
Triaenodes	1	1
Mollusca		
Pisidiidae	15	65
Unionidae	1	0