Mustinka River Watershed Monitoring and Assessment Report

Minnesota Pollution Control Agency

November 2013

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List of acronyms

AUID Assessment Unit Identification Determination

CCSI Channel Condition and Stability Index

CD County Ditch

CI Confidence Interval

CLMP Citizen Lake Monitoring Program

CR County Road

CSAH County State Aid Highway

CSMP Citizen Stream Monitoring Program

CWA Clean Water Act

CWLA Clean Water Legacy Act

DOP Dissolved Orthophosphate

E Eutrophic

EQuIS Environmental Quality Information System

EX Exceeds Criteria (Bacteria)

EXP Exceeds Criteria, Potential Impairment

EXS Exceeds Criteria, Potential Severe Impairment

FS Full Support

FWMC Flow Weighted Mean Concentration

H Hypereutrophic

HUC Hydrologic Unit Code

IBI Index of Biotic Integrity

IF Insufficient Information

K Potassium

LRVW Limited Resource Value Water

M Mesotrophic

MCES Metropolitan Council Environmental Services

MDA Minnesota Department of Agriculture

MDH Minnesota Department of Health

MDNR Minnesota Department of Natural Resources

MINLEAP Minnesota Lake Eutrophication Analysis Procedure

MPCA Minnesota Pollution Control Agency

MSHA Minnesota Stream Habitat Assessment

MTS Meets the Standard?

N Nitrogen

Nitrate-N Nitrate Plus Nitrite Nitrogen

NA Not Assessed

NHD National Hydrologic Dataset

NH3 Ammonia

NS Not Supporting

NT No Trend

OP Orthophosphate

P Phosphorous

PCB Poly Chlorinated Biphenyls

PWI Protected Waters Inventory

RNR River Nutrient Region

SWAG Surface Water Assessment Grant

SWCD Soil and Water Conservation District

SWUD State Water Use Database

TALU Tiered Aquatic Life Uses

TKN Total Kjeldahl Nitrogen

TMDL Total Maximum Daily Load

TP Total Phosphorous

TSS Total Suspended Solids

USGS United States Geological Survey

WPLMN Water Pollutant Load Monitoring Network

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Executive summary

The Mustinka River Watershed lies within the headwaters region of the Red River Basin. Encompassing an area of 909 square miles, the watershed lies within a flat area of west central Minnesota used predominately for agricultural row crop production. Extensive hydrologic alterations such as stream channelization and ditching have been made throughout the watershed to promote soil drainage. Flooding occurs frequently within the watershed due to the low gradient nature of the watershed, broad flood plains, and often saturated soil conditions during spring snowmelt. Major rivers and streams include the Mustinka River, Twelve Mile Creek, Five Mile Creek and Eighteen Mile Creek. Numerous small unnamed creeks and ditches occur throughout the watershed. There are also 179 lakes greater than 10 acres within the Mustinka River Watershed.

In 2010 the Minnesota Pollution Control Agency (MPCA) began an intensive watershed monitoring (IWM) effort of surface waters within the Mustinka River Watershed. Twenty-seven sites were sampled for biology at the outlet of variable sized sub-watersheds. Water chemistry was monitored at six stream sites and several lakes. In 2012 the surface water bodies within the watershed were assessed for aquatic life, aquatic recreation, and aquatic consumption use support. Twelve streams and three lakes were assessed. Twelve stream segments, known as assessment units (AUIDs) 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.

Every stream segment assessed within the Mustinka River Watershed failed to support aquatic life use standards. Only one assessed stream segment fully supported aquatic recreation use. Most aquatic life impairments were the result of low dissolved oxygen (DO) and/or excess turbidity. Poor fish and macro-invertebrate communities also resulted in aquatic life impairment designations. Excessive bacteria levels resulted in aquatic recreation impairments. Lakes with enough data to assess failed to support aquatic recreation. Most lakes had high total phosphorus levels and low transparencies.

Introduction

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

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

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

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

This watershed-wide monitoring approach was implemented in the Mustinka River Watershed beginning in the summer of 2010. This report provides a summary of all water quality assessment results in the Mustinka River Watershed and incorporates all data available for the assessment process including watershed monitoring, volunteer monitoring and monitoring conducted by local government units.

I. The watershed monitoring approach

The watershed approach is a 10-year rotation for monitoring and assessing waters of the state on the level of Minnesota's 81 major watersheds (Figure 1). The major benefit of this approach is the integration of monitoring resources to provide a more complete and systematic assessment of water quality at a geographic scale useful for the development and implementation of effective TMDLs, project planning, effectiveness monitoring, and protection strategies. The following paragraphs provide details on each of the four principal monitoring components of the watershed approach. For additional information see: *Watershed Approach to Condition Monitoring and Assessment* (MPCA 2008) (http://www.pca.state.mn.us/publications/wq-s1-27.pdf).

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, as well as outlets of 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, local monitoring organizations and MPCA WPLMN staff to compute annual pollutant loads at 79 river monitoring sites across Minnesota. Intensive water quality sampling occurs year round at all WPLMN sites. Data will also be used to assist with TMDL studies and implementation plans, watershed modeling efforts and watershed research projects.

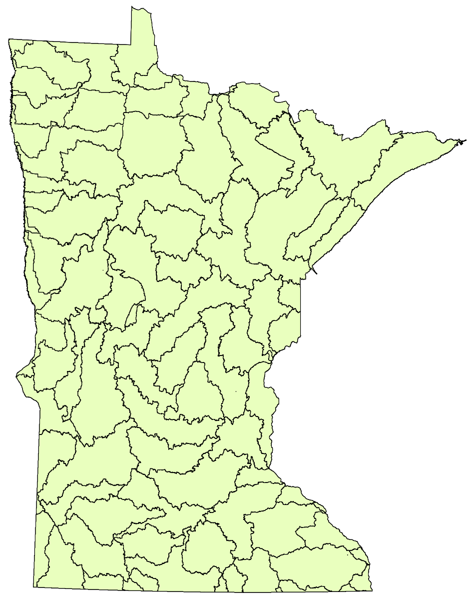

Figure 1. Major watersheds within Minnesota

Citizen and local monitoring

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

The MPCA also coordinates two programs aimed at encouraging long term citizen surface water monitoring: the Citizen Lake Monitoring Program (CLMP) and the Citizen Stream Monitoring Program (CSMP). Like the permanent load monitoring network, having citizen volunteers monitor a given lake or stream site monthly and from year to year can provide the long-term picture needed to help evaluate current status and trends. Citizen monitoring is especially effective at helping to track water quality changes that occur in the years between intensive monitoring years. Figure 2 provides an illustration of the locations where citizen monitoring data were used for assessment in the Mustinka River Watershed.

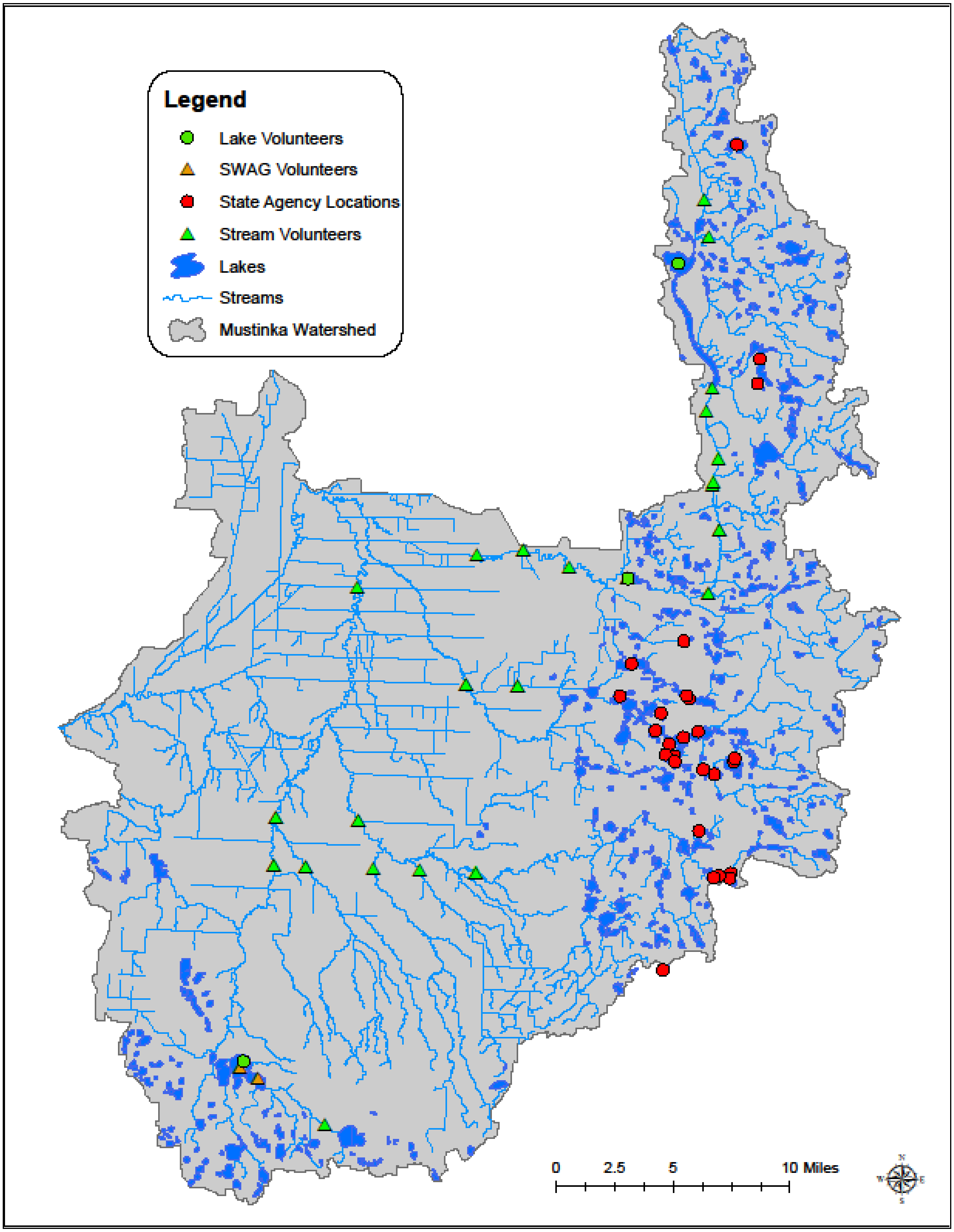

Figure 2. Monitoring locations of local groups, citizens and the MPCA lake monitoring staff in the Mustinka River Watershed

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 3). Each watershed scale is defined by a hydrologic unit code (HUC). These HUCs define watershed boundaries for water bodies within a similar geographic and hydrologic extent. The foundation of this approach is the 81 major watersheds (8-HUC) within Minnesota. Using this approach many of the smaller headwaters and tributaries to the main stem river are sampled in a systematic way so that a more holistic assessment of the watershed can be conducted and problem areas identified without monitoring every stream reach. Each major watershed is the focus of attention for at least one year within the 10-year cycle.

River/stream sites are selected near the outlet of each of three watershed scales, 8-HUC, 11-HUC and 14-HUC (Figure 2). Within each scale, different water uses are assessed based on the opportunity for that use (i.e., fishing, swimming, supporting aquatic life such as fish and insects). The major river watershed is represented by the 8-HUC scale. The outlet of the major 8-HUC watershed (purple dot in Figure 4) is sampled for biology (fish and macroinvertebrates), water chemistry, and fish contaminants to allow for the assessment of aquatic life, aquatic recreation and aquatic consumption use support. The 11-HUC is the next smaller watershed scale which generally consists of major tributary streams with drainage areas ranging from 75 to 150 mi^2. Each 11-HUC outlet (green triangles in Figure 4) is sampled for biology and water chemistry for the assessment of aquatic life and aquatic recreation use support. Within each 11-HUC, smaller watersheds (14 HUCs, 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 to assess aquatic life use support (red dots in Figure 4).

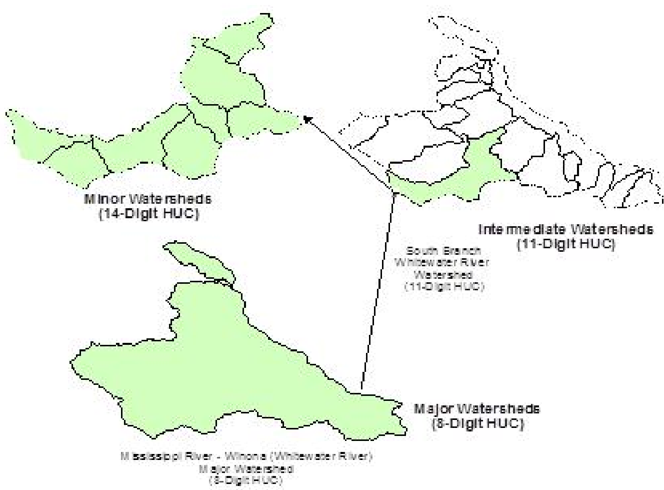

Figure 3. The intensive watershed monitoring design

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

Specific locations for sites sampled as part of the intensive monitoring effort in the Mustinka River Watershed are shown in Figure 4 and are listed in Appendix 2, Appendix 4.2, Appendix 4.3, Appendix 5.2 and Appendix 5.3.

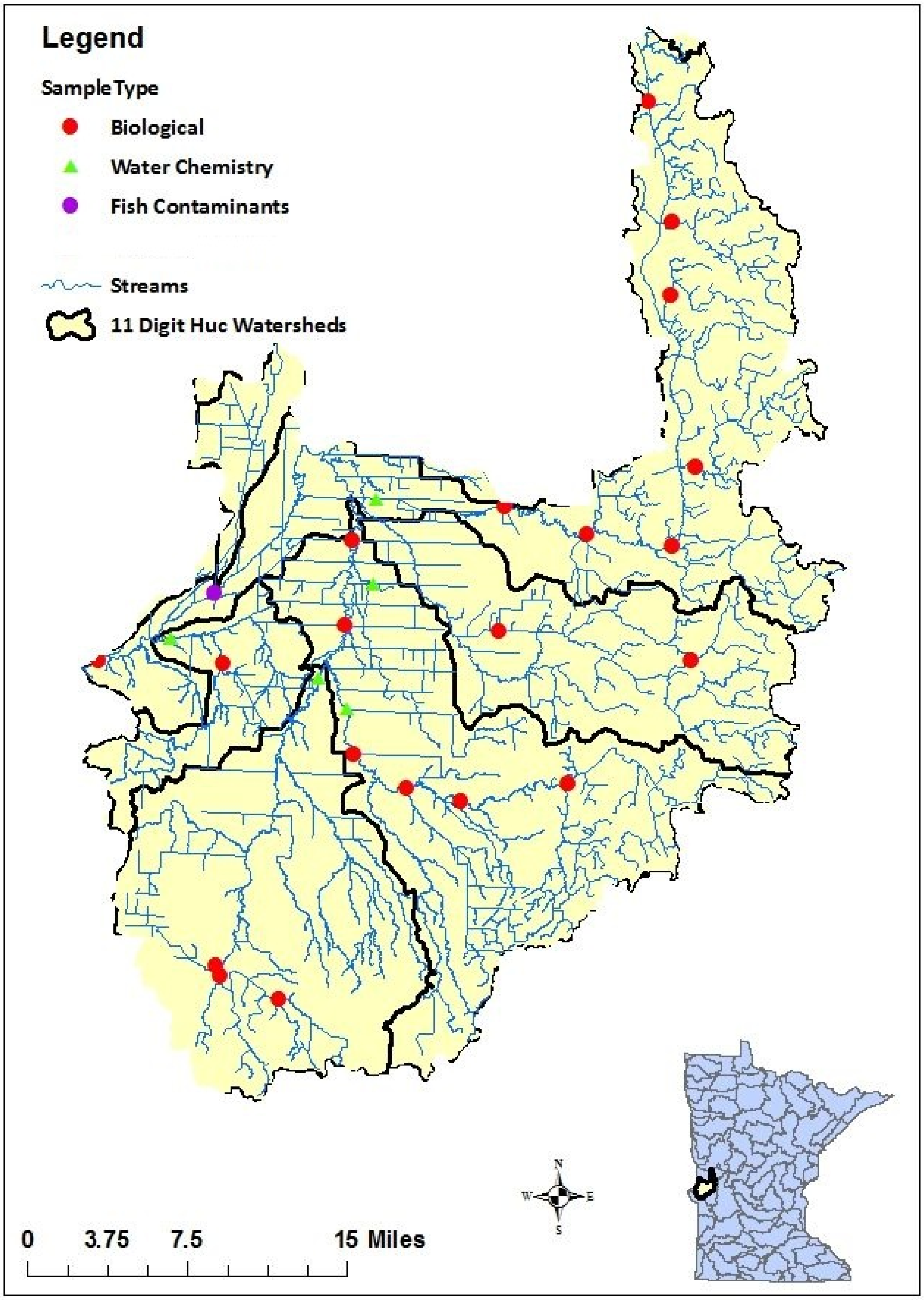

Figure 4. Intensive watershed monitoring sites for streams in the Mustinka River Watershed

II. Assessment methodology

The CWA requires states to report on the condition of the waters of the state every two years. This biennial report to Congress contains an updated list of surface waters that are determined to be supporting or non-supporting of their designated uses as evaluated by the comparison of monitoring data to criteria specified by Minnesota Water Quality Standards (Minn. R. Ch. 7050 2008; https://www.revisor.leg.state.mn.us/rules/?id=7050). The assessment and listing process involves dozens of MPCA staff, other state agencies and local partners. The goal of this effort is to use the best data and best science available to assess the condition of Minnesota's water resources. For a thorough review of the assessment methodologies see: *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment 305(b) Report and 303(d) List* (MPCA 2012). http://www.pca.state.mn.us/index.php/view-document.html?gid=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 (Fish IBI), which evaluates the health of the fish community, and the Macroinvertebrate Index of Biological Integrity (MIBI), which evaluates the health of the aquatic 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 that are enriched with nutrients and have abundant algal growth are eutrophic and do not support aquatic recreation.

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

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

Assessment units

Assessments of use support in Minnesota are made for individual water bodies. 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 that are variable in length. The MPCA is using the 1:24,000 scale high resolution National Hydrologic Dataset (NHD) to define and index stream, lake and wetland assessment units. Each river or stream reach is identified by a unique water body identifier (known as its AUID), comprised of the USGS eight digit hydrologic unit code (8-HUC) plus a three character code that is unique within each HUC. Lake and wetland identifiers are assigned by the MDNR. The Protected Waters Inventory (PWI) provides the identification numbers for lake, reservoirs and wetlands. These identification numbers serve as the AUID and are composed of an eight digit number indicating county, lake and bay for each basin.

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

Determining use attainment

For beneficial uses related to human health, such as drinking water or aquatic recreation, the relationship is well understood and thus the assessment process is a relatively simple comparison of monitoring data to numeric standards. In contrast, assessing whether a 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, or habitat).

The next step in the process is a Comprehensive Watershed Assessment meeting where reviewers convene to discuss the results of their desktop assessments for each individual waterbody. Implementing a comprehensive approach to water quality assessment requires a means of organizing and evaluating information to formulate a conclusion utilizing multiple lines of evidence. Occasionally, the evidence stemming from individual parameters are not in agreement and would result in discrepant assessments if the parameters were evaluated independently. However, the overall assessment considers each piece of evidence to make a use attainment determination based on the preponderance of information available. See the *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment 305(b) Report and 303(d) List* (MPCA 2012) http://www.pca.state.mn.us/index.php/view-document.html?gid=16988 for guidelines and factors considered when making such determinations.

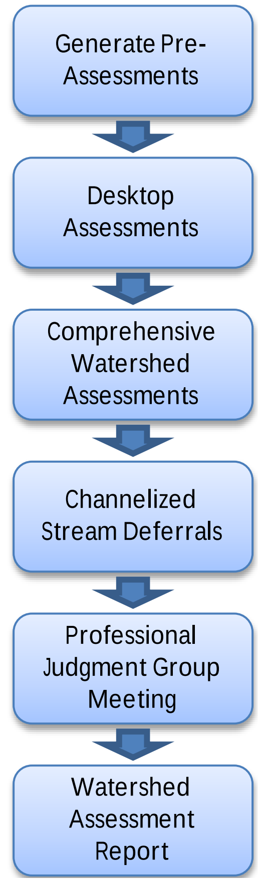

Figure 5. Flowchart of aquatic life use assessment

Any new impairment (i.e., waterbody not attaining its beneficial use) is first reviewed using GIS to determine if greater than 50% of the assessment unit is channelized. Currently, the MPCA is deferring any new impairments on channelized reaches until new aquatic life use standards have been developed as part of the Tiered Aquatic Life Use (TALU) framework. For additional information, see: http://www.pca.state.mn.us/index.php/view-document.html?gid=18309. However, in this report, channelized reaches with biological data are evaluated on a "good-fair-poor" system to help evaluate their condition (see Section IV and Appendix 5.1).

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

Data management

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

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

Period of record

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

III. Watershed overview

The Mustinka River Watershed covers 562,112 acres (909 square miles) of west central Minnesota. Beginning its 68 mile flow length in southwestern Ottertail County, the Mustinka River flows southward into Grant County through Lightning Lake and Stony Brook Lake (Waters 1977). The river maintains a southward course until turning west in southern Grant County. The river continues flowing west past Norcross and into Traverse County. In north-central Traverse County two main tributaries, Twelve Mile Creek and Five Mile Creek, feed into the Mustinka. Just west of the confluence of these tributaries the Mustinka River turns southwest and flows past Wheaton into Lake Traverse

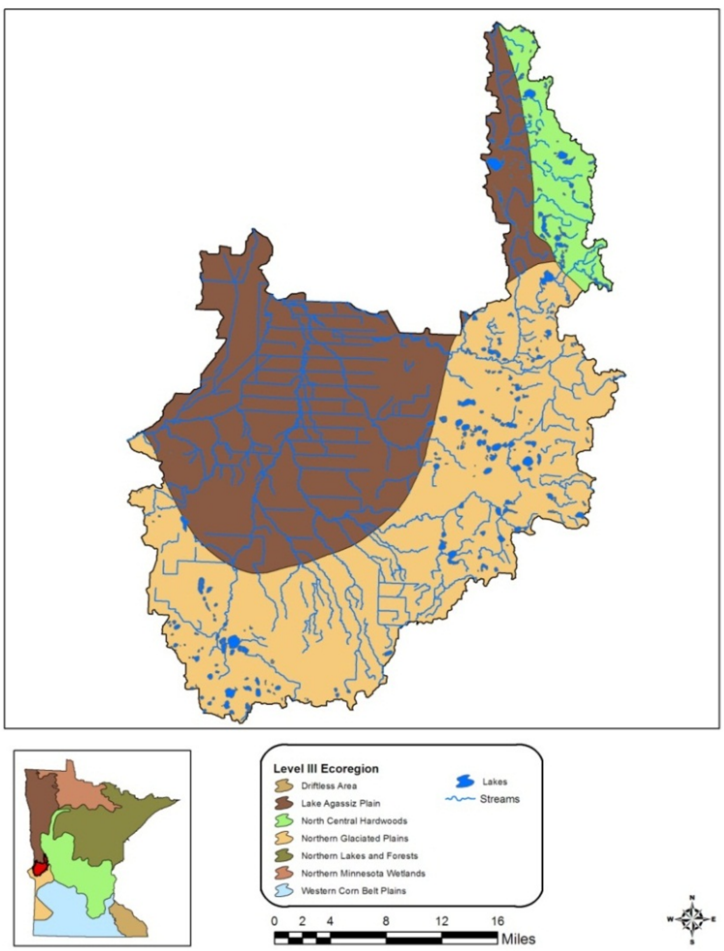

Figure 6. The Mustinka River Watershed lies within three ecoregions in west-central Minnesota

The Mustinka River Watershed lies within three of Minnesota's ecoregions (Figure 6). The eastern portion of the headwaters region lies within the Northern Lakes and Forests (NLF) ecoregion. The glacial soils of the NLF region are thick and nutrient poor (Omernik *et al.* 1988). Moraine hills, undulating till plains, and lacustrine basins occur in the NLF ecoregion (Omernik *et al.* 1988). Both the western headwaters and west central portion of the watershed lie within the Lake Agassiz Plain (LAP) ecoregion. Glacial Lake Agassiz deposited thick layers of silt and clay to form the fertile soils of the LAP ecoregion (Krenz 1993). Similar to most remnant lake beds, the LAP ecoregion is very flat and featureless. Downstream of the headwaters the ecoregion changes to the Northern Glaciated Plains, which wraps around the entire southern half of the watershed. Soils found within this ecoregion are generally very fertile (Omernik *et al.* 1988). The terrain varies from flat to gently rolling hills within this ecoregion (Omernik *et al.* 1988).

Land use summary

Historically much of the Mustinka River Watershed was covered in tall grass prairie and featured large areas of permanent and temporary wetlands (Krenz 1993). Throughout the mid to late 1800s steamboats and the railroad fostered settlement within the area (Krenz 1993). Settlers could purchase cheap land from the railroads or acquire it through government programs such as the Homestead Act (Krenz 1993). Most early residents settled along waterways in well drained areas due to the availability of natural resources and fertile river bottom soil (Krenz 1993). Eventually a shortage of well drained land occurred and attention was directed towards the flat saturated lands within the Red River Valley (Krenz 1993). Agricultural land drainage began as early as the mid 1800s to make more land within the Red River basin available for agricultural production.

Today approximately 84% of the Mustinka River Watershed acreage is used for agricultural purposes. Most of the original wetlands have been lost to agricultural drainage. Primary crops include corn, soybeans, sugar beets, and small grains. The constant wind and large areas of exposed soil lead to problems with soil loss from wind erosion (NRCS 2010). Soil erosion from surface water runoff and agricultural drainage systems is also a problem within the Mustinka River Watershed. Residential development accounts for only 5% of land use (NRCS 2010).Wetlands and open water account for the majority of the remaining land use within the watershed. Almost the entire Mustinka River Watershed (97%) is held under private ownership (NRCS 2010). Besides agricultural production, activities such as big and small game hunting, upland bird hunting, waterfowl hunting, and fishing commonly take place within the watershed.

Cities and towns within the Mustinka River Watershed include: Clinton, Donnelly, Elbow Lake, Graceville, Herman, Morris, Norcross, Wendell, and Wheaton.

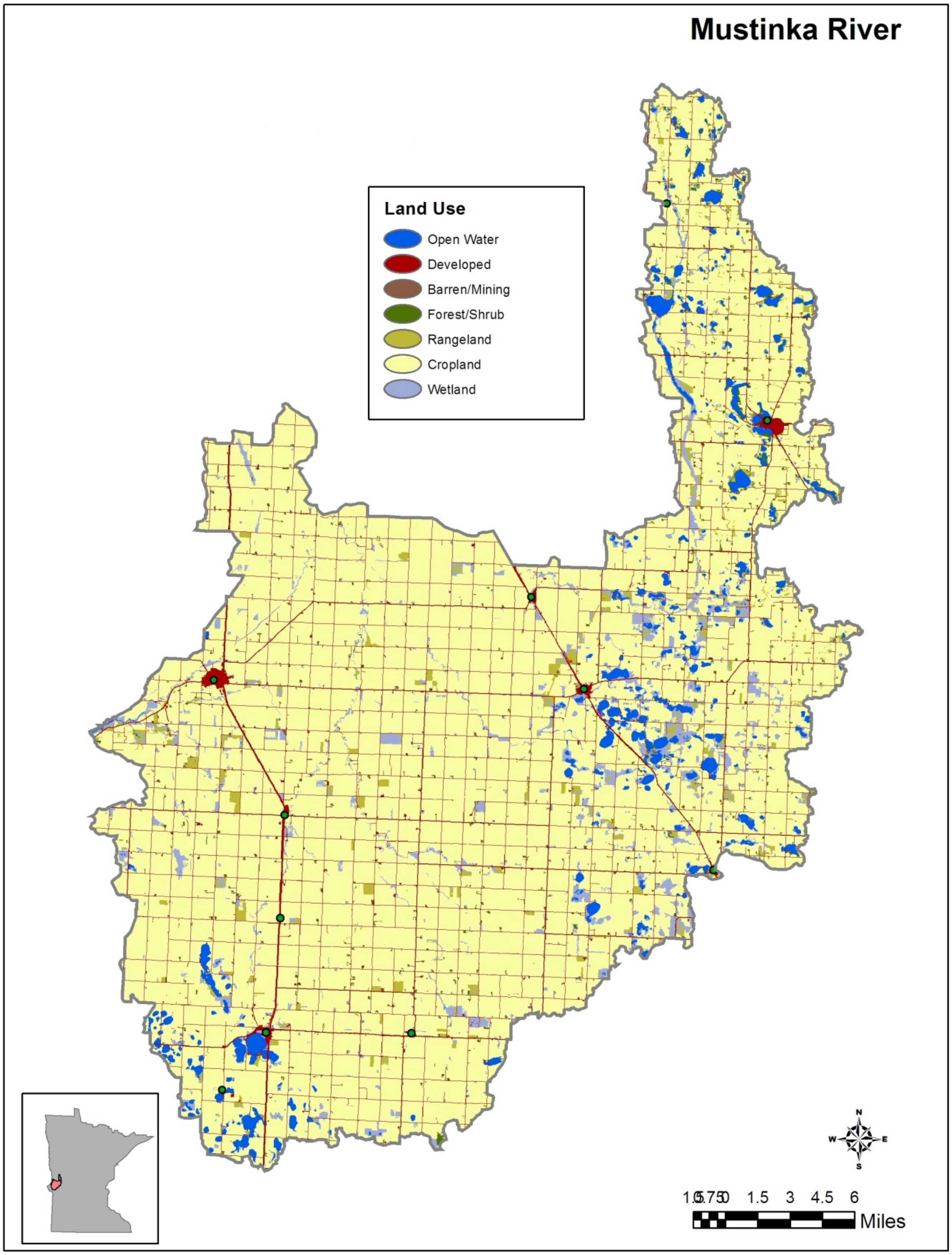

Figure 7. Land use in the Mustinka River Watershed

Surface water hydrology

The Mustinka River originates five miles southwest of Fergus Falls in Ottertail County. The river flows south before entering Stony Brook Lake and Lightning Lake in Grant County. The river continues to flow south approximately 15 miles before turning west in southern Grant County. After passing through the Mustinka River Flowage Dam, the river continues west, passing near the community of Norcross and crossing into Traverse County. Primary tributaries, Five Mile Creek and Twelve Mile Creek, join the Mustinka River in Traverse County. Both tributaries drain the southern region of the Mustinka River Watershed. Just west of the confluence of these tributaries the river turns toward the southwest and flows another 20 miles before emptying into Lake Traverse. Numerous smaller streams and ditches enter the Mustinka River throughout its flow length. Along the way the Mustinka falls 160 feet from its source elevation and averages 2.5 feet per mile of gradient (Waters 1977).

Extensive drainage modifications have occurred within the Mustinka River Watershed and throughout the entire Red River of the North Basin. The flat topography and poor natural drainage within the watershed necessitated the removal of excess water for agricultural production. Drainage activities began to occur within the Mustinka Watershed during the mid to late nineteenth century. Most early drainage activities consisted of digging ditches to move water from one location to another and channelizing streams (Krenz 1993). Today hundreds of miles of drainage ditches exist within the watershed. The Bois de Sioux Watershed District legal ditch system contains four hundred lineal miles of ditch (Bois de Sioux Watershed District 2011). The ditch system area covers both the Bois de Sioux and Mustinka River Watershed. Routine maintenance, such as brush and sediment removal, is performed on most ditches within the watershed (Bois de Sioux Watershed District 2011). Another artificial drainage method increasingly used on agricultural lands within the Mustinka River Watershed is drain tiling. The Bois de Sioux Watershed District, whose area includes the Mustinka River Watershed, has documented the amount of drain tile installed in their district through the use of permitting. "In 1999, the Bois de Sioux Watershed District approved permits for 2.9 miles of subsurface tile, an artificial way to drain water from land. In 2009, it permitted 779.3 miles of drainage tile. Last year, it signed off on 1,558.3 miles. By mid-April, the total was approaching 1,000 miles, on pace to surpass 2011 (Lien and Orrick 2012)." As a result of extensive ditching and tiling, the natural hydrologic functions of the Mustinka Watershed have been radically altered.

Spring and summer flooding is a major concern within the Mustinka River Watershed and the Red River of the North Basin itself. Most flooding occurs due to spring snowmelt but some flooding also occurs as a result of heavy summer rains. Level slopes within the watershed result in prolonged floods due to slow runoff (Krenz 1993). Urban flooding has caused damage to most cities within the watershed, especially the floods of 1993, 1996, 1997, and 2011. Flooding due to spring runoff causes damage to infrastructure throughout the watershed on an annual basis (Red River Basin Commission). Constructing large retention basins, channelizing streams, and building levees are some of the methods utilized to attempt to reduce flooding in the watershed.

Climate and precipitation

Precipitation is the source of almost all water inputs to a watershed. Figure 8 shows two representations of precipitation for water year 2012 (October – September). On the left is total precipitation, which shows that the watershed received between 16 to 24 inches. The display on the right shows the amount that the precipitation levels in water year 2012 departed from normal. Within the Mustinka River Watershed precipitation varied from 4 - 10 inches below normal. Most of Minnesota shows the effect of persistent drought for this period.

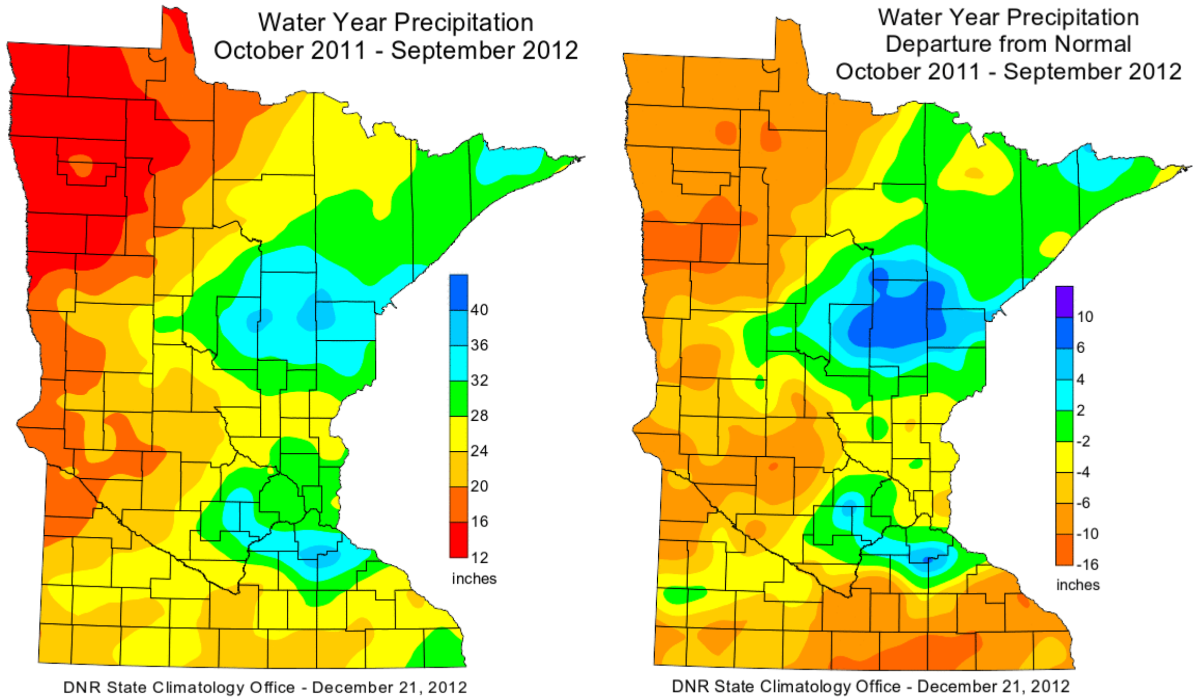

Figure 8. State-wide precipitation levels during the 2012 water year

Figure 9 displays the areal average representation of precipitation in west-central Minnesota. An areal average is a spatial average of all the precipitation data collected within a certain area presented as a single dataset. This data is taken from the Western Regional Climate Center, available as a link on the University of Minnesota Climate website: http://www.wrcc.dri.edu/spi/divplot1map.html.

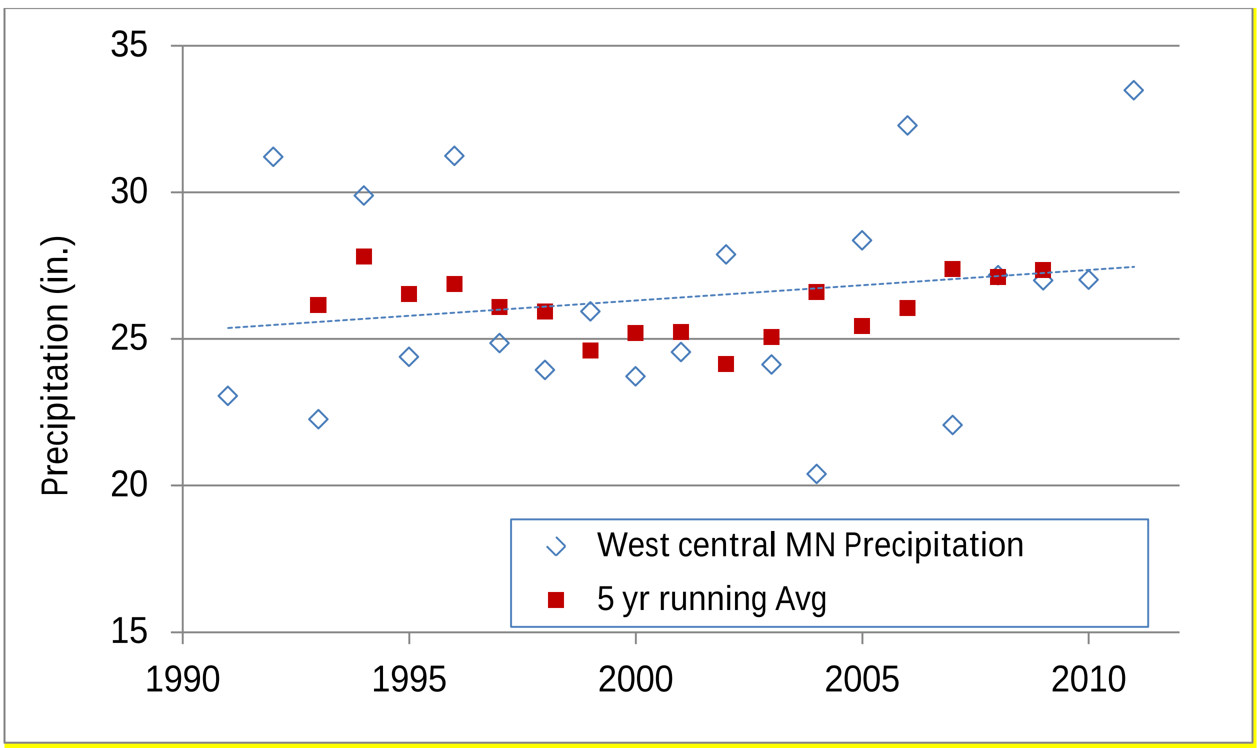

Figure 9. Precipitation trends in west-central Minnesota (1990-2010) with five year running average

Rainfall in the west-central region displays no statistically significant trend over the last 20 years. Though rainfall can vary in intensity and time of year, it would appear that west-central Minnesota precipitation has not changed dramatically over this time period. However, precipitation in west-central Minnesota does exhibit a statistically significant rising trend over the past 100 years, p = 0.001 (Figure 10). This is a strong trend and matches similar trends throughout Minnesota for this time period.

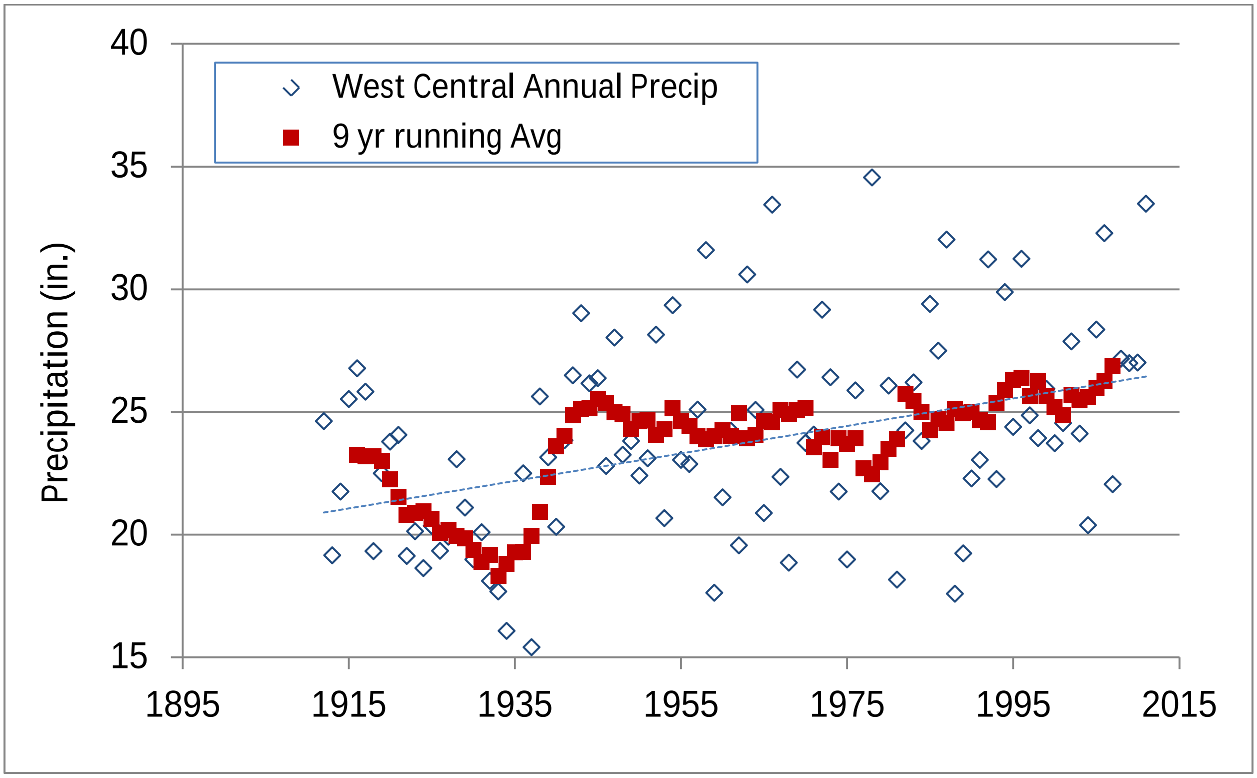

Figure 10. Precipitation trends in western Minnesota (1895-2015) with nine year running average

Hydrogeology and groundwater quality

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

Surface topography

Figure 11 superimposes three different map coverages: the outline of the Mustinka River Watershed, the newly available LiDAR (light detection and ranging) digital elevation display, and surface water features. The LIDAR data reveal previously unavailable detail on the drainage patterns off the highlands to the east. This data is collected using optical remote sensing technology.

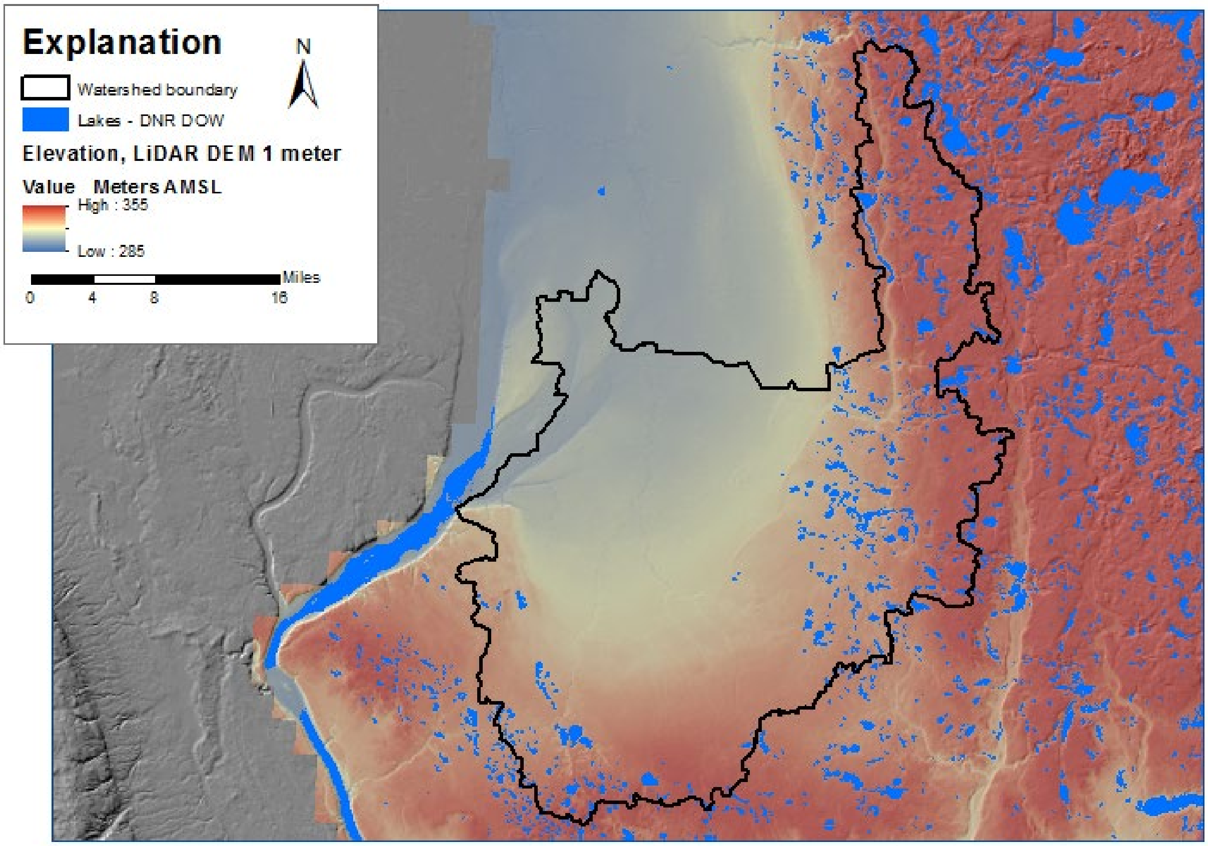

Figure 11. Topography of the Mustinka River Watershed

High capacity water withdrawals

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

Displayed below are the locations of these permitted groundwater and surface water withdrawals in the Mustinka River Watershed, and neighboring area. Blue symbols are groundwater withdrawals and red are surface water, taken from a lake, stream or other surface water feature. The three largest permitted consumers of water in the state (in order) are municipalities, industry, and irrigation. The Mustinka River Watershed high-capacity withdrawals are mostly municipal with a few for agricultural use. The Mustinka River Watershed has relatively little crop irrigation compared to other watersheds in farm country.

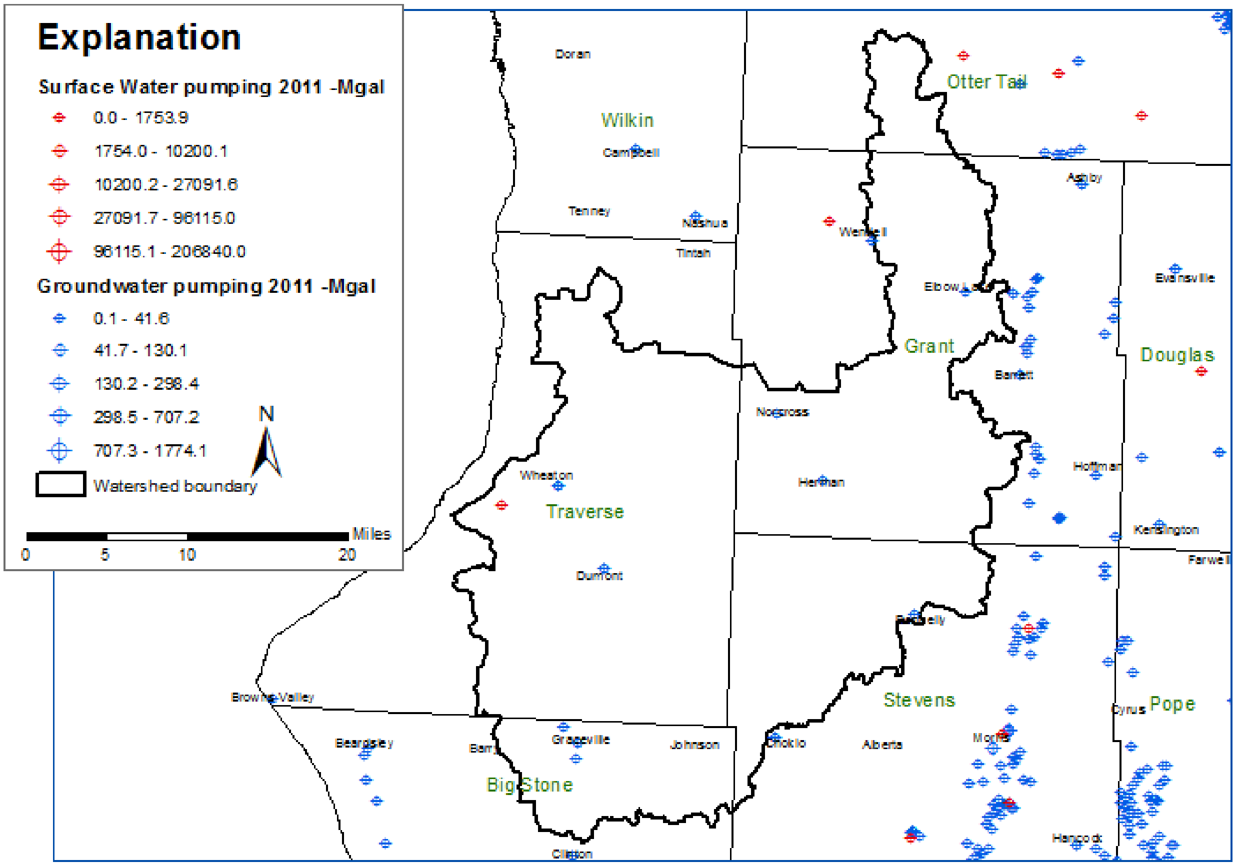

Figure 12. Locations of permitted groundwater withdrawals in the Mustinka River Watershed

Total groundwater withdrawals for the watershed from 1991-2011 are displayed in Figure 13 as blue diamonds, surface water withdrawals as red squares. The data is taken from the MDNR State Water Use Database (SWUD). Groundwater withdrawals have decreased at a statistically significant rate (p=0.001) over that time. Surface water withdrawals are more than an order of magnitude lower in this area.

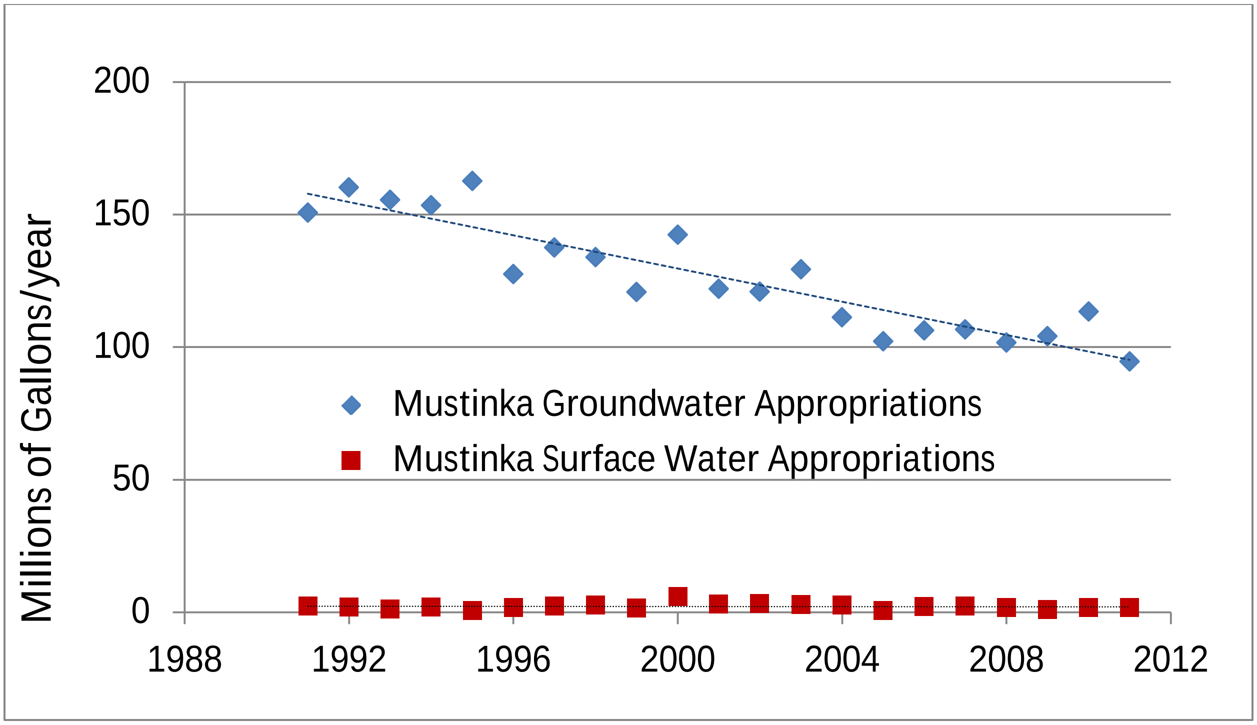

Figure 13. Total groundwater and surface water withdrawals in the Mustinka River Watershed (1991 - 2011)

IV. Watershed-wide data collection methodology

Load monitoring

Water quality samples are collected year-round at all Minnesota Watershed Pollutant Load Monitoring sites. Approximately 30-35 mid-stream grab samples are collected per site each year. Sample collection intensity is greatest during periods of moderate and high flow due to the importance these samples carry in pollutant load calculations. Sampling also occurs during low flow periods but at a lower frequency. Water quality and discharge data are combined in the "Flux32 Pollutant Load Model" to create concentration/flow regression equations. These equations are used to estimate pollutant concentrations and loads on days when samples are not collected. Primary outputs from the Flux32 model include pollutant loads and flow weighted mean concentrations (FWMC). A pollutant load is defined as the amount (mass) of a pollutant passing a stream location over a given period of time. The flow weighted mean concentration is an estimate of the overall water quality and is computed by dividing the pollutant load by the total flow volume. Estimated annual pollutant loads are calculated for total suspended solids (TSS), total phosphorus (TP), dissolved orthophosphate (DOP), total Kjeldahl nitrogen (TKN) and nitrate plus nitrite-nitrogen (NO3_2). The primary Flux32 outputs include pollutant loads and FWMC. When fully implemented, the MWPLM network will monitor and compute pollutant loads at the major watershed outlets across the state.

The continuous monitoring performed by this program is designed to measure and compare regional differences and long-term trends in water quality. Given that 'intensive' watershed monitoring will occur only once every 10 years, comparing these regional differences and long-term trends will be particularly helpful when the IWM data is represented contextually over time. The load monitoring network will also provide critical information for identifying baseline or acceptable loads for maintaining and protecting water resources. In the case of impaired waters, the data collected through these efforts will be used to aid in the development of TMDL studies, implementation of plans, assist watershed modeling efforts, and provide information to watershed research projects. The Mustinka River is monitored at the MDNR gauge site H55060002 near Wheaton, Minnesota which is approximately five miles upstream of the Lake Traverse inlet. Annual FWMCs and pollutant loads for 2010 – 2012 will be calculated when final flows are made available. Finalized flows will not be available until winter of 2013. Two years of water elevation and flow data are required to compute the stage vs. flow relationship which is then applied to the continuously monitored stage data for computing daily discharge.

Stream water sampling

Six water chemistry stations were sampled from May through September in 2010, and again in June through August of 2011, to provide sufficient water chemistry data to assess aquatic life and recreation. Following the IWM design, water chemistry stations were placed at the outlet of each 11 HUC subwatershed that was >40 square miles in area (purple circles and green circles/triangles in (Figure 3). All of these stations were sampled by the MPCA staff. (See Appendix 2 for locations of stream water chemistry monitoring sites. See Appendix 1 for definitions of stream chemistry analytes monitored in this study). Due to the small drainage area (25 mi²) of the C.D #27 watershed (11-HUC) an intensive chemistry collection station and biological station was not placed at the outlet.

Stream biological sampling

The biological monitoring component of the IWM in the Mustinka River Watershed was completed during the summer of 2010. A total of 26 sites were newly established throughout the watershed and sampled. These sites were located near the outlets of most minor HUC-14 watersheds. In addition, 3 existing biological monitoring stations within the watershed were revisited in 2010. These monitoring stations were initially established as part of a random Red River Basin-wide survey in 2005, or as part of a 2007 survey which investigated the quality of channelized streams with intact riparian zones. While data from the preceding 10 years contributed to the watershed assessments, the majority of data utilized for the 2012 assessment was collected in 2010. A total of 19 stream segments (AUIDs) were sampled for biology in the Mustinka River Watershed. Water body assessments to determine aquatic life use support were conducted for 12 stream segments. Water body assessments to determine aquatic life use support were not conducted for 7 stream segments because criteria for assessing channelized reaches had not been developed prior to the assessments. Nonetheless, the biological information that was not used in the assessment process will be crucial to the stressor identification process and will also be used as a basis for long term trend results in subsequent reporting cycles. Qualitative ratings for non-assessed reaches area included in each 11 digit summary where applicable and in Appendix 5.1.

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 Invert IBI. Each IBI class uses a unique suite of metrics, scoring functions, impairment thresholds, and confidence intervals (CIs) (For IBI classes, thresholds and CIs, see Appendix 4.1). IBI scores higher than the impairment threshold and upper CI indicate that the stream reach supports aquatic life. Contrarily, scores below the impairment threshold and lower CI indicate that the stream reach does not support aquatic life. When an IBI score falls within the upper and lower confidence limits additional information may be considered when making the impairment decision such as the consideration of potential local and watershed stressors and additional monitoring information (e.g., water chemistry, physical habitat, observations of local land use activities). For IBI results for each individual biological monitoring station, see Appendix 4 and Appendix 5.

Fish contaminants

Mercury and PCBs were analyzed in fish tissue samples collected from the Mustinka River and three lakes in the watershed. MPCA biomonitoring staff collected the fish from the Mustinka River. The MDNR fisheries staff collected fish from the lakes. 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 MPCA has included waters impaired for contaminants in fish on the 303d Impaired Waters List since 1998. Impairment assessment for PCBs 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 PFCs, the MPCA considers the lake or river impaired. The threshold concentration for impairment (consumption advice of one meal per month) is 0.22 mg/kg for PCBs.

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 are required per species to make this assessment and only the last 10 years of data are used for statistical analysis. MPCA's Impaired Waters Inventory includes waterways that were assessed as impaired prior to 2006 as well as more recent assessments.

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

Lake water sampling

The MPCA sampled Lightning Lake for two years; lakes Lannon and East Toqua were sampled through the Red River Watershed Management Board. There are currently three volunteers enrolled in the MPCA's CLMP and 35 volunteers enrolled in the MPCA's CSMP that are conducting lake and stream monitoring within the watershed. Sampling methods are similar among monitoring groups and are described in the document entitled "*MPCA Standard Operating Procedure for Lake Water Quality*" found at http://www.pca.state.mn.us/publications/wq-s1-16.pdf. The lake water quality assessment standard requires eight observations/samples within a 10 year period for phosphorus, chlorophyll-*a* and Secchi depth.

Groundwater monitoring

Groundwater quantity is monitored by the MDNR through a network of observation wells. Figure 14 shows the locations of wells in the watershed and neighboring counties.

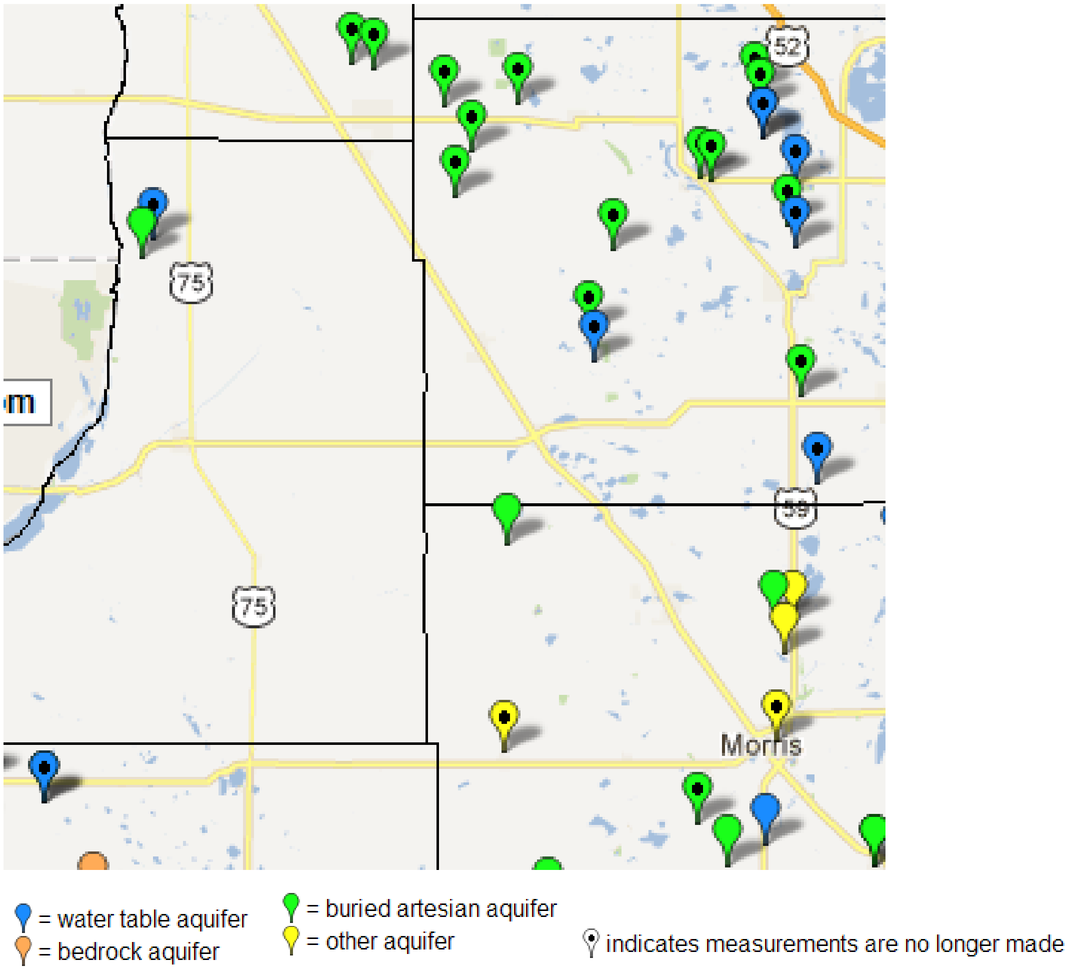

Figure 14. Locations of area MDNR observation wells

Figure 15 is the hydrograph generated by elevation readings from the only active observation well in the watershed. Well 75001 is a water table well in Stevens County. There is no trend to the groundwater levels from this well.

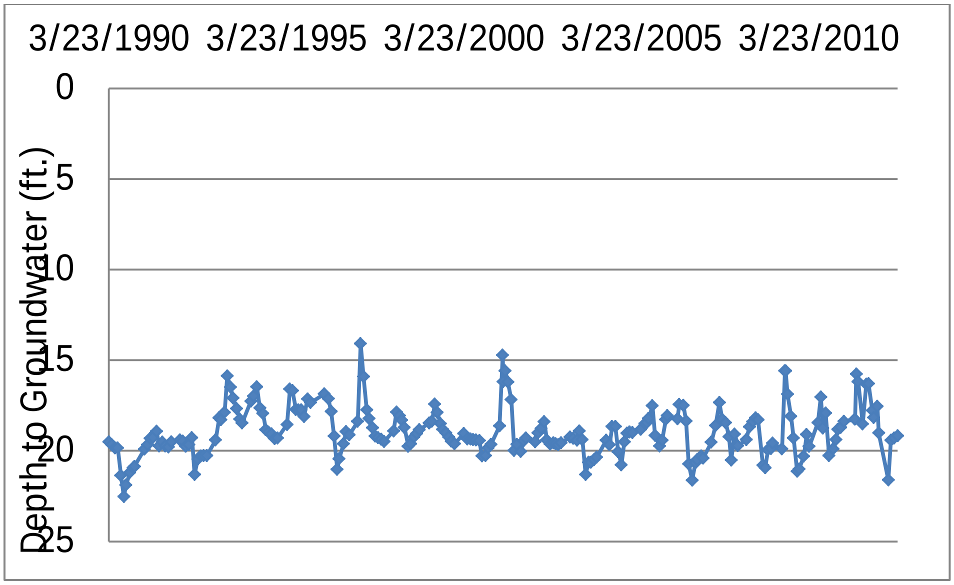

Figure 15. Hydrograph from observation well 75001 in Stevens County

Groundwater quality is monitored by the MPCA through a smaller network of observation wells. Figure 16 shows the locations of the Ambient Groundwater Monitoring Program wells that surround the Mustinka River Watershed. Though there are no Ambient Network wells within the watershed, information from wells in the neighboring watersheds can be used to evaluate groundwater within the Mustinka River Watershed.

The MPCA Ambient Network monitors trends in statewide groundwater quality by sampling for a comprehensive suite of chemicals including nutrients, metals, and volatile organic compounds.

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

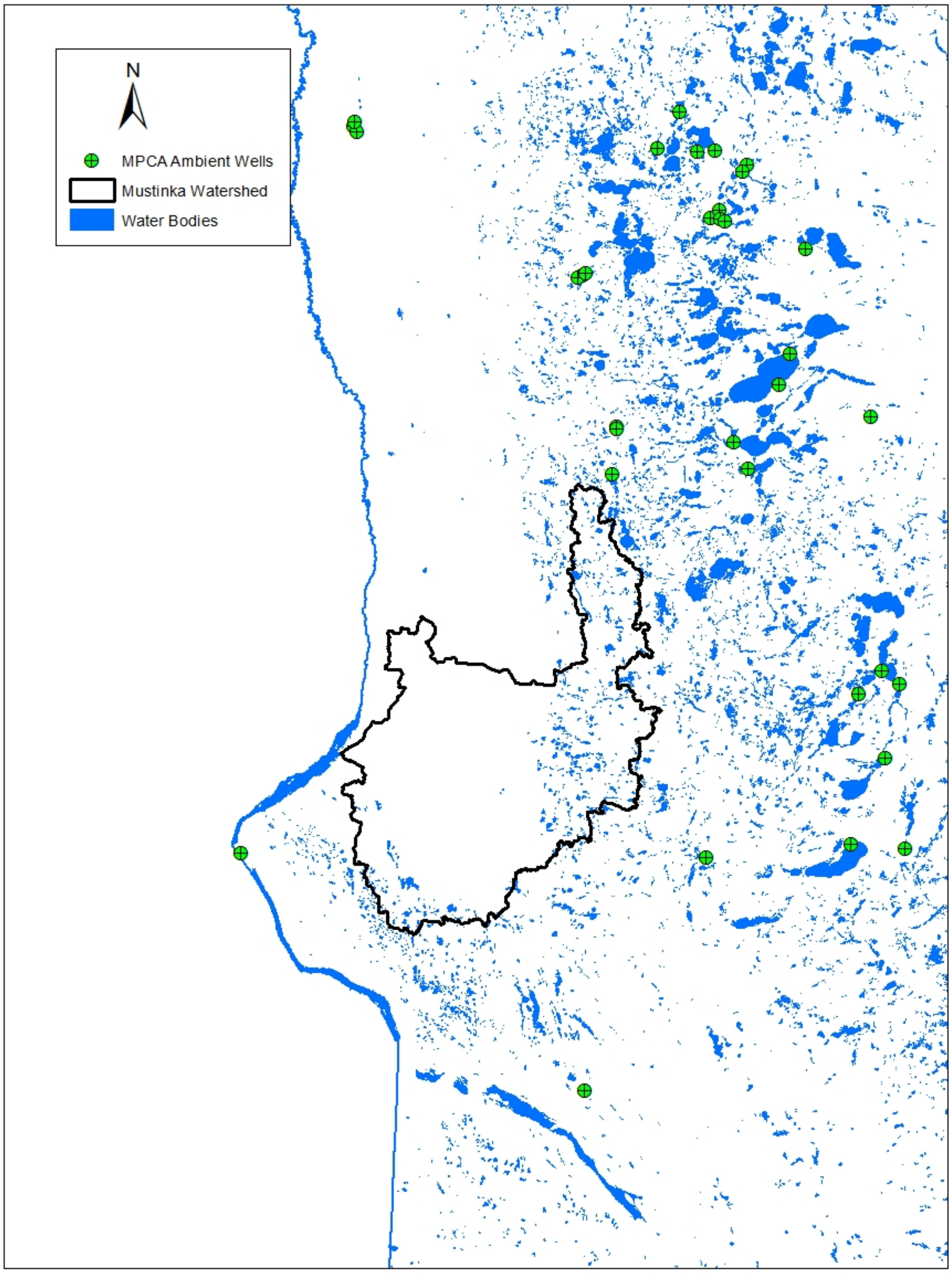

Figure 16. Locations of wells in the MPCA Ambient Groundwater Monitoring Program

Arsenic concentrations in groundwater

Another source of information on groundwater quality comes from the MDNR Traverse-Grant Regional Hydrogeologic Assessment, which investigated the concentration of naturally occurring arsenic in regional aquifers (Figure 17).

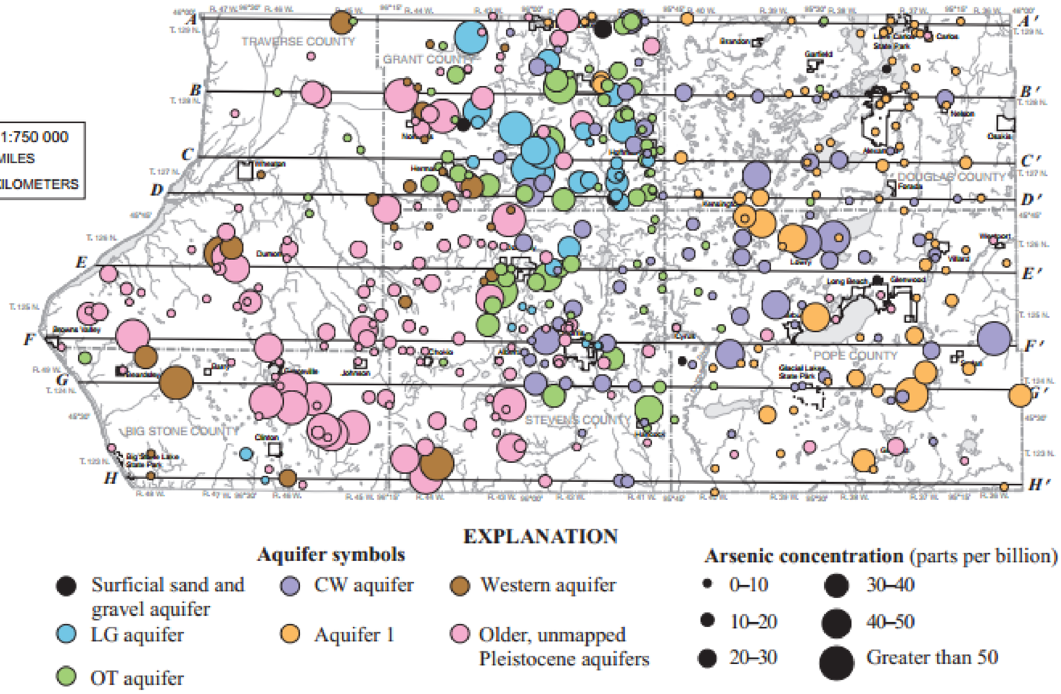

Figure 17. Summary of naturally occurring aresenic values from groundwater samples (Traverse-Grant Regional Hydrogeologic Assessment, MDNR)

Lake levels

Few major lakes are present in the watershed. East Toqua has an active record of elevation readings from 2002 to 2012 (Figure 18).

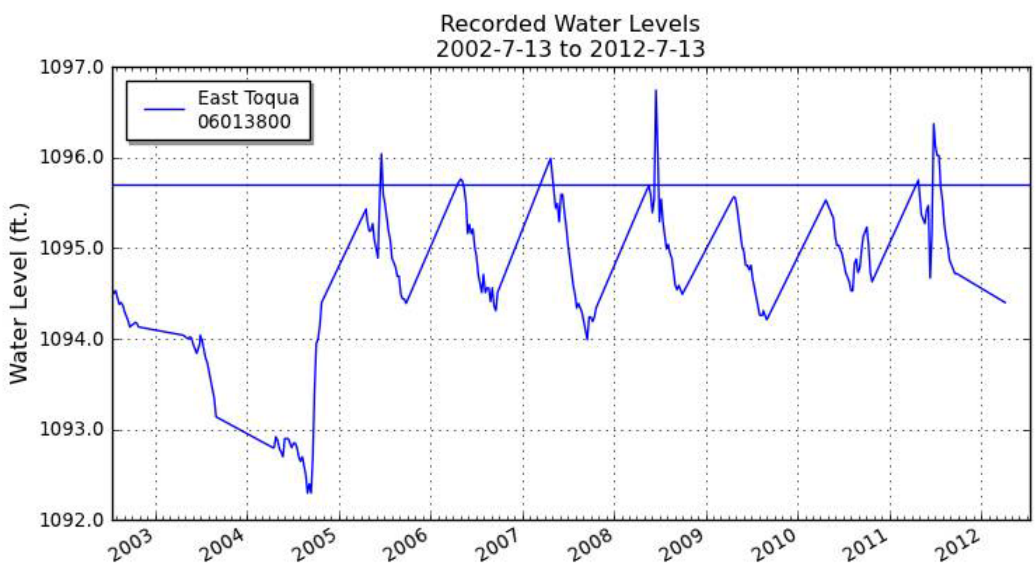

Figure 18. Water evelvation for East Toqua Lake 2003-2012

V. Individual watershed results

HUC-11 watershed units

Assessment results for aquatic life and recreation use are presented for each HUC-11 watershed within the Mustinka River HUC-8 watershed. The primary objective is to portray all the full support and impairment listings 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). 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 2012 Assessment Cycle as well as any impairment listings from previous assessment cycles. Discussion of assessment results focuses primarily on the 2010 IWM effort, but also considers available data from the last 10 years.

The following pages provide an account of each HUC-11 watershed. Each account includes a brief description of the sub-watershed, 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 and pertinent water quality projects completed or planned for the sub-watershed. A brief description of each of the summary tables is provided below.

Stream assessments

A table is provided in each section summarizing aquatic life and aquatic recreation assessments of all assessable stream reaches within the watershed (i.e., where sufficient information was available to make an assessment). Primarily, these tables reflect the results of the 2012 assessment process 2014 EPA reporting cycle; however, impairments from previous assessment cycles are also included and are distinguished from new impairments via cell shading (see footnote section of each table). These tables also denote the results of comparing each individual aquatic life and aquatic recreation indicator to their respective criteria (i.e., standards); determinations 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 invert IBIs), DO, turbidity, chloride, pH and un-ionized ammonia (NH3) data, while the assessment of aquatic recreation in streams is based solely on bacteria (Escherichia coli or fecal coliform) data. Included in each table is the specific aquatic life use classification for each stream reach: cold water community (2A); cool or warm water community (2B); or indigenous aquatic community (2C). Stream reaches that do not have sufficient information for either an aquatic life or aquatic recreation assessment (from current or previous assessment cycles) are not included in these tables, but are included in Appendix 5.2 and Appendix 5.3. Where applicable and sufficient data exists, assessments of other designated uses (e.g., class 7, drinking water, aquatic consumption) are discussed in the summary section of each HUC-11 as well as in the Watershed-Wide Results and Discussion section.

Channelized stream evaluations

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

Stream habitat results

Habitat information documented during each fish sampling visit is provided in each HUC-11 section. These tables convey the results of the Minnesota Stream Habitat Assessment (MSHA) survey, which evaluates the section of stream sampled for biology and can provide an indication of potential stressors (e.g., siltation, eutrophication) impacting fish and macroinvertebrate communities. The MSHA score is comprised of five scoring categories including adjacent land use, riparian zone, substrate, fish cover and channel morphology, which are summed for a total possible score of 100 points. Scores for each category, a summation of the total MSHA score, and a narrative habitat condition rating are provided in the tables for each biological monitoring station. Where multiple visits occur at the same station, the scores from each visit have been averaged. The final row in each table displays average MSHA scores and a rating for the HUC-11 watershed.

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. While not all of the water chemistry parameters of interest have established water quality standards, McCollor and Heiskary (1993) developed ecoregion expectations for a number of parameters that provide a basis for evaluating stream water quality data and estimating attainable conditions for an ecoregion. For comparative purposes, water chemistry results for the Mustinka River Watershed are compared to expectations developed by McCollor and Heiskary (1993) that were based on the 75th percentile of a long-term dataset of least impacted streams within each ecoregion.

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.

Mustinka River Watershed Unit HUC 09020102010

The Mustinka River subwatershed is the largest 11 digit subwatershed in the Mustinka River Watershed, encompassing 262.4 square miles of land within Grant and Traverse Counties. The subwatershed contains the entire flow path of the Mustinka River from its headwaters to Lake Traverse. Major tributaries, Twelve Mile Creek and Five Mile Creek, join the Mustinka River within the subwatershed. Land use is primarily cropland (81.7%). The remaining small percentages of land use are developed (5.2%), rangeland (2.9%), forest (1.4%), wetland (4.6%), and open water (4.1%). The communities of Norcross, Wheaton, and Elbow Lake are within the subwatershed. In 2010, the MPCA monitored 11 stream segments including twelve biological monitoring stations.

Table 1. Aquatic life and recreation assessments on stream reaches: Mustinka River subwatershed. Reaches are organized upstream to downstream in the table.

AUID *Reach Name,* Reach Description	Reach Length (miles)	Use Class	Biological Station ID	Location of Biological Station	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	Aquatic Life	Aquatic Rec.
09020102-506 Mustinka River Headwaters to Lightning Lk	9.32	2B, 3C	10RD044	Upstream of 140th St, 2 mi. N of Squier	NA	NA	EXS	MTS	MTS	MTS	MTS		EX	NS	NS
09020102-538 Unnamed Creek Unnamed cr to Mustinka R	1.96	2B, 3C	10RD042	Upstream of CR 15, 2 mi. S of Aastad	EXS	EXS	--	MTS	--	--	--	--	--	NS	NA
09020102-580 Mustinka River Lightning Lk to Mustinka River Flowage	20.64	2B, 3C	10RD037	Upstream of CR 13, 7 mi. E of Norcross	EXS	MTS	EXS	EXP	MTS	MTS	MTS	--	EX	NS	NS
09020102-582 Mustinka River Mustinka River Flowage to Grant/Traverse County Line	12.29	2B, 3C	10RD034 10RD036	Upstream of CR 9, 1.5 mi. NW of Norcross Upstream of CR 11, 3.5 mi. E of Norcross	MTS	MTS	IF	EXS	--	MTS	MTS	--	IF	NS	IF
09020102-553 Mustinka River Ditch Twelvemile Cr to Mustinka R	2.53	2C	--	--	--	--	--	EXS	--	--	--	--	--	IF*	NA
09020102-502 Mustinka River Fivemile Cr to Unnamed cr	12.84	2C	10RD032	Upstream of Hwy 75, 1 mi. N of Wheaton	--	--	MTS	EXS	MTS	MTS	MTS	--	MTS	NS	FS
09020102-503 Mustinka River Unnamed cr to Lk Traverse	8.45	2C	05RD125	Just W of Wheaton	--	--	IF	EXS	MTS	MTS	MTS	--	--	NS	IF

Abbreviations for Indicator Evaluations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **MTS** = Meets criteria; **EXP** = Exceeds criteria, potential impairment;
EXS = Exceeds criteria, potential severe impairment; **EX** = Exceeds criteria (Bacteria).
Abbreviations for Use Support Determinations: **NA** = Not Assessed, **IF** = Insufficient Information, **NS** = Non-Support, **FS** = Full Support
Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use.
*Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

Table 2. Non-assessed biological stations on channelized AUIDs: Mustinka River 11-HUC.

AUID ***Reach Name***, *Reach Description*	**Reach length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Fish IBI**	**Invert IBI**
09020101-506 Mustinka River Headwaters to Lightning Lk	9.32	2B, 3C	10RD044	Upstream of 140th St, 2 mi. N of Squier	Poor	Poor
09020102-559 Unnamed Creek Unnamed cr to Unnamed cr	1.94	2B, 3C	10RD041	Upstream of CR 15, 2 mi. E of Wendell	Poor	Poor
09020102-561 Trib. to Mustinka River Unnamed cr to Mustinka R	1.77	2B, 3C	10RD038	Upstream of 230th Ave., 8 mi. SW of Elbow Lake	Fair	Poor
09020102-562 Unnamed Creek Unnamed cr to Unnamed cr	3.17	2B, 3C	10EM170	Downstream of CR 34, 6 mi. SW of Barrett	Poor	Poor
09020102-582 Mustinka River Mustinka River Flowage to Grant/Traverse County Line	12.29	2B, 3C	10RD034	Upstream of CR 9, 1.5 mi. NW of Norcross	Fair	Good
09020102-518 Mustinka River Grant/Traverse County Line to Fivemile Cr	4.76	2C	10RD033	Upstream of CR 13, 7.5 mi. NW of Norcross	Fair	Fair
09020102-503 Mustinka River Unnamed cr to Lk Traverse	8.45	2C	10RD030	Upstream of Unnamed Rd, 3.5 mi. SW of Wheaton	Good	Fair
09020102-502 Mustinka River Fivemile Cr to Unnamed cr	12.84	2C	10RD032	Upstream of Hwy 75, 1 mi. N of Wheaton	Good	Poor

See Appendix 5.1 for clarification on the good/fair/poor thresholds and Appendix 5.2 and Appendix 5.3 for IBI results.

Table 3. Minnesota Stream Habitat Assessment (MSHA): Mustinka River 11-HUC.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	05RD125	Mustinka River	0	7	12.8	12	9	40.8	Poor
1	10RD030	Mustinka River	0	9	10	15	15	49	Fair
1	10RD032	Mustinka River	0	8.5	18	7	7	40.5	Poor
1	10RD033	Mustinka River	0	5	20.25	7	20	52.25	Fair
2	10RD034	Mustinka River	0	3.5	17.3	7	23.5	51.34	Fair
1	10RD036	Mustinka River	0	6.5	18.8	7	13	45.3	Fair
1	10RD037	Mustinka River	1.5	5.5	7.2	12	15	41.2	Poor
1	10RD038	Trib. to Mustinka River	0	10	12.75	14	15.5	63.9	Fair
1	10RD041	Trib. to Mustinka River	0	9	4	5	7	25	Poor
1	10RD042	Unnamed Creek	0	13.5	12.3	13	32	70.8	Good
1	10RD044	Mustinka River	0	7	3	11	7	28	Poor
1	10EM170	Unnamed Creek	2.5	13	13.8	16	29	74.3	Good
		Average Habitat Results: *Mustinka River 11 HUC*	**0.4**	**8.1**	**12.5**	**10.5**	**16.1**	**48.5**	**Fair**

Qualitative habitat ratings

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

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

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

Table 4. Outlet water chemistry results: Mustinka River 11-HUC.

Station location:	Mustinka River, at US 75, 1mi. N of Wheaton							
STORET/EQuIS ID:	S000-062							
Station #:	09020102010							
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**Median**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	4	0.04	0.07	0.06	0.06		
Chloride	mg/L						> 230	
Chlorophyll-a, Corrected	ug/L	7	10	29	20.86	22		
Dissolved Oxygen (DO)	mg/L	17	3.75	9.8	6.66	6.6	5	1
Escherichia coli	MPN/100ml	14	25	920.8	254.59	157.65		
Inorganic nitrogen (nitrate and nitrite)	mg/L	6	0.09	1.67	0.51	0.28		
Kjeldahl nitrogen	mg/L	9	1.19	1.68	1.48	1.46		
Orthophosphate	ug/L							
pH		17	7.63	8.8	8.09	8.08	6.5 – 9	0
Pheophytin-a	ug/L	2	6	8	7	7		
Phosphorus	ug/L	9	0.21	0.51	0.37	0.37		
Specific Conductance	uS/cm	17	155	1575	1116.47	1268		
Temperature, water	deg °C	17	8	27.28	21.67	22.4		
Total suspended solids	mg/L	9	25	78	46.67	48		
Total volatile solids	mg/L	9	6	13	8.22	7		
Transparency tube	100 cm	17	8	36	17.62	16	< 20	13
Transparency tube	60 cm						>20	
Turbidity	FNU	2	36.7	69.7	53.2	53.2	25 NTU	2
Sulfate	mg/L							
Hardness	mg/L							

Geometric mean of all samples is provided

2 Thresholds are surrogates for the 25 NTU turbidity standard

3 Represents exceedances of individual maximum standard for E. coli (1260/100ml) or fecal coliform

Table 5. Outlet water chemistry results: Mustinka River 11-HUC.

Station location:	Mustinka River, at CR 13, 7.5 mi. NW of Norcross							
STORET/EQuIS ID:	S004-107							
Station #:	09020102010							
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**Median**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	5	0.05	0.09	0.07	0.07		
Chloride	mg/L						> 230	
Chlorophyll-a, Corrected	ug/L							
Dissolved Oxygen (DO)	mg/L	18	4.88	12.9	7.82	7.55	5	1
Escherichia coli	MPN/100ml	14	15	866.4	189.71	109.3		
Inorganic nitrogen (nitrate and nitrite)	mg/L	7	0.17	2.03	0.62	0.39		
Kjeldahl nitrogen	mg/L	10	1.31	1.82	1.60	1.60		
Orthophosphate	ug/L							
pH		18	7.5	9.14	8.16	8.21	6.5 – 9	1
Pheophytin-a	ug/L							
Phosphorus	ug/L	10	0.17	0.39	0.29	0.29		
Specific Conductance	uS/cm	18	147	1620	946.83	1058		
Temperature, water	deg °C	18	8.3	27.9	21.58	22.75		
Total suspended solids	mg/L	10	18	148	70.1	73.5		
Total volatile solids	mg/L	10	6	24	12.3	12.5		
Transparency tube	100 cm	18	9	48	18.61	15	< 20	10
Transparency tube	60 cm						>20	
Turbidity	FNU	2	28.3	103	65.65	65.65	25 NTU	2
Sulfate	mg/L							
Hardness	mg/L							

Geometric mean of all samples is provided

2 Thresholds are surrogates for the 25 NTU turbidity standard

3 Represents exceedances of individual maximum standard for E. coli (1260/100ml) or fecal coliform

Summary

Seven stream segments (AUIDs) within the Mustinka River subwatershed were assessed for aquatic life use support. Every stream segment on the Mustinka River main stem and its tributaries is impaired for at least one aquatic life indicator. Twelve biological monitoring stations were sampled; eight stations were on the main stem of the Mustinka River and four stations were on direct tributaries. Nine of the twelve biological monitoring stations were on a channelized stream segment; therefore, biological data collected at these sites will not be assessed until tiered aquatic life standards are implemented.

Stations located on the main stem of the Mustinka River below the Mustinka River Flowage Dam had higher Fish IBI scores than stations located above the dam. The fish communities at stations below the flowage generally contained fewer tolerant species, more sensitive species, and the presence of simple lithophilic spawners. Stations located below the flowage also featured coarse substrate such as gravel which is necessary to support lithophilic spawners. The Mustinka River Flowage Dam prevents the upstream migration of large river migratory species such as freshwater drum, white bass, and walleye. Some of these larger river species, like the golden redhorse, are also lithophilic spawners. Large river migratory species were absent from samples collected above the dam. Stations above the flowage were located on a section of the Mustinka River that has a DO impairment; this segment is wetland dominated, but samples were collected during “moderate” to “good” flow conditions. Coarse substrate was lacking or severely embedded at these sites. The fish communities at stations above the flowage contained high numbers of tolerant species and few sensitive species. Other stations located on tributaries within the headwaters region generally scored poorly. Tolerant species also dominated the fish community samples at these stations. Biological stations 10RD034 and 10RD037 on the Mustinka River were the only stations to have a good macroinvertebrate IBI score. Unlike most other stations in this watershed, these stations featured coarse substrate and multiple macroinvertebrate habitats.

Water quality data were available on ten of the twenty-one stream reaches that are in the Mustinka River subwatershed. Eight would otherwise be considered impaired, but the Mustinka River ditch is currently being deferred for assessment as it is 100% channelized. Aquatic recreation use impairments, based on excess bacteria, were found on several reaches of the Mustinka River. Low DO levels and/or high turbidity were identified as impairing aquatic life use throughout the subwatershed as well.

Five lakes out of the seventy-three lakes greater than four hectares (10 acres) that are in the Mustinka River subwatershed were reviewed for assessment. Only Lightning Lake had sufficient data to assess for aquatic recreation and was determined to not support aquatic recreation due to elevated phosphorus and chlorophyll-a concentrations.

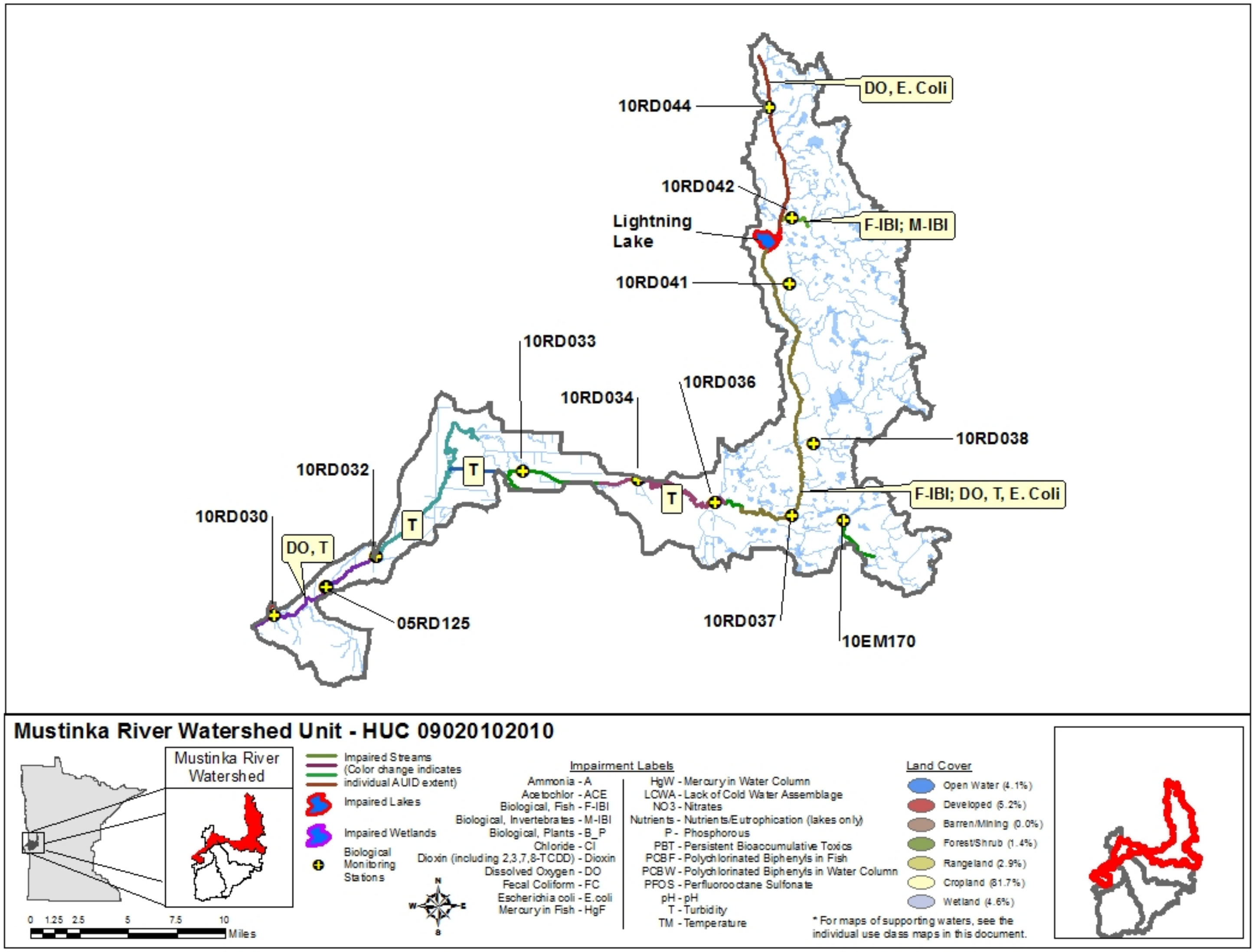

Figure 19. Currently listed impaired waters by parameter and land use characteristics in the Mustinka River Subwatershed

Five Mile Creek Watershed Unit HUC 09020102020

The Five Mile Creek subwatershed drains 128 square miles of land distributed across Grant, Stevens, and Traverse County. The headwaters of Five Mile Creek begin a few miles southwest of Herman. The creek flows southwest briefly before turning and flowing toward the northwest along the western border of the watershed. Five Mile Creek continues flowing northwest until it reaches the Mustinka River ditch. Numerous small ditches and streams flow into Five Mile Creek along its course. Land use is primarily cropland (79.4 %). The remaining small percentages of land use include rangeland (2.2%), wetland (7.8%), forest (0.6%), developed (4.8%), and open water (5.2%). In 2010, the MPCA monitored four stream segments within this subwatershed. Two biological monitoring stations are also within the watershed unit.

Table 6. Aquatic life and recreation assessments on stream reaches: Five Mile Creek Watershed unit. Reaches are organized upstream to downstream in the table.

AUID *Reach Name*, Reach Description	Reach Length (miles)	Use Class	Biological Station ID	Location of Biological Station	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	Aquatic Life	Aquatic Rec.
09020102-578 Unnamed Creek Unnamed cr to Unnamed cr	3.09	2B, 3C	--	--	EXS	--	--	--	--	--	--	--	--	NS	NA
09020102-510 Fivemile Creek T127 R45W S24, East Line to Mustinka River Ditch	11.41	2C	10RD054	Upstream of 120th St, 6.5 mi. SE of Herman	--	--	IF	MTS	MTS	MTS	MTS	--	EX	IF	NS
09020102-525 Unnamed Ditch Unnamed ditch to Fivemile Cr	2.14	2B, 3C	--	--	--	--	IF	MTS	--	MTS	--	--	--	NA*	NA

Abbreviations for Indicator Evaluations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **MTS** = Meets criteria; **EXP** = Exceeds criteria, potential impairment;
EXS = Exceeds criteria, potential severe impairment; **EX** = Exceeds criteria (Bacteria).
Abbreviations for Use Support Determinations: **NA** = Not Assessed, **IF** = Insufficient Information, **NS** = Non-Support, **FS** = Full Support
Key for Cell Shading: ☐ = existing impairment, listed prior to 2012 reporting cycle; ☐ = new impairment; ☐ = full support of designated use.
Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

Table 7. Non-assessed biological stations on channelized AUIDs: Five Mile Creek 11-HUC.

AUID ***Reach Name*****,** *Reach Description*	**Reach length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Fish IBI**	**Invert IBI**
09020102-564 Unnamed Ditch Unnamed Cr to Unnamed ditch	1.78	2B, 3C	10RD050	Upstream of 320th Ave, 3.5 mi W of Herman	Fair	Poor

See Appendix 5.1 for clarification on the good/fair/poor thresholds and Appendix 5.2 and Appendix 5.3 for IBI results.

Table 8. Minnesota Stream Habitat Assessment (MSHA): Five Mile Creek 11-HUC.

# Visits	**Biological Station ID**	**Reach Name**	**Land Use (0-5)**	**Riparian (0-15)**	**Substrate (0-27)**	**Fish Cover (0-17)**	**Channel Morph. (0-36)**	**MSHA Score (0-100)**	**MSHA Rating**
1	10RD050	Trib. to Five Mile Creek	0	7.5	13.9	15	31	67.4	Good
1	10RD054	Five Mile Creek	0	3.5	13.1	13	12	41.6	Poor
Average Habitat Results: *Five Mile Creek 11 HUC*			**0**	**5.5**	**13.5**	**14**	**21.5**	**54.5**	**Fair**

Qualitative habitat ratings

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

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

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

Summary

Two biological stations, 10RD050 and 10RD054, were located in the Five Mile Creek subwatershed. Biological data from both stations was not assessed due to channelization at 10RD050 and insufficient data at 10RD054. Station 10RD054 was located on a natural section of a tributary to Five Mile Creek. The fish community was comprised of two very tolerant species, fathead minnows and brook stickleback, and therefore received a poor Fish IBI score. Invertebrates were not sampled at 10RD054. Several small, possibly eutrophic lakes are located immediately downstream of 10RD054 and may interfere with the upstream migration of other stream species. Station 10RD050 was located on a channelized tributary to Five Mile Creek. The fish community contained simple lithophilic spawners and sensitive species in addition to some tolerant taxa. The fish community received a fair Fish IBI rating. The macroinvertebrate community sample was poor at 10RD050. Almost the entire sample was comprised of tolerant taxa. The macroinvertebrate habitat was limited to overhanging vegetation along the bank, and may have been a factor in the poor macroinvertebrate community results.

Water quality data were available on two of the stream reaches out of the eighteen that are in the Five Mile Creek Watershed. Five Mile Creek extends into the Mustinka River subwatershed (see previous subwatershed report section) approximately 1.6 miles; the data collected and results carry over for the entire length of the stream in both subwatersheds. The majority of the stream (11.4 miles) is in the Five Mile Creek subwatershed. Five Mile Creek does not support aquatic recreation and there is not enough data on the remaining reaches in the watershed to determine aquatic life use support.

There was limited data on 14 shallow lakes greater than four hectares (ten acres). None of these lakes had sufficient data for assessment.

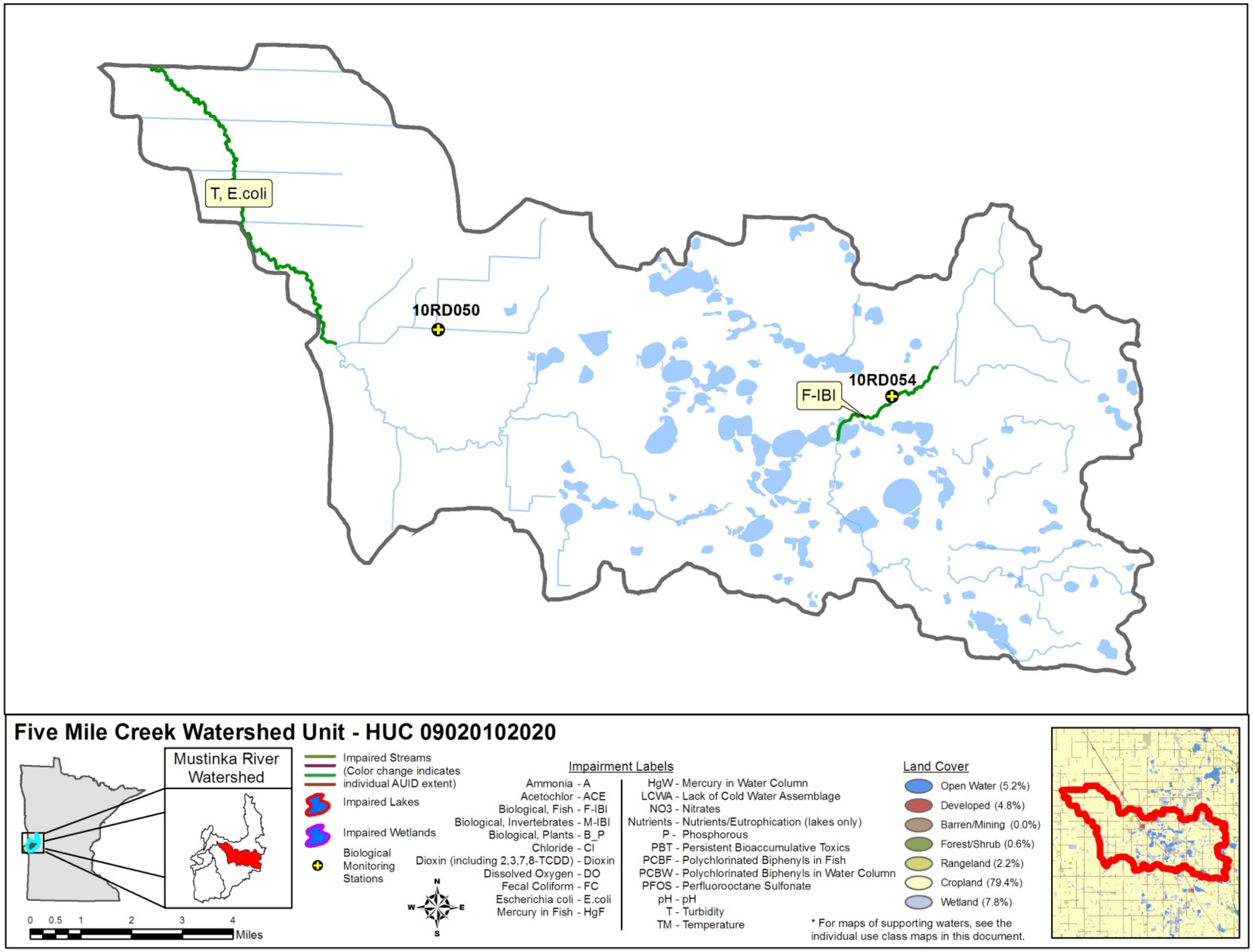

Figure 20. Currently listed impaired waters by parameter and land use characteristics in the Five Mile Creek subwatershed

West Branch Mustinka River Watershed Unit — HUC 09020102030

The west branch Mustinka River subwatershed drains 200 square miles of Big Stone and Traverse County. The largest stream in the subwatershed, west branch of Twelve Mile Creek, originates west of Graceville and flows north through the central portion of the watershed. Numerous small ditches and streams flow into the west branch of Twelve Mile Creek throughout its course. Land use is primarily cropland (85%) with remaining small percentages of developed land (5.2%), open water (5%), forest (0.4%), rangeland (1.5%), and wetland (2.9%). The communities of Johnson, Graceville, and Dumont are within the subwatershed. In 2010, the MPCA monitored five stream segments within this subwatershed including three biological monitoring stations.

Table 9. Aquatic life and recreation assessments on stream reaches: West Branch Mustinka River subwatershed. Reaches are organized upstream to downstream in the table.

AUID *Reach Name*, Reach Description	Reach Length (miles)	Use Class	Biological Station ID	Location of Biological Station	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	Aquatic Life	Aquatic Rec.
09020102-511 Twelvemile Creek, West Branch T125 R46W S33, south line to Twelvemile Cr	21.4	2C	--	--	--	--	EXS	MTS	--	MTS	MTS	--	EX	NS	NS
09020102-524 Unnamed Creek CD 33 to W Br Twelvemile Cr	4.98	2B, 3C	--	--	--	--	EXS	MTS	--	MTS	--	--	--	IF	NA

Abbreviations for Indicator Evaluations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **MTS** = Meets criteria; **EXP** = Exceeds criteria, potential impairment;
EXS = Exceeds criteria, potential severe impairment; **EX** = Exceeds criteria (Bacteria).
Abbreviations for Use Support Determinations: **NA** = Not Assessed, **IF** = Insufficient Information, **NS** = Non-Support, **FS** = Full Support
Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use.
Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.

Table 10. Non-assessed biological stations on channelized AUIDs: West Branch Mustinka River 11-HUC.

AUID ***Reach Name,*** *Reach Description*	Reach length (miles)	Use Class	Biological Station ID	Location of Biological Station	Fish IBI	Invert IBI
09020102-512 Judicial Ditch 4 Headwaters to Twelvemile Cr	7.48	2B, 3C	10RD078	Upstream of 750th Ave, 2 mi. W of Graceville	Poor	Poor
09020102-527 County Ditch 8 Headwaters to Lannon Lk	6.91	2B, 3C	10RD076	Upstream of 720th Ave, 2 mi. SE of Graceville	Poor	Not Sampled
09020102-532 Unnamed Creek Unnamed cr to Unnamed cr	0.87	2B, 3C	10RD077	Downstream of Hwy 28, 1 mi. W of Graceville	Poor	Not Sampled

See Appendix 5.1 for clarification on the good/fair/poor thresholds and Appendix 5.2 and Appendix 5.3 for IBI results.

Table 11. Minnesota Stream Habitat Assessment (MSHA): west branch Mustinka River 11-HUC.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	10RD076	County Ditch 8	0	11	16.4	14	12	53.4	Fair
1	10RD077	Unnamed Creek	0	7	7	13	7	34	Poor
1	10RD078	Judicial Ditch 4	0	8	8	13	4	37	Poor
Average Habitat Results: *West Branch Mustinka River 11 HUC*			**0**	**8.7**	**10.5**	**13.3**	**7.7**	**41.5**	**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 12. Outlet water chemistry results: west branch Mustinka River 11-HUC.

Station location:	**Twelve Mile Creek, West Branch, at CR 71, 4 mi. NE of Dumont**							
STORET/EQuIS ID:	**S006-151**							
Station #:	**09020102030**							
	.							
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**Median**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	4	0.04	0.05	0.04	0.04		
Chloride	mg/L						> 230	
Chlorophyll-a, Corrected	ug/L							
Dissolved Oxygen (DO)	mg/L	18	2.4	10.9	6.65	6.42	5	2
Escherichia coli	MPN/100ml	14	53.7	1553.1	279.39	130		
Inorganic nitrogen (nitrate and nitrite)	mg/L	4	0.07	0.27	0.15	0.14		
Kjeldahl nitrogen	mg/L	10	1.13	2.06	1.42	1.38		
Orthophosphate	ug/L							
pH		18	7.2	8.3	7.82	7.9	6.5 – 9	0
Pheophytin-a	ug/L							
Phosphorus	ug/L	10	0.32	1.62	0.87	0.88		
Specific Conductance	uS/cm	18	163	1497	1141.11	1253		
Temperature, water	deg °C	18	8.2	28.23	20.86	21.71		
Total suspended solids	mg/L	10	4	17	6.3	5		
Total volatile solids	mg/L	10	2	5	2.4	2		
Transparency tube	100 cm	18	21	100	80.56	100	< 20	0
Transparency tube	60 cm						>20	
Turbidity	FNU	2	9.4	18.7	14.05	14.05	25 NTU	0
Sulfate	mg/L							
Hardness	mg/L							

Geometric mean of all samples is provided
2 Thresholds are surrogates for the 25 NTU turbidity standard
3 Represents exceedances of individual maximum standard for E. coli (1260/100ml) or fecal coliform

Summary

Three non-assessed biological monitoring stations were located in the west branch Mustinka River subwatershed. All stations were located within close proximity to one another in the headwaters region of the west branch of Twelve Mile Creek. Every station featured poor Fish IBI scores, and almost all fish species sampled were tolerant. High amounts of phosphorus were present in water samples collected at all three stations. Stations 10RD076 and 10RD078 both featured coarse substrate; however, the substrate was severely embedded at 10RD078. Station 10RD077 lacked hard substrate and is directly influenced by Lake Toqua, which is impaired due to high levels of nutrients. Only two species were sampled at 10RD077, and both are tolerant. Invertebrates were sampled only at 10RD078. The majority of the sample contained tolerant taxa and habitat was limited to overhanging vegetation. The station received a poor macroinvertebrate IBI rating.

Water quality data were available on five of the fourteen streams in the west branch Mustinka River subwatershed with assessments made on the west branch Twelve Mile Creek. The creek was previously listed as not supporting aquatic life use due to low DO levels. The bacteria values also exceed the standard and do not support aquatic recreation.

Two of the 54 lakes greater than four hectares (10 acres) that are in the west branch Twelve Mile Creek subwatershed were assessed. Both East Toqua and Lannon do not support aquatic recreation. These lakes are shallow and have high total phosphorus concentrations and consistently low transparencies. Internal loading of phosphorus will need to be addressed, in addition to watershed contributions, to improve the water quality of these basins.

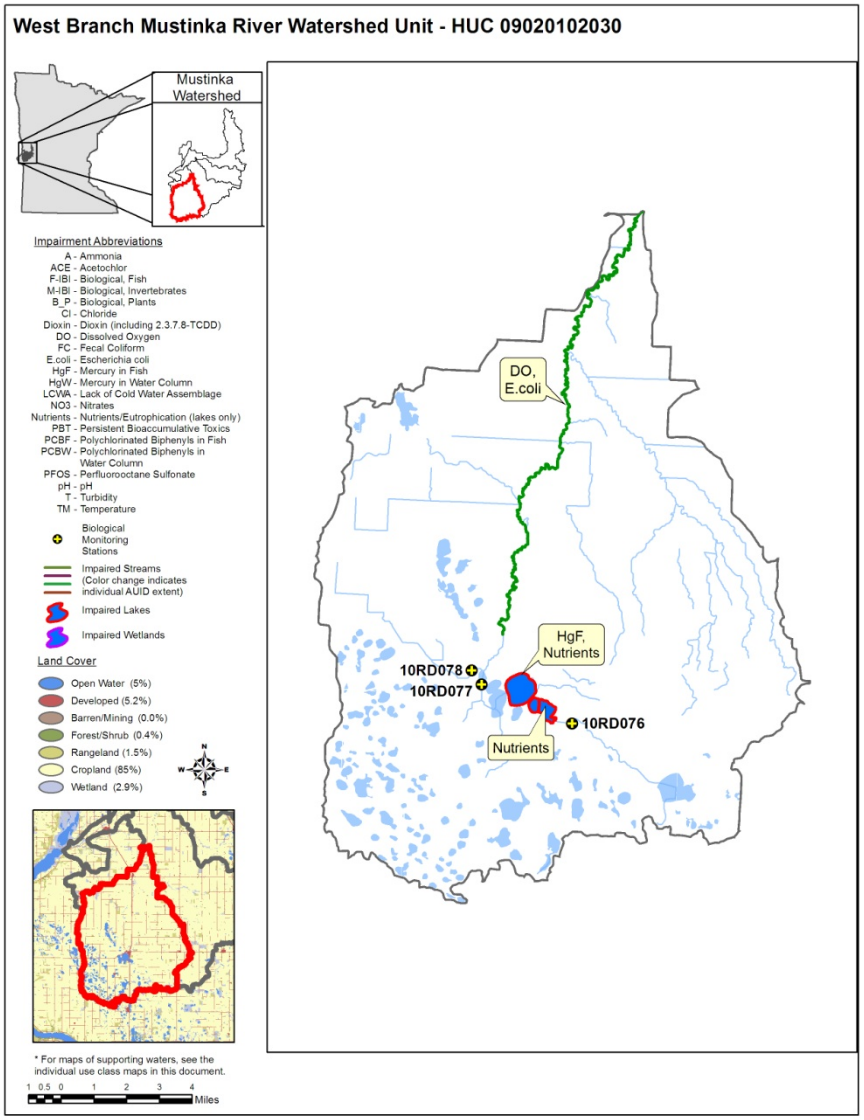

Figure 21. Currently listed impaired waters by parameter and land use characteristics in the west branch Mustinka River subwatershed

Twelve Mile Creek Watershed Unit HUC 09020102040

The Twelve Mile Creek subwatershed drains 214 square miles of land and lies within Stevens, Traverse, and Big Stone Counties. Twelve Mile Creek originates in the far eastern portion of the subwatershed near Donnelly and flows westward across the subwatershed before joining with the west fork of Twelve Mile Creek. The west fork of Twelve Mile Creek drains the southwest portion of the watershed unit. Twelve Mile Creek turns and flows north approximately six miles before its confluence with the west branch of Twelve Mile Creek. The west branch of Twelve Mile Creek drains the west branch Mustinka River subwatershed. Twelve Mile Creek continues flowing north to the Mustinka River Ditch. Numerous ditches join Twelve Mile Creek within the north-central portion of the watershed. Land use within the subwatershed is primarily cropland (87.9%). The remaining small percentages of land use are developed (4.8%), wetland (4.2%), rangeland (1.4%), open water (1%), and forest (0.6%). In 2010, the MPCA monitored four stream segments within this watershed unit. Eight biological monitoring stations are also within the subwatershed.

Table 13. Aquatic life and recreation assessments on stream reaches: Twelve Mile Creek subwatershed. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name,*** *Reach Description*	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	**Aquatic Life**	**Aquatic Rec.**
09020102-514 Twelvemile Creek T126 R45W S21, south line to W Br Twelvemile Cr	8.2	2C	10RD057 10RD059	Downstream of CR 13, 4 mi. NE of Dumont Downstream of CR 6, 3.5 mi. E of Dumont	EXS	EXS	EXS	EXS	--	MTS	MTS	--	EX	NS	NS
09020102-557 Twelvemile Creek W Br Twelvemile Cr to Mustinka River Ditch	16.17	2C	05RD008 10RD055 10RD056	Downstream of CR 84, 7 miles NE of Wheaton Upstream of CR 14, 7.5 mi. NE of Wheaton Upstream of Hwy 27, 6 mi. NE of Wheaton	EXS	EXS	IF	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.

Table 14. Non-assessed biological stations on channelized AUIDs: Twelve Mile Creek 11-HUC.

AUID ***Reach Name,*** *Reach Description*	**Reach length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Fish IBI**	**Invert IBI**
09020102-513 Twelvemile Creek (County Ditch 1) Lundberg Lk to T126 R45W S28, north line	24.55	7	05RD117	6m S of Herman, upstream of CR 71	Poor	Poor
09020102-513 Twelvemile Creek (County Ditch 1) Lundberg Lk to T126 R45W S28, north line	24.55	7	10RD062	Downstream of CR 15, 6.5 mi. SE of Dumont	Poor	Not Sampled
09020102-579 County Ditch 42 Between Twelvemile Cr and Fivemile Cr	3.32	2B, 3C	10RD049	Upstream of CR 13, 7.5 mi. NE of Wheaton	Fair	Poor

See Appendix 5.1 for clarification on the good/fair/poor thresholds and Appendix 5.2 and Appendix 5.3 for IBI results.

Table 15. Minnesota Stream Habitat Assessment (MSHA): Twelve Mile Creek 11-HUC.

# Visits	**Biological Station ID**	**Reach Name**	**Land Use (0-5)**	**Riparian (0-15)**	**Substrate (0-27)**	**Fish Cover (0-17)**	**Channel Morph.**	**MSHA Score (0-100)**	**MSHA Rating**
1	05RD008	Twelve Mile Creek	0	9.5	18.1	12	21	60.6	Fair
1	05RD117	Twelve Mile Creek	1	3	3	2	7	16	Poor
1	10RD049	Twelve Mile Creek	0	6	14.8	13	21	54.8	Fair
1	10RD055	Twelve Mile Creek	0	9.5	20	7	13	49.5	Fair
2	10RD056	Twelve Mile Creek	0	9	15.2	13.5	20	58.2	Fair
2	10RD057	Twelve Mile Creek	0	11	12.2	12.5	18	58.2	Fair
1	10RD059	Twelve Mile Creek	0	7.5	6.6	12	22	48.1	Fair
1	10RD062	Twelve Mile Creek	0	8	7	10	12	37	Poor
Average Habitat Results: *Twelve Mile Creek 11 HUC*			**0.1**	**7.9**	**12.1**	**10.3**	**16.8**	**47.8**	**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 16. Outlet water chemistry results: Twelve Mile Creek 11-HUC.

Station location:	**Five Mile Creek, at CR 13, 7.5 mi. NE of Wheaton**
STORET/EQuIS ID:	**S006-150**
Station #:	**09020102040**

Parameter	Units	# of Samples	Minimum	Maximum	Mean	Median	WQ Standard[1]	# of WQ Exceedances[2]
Ammonia-nitrogen	mg/L	2	0.04	0.08	0.06	0.06		
Chloride	mg/L						> 230	
Chlorophyll-a, Corrected	ug/L							
Dissolved Oxygen (DO)	mg/L	18	4.17	11.4	7.65	7.92	5	3
Escherichia coli	MPN/100ml	14	13	461.1	132.96	115.75		
Inorganic nitrogen (nitrate and nitrite)	mg/L	2	0.08	0.1	0.09	0.09		
Kjeldahl nitrogen	mg/L	10	0.93	1.4	1.22	1.24		
Orthophosphate	ug/L							
pH		18	6.6	8.8	7.91	7.88	6.5 – 9	0
Pheophytin-a	ug/L							
Phosphorus	ug/L	10	0.07	0.4	0.18	0.14		
Specific Conductance	uS/cm	18	171	1360	1131	1205.5		
Temperature, water	deg °C	18	7.8	26.96	20.37	21.62		
Total suspended solids	mg/L	10	2	15	8.5	9		
Total volatile solids	mg/L	10	1	4	2.6	2		
Transparency tube	100 cm	18	5	100	65.17	70	< 20	1
Transparency tube	60 cm						>20	
Turbidity	FNU	2	9.4	16.9	13.15	13.15	25 NTU	0
Sulfate	mg/L							
Hardness	mg/L							

Geometric mean of all samples is provided

2 Thresholds are surrogates for the 25 NTU turbidity standard

3 Represents exceedances of individual maximum standard for E. coli (1260/100ml) or fecal coliform

Table 17. Outlet water chemistry results: Twelve Mile Creek 11-HUC.

Station location:	Twelve Mile Creek, downstream of CR 13, 4 mi. NE of Dumont							
STORET/EQuIS ID:	S006-152							
Station #:	09020102040							
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**Median**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	8	0.05	0.14	0.08	0.08		
Chloride	mg/L						> 230	
Chlorophyll-a, Corrected	ug/L	1.0	1.0	1.0	1.0	1.0		
Dissolved Oxygen (DO)	mg/L	18	3.64	9.20	5.65	5.66	5	7
Escherichia coli	MPN/100ml	14	60	976.8	291.8	185		
Inorganic nitrogen (nitrate and nitrite)	mg/L	8	0.14	1.19	0.60	0.47		
Kjeldahl nitrogen	mg/L	10	1.14	2.15	1.65	1.65		
Orthophosphate	ug/L							
pH		18	7.28	8.7	7.8	7.8	6.5 – 9	0
Pheophytin-a	ug/L							
Phosphorus	ug/L	10	0.37	0.76	0.58	0.59		
Specific Conductance	uS/cm	18	158	2066	1115.28	1367		
Temperature, water	deg °C	18	8.10	27.51	19.83	21.05		
Total suspended solids	mg/L	10	4	28	11.6	6.5		
Total volatile solids	mg/L	10	2	7	3.3	2.5		
Transparency tube	100 cm	18	9	100	57.91	64.5	< 20	4
Transparency tube	60 cm						>20	
Turbidity	FNU	2	14.5	128	71.25	71.25	25 NTU	1
Sulfate	mg/L							
Hardness	mg/L							

Geometric mean of all samples is provided

2 Thresholds are surrogates for the 25 NTU turbidity standard

3 Represents exceedances of individual maximum standard for E. coli (1260/100ml) or fecal coliform

Summary

Eight biological monitoring stations were located in the Twelve Mile Creek subwatershed. Seven of the stations were located on the main stem of Twelve Mile Creek and one was on a tributary. A 25 mile segment of Twelve Mile Creek upstream of the assessed reaches is classified as a limited resource value water (i.e. Class 7). Biological monitoring stations located within the LRVW segment and immediately downstream had the lowest Fish IBI scores when compared to stations located further downstream. Fish communities at these stations were almost exclusively comprised of tolerant species. Both stream segments downstream of the LRVW segment are impaired for excessive turbidity and bacteria. The first downstream segment also has an existing DO impairment. Though most Fish IBI scores on Twelve Mile Creek suggest that this stream is degraded, station 10RD055 had the highest Fish IBI scores. Station 10RD055 was the furthest downstream station on Twelve Mile Creek and was not located on the segment impaired due to low DO. Compared to other stations, coarse substrate at 10RD055 was less embedded. Several piscivorous and insectivorous species of fish were sampled only at 10RD055. Macroinvertebrate IBI scores were low at every station except 10RD057. Station 10RD057 was the only station in the subwatershed that featured cobble for invertebrate habitat. Invertebrate habitat was limited to overhanging vegetation at most other sites. Considerable evidence of dramatic flow fluctuations, such as excess erosion and bank failure, was present at most stations within the subwatershed. Frequent high flow events and flow variability are likely contributing to poor fish and invertebrate community development as well as increased turbidity in Twelve Mile Creek.

Water quality data were available on four of the 22 streams in the Twelve Mile Creek subwatershed. Two water chemistry stations were located within the subwatershed. Twelve Mile Creek is broken into two reaches (8.2 miles and 16.17 miles); both reaches do not support aquatic life and aquatic recreation due to bacteria, DO and turbidity impairments.

Two of the 15 lakes greater than four hectares (10 acres) that are in the Twelve Mile Creek subwatershed were attempted to be assessed. Both are unnamed lakes (2.7 miles northwest and 5.3 miles southwest of Donnelly, Minnesota) and have insufficient data to be assessed. Both are noted for having considerable emergent vegetation during dry years.

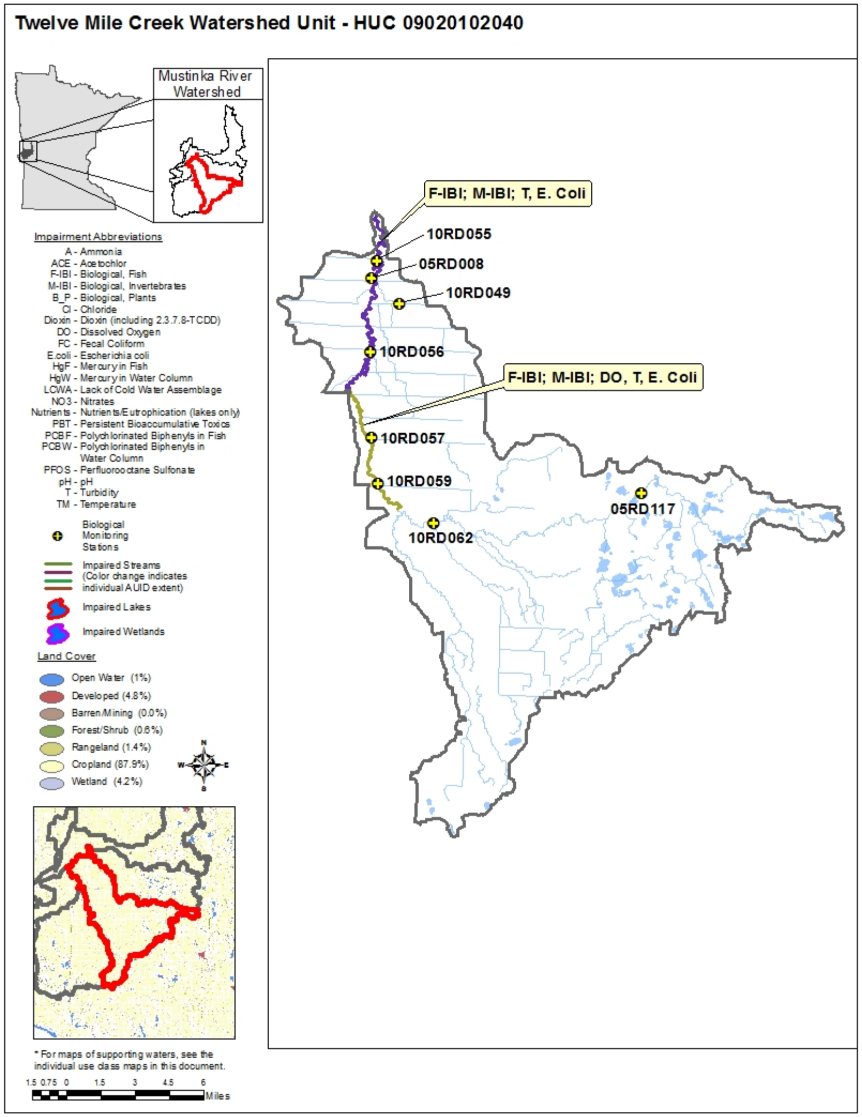

Figure 22. Currently listed impaired waters by parameter and land use characteristics in the Twelve Mile Creek subwatershed

C.D. #27 Watershed Unit HUC 09020102050

The County Ditch # 27 watershed is the smallest in the Mustinka River Watershed, draining 25 square miles of Traverse County. County Ditch # 27 flows through the central portion of the subwatershed and receives flow from several other ditches. Land use is primarily cropland (90.9%) with remaining small percentages of developed land (5%), forest (0.5%), rangeland (0.5%), and wetland (3%). Open water is not listed as a land use. No water quality or biological data have been collected from the one stream reach that is located in this subwatershed. No lakes are located in this subwatershed.

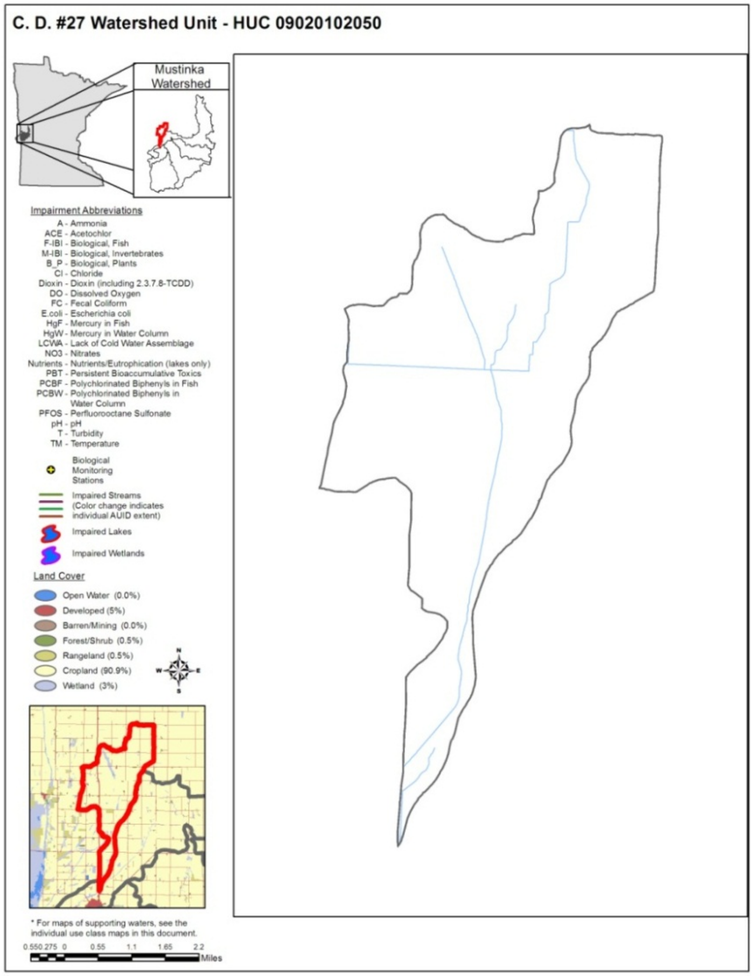

Figure 23. Currently listed impaired waters by parameter and land use characteristics in the C.D. #27 subwatershed

Eighteen Mile Creek Watershed Unit HUC 09020102060

The Eighteen Mile Creek subwatershed drains 47 square miles of Traverse County. Eighteen Mile Creek flows across the northern end of the subwatershed. A substantial network of streams originates in the southern portion of the subwatershed and flow north into Eighteen Mile Creek. Land use is primarily cropland (87.1%). Remaining small percentages of land use include developed (6%), wetland (4.2%), rangeland (2%), and open water (0.1%). In 2010, the MPCA monitored one stream segment and had one biological monitoring site within the subwatershed.

Table 18. Aquatic life and recreation assessments on stream reaches: Eighteen Mile Creek Watershed unit. Reaches are organized upstream to downstream in the table.

AUID *Reach Name*, *Reach Description*	Reach Length (miles)	Use Class	Biological Station ID	Location of Biological Station	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	Aquatic Life	Aquatic Rec.
09020102-508 Eighteenmile Creek Unnamed cr to Mustinka R	10	2C	10RD045	Upstream of CR 7, 2 mi. SW of Wheaton	EXS	EXS	EXS	MTS	MTS	MTS	MTS	--	EX	NS	IF

Abbreviations for Indicator Evaluations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **MTS** = Meets criteria; **EXP** = Exceeds criteria, potential impairment
EXS = Exceeds criteria, potential severe impairment; **EX** = Exceeds criteria (Bacteria)
Abbreviations for Use Support Determinations: **NA** = Not Assessed, **IF** = Insufficient Information, **NS** = Non-Support, **FS** = Full Support
Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use.
Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream

Table 19. Minnesota Stream Habitat Assessment (MSHA): Eighteen Mile Creek 11-HUC.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	10RD045	Eighteen Mile Creek	0	8.5	16.3	15	13	52.8	Fair
		Average Habitat Results: *Eighteen Mile Creek 11 HUC*	**0**	**8.5**	**16.3**	**15**	**13**	**52.8**	**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 20. Outlet water chemistry results: Eighteen Mile Creek 11-HUC.

Station location:	Eighteen Mile Creek, at CR 7, 2 mi. SW of Wheaton							
STORET/EQuIS ID:	S005-143							
Station #:	09020102060							
Parameter	Units	# of Samples	Minimum	Maximum	Mean	Median	WQ Standard[1]	# of WQ Exceedances[2]
Ammonia-nitrogen	mg/L	6	0.04	0.21	0.10	0.09		
Chloride	mg/L						> 230	
Chlorophyll-a, Corrected	ug/L							
Dissolved Oxygen (DO)	mg/L	18	3.27	12.50	5.94	4.92	5	10
Escherichia coli	MPN/100ml	14	24.9	651	202.91	145		
Inorganic nitrogen (nitrate and nitrite)	mg/L	4	0.08	0.26	0.15	0.13		
Kjeldahl nitrogen	mg/L	9	1.1	1.48	1.34	1.37		
Orthophosphate	ug/L							
pH		18	7.2	8.4	7.78	7.75	6.5 – 9	0
Pheophytin-a	ug/L							
Phosphorus	ug/L	9	0.4	0.88	0.58	0.55		
Specific Conductance	uS/cm	18	168	2342	1240.11	1188		
Temperature, water	deg °C	18	8.6	28.08	20.4	21.25		
Total suspended solids	mg/L	10	3	12	5	4		
Total volatile solids	mg/L	9	1	4	2.22	2		
Transparency tube	100 cm	18	23	100	80.61	100	< 20	0
Transparency tube	60 cm						>20	
Turbidity	FNU	2	6.3	87.20	46.75	46.75	25 NTU	1
Sulfate	mg/L							
Hardness	mg/L							

Geometric mean of all samples is provided

2 Thresholds are surrogates for the 25 NTU turbidity standard

3 Represents exceedances of individual maximum standard for E. coli (1260/100ml) or fecal coliform

Summary

One biological monitoring station (10RD045) was located on Eighteen Mile Creek near its confluence with the Mustinka River. Both the Fish IBI and macroinvertebrate IBI scored poorly. Only five black bullheads, a tolerant species, were sampled. The invertebrate sample was comprised entirely of tolerant taxa. The station featured abundant filamentous algae and dense aquatic macrophytes. The entire stream segment is impaired by low DO levels, and DO levels were unusually high at the time fish were sampled, suggesting large diurnal fluctuations in oxygen levels. Some coarse substrate was present at the site.

Water quality data were available on Eighteen Mile Creek for a 10 mile reach upstream of its confluence of the Mustinka River. The creek does not support aquatic life due to low DO. During the 2008 and 2009 sampling period flow in the creek was very slow and high amounts of filamentous algae covered the bottom of the stream bed. During this time frame all but two of the DO values met the standard. Lower DO was found in 2010 and 2011 and there were no indications of low flow or filamentous algae on the stream bed at these locations. There was insufficient information to assess whether or not this reach supported aquatic recreation.

There are two lakes in the Eighteen Mile Creek Watershed and neither has been sampled.

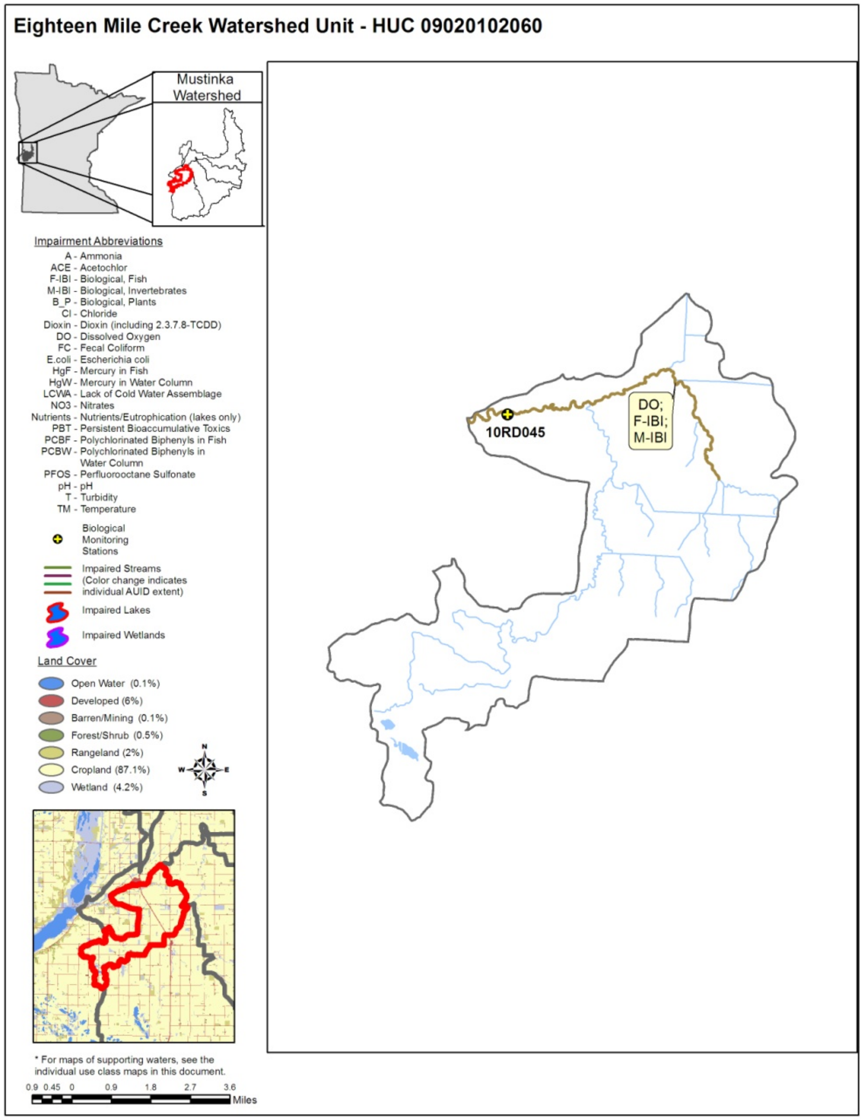

Figure 24. Currently listed impaired waters by parameter and land use characteristics in the Eighteen Mile Creek subwatershed

VI.Watershed-wide results and discussion

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

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

Pollutant load monitoring

The Mustinka River is monitored at the MDNR gauge site H55060002 near Wheaton, Minnesota which is approximately five miles upstream of the Lake Traverse inlet. Annual FWMCs and pollutant loads for 2010 – 2012 will be calculated when final flows are made available. Two years of water elevation and flow data are required to compute the stage vs. flow relationship which is then applied to the continuously monitored stage data for computing daily discharge. It should be noted that while a FWMC exceeding given water quality standard is generally a good indicator the water body is out of compliance with the River Nutrient Region standard, the relationship 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 (MPCA 2010a), over the most recent 10 year period and not based on comparisons with FWMCs. 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 (nitrate-N) are generally regarded as “non-point” source derived pollutants originating from many small diffuse sources such as urban or agricultural runoff. Excess TP and DOP can be attributed to either “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 with DOP and nitrate-N concentrations tending to be lower. In contrast, during years with high snow melt runoff and less intense rainfall events, TSS levels tend to be lower while TP, DOP, and nitrate-N levels tend to be elevated. In many cases, it is a combination of climatic factors from which the pollutant loads are derived.

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

Currently, the state of Minnesota does not have a river standard for TSS but does have one for turbidity. Because turbidity is an optical measurement and not a measure of mass, TSS "surrogate" standards for turbidity were developed for each ecoregion of the state and are applicable to water quality data collected within each respective ecoregion. Total suspended solid concentrations in the Mustinka River Watershed with greater than 10% of the samples at or above 60 mg/L are considered out of compliance with the turbidity standard of 25 Nephelometric Turbidity Units (NTUs) for waters within the LAP Ecoregion (Aquatic Life Water Quality Standards Draft Technical Support Document for Total Suspended Solids (Turbidity), Revised Draft, Markus, May 2011). In 2008, the percent of TSS samples that exceeded the 60 mg/L surrogate standard was 46%. In 2009, 26% of the samples collected exceeded the surrogate standard and in 2010, 18% of the samples collected exceeded the surrogate standard.

Total phosphorus

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

Total phosphorus standards for Minnesota's rivers are currently in development. Many years of water quality data collected throughout Minnesota, combined with previous analysis of Minnesota's ecoregion patterns, resulted in the development of three "River Nutrient Regions" (RNR), each with unique standards. Of the state's three proposed RNRs, the Mustinka River load monitoring station is located within the South RNR which has a TP draft standard of 0.150 mg/L as a summer average. The TP standard is yet to be approved and this threshold must be considered draft until final approval. Summer average violations of one or more "response" variables (pH, biological oxygen demand (BOD), DO flux, chlorophyll-a) must also occur along with the TP numeric violation for the water to be listed as impaired. In 2008, the percent of TP samples that exceeded the 0.150 mg/L proposed standard was 88%. In 2009, 71% of the samples collected exceeded the proposed standard, and in 2010, 95% of the samples collected exceeded the proposed standard.

Dissolved orthophosphate

Dissolved orthophosphate (DOP) is a water soluble form of phosphorus that is readily available to algae (bioavailable) (MPCA and MSUM 2009). While orthophosphates occur naturally in the environment, river and stream concentrations may become elevated with additional inputs from waste water treatment plants, noncompliant septic systems, and fertilizers in urban and agricultural runoff. Computation of OP/ TP ratios from 2008 to 2010 shows an average value of 0.58 or 58% of the TP is in the orthophosphate form.

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 2010b). 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 (2012) 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, Aquatic Life Water Quality Standards Technical Support Document for Nitrate, Nov 2010). Nitrate-N FWMCs from 2010 - 2012 will be calculated for the Mustinka River when final flows are made available.

Stream water quality

Twenty-two segments out of 82 stream segments in the watershed had water quality data available on them to be assessed against the aquatic recreation use and aquatic life standards. Of these 22 segments, 8 had sufficient data to assess for aquatic recreation; twelve were assessed for aquatic life (Table 21). No stream segments fully supported aquatic life and only one stream segment, the old channel of the Mustinka River, fully supported aquatic recreation. One stream segment was not assessed due to its classification as a limited resource water. Seven stream segments 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.

Table 21. Assessment summary for stream water quality in the Mustinka River Watershed.

				Supporting		Non-supporting		
Watershed	Area (acres)	# Total AUIDs	# Assessed AUIDs	# Aquatic Life	# Aquatic Recreation	# Aquatic Life	# Aquatic Recreation	Insufficient Data
09020102 **HUC 8**	**550,852**	**82**	**13**	**0**	**1**	**12**	**7**	**5 AL, 4 AR**
09020102010	167,985	21	7	0	1	7	3	2 AL, 2 AR
09020102020	82,043	18	2	0	0	1	1	1 AL
09020102030	128,332	14	1	0	0	1	1	1 AL
09020102040	137,339	22	2	0	0	2	2	1 AL, 1 AR
09020102050	16,470	1	0	0	0	0	0	0
09020102060	30,717	5	1	0	0	1	0	1 AR

Lake water quality

There are 179 lakes greater than four hectares in the Mustinka River Watershed, 3 of which have sufficient data to review against the aquatic recreation use standard. All 3 of the lakes do not support aquatic recreation.

Table 22. Assessment summary for lake water chemistry in the Mustinka River Watershed.

				Supporting		Non-Supporting		
Watershed	Area (acres)	Lakes >10 Acres	# of Assessed Lakes	# Aquatic Life	# Aquatic Recreation	# Aquatic Life	# Aquatic Recreation	Insufficient Data
09020102 **HUC 8**	**550,852**	**179**	**23**	**0**	**0**	**0**	**3**	**20**
09020102050	167,985	0	0	0	0	0	0	0
09020102060	82,043	2	0	0	0	0	0	0
09020102020	128,332	35	14	0	0	0	0	14
09020102010	137,339	73	5	0	0	0	1	4
09020102040	16,470	15	2	0	0	0	0	2
09020102030	30,717	54	2	0	0	0	2	0

Fish contaminant results

Fish species are identified by codes that are defined by their common and scientific names in Table 23. Within the Mustinka River Watershed, mercury was measured in the five fish species listed. PCBs were measured in two species: common carp (C) and northern pike (NP). Table 24 summarizes the contaminant concentrations by waterway, fish species, and year. The table shows which contaminants, species, and years were sampled within a given lake. "Total Fish" and "Samples" are shown because many of the panfish, such as black crappie (BKS), bluegill sunfish (BGS) and yellow perch (YP) were composite samples—multiple fish homogenized into a single sample. Sample years ranged from 2001 to 2010. All of the samples were skin-on fillets (FILSK).

Mercury was measured in 58 fish (33 samples) from the river and lakes. East Toqua Lake is on the Impaired Waters List because of mercury in fish tissue. The impairment was determined by the northern pike collected in 2001. They met the minimum sample size of five fish and had a 90th percentile mercury concentration exceeding the 0.2 mg/kg impairment threshold. The highest mercury concentration was 0.27 mg/kg in northern pike. PCBs were measured in 5 fish samples. All PCBs concentrations in common carp and northern pike from the Mustinka River were below the detection limit. The single carp tested from East Toqua was above the detection limit but at a low concentration (0.02 mg/kg).

Overall, these results indicate very low concentrations of mercury and PCBs in fish from the Mustinka River. Because mercury concentrations in northern pike from East Toqua Lake were sufficient to cause impairment, the fish should be tested during the next fish survey of the lake.

Table 23. Fish species codes, common names, and scientific names.

Code	Common Name	*Scientific Name*
BKS	Black crappie	*Pomoxis Nigromaculatis*
C	Common Carp	*Cyprinus carpio*
NP	Northern pike	*Esox Lucius*
WE	Walleye	*Sander vitreus*
WHS	White crappie	*Pomoxis Annularis*

Table 24. Fish contaminants table.

Waterway	AUID	Species[1]	Year	Anat[2]	Total Fish	Samples	Length (in)			Mercury (mg/kg)				PCBs (mg/kg)			
							Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max
Mustinka R.	09020102-506 -537 -580 -581 -582 -518 -558 -553 -502 -503 -556	C	2010	FILSK	5	5	22.5	20.5	24.6		0.076	0.063	0.098	2		< 0.025	< 0.025
		NP	2010	FILSK	5	5	17.3	11.3	24.4		0.113	0.058	0.182	2		< 0.025	< 0.025
Botkers	6012100	C	2006	FILSK	1	1	19.5			1	0.326						
		WE	2006	FILSK	1	1	13.2			1	0.119						
		WHS	2006	FILSK	10	1	9.4			1	0.08						
East Toqua*	6013800	BKS	2001	FILSK	10	1	7.3			1	0.024						
		C	2001	FILSK	6	1	22.7			1	0.053			1	0.02		
		NP	2001	FILSK	5	5	25.1	23.5	27	5	0.142	0.07	0.27				
		WE	2001	FILSK	7	7	17.6	14.3	21.6	7	0.1	0.059	0.151				
Lightning	26028200	C	2008	FILSK	3	1	21.3			1	0.021						
	09020102-	NP	2008	FILSK	5	5	20.8	15.8	24.6	5	0.053	0.027	0.071				

* Impaired for aquatic consumption – mercury in fish tissue

1 Species codes are defined in Table F1

2 Anatomy codes: FILSK – fillet skin-on

Water clarity trends at citizen monitoring sites

Citizen volunteer monitoring occurs at 39 stream sites and 3 lakes in the watershed. There are very few sites with enough data to calculate a trend, but; none of them have a decreasing trend.

Table 25. Water clarity trends at citizen stream monitoring sites.

Mustinka HUC 09020102	Citizen Stream Monitoring Program	Citizen Lake Monitoring Program
Number of sites w/ increasing trend	1	0
Number of sites w/ decreasing trend	0	0
Number of sites w/ no trend	2	2

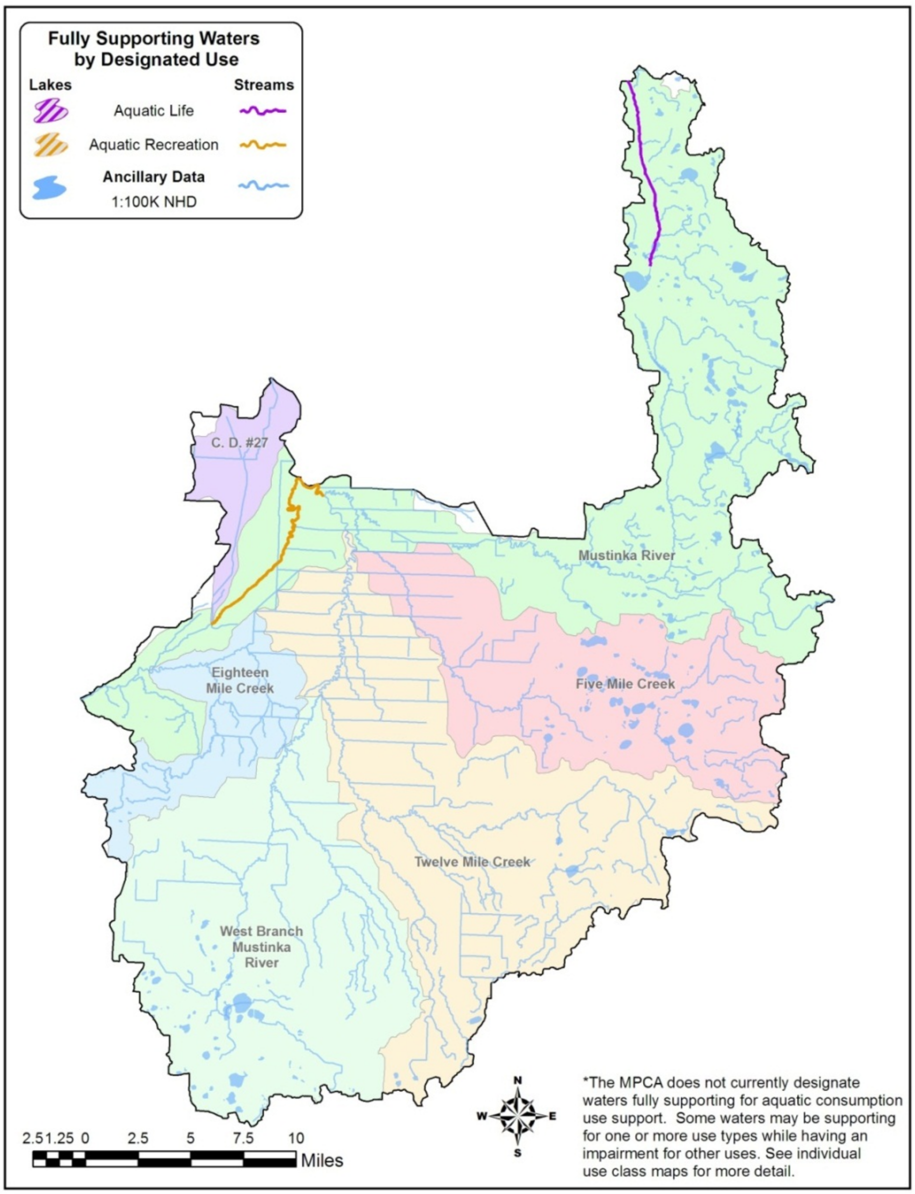

Figure 25. Fully supporting waters by designated use in the Mustinka River Watershed

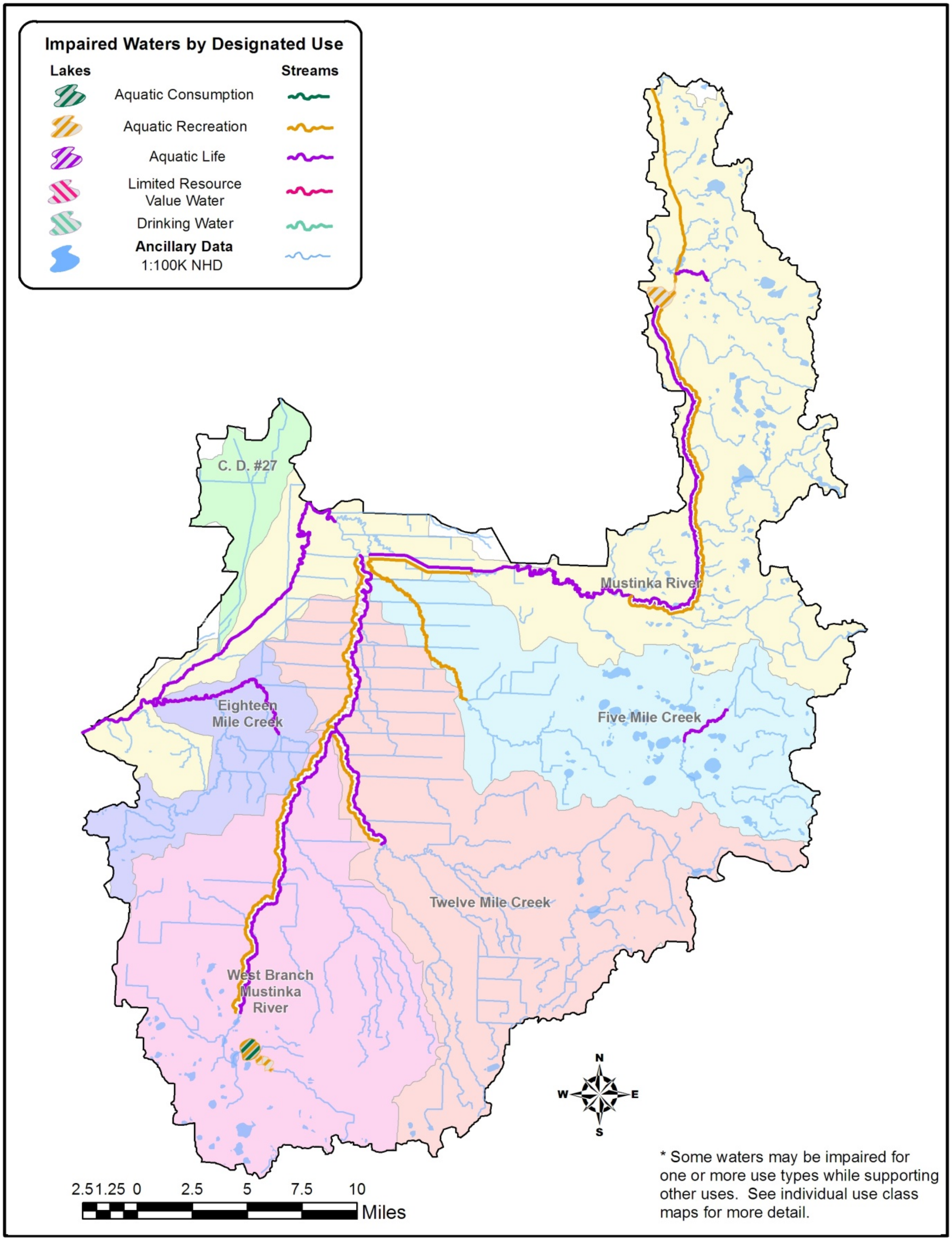

Figure 26. Impaired waters by designated use in the Mustinka River Watershed

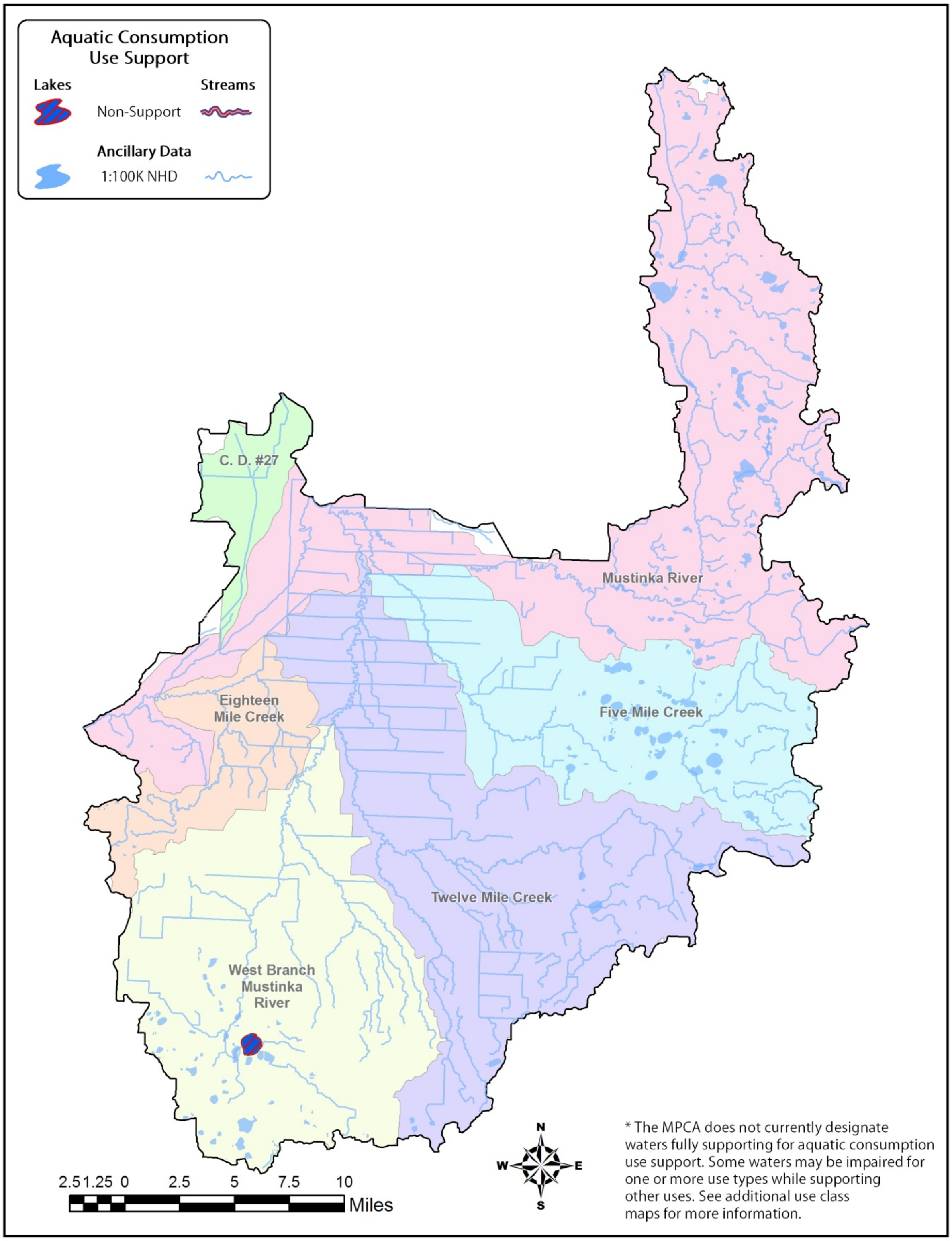

Figure 27. Aquatic consumption use support in the Mustinka River Watershed

VII. Summary and recommendations

There have been 86 species of fish documented in the Red River Basin. MPCA biological monitoring crews sampled 28 species of fish during the IWM effort in the Mustinka River Watershed. No species of special concern were found. The most diverse fish communities were sampled at stations on the main stem of the Mustinka River below the Mustinka River Flowage Dam. Some of these sites had coarse substrate necessary to support the reproduction of species classified as simple lithophilic spawners, such as golden red horse and walleye. Coarse substrates also support the invertebrate food sources utilized by benthic insectivores. The low gradient character of streams in the Lake Agassiz Plain (LAP) combined with a limited amount of coarse substrate generally limits the abundance and distribution of lithophilic spawning fish. The preferable habitat of large river species such as white bass, channel catfish, and freshwater drum was exclusive to lower main stem stations; consequently, those were some of the least common species sampled within the Mustinka River Watershed. Only one bigmouth buffalo was sampled within the watershed. The bigmouth buffalo is tolerant of low DO and prefers larger rivers with low current velocities. The one specimen sampled was located in its preferable habitat at the furthest downstream station on the Mustinka River. The most abundant species sampled was the fathead minnow, which was present at 20 stations. Fathead minnows are tolerant of low DO and are often able to survive in pools during dry periods. Such conditions are found in the intermittent streams that are prevalent in western Minnesota and the Red River Basin (EOR 2009). Fathead minnows are also the first species to move into disturbed habitat that ditching and dredging activities performed within the Mustinka River Watershed create. Other commonly sampled species included black bullhead, yellow bullhead, northern pike, brook stickleback, and white sucker. All of these species are tolerant of low DO levels, and most are tolerant of increased turbidity.

The Mustinka River Watershed contains many aquatic macroinvertebrate species. A total of 157 unique aquatic macroinvertebrate taxa were collected from 21 different locations throughout the watershed. Macroinvertebrates were sampled from myriad of habitats, including undercut banks/overhanging vegetation, aquatic macrophytes, riffle/rock and woody debris. The most frequently observed macroinvertebrate taxa within this watershed are: *Physa* (Gastropoda), *Paratanytarsus* (Diptera), *Polypedilum* (Diptera), *Hyalella* (Amphipoda), *Ablabesmyia* (Diptera), *Oligochaeta* (Annelida), *Pisidiidae* (Bivalvia), *Oronectes* (Crustacea), *Dubiraphia* (Coleoptera), *Cricotopus* (Diptera) and *Glyptotendipes* (Diptera). The most abundant taxa (total number of organisms) are: *Physa* (742), *Hyallela* (481), *Pseudocloeon propinquum* (377), *Tricorythodes* (300), *Polypedilum* (295), *Glyptotendipes* (284), *Oligochaeta* (260) and *Cricotopus* (208). All of the above mentioned taxa are very tolerant of environmental stress (i.e. lack of habitat, elevated nutrients, low DO). Very few sensitive aquatic macroinvertebrate taxa were encountered in this watershed and were often found at one or two locations, in single digit numbers. Some of these taxa include: *Perlidae* (Plecoptera), *Atherix* (Diptera), *Corydalidae* (Megaloptera) and *Limnephilidae* (Trichoptera). The low gradient and fine substrates typical of streams within the LAP limit the abundance and distribution of sensitive riffle dwelling Ephemeroptera and Plecoptera species.

Excessive turbidity and low DO were the two most prevalent parameters causing aquatic life impairments within the Mustinka River Watershed. Both impairments may be influenced by a multitude of factors including the surrounding land use, stream morphology, and nutrient inputs. Excessive nutrients, such as nitrogen and phosphorus, can increase algae and macrophyte production in streams leading to low levels of DO, larger diel DO fluctuations and increased turbidity. Streams within the Mustinka River Watershed are particularly susceptible to excessive nutrients because they are low gradient, often have a limited riparian zone, and many are channelized. 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). The low gradient, channelized streams in the Mustinka River Watershed retain nutrients during floods resulting in more time for algal biomass and bacteria to utilize the nutrients and increase production (Rankin *et al*. 1999). In addition to the high nutrient levels, high levels of bacteria found in some streams in the watershed can increase biological oxygen demand and also reduce DO.

Nutrient sources within the Mustinka River Watershed include fertilizer, wastewater treatment plants, septic systems, feed lot runoff, and nutrient recycling from stream bed sediment (Red River Basin Board 2001). Counties adjacent to the Red River have been identified as having high fertilizer applications (Tornes and Brigham 1994). In the Red River Basin approximately 2.81 (lb/acre)/yr nitrogen and 0.58 (lb/acre)/yr total phosphorus are exported to surface water from agricultural land (Bourne and others, 2002). Numerous feedlots are also present within the Mustinka River Watershed (manure is a primary contributor of nitrogen and phosphorus to surface water). Phosphorus and organic compounds containing nitrogen are often transported to surface water on substrate surfaces found in field sediment run off. Soluble nutrients, such as nitrate, are transported in both surface and subsurface run off. Drainage practices such as tiling can increase the amount of nitrate delivered to streams because the tiles rapidly convey drainage water and bypass the riparian zone that would otherwise serve as a buffer. Current MPCA draft standards consider phosphorus levels below 55 ug/L good and phosphorus levels above 150 ug/L poor (MPCA 2013). Total phosphorus concentrations exceeded the 150 ug/ L standard in 85% of the samples taken at biological stations in 2010. Sixty-six percent of the samples contained TP concentrations > 300 ug/L and 40% contained concentrations > 450 ug/L. Total phosphorus levels were particularly high at stations located on Twelve Mile Creek, a LRVW. Numerous feedlots are adjacent to Twelve Mile Creek and within the Twelve Mile Creek Watershed unit. Exceptionally high phosphorus concentrations were also noted in the west branch Mustinka River Watershed unit. Several eutrophic lakes influence the water quality at these stations. In spite of the increase in tile drainage in recent years, nitrogen levels were below the draft standards at all biological monitoring stations. Biological data is not collected during high flow events so these samples represent base flow conditions

Soil loss from agricultural land has been identified as the main source of sediment causing excess turbidity on two separate segments of the Mustinka River (TMDL 2010). Simon et al. found that streams within the Red River Basin have the highest median suspended sediment concentration of any given region in Minnesota except the Western Cornbelt Plains ecoregion (EOR 2009). Streams within the LAP ecoregion, which constitutes a substantial portion of the Mustinka River Watershed, often have high sediment levels despite the fact that sediment delivery is reduced by the flat topography (EOR 2009). Unfortunately, the combination of a very flat topography and fertile soils has resulted in cultivation of most of the floodplain of the Mustinka River Watershed which in turn has resulted in stream sedimentation problems, mainly during the frequent spring flood events. The highest sediment loads within Red River tributaries occur during intense spring rain falls when agricultural fields have little cover (EOR 2009). Wilkin and Hebel (1982) found that cultivated floodplains are a major contributor of stream sediment during flood events. The lack of riparian buffers, development of farm field gullies, and stream bank erosion exacerbate the problem and contribute to excessive turbidity in the streams of the LAP ecoregion (2009). Extensive channelization and other drainage modifications present throughout the watershed cause increased flow velocities which result in increased steam bank erosion and head cutting (TMDL 2010). Channelized streams naturally try to meander, further causing erosion (Waters 1995).

In summary, streams in the Mustinka River Watershed are in overall poor condition. Because of their geographic and geologic setting on the landscape, they are highly susceptible to the disturbances that are prevalent throughout the watershed. As a consequence, stream habitat, water chemistry, and the biology have all been compromised. Assessments for support of aquatic life, recreation, and fish consumption indicate non-support in most cases where sufficient data has been collected. Widespread changes in land use practices will need to occur before we are likely to see a significant improvement in most indicators. Since the vast majority of land in the watershed is privately owned and the likely “fixes” will involve a change in agricultural practices and are largely voluntary, public education and engagement regarding the condition and value of stream resources in this region will be necessary.

The Mustinka River Watershed contains 179 lakes greater than 4 hectares, three of which have sufficient data to review against the aquatic recreation use standard. East Toqua and Lannon both have high total phosphorus concentrations and consistently low transparencies. Internal loading of phosphorus will need to be addressed, in addition to watershed contributions, to improve the water quality of these basins. Lightning Lake had sufficient data to assess for aquatic recreation and was determined to not support aquatic recreation due to elevated phosphorus and chlorophyll-a concentrations. All three of the lakes do not support aquatic recreation standard. Many of the Mustinka River Watershed lakes are shallow and have significant emergent vegetation covering the water bodies. The overall conditions of the lakes are poor because of the landscape surrounding them. Runoff is a major contributing factor in the impairments therefore improving the land cover will play a major role in improving the water quality.

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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 Mustinka River Watershed

Biological Station ID	STORET/ EQuIS ID	Waterbody Name	Location	11-digit HUC
10RD032	S000-062	Mustinka River	At US 75, 1 mi. N of Wheaton	09020102010
10RD033	S004-107	Mustinka River	At CR 13, 7.5 mi. NW of Norcross	09020102010
10RD045	S005-143	Eighteen Mile Creek	At CR 7, 2 mi. SW of Wheaton	09020102060
10RD049	S006-150	Five Mile Creek	At CR 13, 7.5 mi. NE of Wheaton	09020102040
10RD057	S006-152	Twelvemile Creek	Downstream of CR 13, 4 mi. NE of Dumont	09020102040
10RD067	S006-151	Twelvemile Creek, West Branch	At CR 71, 4 mi. NE of Dumont	09020102030

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

AUID DESCRIPTIONS				USES					BIOLOGICAL CRITERIA		WATER QUALITY STANDARDS										ECOREGION EXPECTATIONS			
National Hydrography Dataset (NHD) Assessment Segment AUID	Stream Segment Name	Segment Description	NHD Length (Miles)	Use Class	Aquatic Life	Aquatic Recreation	Aquatic Consumption	Class 7	Fish	Macroinvertebrates	Acetochlor	Alachlor	Atrazine	Chloride	Bacteria (Aquatic Recreation)	Metolachlor	Dissolved Oxygen	pH	Turbidity	Un-ionized ammonia	Oxygen Demand (BOD)	Nitrite/Nitrate	Total Phosphorous	Suspended Solids
HUC 11: 09020102010 Mustinka River																								
09020102-502	Mustinka River (Old Channel)	Fivemile Cr to Unnamed Cr	12.84	2C	NS	FS			NA	NA				MTS	MTS		MTS	MTS	EXS	MTS				
09020102-503	Mustinka River	Unnamed Cr to Lake Traverse	8.45	2C	NS	IF			NA	NA				MTS	--		IF	MTS	EXS	MTS				
09020102-506	Mustinka River	Headwaters to Lightning Lake	9.32	2B, 3C	NS	NS			NA	NA				MTS	EX		EXS	MTS	MTS	MTS				
09020102-538	Unnamed creek	Unnamed Cr to Mustinka River	1.96	2B, 3C	NS	NA			EXS	EXS				--	--		--	--	MTS	--				
09020102-553	Mustinka River Ditch	Twelvemile Cr to Mustinka River	2.53	2C	IF*	NA			NA	NA				--	--		--	--	EXS	--				
09020102-559	Unnamed creek	Unnamed Cr to Unnamed Cr	1.94	2B, 3C	NA*	NA			--	--				--	--		--	--	--	--				
09020102-561	Unnamed creek	Unnamed Cr to Mustinka R	1.77	2B, 3C	NA*	NA			NA	NA				--	--		--	--	--	--				
09020102-562	Unnamed creek	Unnamed Cr to Unnamed Cr	3.17	2B, 3C	IF*	NA			EXS	EXS	IF	NA	IF	--	--	IF	--	--	--	--				
09020102-580	Mustinka River	Lightning Lake to Mustinka River Flowage	20.64	2B, 3C	NS	NS			EXS	MTS				MTS	EX		EXS	MTS	EXP	MTS				

09020102-582	Mustinka River	Mustinka River Flowage to Grant/Traverse County Line	12.29	2B, 3C	NS	IF				MTS	MTS				--	IF		IF	MTS	EXS	MTS				

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.

AUID DESCRIPTIONS				**USES**						**BIOLOGICAL CRITERIA**		**WATER QUALITY STANDARDS**											**ECOREGION EXPECTATIONS**		
National Hydrography Dataset (NHD) Assessment Segment AUID	**Stream Segment Name**	**Segment Description**	**NHD Length (Miles)**	**Use Class**	**Aquatic Life**	**Aquatic Recreation**	**Aquatic Consumption**	**Class 7**		**Fish**	**Macroinvertebrates**	**Acetochlor**	**Alachlor**	**Atrazine**	**Chloride**	**Bacteria (Aquatic Recreation)**	**Metolachlor**	**Dissolved Oxygen**	**pH**	**Turbidity**	**Un-ionized ammonia**		**Nitrite/Nitrate**	**Total Phosphorous**	**Suspended Solids**
HUC 11: 09020102020 Five Mile Creek																									
09020102-510	Fivemile Creek	T127 R45W S24, East Line to Mustinka River Ditch	11.41	2C	IF	NS				--	--				MTS	EX		IF	MTS	MTS	MTS				
09020102-525	Unnamed Ditch	Unnamed ditch to Fivemile Cr	2.14	2B, 3C	IF	NA				--	--				--	--		IF	MTS	MTS	--				
09020102-564	Unnamed Ditch	Unnamed Cr to Unnamed Ditch	1.78	2B, 3C	NA*	NA				NA	NA				--	--		--	--	--	--				
09020102-578	Unnamed Creek	Unnamed Cr to Unnamed Cr	3.09	2B, 3C	NS	NA				EXS	--				--	--		--	--	--	--	--			

Full Support (FS); Not Supporting (NS); Insufficient Data (IF); Not Assessed (NA); Meets standards or ecoregion expectations (MT/MTS), Potential Exceedence (EXP), Exceeds standards or ecoregion expectations (EX/EXS).
Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use. *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.

AUID DESCRIPTIONS				USES						BIOLOGICAL CRITERIA		WATER QUALITY STANDARDS											ECOREGION EXPECTATIONS		
National Hydrography Dataset (NHD) Assessment Segment AUID	Stream Segment Name	Segment Description	NHD Length (Miles)	Use Class	Aquatic Life	Aquatic Recreation	Aquatic Consumption	Class 7		Fish	Macroinvertebrates	Acetochlor	Alachlor	Atrazine	Chloride	Bacteria (Aquatic Recreation)	Metolachlor	Dissolved Oxygen	pH	Turbidity	Un-ionized ammonia		Nitrite/Nitrate	Total Phosphorous	Suspended Solids
HUC 11: 09020102030 West Branch Mustinka River																									
09020102-511	Twelvemile Creek, West Branch	T125 R46W S33, south line to Twelvemile Cr	21.4	2C	NS	NS				--	--				--	EX		EXS	MTS	MTS	MTS				
09020102-512	Judicial Ditch 4	Headwaters to Twelvemile Cr	7.48	2B, 3C	NA*	NA				NA	NA				--	--		--	--	--	--				
09020102-524	Unnamed Creek	CD 33 to W Br Twelvemile Cr	4.98	2B, 3C	IF	NA				--	--				--	--		EXS	MTS	MTS	--				
09020102-527	County Ditch 8	Headwaters to Lannon Lake	6.91	2B, 3C	NA*	NA				NA	NA				--	--		--	--	--	--				
09020102-532	Unnamed Creek	Unnamed Cr to Unnamed Cr	0.87	2B, 3C	NA*	NA				NA	NA				--	--		--	--	--	--	--			
HUC 11: 09020102040 Twelve Mile Creek																									
09020102-513	Twelve Mile Creek (County Ditch 1)	Lundberg Lk to T126 R45W S28, north line	24.55	2C	NA*	--				NA	NA				--	--	--	--	--	--	--				
09020102-514	Twelve Mile Creek	T126 R45W S21, south line to W Br Twelve Mile Cr	8.2	2C	NS	NS		x		EXS	EXS				--	EX		EXS	MTS	EXS	MTS				
09020102-557	Twelve Mile Creek	W Br Twelve Mile Cr to Mustinka River Ditch	16.17	2C	NS	NS				EXS	EXS				MTS	EX		IF	MTS	EXS	MTS				
09020102-579	County Ditch 42	Between Twelve Mile Cr and Five Mile Cr	3.32	2B, 3C	IF*	IF				NA	NA				--	--		EXP	--	MTS	MTS				

HUC 11: 09020102060 Eighteen Mile Creek

09020102-508	Eighteenmile Creek	Unnamed cr to Mustinka River	10.11	2C	NS	IF				EXS	EXS				MTS	EX		EXS	MTS	MTS	MTS				

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 Mustinka River Watershed

Lake ID	Lake Name	County	HUC – 11	Ecoregion	Lake Area (ha)	Max depth (m)	Mean Depth (m)	Watershed Area (ha)	% Littoral	Aquatic Recreation Use Support²
06-0082-00	Unnamed	Big Stone	9020102040	NGP	24					
06-0086-00	Unnamed	Big Stone	9020102030	NGP	28					
06-0087-00	Unnamed	Big Stone	9020102030	NGP	38					
06-0118-00	Campbell Slough	Big Stone	9020102030	NGP	107					
06-0120-00	Cup	Big Stone	9020102030	NGP	65					
06-0121-00	Unnamed	Big Stone	9020102030	NGP	44	18.5			81	
06-0122-00	Unnamed	Big Stone	9020102030	NGP	37					
06-0124-00	Unnamed	Big Stone	9020102030	NGP	30					
06-0125-00	Unnamed	Big Stone	9020102030	NGP	19					
06-0127-00	Unnamed	Big Stone	9020102030	NGP	24					
06-0135-00	South Rothwell	Big Stone	9020102030	NGP	177	9				
06-0137-00	West Toqua	Big Stone	9020102030	NGP	460	4.5	3		100	
06-0138-00	East Toqua	Big Stone	9020102030	NGP	446	9	6.29	15,265	98	NS

Lake ID	Lake Name	County	HUC – 11	Ecoregion	Lake Area (ha)	Max depth (m)	Mean Depth (m)	Watershed Area (ha)	% Littoral	Aquatic Recreation Use Support[2]
06-0139-00	Lannon	Big Stone	9020102030	NGP	211	4	1.0[1]	13,384	100	NS
06-0140-00	Unnamed	Big Stone	9020102030	NGP	80	5.5			100	
06-0141-00	Unnamed	Big Stone	9020102030	NGP	31					
06-0142-00	Unnamed	Big Stone	9020102030	NGP	38					
06-0143-00	Unnamed	Big Stone	9020102030	NGP	33					
06-0144-00	Lone Tree Slough	Big Stone	9020102030	NGP	93	8.5				
06-0145-00	Humpty Dumpty	Big Stone	9020102030	NGP	121	8				
06-0146-00	Government Slough	Big Stone	9020102030	NGP	111					
06-0147-00	North Rothwell Slough	Big Stone	9020102030	NGP	228	13			100	
06-0148-00	Leo	Big Stone	9020102030	NGP	78					
06-0150-00	Unnamed	Big Stone	9020102030	NGP	29					
06-0151-00	Smithwicks	Big Stone, Traverse	9020102030	NGP	31					
06-0153-00	Unnamed	Big Stone	9020102030	NGP	23					
06-0162-00	Unnamed	Big Stone	9020102030	NGP	115					
06-0163-00	Unnamed	Big Stone	9020102030	NGP	108					
06-0164-00	Unnamed	Big Stone	9020102030	NGP	65					
06-0165-00	Smithwick's Slough	Big Stone	9020102030	NGP	103					
06-0172-00	Unnamed	Big Stone	9020102030	NGP	19					
06-0176-00	Unnamed	Big Stone	9020102030	NGP	127					
06-0177-00	Unnamed	Big Stone	9020102030	NGP	53					

Lake ID	Lake Name	County	HUC – 11	Ecoregion	Lake Area (ha)	Max depth (m)	Mean Depth (m)	Watershed Area (ha)	% Littoral	Aquatic Recreation Use Support²
06-0178-00	Unnamed	Big Stone	9020102030	NGP	82	7			100	
06-0185-00	Unnamed	Big Stone	9020102030	NGP	102					
06-0186-00	Unnamed	Big Stone	9020102030	NGP	75					
06-0187-00	Unnamed	Big Stone	9020102030	NGP	65					
06-0188-00	Unnamed	Big Stone	9020102030	NGP	192					
06-0191-00	Unnamed	Big Stone	9020102030	NGP	43					
06-0216-00	Unnamed	Big Stone	9020102030	NGP	17					
06-0222-00	Unnamed	Big Stone	9020102030	NGP	21					
06-0227-00	Unnamed	Big Stone	9020102030	NGP	20					
06-0234-00	Unnamed	Big Stone	9020102030	NGP	42					
06-0235-00	Unnamed	Big Stone	9020102030	NGP	33					
06-0245-00	Unnamed	Big Stone	9020102030	NGP	30					
06-0249-00	Unnamed	Big Stone	9020102030	NGP	37					
09-0250-00	Unnamed	Big Stone	9020102030	NGP	40					
06-0251-00	Unnamed	Big Stone	9020102030	NGP	60	9.5			100	
06-0252-00	Unnamed	Big Stone	9020102030	NGP	37					
06-0253-00	Unnamed	Big Stone	9020102030	NGP	48					
06-0254-00	Unnamed	Big Stone	9020102030	NGP	16					
06-0255-00	Unnamed	Big Stone	9020102030	NGP	44					
06-0256-00	Unnamed	Big Stone	9020102030	NGP	26					

Lake ID	Lake Name	County	HUC – 11	Ecoregion	Lake Area (ha)	Max depth (m)	Mean Depth (m)	Watershed Area (ha)	% Littoral	Aquatic Recreation Use Support²
06-0262-00	Unnamed	Big Stone	9020102030	NGP	15					
06-0317-00	Unnamed	Big Stone	9020102030	NGP	13					
06-0324-00	Unnamed	Big Stone	9020102030	NGP	18					
06-0351-00	Unnamed	Big Stone	9020102030	NGP	14					
06-0380-00	Unnamed	Big Stone	9020102030	NGP	12					
06-0381-00	Unnamed	Big Stone	9020102030	NGP	13					
26-0110-00	Unnamed	Grant	9020102020	NGP	67					
26-0120-00	Horseshoe	Grant	9020102010	NCHF	117					
26-0121-00	Huset	Grant	9020102010	NGP	126					
26-0126-00	Unnamed	Grant	9020102010	NGP	73					
26-0133-00	Unnamed	Grant	9020102010	NGP	77					
26-0135-00	Unnamed	Grant	9020102010	NGP	25					
26-0140-00	Elbow	Grant	9020102010	NCHF	227					IF
26-0141-00	Trisko	Grant	9020102010	NCHF	62					IF
26-0142-00	Flekkefjord	Grant	9020102010	NCHF	345	5			100	
26-0142-01	Flekkefjord	Grant	9020102010	NCHF						
26-0142-02	Flekkefjord	Grant	9020102010	NCHF						
26-0142-03	Flekkefjord	Grant	9020102010	NCHF						
26-0142-04	Flekkefjord	Grant	9020102010	NCHF						
26-0146-00	Unnamed	Grant	9020102010	NCHF	12					

Lake ID	Lake Name	County	HUC – 11	Ecoregion	Lake Area (ha)	Max depth (m)	Mean Depth (m)	Watershed Area (ha)	% Littoral	Aquatic Recreation Use Support²
26-0147-00	Island	Grant	9020102010	NCHF	142					
26-0147-01	Island (North)	Grant	9020102010	NCHF						
26-0147-02	Island (South)	Grant	9020102010	NCHF						
26-0148-00	Long	Grant	9020102010	NCHF	387					
26-0149-00	Round	Grant	9020102010	NGP	403					
26-0159-00	Four Mile	Grant	9020102010	NCHF	196					
26-0160-00	Field	Grant	9020102010	NCHF	143					
26-0168-00	Unnamed	Grant	9020102010	NCHF	51					
26-0174-00	Scotts	Grant	9020102010	NCHF	131					
26-0182-00	Jones	Grant	9020102010	NGP	93					
26-0183-00	Unnamed	Grant	9020102010	NCHF	81					
26-0184-00	Unnamed	Grant	9020102010	NCHF	51					
26-0185-00	Cottonwood	Stevens, Grant	9020102020	NGP	247	16	10.1		96	IF
26-0186-00	Burr	Grant	9020102010	NGP	123					
26-0188-00	Unnamed	Grant	9020102020	NGP	55					IF
26-0191-00	Unnamed	Grant	9020102020	NGP	37					
26-0194-00	Big	Grant	9020102020	NGP	262					IF
26-0195-00	Johnson	Grant	9020102020	NGP	81					
26-0199-00	Unnamed	Grant	9020102020	NGP	58					IF
26-0201-00	Unnamed	Grant	9020102020	NGP	42					

Lake ID	Lake Name	County	HUC – 11	Ecoregion	Lake Area (ha)	Max depth (m)	Mean Depth (m)	Watershed Area (ha)	% Littoral	Aquatic Recreation Use Support[2]
26-0202-00	Slough	Grant	9020102020	NGP	43					
26-0203-00	Nelson	Grant	9020102020	NGP	105	7			100	IF
26-0204-00	Graham	Grant	9020102020	NGP	131	7			100	
26-0205-00	Unnamed	Grant	9020102020	NGP	62					
26-0206-00	Keitzman Slough	Grant	9020102020	NGP	79					IF
26-0207-00	Doughty	Grant	9020102020	NGP	232					
26-0208-00	Ohlsrud	Grant	9020102020	NGP	183					IF
26-0209-00	Werk Slough	Grant	9020102020	NGP	131					
26-0212-00	Unnamed	Grant	9020102020	NGP	12					
26-0213-00	East Niemaki	Grant	9020102020	NGP	212					IF
26-0214-00	West Niemaki	Grant	9020102020	NGP	75					IF
26-0215-00	Unnamed	Grant	9020102020	NGP	162					IF
26-0216-00	Barrows	Grant	9020102020	NGP	226					
26-0217-00	Unnamed	Grant	9020102020	NGP	48					IF
26-0218-00	Unnamed	Grant	9020102020	NGP	162					IF
26-0224-00	Unnamed	Grant	9020102010	LAP, NGP	81					
26-0227-00	Unnamed	Grant	9020102010	NGP	25					
26-0228-00	Hodgson	Grant	9020102010	NGP	59					
26-0235-00	Mustinka River Flowage	Grant	9020102010	NGP	106	10			99	IF
26-0237-00	Prescott	Grant	9020102010	NGP	48					

Lake ID	Lake Name	County	HUC – 11	Ecoregion	Lake Area (ha)	Max depth (m)	Mean Depth (m)	Watershed Area (ha)	% Littoral	Aquatic Recreation Use Support²
26-0238-00	Moses	Grant	9020102010	NGP	104					
26-0242-00	Unnamed	Grant	9020102010	NGP	20					
26-0243-00	Unnamed	Grant	9020102010	NGP	25					
26-0244-00	Hibrooten	Grant	9020102010	NGP	50					
26-0246-00	Unnamed	Grant	9020102010	NGP	25					
26-0248-00	Phimey	Grant	9020102010	NGP	118					
26-0264-00	Stony Brook	Grant	9020102010	LAP	100					
26-0265-00	Pletan	Grant	9020102010	LAP	62					
26-0275-00	Elling	Grant	9020102010	LAP	25					
26-0277-00	Unnamed	Grant	9020102010	LAP	28					
26-0279-00	Foss	Grant	9020102010	LAP	53					
26-0280-00	Engralson	Grant	9020102010	LAP	42					
26-0282-00	Lightning	Grant	9020102010	LAP	504	11	7	36,273	91	NS
26-0287-00	Unnamed	Grant	9020102010	LAP, NCHF	58					
26-0290-00	Unnamed	Grant	9020102010	LAP	579					
26-0295-00	Unnamed	Stevens, Grant	9020102020	NGP	60					
26-0298-00	Pullman	Grant	9020102020	NGP	134					
26-0299-00	Unnamed	Grant	9020102020	LAP, NGP	110					
26-0300-00	Unnamed	Grant	9020102020	NGP	34					
26-0313-00	Unnamed	Grant	9020102010	NGP	132					

Lake ID	Lake Name	County	HUC – 11	Ecoregion	Lake Area (ha)	Max depth (m)	Mean Depth (m)	Watershed Area (ha)	% Littoral	Aquatic Recreation Use Support[2]
26-0343-00	Unnamed	Grant	9020102020	NGP	74					IF
26-0347-00	Unnamed	Grant	9020102020	NGP	21					
26-0348-00	Unnamed	Grant	9020102010	NCHF	10					
26-0350-00	Unnamed	Grant	9020102010	NCHF, LAP	10					
26-0353-00	Unnamed	Grant	9020102010	NCHF, LAP	11					
26-0379-00	Unnamed	Grant	9020102010	NGP	12					
26-0382-00	Unnamed	Grant	9020102010	NGP	14					
26-0383-00	Unnamed	Grant	9020102010	NGP	12					
26-0392-00	Unnamed	Grant	9020102020	LAP	19					
26-0407-00	Unnamed	Grant	9020102010	NGP	17					
26-0408-00	Unnamed	Grant	9020102010	NGP	25					
56-0608-00	Unnamed	Otter Tail	9020102010	NCHF	20					
56-0609-00	Unnamed	Otter Tail	9020102010	NCHF	52					
56-0610-00	Unnamed	Otter Tail	9020102010	NCHF	19					
56-0787-00	Unnamed	Otter Tail	9020102010	NCHF	20					
56-0788-00	Unnamed	Otter Tail	9020102010	NCHF	34					
56-0790-00	Unnamed	Otter Tail	9020102010	NCHF, LAP	89					
56-0794-00	Unnamed	Otter Tail	9020102010	NCHF, LAP	33					
56-0797-00	Unnamed	Otter Tail	9020102010	NCHF, LAP	131					
56-0799-00	Unnamed	Otter Tail	9020102010	LAP	26					

Lake ID	Lake Name	County	HUC – 11	Ecoregion	Lake Area (ha)	Max depth (m)	Mean Depth (m)	Watershed Area (ha)	% Littoral	Aquatic Recreation Use Support²
56-0804-00	Mud	Otter Tail	9020102010	NCHF	253					IF
56-0805-00	Unnamed	Otter Tail	9020102010	NCHF	26					
56-0812-00	Unnamed	Otter Tail	9020102010	NCHF	29					
56-0814-00	Unnamed	Otter Tail	9020102010	NCHF, LAP	24					
56-0853-00	Unnamed	Grant	9020102010	NCHF	36					
56-1115-00	Unnamed	Otter Tail	9020102010	NCHF	10					
56-1116-00	Unnamed	Otter Tail	9020102010	NCHF, LAP	49					
56-1387-00	Unnamed	Otter Tail	9020102010	NCHF	26					
56-1390-00	Unnamed	Otter Tail	9020102010	NCHF	18					
56-1414-00	Unnamed	Otter Tail	9020102010	LAP	49					
75-0149-00	Unnamed	Stevens	9020102020	NGP	170					
75-0155-00	Unnamed	Stevens	9020102040	NGP	138					
75-0219-00	Unnamed	Stevens	9020102040	NGP	45					
75-0238-00	Moose Island	Stevens	9020102040	NGP	108					
75-0241-00	Unnamed	Stevens	9020102020	NGP	162					IF
75-0245-00	Barrett	Stevens	9020102020	NGP	157					
75-0250-00	Unnamed	Stevens	9020102020	NGP	61					
75-0253-00	Unnamed	Stevens	9020102020	NGP	16					
75-0258-00	Unnamed	Stevens	9020102040	NGP	64					IF
75-0266-00	Unnamed	Stevens	9020102040	NGP	85					

Lake ID	Lake Name	County	HUC – 11	Ecoregion	Lake Area (ha)	Max depth (m)	Mean Depth (m)	Watershed Area (ha)	% Littoral	Aquatic Recreation Use Support[2]
75-0268-00	Unnamed	Stevens	9020102040	NGP	99					
75-0277-00	Fish	Stevens	9020102040	NGP	267					
75-0291-00	Gravel	Stevens	9020102040	NGP	117					
75-0304-00	Unnamed	Stevens	9020102020	NGP	95					
75-0310-00	Mud	Stevens	9020102040	NGP	95					
75-0320-00	Unnamed	Stevens	9020102040	NGP	127					
75-0348-00	Unnamed	Stevens	9020102040	NGP	10					IF
75-0350-00	Unnamed	Stevens	9020102040	NGP	15					
75-0351-00	Unnamed	Stevens	9020102040	NGP	22					
75-0391-00	Unnamed	Stevens	9020102040	NGP	14					
78-0001-00	St. Mary's	Traverse	9020102030	NGP	208					
78-0004-00	Unnamed	Traverse	9020102030	NGP	176					
78-0006-00	Unnamed	Traverse	9020102030	NGP	25					
78-0020-00	Unnamed	Traverse	9020102060	NGP	45					
78-0021-00	Unnamed	Traverse	9020102060	NGP	54					

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: 09020102010 (Mustinka River)							
09020102-503	05RD125	Mustinka River	793.05	1	39	0	8/21/2006
09020102-538	10RD042	Unnamed Creek	20.17	3	51	9	7/27/2010
09020102-580	10RD037	Mustinka River	150.83	2	45	25	6/16/2010
09020102-582	10RD036	Mustinka River	171.30	2	45	60	6/16/2010
HUC 11: 09020102020 (Five Mile Creek)							
09020102-578	10RD054	Unnamed Ditch	10.85	3	51	0	6/9/2010
HUC 11: 09020102030 (West Branch Mustinka River) *See appendix 5.2*							
HUC 11: 09020102040 (Twelve Mile Creek)							
09020102-514	10RD057	Twelve Mile Creek	167.36	2	45	0	7/27/2010
09020102-514	10RD057	Twelve Mile Creek	167.36	2	45	0	6/10/2010
09020102-514	10RD059	Twelve Mile Creek	145.04	2	45	19	6/10/2010
09020102-557	05RD008	Twelve Mile Creek	493.41	1	39	21	7/27/2006
09020102-557	10RD055	Twelve Mile Creek	514.72	1	39	46	7/26/2010
09020102-557	10RD056	Twelve Mile Creek	360.72	1	39	8	6/17/2010
09020102-557	10RD056	Twelve Mile Creek	360.72	1	39	26	7/27/2010
HUC 11: 09020102060 (Eighteen Mile Creek)							
09020102-508	10RD045	Eighteen Mile Creek	50.07	2	45	0	7/7/2010

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: 09020102010 (Mustinka River)							
09020102-503	05RD125	Mustinka River	793.05	2	30.7	18.58	9/19/2005
09020102-538	10RD042	Unnamed Creek	20.17	7	38.3	24.66	8/9/2010
09020102-582	10RD036	Mustinka River	171.30	7	38.3	37.63	8/10/2010
09020102-580	10RD037	Mustinka River	150.83	5	35.9	46.1	8/10/2010
HUC 11: 09020102040 (Twelve Mile Creek)							
09020102-514	10RD057	Twelve Mile Creek	167.36	7	38.3	47.2	8/2/2010
09020102-514	10RD059	Twelve Mile Creek	145.04	7	38.3	12.9	8/2/2010
09020102-557	05RD008	Twelve Mile Creek	493.41	7	38.3	28.8	9/19/2005
09020102-557	10RD055	Twelve Mile Creek	514.72	2	30.7	17.2	8/3/2010
09020102-557	10RD056	Twelve Mile Creek	360.72	7	38.3	20.2	8/10/2010
HUC 11: 09020102060 (Eighteen Mile Creek)							
09020102-508	10RD045	Eighteen Mile Creek	50.07	2	45	0	6/7/2010

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 (non-assessed)

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Good	Fair	Poor	FIBI	Visit Date
HUC 11: 09020102010 (Mustinka River)									
09020102-506	10RD044	Mustinka River	7.59	7			x	0	7/14/2010
09020102-559	10RD041	Unnamed Creek	11.19	3			x	12	6/7/2010
09020102-561	10RD038	Unnamed Creek	24.67	3		x		39	6/8/2010
09020102-562	10EM170	Unnamed Creek	15.49	3			x	0	6/8/2010
09020102-582	10RD034	Mustinka River	192.20	2		x		44	6/16/10
09020102-518	10RD033	Mustinka River	199.27	2		x		42	7/26/10
09020102-502	10RD032	Mustinka River	761.35	1	x			69	7/27/2010
HUC 11: 09020102020 (Five Mile Creek)									
09020102-564	10RD050	Unnamed Creek	65.02	2	x			44	6/9/2010
HUC 11: 09020102030 (West Branch Mustinka River)									
09020102-512	10RD078	Judicial Ditch 4	16.78	7			x	22	6/9/2010
09020102-527	10RD076	County Ditch 8	12.67	3			x	21	6/9/2010
09020102-532	10RD077	Unnamed Creek	38.44	2			x	11	6/9/2010
HUC 11: 09020102040 (Twelve Mile Creek)									
09020102-513	05RD117	Twelve Mile Creek	30.34	2			x	0	8/24/2005
09020102-513	10RD062	Twelve Mile Creek	85	2			x	0	6/10/2010
09020102-579	10RD049	Twelve Mile Creek	102.89	2		x		43	6/9/2010
HUC 11: 09020102060 (HUC Name)									
No non-assessed channelized reach									

Appendix 5.3 - Channelized stream reach and AUID IBI scores-macro invertebrates (non- assessed)

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: 09020102010 (Mustinka River)									
09020102-506	10RD044	Mustinka River	7.59	7			x	13.7	9/21/2010
09020102-559	10RD041	Unnamed Creek	11.19	7			x	17.95	8/5/2010
09020102-561	10RD038	Unnamed Creek	24.67	7			x	7.66	8/10/2010
09020102-562	10EM170	Unnamed Creek	15.49	7			x	16.24	8/10/2010
09020102-582	10RD034	Mustinka River	192.20	7	x			41.2	8/9/2010
09020102-518	10RD033	Mustinka River	199.27	7		x		31.8	8/3/2010
09020102-502	10RD032	Mustinka River	761.35	2			x	14.3	8/3/2010
HUC 11: 09020102020 (Five Mile Creek)									
09020102-564	10RD050	Unnamed Creek	65.02	7			x	7.15	8/2/2010
HUC 11: 09020102030 (West Branch Mustinka River)									
09020102-512	10RD078	Judicial Ditch 4	16.78	7			x	14.14	8/4/2010
HUC 11: 09020102040 (Twelve Mile Creek)									
09020102-513	05RD117	Twelve Mile Creek	30.34	7			x	21.54	9/19/2005
09020102-579	10RD049	Twelve Mile Creek	102.89	7			x	22.37	8/3/2010

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 Mustinka 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
06-0138-00	East Toqua	583	147	33.9	96.5	0.3	0.5	1,632	11,583		91	7.10	4.0	1.59	
06-0139-00	Lannon	764	439	29.3	476.7	0.3	0.2	1,569	10,101		72	6.44	0.3	3.05	
26-0282-00	Lightning*	157	198	44.4	149.5	0.9	0.4	1,560	27,356	23.2	87	17.53	2.0	3.48	

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