Upper/Lower Red Lake Watershed Monitoring and Assessment Report

Minnesota Pollution Control Agency

June 2017

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Minnesota Department of Agriculture
Red Lake Department of Natural Resources
Red Lake Watershed District

Project dollars provided by the Clean Water Fund
(from the Clean Water, Land and Legacy Amendment).

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Document number: wq-ws3-09020302b

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List of Acronyms

AUID Assessment Unit Identification Determination

CI Confidence Interval

CLMP Citizen Lake Monitoring Program

CSAH County State Aid Highway

CSMP Citizen Stream Monitoring Program

CWA Clean Water Act

CWLA Clean Water Legacy Act

DNR Minnesota Department of Natural Resources

EPA U.S. Environmental Protection Agency

EQuIS Environmental Quality Information System

FIBI Fish Index of Biotic Integrity

FWMC Flow Weighted Mean Concentration

HUC Hydrologic Unit Code

IBI Index of Biotic Integrity**IWM** Intensive Watershed Monitoring

LRVW Limited Resource Value Water

MCL Maximum Contaminant Level

MDA Minnesota Department of Agriculture

MDH Minnesota Department of Health

MIBI Macroinvertebrate Index of Biotic Integrity

MINLEAP Minnesota Lake Eutrophication Analysis Procedure

MPCA Minnesota Pollution Control Agency

MSHA Minnesota Stream Habitat Assessment

NCHF North Central Hardwood Forest

Nitrate-N Nitrate Plus Nitrite Nitrogen

NHD National Hydrologic Dataset

NH3 Ammonia

NLF Northern Lakes and Forests Ecoregion

PCB Poly Chlorinated Biphenyls

PFOS Perfluorooctane Sulfonate

PWI Protected Waters Inventory

RLDNR Red Lake Department of Natural Resources

RNR River Nutrient Region

SWAG Surface Water Assessment Grant

SWCD Soil and Water Conservation District

TMDL Total Maximum Daily Load

TP Total Phosphorous

TSS Total Suspended Solids

UAA Use Attainability Analysis

USGS United States Geological Survey

WIMN What's In My Neighborhood

WPLMN Water Pollutant Load Monitoring Network

Executive summary

The Upper/Lower Red Lake Watershed covers 1,263,678 acres (1,974 square miles) of northern Minnesota. Most of this forested watershed is located in the Minnesota Northern Wetlands Ecoregion (NCHF). Smaller portions of the watershed are located in the North Central Hardwood Forest Ecoregion and Northern Lakes and Forests (NLF) Ecoregion. Extensive areas of black spruce bog and other wetland types are present in the northern and eastern portions of the watershed. Upper and Lower Red Lake, two of the largest bodies of water in Minnesota, are located within the watershed. Due to the sheer size of these lakes, open water accounts for almost 25% of the watersheds surface area. Other major lakes found within the watershed include Blackduck, Puposky, Bartlett, Medicine, White Fish, Balm, and Kesagiagan. Major rivers within the Upper/Lower Red Lake Watershed include the Blackduck River, South Cormorant River, North Cormorant River, Battle River, Tamarac River, and Sandy River. Other smaller tributaries within the watershed include the North Branch of the Battle River, South Branch of the Battle River, Lost River, Mud River, Little Tamarac River, Shotley Brook, O'Brien Creek, and Pike Creek. A substantial portion of the watershed lies within the Red Lake Indian Reservation. Less than 2% of the land within the watershed is considered developed. Agricultural land use, consisting primarily of pasture and hay production, occurs primarily within the southeastern portion of the watershed. Only 0.8% of the land is utilized for row crop production. The vast expanses of wetland and forest combined with light development promote good water quality within the Upper/Lower Red Lake Watershed.

In 2014, the Minnesota Pollution Control Agency (MPCA) began an intensive watershed monitoring (IWM) effort of lakes and streams within the Upper/Lower Red Lake Watershed. Thirty-five stream sites were sampled for biology at the outlet of variable sized subwatersheds. As part of this effort, MPCA contracted with the Red Lake Department of Natural Resources (RLDNR) to complete water chemistry sampling on 16 stream reaches. In 2016, lakes and streams with sufficient data were assessed for aquatic life, aquatic recreation, and aquatic consumption use support. Considerable data was provided by the RLDNR. The RLDNR monitored numerous lakes within the reservation boundary and provided this data to the MPCA for assessment despite the fact that the agency was unable to provide funding for this monitoring. During this process, 28 stream segments were assessed for aquatic life; 20 were assessed for aquatic recreation. Sixty-six lakes were assessed for aquatic recreation and five lakes were assessed for aquatic life.

Eighteen stream segments fully supported aquatic life. The remaining 10 segments did not support aquatic life and were considered impaired. Twelve of the stream segments assessed for aquatic recreation were found to be impaired. Seven aquatic life impairments were the result of poor fish and/or macroinvertebrate communities. In some cases, the poor biological communities were attributed to a lack of habitat heterogeneity (i.e. limited habitat types). Excess fine sediment was covering coarse substrate or reducing channel development in these reaches. Other biological impairments appear to be the result of low dissolved oxygen (DO) from natural wetland influence. Wetlands have a profound effect on the aquatic ecosystems within the Upper/Lower Red Lake Watershed. The flushing of organic matter from wetlands into streams causes DO levels to decline significantly. Such phenomenon were observed during intensive water chemistry monitoring on the Tamarac River and North Branch of the Battle River. Other systems in the watershed likely experience reduced DO from wetland input. The remaining three aquatic life impairments were the result of low DO and/or elevated Total Suspended Solids (TSS). The Upper/Lower Red Lake Watershed has approximately 214 lakes. Of the 66 lakes assessed for aquatic recreation, 7 were found to not support aquatic recreation.

Introduction

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

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

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

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

This watershed-wide monitoring approach was implemented in the Upper/Lower Red Lake Watershed beginning in the summer of 2014. This report provides a summary of all water quality assessment results in the Upper and Lower Red Lake Watershed and incorporates all data available for the assessment process including watershed monitoring, volunteer monitoring and monitoring conducted by local government units.

The watershed monitoring approach

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

Intensive watershed monitoring

The intensive watershed monitoring strategy utilizes a nested watershed design allowing the sampling of streams within watersheds from a coarse to a fine scale (Figure 1). Each watershed scale is defined by a hydrologic unit code (HUC). These HUCs define watershed boundaries for water bodies within a similar geographic and hydrologic extent. The foundation of this approach is the 80 major watersheds (8-HUC) within Minnesota. Using this approach, many of the smaller headwaters and tributaries 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, aggregated 12-HUC and 14-HUC (Figure 1). Within each scale, different water uses are assessed based on the opportunity for that use (i.e., fishing, swimming, supporting aquatic life such as fish and insects). The major river watershed is represented by the 8-HUC scale. The outlet of the major 8-HUC watershed (purple dot in Figure 2) is sampled for biology (fish and macroinvertebrates), water chemistry and fish contaminants to allow for the assessment of aquatic life, aquatic recreation and aquatic consumption use support. The aggregated 12-HUC is the next smaller subwatershed scale which, generally consists of major tributary streams with drainage areas ranging from 75 to 150 mi2. Each aggregated 12-HUC outlet (green triangles in Figure 2) is sampled for biology and water chemistry for the assessment of aquatic life and aquatic recreation use support. Within each aggregated 12-HUC, smaller watersheds (14 HUCs, typically 10-20 mi2), are sampled at each outlet that flows into the major aggregated 12-HUC tributaries. Each of these minor subwatershed outlets is sampled for biology to assess aquatic life use support (red dots in Figure 2).

Figure 1. The Intensive Watershed Monitoring Design.

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

Specific locations for sites sampled as part of the intensive monitoring effort in the Upper/Lower Red Lake Watershed are shown in Figure 2 and are listed in Appendices 2.1 and 2.2.

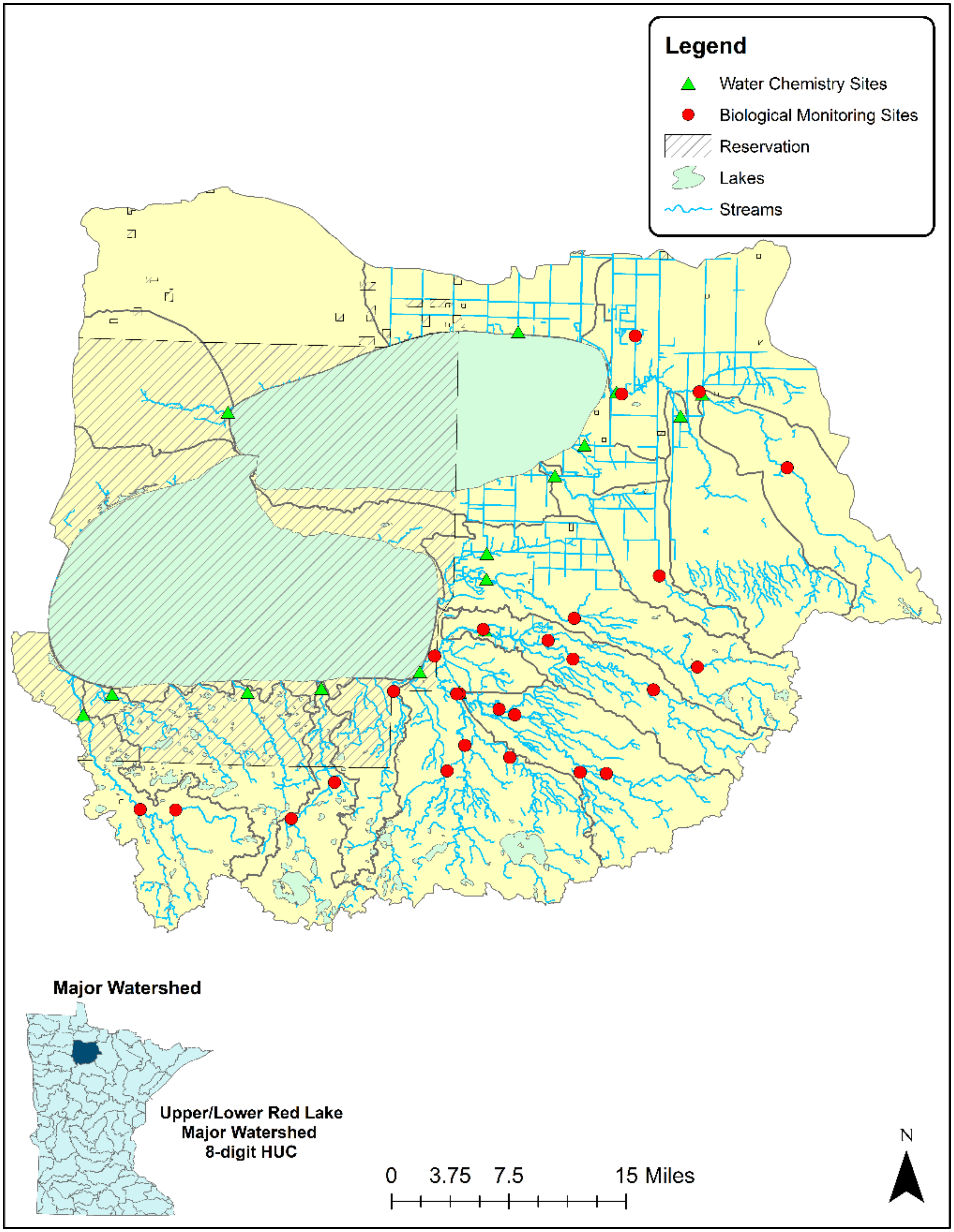


Figure 2. Intensive Watershed Monitoring Sites for Streams in the Upper/Lower Red Lake Watershed.

Citizen and local monitoring

Citizen and local monitoring is an important component of the watershed approach. The MPCA and its local partners jointly select the stream sites and lakes to be included in the intensive watershed monitoring 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 3 provides an illustration of the locations where citizen monitoring data were used for assessment in the Upper/Lower Red Lake Watershed.

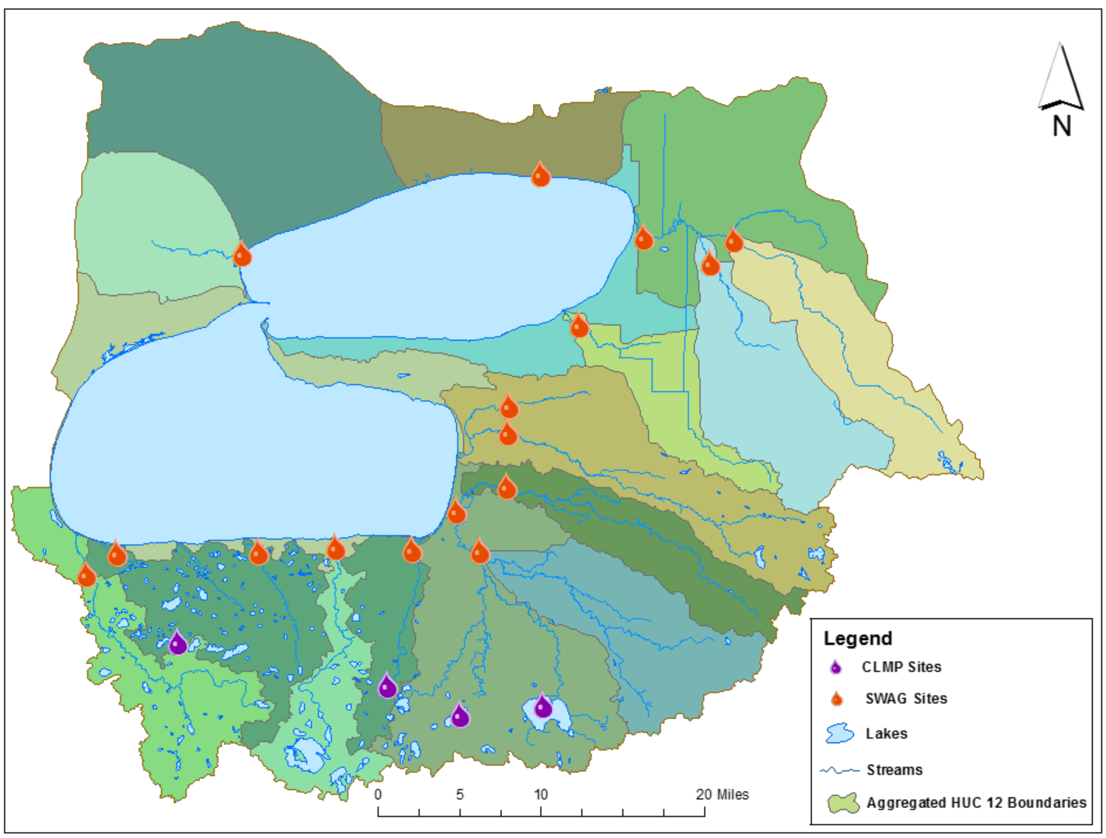


Figure 3. Monitoring Locations of Local Groups, Citizens and the MPCA Lake Monitoring Staff in the Upper/Lower Red Lake Watershed.

Assessment methodology

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

Water quality standards

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

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

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

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

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

Table 1. Table of Proposed Tiered Aquatic Life Use Standards.

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

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

Assessment units

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

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

Determining use attainment

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

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

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

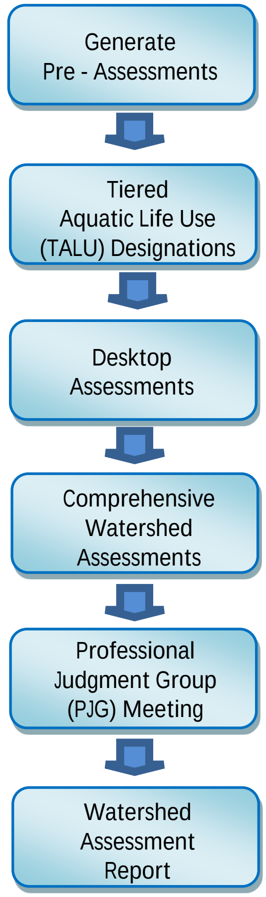


Figure 4. Flowchart of aquatic life use assessment process.

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

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

Watershed overview

The Upper/Lower Red Lake Watershed covers 1,263,678 acres (1,974 square miles) of northern Minnesota. The majority of the watershed is within Beltrami County; however, portions are found within Koochiching, Itasca, and Clearwater County. The Red Lake Indian Reservation encompasses a portion of the watershed. Most of the watershed is forested and contains large areas of wetland and open water. Agricultural land use, consisting primarily of pasture and hay production, occurs mostly within the southeastern region. Approximately 214 lakes are in the Upper/Lower Red Lake Watershed. The two largest lakes, Upper and Lower Red Lake, encompass an area of 288,800 acres and are the two largest bodies of water in Minnesota. These lakes are an important resource that the Red Lake Band of Ojibwe use for sustenance and commercial fishing. Other major lakes include Blackduck, Puposky, Bartlett, Medicine, White Fish, Balm, and Kesagiagan. Major tributaries within the watershed include the Sandy River, Blackduck River, South Cormorant River, North Cormorant River, North Branch of the Battle River, South Branch of the Battle River, Battle River, Lost River, and Tamarac River. Other smaller tributaries include Big Rock Creek, Little Rock Creek, Pike Creek, Mud River, Hay Creek, O'Brien Creek, and Shotley Brook. Municipalities within the watershed include Blackduck, Kelliher, Redby, Red Lake, and Waskish.

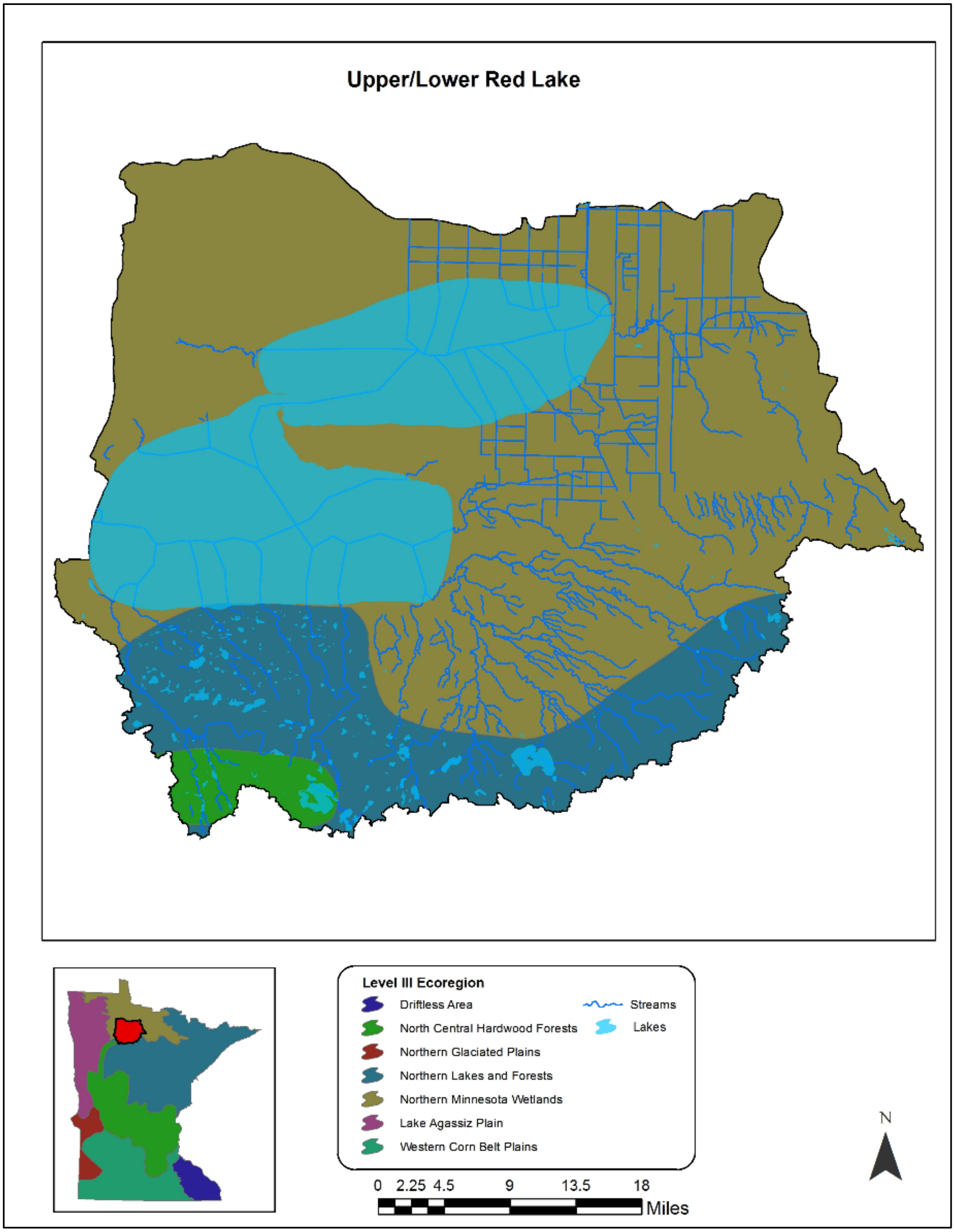


Figure 5. The Upper/Lower Red Lake Watershed lies within the Northern Minnesota Wetlands Ecoregion, Northern Lakes and Forests Ecoregion, and Northern Central Hardwood Forests Ecoregion.

The Upper/Lower Red Lake Watershed lies within three ecoregions – the Northern Minnesota Wetlands Ecoregion (NMW), NCHF, and Northern Lakes and Forests Ecoregion (NLF) (Figure 6). The majority of the watershed lies within the NMW ecoregion. The NMW ecoregion is characterized by extensive areas of standing water and flat topography; wetland and boreal forest dominate the landscape (Omernik *et al.* 1988). The NLF ecoregion extends across the entire southern edge of the watershed and borders the southern shoreline of Lower Red Lake. Moraine hills, undulating till plains, and lacustrine basins occur in the NLF ecoregion (Omernik *et al.* 1988). Both hardwood forests and coniferous forests commonly occur within this ecoregion (Omernik *et al.* 1988). The majority of the lakes within the Upper/Lower Red Lake Watershed are located in this ecoregion. Lakes within this region are often clear due to low nutrient input from the infertile soil and forested watersheds. A small portion of the southwest corner of the watershed lies within the NCH ecoregion. The soils within the NCH ecoregion are generally fertile and suitable to row crop agriculture. Forests, wetlands, lakes, pasture, and croplands are all found within this ecoregion.

Land use summary

The Upper/Lower Red Lake Watershed was originally occupied by the Dakota Indian tribe; the Ojibwe tribe arrived in the area during the mid to late 1600s (Red Lake Nation 2017). The Ojibwe gained control of the land within the watershed as well as the surrounding land stretching to the north and far west. Eventually French explorers and fur traders came to the area; many French Canadian fur traders formed an alliance with the Ojibwe and settled in the area (Red Lake Nation 2017). In the 1860s, the Red Lake Band of Ojibwe began giving up land through negotiations with the US government (Red Lake Nation). The negotiations and agreements continued into the early 1900s (Hagg 1972). The amount of land held by the Red Lake Band of Ojibwe was significantly reduced. Unlike other reservations in Minnesota, the Red Lake Band of Ojibwe refused to have their diminished reservation lands allotted by the Dawes Act of 1887 (Red Lake Nation 2017). All of the land on the remaining reservation, which includes a substantial portion of the Upper/Lower Red Lake Watershed, is held in common by members of the band. Logging became a prominent industry within the reservation and throughout the watershed during the late 1800s. By the mid to late 1800s, most of the white pine in Minnesota had been cut; however, existing treaties prevented logging within reservations (MAICC 2016). The passage of the Nelson Act, along with negotiations with the Red Lake Band of Ojibwe, opened reservation lands to logging (Red Lake Nation). In 1898, a logging railroad was constructed that ran from the town of Nebish to the southern shore of Lower Red Lake in order to log pinelands in areas of reservation land ceded under terms of the Nelson Act (Hagg 1972). The US Department of Interior also granted permission to construct a railroad line along the southern shore of Red Lake within the diminished reservation land (Hagg). By December of 1898, the logging railroad ran from Nebish to Redby (Hagg). A line was constructed from Nebish to Bemidji in the early 1900s, providing for the creation of new towns and the transportation of goods and people throughout much of the southern Upper/Lower Red Lake Watershed (Hagg). In 1916, a large area of the southeastern portion of the Red Lake Reservation was opened up to logging (Hagg). Heavy logging continued within this area through the late 1920s.

As logging began to decline, lumber companies sold cutover land to farmers and other settlers (Larson, 2007). Clearing the land proved to be very difficult and as a result most cutover farms remained small (Granger and Kelly 2005). Many of the ceded lands outside of the reservation (especially to the north, northwest, and northeast of Upper Red Lake) featured poor natural drainage and were not suitable for agricultural land use. In 1906, Congress authorized the drainage of these wet lands that had originally been ceded by the Chippewa Indians in an attempt to reclaim some of these lands for other uses (A Red Lake Project History). Drainage ditches were constructed throughout the Upper and Lower Red Lake Watershed area during the years 1910-1916 (A Red Lake Project History). Some of the lands benefitted from these drainage ditches; however, most lowland areas still remained too wet to support agricultural land use (A Red Lake Project History). Despite years of effort to improve drainage, wetlands still account for 48% of the land area within the watershed (Figure 6). Less than 1% of the land within the Upper/Lower Red Lake Watershed is used for crop production. Approximately 6% of the land within the watershed is utilized for pasture or hay. The NRCS estimates that there are 445 farms within the watershed; over 80% of these farms are under 500 acres in size (USDA). Upper and Lower Red Lake, two of the largest bodies of water within Minnesota, occupy 440 square miles (284,000 acres) of area within the watershed. These two large bodies of water combined with other lakes comprise 24% of watersheds surface area. Only 1.5% of the Upper/Lower Red Lake Watershed is developed. The majority of the communities within the watershed are small and feature less than 200 people.

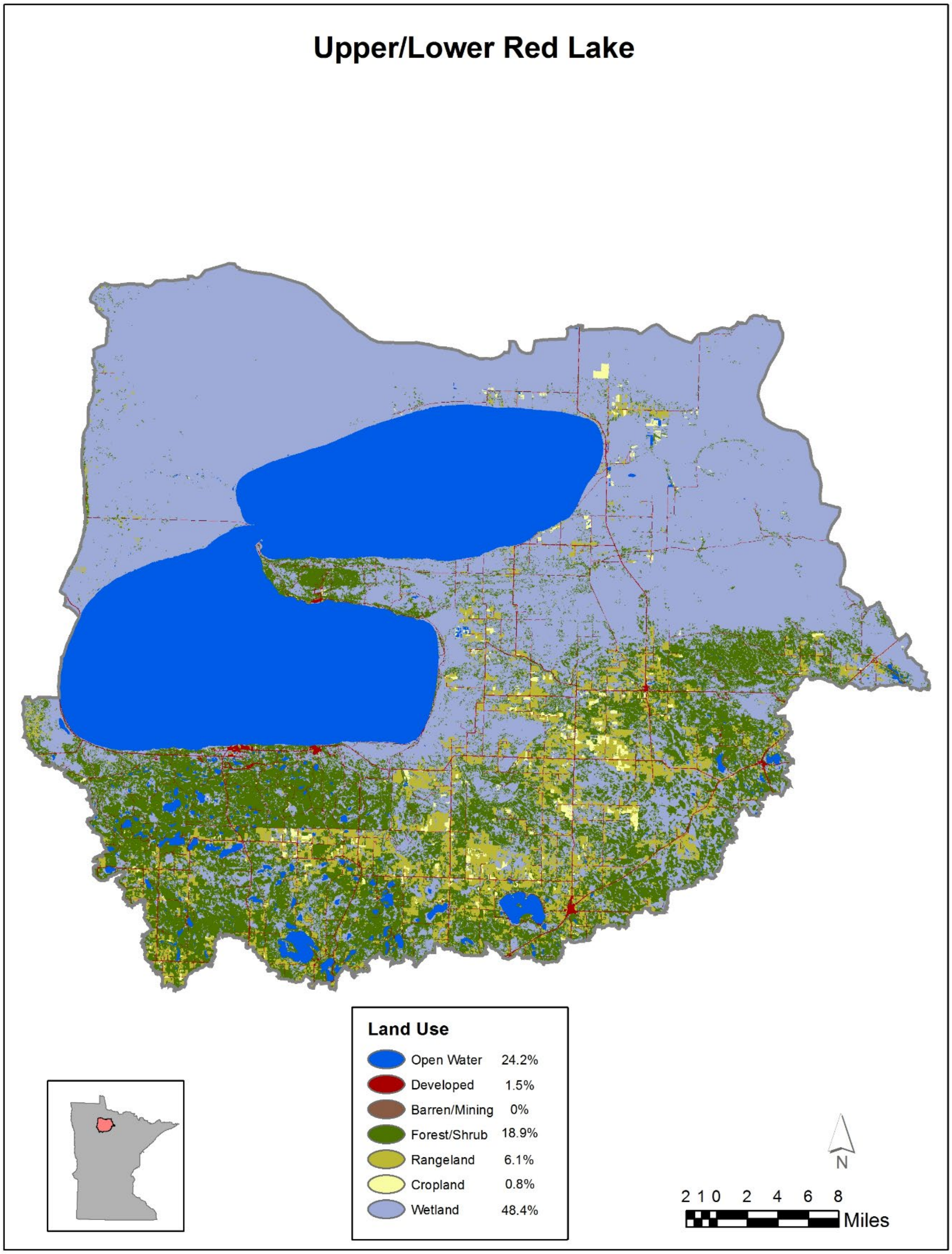


Figure 6. Land Use in the Upper/Lower Red Lake Watershed.

Surface water hydrology

The Red Lake River serves as the only outlet of Upper and Lower Red Lake; however, numerous tributaries flow into both lakes. Significant tributaries that flow directly into Lower Red Lake (from west to east) include the Sandy River, Pike Creek, Mud River, Hay Creek, Blackduck River, and Battle River. The Sandy River originates from Sandy Lake and flows northwest for 25 miles along the southwestern edge of the Upper/Lower Red Lake Watershed before entering Lower Red Lake. The river passes through some agricultural land (pasture and hay) before entering the heavily forested Red Lake Reservation. Pike Creek originates from a complex of small wetland lakes located 3 miles north of Lake Puposky. The stream flows north for 14 miles, passing through the Red Lake Reservation and the community of Red Lake before entering Lower Red Lake. The Mud River originates from Lake Puposky and winds northward through areas of agricultural land for approximately 10 miles before entering the Red Lake Reservation. The Mud River continues through the forests and wetlands of the reservation, passing by the community of Redby before entering Lower Red Lake. Hay Creek originates from a wetland just southeast of Nebish. The stream flows north for approximately 15 miles, passing along hayfields and through forests before entering Lower Red Lake.

The Blackduck River and its numerous tributaries collectively drain a large portion of land located in the southeast corner of the Upper/Lower Red Lake Watershed. The Blackduck River originates from Blackduck Lake and flows northwest for approximately 17 miles before being joined by O'Brien Creek. O'Brien Creek originates from a forested area just west of Blackduck Lake and flows north. Darrigans Creek and several small unnamed streams flow into O'Brien Creek. Significant areas of row crop and hay/pasture land occur within the O'Brien Creek Watershed. Three miles after the confluence of O'Brien Creek, the Blackduck River is joined by the South Cormorant River. The South Cormorant River originates from a series of small wetlands by Funkley and flows 31 miles toward the west. Several small tributaries, including Fish Creek, Spring Creek, and Perry Creek, flow into the South Cormorant River. The land within the South Cormorant River Watershed is interspersed with row crop, hay, pasture, and forest. The North Cormorant River enters the Blackduck River approximately 8 miles after the confluence of the South Cormorant River. The North Cormorant River originates from a wetland area a few miles north of where the South Cormorant River begins. The majority of the land along the 40-mile flow length of the North Cormorant River is used for hay, pasture, or row crop production. Numerous tributaries, including Haden and Meadow Creek, flow into the North Cormorant River. After the confluence of the North Cormorant River, the Blackduck River winds toward the southwest before emptying into Lower Red Lake.

The North and South Branch of the Battle River join together to form the main branch of the Battle River. The Battle River has a short flow length (< 3 miles); however, the North and South Branch of the Battle have flow lengths of 13 miles and 35 miles, respectively. Originating from Battle Lake, the South Branch of the Battle flows northwest for approximately 8 miles before becoming a designated cold water stream. The cold water segment is approximately 5 miles long and is located just south of Kelliher. A small tributary stream named Armstrong Creek joins the cold water segment of the South Branch of the Battle River. The river continues winding westward, passing through agricultural land and forest before joining the North Branch of the Battle River. The North Branch of the Battle River originates from a large wetland complex 5 miles northwest of Kelliher. The river flows west for seven miles before turning south to join with the South Branch of the Battle River. Numerous ditches flow into the North Branch of the Battle River from both the south and north. Most of the land along the North Branch of the Battle River is wetland and forest with some agricultural land near the confluence of the South Branch of the Battle River.

Shotley Brook and the Tamarac River are the most prominent tributaries that flow directly into Upper Red Lake. An extensive network of ditches also flow into Upper Red Lake – especially along the north and southeastern shoreline. The ditches along the north shore drain approximately 60 square miles of land. Shotley Brook originates from a large wetland just west of HWY 72. Several ditches enter the stream from the north and south at this location. These ditches are connected to a larger network of ditches, which drain the land north and south of Shotley Brook. Shotley Brook flows west for three miles before turning toward the northwest and winding another nine miles before emptying into Upper Red Lake.

The Tamarac River and its tributaries pass through bogs and wetlands in some of the most remote land within the Upper/Lower Red Lake Watershed. The Tamarac River originates from a large wetland complex in the east central region of the Upper/Lower Red Lake Watershed. The rivers gradient is low with an extensive wetland riparian along most of its 23-mile flow length. The Lost River, Little Tamarac River, and numerous ditches flow into the Tamarac River. The ditch network on the north side of the river drains approximately 70 square miles of land. The Tamarac River flows west for approximately 7 miles before joining the Lost River. The Lost River originates in the heavily forested far southeast corner of the Upper/Lower Red Lake Watershed. The river flows north for approximately 20 miles before turning toward the west and joining the Tamarac River. Most of the river has a low gradient and features a wetland riparian. Two miles after the confluence of the Lost River, the Tamarac River is joined by the Little Tamarac River. The Little Tamarac River originates from a densely forested area within the Pine Island State Forest and flows north for 14 miles before joining the Tamarac River. Other smaller tributaries to Upper and Lower Red Lake include Big Rock Creek, Little Rock Creek, and Manomin Creek.

Besides Upper and Lower Red Lake, most lakes within the watershed are small (< 300 acres) and concentrated within the Northern Lakes and Forests ecoregion, south of Lower Red Lake. Major lakes include: Kesagiagan, Balm, Island, Puposky, Julia, Whitefish, Medicine, and Blackduck.

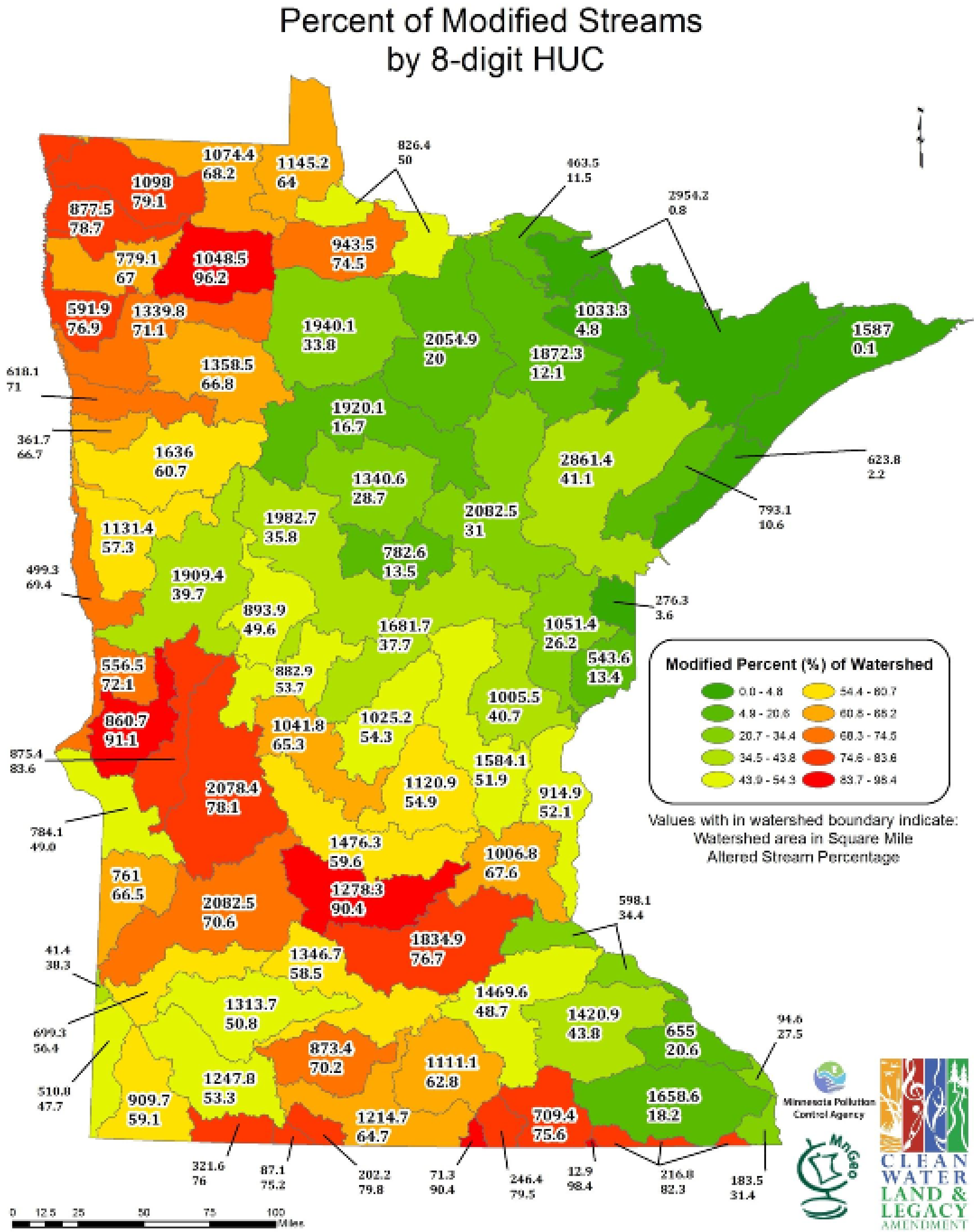


Figure 7. Map of Percent Modified Streams by Major Watershed (8-HUC).

Climate and precipitation

Minnesota has a continental climate, marked by warm summers and cold winters. The mean annual temperature for Minnesota is 4.6˚C (NOAA, 2016); the mean summer (June-August) temperature for the Upper/Lower Red Lake Watershed is 17.2˚C and the mean winter (December-February) temperature is -13.9˚ C (MDNR: Minnesota State Climatology Office, 2003). Precipitation is an important source of water input to a watershed. Figure 8 displays two representations of precipitation for calendar year 2014. On the left is total precipitation, showing the typical pattern of increasing precipitation toward the eastern portion of the state. According to this figure, the Upper/Lower Red Lake Watershed area received 20 to 24 inches of precipitation in 2014. The display on the right shows the amount that precipitation levels departed from normal. The Upper/Lower Red Lake Watershed area primarily experienced precipitation that ranged from two to four inches below normal in 2014.

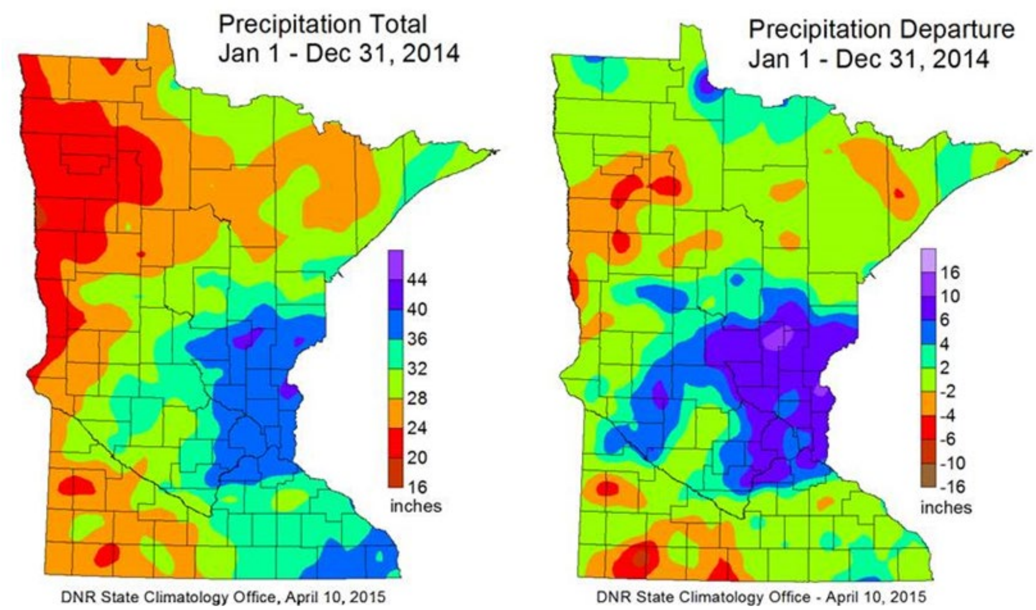


Figure 8. Statewide Precipitation Total (left) and Precipitation Departure (right) during 2014. (Source: MDNR State Climatology Office, 2015)

The Upper/Lower Red Lake Watershed is located within the North Central precipitation region. Figure 9 and Figure 10 display the areal average representation of precipitation in North Central Minnesota for 20 and 100 years, respectively. An areal average is a spatial average of all the precipitation data collected within a certain area presented as a single dataset. Though rainfall can vary in intensity and time of year, rainfall totals in the North Central region display no significant trend over the last 20 years. However, precipitation in North Central Minnesota exhibits a significant rising trend over the past 100 years ($p=0.01$). This is a strong trend and matches similar trends throughout Minnesota.

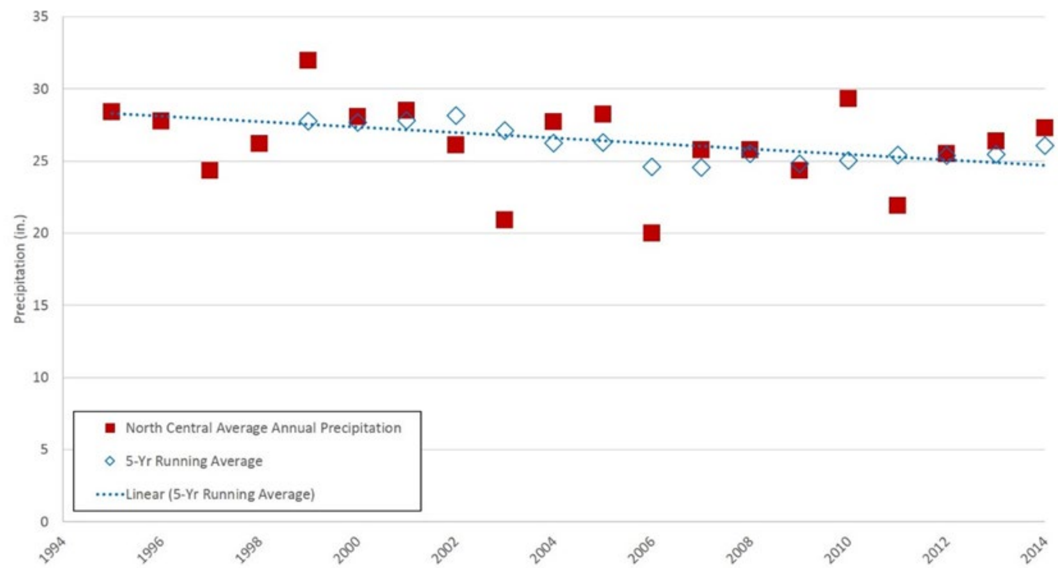


Figure 9. Precipitation Trends in North Central Minnesota (1995-2014) with 5-Year Running Average (Source: WRCC, 2016).

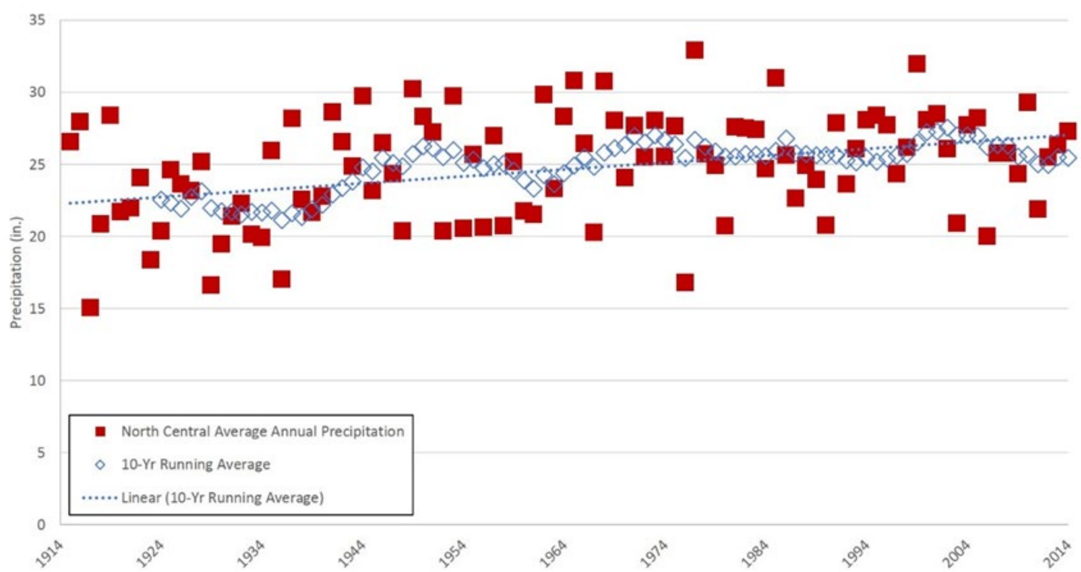


Figure 10. Precipitation Trends in North Central Minnesota (1915-2014) with 10-Year Running Average (Source: WRCC, 2016).

Hydrogeology and groundwater quality

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

Surficial and bedrock geology

Surficial geology is identified as the earth material located below the topsoil and overlying the bedrock. Glacial sediment is at the surface in much of the Upper/Lower Red Lake Watershed and is the parent material for the soils that have developed since glaciation. The depth to bedrock ranges from exposed at the surface to over 560 feet. The bedrock is buried by deposits from the various ice lobes that reached this watershed during the last glacial period, as well as during previous glaciations in the last 2.58 million years. The deposits at the surface are associated with the Des Moines lobe and post-glacial alterations to that sediment, including soil formation and peat accumulation. The geomorphology includes glacial lake sediment, lake modified till, stagnation and ground moraines (Des Moines Lobe-Erskine Moraine, Des Moines Lobe-Big Stone Moraine), and peat (Holocene) (Figure 11, *left*) (Hobbs & Goebel, 1982). The glacial sediment consists of sand and gravel glacial lake sediment and silty calcareous till with a predominantly clayey texture.

Bedrock is the main mass of rocks that form the Earth, located underneath the surficial geology and can only be seen in only a few places where weathering has exposed the bedrock. Precambrian bedrock lies under the extent of the Upper/Lower Red Lake Watershed, displaying evidence of volcanic activity. The main terrane groups include Quetico Subprovince (biotite schist, paragneiss, schist- and granite-rich migmatite) and the Wawa Subprovince (mafic metavolcanic, volcanic and volcaniclastic rocks) (Jirsa et al., 2011). Foliated to gneissic metamorphic rocks (tonalite, diorite and granodiorite) are concentrated in the southeast region while mafic plug-like intrusions are scattered throughout the watershed. Additionally, areas of massive to weakly foliated gabbro, pyoxenite, peridotite, and lamprophyre and granitoid intrusions are identified in the southern half of the watershed (Jirsa et al., 2011). The rock types that are found in the uppermost bedrock include graywacke and paragneiss in the northern half and granite, mafic metavolcanic rock, basalt and monzonite in the southern half of the watershed (Figure 11, *right*) (Morey & Meints, 2000).

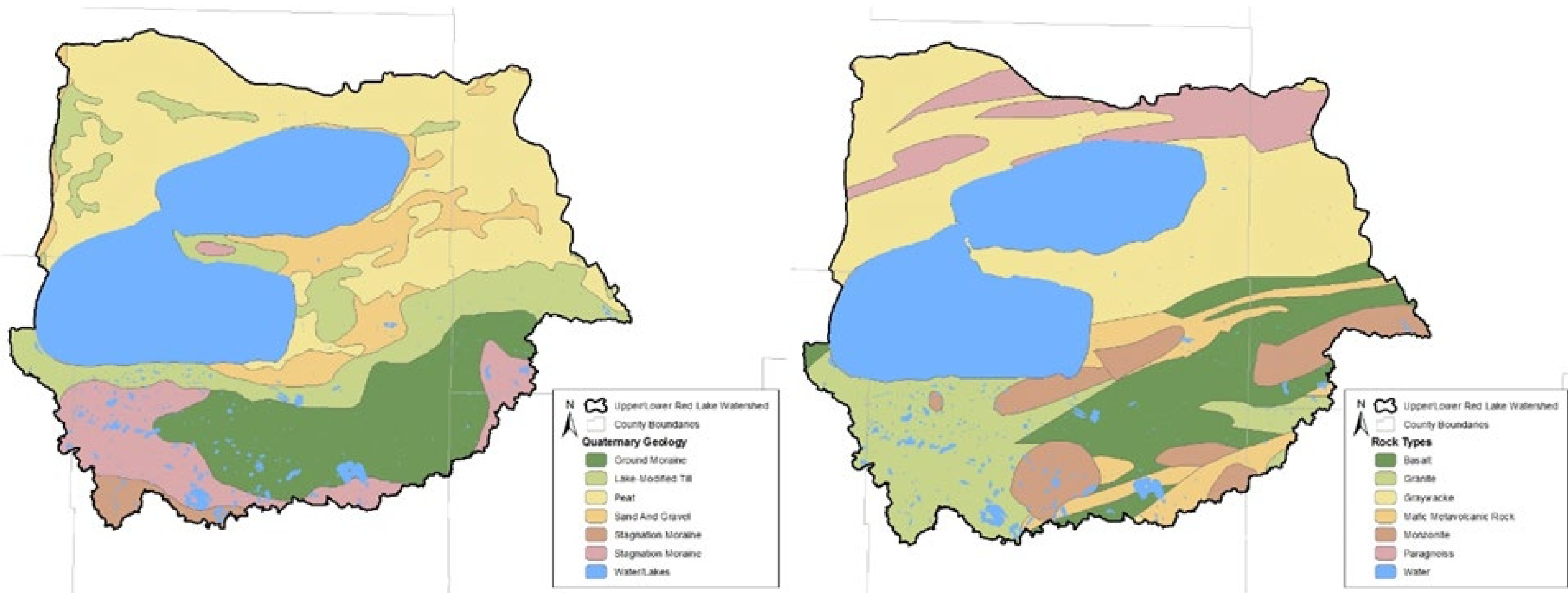


Figure 11. Quaternary Geology (left) and Bedrock Geology Rock Types (right) within Upper/Lower Red Lake Watershed (GIS Source: Hobbs & Goebel, 1982; Morey & Meints, 2000).

Aquifers

Groundwater aquifers are layers of water-bearing units that readily transmit water to wells and springs (USGS, 2016a). As precipitation hits the surface, it infiltrates through the soil zone and into the void spaces within the geologic materials underneath the surface, saturating the material and becoming groundwater (Zhang, 1998). The water table is the uppermost portion of the saturated zone, where the pore-water pressure is equal to local atmospheric pressure. The geologic material determines the permeability and availability of water within the aquifer. Minnesota's groundwater system is comprised of three types of aquifers: 1) igneous and metamorphic bedrock aquifers, 2) sedimentary rock aquifers, and 3) glacial sand and gravel aquifers (MPCA, 2005). The Upper/Lower Red Lake Watershed has fractured igneous and metamorphic bedrock aquifers lying deep beneath clayey and sandy unconsolidated sediments (MDNR, 2016a). In the southern region of the watershed, glacial sand and gravel aquifers are present, with the Quaternary Buried Artesian Aquifer as the primary source for groundwater withdrawals, while the northern region of the watershed is limited in surficial and buried sand aquifers. The general availability of groundwater for this watershed can be categorized as good to moderate in the surficial sands, moderate to limited in the buried sands, and limited in the bedrock (MDNR, 2016a)

Groundwater pollution sensitivity

Bedrock aquifers are typically covered with thick till, indicating that they would normally be better protected from contaminant releases at the land surface. It is also less likely that withdrawals from wells would have a direct and significant impact on local surface water bodies. In contrast, surficial aquifers are typically more likely to 1) be vulnerable to contamination, 2) have direct hydrologic connections to local surface water, and 3) influence the quality and quantity of local surface water. The DNR is working on a hydrogeological atlas focused on the pollution sensitivity of the bedrock surface. It is being produced county-by-county and awaiting completion for those counties within the Upper/Lower Red Lake Watershed. Until the hydrogeological atlas is finished, a 2016 statewide evaluation of pollution sensitivity of near-surface materials completed by the DNR is utilized to estimate pollution vulnerability up to ten feet from the land surface. This display is not intended to be used on a local scale, but as a coarse-scale planning tool. According to this data, the Upper/Lower Red Lake Watershed is estimated to be comprised of mostly peatlands and water (approximately half) while the rest of the area is categorized as having ultra low to low pollution sensitivity (Figure 12) (MDNR, 2016b). There are some areas with a high rating scattered throughout the watershed, most likely due to the presence of sand and gravel quaternary geology.

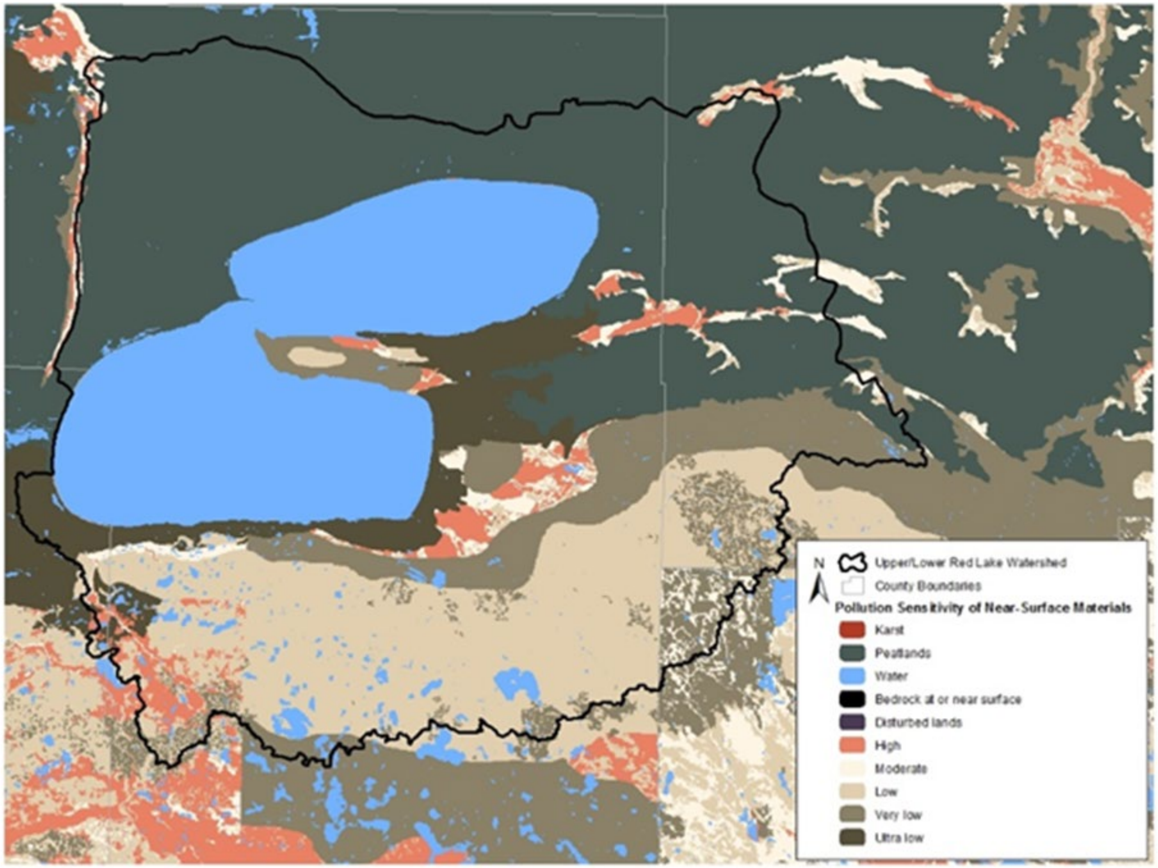


Figure 12. Pollution Sensitivity of Near-Surface Materials for the Upper/Lower Red Lake Watershed (GIS Source: MDNR, 2016b).

Groundwater potential recharge

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

Recharge of these aquifers is important and limited to areas located at topographic highs, those with surficial sand and gravel deposits, and those along the bedrock-surficial deposit interface (Figure 13). Typically, recharge rates in unconfined aquifers are estimated at 20 to 25% of precipitation received, but can be less than 10% of precipitation where glacial clays or till are present (USGS, 2007). For the Upper/Lower Red Lake Watershed, the average annual potential recharge rate to surficial materials ranges from 0.93 to 8.88 inches per year, with an average of 3.97 inches per year (Figure 16). The statewide average potential recharge is estimated to be four inches per year with 85% of all recharge ranging from 3 to 8 inches per year (Figure 14). When compared to the statewide average potential recharge, the Upper/Lower Red Lake Watershed receives approximately the same average potential recharge.

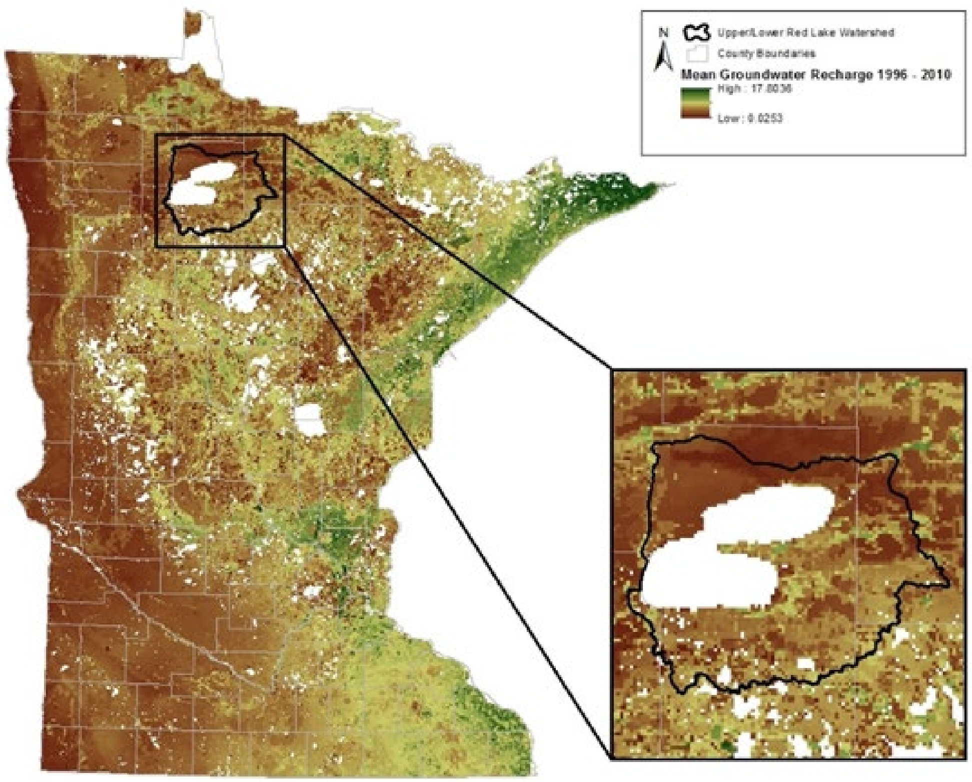


Figure 13. Average Annual Potential Recharge Rate to Surficial Materials in Upper/Lower Red Lake Watershed (1996-2010) (GIS Source: USGS, 2015).

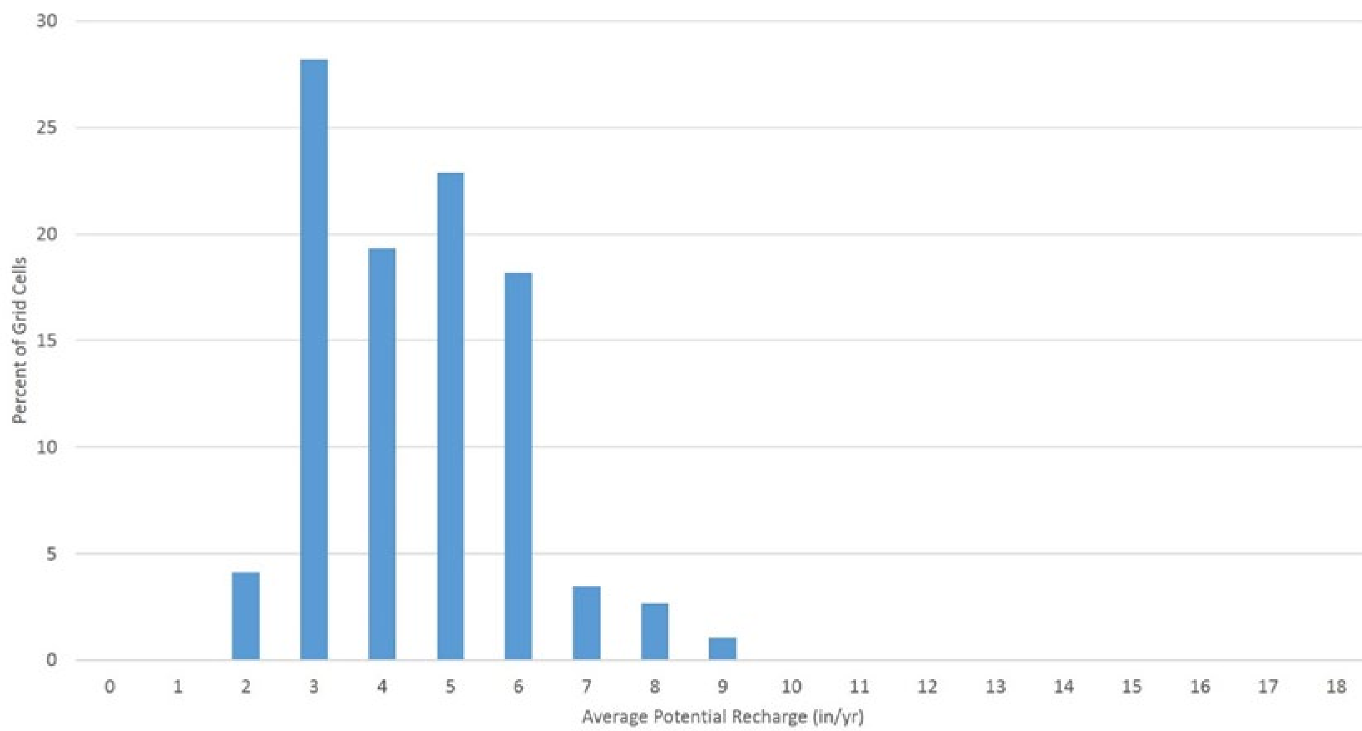


Figure 14. Average Annual Potential Recharge Rate Percent of Grid Cells in the Upper/Lower Red Lake Watershed (1996-2010).

Groundwater quality

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

There are currently no MPCA ambient groundwater monitoring wells within the Upper/Lower Red Lake Watershed. Figure 15 displays the locations of the closest ambient groundwater wells around the specified watershed. Due to the lack of data available, no ambient groundwater quality analysis was completed for the Upper/Lower Red Lake Watershed.

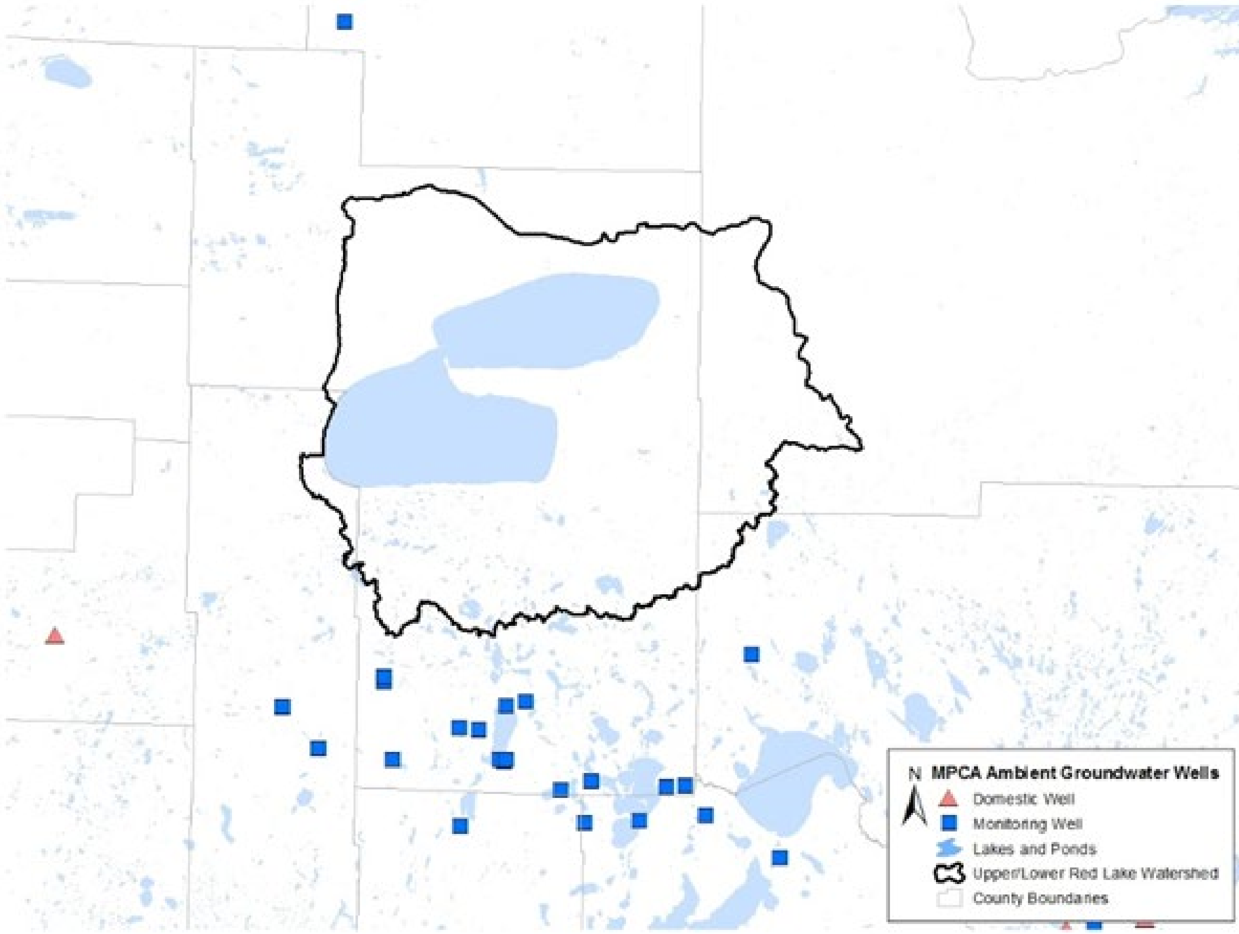


Figure 15. MPCA Ambient Groundwater Monitoring Well Locations within the Upper/Lower Red Lake Watershed.

Regional groundwater quality

From 1992 to 1996, the MPCA conducted baseline water quality sampling and analysis of Minnesota's principal aquifers. The Upper/Lower Red Lake Watershed lies primarily within the Northwest Region, which was identified as having higher concentrations of chemicals in the sand and gravel aquifers when compared to other areas with similar aquifers. The greatest indicator of poor water quality in this region was the presence of Cretaceous bedrock, which is not present in this watershed. The number of exceedances of drinking criteria for arsenic, barium, boron, manganese, nitrate and selenium ranged from one to twelve, depending on the aquifer (MPCA, 1999). Nitrate was identified as the chemical of greatest concern in this hydrogeologic region, with probable anthropogenic sources contributing to the elevated concentrations. Volatile organic compounds were also detected with chloroform as the most commonly detected compound, which is correlated with well disinfection (MPCA, 1999).

Another source of information on groundwater quality comes from the Minnesota Department of Health (MDH). Mandatory testing for arsenic, a naturally occurring but potentially harmful contaminant for humans, of all newly constructed wells has found that 10.7% of all wells installed from 2008 to 2015 have arsenic levels above the maximum contaminant level (MCL) for drinking water of 10 micrograms per liter (MDH, 2016a). In the Upper/Lower Red Lake Watershed, the majority of new wells are within the water quality standards for arsenic levels, but there are exceedances to the MCL (Figure 16). When observing concentrations of arsenic by percentage of wells that exceed the MCL per county, the watershed lies within counties that range from less than five to greater than 20%. High levels of arsenic can sometimes be linked to anthropogenic causes, but most are likely related to the clay-rich material left behind by the Des Moines glacial lobe till (MDH, 2016a). By county, the percentages of wells identified with concentrations exceeding the MCL are as follows: Clearwater (12.4%), Beltrami (10.8%), Koochiching (10.2%) and Hubbard (2.0%) (MDH, 2016b) (Figure 19). It is important to reiterate that the percentages of arsenic concentration exceedances are per county, not specifically for the Upper/Lower Red Lake Watershed. For more information on arsenic in private wells, please refer to the MDH's website: https://apps.health.state.mn.us/mndata/arsenic_wells.

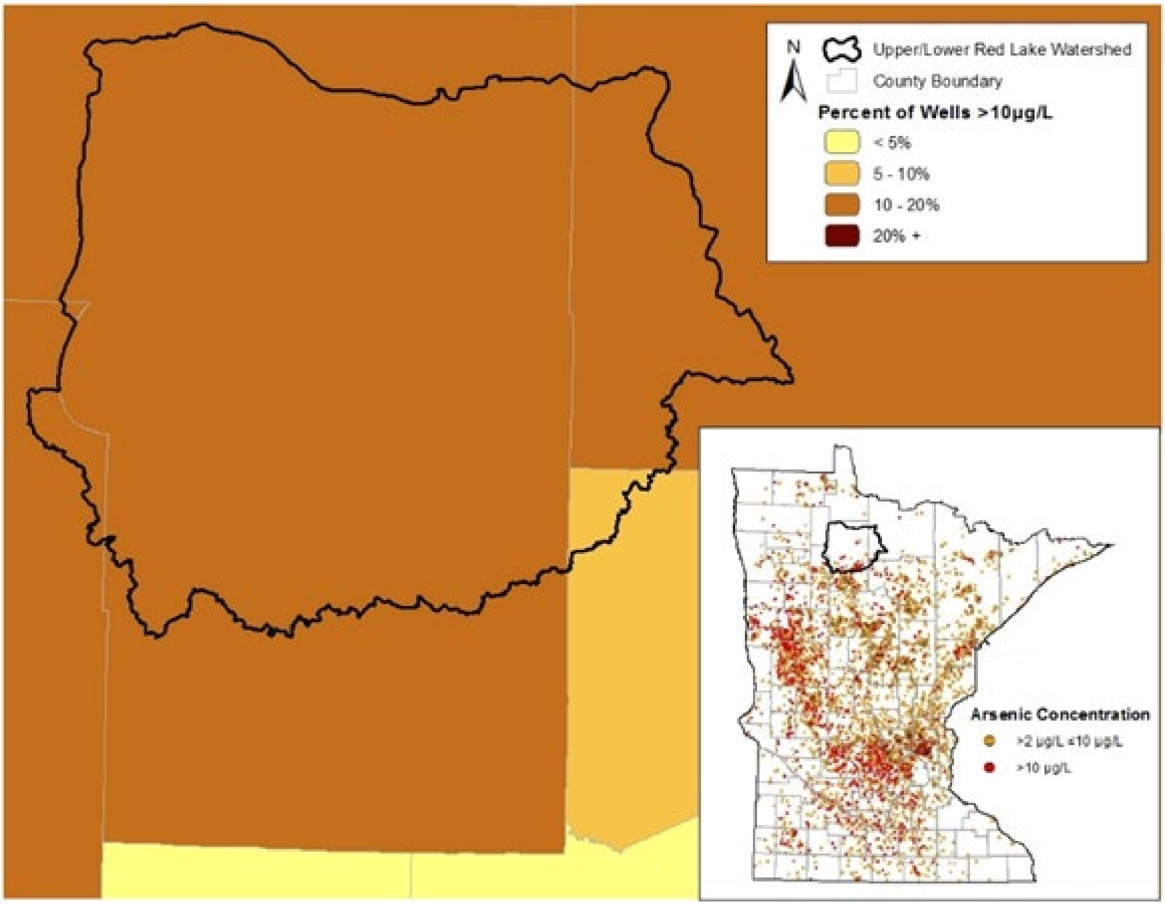


Figure 16. Percent Wells with Arsenic Occurrence Greater than the MCL for the Upper/Lower Red Lake Watershed (2008-2015) (Source: MDH, 2016b).

A statewide dataset of potentially contaminated sites and facilities with environmental permits and registrations is available at the MPCA's website, through a web-based application called, "What's In My Neighborhood" (WIMN). This MPCA resource provides the public with a method to access a wide variety of environmental information about communities across the state. The data is divided into two groups. The first is potentially contaminated sites, and includes contaminated properties, formerly contaminated sites, and those that are being investigated for suspicion of being contaminated. The second category is made up of businesses that have applied for and received different types of environmental permits and registrations from the MPCA. An example of an environmental permit would be for a business acquiring a permit for a storm water or wastewater discharge, requiring it to operate within limits established by the MPCA. In the Upper/Lower Red Lake Watershed, there are currently 166 active sites identified by WIMN: 78 feedlots, 16 hazardous waste, 52 tanks and leaks, 14 water quality (construction and industrial stormwater, wastewater discharger), 3 air quality, 2 solid waste, and 1 investigation and cleanup site (Figure 17). For more information regarding "What's in My Neighborhood", refer to the MPCA webpage at http://www.pca.state.mn.us/index.php/data/wimn-whats-in-my-neighborhood/whats-in-my-neighborhood.html.

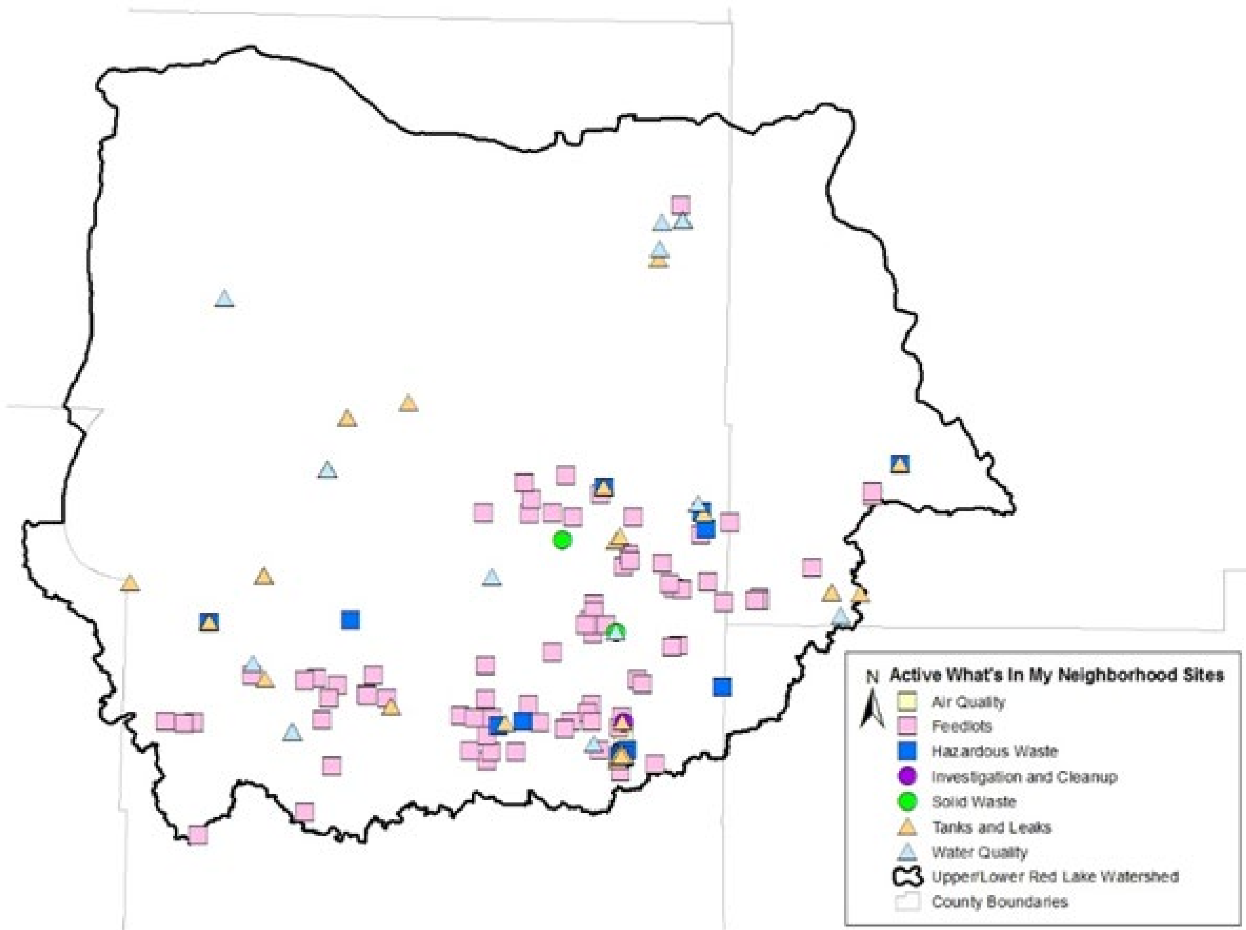


Figure 17. Active "What's In My Neighborhood" Site Programs and Locations for the Upper/Lower Red Lake Watershed (Source: MPCA, 2016).

Groundwater quantity

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

The three largest permitted consumers of water in the state for 2014 are (in order) power generation, public water supply (municipals), and irrigation (MDNR, 2016c). According to the most recent DNR Site-specific Water-Use Data System, in 2013 the withdrawals within the Upper/Lower Red Lake Watershed are primarily utilized for agricultural irrigation (93.8%), such as for crops and wild rice. The remaining withdrawals include: water supply (municipal/public) (3.8%), water level maintenance (1.4%), and non-crop irrigation (golf course irrigation) (0.9%). From 1994 to 2013, withdrawals associated with agricultural irrigation and water supply have decreased (without statistical significance), while all other categories did not have an adequate amount of reported data to perform statistical analysis.

Figure 18 displays total high capacity withdrawal locations within the watershed with active permit status in 2013. Permitted groundwater withdrawals are displayed below as blue triangles and surface water withdrawals as red squares. During 1994 to 2013, groundwater withdrawals within the Upper/Lower Red Lake Watershed exhibit a significant decreasing withdrawal trend ($p<0.001$) (Figure 19, *left*), while surface water withdrawals also experienced a declining trend ($p<0.1$) (Figure 19, *right*).

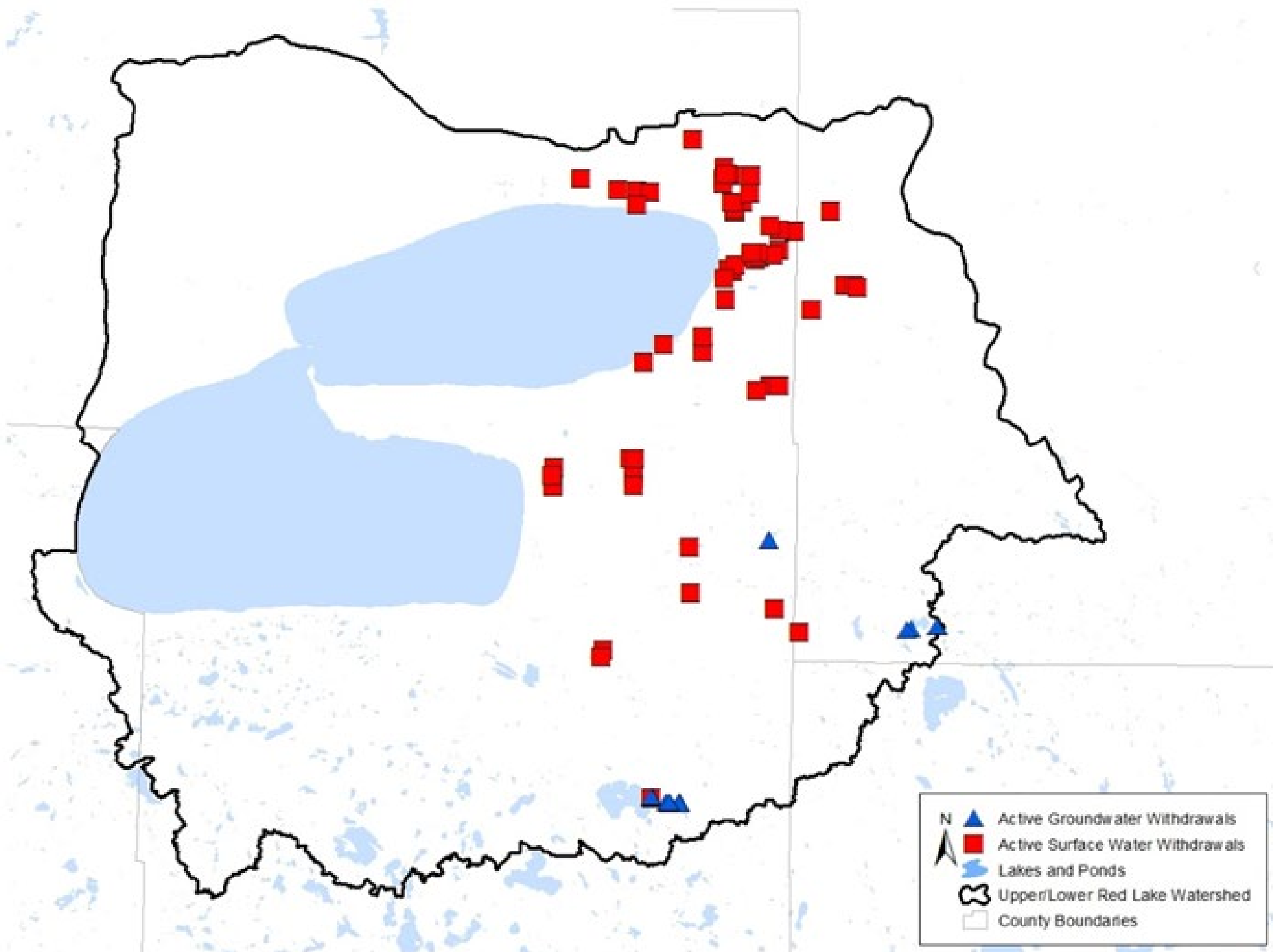
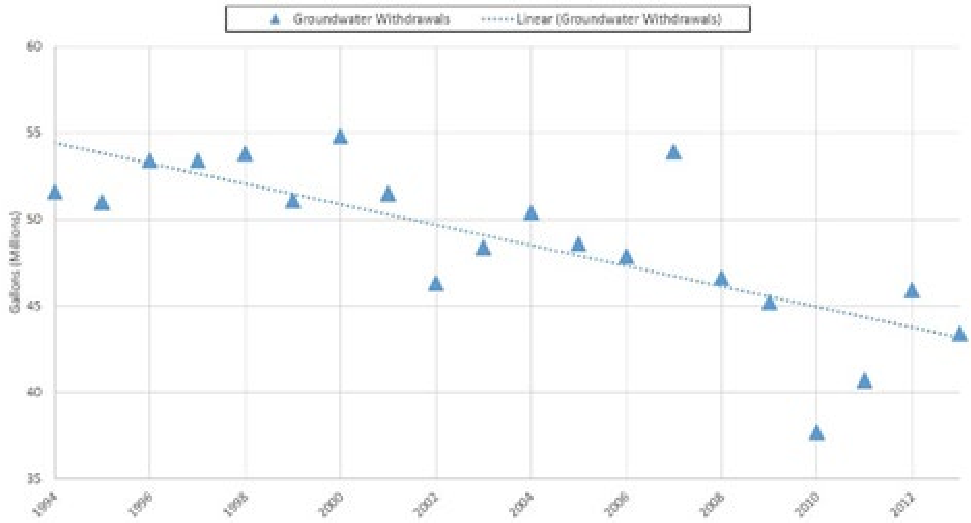


Figure 18. Locations of Active Status Permitted High Capacity Withdrawals in 2013 within the Upper/Lower Red Lake Watershed.



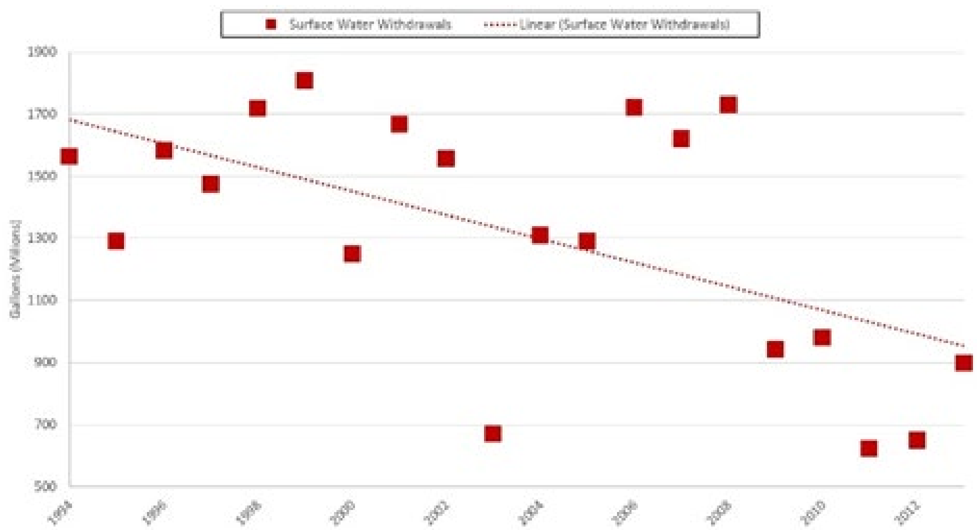


Figure 19. Total Annual Groundwater (top) and Surface Water (bottom) Withdrawals in the Upper/Lower Red Lake Watershed (1994-2013)

Wetlands

Wetlands are a prevalent feature in the Upper/Lower Red Lake Watershed. There are an estimated 562,167 acres of wetland—or about 45% of the watershed area—according to National Wetlands Inventory (NWI) data (Figure 20). This coverage rate is much higher than the statewide rate of 19% (Kloiber and Norris 2013). Extensive peatlands occur in the northern half of the watershed—including a portion of the Red Lake Peatland which is the largest, most highly developed, and diversely patterned peatland in the contiguous US (Wright et al. 1992). The dominant wetland vegetation types in the watershed are forested swamps and bogs, as well as open bogs that have a thick carpet of *Sphagnum* moss and are dominated by low shrubs.

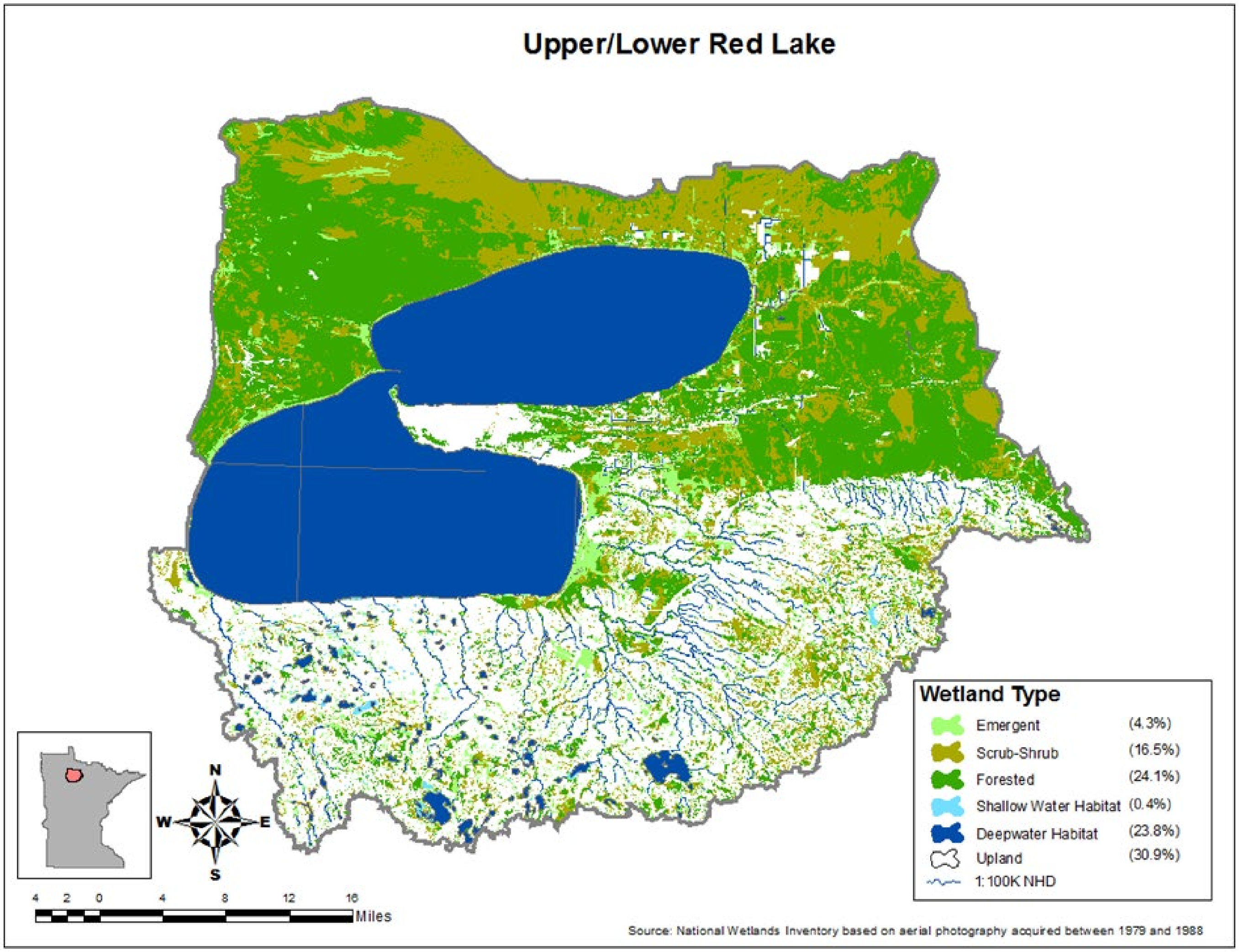


Figure 20. Wetlands and Surface Water in the Upper/Lower Red Lake Watershed. (Wetland data are from the National Wetlands Inventory)

The majority of the pre-settlement wetlands remain intact in the watershed, despite attempts to drain them. Extensive ditch networks were created in the 1910's-20's in the Red Lake Peatland and east of Upper Red Lake. These efforts were largely unsuccessful, resulting in limited permanent development along the margins of peatlands and localized impacts in proximity to the ditches. In the southern portion of the watershed, there has also been some localized smaller scale wetland drainage associated with farming activities.

Two predominant landforms are present which leads to contrasting hydrogeomorphic (HGM) wetland patterns in the watershed. The southern third of the watershed consists of terminal and ground moraine landforms created by glacial advancement (MNGS 1997). The hill and basin topography of the moraine landform produces numerous lakes and depressional wetlands. Depressional wetland hydrology may be dominated by surface flow, precipitation, and/or groundwater depending on the local setting and whether the basin has a surface water connection (Smith et al. 1995). The remainder of the watershed is a glacial lake plain landform created by Glacial Lake Agassiz (MNGS 1997). The extremely flat landscape that remained following Lake Agassiz had little capacity to drain surface water—promoting saturated soil conditions over expansive areas. Organic flat HGM type wetlands formed as peat accumulated vertically on saturated soils (i.e., peatlands). The predominant water exchange in organic flat wetlands is through precipitation and evapotranspiration (Smith et al. 1995). As peat has low hydrologic conductivity, excess precipitation can slowly runoff via overland saturation flow along very low elevation gradients, providing source water for streams that has low pH, low DO, and is high in dissolved organic matter (Acreman and Holden 2013). The Tamarac River is an example of a stream likely originating from significant peatland saturation overland flow.

The Upper/Lower Red Lake Watershed also supports some notable wetland features. The western water track of the Red Lake Peatland in located near and along the northwestern boundary of the watershed. Water tracks are rare features that support a number or rare plant species and form within patterned peatlands where calcium rich groundwater is forced through peat via artesian pressure. The western water track flows from west to east, is approximately 14 miles long, and is the largest and most developed water track in the contiguous US (Wright et al. 1992). It is protected as a state Scientific and Natural Area. In addition, wild rice populations have been documented on a number of mid-small sized lakes and ponds in the southern portion of the watershed, as well as on Upper and Lower Red Lake (MPCA Protecting Wild Rice Waters). Given the distribution, it is likely that wild rice may also be present in many of the streams and sloughs in that portion of the watershed where habitat conditions are favorable.

Watershed-wide data collection methodology

Lake water sampling

The MPCA sampled five lakes in 2014 and 2015 to complete datasets for lake aquatic recreation assessments. Many of the lakes in the Upper/Lower Red Lake Watershed were within the Red Lake Reservation. Lakes wholly within the reservation were sampled by the RLDNR and they provided data for review during the assessment period. There are currently four volunteers enrolled in the MPCA's Citizens Lake Monitoring Program (CLMP) that are conducting lake monitoring within the watershed. Sampling methods are similar among monitoring groups and are described in the document entitled "MPCA Standard Operating Procedure for Lake Water Quality" found at http://www.pca.state.mn.us/publications/wq-s1-16.pdf. The lake water quality assessment standard requires eight observations/samples within a 10-year period (June to September) for phosphorus, chlorophyll-a and Secchi depth.

Stream water sampling

Sixteen water chemistry stations were sampled from May thru September in 2014, and again June thru August of 2015, to provide sufficient water chemistry data to assess all components of the aquatic life and recreation use standards. Following the IWM design, water chemistry stations were placed at the outlet of each aggregated 12-HUC subwatershed that was >40 square miles in area (purple circles and green circles/triangles in (Figure 2). A Surface Water Assessment Grant (SWAG) was awarded to the RLDNR and they collected water chemistry at the IWM subwatershed sites (See Appendix 2.1 for locations of stream water chemistry monitoring sites; see Appendix 1 for definitions of stream chemistry analytes monitored in this study). The Upper Red Lake Frontal aggregated 12-HUC subwatershed did not have an intensive chemistry collection station at the outlet; there is no definitive outlet for this subwatershed given it is comprised of a vast bog complex. The Manomin Creek and Deer River-Frontal Upper Red Lake subwatersheds had intensive chemistry collection stations placed at their outlets. However, chemistry and biological data were deemed not assessable due to the predominant wetland characteristics of these two watersheds. The aggregated 12-HUC subwatersheds Upper Red Lake and Lower Red Lake did not have outlet chemistry sites because of the heavy lake influence. The Battle River and Lower Red Lake Frontal Subwatersheds had two and three IWM stream water chemistry sites respectively, because there were sizable sub watersheds that contributed to the aggregated HUC 12s.

Stream flow methodology

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

Lake biological sampling

Seven lakes were monitored for fish community health in the Upper/Lower Red Lake Watershed. While data from the last 10 years contributed to the watershed assessments, the majority of data utilized for the 2016 assessment was collected in 2010 to 2014. Waterbody assessments to determine aquatic life use support were completed for six lakes.

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

Stream biological sampling

The biological monitoring component of the intensive watershed monitoring in the Upper/Lower Red Lake Watershed was completed during the summer of 2014. A total of 35 sites were newly established across the watershed and sampled. These sites were located near the outlets of most minor HUC-14 watersheds. While data from the last 10 years contributed to the watershed assessments, the majority of data utilized for the 2016 assessment was collected in 2014-2015. A total of 31 AUIDs were sampled for biology in the Upper/Lower Red Lake Watershed. Waterbody assessments to determine aquatic life use support were conducted for 28 AUIDs. Biological information that was not used in the assessment process will be crucial to the stressor identification process and will also be used as a basis for long term trend results in subsequent reporting cycles.

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

Fish contaminants

The DNR fisheries staff collect most of the fish for the Fish Contaminant Monitoring Program. In addition, MPCA's biomonitoring staff collect up to five piscivorous (top predator) fish and five forage fish as part of the Intensive Watershed Monitoring. All fish collected by the MPCA are analyzed for mercury and the two largest individual fish of each species are analyzed for polychlorinated biphenyls (PCBs). Captured fish were wrapped in aluminum foil and frozen until they were thawed, scaled (or skinned), filleted, and ground to a homogenized tissue sample. Homogenized fillets were placed in 60 mL glass jars with Teflon™ lids and frozen until thawed for lab analysis. The Minnesota Department of Agriculture Laboratory analyzed the samples for mercury and PCBs. If fish were tested for perfluorochemicals (PFCs), whole fish were shipped to AXYS Analytical Laboratory, which analyzed the homogenized fish fillets for 13 PFCs. Of the measured PFCs, only perfluorooctane sulfonate (PFOS) is reported because it bioaccumulates in fish to levels that are potentially toxic and a reference dose has been developed.

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

Monitoring of fish contaminants in the 1970s and 1980s showed high concentrations of PCBs were primarily a concern downstream of large urban areas in large rivers, such as the Mississippi River, and in Lake Superior. Therefore, PCBs are now tested where high concentrations in fish were measured in the past and the major watersheds are screened for PCBs in the watershed monitoring collections. Before 2006, mercury in fish tissue was assessed for water quality impairment based on MDH's fish consumption advisory, the same as PCBs. With the adoption of a water quality standard for mercury in edible fish tissue, a waterbody has been classified as impaired for mercury in fish tissue if 10% of the fish samples (measured as the 90th percentile) exceed 0.2 mg/kg of mercury. At least five fish samples of the same species are required to make this assessment and only the last 10 years of data are used for the assessment. MPCA's Impaired Waters List includes waterways that were assessed as impaired prior to 2006 as well as more recent impairments.

Load monitoring

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; at the outlets of the major tributaries (8 digit HUC scale) draining to these rivers; and for subwatersheds of the major watersheds. Intensive water quality sampling occurs at all WPLMN sites. Thirty-five samples per year are allocated for basin and major watershed sites and 25 samples per season (ice out through October 31) for subwatershed sites. Water sample results and daily average flow data are coupled in the FLUX32 pollutant load model to estimate the transport (load) of nutrients and other water quality constituents past a sampling station over a given period of time. Loads and flow weighted mean concentrations (FWMCs) are calculated for TSS, TP, dissolved orthophosphate, nitrate plus nitrite nitrogen (NO_3+NO_2-N), and total Kjeldahl nitrogen.

More information can be found at the WPLMN website.

Groundwater monitoring

The MPCA maintains an Ambient Groundwater Monitoring Network that monitors the aquifers that are most likely to be polluted with non-agricultural chemicals. This network primarily targets the shallow aquifers that underlie the urban parts of the state, due to the higher tendency of vulnerability to pollution. The MPCA's Ambient Groundwater Monitoring Network as of 2016, when this report was produced, consisted of approximately 250 wells that are primarily located in the sand and gravel and Prairie du Chien- Jordan aquifers. Some wells in the MPCA's network are used to discern the effect of urban land use on groundwater quality and comprise an early warning network. Most wells in this early warning network contain water that was recently recharged into the groundwater, some even less than one year old. The wells in the early warning network are distributed among several different settings to determine the effect land use has on groundwater quality. These assessed land use settings are: 1) sewered residential, 2) residential areas that use subsurface sewage treatment systems for wastewater disposal, and 3) commercial or industrial, and 4) undeveloped. The data collected from the wells in the undeveloped areas provide a baseline to assess the extent of any pollution from all other land use settings.

Water samples from the MPCA's Ambient Groundwater Monitoring Network wells generally are collected annually by MPCA staff. This sampling frequency provides sufficient information to determine trends in groundwater quality. The water samples are analyzed to determine the concentrations of over 100 chemicals, including nitrate, chloride, and VOCs. Information on groundwater monitoring methodology is taken from Kroening and Ferrey's report: The Condition of Minnesota's Groundwater, 2007-2011 (2013). To download ambient groundwater monitoring data, please refer to: https://www.pca.state.mn.us/data/groundwater-data.

Wetland monitoring

The MPCA is actively developing methods and building capacity to conduct wetland quality monitoring and assessment. Our primary approach is biological monitoring—where changes in biological communities may be indicating a response to human-caused impacts. The MPCA has developed Indices of Biological Integrity (IBIs) to monitor the macroinvertebrate condition of depressional wetlands that have open water and the Floristic Quality Assessment to assess vegetation condition in all of Minnesota's wetland types. For more information about the wetland monitoring (including technical background reports and sampling procedures), please visit the MPCA Wetland monitoring and assessment webpage. The MPCA currently does not monitor wetlands systematically by watershed. Alternatively, the overall status and trends of wetland quality in the state and by major ecoregion is being tracked through probabilistic monitoring. Probabilistic monitoring refers to the process of randomly selecting sites to monitor; from which, an unbiased estimate of the resource can be made. Regional probabilistic survey results can provide a reasonable approximation of the current wetland quality in the watershed.

Individual aggregated 12-HUC subwatershed results

Aggregated 12-HUC subwatersheds

Assessment results for aquatic life and recreation use are presented for each Aggregated HUC-12 subwatershed within the Upper/Lower Red Lake. The primary objective is to portray all the full support and impairment listings within an aggregated 12-HUC subwatershed resulting from the complex and multi-step assessment and listing process. This scale provides a robust assessment of water quality condition at a practical size for the development, management, and implementation of effective TMDLs and protection strategies. The graphics presented for each of the aggregated HUC-12 subwatersheds contain the assessment results from the 2016 Assessment Cycle as well as any impairment listings from previous assessment cycles. Discussion of assessment results focuses primarily on the 2014 intensive watershed monitoring effort, but also considers available data from the last ten years.

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

Stream assessments

A table is provided in each section summarizing aquatic life and aquatic recreation assessments of all assessable stream reaches within the aggregated HUC-12 subwatershed (i.e., where sufficient information was available to make an assessment). Primarily, these tables reflect the results of the 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 4). Assessment of aquatic life is derived from the analysis of biological (fish and invert IBIs), DO, TSS, chloride, pH, TP, chlorophyll-a, biochemical oxygen demand and un-ionized ammonia (NH_3) data, while the assessment of aquatic recreation in streams is based solely on bacteria (Escherichia coli) data. Included in each table is the specific aquatic life use classification for each stream reach: cold water community (2A); cool or warm water community (2B); or indigenous aquatic community (2C). Where applicable and sufficient data exists, assessments of other designated uses (e.g., Class 7, drinking water, aquatic consumption) are discussed in the summary section of each aggregated HUC-12 subwatershed as well as in the watershed-wide results and discussion section.

Lake assessments

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

Sandy River Aggregated 12-HUC HUC 0902030208-01

The Sandy River Subwatershed drains approximately 85 square miles of land within the southwestern portion of the Upper/Lower Red Lake Watershed. The Sandy River originates out of Sandy Lake and flows north for several miles before being joined by a small tributary known as Unnamed Creek (North Fork River). The tributary originates from a wetland on the eastern edge of the subwatershed and flows east. The tributary has low gradient and a wetland dominated riparian area for most of its 9-mile flow length. After the confluence of unnamed creek, the Sandy River turns and flows toward the west before being joined by another small unnamed tributary. The tributary originates out of Whitefish Lake in the southwestern corner of the subwatershed and flows north for five miles before entering the Sandy River. The Sandy River continues following a sinuous path toward the northwest for approximately 19 miles, passing through the Red Lake Indian Reservation before emptying into Lower Red Lake. The Sandy River has a wetland and/or wooded riparian for most of its 25-mile flow length. Several small lakes (< 200 acres) are within the subwatershed; they include Sandy, Sylvia, Myrtle, Whitefish, and Pickerel Lake. The land in the subwatershed is primarily forested (56.4 %) followed by wetland (25.3 %), rangeland (11.0 %), open water (3.4 %), developed (3.0 %), and cropland (0.8 %). In 2014, the MPCA monitored three biological monitoring stations on two stream segments. Intensive water chemistry monitoring was conducted at one location on the Sandy River that coincided with one of the biological monitoring stations.

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

AUID ***Reach Name*,** *Reach Description*	**Biological Station ID**	**Reach Length (miles)**	**Use Class**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides ***	Eutrophication	**Aquatic Life**	**Aquatic Rec. (Bacteria)**
09020302-604 ***Unnamed Creek,*** Bog Lake to Sandy River	14RD103	9.32	WWg	MTS	IF	IF	IF	IF	--	IF	IF		IF	SUP	--
09020302-522 ***Sandy River,*** Headwaters (Sandy Lake 04-0307-00) to Lower Red Lake	14RD102 14RD100	25.50	WWg	MTS	MTS	MTS	MTS	MTS	MTS	MTS	MTS		IF	SUP	IMP

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

Table 3. Lake Assessments for Sandy River Aggregated 12-HUC.

Lake Name	DNR ID	Area (acres)	Max Depth (ft)	Assessment Method	Ecoregion	Secchi Trend	Aquatic Life Indicators: Fish IBI	Aquatic Life Indicators: Chloride	Aquatic Life Indicators: Pesticides ***	Aquatic Recreation Indicators: Total Phosphoru	Aquatic Recreation Indicators: Chlorophyll -a	Aquatic Recreation Indicators: Secchi	Aquatic Life Use	Aquatic Recreation Use
Bog	04-0243-00	142	6	Shallow Lake	NMW	--	--	--	--	MTS	MTS	IF	--	FS
Myrtle	04-0304-00	118	58	Deep Lake	NMW	--	--	--	--	MTS	MTS	MTS	--	FS
Sandy	04-0307-00	104	72	Deep Lake	NMW	--	MTS	--	--	MTS	MTS	MTS	FS	FS
Whitefish	04-0309-00	122	18	Deep Lake	NLF	--	--	--	--	EX	EX	EX	--	NS
Dunbar	04-0320-00	53	25	Deep Lake	NLF	--	--	--	--	IF	IF	IF	--	IF
Sylvia	04-0322-00	177	38	Deep Lake	NMW	--	--	--	--	MTS	MTS	MTS	--	FS
Frisby	04-0324-00	40	28	Deep Lake	NLF	--	--	--	--	IF	IF	IF	--	IF
Dellwater	04-0331-00	191	29	Deep Lake	NMW	--	NA	--	--	MTS	MTS	MTS	NA	FS
Haggerty	15-0002-00	145	--	Shallow Lake	NMW	--	--	--	--	MTS	MTS	MTS	--	FS
Pickerel	15-0003-00	74	38	Deep Lake	NLF	--	--	--	--	IF	IF	IF	--	IF
Bender	15-0042-00	14	5	Shallow Lake	NLF	--	--	--	--	MTS	MTS	IF	--	FS
Morrison	15-0045-00	29	30	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Unnamed (Heritage)	15-0198-00	9	5	Shallow Lake	NLF	--	--	--	--	MTS	MTS	IF	--	FS

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

Summary

Two stream segments within the Sandy River Subwatershed were assessed for aquatic life. Biological monitoring stations 14RD100 and 14RD102 were located on the Sandy River; both stations had a good FIBI score. Station 14RD102 was located near the headwaters of the Sandy River. Sensitive species, insectivores, and good numbers of lithophilic spawners (fish that utilize coarse substrate for spawning) were present in the fish sample. Habitat within the sampling reach consisted of moderate amounts submergent vegetation, woody debris, and some riffle habitat. The MIBI score at station 14RD102 was fair. Several taxa tolerant of low DO were present in the sample despite coarse substrate and good flow. The presence of these taxa could be due to the influence of adjacent and upstream wetlands. Station 14RD100 was located 9 miles downstream of station 14RD102 and approximately 3 miles upstream of Lower Red Lake. A diverse fish community of 23 species was sampled at station 14RD100. The fish sample contained high numbers of trophic generalist species (i.e., white sucker, blacknose dace, common shiner, and creek chub). Generalist species are able to utilize a variety of food sources and can persist in degraded environments. High numbers of generalist species are often indicative of degradation; however, highnumbers of insectivores and lithophilic spawners as well as six sensitive species were also present in the fish sample. Habitat within the sampling reach consisted of abundant submergent vegetation, limited amounts of coarse substrate, and no riffle habitat. The Macroinvertebrate Index of Biotic Integrity (MIBI) score at station 14RD100 was good – 45 taxa were collected in the sample.

Station 14RD103 was located on the North Fork River (Unnamed Creek) one mile upstream of its confluence with the Sandy River. Sampling crews have noted the presence of groundwater seepage at this station. Temperature data collected on this reach indicate cold water is present but no cold water obligate fish species were sampled. The FIBI score was good. The fish sample contained good numbers of sensitive species, insectivores, and lithophilic spawners. Good channel development, including riffle habitat and deep pools, was present within the sampling reach. Woody debris, submergent vegetation, and gravel were also present. The 2014 MIBI score was poor; an attempt was made to resample in 2015 but the stream had gone dry. Several cool water taxa along with an abundance of midges were collected in the macroinvertebrate sample. The prevalence of chironomidae taxa within the sample suggests that the North Fork River regularly goes dry. Unlike fish, macroinvertebrates cannot migrate out of the reach as water levels decrease.

Two stream reaches within the Sandy River Subwatershed had assessable water chemistry data available. These reaches included the Sandy River from its headwaters (Sandy Lake) to the confluence with Lower Red Lake and an unnamed tributary to the Sandy River. Sediment levels were low and oxygen levels were high enough to support a healthy aquatic community. Elevated bacteria were found during the summer months on the Sandy River, which will warrant an aquatic recreation impairment.

Thirteen lakes in the subwatershed were assessed for aquatic recreation use. TP, chlorophyll-a, and Secchi depth all failed to meet aquatic recreation standards for Whitefish Lake over the assessment period. Compared to other lakes in the subwatershed, the catchment to Whitefish Lake has a higher density of pastures and cropland that could be contributing excess nutrients. In addition, the lake has a long fetch; winds from the north or south could lead to resuspension of the bottom sediments and release of phosphorus to drive continued algal blooms.

Sandy Lake and Dellwater Lake were the only lakes that had biological data. Surveys on Sandy Lake indicated an exceptional fish community. The fish IBI scores were positively influenced by the lack of omnivorous species sampled, the lack of any omnivorous species biomass in the trap nets, and the high percentage of top carnivore biomass in the gill nets. The presence and number of intolerant species, such as Banded Killifish, Blacknose Shiner, Iowa Darter, Mimic Shiner, and Rock Bass, also resulted in high Fish Index of Biotic Intergrity (FIBI) scores. The scores were negatively influenced by the percent of biomass of tolerant species (Green Sunfish) in the trap nets. According to the high FIBI score, Dellwater Lake had an exceptional fish community, but unfortunately, this lake has a history of frequent and severe winterkills. The fish community was mainly the result of stocking; therefore, the fish data on Dellwater Lake was deemed not assessable. The aquatic plant surveys on both lakes indicate healthy plant communities.

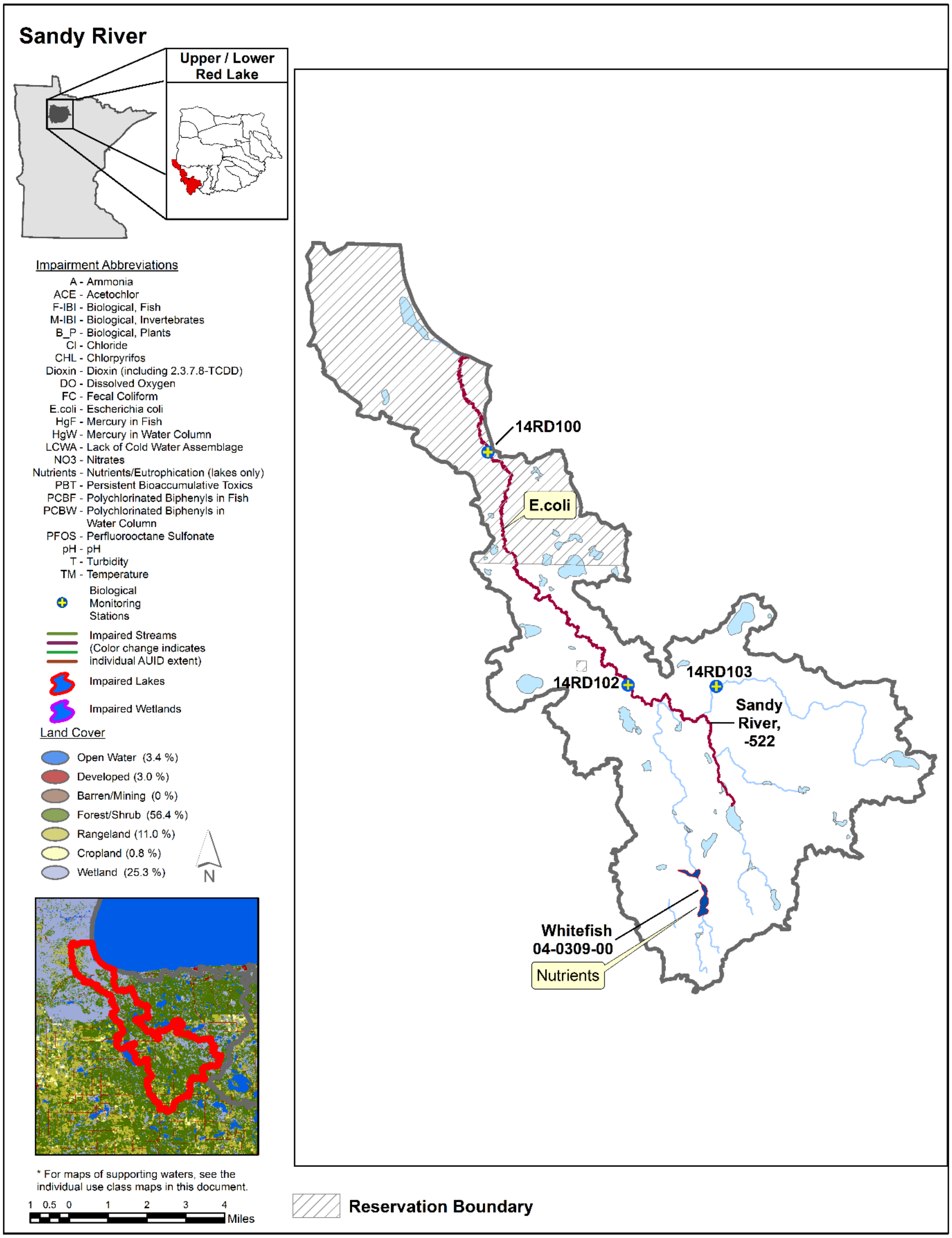


Figure 21. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the Sandy River Aggregated 12-HUC.

Lower Red Lake Frontal Aggregated 12-HUC HUC 0902030207-01

The Lower Red Lake Frontal Subwatershed drains approximately 135 square miles of land along the southern edge of Lower Red Lake. Tributaries to Lower Red Lake within the subwatershed include Big Rock Creek, Little Rock Creek, Pike Creek, and Hay Creek. Big Rock Creek originates from Kesagiagan Lake and flows northwest, passing through extensive wetlands before emptying into Lower Red Lake. The entire seven-mile flow length of Big Rock Creek is within the heavily forested Red Lake Indian Reservation. Little Rock Creek originates from a wetland area one-mile south of the reservation border near Island Lake. The creek flows northwest, passing through numerous wetland lakes along its 9-mile course to Lower Red Lake. Pike Creek originates from a complex of wetland lakes and flows north for approximately 2.5 miles before entering the Red Lake Indian Reservation. From the reservation border, the creek winds northwest through forests and wetlands for approximately 12 miles before passing through the community of Red Lake and emptying into Lower Red Lake. Hay Creek, located at the far eastern edge of the subwatershed, originates from Dark Lake and flows north. The creek winds through hayfields along the edge of the Red Lake Indian Reservation for approximately 12 miles before entering the reservation and emptying into Lower Red Lake. This is a lake and wetland dominated watershed. Dozens of small lakes and several moderate sized lakes (> 300 acres) including Kesagiagan, Balm, and Island lakes cover the watershed. The land within the subwatershed is primarily forested (58.6 %) followed by wetland (23.7 %), rangeland (7.5 %), open water (5.4 %), developed (3.6 %) and cropland (1.2 %). The communities of Red Lake, Redby, and Nebish are within the subwatershed. In 2014, the MPCA collected biological samples from three stations located on two stream segments within the Lower Red Lake Frontal Subwatershed. Water chemistry was intensively monitored at two stations.

Table 4. Aquatic Life and Recreation Assessments on Stream Reaches in the Lower Red Lake Frontal Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name*,** *Reach Description*	**Biological Station ID**	**Reach Length (miles)**	**Use Class**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides ***	Eutrophication	**Aquatic Life**	**Aquatic Rec. (Bacteria)**
09020302-518 ***Hay Creek*,** Headwaters (Dark Lk 04-0167-00) to Lower Red Lake	14RD109	14.59	WWg	MTS	MTS	IF	MTS	MTS	MTS	MTS	MTS	-	IF	SUP	IMP
09020302-521 ***Pike Creek*,** Headwaters (Tenmile Lake 04-0267-00) to Lower Red Lake	14RD153 14RD126		WWg	MTS	EXS	EXS	EXS	MTS	MTS	MTS	MTS	-	IF	IMP	SUP
09020302-548 **Big Rock Creek** **Johnson Lk to Lower Red Lk**	-	3.55	WWg	-	-	NA	NA	NA	NA	NA	NA	-	NA	NA	NA
09020302-563 **Little Rock Creek** **Unnamed lk (04-0259-00 to Unnamed lk (04-0432-00)**	-	3.95	WWg	-	-	-	-	-	-	IF	-	-	--	IF	-
09020302-608 **Unnamed creek (Shemahgun Lake)** **Shemahgun Lk to Lower Red Lk**	-	0.94	WWg	-	-	NA	-	-	-	NA	-	-	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.

Table 5. Lake Water Aquatic Recreation Assessments in the Lower Red Lake Frontal Aggregated 12-HUC.

Lake Name	DNR ID	Area (acres)	Max Depth (ft)	Assessment Method	Ecoregion	Secchi Trend	Aquatic Life Indicators:			Aquatic Recreation Indicators:			Aquatic Life Use	Aquatic Recreation Use
							Fish IBI	Chloride	Pesticides ***	Total Phosphorus	Chlorophyll-a	Secchi		
Alaska	04-0319-00	39	7	Shallow Lake	NLF	I	--	--	--	MTS	IF	IF	--	IF
Dark	04-0167-00	87	130	Deep Lake	NLF	NT	--	--	--	MTS	MTS	MTS	--	FS
Kinney	04-0181-00	31	58	Deep Lake	NLF	I	--	--	--	MTS	MTS	MTS	--	FS
Head	04-0182-00	27	21	Deep Lake	NLF	--	--	--	--	IF	--	IF	--	IF
Wending	04-0183-00	20	7	Shallow Lake	NMW	--	--	--	--	MTS	MTS	IF	--	FS
Gibibwisher	04-0184-00	117	24	Deep Lake	NMW	--	--	--	--	IF	--	IF	--	IF
Unnamed (Mistic)	04-0185-00	21	15	Shallow Lake	NLF	--	--	--	--	MTS	MTS	IF	--	FS
Smith (Island)	04-0194-00	32	48	Deep Lake	NLF	I	--	--	--	MTS	MTS	MTS	--	FS
Williams	04-0199-00	36	19.7	Shallow Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Unnamed (Squaw Smith)	04-0200-00	13	41	Deep Lake	NLF	I	--	--	--	MTS	MTS	MTS	--	FS

Lake Name	DNR ID	Area (acres)	Max Depth (ft)	Assessment Method	Ecoregion	Secchi Trend	Aquatic Life Indicators: Fish IBI	Aquatic Life Indicators: Chloride	Aquatic Life Indicators: Pesticides ***	Aquatic Recreation Indicators: Total Phosphorus	Aquatic Recreation Indicators: Chlorophyll-a	Aquatic Recreation Indicators: Secchi	Aquatic Life Use	Aquatic Recreation Use
South Chain	04-0201-01	21	40	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Middle Chain	04-0201-02	10	28	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Shackle	04-0201-03	17	62	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Fox	04-0251-00	38	25	Deep Lake	NLF	I	--	IF	--	MTS	MTS	MTS	IF	FS
Unnamed	04-0252-00	18	53	Deep Lake	NLF	I	--	--	--	MTS	MTS	MTS	--	FS
Unnamed (Gourd)	04-0253-00	19	21.5	Deep Lake	NLF	I	--	--	--	IF	IF	IF	--	IF
Leslin	04-0255-00	12	23	Shallow Lake	NLF	--	--	--	--	IF	IF	IF	--	IF
Dickens	04-0256-00	31	63	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Unnamed (Border)	04-0257-00	28	23	Deep Lake	NLF	--	--	--	--	MTS	IF	IF	--	IF
Ankeewinsee	04-0258-00	25	33	Deep Lake	NLF	--	--	--	--	MTS	IF	IF	--	IF

Lake Name	DNR ID	Area (acres)	Max Depth (ft)	Assessment Method	Ecoregion	Secchi Trend	Aquatic Life Indicators: Fish IBI	Aquatic Life Indicators: Chloride	Aquatic Life Indicators: Pesticides ***	Aquatic Recreation Indicators: Total Phosphorus	Aquatic Recreation Indicators: Chlorophyll-a	Aquatic Recreation Indicators: Secchi	Aquatic Life Use	Aquatic Recreation Use
Muerlin	04-0260-00	12	38	Deep Lake	NLF	--	--	--	--	IF	IF	IF	--	IF
McCall	04-0261-00	31	23	Shallow Lake	NLF	--	--	--	--	IF	IF	IF	--	IF
Island	04-0265-00	418	14	Shallow Lake	NMW	--	--	--	--	MTS	MTS	MTS	--	FS
Ten Mile	04-0267-00	79	38	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Town Line	04-0268-00	20	29	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Shemahgun	04-0269-00	59	50	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Emerald	04-0270-00	31	21	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Heart	04-0271-00	12	37	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Columbo	04-0272-00	17	20	Deep Lake	NLF	--	--	--	--	MTS	IF	IF	--	IF
Balif	04-0273-00	12	25	Deep Lake	NLF	--	--	--	--	MTS	IF	IF	--	IF

Lake Name	DNR ID	Area (acres)	Max Depth (ft)	Assessment Method	Ecoregion	Secchi Trend	Aquatic Life Indicators: Fish IBI	Chloride	Pesticides ***	Aquatic Recreation Indicators: Total Phosphorus	Chlorophyll-a	Secchi	Aquatic Life Use	Aquatic Recreation Use
Jordan (Jourdain)	04-0274-00	14	22	Deep Lake	NLF	--	--	--	--	MTS	IF	IF	--	IF
Thunder	04-0275-00	87	25	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Green	04-0277-00	82	49	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Unnamed (Lussier)	04-0278-00	13	33	Deep Lake	NLF	--	--	--	--	IF	IF	IF	--	IF
Bass	04-0281-00	201	36	Deep Lake	NMW	--	--	--	--	MTS	MTS	MTS	--	FS
Isle (Fuller)	04-0283-00	90	33	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Burt	04-0284-00	77	50	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Fairbanks	04-0311-00	19	25	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Sandy	04-0312-00	116	59	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Crooked	04-0314-00	23	10	Shallow Lake	NLF	--	--	--	--	IF	IF	IF	--	IF

Lake Name	DNR ID	Area (acres)	Max Depth (ft)	Assessment Method	Ecoregion	Secchi Trend	Aquatic Life Indicators:			Aquatic Recreation Indicators:			Aquatic Life Use	Aquatic Recreation Use
							Fish IBI	Chloride	Pesticides ***	Total Phosphorus	Chlorophyll-a	Secchi		
Kesagiagan	04-0315-00	515	9	Shallow Lake	NMW	--	--	--	--	IF	--	IF	--	IF
Neill (Gwin)	04-0317-00	19	23	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Shell	04-0318-00	49	50	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Moose	04-0326-00	116	61	Deep Lake	NMW	--	--	--	--	MTS	MTS	MTS	--	FS
Balm	04-0329-00	526	33	Deep Lake	NMW	NT	MTS	--	--	MTS	MTS	MTS	FS	FS
Blake	04-0333-00	15	41	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Stone	04-0334-00	21	26	Deep Lake	NLF	--	--	--	--	IF	IF	IF	--	IF
Johnson	04-0336-00	19	23	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Graning	04-0337-00	26	26	Deep Lake	NLF	--	--	--	--	IF	IF	IF	--	IF
Rush	04-0338-00	35	27	Deep Lake	NLF	--	--	--	--	MTS	IF	EX	--	IF

Lake Name	DNR ID	Area (acres)	Max Depth (ft)	Assessment Method	Ecoregion	Secchi Trend	Aquatic Life Indicators:			Aquatic Recreation Indicators:			Aquatic Life Use	Aquatic Recreation Use
							Fish IBI	Chloride	Pesticides ***	Total Phosphorus	Chlorophyll-a	Secchi		
Unnamed (Francis)	04-0339-00	18	32	Deep Lake	NLF	--	--	--	--	MTS	EX	IF	--	IF
Ahlin (Grass Island)	04-0340-00	25	31	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Laxon	04-0341-00	18	29	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Unnamed (Beasty)	04-0405-00	12	27	Deep Lake	NLF	--	--	--	--	IF	IF	IF	--	IF
Unnamed (Burt)	04-0429-00	15	20	Deep Lake	NLF	--	--	--	--	IF	IF	IF	--	IF
Unnamed (Bitney)	04-0430-00	11	22	Shallow Lake	NLF	--	--	--	--	IF	IF	IF	--	IF
Unnamed (Dune)	04-0469-00	12	31	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Unnamed	04-0480-00	12	12	Shallow Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS

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

Summary

Two stream segments within the Lower Red Lake Frontal Subwatershed were assessed for aquatic life. Stations 14RD153 and 14RD126 were located on Pike Creek. DO measurements taken at both stations indicate low DO is present throughout Pike Creek. Station 14RD126 was located approximately 1.5 miles upstream of Lower Red Lake. The habitat at this station was wetland like – fine sediment, emergent macrophytes, and submergent macrophytes were present throughout the reach. The FIBI score was good. Seventeen species of fish were captured, including several sensitive species and numerous lithophilic spawners. The MIBI score was also good despite slow flow and marginal macroinvertebrate habitat. Station 14RD153 was located near the headwaters approximately 2.5 miles downstream of Ten Mile Lake. The habitat at station 14RD153 was negatively impacted by channel instability. The upstream culvert had been washed out numerous times resulting in sand deposition and unstable substrates throughout the sampling reach. Surprisingly, the FIBI score at station 14RD153 was exceptional. The fish sample contained multiple sensitive species, headwaters species, and several lithophilic spawning species. Most of the sensitive and headwater species (pearl dace, Iowa darters, finescale dace, and northern redbelly dace) are commonly found in wetland habitats and tolerant of low DO. The MIBI score at station 14RD153 was poor. The macroinvertebrate sample, dominated by midges and tolerant taxa, was indicative of excessive sediment and low DO. Pike Creek is impaired for aquatic life based on the MIBI score. Pike Creek is also impaired for aquatic life based on water chemistry data. DO exceeded the standard in 35% of samples collected over the assessment period, with readings as low as 0.9 mg/L. This stream was also found to be impaired for TSS; 18% of samples were in excess of the North TSS standard.

Station 14RD109 was located on Hay Creek. The FIBI and MIBI scores were good. The fish sample contained several sensitive species, wetland species, and lithophilic spawners. Hay Creek is a low gradient stream; habitat within the reach consisted of fine sediment, limited woody debris, and aquatic macrophytes. Excessive bacteria concentrations were found on Hay Creek during several summer months; the reach will be listed for *E. coli*.

Other stream reaches within the subwatershed that had available water chemistry data were primarily small tributaries that flow directly into Lower Red Lake. Data from Big Rock Creek and Little Rock Creek were deemed not assessable due to the influence of wetlands and impoundments created by beaver dams along these reaches. The outlet creek of Shemahgun Lake was not assessed because it was a short reach between lakes, thus the water was more indicative of a lake environment than a stream.

Fifty-nine lakes within the Lower Red Lake Frontal Subwatershed were assessed for aquatic recreation (Table 5); only one of these had biological data and could be assessed for aquatic life. The vast majority of the lakes in the subwatershed fully supported aquatic recreation. Several of these lakes are wholly within the Red Lake Reservation and are secluded from human contact; the water quality of these lakes is superb. It was noted by the RLDNR that there are lakes in the subwatershed managed for stream trout (Kinney, Squaw Smith, and Heart). These lakes exhibited excellent water quality and meet the NLF Ecoregion stream trout lake standards. Balm Lake was the lone lake that was assessed for aquatic life; it was found to have a healthy fish community. The FIBI score was positively influenced by the low numbers of tolerant and omnivorous species collected. The high proportion of insectivorous species biomass and low proportion of omnivores in the trap net catch also resulted in a high FIBI score. Intolerant species that were collected included the Banded Killifish, Iowa Darter, and Bluntnose Minnow. The most recent aquatic plant survey indicated a healthy plant community.

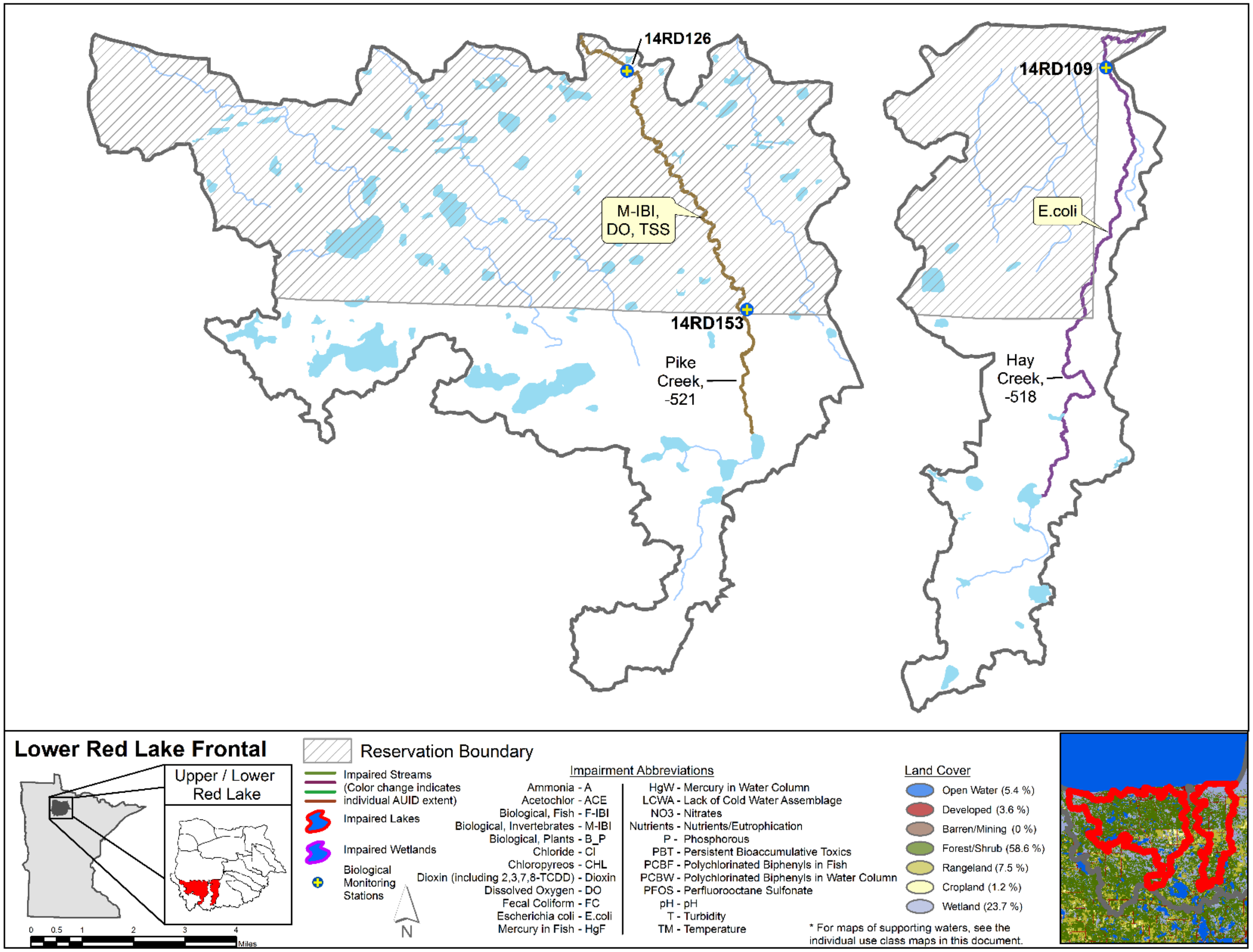


Figure 22. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the Lower Red Lake Frontal Aggregated 12-HUC.

Mud River Aggregated 12-HUC HUC 0902030207-02

The Mud River Subwatershed drains 51 square miles of land within the south central portion of the Upper/Lower Red Lake Watershed. Originating from Puposky Lake, the Mud River consists of a channelized ditch through a wetland and flows north for 1.5 miles. The Mud River then turns and winds toward the northwest for 2.5 miles before turning toward the northeast. The Mud River continues flowing toward the northeast for 5 miles, passing along hayfields and pastures before turning toward the north. After turning north, the Mud River flows a short distance and enters the heavily forested Red Lake Indian Reservation. The Mud River continues flowing north for nine miles, passing through the community of Redby before emptying into Lower Red Lake. Numerous small lakes and wetlands drain into the Mud River along its 22.5-mile flow length. Puposky Lake and Julia Lake are the only major lakes within the subwatershed. The land within the subwatershed is primarily forested (51.3 %) followed by wetland (18.4 %), rangeland (15.5 %), open water (10.8 %), developed (3.3 %), and cropland (0.7 %). The community of Redby is within the subwatershed. In 2014, the MPCA collected biological samples from three stations located on three stream segments within the Mud River Subwatershed. Water chemistry was intensively monitored at one station.

Table 6. Aquatic Life and Recreation Assessments on Stream Reaches in the Mud River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name***, *Reach Description*	**Biological Station ID**	**Reach Length (miles)**	**Use Class**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides ***	Eutrophication	**Aquatic Life**	**Aquatic Rec. (Bacteria)**
09020302-613 **Mud River** **-94.9232 47.7364 to T150 R33W S29, east line**	14RD157	6.52	WWg	MTS	MTS	IF	IF	IF	-	IF	IF	-	IF	SUP	-
09020302-540 **Mud River** **T150 R33W S28, west line to T150 R33W S21, north line**	14RD107	2.89	WWg	MTS	MTS	IF	IF	IF	-	IF	IF	-	IF	SUP	-
09020302-541 **Mud River** **T150 R33W S16, south line to Lower Red Lk**	14RD106	9.33	WWg	MTS	MTS	MTS	EXS	IF	MTS	MTS	MTS	-	IF	IMP	IMP

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

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

Table 7. Lake Assessments in the Mud River Aggregated 12-HUC.

Lake Name	DNR ID	Area (acres)	Max Depth (ft)	Assessment Method	Ecoregion	Secchi Trend	Aquatic Life Indicators:			Aquatic Recreation Indicators:			Aquatic Life Use	Aquatic Recreation Use
							Fish IBI	Chloride	Pesticides ***	Total Phosphorus	Chlorophyll-a	Secchi		
Crane	04-0165-00	99	--	Deep Lake	NMW	--	--	--	--	EX	EX	IF	--	NS
Julia	04-0166-00	506	44	Deep Lake	NMW	NT	MTS	MTS	--	MTS	MTS	MTS	FS	FS
George	04-0175-00	55	--	Shallow Lake	NCHF	--	--	--	--	IF	IF	IF	--	IF
Strand	04-0178-00	137	--	Deep Lake	NMW	--	--	--	--	EX	EX	EX	--	NS
Little Puposky	04-0197-00	130	6	Shallow Lake	NMW	--	--	--	--	IF	IF	IF	--	IF
Puposky	04-0198-00	2086	14	Shallow Lake	NMW	--	--	MTS	--	MTS	MTS	MTS	IF	FS
Boston	04-0244-00	94	30	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
Burns	04-0433-00	17	7	Shallow Lake	NLF	--	--	--	--	MTS	MTS	IF	--	FS

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

Summary

Stations 14RD157, 14RD107, and 14RD106 were located on three separate reaches of the Mud River. Station 14RD157 was the furthest upstream station and was located approximately 6 miles downstream of Lake Puposky. The 2014 visit FIBI score was poor. The fish sample was dominated by tolerant species and lacked sensitive species. Prolonged high water levels during 2014 likely had a negative influence on the fish community. The 2015 visit FIBI score was good. High numbers of a tolerant species (central mudminnow) were still present in the sample; however, northern redbelly dace (a sensitive headwaters species) was the second most abundant species sampled. The 2015 sample also contained more lithophilic spawning species. Coarse substrate, consisting of gravel and cobble, was present throughout the sampling reach along with abundant submerged macrophytes. No riffle habitat was present in the reach. Macroinvertebrates were only sampled in 2014 – the MIBI score was good.

Station 14RD107 was located approximately four miles downstream of station 14RD157. The June 2014 visit FIBI score was good. The September 2014 FIBI score (75.7) exceeded the exceptional use criteria and was one of the highest FIBI scores in the Upper / Lower Red Lake Watershed. Multiple sensitive species, headwaters species, and insectivores were present in both samples. The September sample contained greater numbers of sensitive species and insectivores. Earlier high water levels may have had an influence on the June sample. Excellent stream habitat consisting of coarse substrate, woody debris, good channel development, and riffle habitat was present. The 2014 MIBI score was almost exceptional. Excellent taxa richness was present in the sample; nine Trichoptera taxa were present along with three Plecopetera taxa and several Odonates.

Station 14RD106 was located one mile upstream of Lower Red Lake on the lower section of the Mud River that runs from the southern Red Lake Indian Reservation border to Lower Red Lake. The FIBI score was passing but somewhat lower than expected. The most abundant species sampled (blacknose dace, creek chub, and fathead minnow) were trophic generalists and tolerant species; however, four sensitive species, including two intolerant species (burbot and blacknose shiner), were present in moderate numbers. Good numbers of insectivores and some lithophilic spawning species, including adult walleye, were also present in the sample. Good riffle habitat, various forms of coarse substrate, and several cover types were present within the sampling reach. The MIBI score was good. Of the 41 taxa sampled, 20 were unique clinger taxa which, is indicative of the good riffle habitat and flow stability. Water chemistry data from this lower reach of the Mud River indicate that over a quarter of the TSS samples taken during the assessment period were in excess of the North TSS standard. *E. coli* concentrations across the summer months indicate an aquatic recreation impairment. As a result, this reach is impaired for both aquatic life and aquatic recreation.

Eight lakes in the subwatershed were assessed for aquatic recreation use (Table 7); one of these had biological data and could be assessed for aquatic life. Crane Lake and Strand Lake, which are connected by a small tributary, were impaired for aquatic recreation. Wetlands can be a source of phosphorus and may supply some of the nutrients observed in these lakes. Julia Lake is the only lake in the subwatershed that was assessed for aquatic life. The survey indicated an exceptional fish community. The high FIBI score was influenced by the presence and number of intolerant species. Intolerant species found in the Julia Lake survey included Banded Killifish, Blackchin Shiner, Blacknose Shiner, Iowa Darter, and Rock Bass. The score was also positively influenced by several factors, such as: the high number of small benthic dwelling species; the high ratio of these species in the nearshore catch; the high numbers of intolerant species and vegetative species; the low numbers of omnivorous species; and the presence of intolerant species in the gill net catch. Samplers noted that the fish community on Julia Lake was relatively diverse. The score was negatively influenced by the high number of tolerant species, such as Black Bullhead and Fathead Minnow, as well as the low percentage of insectivorous biomass in the trap net catch. The aquatic plant survey indicated a healthy plant community.

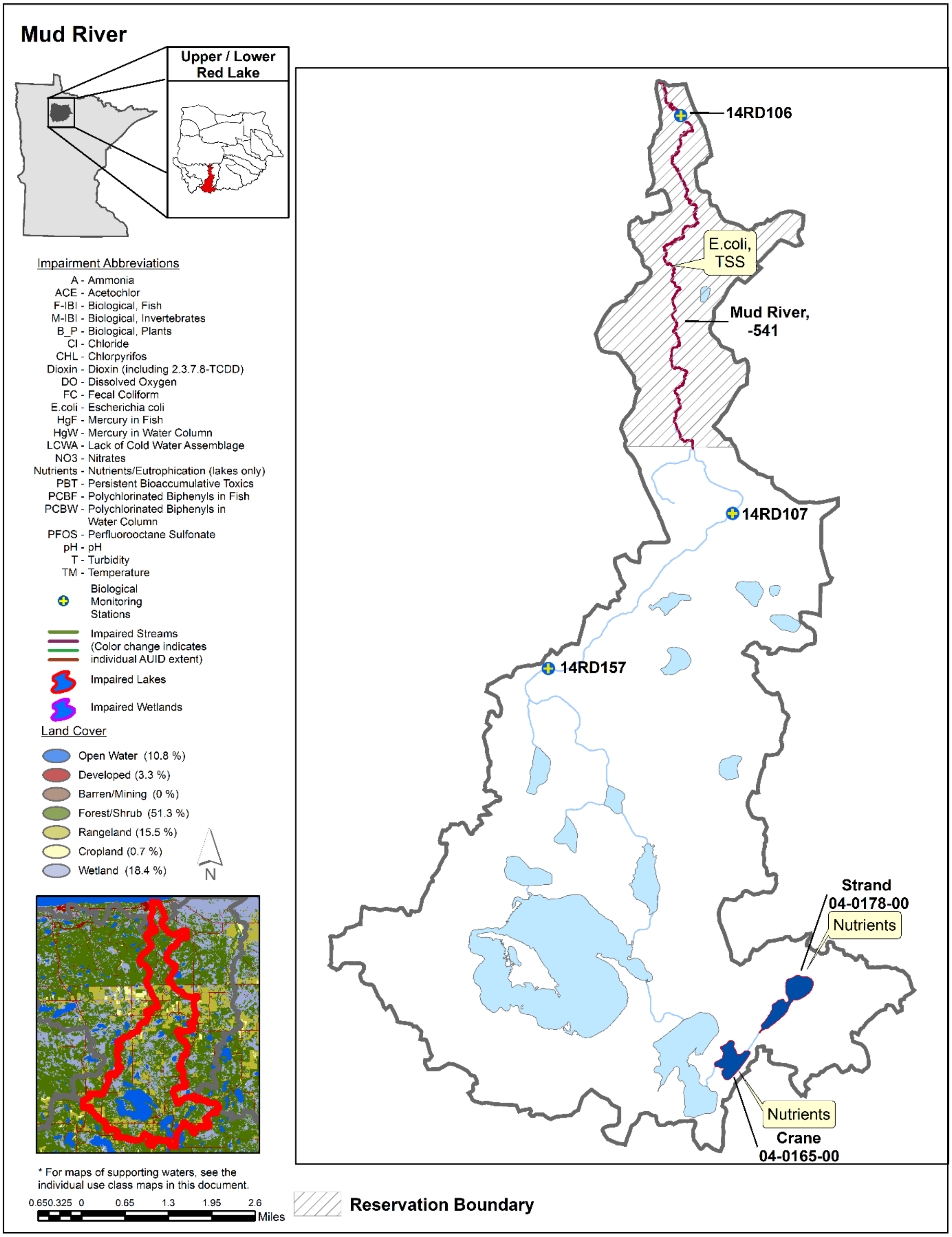


Figure 23. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the Mud River Aggregated 12-HUC.

Blackduck River Aggregated 12-HUC HUC 0902030206-01

The Blackduck River Subwatershed drains 159 square miles of land within the southern region of the Upper/Lower Red Lake Watershed. The Blackduck River originates from Blackduck Lake and flows north for approximately six miles before turning toward the northwest. The Blackduck River continues winding toward the northwest for 11 miles before being joined by a larger tributary called O'Brien Creek. O'Brien Creek originates near Medicine Lake in the south central region of the subwatershed and flows toward the north. Darrigans Creek, a tributary of O'Brien Creek, flows northwest out of Whitefish Lake. Almost all of the land that Darrigans Creek passes through is pasture. After the confluence of O'Brien Creek, the Blackduck River continues toward the northwest for 3 miles and is joined by a major tributary called the South Cormorant River. The South Cormorant River drains a 90 square mile subwatershed located in the southeast corner of the Upper/Lower Red Lake Watershed. After the confluence of the South Cormorant River, the Blackduck River continues flowing northwest for three miles before turning toward the north. The Blackduck River flows north for two miles and enters a large wetland area along the southeast corner of Lower Red Lake. At this location, the Blackduck River has an extensive wetland riparian and has low gradient. Another major tributary called the North Cormorant River joins the Blackduck River within this wetland area. The North Cormorant River flows from east to west for 39 miles and drains a 69 square mile subwatershed. After joining with the North Cormorant River, the Blackduck River flows southwest for four miles, passing through the Red Lake Indian Reservation before entering Lower Red Lake. Major lakes within the Blackduck River Subwatershed include Blackduck Lake, Medicine Lake, Whitefish Lake, and Sandy Lake. Most of the land within the subwatershed is forested (34.8 %) followed by wetland (34.2 %), rangeland (21.3 %), open water (4.6 %), developed (3.1 %), and cropland (1.9 %). The community of Blackduck is within the subwatershed. In 2014, the MPCA collected biological samples from five stations located on five stream segments within the Mud River Subwatershed. Water chemistry was intensively monitored at one station.

Table 8. Aquatic Life and Recreation Assessments on Stream Reaches in the Blackduck River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

AUID *Reach Name*, Reach Description	Biological Station ID	Reach Length (miles)	Use Class	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides ***	Eutrophication	Aquatic Life	Aquatic Rec. (Bacteria)
09020302-515 Coburn Creek Headwaters to Blackduck Lk	-	3.29	WWg	-	-	IF	IF	IF	MTS	IF	IF	-	IF	IF	IF
09020302-508 Darrigans Creek Headwaters (Whitefish Lk 04-0137-00) to O'Brien Cr	14RD112	11.39	WWg	MTS	EXS	IF	MTS	IF	MTS	MTS	MTS	-	IF	IMP	IMP
09020302-544 O'Brien Creek T149 R32W S2, south line to T150 R32W S23, north line	-	8.57	CWg	-	-	EXS	MTS	IF	MTS	MTS	MTS	-	IF	IMP	IMP
09020302-514 O'Brien Creek Darrigans Cr to Blackduck R	14RD110	5.70	WWg	MTS	MTS	IF	IF	IF	-	IF	IF	-	IF	SUP	-
09020302-510 Blackduck River Blackduck Lk to O'Brien Cr	14RD114	17.86	WWg	MTS	MTS	IF	MTS	IF	MTS	MTS	MTS	-	IF	SUP	IMP
09020302-511 Blackduck River O'Brien Cr to South Cormorant R	14RD158	3.02	WWg	MTS	MTS	IF	IF	IF	-	IF	IF	-	IF	SUP	-
09020302-512 Blackduck River South Cormorant R to North Cormorant R	-	7.94	WWg	IF	-	MTS	EXS	MTS	IF	MTS	MTS	-	IF	IF	IMP
09020302-513 Blackduck River North Cormorant R to Lower Red Lk	14RD122	4.35	WWg	NA	-	NA	NA	NA	NA	NA	NA	-	NA	NA	SUP

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

Table 9. Lake Assessments in the Blackduck River Aggregated 12-HUC.

Lake Name	DNR ID	Area (acres)	Max Depth (ft)	Assessment Method	Ecoregion	Secchi Trend	Aquatic Life Indicators:			Aquatic Recreation Indicators:			Aquatic Life Use	Aquatic Recreation Use
							Fish IBI	Chloride	Pesticides ***	Total Phosphorus	Chlorophyll-a	Secchi		
Blackduck	04-0069-00	2635	28	Deep Lake	NLF	I	IF	MTS	--	EX	EX	MTS	IF	NS
Rice	04-0121-00	41	--	Shallow Lake	NLF	--	--	--	--	IF	--	--	--	IF
Medicine	04-0122-00	461	44	Deep Lake	NLF	I	MTS	MTS	--	MTS	MTS	MTS	FS	FS
Cranberry	04-0123-00	61	19	Shallow Lake	NLF	--	--	--	--	IF	IF	IF	--	IF
Sandy	04-0124-00	255	30	Deep Lake	NMW	--	MTS	MTS	--	MTS	MTS	MTS	FS	FS
Loon	04-0125-00	136	3	Shallow Lake	NLF	--	--	--	--	MTS	MTS	IF	--	FS
Hagali	04-0136-00	95	26	Shallow Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS
White Fish	04-0137-00	396	98	Deep Lake	NMW	NT	--	--	--	MTS	MTS	MTS	--	FS
Jackson	04-0138-00	124	35	Deep Lake	NMW	--	--	--	--	MTS	MTS	MTS	--	FS
Bass	04-0139-00	113	93	Deep Lake	NMW	--	--	--	--	MTS	MTS	MTS	--	FS

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

Summary

Stations 14RD114, 14RD158, and 14RD122 were located on separate segments of the Blackduck River. Station 14RD114, the furthest upstream station, was located approximately 8 miles downstream of Blackduck Lake. The 2014 visit FIBI score (85.1) exceeded the exceptional use criteria and was the highest score in the Upper/Lower Red Lake Watershed. The fish sample contained high numbers of lithophilic spawners and insectivores. Excellent stream habitat consisting of coarse substrate, woody debris, and abundant aquatic macrophytes was present within the sampling reach. Good riffle habitat and channel development was also present. Macroinvertebrates were sampled in 2014 and 2015. Surprisingly, the 2014 visit MIBI score was poor. Tolerant black fly larvae (Simuliidae) were the most abundant taxa in the sample. The 2015 visit MIBI score was good. Prolonged high water levels during 2014 may have had a negative influence on the macroinvertebrate community. Station 14RD158 was located approximately six miles downstream of station 14RD114, immediately upstream of the confluence of the South Cormorant River. The 2014 visit FIBI score exceeded the exceptional use criteria. High numbers of insectivores, lithophilic spawners, and sensitive species were present in the sample. Stream habitat within the sampling reach consisted of clay and sand substrate, sparse amounts of aquatic vegetation, and woody debris. Channel development was poor; no riffle or pool habitat was present in the reach. Despite limited macroinvertebrate habitat, the 2014 visit MIBI score was good. Station 14RD122 was located two miles upstream of Lower Red Lake on the lower segment of the Blackduck River. At this location, the Blackduck River has an extensive wetland riparian and abundant submergent vegetation. Only six species of fish were collected. The fish sample was dominated by a wetland inhabiting species. The FIBI score was poor. Low DO levels were measured during the fish visit. Biological data from this station was not assessed due to the lack of an adequate FIBI for large drainage area, low gradient streams. Macroinvertebrates were not sampled because the river could not be waded at this location.

Station 14RD110 was located on the segment of O'Brien Creek that runs from the confluence of Darrigans Creek to the Blackduck River. The 2014 visit FIBI score was good. High numbers of tolerant generalist species were present in the sample; however, good numbers insectivores and lithophilic spawning species (including redhorse and adult walleye) were also present. Good channel development, in the form of several riffles and large pools, was present within the sampling reach. Coarse substrate, moderate amounts of submergent macrophytes, undercut banks, and woody debris were also present. The 2014 MIBI score was good. High numbers of tolerant black fly larvae (Simuliidae) were present in the sample along with good numbers of sensitive taxa (especially Trichoptera). Station 14RD112 was located on Darrigans Creek approximately 1.2 miles upstream of where it meets O'Brien Creek. The 2014 FIBI score was good. Good numbers of lithophilic spawners and several sensitive species were present in the fish sample. Stream habitat consisted of cobble and gravel substrate along with sparse amounts of woody debris and submergent macrophytes. Good riffle habitat was present throughout the sampling reach. Macroinvertebrates were sampled in 2014 and 2015; both MIBI scores were poor. Both macroinvertebrate samples lacked the stonefly and mayfly taxa that inhabit interstitial habitat (i.e., the space between two rocks), resulting in a low MIBI score. Follow up investigations to determine the cause of the poor macroinvertebrate community have identified the occurrence of high levels of suspended fine sediment following rain events. The sediment likely washes in from eroded banks upstream and accumulates within the rocky interstitial spaces found in the sampling reach. The stream segment is impaired for aquatic life based on the MIBI score. Extremely high *E. coli* concentrations were found in Darrigans Creek during several months of water chemistry monitoring; this reach is impaired for aquatic recreation.

Other stream reaches in the Blackduck River Subwatershed that had water chemistry data available include portions of the Blackduck River, O'Brien Creek, and Colburn Creek. The upper portion of O'Brien Creek was the only reach where chemistry data indicated an aquatic life impairment. DO concentrations (sometimes as low as 3.20 mg/L) exceeded the standard in 21.2% of samples taken during the assessment period. The segment of the Blackduck River that extends from the confluence of the South Branch Cormorant River to the confluence of the North Branch Cormorant River was previously listed impaired for aquatic life based on exceedances of the DO standard. Recent DO data collected from this reach indicate support for aquatic life. The robust early-morning DO dataset showed exceedances in only 2.8% of measurements; the reach will be removed from the impaired waters list. Water chemistry data on the downstream-most reach of the Blackduck River, from the confluence of the North Branch Cormorant River to Lower Red Lake, was deemed not assessable due to wetland influence. Excessive bacteria concentrations were found throughout the subwatershed. Four of the six stream reaches with assessable bacteria data will be impaired for aquatic recreation.

Ten lakes within the subwatershed were assessed for aquatic recreation (Table 9); three of these had biological data available for aquatic life assessment. Blackduck Lake did not meet aquatic recreation standards; this confirms the existing eutrophication impairment from 2010. The remaining lakes fully supported aquatic recreation or had insufficient data to assess. The two lakes assessed for aquatic life were Medicine Lake and Sandy Lake. The fish survey results from Medicine and Sandy indicated healthy fish communities. The Medicine Lake FIBI score was positively influenced by the low number of tolerant species sampled and the high proportion of small benthic-dwelling species captured nearshore. The scores were negatively influenced by the low percentage of insectivorous biomass captured in trap nets and the generally low species richness of intolerant, small benthic-dwelling, and vegetative-dwelling species. The Sandy Lake FIBI score was positively influenced by several factors, including: the low number of omnivorous species sampled; the high proportion of small benthic dwelling species captured near shore; the low percent of omnivorous species biomass captured in trap nets; and the high percent of top carnivore biomass captured in gill nets. The score was negatively influenced by low species richness of small benthic and intolerant species. Intolerant species found in both lakes included the Iowa Darter and Blackchin Shiner. The FIBI score for Blackduck Lake was at the aquatic life use threshold; however, sampling issues (such as seining difficulties in abundant emergent vegetation) may have affected the sample composition. Due to the lack of a representative sample, Blackduck Lake was not assessed for aquatic life. A preliminary investigation of stressors affecting Blackduck Lake revealed that treated wastewater effluent was discharged into a tributary of the lake. The lake also has elevated nutrients and considerable disturbance within its watershed. For these reasons, Blackduck Lake is considered vulnerable to exceeding aquatic life use standards. Aquatic plant surveys on all three lakes indicated a healthy plant community.

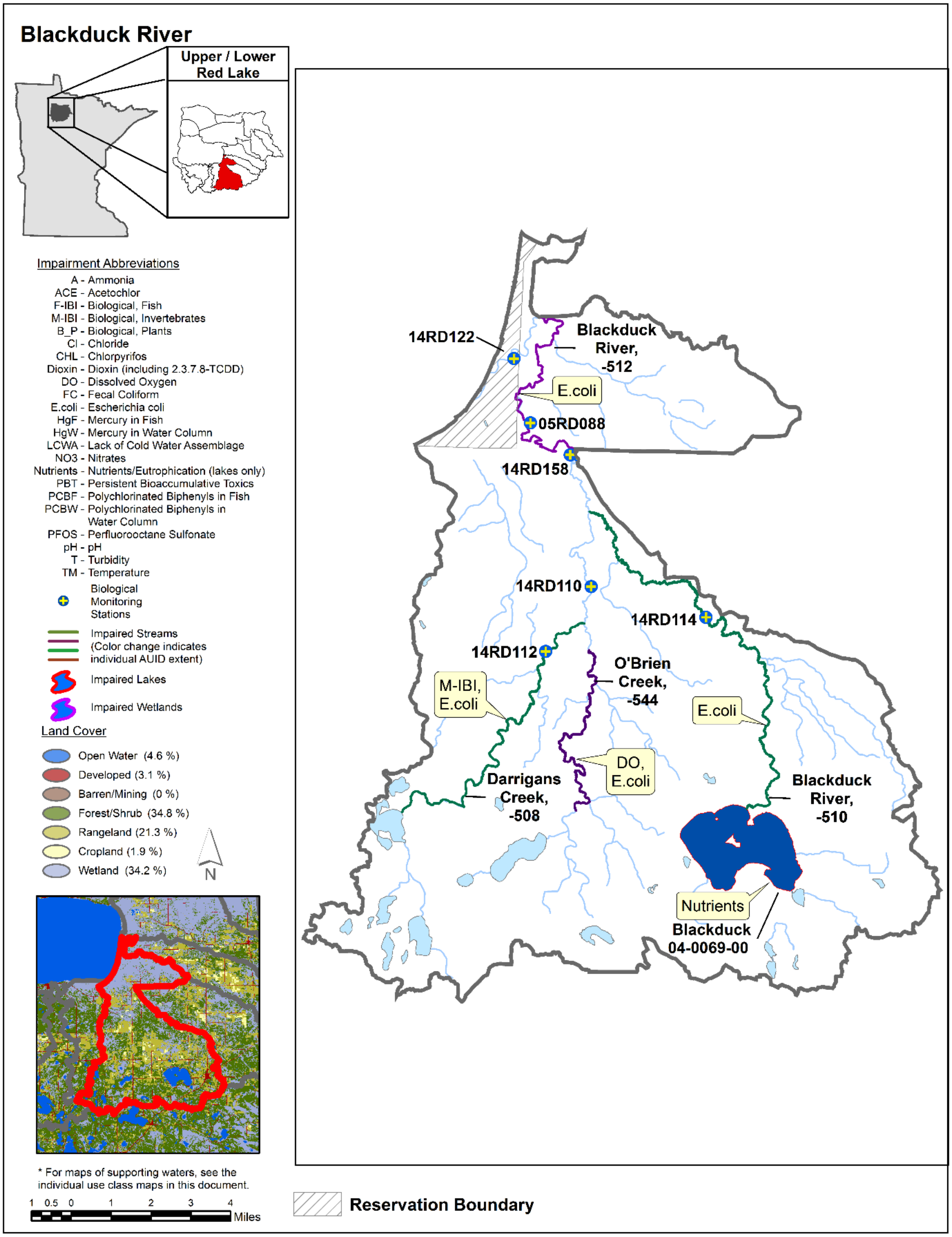


Figure 24. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the Blackduck River Aggregated 12-HUC.

South Cormorant River Aggregated 12-HUC HUC 0902030206-03

The South Cormorant River Subwatershed drains 90 square miles of land within the southeast region of the Upper/Lower Red Lake Watershed. The South Cormorant River originates from a wetland area northwest of Funkley, on the far eastern edge of the subwatershed. The South Cormorant winds toward the northwest for approximately 10 miles before being joined by a small tributary called Spring Creek. After the confluence of Spring Creek, the South Cormorant River continues flowing northwest for six miles and turns west. The South Cormorant River continues west for another 6 miles, turns north, and is joined by the tributary called Perry Creek. Perry Creek flows from east to west and drains 20 square miles of land within the north central region of the subwatershed. After the confluence of Perry Creek, the South Cormorant continues westward for another 3 miles before entering the Blackduck River. The land within the subwatershed is primarily forested (41.2 %) followed by wetland (37.1 %), rangeland (16.8 %), developed (2.3 %), cropland (2.2 %), and open water (0.4 %). The community of Funkley is within the subwatershed. In 2014, the MPCA collected biological samples from five stations located on three stream segments within the South Cormorant River Subwatershed. Water chemistry was intensively monitored at one station.

Table 10. Aquatic Life and Recreation Assessments on Stream Reaches in the South Cormorant River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

AUID *Reach Name*, Reach Description	Biological Station ID	Reach Length (miles)	Use Class	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides ***	Eutrophication	Aquatic Life	Aquatic Rec. (Bacteria)
09020302-546 **Spring Creek** **T149 R30W S10, south line to T149 R30W S5, north line**	-	2.82	WWg	-	-	IF	IF	IF	MTS	IF	IF	-	IF	IF	IF
09020302-552 **Spring Creek** **Unnamed cr to South Cormorant R**	14RD121	0.85	WWg	MTS	MTS	IF	IF	IF	-	IF	IF	-	IF	SUP	-
09020302-605 **Perry Creek** **Unnamed cr to Cormorant R**	14RD116	7.06	WWg	EXS	-	IF	IF	IF	IF	IF	IF	-	IF	IMP	IF
09020302-616 **Fish Creek** **Headwaters to Cormorant R**	-	6.59	WWg	-	-	IF	IF	IF	IF	IF	-	-	IF	IF	IF
09020302-507 **South Cormorant River** **Headwaters to Blackduck R**	14RD119 14RD117 14RD115	31.59	WWg	MTS	MTS	IF	MTS	IF	MTS	MTS	MTS	MTS	IF	SUP	IMP

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

Summary

Stations 14RD119, 14RD117, and 14RD115 were located on the South Cormorant River. Station 14RD119, the furthest upstream station, was located in the headwaters region approximately 3.5 miles northwest of Funkley. Fish were sampled in 2014 and 2015; the 2014 visit was non-reportable due to incorrect gear type. The 2015 visit FIBI score exceeded the exceptional use criteria, despite the fact that the most abundant fish sampled was the tolerant mud minnow. High numbers of lithophilic spawners and multiple sensitive species were present in the fish sample. Coarse substrate, woody debris, and moderate amounts of submerged macrophytes were present in the sampling reach. Good riffle habitat and channel development were also present. The 2014 MIBI score was fair. The macroinvertebrate sample contained numerous taxa that are tolerant of low DO and indicative of a wetland type stream. Several sensitive taxa were also present in the macroinvertebrate sample. Station 14RD117 was located approximately 10 miles downstream of station 14RD119. The 2014 FIBI score exceeded exceptional use criteria. High numbers of lithophilic spawners, multiple insectivorous species, and some sensitive species were present in the fish sample. Coarse substrate, in the form of lightly embedded gravel, was present throughout the sampling reach. Many different cover types were also present in the reach. The MIBI score was good. The macroinvertebrate community present was representative of a riffle run class northern stream. Station 14RD115 was located immediately upstream of the confluence of the Blackduck River. The 2014 FIBI exceeded the exceptional use criteria. Lithophilic spawners and insectivorous species were present in the fish sample but less abundant when compared to samples from the other stations. The MSHA score for this station (48) was considerably lower than the scores at station 14RD119 and 14RD117 (67 and 59, respectively). Substrate within the sampling reach consisted of unstable sand and silt; most of the coarse substrate present was severely embedded. Cover, in the form of woody debris and submerged macrophytes, was sparse. The MIBI score was good despite marginal stream habitat. Several sensitive caddis and mayfly taxa were present in the macroinvertebrate sample. Water chemistry data available on the South Cormorant River indicated high levels of bacteria were present throughout the summer months. The river will be impaired for aquatic recreation. Other measured parameters, such as DO, TSS, unionized ammonia, pH, and chloride, were within acceptable levels.

Station 14RD121 was located on Spring Creek, approximately a half mile upstream of the confluence of the South Cormorant River. The 2014 visit FIBI score (78.4), which exceeded exceptional use criteria, was among the highest FIBI scores in the Upper/Lower Red Lake Watershed. The fish sample contained multiple headwaters species and sensitive species. Good stream habitat consisting of coarse substrate, abundant macrophytes, and excellent channel development was present within the sampling reach. The MIBI score was good and the macroinvertebrate community was similar to other healthy communities found within this stream type.

Station 14RD116 was located on Perry Creek approximately 1.75 miles upstream of the confluence of Perry Creek and the South Cormorant River. Fish were sampled in 2014 and 2015; the 2014 visit was non-reportable due to unsatisfactory taxis. The 2015 visit FIBI score was poor. Only six species of fish were captured. The fish sample was dominated by a tolerant species (central mudminnow). Low numbers of lithophilic spawning species were present in the sample. Interestingly, station 14RD116 had the highest MSHA score (81) in the Upper / Lower Red Lake Watershed. Excellent stream habitat consisting of coarse substrate, woody debris, deep pools, and good channel development was present. Stream habitat does not appear to be a limiting factor. A beaver dam or some other barrier preventing fish migration is likely responsible for the poorly developed fish community. Macroinvertebrates were not sampled at station 14RD116 due to insufficient flow.

The South Cormorant River was the only reach with water chemistry datasets sufficient for assessment. Limited water chemistry data were available on Spring Creek, Perry Creek and Fish Creek; these stream reaches lacked the required number of samples for assessment. No lakes in the subwatershed had data available to assess aquatic recreation or aquatic life.

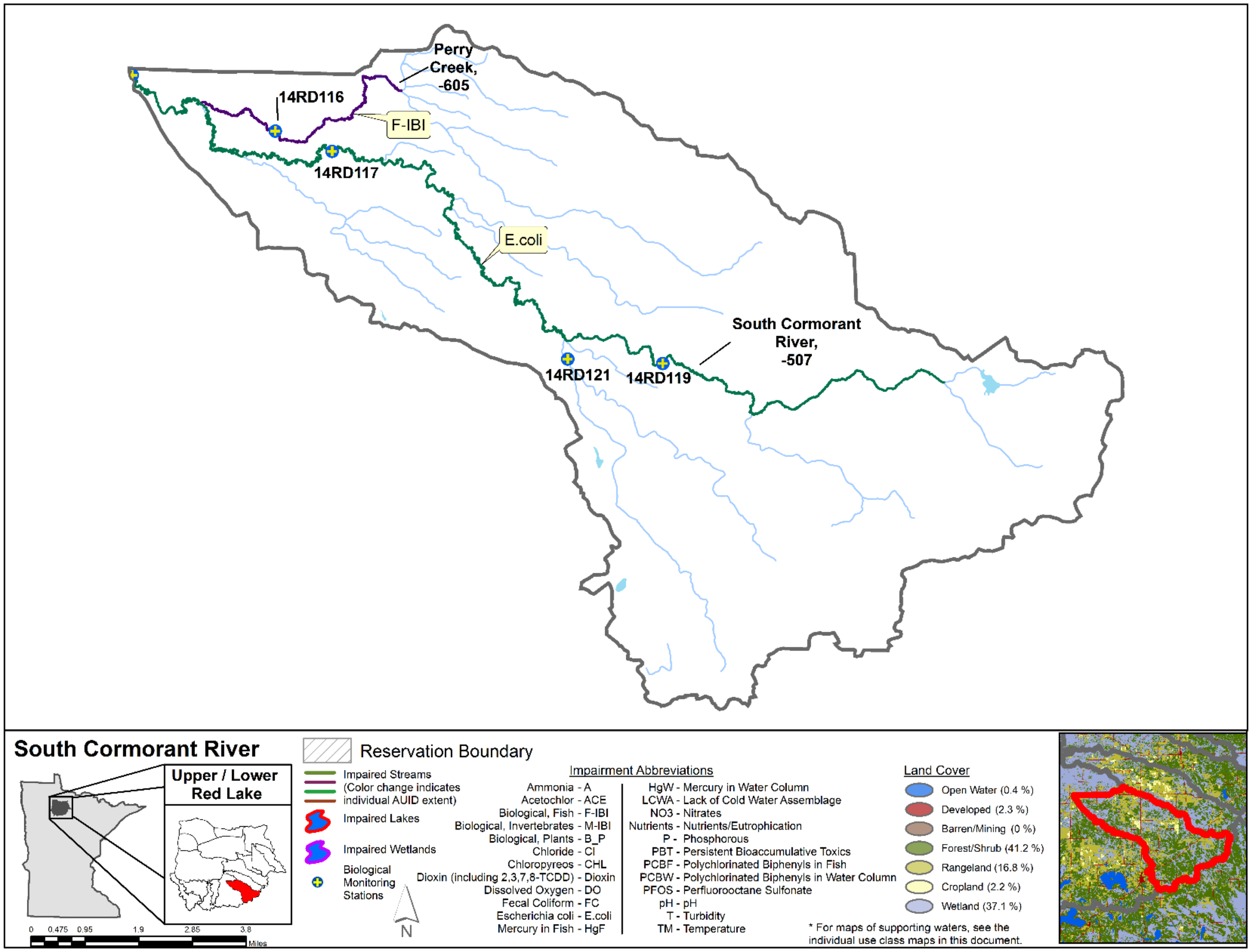


Figure 25. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the South Cormorant River Aggregated 12-HUC.

North Cormorant River Aggregated 12-HUC HUC 0902030206-02

The North Cormorant River Subwatershed drains 69 square miles of land within the eastern region of the Upper/Lower Red Lake Watershed. The North Cormorant River originates from a wetland area located approximately 5 miles southwest of Northome, on the eastern edge of the Upper/Lower Red Lake Watershed. The river winds toward the northwest for approximately 17 miles, passing through hayfields and forests before being joined by a small tributary called Meadow Creek. After the confluence of Meadow Creek, the river flows west for two miles and is joined by another small tributary called Haden Creek. After the confluence of Haden Creek, the North Cormorant River continues winding west for approximately 7 miles and joins the Battle River. The land within the subwatershed is primarily wetland (40.5 %) followed by forest (28.1 %), rangeland (24.2 %), cropland (4.4 %), developed (2.5 %), and open water (0.3 %). In 2014, the MPCA collected biological samples from four stations located on two stream segments within the North Cormorant River Subwatershed. Water chemistry was intensively monitored at one station.

Table 11. Aquatic Life and Recreation Assessments on Stream Reaches in the North Cormorant River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

				Aquatic Life Indicators:											
UID ***Reach Name*****,** *Reach Description*	**Biological Station ID**	**Reach Length (miles)**	**Use Class**	Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides ***	Eutrophication	**Aquatic Life**	**Aquatic Rec. (Bacteria)**
09020302-506 **North Cormorant River** **Headwaters to Blackduck R**	14RD127 14RD128 14RD124	39.13	WWg	MTS	MTS	EXS	EXS	IF	MTS	MTS	MTS	-	IF	IMP	IMP
09020302-542 **Meadow Creek** **T151 R30W S6, east line to T151 R31W S2, west line**	14RD141	4.33	WWg	MTS	MTS	IF	IF	IF		IF	IF	-	IF	SUP	-
09020302-543 **Meadow Creek** **T151 R31W S3, east line to North Cormorant R**	-	0.35	WWg	-	-	IF	IF	IF	IF	IF		-	IF	IF	IF

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

Summary

Stations 14RD127, 14RD128, and 14RD124 were located on a 39-mile long reach of the North Cormorant River. Station 14RD127, the furthest upstream station, was located within the headwaters region near HWY 72. The 2015 visit FIBI score was good and almost met exceptional use criteria. Numerous lithophilic spawning species and several sensitive species were present in the fish sample. The lack of riffle habitat and abundant aquatic vegetation found within the sampling reach was somewhat representative of a low gradient stream; however, several forms of coarse substrate were present. Macroinvertebrates were not sampled at station 14RD127 due to inadequate flow later in the summer. Station 14RD128 was located approximately 7 miles downstream of station 14RD127 near the middle of the reach. The 2015 visit produced the highest FIBI score in the Upper/Lower Red Lake Watershed. High numbers of insectivores, lithophilic spawners, and sensitive species were present in the fish sample. Excellent habitat, consisting of boulder and cobble substrate, riffles, deep pools, and woody debris was present within the sampling reach. The MIBI score was good. Fifty-six unique taxa were present in the macroinvertebrate sample, including multiple Plecoptera, Trichoptera, and Ephemeroptera taxa. Station 14RD124 was located 3 miles upstream of the confluence of the North Cormorant River and Battle River. The FIBI was just below passing. The most abundant fish species sampled was the very tolerant central mudminnow. The fish sample also contained higher numbers of trophic generalist species and serial spawning species; however, good numbers of insectivores and some sensitive species were present. Prolonged high flows during 2014 likely had a negative influence on the sample. Stream habitat within the sampling reach consisted of deep pools, woody debris, and sparse aquatic vegetation along with shifting sand and clay substrate. Most coarse substrate (gravel) was moderately to severely embedded. Evidence of channel instability, in the form of bank erosion and collapsing trees along the bank, was present throughout the sampling reach. The MIBI score was just below passing. Like the fish community, high flows during much of 2014 may have negatively affected the macroinvertebrate community. The community may also be impacted by shifting sediment and reduced habitat heterogeneity. The stations upstream of station 14RD124 had higher gradient, excellent habitat, and good biological communities. The accumulation of sediment and reduced habitat heterogeneity at station 14RD124 may be a result of the lower gradient. Channel morphology work will be done within the lower reach of the North Cormorant River to evaluate channel stability within the reach. The North Cormorant River is impaired for aquatic life based on exceedances of the DO and TSS standards. DO concentrations on this reach fell below the 5.0 mg/L standard in 18.6% of the samples collected over the 10-year assessment window, with readings as low as 1.00 mg/L. TSS concentration exceeded the 15 mg/L standard in 14.3% of samples. The North Cormorant River is also impaired for aquatic recreation. *E.coli* concentrations exceeded the standard during the summer months. Locals did note that significant habitat and landscape improvements have been made along the North Cormorant River to improve water quality – primarily along the upstream half of this reach. If the reach were split at the confluence with Meadow Creek the upper portion of the North Cormorant River would then meet TSS standards, but DO data would be inconclusive and bacteria data would still indicate an aquatic recreation impairment. The reach downstream of Meadow Creek would still be impaired for DO and TSS, but resulting *E. coli* dataset after a split would show no aquatic recreation impairment.

Station 14RD141 was located on Meadow Creek just upstream of the confluence of Meadow Creek and the North Cormorant River. The 2014 visit FIBI score (73.3) exceeded exceptional use criteria and was among the highest FIBI scores in the Upper/Lower Red Lake Watershed. The fish sample was dominated by pearl dace – a sensitive headwater species. Good numbers of lithophilic spawners, insectivores, and other sensitive species were also present in the sample. Habitat within the sampling reach consisted of sand and gravel substrate, riffles, a variety of cover types, and good channel development. The MIBI score was good. Several sensitive taxa were present in the macroinvertebrate sample. The limited water chemistry data available for Meadow Creek was insufficient for assessment.

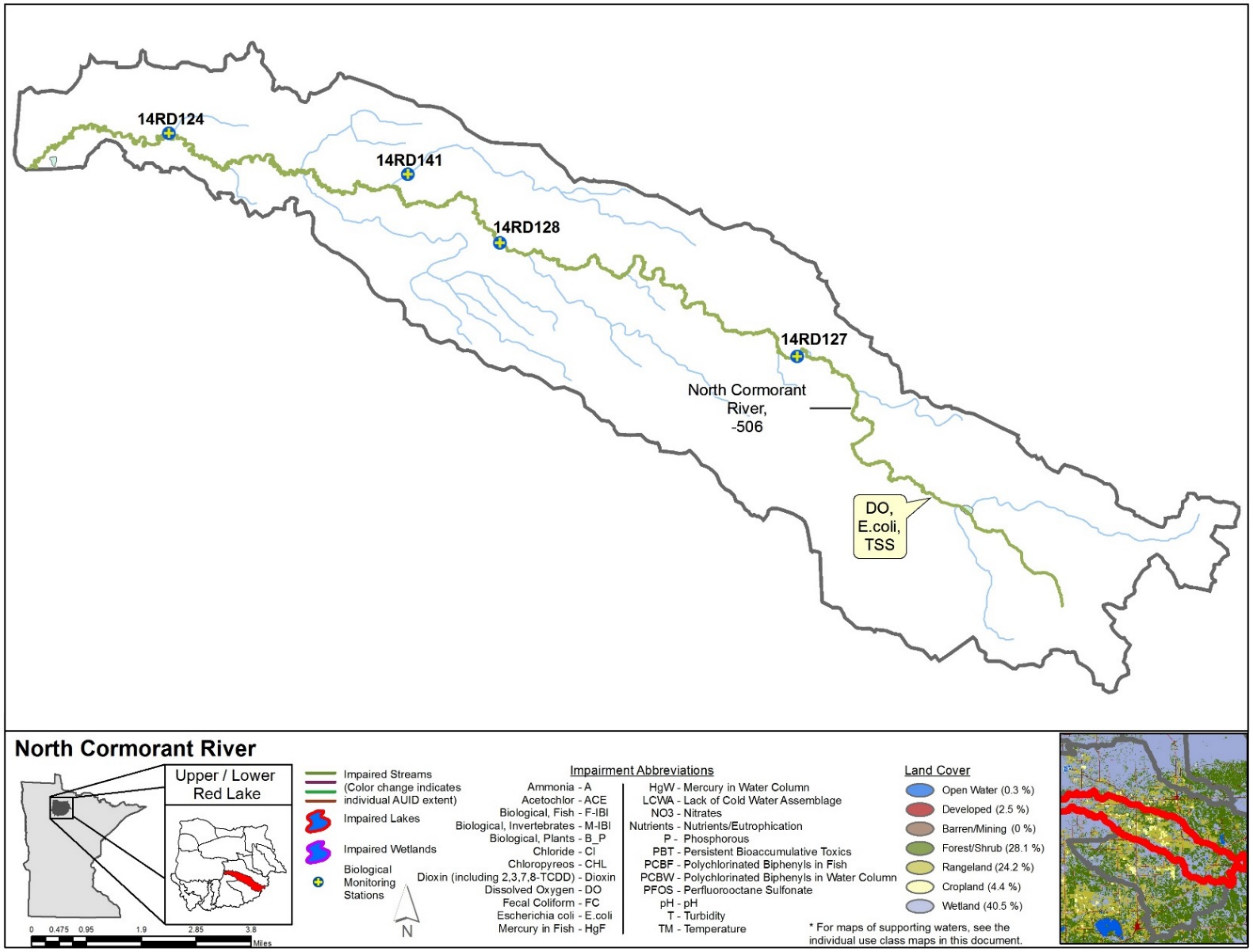


Figure 26. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the North Cormorant Aggregated 12-HUC.

Battle River Aggregated 12-HUC HUC 0902030205-01

The Battle River Subwatershed drains 122 square miles of land within the eastern region of the Upper/Lower Red Lake Watershed. The North Branch of the Battle River originates from a wetland in the Red Lake State Forest and winds west for 11 miles before turning south. The river continues south for approximately two miles and joins with the South Branch of the Battle River. Wetlands border the North Branch of the Battle River along most of its 13-mile flow length. Numerous ditches, draining extensive areas of wetland, flow into the river from the north and south. The South Branch of the Battle River originates from Battle Lake and flows west a short distance before turning toward the northwest. The river continues flowing northwest for approximately 3 miles before being joined by the small tributary Armstrong Creek. The river continues winding northwest for approximately 2.5 miles before transitioning to a cold water stream that supports a trout fishery. After winding northwest for approximately five miles, the South Branch of the Battle River transitions back to a warm water stream. The river continues flowing west/northwest for 13 miles and joins the North Branch of the Battle River. The North and South Branch of the Battle River join together to form the Battle River. The Battle River flows toward the south for approximately one mile before turning toward the southwest. The river eventually winds toward the north and enters Lower Red Lake. The Battle River features an extensive wetland riparian area along its entire 2.7-mile flow length. Land use within the subwatershed is primarily wetland (52.6 %) followed by forest (30.8 %), rangeland (10.9 %), developed (2.7 %), crop land (1.4 %), and open water (1.4 %). The community of Kelliher is within the subwatershed. In 2014, the MPCA collected biological samples from four stations located on four stream segments. Water chemistry was intensively monitored at two locations.

Table 12. Aquatic Life and Recreation Assessments on Stream Reaches in the Battle River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

AUID *Reach Name*, *Reach Description*	Biological Station ID	Reach Length (miles)	Use Class	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides ***	Eutrophication	Aquatic Life	Aquatic Rec. (Bacteria)
09020302-573 **Armstrong Creek** **Unnamed lk (36-0016-00) to Unnamed cr**	--	2.92	WWg	--	--	--	--	--	--	IF	--	--	--	IF	--
09020302-574 **Armstrong Creek** **Unnamed cr to Battle R**	14RD132	3.92	WWg	MTS	MTS	IF	IF	IF		IF	IF	--	IF	SUP	--
09020302-538 **Battle River, South Branch** **T151 R30W S11, east line to T151 R30W S4, west line**	09RD064	4.83	CWg	--	--	IF	IF	IF	MTS	IF	IF	--	IF	SUP	IF
09020302-539 **Battle River, South Branch** **T151 R30W S5, east line to N Br Battle R**	14RD129	22.12	WWg	MTS	MTS	MTS	MTS	MTS	MTS	MTS	MTS	--	IF	SUP	SUP
09020302-523 **Unnamed Creek** **Headwaters to S Br Battle R**	14RD134	4.66	WWg	MTS	MTS	IF	IF	IF		IF	IF	--	IF	SUP	--
09020302-503 **Battle River, North Branch** **Headwaters (Unnamed ditch) to S Br Battle R**	14RD130	13.00	WWg	EXS	MTS	EXS	MTS	MTS	MTS	MTS	MTS	--	IF	IMP	IMP
09020302-505 **Battle River** **N Br Battle R to Lower Red Lk (Tribal water)**	--	2.68	WWg	--	--	NA	NA	NA	NA	NA	NA	--	NA	NA	SUP

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

Table 13. Lake Assessments in the Battle River Aggregated 12-HUC.

Lake Name	DNR ID	Area (acres)	Max Depth (ft)	Assessment Method	Ecoregion	Secchi Trend	Aquatic Life Indicators: Fish IBI	Aquatic Life Indicators: Chloride	Aquatic Life Indicators: Pesticides ***	Aquatic Recreation Indicators: Total Phosphorus	Aquatic Recreation Indicators: Chlorophyll-a	Aquatic Recreation Indicators: Secchi	Aquatic Life Use	Aquatic Recreation Use
Bartlett	36-0018-00	294	16	Shallow Lake	NLF	I	--	MTS	--	EX	EX	EX	IF	NS
Silversack	36-0039-00	18	24	Deep Lake	NMW	--	--	--	--	IF	--	--	--	IF

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

Summary

Station 14RD129 was located on the South Branch of the Battle River, approximately two miles upstream of the confluence of the North and South Branch of the Battle River. The 2014 visit FIBI score was good. The fish sample was dominated by a tolerant species (brook stickleback); however, good numbers of lithophilic spawners, several sensitive species, and one intolerant species (burbot) were present in the sample. Habitat within the sampling reach consisted of shifting sand and clay, severely embedded gravel, woody debris, and sparse aquatic vegetation. The MIBI score was good. An extensive water chemistry dataset was available on this reach of the South Branch of the Battle River. DO and TSS/transparency indicated that was quality was good and supportive of aquatic life. Phosphorus was elevated; however, no eutrophication (excess productivity) was observed along the reach – oxygen flux was low (i.e. good) and aquatic vegetation was noted as sparse.

Station 09RD064 was located on the cold water segment of the South Branch of the Battle River. Due to a beaver impoundment, biological data was not collected on this reach in 2014. Fish and macroinvertebrates were sampled in 2010. The 2010 visit FIBI score was good. The fish sample consisted primarily of warm water species. Low numbers of rainbow trout and northern brook lamprey (cold water species) were present in the sample. Sand and gravel substrate was present throughout the reach along with limited amounts of cobble. An extensive amount of cover and a variety of different cover types was also present. The MIBI score was passing. Several sensitive caddis and mayfly taxa were present in the sample.

Station 14RD134 was located on a tributary to the South Branch of the Battle River. The 2014 visit FIBI was good. The fish sample was dominated by a tolerant, poineer species (creek chub); however, lithophilic spawners, insectivores, and sensitive species were also present in the sample. Sand and gravel substrate along with limited amounts of cobble was present throughout the sampling reach. A variety of cover types, including deep pools, woody debris, submergent vegetation, and undercut banks were also present. The MIBI score was good. Fifty-six unique taxa were present in the sample, including several sensitive mayfly taxa.

Station 14RD130 was located on the North Branch of the Battle River, approximately 4 miles upstream of the confluence of the North and South Branch of the Battle River. Both fish and macroinvertebrates were sampled in 2014 and 2015; the 2014 fish visit was not reportable due to sampling equipment problems. The 2015 visit FIBI score was poor. The fish sample was dominated by tolerant and generalist species. Substrate within the sampling reach consisted primarily of sand and silt with limited areas of moderately embedded gravel. Woody debris and sparse amounts of aquatic vegetation were also present. Stream habitat did not appear to be a limiting factor. The poor fish community may be a result of a downstream barrier preventing migration. DO concentrations were as low as 0.40 mg/L on the North Branch of the Battle River; low DO is stressing the fish community. The 2014 visit MIBI score was poor. Thirty-seven taxa, including high numbers of the tolerant Simulium (black fly) and Dubiraphia (riffle beetle), were present in the sample. The 2015 visit MIBI was good and 56 taxa were present in the sample. Prolonged high flows during 2014 may have negatively affected the macroinvertebrate community. In addition, aquatic macrophytes were a habitat type sampled in 2015 but not sampled in 2014 (they were too sparse). The stream segment is impaired for aquatic life based on the FIBI score. Elevated bacteria levels occurred throughout the summer months; increasing the risk of illness from recreating in the stream. The river is considered impaired for aquatic recreation.

Two lakes in the subwatershed had data available for aquatic recreation use assessment. Silversack Lake was not assessed due to insufficient data. The lake has a single phosphorus value indicating it is just above the water quality standard; DNR notes that it is a productive lake. Algae blooms likely occur. Bartlett Lake is impaired for aquatic recreation – all three eutrophication indicators exceeded the NLF Ecoregion standard. Historical activities on or near this lake could explain the deterioration of water quality. A dairy operation, lumber mills, and wastewater treatment facility all used to discharge into this lake. All of these are probable sources of nutrient enrichment to the lake. Bartlett Lake winterkills about every 10 years and is subsequently stocked with panfish following the winterkills; due to winterkills, an aquatic life assessment using the fish community could not be made. Chloride data for Bartlett Lake is meeting aquatic life standards. The most recent plant survey indicated a healthy plant community is present.

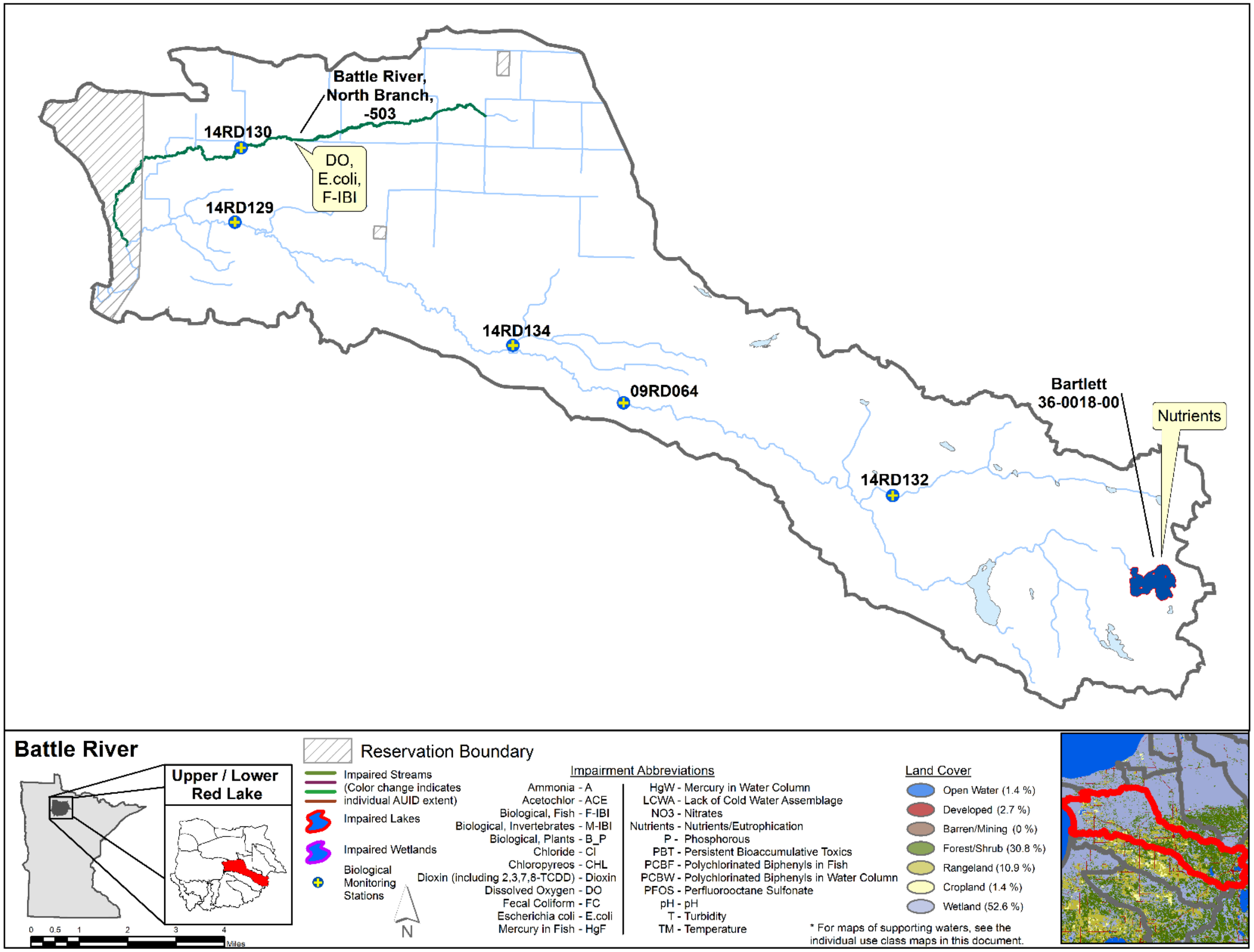


Figure 27. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the Battle River Aggregated 12-HUC.

Lower Red Lake Aggregated 12-HUC HUC 0902030209-01

The Lower Red Lake Subwatershed drains 330 square miles of land within the Upper/Lower Red Lake Watershed. Lower Red Lake, one of the largest lakes in Minnesota, is found within the subwatershed. The entire subwatershed lies within the Red Lake Indian Reservation. The Red Lake River, a major tributary to the Red River, originates from Lower Red Lake. No other significant tributaries occur within the subwatershed. Land use within the subwatershed is primarily open water (77.8 %) followed by wetland (16.6 %), forest (4.4 %), developed (0.9 %), and rangeland (0.2 %). The communities of Red Lake, Redby, and Ponemah are within the subwatershed. There were no significant streams present within the subwatershed.

Table 14. Lake Assessments in the Lower Red Lake Aggregated 12-HUC.

Lake Name	DNR ID	Area (acres)	Max Depth (ft)	Assessment Method	Ecoregion	Secchi Trend	Aquatic Life Indicators:			Aquatic Recreation Indicators:			Aquatic Life Use	Aquatic Recreation Use
							Fish IBI	Chloride	Pesticides ***	Total Phosphorus	Chlorophyll-a	Secchi		
Lower Red	04-0035-02	164699	32	Deep Lake	NMW	--	--	--	--	NA	NA	NA	--	NA
Green	04-0193-00	66	66	Deep Lake	NLF	--	--	--	--	MTS	MTS	MTS	--	FS

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

Summary

Lower Red Lake and Green Lake had sufficient data to assess for aquatic recreation. It was noted by the RLDNR that Green Lake is managed for lake trout. This lake exhibited excellent water quality and would meet the NLF lake trout lake standards. Lower Red Lake is a very large, relatively shallow, windswept basin that drains a large bog complex. The catchment to Lower Red Lake falls across three ecoregions – the Northern Minnesota Wetlands (NMW), the North Central Hardwood Forest, and the Northern Lakes and Forests (NLF). While the lake is predominantly in the NMW ecoregion, that region does not have specific water quality standards. The nearest ecoregion with standards (that is most similar in land use) is the NLF ecoregion. TP, chlorophyll-a, and Secchi depth all would be exceeding aquatic recreation standards if held to NLF Ecoregion standards. The RLDNR has already collected sediment cores to help determine an appropriate, lake-specific standard for both Upper and Lower Red Lakes. With work already underway to determine site specific standards, the lake will be not assessed at this time.

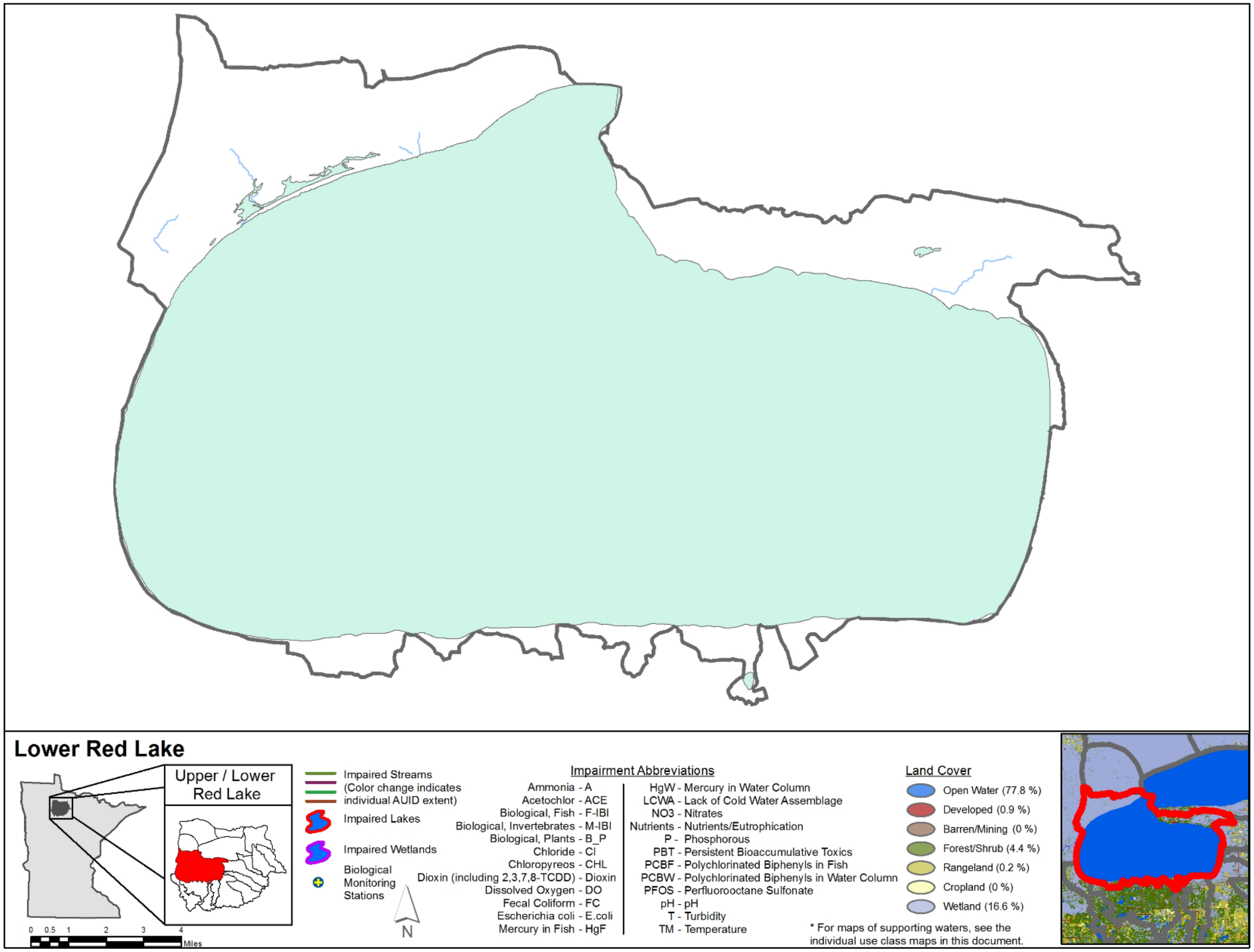


Figure 28. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the Lower Red Lake Aggregated 12-HUC.

Shotley Brook Aggregated 12-HUC

HUC 0902030204-02

The Shotley Brook Subwatershed drains 46 square miles of land within the eastern region of the Upper/Lower Red Lake Watershed. Shotley Brook originates from a large wetland located in the Red Lake State Forest near Highway 72. A network of ditches draining an extensive area of wetlands flow into the headwaters of Shotley Brook. The stream flows west for approximately 3.5 miles before turning toward the northwest. Shotley Brook continues winding northwest for eight miles and empties into Upper Red Lake. Other tributaries within the subwatershed include Hoover Creek. Hoover Creek originates from a wetland located approximately 4 miles northeast of Kelliher. The stream flows northwest for 8.5 miles before turning north and flowing along CR 105. Once Hoover Creek turns toward the north, the stream becomes a channelized ditch that connects with a network of other ditches. Land use within the subwatershed is primarily wetland (71.6 %) followed by forest (19.9 %), rangeland (5.5 %), developed (2.2 %), cropland (0.5 %), and open water (0.1 %). In 2014, the MPCA collected biological samples from two stations located on two stream segments within the Shotley Brook Subwatershed. Water chemistry was intensively monitored at one station.

Table 15. Aquatic Life and Recreation Assessments on Stream Reaches in the Shotley Brook Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name***, *Reach Description*	**Biological Station ID**	**Reach Length (miles)**	**Use Class**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides ***	Eutrophication	**Aquatic Life**	**Aquatic Rec. (Bacteria)**
09020302-547 **Hoover Creek** **Headwaters to T152 R30W S13, north line**	14RD137	8.40	WWg	MTS	MTS	IF	IF	IF	MTS	IF	MTS		IF	SUP	IF
09020302-502 **Shotley Brook** **Headwaters to Upper Red Lk**	14RD136	11.56	WWg	MTS	EXS	NA	IF	IF	IF	IF	IF		IF	IMP	IMP

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

Summary

Station 14RD136 was located on Shotley Brook approximately 2 miles upstream of Upper Red Lake. The 2014 visit FIBI score was good. Multiple lithophilic spawning species, including adult walleye, were present in the fish sample. Substrate within the sampling reach consisted of shifting sand and embedded gravel. The woody debris present within the reach was also partially embedded in sand. Bank erosion and channel incision was present throughout the reach; both are indications of channel instability. The MIBI score was poor. Woody debris was the only macroinvertebrate habitat present within the sampling reach. The excess sedimentation covering the woody debris is likely having a negative effect on the macroinvertebrate community. The reach is impaired for aquatic life based on the MIBI. Water chemistry data was available on this reach of Shotley Brook. Due to heavy wetland influence, the DO data was not used for aquatic life assessment. The current standard is not a reliable indicator for this type of wetland influenced stream. Concentrations were all above 6 mg/L, but little early morning data was available. While datasets were small, sediment and phosphorus concentrations were low on this reach. Bacteria concentrations consistently exceeded the standard during the month of August; as a result, the reach is impaired for aquatic recreation.

Station 14RD137 was located on Hoover Creek just upstream of where the stream becomes channelized. The 2014 visit FIBI almost met exceptional use criteria. High numbers of sensitive species and lithophilic spawners were present in the fish sample. The substrate within the sampling reach was primarily sand and clay with limited amounts of gravel, cobble, and boulders. Submergent vegetation, woody debris, and riffle habitat were present. The MIBI score (69.43) was among the highest scores in the Upper Lower Red Lake Watershed. Good taxa diversity was present in the sample. Taxa from the orders Plecopetera, Trichoptera, Odonata, and Ephemeroptera were among the 35 taxa present in the sample. The small water chemistry dataset available for this segment of Hoover Creek was insufficient for assessment. Within the dataset, DO concentrations were below the 5 mg/L standard in four of the seven measurements taken.

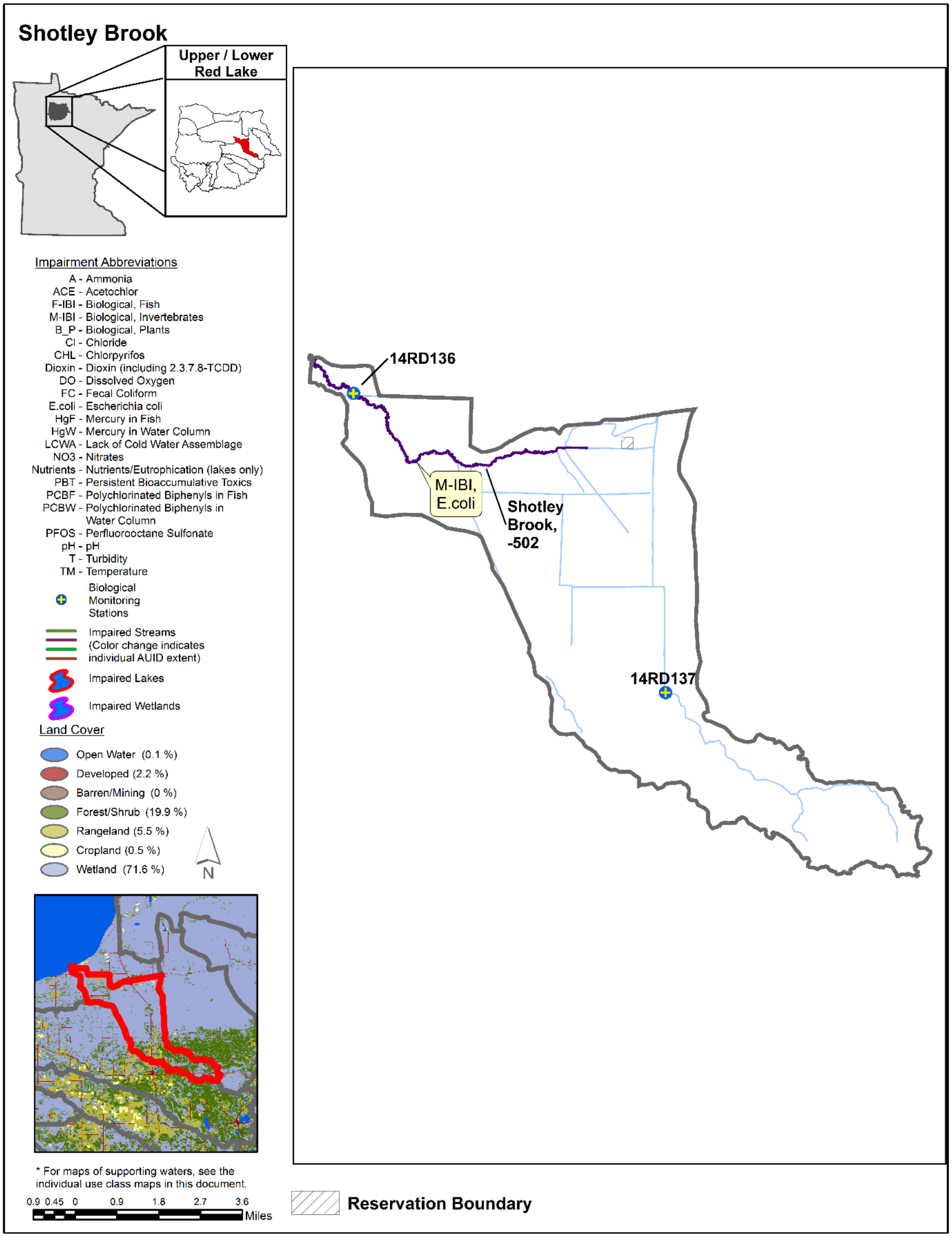


Figure 29. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the Shotley Brook Aggregated 12-HUC.

Tamarac River Aggregated 12-HUC HUC 0902030201-02

The Little Tamarac River Subwatershed drains 94 square miles of land within the northeast portion of the Upper/Lower Red Lake Watershed. The Little Tamarac River originates from a large black spruce bog and winds northwest for approximately 12 miles before joining with the Tamarac River. The last 1.9 miles of the Little Tamarac River have been channelized. Several ditches, which drain areas of spruce bog, flow into the Little Tamarac River. Numerous short streams drain a lobe of lake modified till present within the upper portion of the subwatershed. These small streams disappear once they enter the vast, flat peat lands present within the central portion of the subwatershed. Land use within the subwatershed is primarily wetland (72.9 %) followed by forest (23.7 %), rangeland (2.9 %), developed (0.9 %), cropland (0.2 %), and open water (0.2 %). In 2014, the MPCA collected biological samples from one station within the Little Tamarac River Subwatershed. Water chemistry was intensively monitored at one station.

Table 16. Aquatic Life and Recreation Assessments on Stream Reaches in the Little Tamarac River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

				Aquatic Life Indicators:											
AUID ***Reach Name***, *Reach Description*	**Biological Station ID**	**Reach Length (miles)**	**Use Class**	Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides ***	Eutrophication	**Aquatic Life**	**Aquatic Rec. (Bacteria)**
09020302-607 **Unnanmed Creek** **Unnamed creek to Unidentified wetland**	15EM061	2.68	WWg	--	IF	--	--	IF	--	--	IF	--	IF	IF	--
09020302-614 **Little Tamarac River** **Headwaters to State Forest Rd 98**	14RD138	12.24	WWg	MTS	MTS	NA	IF	IF	MTS	MTS	MTS	--	IF	SUP	SUP

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

Summary

Station 14RD138 was located on the Little Tamarac River approximately 1.8 miles upstream of the confluence of the Little Tamarac and Tamarac River. Most of the sampling reach was located on the channelized portion of the river. The 2014 visit FIBI score was low but passing. The central mudminnow, a very tolerant species, was the second most abundant species in the fish sample. Multiple trophic generalist species were also present in the sample along with some lithophilic spawners and insectivores. Stream habitat within the sampling reach was poor. Substrate consisted of shifting sand and silt; no coarse substrate was present. Sparse amounts of woody debris and aquatic vegetation were present. The poor habitat is likely the result of channelization. Despite marginal habitat, the MIBI score (71.3) was among the highest scores in the Upper/Lower Red Lake Watershed. Good taxa diversity, including several sensitive mayfly taxa, were present in the sample. Water chemistry data available on this segment of the Little Tamarac River indicate the reach supports aquatic recreation. Due to wetland influence, the DO data was not used to assess aquatic life. Though early morning data was not available, concentrations remained above 6 mg/L on the river. Phosphorus and sediment concentrations were low.

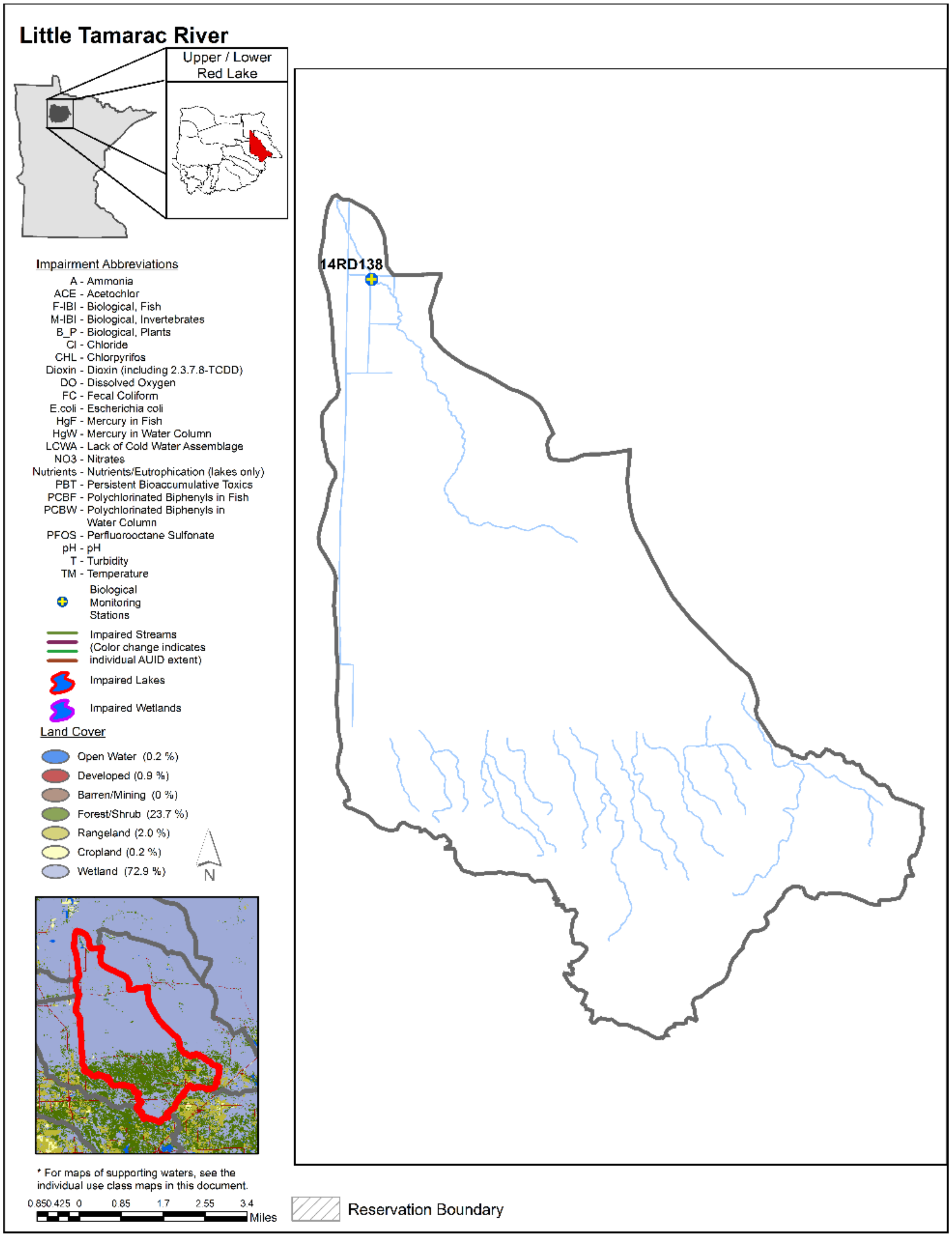


Figure 30. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the Little Tamarac River Aggregated 12-HUC.

Lost River Aggregated 12-HUC HUC 0902030201-03

The Lost River Subwatershed drains 79 square miles of land within the northeast portion of the Upper/Lower Red Lake Watershed. The Lost River originates from a large black spruce bog located near the community of Gemmell. The stream flows northwest and features a broad wetland riparian. After flowing northwest for approximately 4.5 miles, the stream enters another large black spruce bog and the channel becomes undiscernible in aerial imagery. The channel becomes visible again 2.5 miles northwest of where it disappeared. The river continues winding northwest for 13 miles before the channel again appears to fade away into a black spruce bog. The river reappears 1.5 miles to the west and flows another 2 miles before entering the Tamarac River. Several small, unnamed tributaries flow into the Lost River. Two recreational lakes exist in the watershed just southeast of Gemmell, Clear and Dark lakes. Both provide opportunity for sport fishing and are publically accessible. Land use within the subwatershed is primarily wetland (90.3 %) followed by forest (6.0 %), rangeland (1.8 %), developed (1.0 %), open water (0.5 %), and cropland (0.3 %). In 2014, the MPCA collected biological samples from two stations located on two stream segments. Water chemistry was intensively monitored at one station.

Table 17. Aquatic Life and Recreation Assessments on Stream Reaches in the Lost River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name***, *Reach Description*	**Biological Station ID**	**Reach Length (miles)**	**Use Class**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides ***	Eutrophication	**Aquatic Life**	**Aquatic Rec. (Bacteria)**
09020302-603 **Lost River** **Headwaters to Unnamed cr**	14RD142	13.68	WWg	MTS	MTS	NA	IF	IF	--	IF	IF	--	IF	SUP	--
09020302-602 **Lost River** **Unnamed cr to Tamarac R**	14RD148	10.67	WWg	EXS	MTS	NA	IF	IF	MTS	MTS	MTS	--	IF	IMP	SUP

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

Table 18. Lake Assessments in the Lost River Aggregated 12-HUC.Table 18. Lake assessments: Lost River Aggregated 12-HUC.

Lake Name	DNR ID	Area (acres)	Max Depth (ft)	Assessment Method	Ecoregion	Secchi Trend	Aquatic Life Indicators:			Aquatic Recreation Indicators:			Aquatic Life Use	Aquatic Recreation Use
							Fish IBI	Chloride	Pesticides ***	Total Phosphorus	Chlorophyll-a	Secchi		
Clear	36-0011-00	112	30	Deep Lake	NMW	--	--	MTS	--	MTS	MTS	MTS	IF	FS
Dark	36-0014-00	114	50	Deep Lake	NMW	--	--	MTS	--	MTS	EX	MTS	IF	FS

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

Summary

Station 14RD142 was located in the headwaters region of the Lost River, upstream of Lost River Road. The 2014 visit FIBI score was good. The most abundant species sampled were pearl dace, finescale dace, and northern redbelly dace – all sensitive, headwater species. Several lithophilic spawning species were also present in the sample. Excellent stream habitat consisting of riffles, coarse substrate, woody debris, and good channel development were present within the reach. Macroinvertebrates were sampled in 2014 and 2015. Station 14RD148 was located on the Lost River just upstream of the confluence of the Lost and Tamarac River. Both fish and macroinvertebrates were sampled in 2014 and 2015. The FIBI scores (9) from both visits were poor. Three species of fish were collected during the 2014 visit and four species were collected in 2015. Both samples were dominated by tolerant species. Habitat does not appear to be a limiting factor. The 2014 macroinvertebrate sample was dominated by the tolerant Simulium (black fly) and the MIBI score was poor. The 2015 visit MIBI was good. Water chemistry data available on this segment indicate frequent occurrences of low DO concentrations. DO concentrations as low as 3.90 mg/L were measured; 25% of the total measurements exceeded the standard. Land use along the entire flow length of the Lost River consists of wetlands and spruce bog. The low DO concentrations are likely the result of wetland influence, and assessment of aquatic life will rely on the biological community. Phosphorus and sediment concentrations, based on limited data, were low.

Bacteria levels were low in all samples indicating support for aquatic recreation.

Two lakes in the Lost River Subwatershed were assessed for aquatic recreation. Clear Lake and Dark Lake are located southeast of the town of Gemmell. The two lakes are just over 100 acres in size and considered deep basins; the Northern Lakes and Forests Ecoregion standard was applied to both lakes. Clear Lake met recreation standards. For Dark Lake, aquatic recreation parameters, TP and Secchi transparency indicated support for aquatic recreation. Chl-a exceeded the standard. Some types of algae, such as aphanizominon, allow for greater light to penetrate the surface and may be the reason the lake still has good clarity. Protecting Dark Lake to prevent an impairment should be considered a high priority.

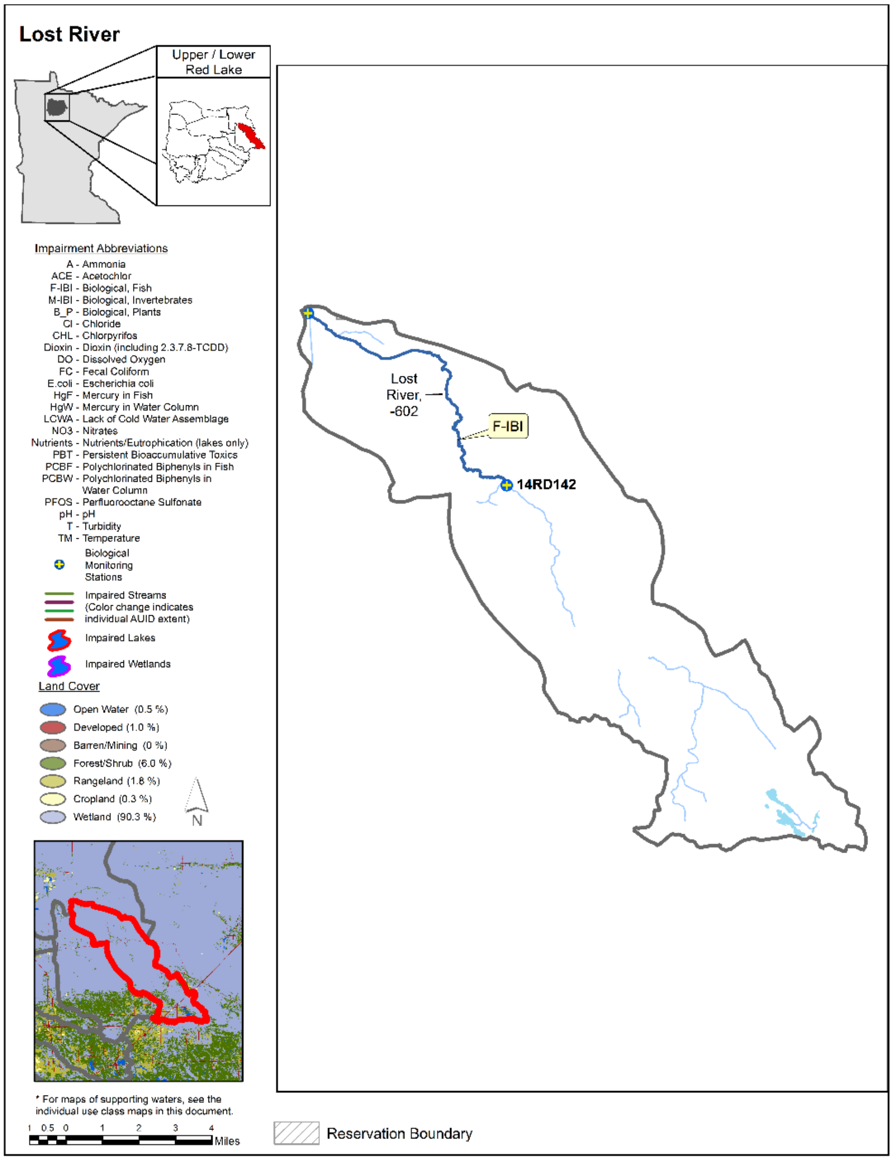

Figure 31. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the Lost River Aggregated 12-HUC.

Tamarac River Aggregated 12-HUC HUC 0902030201-01

The Tamarac River Subwatershed drains 131 square miles of land within the northeast region of the Upper/Lower Red Lake Watershed. The Tamarac River originates from a vast black spruce bog located within the Pine Island State Forest. From its headwaters, the river flows toward the west for approximately six miles before turning toward the southwest. Along this stretch of river, numerous ditches that drain extensive areas of wetland and spruce bog flow into the river from both the north and the south. The river continues flowing southwest for approximately 1.5 miles before joining a major tributary called the Lost River. The Lost River drains a 79 square mile subwatershed that is predominately wetland/spruce bog. After the confluence of the Lost River, the Tamarac River flows west for another two miles before encountering another major tributary called the Little Tamarac River. The Little Tamarac River drains a 94 square mile subwatershed that is predominately wetland/spruce bog. After the confluence of the Little Tamarac River, the Tamarac River continues winding west for 11 miles. Along this segment of river, several large drainage ditches that drain areas of agricultural land use and wetland flow into the Tamarac River from the north. The river eventually turns and flows north for two miles before emptying into Upper Red Lake. The river features an extensive wetland riparian along most of its 23-mile flow length. Land use within the subwatershed is primarily wetland (94.8 %) followed by forest (1.5 %), rangeland (1.4 %), cropland (1.4 %), developed (0.5 %) and open water (0.3 %). In 2014, the MPCA collected biological samples from two stations located on two stream segments within the Tamarac River Subwatershed. Water chemistry was intensively monitored at one station.

Table 19. Aquatic Life and Recreation Assessments on Stream Reaches in the Tamarac River Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

AUID *Reach Name*, *Reach Description*	Biological Station ID	Reach Length (miles)	Use Class	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides ***	Eutrophication	Aquatic Life	Aquatic Rec. (Bacteria)
09020302-501 **Tamarac River** **Headwaters to Upper Red Lk**	14RD143 14RD139	22.79	WWg	EXS	MTS	NA	NA	NA	NA	NA	NA	--	NA	IMP	SUP

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
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*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Summary

Stations 14RD139 and 14RD143 were located on the 23 mile long segment of the Tamarac River that extends from the confluence of the Lost River to Upper Red Lake. Fish were sampled in 2014 and 2015 at both stations. Station 14RD143 was located near the confluence of the Lost River and Tamarac River. The 2014 visit FIBI score (8.9) was poor. Only five species of fish were present in the sample, and the tolerant central mudminnow was the most abundant species. The 2015 visit FIBI score (31.2) was considerably higher but still poor. Eight species of fish were present in the sample. The 2015 sample was also dominated by the tolerant central mudminnow; however, more lithophilic spawning species (including juvenile walleye) were present in this sample. Stream habitat within the reach consisted of sparse amounts of woody debris, sparse vegetation, predominantly sand substrate, and no riffles. The marginal stream habitat may be limiting fish community development. Natural phenomenon, such as low DO resulting from wetland influence may also be effecting the fish community. Further investigation is needed to determine the cause of the poor fish community. This segment is impaired for aquatic life based on the FIBI score. Macroinvertebrates were sampled in 2014 and 2015. The 2014 sample was dominated by the tolerant Simulium (black fly) and the MIBI score was poor. The 2015 visit MIBI score was good. The 2015 sample featured a much lower number of the tolerant Simulium and additional sensitive taxa. Prolonged high flows during 2014 may have had a negative effect on the macroinvertebrate community. Station

14RD139 was located 2.5 miles upstream of where the Tamarac River enters Upper Red Lake. The 2014 visit FIBI (0) was very poor. Only four species of fish were present in the sample (15 fish total). Prolonged high flows during 2014 may have affected the fish community. The 2015 visit FIBI score (37.9) was considerably higher but still below passing. Seven species of fish were present in the sample (53 fish total). The fish community was indicative of a wetland type stream and lacked the expected numbers of lithophilic spawners, insectivores, and sensitive species necessary to support a passing northern streams FIBI score. The fish data collected from station 14RD139 was not used to assess aquatic life due to the low gradient characteristics and a large drainage area of this reach. Both the low gradient FIBI and northern streams FIBI are not applicable to this stream type. Macroinvertebrates were not sampled at station 14RD139. Water chemistry data available on the Tamarac River were not used to assess aquatic life due to predominant wetland influence throughout the subwatershed and backwater influence from Upper Red Lake. DO concentrations were below the 5 mg/L standard in 32.5 % of the measurements taken during the sampling period; as low as 0.2 mg/L. The mean TP concentration (63.6 ug/L) was above the regional standard. The low DO and elevated TP are likely the result of wetland influence.

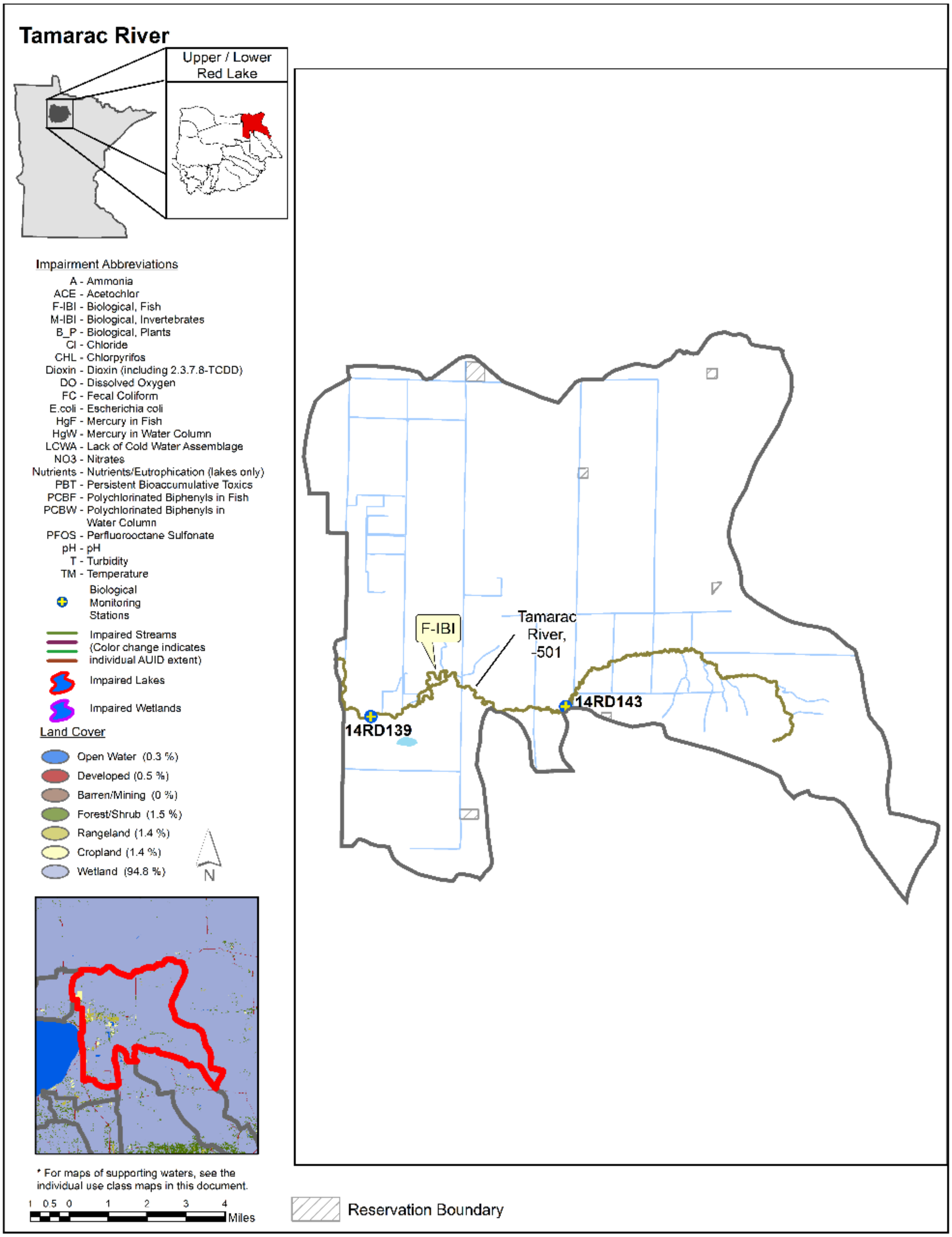

Figure 32. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the Tamarac River Aggregated 12-HUC.

Deer River – Frontal Upper Red Lake Aggregated 12-HUC HUC 0902030202-02

The Deer River – Frontal Upper Red Lake Subwatershed drains 61 square miles of land in the northern region of the Upper/Lower Red Lake Watershed. An extensive network of drainage ditches is present throughout the subwatershed. The ditches drain large areas of wetland and flow into Upper Red Lake. The only natural stream channels present within the subwatershed are several short (< 1 mile) streams that flow directly into Upper Red Lake. No lakes are present within the subwatershed. Land use within the subwatershed is primarily wetland (97 %) followed by forest (1.1 %), developed (0.8 %), cropland (0.5 %), rangeland (0.3 %), and open water (0.2 %). There were no suitable locations to establish a biological monitoring station within the subwatershed. Water chemistry was intensively monitored at one location within the Deer River – Frontal Upper Red Lake Subwatershed.

Table 20. Aquatic Life and Recreation Assessments on Stream Reaches: Deer River-Frontal Upper Red Lake Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name***, *Reach Description*	**Biological Station ID**	**Reach Length (miles)**	**Use Class**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides ***	Eutrophication	**Aquatic Life**	**Aquatic Rec. (Bacteria)**
09020302-600 **Unnamed creek** **Headwaters to Upper Red Lk (04-0035-01)**	--	0.57	WWg	--	--	NA	NA	NA	NA	NA	NA	--	NA	NA	NS

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

Summary

Water chemistry data was available on one 0.57 mile long stream segment (unnamed creek, 09020302-600) within the Deer River-Frontal Upper Red Lake Subwatershed. Numerous ditches draining an extensive area of bog flow into this stream segment. DO data collected from this reach was not used to assess aquatic life due to extensive wetland influence. The monitoring location was also located fairly close to Upper Red Lake. Flow was noted during the 2014 and 2015 sampling period; however, there is concern that the lake may be influencing water chemistry at this location. DO concentrations fell below the standard several times during the monitoring period with concentrations as low as 1.60 mg/L. The low DO concentrations are likely the result of wetland influence. Elevated bacteria levels were present on this reach, which resulted in an aquatic recreation impairment. With the exception of one wild rice farm, there are few anthropogenic influences on this reach. The presence of wildlife, such as beavers, could be the source of the high bacteria concentrations observed.

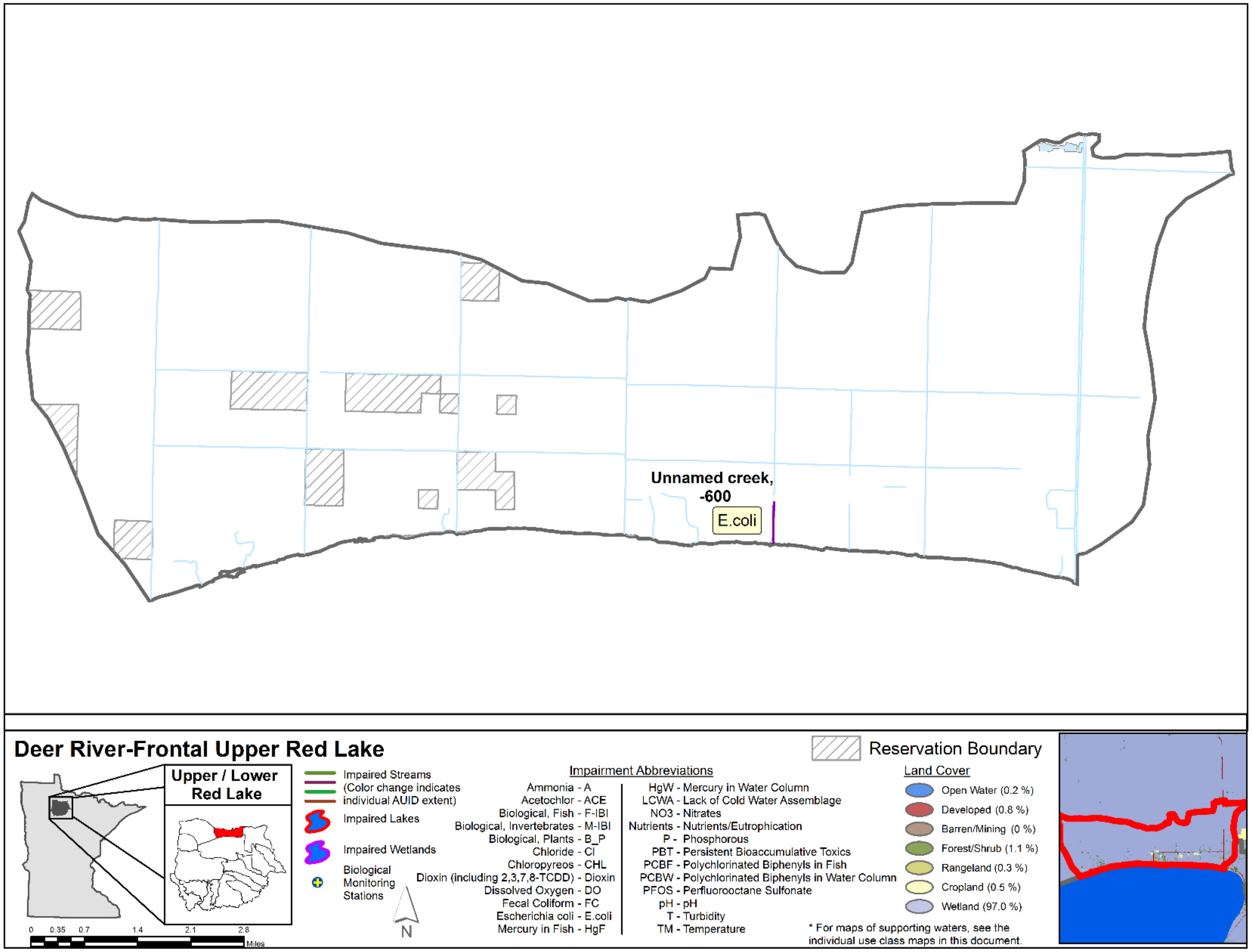

Figure 33. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the Deer River-Frontal Upper Lower Red Lake Aggregated 12-HUC.

Upper Red Lake Aggregated 12-HUC HUC 0902030204-01

The Upper Red Lake Subwatershed occupies 240 square miles of land within the central region of the Upper/Lower Red Lake Subwatershed. Upper Red Lake, one of the largest lakes in Minnesota, lies within the subwatershed. Most of the watershed consists of open water. A network of ditches are present within the southeastern portion of the subwatershed. Only a few short (< 1 mile) natural steam segments are present within the subwatershed. Land use within the subwatershed is primarily open water (77.2 %) followed by wetland (17.9 %), forest (3.4 %), developed (0.7 %), rangeland (0.6 %), and cropland (0.1 %). No significant streams were present within the subwatershed.

Table 21. Lake Assessments in the Upper Red Lake Aggregated 12-HUC.

Lake Name	DNR ID	Area (acres)	Max Depth (ft)	Assessment Method	Ecoregion	Secchi Trend	Aquatic Life Indicators: Fish IBI	Aquatic Life Indicators: Chloride	Aquatic Life Indicators: Pesticides ***	Aquatic Recreation Indicators: Total Phosphorus	Aquatic Recreation Indicators: Chlorophyll-a	Aquatic Recreation Indicators: Secchi	Aquatic Life Use	Aquatic Recreation Use
Upper Red	04-0035-01	119323	17	Shallow Lake	NMW	NT	--	--	--	NA	NA	NA	--	NA

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

Summary

Upper Red Lake is a very large, shallow, windswept basin that drains a large box complex. The catchment to Upper Red Lake falls across two ecoregions – the Northern Minnesota Wetlands (NMW) and Northern Lakes and Forests (NLF). While the lake is predominantly in the NMW ecoregion, that region does not have specific water quality standards. The nearest ecoregion with standards (that is most similar in land use) is the NLF ecoregion. TP, chlorophyll-a, and Secchi depth all would be exceeding aquatic recreation standards if held to NLF Ecoregion standards. The RLDNR has already collected sediment cores to help determine an appropriate, lake-specific standard for both Upper and Lower Red Lakes. With work already underway to determine site specific standards, the lake will be not assessed at this time.

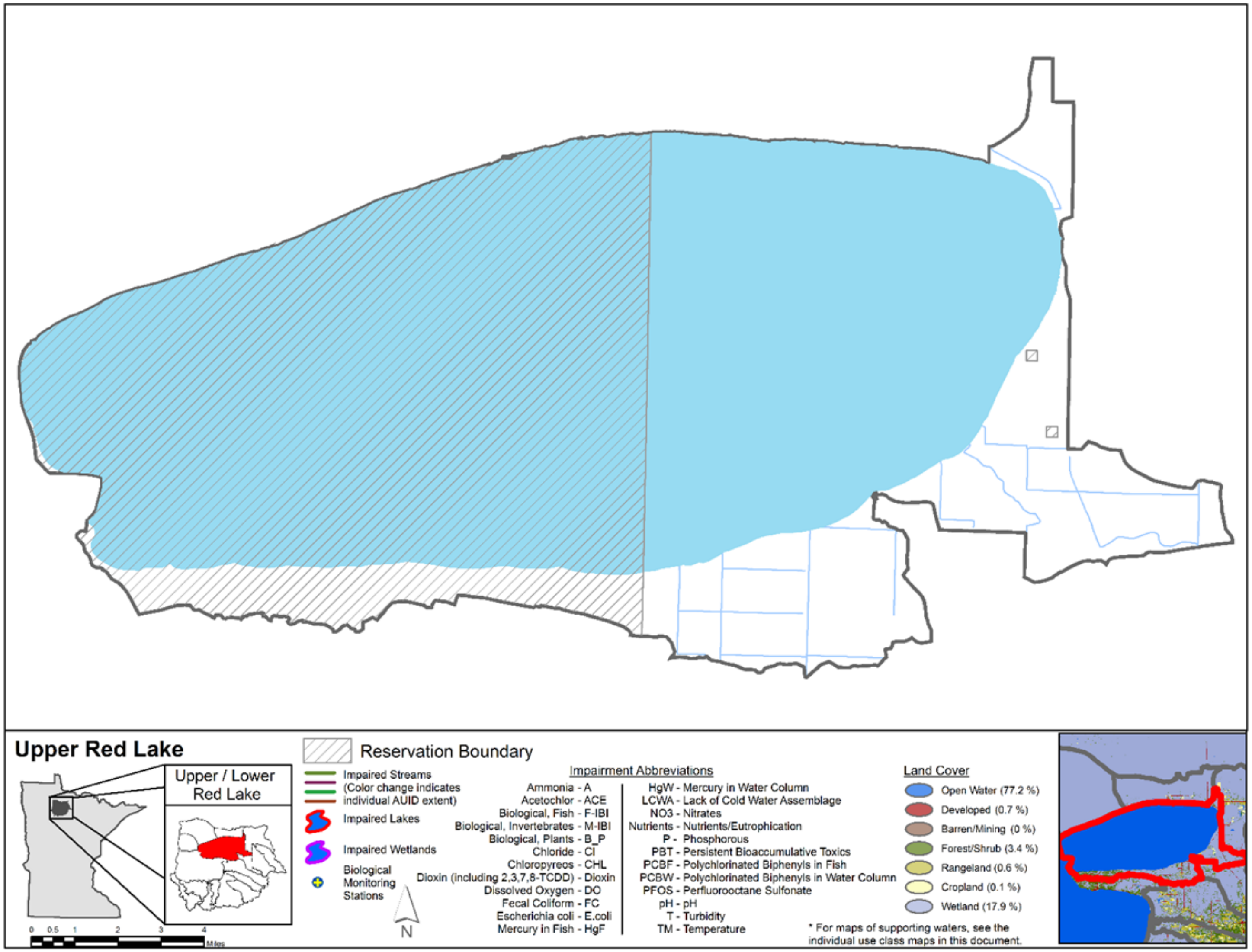

Figure 34. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the Upper Red Lake Aggregated 12-HUC

Upper Red Lake Frontal 12-HUC

HUC 0902030202-01

The Upper Red Lake Frontal Subwatershed drains 165 square miles of land within the northwest region of the Upper/Lower Red Lake Subwatershed. Only a few short (< 0.5 miles) steam segments are present within the subwatershed. Almost the entire subwatershed consists of bog and little anthropogenic activity is present. Land use within the subwatershed is primarily wetland (99.5 %) with small areas of forest (0.4 %) and rangeland (0.1 %). No significant streams were present within the subwatershed; therefore, biology and water chemistry were not monitored within the Upper Red Lake Frontal Subwatershed.

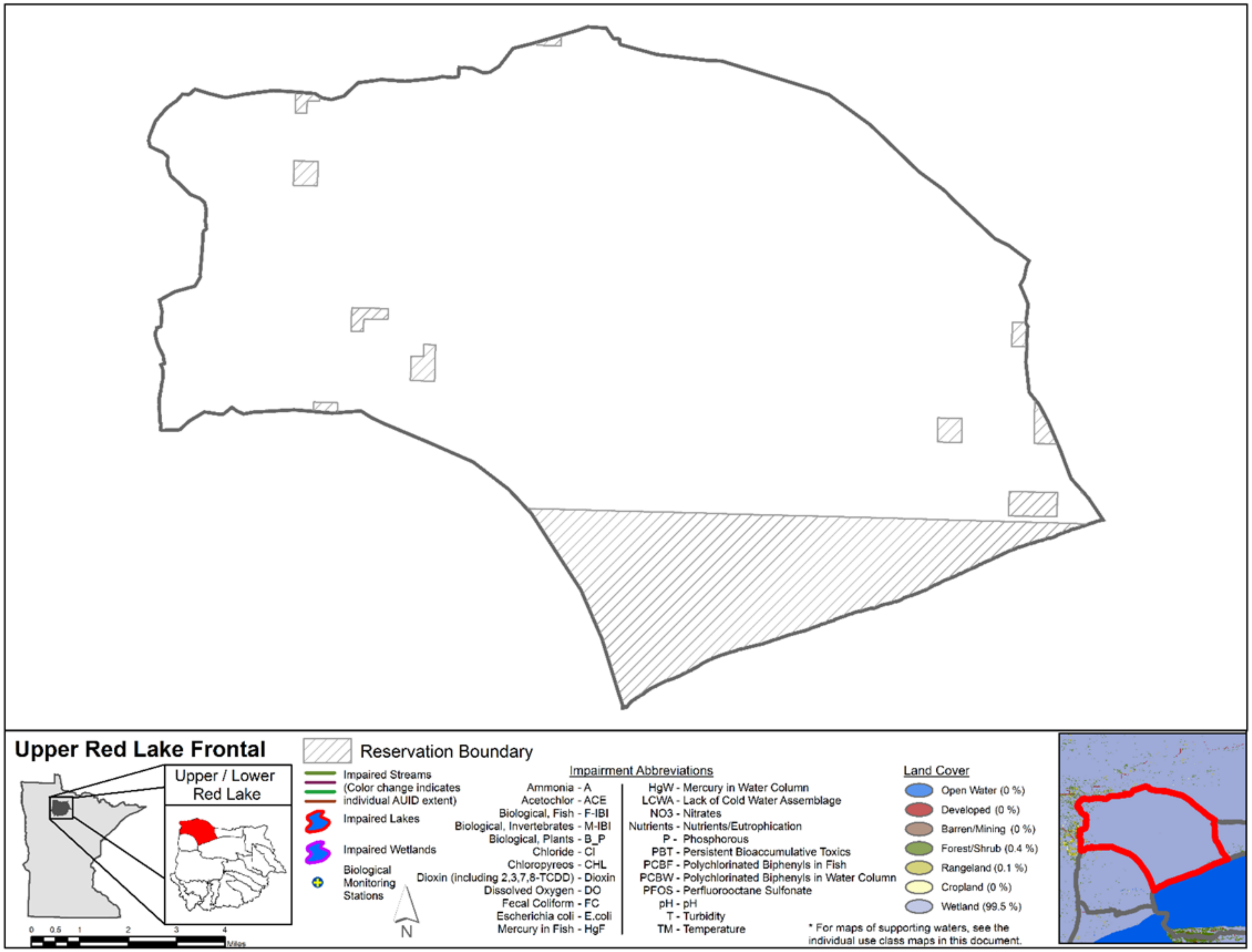

Figure 35. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the Upper Red Lake Frontal Aggregated 12-HUC.

Manomin Creek Aggregated 12-HUC HUC 0902030203-01

The Manomin Creek Subwatershed drains 75 square miles of land within the northeast portion of the Upper/Lower Red Lake Watershed. Manomin Creek originates out of a wetland located near the center of the subwatershed. The stream winds east for 8 miles before emptying into Upper Red Lake. The entire length of Manomin Creek is bordered by wetland. Land use within the subwatershed is primarily wetland (97.9 %) followed by forest (1.2 %), rangeland (0.6 %), developed (0.2 %), and cropland (0.2 %). Due to access difficulties, no biological monitoring stations were located within the subwatershed. Water chemistry was intensively monitored at one location near the outlet of Manomin Creek.

Table 22. Aquatic Life and Recreation Assessments on Stream Reaches in the Manomin Creek Aggregated 12-HUC. Reaches are organized upstream to downstream in the table.

AUID ***Reach Name***, *Reach Description*	**Biological Station ID**	**Reach Length (miles)**	**Use Class**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides ***	Eutrophication	**Aquatic Life**	**Aquatic Rec. (Bacteria)**
09020302-550 Manomin Creek Unnamed lk (04-0466-00) to Upper Red Lk	--	0.40	--	--	--	NA	NA	NA	NA	NA	NA	--	NA	NA	FS

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

Summary

Water chemistry data was available on Manomin Creek. Data collected from this reach were not used to assess aquatic life due to extensive wetland influence and the close proximity of Upper Red Lake. There is concern that the lake may be influencing water chemistry at this location, preventing an accurate characterization of stream conditions. Predominant wetland conditions throughout the subwatershed likely influence DO concentrations within Manomin Creek. The current DO standard is not accurate in these types of systems. The chemistry data was assessed for aquatic recreation. Bacteria levels met standard throughout the summer months.

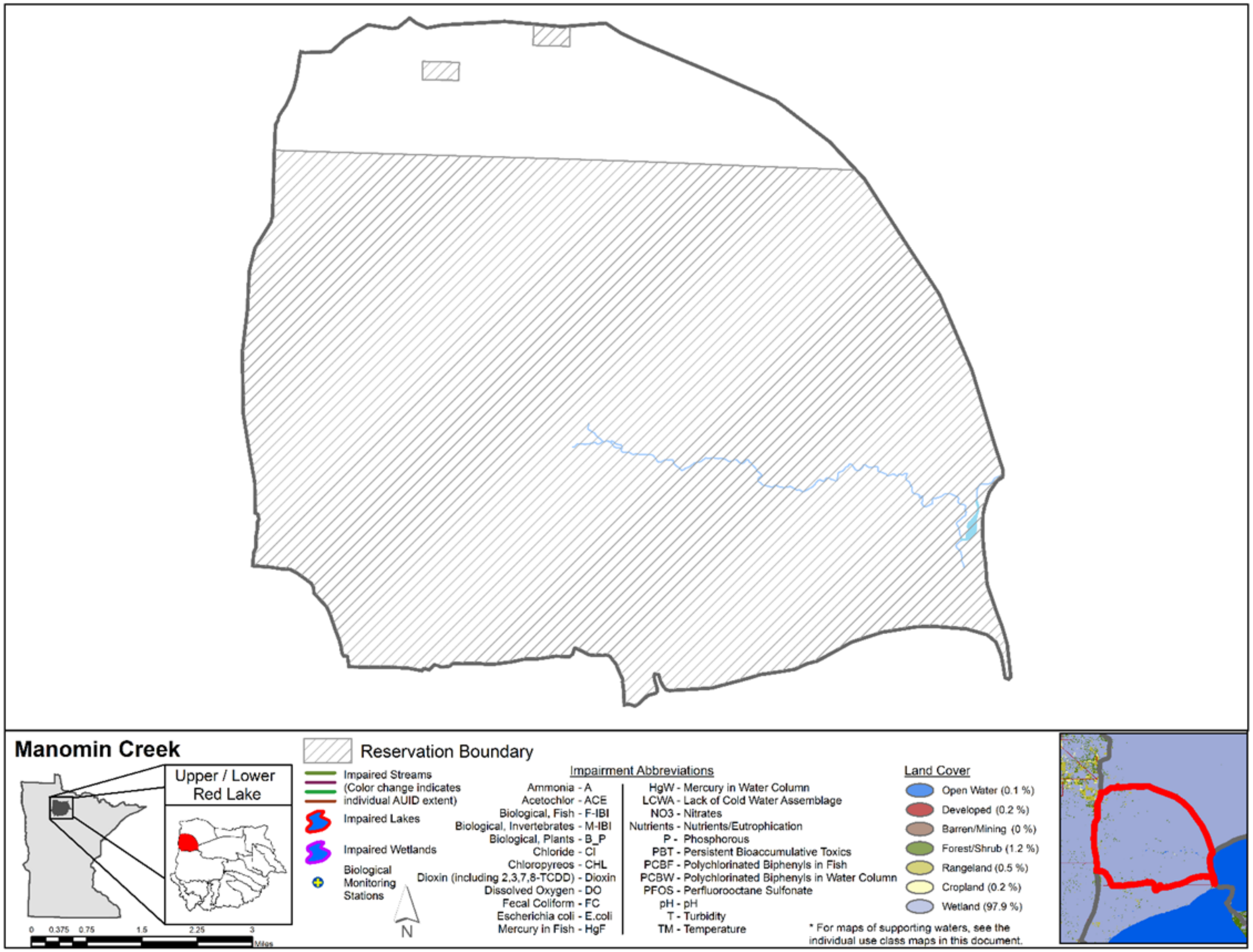

Figure 36. Currently Listed Impaired Waters by Parameter and Land Use Characteristics in the Manomin Creek Aggregated 12-HUC.

Watershed-wide results and discussion

Assessment results and data summaries are included below for the entire HUC-8 watershed unit of the Upper/Lower Red Lake Watershed, grouped by sample type. Summaries are provided for lakes, streams, and rivers in the watershed for the following: aquatic life and recreation uses, aquatic consumption results, load monitoring data results, transparency trends, and remote sensed lake transparency. Additionally, groundwater and wetland monitoring results are included where applicable.

Following the results are a series of graphics that provide an overall summary of assessment results by designated use, impaired waters, and fully supporting waters within the entire Upper/Lower Red Lakes Watershed.

Stream water quality

Forty of the 43 stream AUIDs were assessed (Table 23). Of the assessed streams, 18 streams were considered to fully support aquatic life and 8 streams fully supported aquatic recreation. No streams were classified as limited resource waters.

Throughout the subwatersheds, 16 stream reaches do not support aquatic life and/or recreation. Of those AUIDs, 10 do not support aquatic life and 12 do not support aquatic recreation.

Table 23. Assessment Summary for Stream Water Quality in the Upper/Lower Red Lake Watershed.

				Supporting		Non-supporting			
Watershed	Area (acres)	# Total AUIDs	# Assessed AUIDs	# Aquatic Life	# Aquatic Recreation	# Aquatic Life	# Aquatic Recreation	Insufficient Data	# Delistings
09020302	**1241693**	**43**	**40**	**18**	**8**	**10**	**12**	**8 AL, 7 AR**	**1 AL, 0 AR**
0902030208-01	54728	2	2	2	0	0	1	0 AL, 0 AR	0 AL, 0 AR
0902030207-01	86788	5	2	1	1	1	1	0 AL, 0 AR	0 AL, 0 AR
0902030207-02	33114	3	3	2	0	1	1	0 AL, 0 AR	0 AL, 0 AR
0902030206-01	101853	8	8	3	1	2	4	2 AL, 1 AR	1 AL, 0 AR
0902030206-03	57783	5	5	2	0	1	1	2 AL, 3 AR	0 AL, 0 AR
0902030206-02	44362	3	3	1	0	1	1	1 AL, 1 AR	0 AL, 0 AR
0902030205-01	78614	7	7	4	2	1	1	1 AL, 1 AR	0 AL, 0 AR
0902030209-01	211789	0	0	0	0	0	0	0 AL, 0 AR	0 AL, 0 AR
0902030204-02	29497	2	2	1	0	1	1	0 AL, 1 AR	0 AL, 0 AR
0902030201-02	60278	2	2	1	1	0	0	1 AL, 0 AR	0 AL, 0 AR
0902030201-03	50897	2	2	1	1	1	0	0 AL, 0 AR	0 AL, 0 AR
0902030201-01	84265	2	2	0	1	1	0	1 AL, 0 AR	0 AL, 0 AR
0902030202-02	39506	1	1	0	0	0	1	0 AL, 0 AR	0 AL, 0 AR
0902030204-01	154203	0	0	0	0	0	0	0 AL, 0 AR	0 AL, 0 AR
0902030202-01	105661	0	0	0	0	0	0	0 AL, 0 AR	0 AL, 0 AR
0902030203-01	48355	1	1	0	1	0	0	0 AL, 0 AR	0 AL, 0 AR

Lake water quality

Table 24. Assessment Summary for Lake Water Chemistry in the Upper/Lower Red Lake Watershed.

			Supporting		Non-supporting			
Watershed	Area (acres)	Lakes >10 Acres	# Aquatic Life	# Aquatic Recreation	# Aquatic Life	# Aquatic Recreation	Insufficient Data	# Delistings
09020302	**1241693**	**96**	**5**	**59**	**0**	**7**	**6 AL, 30 AR**	**0 AL, 0 AR**
0902030208-01	54728	13	1	9	0	1	0 AL, 3 AR	0 AL, 0 AR
0902030207-01	86788	58	1	36	0	0	1 AL, 22 AR	0 AL, 0 AR
0902030207-02	33114	8	1	4	0	2	1 AL, 2 AR	0 AL, 0 AR
0902030206-01	101853	10	2	7	0	1	1 AL, 2 AR	0 AL, 0 AR
0902030206-03	57783	0	0	0	0	0	0 AL, 0 AR	0 AL, 0 AR
0902030206-02	44362	0	0	0	0	0	0 AL, 0 AR	0 AL, 0 AR
0902030205-01	78614	2	0	0	0	1	1 AL, 0 AR	0 AL, 0 AR
0902030209-01	211789	2	0	1	0	0	0 AL, 1 AR	0 AL, 0 AR
0902030204-02	29497	0	0	0	0	0	0 AL, 0 AR	0 AL, 0 AR
0902030201-02	60278	0	0	0	0	0	0 AL, 0 AR	0 AL, 0 AR
0902030201-03	50897	2	0	2	0	0	2 AL, 0 AR	0 AL, 0 AR
0902030201-01	84265	0	0	0	0	0	0 AL, 0 AR	0 AL, 0 AR
0902030202-02	39506	0	0	0	0	0	0 AL, 0 AR	0 AL, 0 AR
0902030204-01	154203	1	0	0	0	0	0 AL, 0 AR	0 AL, 0 AR
0902030202-01	105661	0	0	0	0	0	0 AL, 0 AR	0 AL, 0 AR
0902030203-01	48355	0	0	0	0	0	0 AL, 0 AR	0 AL, 0 AR

Fish contaminant results

Mercury was analyzed in fish tissue samples collected from the Blackduck River and eleven lakes in the watershed. Polychlorinated biphenyls (PCBs) were measured in fish from the river and four Lakes. Nine fish species were tested for contaminants. A total of 786 fish were collected for contaminant analysis between 1967 and 2015. Contaminant concentrations are summarized by waterway, fish species, and year (Table 25). “Total Fish” indicates the total number of fish analyzed and “N” indicates the number of samples. The number of fish exceeds the number of samples when fish are combined into a composite sample. This was typically done for panfish, such as bluegill sunfish and yellow perch. “Anatomy” refers to the type of sample; since 1989, most of the samples have been skin-on fillets (FILSK) or for fish without scales (catfish and bullheads), skin-off fillets (FILET).

The Blackduck River and eight lakes were listed as impaired for mercury in fish tissue in MPCA’s 2016 Draft Impaired Waters List, and are indicated in Table 25 with a red asterisk. All of the impaired waters are covered under the Statewide Mercury TMDL. None of the waters in this watershed are listed as impaired for PCBs in fish tissue. All of the PCB concentrations in fish tissue were below the reporting limit (0.01 - 0.05 mg/kg). Fish consumption advice, developed by the Minnesota Department of Health, has meal advice of “unrestricted” for PCBs in fish less than or equal to 0.05 mg/kg. In 2010, five walleye and five yellow perch from Upper Red Lake were tested for PFOS and all were below the reporting limit (approximately 5 parts per billion) and, therefore, have no advised consumption restrictions. Overall, mercury concentrations in fish from the watershed are typical of waters throughout the state. The Fish Contaminant Monitoring Program will continue to retest the fish from impaired waters to assess if mercury levels are changing.

Table 25. Fish Contaminants Table.

DOWID	Waterway	Species	Year	Anatomy[1]	Total Fish	No. Samples	Length (in)			Mercury (mg/kg)			PCBs (mg/kg)				PFOS (µg/kg)			
							Mean	Min	Max	Mean	Min	Max	N	Mean	Max	< RL	N	Mean	Max	< RL
09020302-510, -511, -512, -513*	BLACKDUCK R.	Walleye	2014	FILSK	6	6	20.4	16.5	24.5	0.385	0.169	0.473	2	0.03	0.03	Y				
04003501*	RED (UPPER RED)	Black crappie	2002	FILSK	8	1	12.2	12.2	12.2	0.136	0.136	0.136								
			2005	FILSK	5	1	12.8	12.8	12.8	0.220	0.220	0.220								
		Lake whitefish	2002	FILSK	7	1	15.4	15.4	15.4	0.037	0.037	0.037								
		Northern pike	1970	PLUG	2	2	19.8	18.8	20.7	0.125	0.110	0.140								
				PLUSK	2	2	19.8	18.8	20.7	0.125	0.110	0.140								
			1987	FILSK	12	4	24.4	19.8	27.6	0.220	0.160	0.270								
			1997	FILSK	9	9	19.8	16.8	22.6	0.098	0.047	0.190	1	0.01	0.01	Y				
		Walleye	1987	FILSK	21	7	15.2	13.3	18.4	0.213	0.130	0.340								
			1990	FILSK	17	3	15.8	9.5	20.1	0.113	0.076	0.170	3	0.01	0.01	Y				
			1997	FILSK	10	10	17.0	14.0	20.3	0.206	0.120	0.330	2	0.01	0.01	Y				
			2002	FILSK	5	5	16.6	13.2	21.5	0.210	0.110	0.332								
			2007	FILSK	24	24	18.1	15.5	23.0	0.293	0.137	0.681								
			2009	FILSK	15	15	16.1	14.0	18.1	0.232	0.103	0.337								
04003501*	RED (UPPER RED) (Continued)	Walleye	2010	FILSK	5	5	16.0	13.2	18.7								5	4.81	4.95	Y
			2012	FILSK	8	8	16.2	14.0	18.9	0.256	0.185	0.291								
		White sucker	1970	PLUG	2	2	13.6	13.5	13.7	0.045	0.010	0.080								
				PLUSK	2	2	13.6	13.5	13.7	0.045	0.010	0.080								
			1987	FILSK	3	1	16.0	16.0	16.0	0.043	0.043	0.043	1	0.01	0.01	Y				
			1990	FILSK	5	2	13.9	11.6	16.2	0.028	0.021	0.035	2	0.01	0.01	Y				
			1997	FILSK	6	1	13.9	13.9	13.9	0.073	0.073	0.073	1	0.01	0.01	Y				
		Yellow perch	1990	FILSK	10	1	8.8	8.8	8.8	0.084	0.084	0.084	1	0.01	0.01	Y				
			1997	FILSK	10	1	8.7	8.7	8.7	0.180	0.180	0.180	1	0.01	0.01	Y				
			2002	FILSK	8	1	8.2	8.2	8.2	0.091	0.091	0.091								
			2007	FILSK	5	1	8.0	8.0	8.0	0.091	0.091	0.091								
				WHORG	6	1	5.5	5.5	5.5	0.052	0.052	0.052								
			2010	FILSK	5	5	7.4	6.3	8.7								5	4.754	4.98	Y
			2012	FILSK	9	2	9.1	7.9	10.3	0.110	0.085	0.135								

DOWID	Waterway	Species	Year	Anat-omy[1]	Total Fish	No. Sam-ples	Length (in)			Mercury (mg/kg)			PCBs (mg/kg)				PFOS (µg/kg)			
							Mean	Min	Max	Mean	Min	Max	N	Mean	Max	< RL	N	Mean	Max	< RL
04006900*	BLACKDUCK	Black bullhead	1991	FILET	1	1	15.0	15.0	15.0	0.020	0.020	0.020	1	0.01	0.01	Y				
		Brown bullhead	1991	FILET	1	1	13.4	13.4	13.4	0.020	0.020	0.020	1	0.01	0.01	Y				
		Lake whitefish	2001	FILSK	4	1	20.0	20.0	20.0	0.035	0.035	0.035	1	0.01	0.01	Y				
		Northern pike	1986	FILSK	11	3	22.1	19.3	25.5	0.207	0.190	0.220								
			1991	FILSK	24	9	22.0	14.4	30.0	0.199	0.071	0.390	8	0.01	0.01	Y				
			1996	FILSK	10	10	24.6	17.7	35.4	0.244	0.083	0.407								
			2001	FILSK	21	21	20.8	19.3	23.3	0.155	0.071	0.247								
			2012	FILSK	15	15	20.0	15.5	24.6	0.156	0.123	0.209								
			1967	FILSK	5	1	20.9	20.9	20.9	0.200	0.200	0.200	1	0.05	0.05	Y				
		Walleye	1986	FILSK	15	3	17.0	14.7	20.6	0.147	0.120	0.190								
			1991	FILSK	16	4	18.0	12.7	22.4	0.168	0.080	0.280	3	0.01	0.01	Y				
			1996	FILSK	5	5	16.5	8.7	25.4	0.102	0.038	0.182								
			2001	FILSK	5	5	14.0	11.6	15.9	0.091	0.070	0.105								
			2006	FILSK	20	20	16.1	12.5	25.6	0.120	0.058	0.359								
			1967	FILSK	6	1	17.4	17.4	17.4	0.220	0.220	0.220	1	0.05	0.05	Y				
		White sucker	1986	FILSK	5	1	17.1	17.1	17.1	0.100	0.100	0.100	1	0.02	0.02	Y				
			1991	FILSK	12	5	19.4	17.0	21.9	0.057	0.020	0.091	4	0.01	0.01	Y				
04006900*	BLACKDUCK (Continued)	White sucker	1967	FILSK	5	1	17.5	17.5	17.5	0.030	0.030	0.030	1	0.05	0.05	Y				
		Yellow perch	1991	FILSK	14	5	10.2	9.6	10.4	0.045	0.020	0.075	4	0.01	0.01	Y				
			2001	WHORG	10	2	5.6	5.4	5.8	0.017	0.016	0.018								
			2006	WHORG	12	6	6.0	4.9	7.2	0.020	0.018	0.024								
04012200	MEDICINE	Black crappie	2007	FILSK	5	5	10.3	8.4	12.0	0.024	0.010	0.044								
		Northern pike	1986	FILSK	10	2	19.7	18.5	20.8	0.300	0.280	0.320								
		Walleye	1986	FILSK	9	3	18.0	14.4	21.9	0.367	0.250	0.440								
04012400*	SANDY	Bluegill sunfish	2002	FILSK	10	1	7.4	7.4	7.4	0.048	0.048	0.048								
			2014	FILSK	10	1	7.4	7.4	7.4	0.033	0.033	0.033								
		Brown bullhead	2002	FILET	2	1	13.3	13.3	13.3	0.055	0.055	0.055								
		Northern pike	2002	FILSK	5	5	19.7	17.3	22.3	0.199	0.138	0.258								
			2014	FILSK	8	8	16.1	12.9	19.3	0.094	0.031	0.156								
		Walleye	2002	FILSK	5	5	20.0	13.2	26.4	0.206	0.124	0.418								

DOWID	Waterway	Species	Year	Anat-omy[1]	Total Fish	No. Sam-ples	Length (in)			Mercury (mg/kg)			PCBs (mg/kg)				PFOS (µg/kg)			
							Mean	Min	Max	Mean	Min	Max	N	Mean	Max	< RL	N	Mean	Max	< RL
04016600*	JULIA	Northern pike	1986	FILSK	11	3	21.6	18.9	25.8	0.357	0.280	0.460								
			1996	FILSK	10	10	26.1	18.1	36.7	0.269	0.061	0.705								
			2003	FILSK	24	24	20.4	15.0	27.3	0.246	0.096	0.521								
		Walleye	1986	FILSK	14	3	17.7	14.0	21.2	0.340	0.200	0.490								
			1996	FILSK	5	5	18.0	8.6	25.6	0.183	0.054	0.341								
			2013	FILSK	15	15	18.0	13.5	24.1	0.265	0.164	0.796								
		Yellow perch	2003	WHORG	10	2	5.7	5.4	6.0	0.048	0.041	0.054								
04032900*	BALM	Bluegill sunfish	2004	FILSK	10	1	6.7	6.7	6.7	0.068	0.068	0.068								
			2013	FILSK	5	1	7.6	7.6	7.6	0.018	0.018	0.018								
		Brown bullhead	2004	FILET	3	1	12.4	12.4	12.4	0.027	0.027	0.027								
		Northern pike	2004	FILSK	6	6	24.4	17.9	29.3	0.224	0.116	0.389								
		Walleye	2013	FILSK	8	8	16.9	15.0	19.6	0.137	0.104	0.168								
		White sucker	2013	FILSK	3	1	17.4	17.4	17.4	0.020	0.020	0.020								
04033100*	DELLWATER	Bluegill sunfish	2010	FILSK	5	1	5.1	5.1	5.1	0.023	0.023	0.023								
		Black crappie	2010	FILSK	4	1	7.0	7.0	7.0	0.029	0.029	0.029								
		Brown bullhead	2010	FILET	5	1	10.0	10.0	10.0	0.043	0.043	0.043								
		Northern pike	2010	FILSK	8	8	22.5	19.6	25.9	0.167	0.083	0.222								
036001100*	CLEAR	Bluegill sunfish	1994	FILSK	10	1	6.7	6.7	6.7	0.056	0.056	0.056								
			2015	FILSK	9	1	7.0	7.0	7.0	0.045	0.045	0.045								
		Northern pike	1994	FILSK	30	6	20.9	13.8	28.5	0.178	0.120	0.285	1	0.01	0.01	Y				
			2015	FILSK	8	8	17.7	14.9	19.8	0.079	0.031	0.149								
		Walleye	2015	FILSK	1	1	19.2	19.2	19.2	0.081	0.081	0.081								
036001400*	DARK	Bluegill sunfish	1994	FILSK	10	1	7.2	7.2	7.2	0.060	0.060	0.060								
			2014	FILSK	4	1	8.7	8.7	8.7	0.132	0.132	0.132								
		Northern pike	1994	FILSK	23	5	20.9	14.7	27.4	0.198	0.150	0.240	1	0.01	0.01	Y				
			2014	FILSK	8	8	19.2	15.8	22.7	0.319	0.119	0.434								
		Walleye	1994	FILSK	2	2	15.7	12.0	19.3	0.275	0.220	0.330								

DOWID	Waterway	Species	Year	Anat-omy[1]	Total Fish	No. Sam-ples	Length (in)			Mercury (mg/kg)			PCBs (mg/kg)				PFOS (µg/kg)			
							Mean	Min	Max	Mean	Min	Max	N	Mean	Max	< RL	N	Mean	Max	< RL
			2014	FILSK	3	3	15.9	13.3	17.3	0.195	0.170	0.209								
036001800	BARTLETT	Black crappie	2007	FILSK	10	1	9.0	9.0	9.0	0.088	0.088	0.088								
		Northern pike	2007	FILSK	6	6	23.4	16.9	27.6	0.075	0.039	0.114								
036003800	PINE	Yellow perch	2006	WHORG	8	5	8.7	6.6	9.8	0.086	0.051	0.117								

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

1 Anatomy codes: FILSK – edible fillet, skin-on; FILET—edible fillet, skin-off; PLUG—dorsal muscle piece, without skin; PLUSK—dorsal muscle piece, with skin; WHORG—whole organism

Groundwater monitoring

Stream flow

Streamflow data from the United States Geological Survey's real-time streamflow gaging stations for one river within the Upper/Lower Red Lake Watershed were analyzed for annual mean discharge and summer monthly mean discharge (July and August). Figure 37 (*left*) is a display of the annual mean discharge for the Red Lake River near Red Lake, Minnesota from water years 1990 to 2014, with the exception of 1995 to 1999 due to lack of data availability. The data shows that although streamflow appears to be increasing over time, there is no statistically significant trend. Figure 37 (*right*) displays July and August mean flows for the same time frame, for the same water body. Graphically, the data appears to increase in July and August, but neither at a statistically significant rate. By way of comparison at a state level, summer month flows have declined at a statistically significant rate at a majority of streams selected randomly for a study of statewide trends (Streitz, 2011). For additional streamflow data throughout Minnesota, please visit the USGS website: http://waterdata.usgs.gov/mn/nwis/rt.

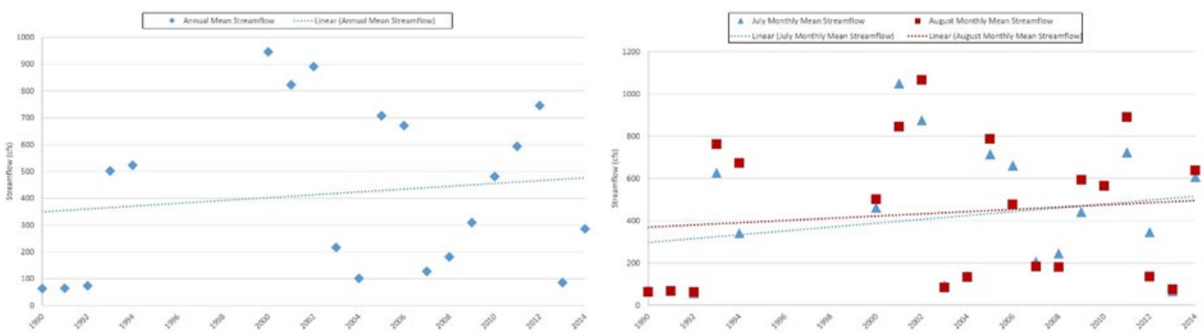

Figure 37. Annual Mean (left) and Monthly Mean (right) Streamflow for Red Lake River near Red Lake, Minnesota (Source: USGS, 2016b).

Wetland condition

Overall wetland quality is generally high in Minnesota (Table 26). This is largely driven by the large share of wetlands in Mixed Wood Shield (i.e., northern) ecoregion where development and resulting stressors are much less widespread (and wetland condition is largely intact) compared to the rest of the state. Wetlands in exceptional or good biological condition have few (if any) changes in their expected native species composition or abundance distribution.

Table 26. Wetland Vegetation Condition Statewide and in the Mixed Wood Shield Ecoregion (MPCA 2015).

Condition Category	Statewide	Mixed Wood Shield
Exceptional	49%	64%
Good	18%	20%
Fair	23%	16%
Poor	10%	

*Results are expressed by extent (i.e., percentage of wetland acres) and include virtually all wetland types.

Since virtually all of the Upper/Lower Red Lake Watershed lies within Mixed Wood Shield ecoregion, wetland condition in the watershed is likely high. An estimated 84% of the wetlands in the ecoregion are in good-exceptional vegetation condition (Table 26). Depressional wetland (a common type in the southern portion of the watershed) macroinvertebrate condition is good at an estimated 64% of the wetland basins in the ecoregion (Genet 2012). Wetland quality impacts in the watershed are likely localized. Primary impacts to vegetation condition include peat subsidence and community changes adjacent to drainage ditches in peatlands (Wright et al. 1992) and logging impacts in coniferous swamps.

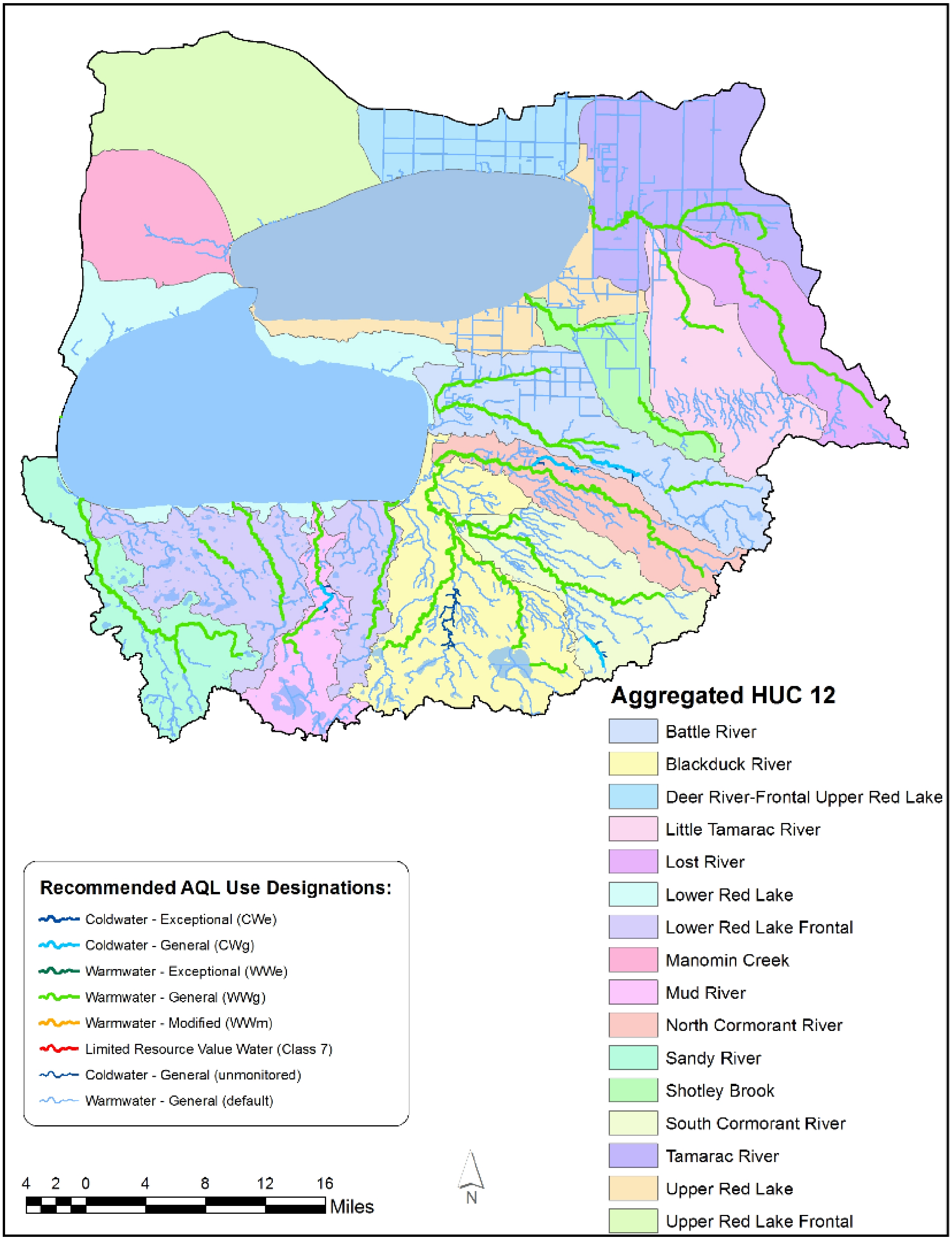

Figure 38. Stream Tiered Aquatic Life Use Designations in the Upper/Lower Red Lake Watershed.

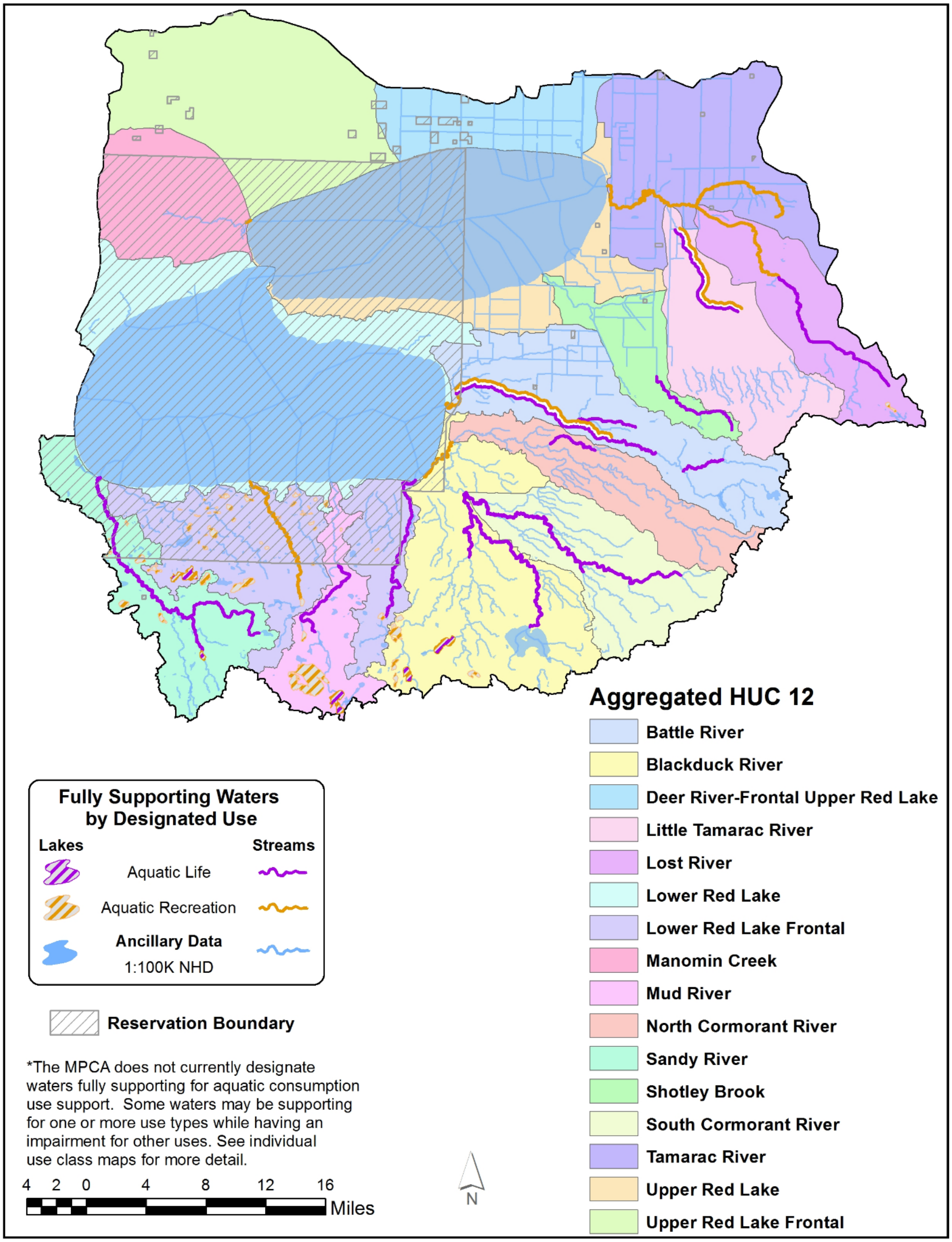

Figure 39. Fully Supporting Waters by Designated Use in the Upper/Lower Red Lake Watershed.

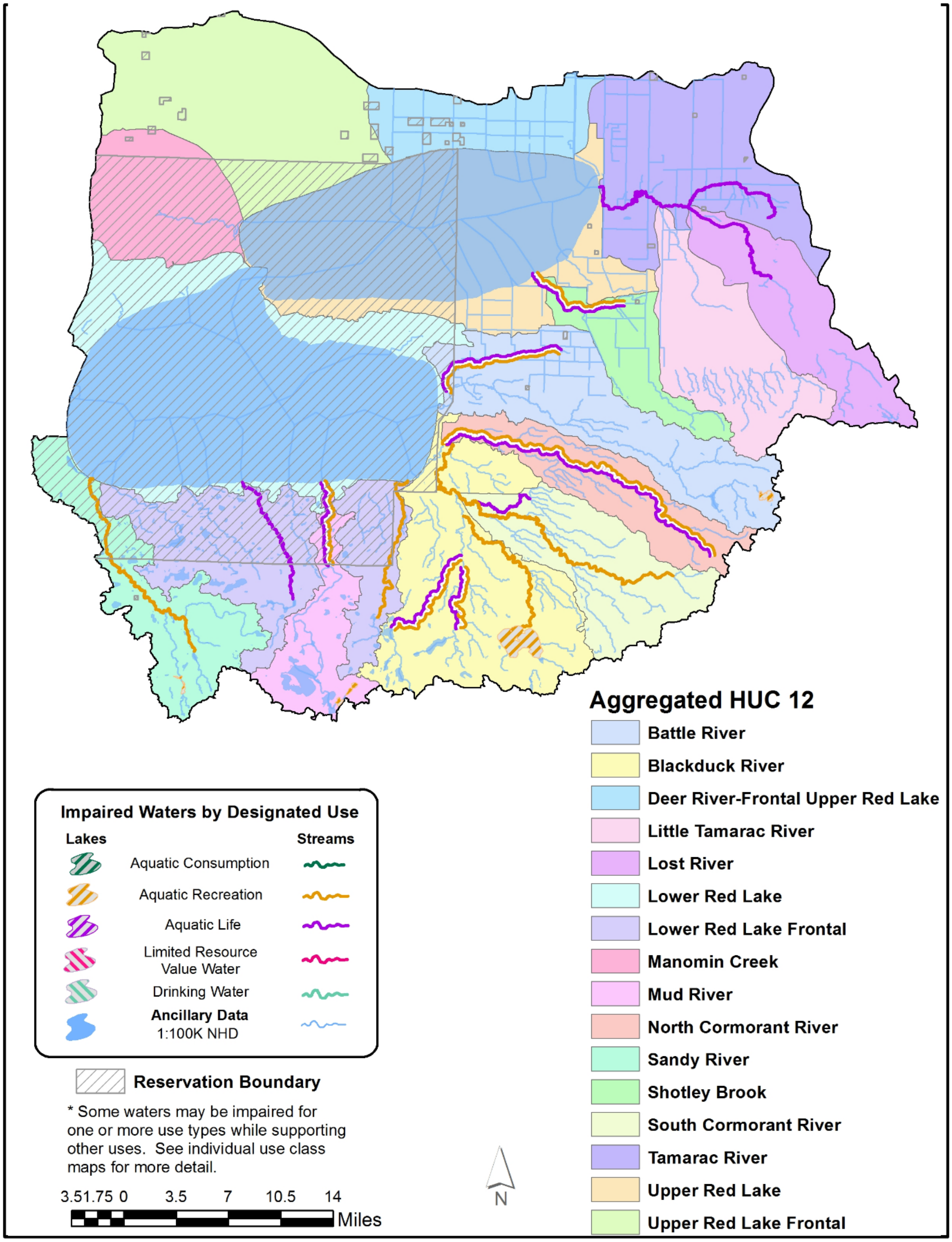

Figure 40. Impaired Waters by Designated Use in the Upper/Lower Red Lake Watershed.

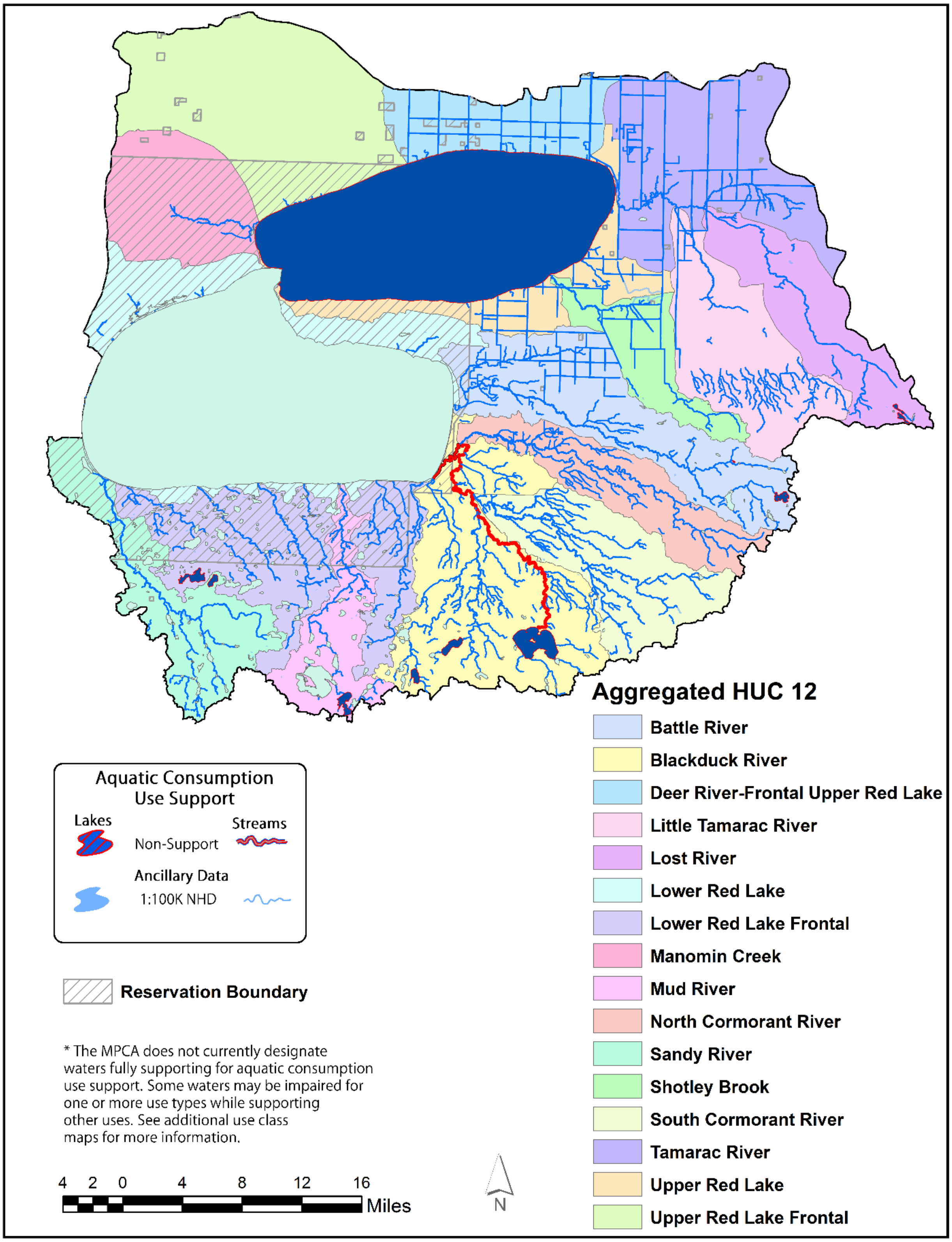

Figure 41. Aquatic Consumption Use Support in the Upper/Lower Red Lake Watershed.

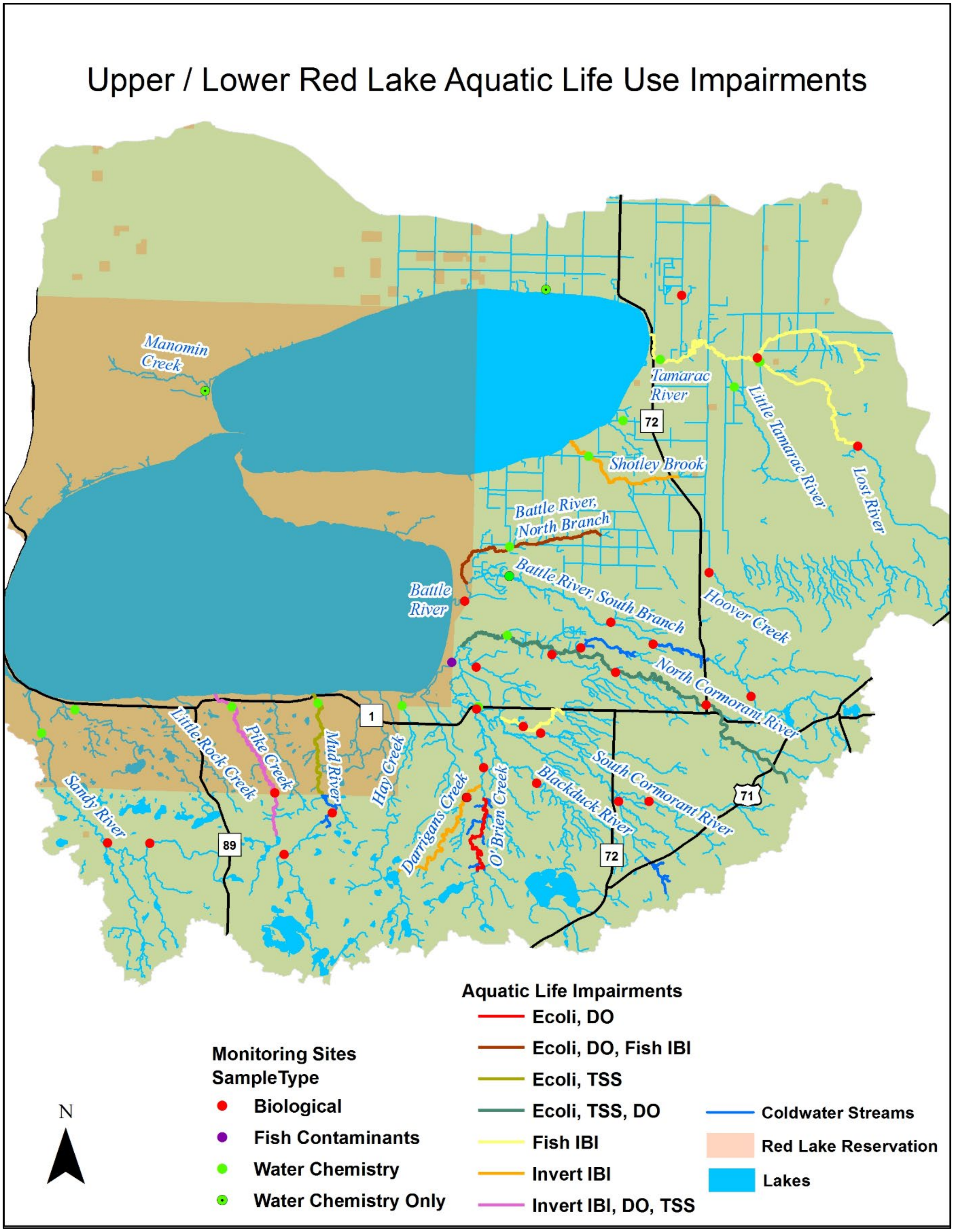

Figure 42. Aquatic Life Use Support in the Upper/Lower Red Lake Watershed.

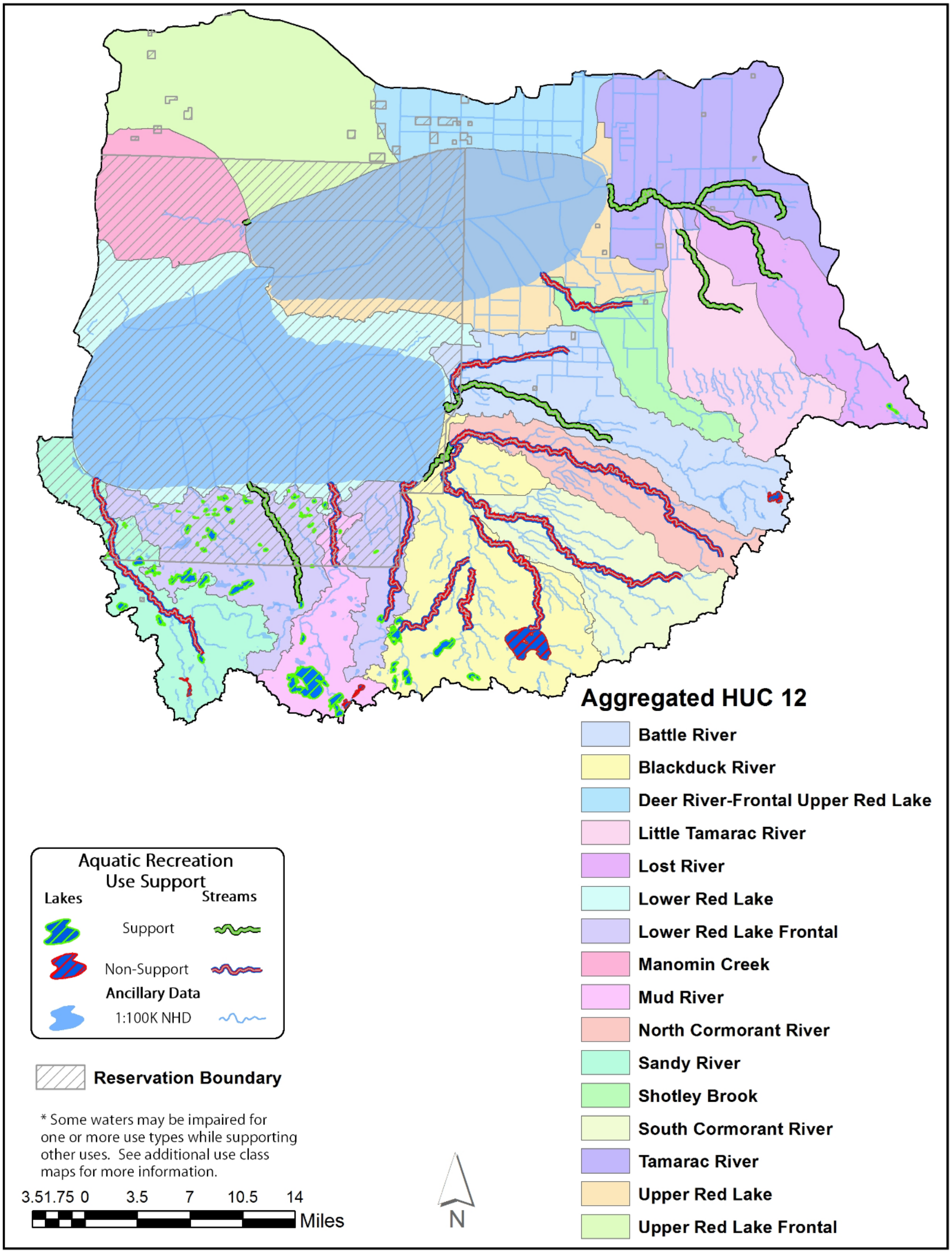

Figure 43. Aquatic Recreation Use Support in the Upper/Lower Red Lake Watershed.

Transparency trends for the Upper and Lower Red Lake Watershed

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

The trends are calculated using a Seasonal Kendall statistical test for waters with a minimum of 8 years of transparency data; Secchi disk measurements in lakes and Secchi Tube measurements in streams.

There are no volunteers enrolled in the CSMP to provide stream transparency data. Four lakes in the watershed have volunteers in the CLMP (Table 27). Water clarity has shown an increasing (improving) trend on Medicine (04-0122-00) and Blackduck (04-0069-00) Lakes and no trend on Dark (04-0167-00) and Balm (04-0329-00) Lakes. The River Watch Citizen Monitoring Program (in partnership with International Water Institute) is conducted throughout the Red River Basin. This citizen program has water chemistry data available from streams, ditches, lakes, and impoundments throughout the Red River Basin. Information on these sites can be found at http://riverwatch.wq.io/.

Table 27. Water Clarity Trends at Citizen Stream Monitoring Sites.

Upper/Lower Red Lake Watershed HUC 09020302	Citizen Stream Monitoring Program	Citizen Lake Monitoring Program
number of sites w/ increasing trend	0	2
number of sites w/ decreasing trend	0	0
number of sites w/ no trend	0	2

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

Remote sensing for lakes in the Upper and Lower Red Lake Watershed

The University of Minnesota, in partnership with MPCA, conducts remote sensing of lake clarity. The information provides a snapshot of water transparency during late summer over a span of 30 years. Secchi disk transparency data is paired with satellite imagery to come up with estimates of water clarity across the state. While there are limitations to the data, such as cloud cover, vegetation, or stained water altering the estimated Secchi transparency, it does provide information to help prioritize monitoring and protection efforts on lakes which do not have water quality data. Lakes with this remote sensing information in the Upper/Lower Red Lakes Watershed, as illustrated in Figure 44 by the red, yellow, and green Secchi disks, include Blackduck Lake, Balm Lake, Puposky Lake, and Upper and Lower Red Lake. Lakes with poor transparency had mean Secchi depths below their respective ecoregion standard over the course of the remote sensing study. Lakes with fair transparency had mean Secchi depths that ranged from their standard up to 50% above their standard. Lakes with good transparency had mean Secchi depths over 50% above their standard. It is important to note that many lakes fall in the Northern Minnesota Wetlands ecoregion, which does not have lake standards. The standards used to create this map reflect the Northern Lakes and Forests ecoregion.

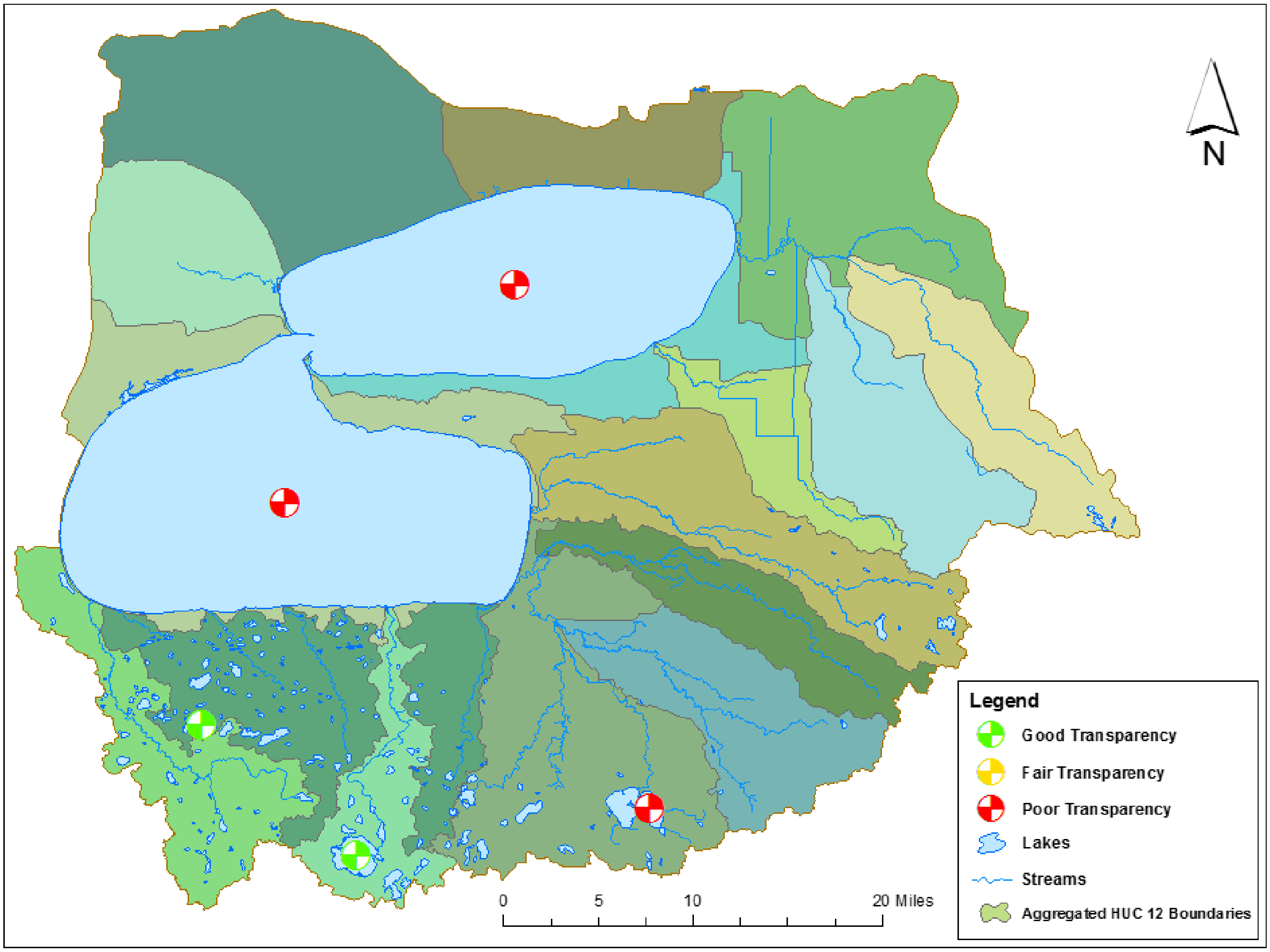

Figure 44. Remotely Sensed Secchi Transparency on Lakes within the Upper/Lower Red Lake Watershed.

Summaries and recommendations

Eighty-six species of fish have been documented in the Red River Basin. MPCA biological monitoring crews captured 37 species of fish during the IWM stream sampling in the Upper/Lower Red Lake Watershed. The majority of the fish samples collected within the watershed contained 10 – 15 species. Common shiners, central mudminnows, johnny darters, and white suckers were the most commonly sampled species within the watershed. These species were present at 30 or more monitoring locations; all of them are commonly found throughout the Midwest. Common shiners were the most abundant species sampled (over 4,000 individuals). Common shiners use a wide range of habitats; however, they are most often found in small to medium sized clear water streams with sand and gravel substrate (Becker 1983). The North and South Cormorant Rivers, as well as many other streams within the watershed, contain such habitat. The central mudminnow prefers stagnant or slow flowing, vegetated waters commonly associated with wetlands and low gradient streams (Becker 1983). Wetland habitat is very common along the margins of lakes and streams throughout the Upper/Lower Red Lake Watershed. White suckers inhabit streams of various gradients as well as many lakes. The species can adapt well to different habitats and is tolerant of higher levels of turbidity (Becker 1983). The johnny darter inhabits both lakes and streams but prefers smaller streams with sand and gravel substrate (Becker 1983). Most of the headwater streams, as well as many larger streams within the watershed provide ideal habitat. Walleye, a species which prefers lakes and larger rivers, were sampled at most stations located on the lower reaches of rivers throughout the watershed. Interestingly, adult walleye were captured in the headwaters region of the Blackduck River and O'Brien Creek. Other commonly sampled species within the Upper/Lower Red Lake Watershed included blacknose dace, creek chub, brassy minnow, and northern pike. All of these species are commonly found in clear water lakes and streams throughout the Midwest.

Many of the most frequently collected species of fish in the Upper/Lower Red Lake Watershed are simple lithophilic spawning species. Simple lithophilic spawning species require clean coarse substrates for reproduction; they do not provide any parental care (such as fanning sediment off eggs). Excess sedimentation and channel instability will result in a decline or elimination of these species from the fish community. The widespread abundance of simple lithophilic spawning species is an indication of good stream habitat stability and low disturbance within the Upper/Lower Red Lake Watershed. Some of the most commonly sampled simple lithophilic spawning species, such as the blacknose dace and creek chub, are trophic generalists. Trophic generalists are capable of utilizing multiple food sources and can persist in unstable, disturbed environments. They are often considered an indicator of degradation; however, these species utilize the most abundant food source. The blacknose dace, for example, is primarily insectivorous unless the availability of that food source declines (Becker 1983). Good numbers of insectivorous taxa were present in samples collected throughout the Upper/Lower Red Lake Watershed. Almost all the samples collected from streams within the northern streams IBI class contained 40% or greater insectivorous taxa. More than half of the samples collected from northern headwaters class streams contained 35% or greater insectivorous taxa. Insectivores feed exclusively upon invertebrates and rely on the existence of a stable invertebrate population. Disturbances that cause a reduction in invertebrate abundance may reduce the number of insectivorous fish species. The most commonly sampled insectivorous species (hornyhead chub, blackside darter, Iowa darter, and pearl dace) are also considered sensitive species. Sensitive species have specialized trophic, reproductive, and/or habitat requirements that can be diminished by environmental stressors. The persistence of a stable macroinvertebrate community and the presence of sensitive species at many locations within the Upper/Lower Red Lake Watershed is an indication of good water quality and low disturbance.

Thirty-seven visits were made to 31 sites within the Upper/Lower Red Lake Watershed to sample macroinvertebrates. During the IWM effort, 234 unique macroinvertebrate taxa were collected. The majority of streams in the watershed were in the low gradient Northern Forest Streams Glide/Pool stream class. Notable sensitive collector/gather taxa present at many of these lower gradient monitoring stations include *Eurylophella* (mayfly), *Oxyethira,* and *Ceraclea* (caddis) and *Stempellinella* (midge). The most abundant genera sampled in the watershed were: *Thienemannimyia* (Chironomidae); *Cheumatospsyche* (Hydropsychidae); *Dubiraphia* (Elmidae); *Polypedilum* (Chironomidae); *Rheotanytarsus* (Chironomidae); *Tanytarsus* (Chironomidae); *Simulium* (Simuliidae); Stenacron (Heptageniidae); and Hyalella (Hyalellidae). Notably, *Simulium* (blackfly) were collected at all but one station and in very high relative abundances in this watershed. *Simulium* are fecund filter feeders, relying on a steady flow of diatoms, bacteria, and silt in the water column feed on. They are well adapted to compete in the largely low gradient wetland dominated Upper/Lower Red Lake Watershed. There were not any endangered, threatened or species of special concern collected during the IWM monitoring efforts. Overall, the macroinvertebrate community within the watershed reflects the healthy/functional lower gradient nature of the system.

The majority of the streams within the Upper/Lower Red Lake Watershed featured biological communities that were in good condition. In general, stream reaches that featured a variety of coarse substrate types (and a higher MSHA substrate category score) had higher FIBI and MIBI scores. Increased habitat heterogeneity, resulting from good channel development and a variety of cover types, allows for greater biological community development. Many of the smaller headwater streams had excellent habitat. The lower reaches of some of the larger streams (South Cormorant River, North Cormorant River, Blackduck River, and South Branch of the Battle River) had reduced habitat complexity. The stations located on these reaches had less depth variability and lower channel stability. Coarse substrate was often embedded or only available in small isolated areas at these stations. Further investigation, including geomorphology measurements, will be conducted on these reaches to determine the cause(s) of sediment instability. Most of the steams with poor biological communities (Tamarac River, Lost River, and North Branch of the Battle River) are profoundly influenced by wetlands. Wetlands are present throughout the Upper/Lower Red Lake Watershed; however, they are especially prevalent in the northeast and northwest region of the watershed. The land within the Tamarac River and Lost River subwatersheds is over 90% wetland. Most wetland streams are characterized by fine sediments, emergent macrophytes within the channel margins, and abundant submergent macrophytes. The lower stream gradient typical of these streams reduces channel development and stream habitat complexity. Besides physical stream characteristics, wetlands also influence water chemistry in these streams. Large precipitation events flush organic matter and water from wetlands into streams causing DO to decline to levels that are stressful to aquatic life. DO was not used to assess aquatic life on stream reaches with profound wetland influence. Regardless of their effect on DO, wetlands are an extremely valuable resource because they maintain water quality and provide other beneficial ecosystem processes. Wetlands play a major role in maintaining water quality in the Upper/Lower Red Lake Watershed.

Lake water chemistry was generally very good across the watershed. Much of the Upper and Lower Red Lakes Watershed falls within the Red Lake Reservation; as a result, many lakes have little to no anthropogenic influences because land uses are primarily forested and wetlands. Some of these lakes within the reservation boundaries, such as Squaw Smith, Heart, Green (04-0193-00), and Kinney, yielded exceptional mean values for TP, chlorophyll-a, and Secchi depth. These values would meet the NLF Ecoregion stream trout or lake trout standards. Only five of the 96 lakes assessed exceeded aquatic recreation standards. Upper & Lower Red Lake both have relatively shallow depths but vast surface areas. With the large fetches of these lakes, resuspension of sediment could result in periodic increases in phosphorus and nuisance algae blooms. A current paleolimnological study being conducted by the RLDNR on the Red Lakes is aimed at developing site-specific standards for the lakes. Until these standards are developed, Upper and Lower Red Lake will not be assessed for aquatic recreation. Fish were assessed on only seven lakes within the watershed, but of those none were impaired for aquatic life and five were fully supporting aquatic life.

From a water chemistry perspective, most stream performed well. Chemical impairments occurred on only five of the 40 assessed reaches – three for TSS and four for DO. Low DO was also observed on seven additional reaches that were greatly influenced by bog and wetlands in the watershed.

Bacteria (*E. coli*) concentrations are a concern in this watershed as 10 stream reaches had concentrations that exceeded the aquatic recreation standards. Elevated bacteria concentrations were typically found as a single month with consistently elevated concentrations. With so little development or land use disturbance through the watershed, a likely cause for elevated bacteria could be from wildlife such as waterfowl and beavers. In stream sections inhabited by beavers, water can become impounded by their dams and stream flow can go stagnant creating prime conditions for bacteria to proliferate. Additional potential sources include failing septics and livestock.

Some examples of measures that could assist in the recovery and protection of streams and lakes throughout the watershed consist of:

- Establishment and reintroduction of riparian zones and shorelines using native vegetation, trees, and shrubs
- Protection of riparian buffer zones, shorelines, and exceptional aquatic habitats
- Institute best management practices to improve reaches with sedimentation and erosion issues and to prevent additional sedimentation
- Restrict livestock access to streams
- Continuation of chemistry and biological monitoring to evaluate and document declining or improving conditions
- Continuous DO monitoring on several stream reaches to determine if low DO concentrations are affecting biological communities

Groundwater protection should be considered both for quantity and quality. Quantity is based on the amount of water withdrawn versus the amount of water being recharged to the aquifer. Groundwater withdrawals in the watershed have decreased by 15.9% from 1994 to 2013 and at a statistically significant rate ($p<0.001$). The primary source of groundwater withdrawal is for water supply (municipal/public), which has decreased by 30% over that time period, but not at a statistically significant rate.

There is limited amount of groundwater quality data available specifically for the Upper/Lower Red Lake Watershed at this time. Baseline water quality data indicated that the Northwest region has higher concentrations of chemicals in the sand and gravel aquifers, however, this is primarily associated with Cretaceous bedrock, which is not present in this specified watershed. There were relatively high numbers of exceedances to the arsenic MCL for drinking water in private wells for this area. Arsenic is primarily naturally occurring and can be linked to presence of a clay layer and low DO levels, often associated with the Des Moines glacial lobe till, which is abundant in this region. Furthermore, the ultra low to low levels of pollution sensitivity of near-surface materials and predominate peatlands throughout the watershed indicate that this area is well protected from groundwater contamination. While this watershed does not appear to be at great risk at this time, it is important to continue to monitor potentially sensitive sites in order to inhibit possible water pollution.

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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.

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

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

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

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

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

Appendix 2.1 – Intensive watershed monitoring water chemistry stations in the Upper and Lower Red Lake Watershed

EQuIS ID	Biological Station ID	AUID	Waterbody Name	Location	Aggregated 12-digit HUC
S003-952	14RD129	09020302-539	South Branch Battle River	At CSAH 23, 0.5 mi N of Saum	0902030205-01
S003-961	14RD124	09020302-506	North Cormorant River	At CSAH 23, 2.5 mi S of Saum	0902030206-02
S003-962	14RD130	09020302-503	North Branch Battle River	At CSAH 23, 2 mi N of Saum	0902030205-01
S007-883	14RD115	09020302-507	South Cormorant River	Adjacent to MN 1, 0.8 mi. SW of Quiring	0902030206-03
S007-884	14RD136	09020302-502	Shotley Brook	At CR 23, 3.5 mi. NE of Shotley	0902030204-02
S007-885	14RD138	09020302-614	Little Tamarack River	At Balsiger Rd, 5 mi SE of Waskish	0902030201-02
S007-887	14RD139	09020302-501	Tamarac River	At Steel Bridge Rd, 0.5 mi S of Waskish	0902030201-01
S007-886	14RD148	09020302-602	Lost River	At Balsiger Rd, 6 mi E of Waskish	0902030201-03
S007-888	14RD149	09020302-600	Tributary to Upper Red Lake	At North Shore Dr, 6.5 mi NW of Waskish	0902030202-02
S007-877	14RD100	09020302-522	Sandy River	Indian Service Rd 6, 7 mi SW of Little Rock, MN	0902030208-01
S007-878	14RD104	09020302-548	Big Rock Creek	At BIA 8, 5mi. W of Little Rock	0902030207-01
S007-881	14RD106	09020302-541	Mud River	On trail W of subdivision road off of BIA 15 in SW Redby	0902030207-02
S007-880	14RD109	09020302-518	Hay Creek	At BIA 18, 5 mi E of Redby	0902030207-01
S007-882	14RD122	09020302-513	Blackduck River	Along BIA 18, 3 mi NW of Quiring	0902030206-01
S007-879	14RD126	09020302-521	Pike Creek	0.5 mi W of unnamed road that meets end of BIA 12, 1 mi S of Red Lake	0902030207-01
S003-955	--	09020302-557	Manomin Creek	0.25 mi upstream of Upper Red Lake, 18 mi N of Red Lake	0902030203-01

Appendix 2.2 – Intensive watershed monitoring biological monitoring stations in the Upper/Lower Red Lake Watershed

AUID	Biological Station ID	Waterbody Name	Biological Station Location	County	Aggregated 12-digit HUC
09020302-501	14RD139	Tamarac River	Upstream of Steel Bridge Rd, 0.5 mi. S of Waskish	Beltrami	0902030201-01
09020302-501	14RD143	Tamarac River	NW of Balsiger Rd, 6 m.i E of Waskish	Koochiching	0902030201-01
09020302-614	14RD138	Little Tamarac River	Upstream of Balsiger Rd, 5 mi. SE of Waskish	Koochiching	0902030201-02
09020302-602	14RD148	Lost River	Downstream of Balsiger Rd, 6 mi. E of Waskish	Koochiching	0902030201-03
09020302-603	14RD142	Lost River	Upstream of Lost River Rd, 8 mi. N of Forest Grove	Koochiching	0902030201-03
09020302-502	14RD136	Shotley Brook	Downstream of CSAH 23, 3.5 mi. NE of Shotley	Beltrami	0902030204-02
09020302-547	14RD137	Hoover Creek	Upstream of CR 105, 2.5 mi. N of Kelliher	Beltrami	0902030204-02
09020302-503	14RD130	Battle River, North Branch	Downstream of CSAH 23, 2 mi. N of Saum	Beltrami	0902030205-01
09020302-523	14RD134	Trib. to Battle River, South Branch	Upstream of CSAH 38, 7 mi. SW of Saum	Beltrami	0902030205-01
09020302-538	09RD064	Battle River, South Branch	Upstream of CR 103, 2.7 mi. SW of Kelliher	Beltrami	0902030205-01
09020302-539	14RD129	Battle River, South Branch	Downstream of CSAH 23, 0.5 mi. N of Saum	Beltrami	0902030205-01
09020302-574	14RD132	Armstrong Creek	Across private property at end of CR 63, 5 mi. NW of Northome	Koochiching	0902030205-01
09020302-508	14RD112	Darrigans Creek	Upstream of Everts Rd (CSAH 23), 5.5 mi. S of Quiring	Beltrami	0902030206-01
09020302-510	14RD114	Blackduck River	Uprstream of Deertrail Rd, 3 mi. NW of Langor	Beltrami	0902030206-01
09020302-511	14RD158	Blackduck River	0.3 mi. E of CSAH 23, 1.25 mi. SW of Quiring	Beltrami	0902030206-01
09020302-512	05RD088	Blackduck River	Upstream of CR 23, 13 mi. SW of Kelliher	Beltrami	0902030206-01
09020302-513	14RD122	Blackduck River	Upstream of BIA 18, 3 mi. NW of Quiring	Beltrami	0902030206-01
09020302-514	14RD110	O'Brien Creek	West of Darrigans Creek Rd NE, 2 mi. S of Quiring	Beltrami	0902030206-01
09020302-506	14RD124	North Cormorant River	Downstream of CSAH 23, 2.5 mi. S of Saum	Beltrami	0902030206-02
09020302-506	14RD127	North Cormorant River	Downstream of Hwy 72, 0.5 mi. N of Shooks	Beltrami	0902030206-02
09020302-506	14RD128	North Cormorant River	Downstream of CSAH 36, 5.5 mi SW of Kelliher	Beltrami	0902030206-02
09020302-542	14RD141	Meadow Creek	Upstream of Fireweed Ln NE, 5.5 mi. SE of Saum	Beltrami	0902030206-02
09020302-507	14RD115	South Cormorant River	Adjacent to Hwy 1, 0.8 mi. SW of Quiring	Beltrami	0902030206-03
09020302-507	14RD117	South Cormorant River	Upstream of fire road crossing S of Buckeye rd, 3 mi. W of Inez	Beltrami	0902030206-03
09020302-507	14RD119	South Cormorant River	Downstream of CSAH 41, 3.5 mi. NW of Funkley	Beltrami	0902030206-03
09020302-552	14RD121	Spring Creek	East end of CR 306 and Hwy 72 intersection, 4 mi. N of Blackduck	Beltrami	0902030206-03
09020302-605	14RD116	Perry Creek	At end of unnamed rd S of Hwy 1, 2.5 mi. SW of Quiring	Beltrami	0902030206-03
09020302-518	14RD109	Hay Creek	Upstream of BIA 18, 5 mi. E of Redby	Beltrami	0902030207-01
09020302-521	14RD126	Pike Creek	On unnamed trail, 0.5 mi. S of Red Lake	Beltrami	0902030207-01
09020302-521	14RD153	Pike Creek	Downstream of BIA 1, 3 mi. NE of Island Lake	Beltrami	0902030207-01
09020302-540	14RD107	Mud River	Downstream of Farmer Dr, 2 mi. NW of Nebish	Beltrami	0902030207-02

09020302-541	14RD106	Mud River	At end of unnamed trail in Redby (streets near trail unnamed)	Beltrami	0902030207-02
09020302-613	14RD157	Mud River	Upstream of CSAH 13, 5 mi. NW of Puposky	Beltrami	0902030207-02
09020302-522	14RD100	Sandy River	Upstream of BIA 5, 7 mi. SW of Little Rock	Clearwater	0902030208-01
09020302-522	14RD102	Sandy River	Upstream of CSAH 32 (Lumberjack Rd), 2 mi. NW of Debs	Beltrami	0902030208-01
09020302-604	14RD103	North Fork River	Downstream of CR 32, 3 mi. NE of Debs	Beltrami	0902030208-01
09020302-501	14RD139	Tamarac River	Upstream of Steel Bridge Rd, 0.5 mi. S of Waskish	Beltrami	0902030201-01

Appendix 3.1 – Minnesota statewide IBI thresholds and confidence limits

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

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

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Threshold	FIBI	Visit Date
HUC 12: 0902030208-01 (Sandy River)							
09020302-604	14RD103	North Fork River	15.52	6	42	62.1	09-Jun-14
09020302-522	14RD102	Sandy River	43.94	6	42	62.6	30-Jun-14
09020302-522	14RD100	Sandy River	69.63	5	47	56.9	15-Jul-14
HUC 12: 0902030207-01 (Lower Red Lake Frontal)							
09020302-521	14RD153	Pike Creek	14.50	6	42	72.1	15-Jul-14
09020302-521	14RD126	Pike Creek	23.70	7	42	63.3	15-Jul-14
09020302-518	14RD109	Hay Creek	21.02	7	42	59.2	15-Jul-14
HUC 12: 0902030207-02 (Mud River)							
09020302-541	14RD106	Mud River	51.49	5	47	49.9	14-Jul-14
09020302-540	14RD107	Mud River	39.67	11	35	29.4	22-Sep-14
09020302-540	14RD107	Mud River	39.67	11	35	15.6	30-Jun-14
09020302-520	14RD157	Mud River	33.97	6	42	30.8	17-Jul-14
09020302-520	14RD157	Mud River	33.97	6	42	48.4	17-Jun-15

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Threshold	FIBI	Visit Date
HUC 12: 0902030206-01 (Blackduck River)							
09020302-508	14RD112	Darrigans Creek	25.12	6	42	61.7	09-Jun-14
09020302-514	14RD110	O'Brien Creek	57.60	5	47	51.1	10-Jul-14
09020302-510	14RD114	Blackduck River	41.76	6	42	84.5	21-Jul-14
09020302-513	14RD122	Blackduck River	298.93	5	47	43.9	29-Jul-14
09020302-511	14RD158	Blackduck River	116.18	5	47	65.3	16-Jul-14
HUC 12: 0902030206-03 (South Cormorant River)							
09020302-552	14RD121	Spring Creek	17.54	6	42	78.4	09-Jun-14
09020302-605	14RD116	Perry Creek	18.41	6	42	36.3	21-Jul-15
09020302-605	14RD116	Perry Creek	18.41	6	42	11.1	10-Jun-14
09020302-507	14RD117	South Cormorant River	57.79	5	47	64.8	21-Jul-14
09020302-507	14RD119	South Cormorant River	23.26	6	42	70.1	27-Jul-15
09020302-507	14RD119	South Cormorant River	23.26	6	42	24.9	11-Jun-14
09020302-507	14RD115	South Cormorant River	90.32	5	47	62.2	16-Jul-14
HUC 12: 0902030206-02 (North Cormorant River)							
09020302-506	14RD124	North Cormorant River	64.76	5	47	44.1	14-Jul-14
09020302-506	14RD127	North Cormorant River	24.23	6	42	66.0	27-Jul-15
09020302-506	14RD128	North Cormorant River	37.48	6	42	79.2	18-Jun-15
09020302-542	14RD141	Meadow Creek	6.95	11	35	18.3	10-Jun-14
HUC 12: 0902030205-01 (Battle River)							
09020302-538	09RD064	Battle River, South Branch	45.93	11	35	39.4	09-Aug-10
09020302-539	14RD129	Battle River, South Branch	83.46	5	47	57.4	15-Jul-14
09020302-503	14RD130	Battle River, North Branch	21.70	6	42	0.0	15-Jul-14
09020302-503	14RD130	Battle River, North Branch	21.70	6	42	28.7	27-Jul-15
09020302-574	14RD132	Armstrong Creek	12.13	6	42	68.5	11-Jun-14
HUC 12: 0902030204-02 (Shotley Brook)							
09020302-502	14RD136	Shotley Brook	45.93	6	42	53.4	16-Jul-14
09020302-547	14RD137	Hoover Creek	10.07	6	42	67.0	10-Jun-14

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Threshold	FIBI	Visit Date
HUC 12: 0902030201-02 (Little Tamarac River)							
09020302-601	14RD138	Little Tamarac River	89.70	5	47	45.8	25-Aug-14
HUC 12: 0902030201-03 (Lost River)							
09020302-603	14RD142	Lost River	10.30	6	42	65.9	26-Aug-14
09020302-602	14RD148	Lost River	79.55	5	47	9.1	27-Jul-15
09020302-602	14RD148	Lost River	79.55	5	47	9.0	26-Aug-14
HUC 12: 0902030201-01 (Tamarac River)							
09020302-501	14RD139	Tamarac River	284.75	5	47	37.9	28-Jul-15
09020302-501	14RD139	Tamarac River	284.75	5	47	0.0	29-Jul-14
09020302-501	14RD143	Tamarac River	68.02	5	47	31.2	04-Aug-15
09020302-501	14RD143	Tamarac River	68.02	5	47	8.9	26-Aug-14

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

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi²	Invert Class	Threshold	MIBI	Visit Date
HUC 12: 0902030208-01 (Sandy River)							
09020302-522	14RD102	Sandy River	43.94	3	53	49.08	7/28/2014
09020302-522	14RD100	Sandy River	69.63	7	41	66.33	8/18/2014
09020302-604	14RD103	North Fork River	15.52	3	53	34.93	7/28/2014
HUC 12: 0902030207-01 (Lower Red Lake Frontal)							
09020302-518	14RD109	Hay Creek	21.02	4	51	66.00	9/3/2014
09020302-521	14RD153	Pike Creek	14.50	4	51	39.53	8/19/2014
09020302-521	14RD126	Pike Creek	23.70	4	51	65.32	8/18/2014
HUC 12: 0902030207-02 (Mud River)							
09020302-540	14RD107	Mud River	39.67	3	53	68.10	8/18/2014
09020302-541	14RD106	Mud River	51.49	3	53	61.03	8/18/2014
09020302-613	14RD157	Mud River	33.97	4	51	60.73	8/27/2014

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi²	Invert Class	Threshold	MIBI	Visit Date
HUC 12: 0902030206-01 (Blackduck River)							
09020302-508	14RD112	Darrigans Creek	25.12	3	53	44.12	8/20/2014
09020302-508	14RD112	Darrigans Creek	25.12	3	53	44.42	8/16/2016
09020302-510	14RD114	Blackduck River	41.76	3	53	46.70	8/20/2014
09020302-510	14RD114	Blackduck River	41.76	3	53	55.00	8/18/2015
09020302-511	14RD158	Blackduck River	116.18	4	51	53.10	9/3/2014
09020302-514	14RD110	O'Brien Creek	57.60	4	51	59.94	8/20/2014
HUC 12: 0902030206-03 (South Cormorant River)							
09020302-507	14RD119	South Cormorant River	23.26	4	51	51.33	8/20/2014
09020302-507	14RD117	South Cormorant River	57.79	3	53	65.85	9/24/2014
09020302-507	14RD115	South Cormorant River	90.32	4	51	65.54	8/19/2014
09020302-552	14RD121	Spring Creek	17.54	3	53	52.81	9/3/2014

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Invert Class	Threshold	MIBI	Visit Date
HUC 12: 0902030206-02 (North Cormorant River)							
09020302-506	14RD128	North Cormorant River	37.48	3	53	61.00	8/5/2015
09020302-506	14RD124	North Cormorant River	64.76	4	51	47.14	8/19/2014
09020302-542	14RD141	Meadow Creek	6.95	4	51	61.23	9/3/2014
HUC 12: 0902030205-01 (Battle River)							
09020302-503	14RD130	Battle River, North Branch	21.70	4	51	41.73	8/19/2014
09020302-503	14RD130	Battle River, North Branch	21.70	4	51	73.00	7/27/2015
09020302-523	14RD134	Trib. to Battle River, South Branch	10.45	4	51	60.99	9/2/2014
09020302-538	09RD064	Battle River, South Branch	45.93	8	32	31.72	9/23/2010
09020302-539	14RD129	Battle River, South Branch	83.46	4	51	60.68	8/19/2014
09020302-574	14RD132	Armstrong Creek	12.13	4	51	73.43	9/2/2014
HUC 12: 0902030204-02 (Shotely Brook)							
09020302-502	14RD136	Shotley Brook	45.93	4	51	35.04	8/19/2014
09020302-547	14RD137	Hoover Creek	10.07	4	51	69.43	9/2/2014
HUC 12: 0902030201-02 (Little Tamarac River)							
09020302-614	14RD138	Little Tamarac River	89.70	4	51	71.28	8/19/2014
HUC 12: 0902030201-03 (Lost River)							
09020302-602	14RD148	Lost River	79.55	4	51	19.70	8/19/2014
09020302-602	14RD148	Lost River	79.55	4	51	61.00	7/27/2015
09020302-603	14RD142	Lost River	10.30	4	51	66.51	8/26/2014
09020302-603	14RD142	Lost River	10.30	4	51	57.48	9/24/2015
HUC 12: 0902030201-01 (Tamarac River)							
09020302-501	14RD143	Tamarac River	68.02	4	51	33.16	8/26/2014
09020302-501	14RD143	Tamarac River	68.02	4	51	53.00	8/4/2015

Appendix 4.1 – Fish species found during biological monitoring surveys

Common Name	Quantity of Stations Where Present	Quantity of Individuals Collected
bigmouth shiner	4	7
black bullhead	6	10
black crappie	3	10
blackchin shiner	1	2
blacknose dace	25	1549
blacknose shiner	7	139
blackside darter	17	412
bluegill	9	98
brassy minnow	21	494
brook stickleback	20	535
brown bullhead	5	14
burbot	2	13
central mudminnow	32	1262
common shiner	31	2877
creek chub	26	1126
fathead minnow	15	231
finescale dace	6	54
freshwater drum	2	9
Gen: redhorses	4	28
golden shiner	8	65
hornyhead chub	18	689
hybrid Phoxinus	1	2
hybrid sunfish	2	2
Iowa darter	10	35
johnny darter	30	1063
lamprey ammocoete	2	6
largemouth bass	4	75
northern brook lamprey	1	1
northern pike	20	220
northern redbelly dace	17	408
pearl dace	19	487
pumpkinseed	2	4
rainbow trout	2	4
rock bass	9	84
shorthead redhorse	5	27
tadpole madtom	1	1
trout-perch	4	17
walleye	11	46
white sucker	31	809
yellow perch	17	340

Appendix 4.2 – Macroinvertebrate species found during biological monitoring surveys

Taxonomic Name	Quantity of Stations Where Present	Quantity of Individuals Collected
Amphipoda		
Crangonyx	2	2
Hyalella	25	360
Architaenioglossa		
Campeloma	1	1
Basommatophora		
Ferrissia	23	223
Gyraulus	8	62
Helisoma	1	1
Helisoma anceps	1	3
Lymnaea stagnalis	2	2
Lymnaeidae	6	13
Physa	1	4
Physella	24	181
Physidae	1	24
Planorbella	2	2
Planorbidae	6	12
Promenetus exacuous	1	1
Stagnicola	4	10
Branchiobdellida		
Branchiobdellida	1	1
Coleoptera		
Acilius	1	1
Anacaena	1	4
Dineutus	4	10
Dubiraphia	29	394
Dytiscidae	1	1
Dytiscus	1	1
Gymnochthebius	2	2
Gyrinus	2	2
Haliplus	4	9
Helichus	5	7
Helophorus	2	2
Hydaticus	1	1
Hydraena	13	52
Hydrochus	2	2
Hydrophilidae	1	1
Laccophilus	1	2
Liodessus	3	11
Macronychus	1	2

Taxonomic Name	Quantity of Stations Where Present	Quantity of Individuals Collected
Macronychus glabratus	10	149
Neoporus	3	3
Ochthebius	1	1
Optioservus	17	111
Platambus	1	4
Stenelmis	14	106
Stictotarsus	1	1
Tropisternus	1	1
Decapoda		
Orconectes	18	27
Diptera		
Ablabesmyia	21	63
Anopheles	5	9
Antocha	3	4
Atherix	1	2
Atrichopogon	5	9
Brillia	12	20
Ceratopogonidae	2	3
Ceratopogoninae	6	14
Chironomini	1	2
Chironomus	2	16
Cladotanytarsus	4	4
Clinocera	1	1
Clinotanypus	2	2
Conchapelopia	10	12
Corynoneura	9	16
Cricotopus	21	165
Cryptochironomus	4	4
Culicidae	2	2
Demicryptochironomus	1	1
Dicranota	2	3
Dicrotendipes	8	25
Diplocladius cultriger	1	1
Diptera	1	1
Dixella	7	24
Doncricotopus bicaudatus	2	6
Empididae	7	19
Endochironomus	1	1
Ephydridae	5	11
Glyptotendipes	2	2
Hemerodromia	14	59
Kiefferulus	1	1
Labrundinia	13	42

Taxonomic Name	Quantity of Stations Where Present	Quantity of Individuals Collected
Larsia	1	1
Limnophyes	1	2
Limonia	1	1
Micropsectra	15	140
Microtendipes	24	67
Muscidae	1	3
Nanocladius	4	6
Natarsia	2	2
Neoplasta	1	1
Nilotanypus	2	2
Orthocladiinae	4	6
Orthocladius	7	28
Orthocladius (Symposiocladius)	11	40
Parachironomus	2	5
Paracladopelma	1	1
Parakiefferiella	5	7
Paralauterborniella nigrohalterale	2	2
Paramerina	9	47
Parametriocnemus	17	50
Paraphaenocladius	1	1
Paratanytarsus	23	160
Paratendipes	3	6
Pentaneura	2	3
Phaenopsectra	14	25
Polypedilum	36	602
Potthastia	3	5
Procladius	6	11
Psectrocladius	2	16
Pseudochironomus	1	1
Rheocricotopus	9	25
Rheotanytarsus	33	490
Saetheria	1	1
Simulium	30	1468
Stempellinella	18	77
Stenochironomus	20	188
Stictochironomus	1	1
Tabanidae	5	5
Tabanus	1	1
Tanypodinae	11	18
Tanytarsini	8	17
Tanytarsus	29	354
Thienemanniella	14	61
Thienemannimyia	29	191

Taxonomic Name	Quantity of Stations Where Present	Quantity of Individuals Collected
Thienemannimyia Gr.	6	43
Tipula	9	29
Tipulidae	1	1
Tribelos	4	4
Trissopelopia ogemawi	1	1
Tvetenia	6	35
Xenochironomus xenolabis	3	3
Xylotopus par	1	1
Zavreliella marmorata	1	1
Zavrelimyia	1	2
Ephemeroptera		
Acentrella parvula	1	1
Acerpenna	7	20
Acerpenna pygmaea	6	23
Anafroptilum	2	3
Baetidae	3	4
Baetis	13	267
Baetis brunneicolor	22	341
Baetis flavistriga	16	120
Baetis intercalaris	3	62
Caenis	7	31
Caenis diminuta	16	197
Caenis hilaris	9	81
Ephemera	1	1
Ephemerella	1	3
Eurylophella	8	45
Heptagenia	2	3
Heptageniidae	5	22
Hexagenia	1	2
Iswaeon	7	49
Labiobaetis	2	5
Labiobaetis dardanus	1	1
Labiobaetis frondalis	11	80
Labiobaetis propinquus	21	186
Leptophlebia	1	11
Leptophlebiidae	18	325
Leucrocuta	4	5
Maccaffertium	17	158
Maccaffertium exiguum	1	1
Maccaffertium terminatum	1	10
Maccaffertium vicarium	6	24
Metretopodidae	1	1
Paraleptophlebia	6	223

Taxonomic Name	Quantity of Stations Where Present	Quantity of Individuals Collected
Procloeon	13	65
Pseudocloeon	1	2
Stenacron	27	263
Tricorythodes	4	15
Haplotaxida		
Enchytraeus	2	4
Fridericia	2	7
Oligochaeta	14	41
Tubificinae	3	4
Hemiptera		
Aquarius	1	1
Belostoma	1	1
Belostoma flumineum	8	16
Corixidae	5	7
Gerridae	1	1
Hesperocorixa	1	1
Limnoporus	1	1
Neoplea striola	3	5
Rheumatobates	1	4
Sigara	3	4
Lepidoptera		
Parapoynx	1	1
Petrophila	1	1
Megaloptera		
Sialis	3	7
Neotaenioglossa		
Hydrobiidae	19	244
Odonata		
Aeshna	2	6
Aeshna umbrosa	2	2
Aeshnidae	5	26
Anisoptera	1	2
Basiaeschna janata	1	1
Boyeria vinosa	12	17
Calopterygidae	6	26
Calopteryx	7	29
Calopteryx aequabilis	17	52
Calopteryx maculata	1	1
Coenagrionidae	6	11
Cordulegaster maculata	1	1
Corduliidae	4	6
Epitheca canis	6	16
Gomphidae	1	1

Taxonomic Name	Quantity of Stations Where Present	Quantity of Individuals Collected
Gomphus	1	1
Hetaerina	2	11
Macromiinae	1	1
Somatochlora elongata	1	5
Somatochlora minor	1	1
Somatochlora walshii	2	2
Plecoptera		
Acroneuria	1	1
Acroneuria lycorias	1	1
Isoperla	1	5
Paragnetina media	6	22
Perlesta	4	8
Perlidae	1	1
Perlodidae	2	2
Pteronarcidae	1	1
Pteronarcys	2	6
Taeniopteryx	1	2
Trichoptera		
Brachycentrus numerosus	6	10
Ceraclea	12	43
Ceratopsyche	8	81
Ceratopsyche alhedra	1	11
Ceratopsyche bronta	2	14
Ceratopsyche morosa	4	25
Ceratopsyche slossonae	12	68
Ceratopsyche sparna	2	19
Cheumatopsyche	25	361
Glyphopsyche irrorata	1	1
Helicopsyche borealis	15	269
Hydropsyche	5	27
Hydropsyche betteni	13	56
Hydropsychidae	12	100
Hydroptila	11	34
Hydroptilidae	5	33
Leptoceridae	2	7
Limnephilidae	11	59
Micrasema	5	25
Micrasema rusticum	2	42
Nectopsyche	1	3
Nectopsyche diarina	2	2
Nyctiophylax	1	1
Ochrotrichia	1	1
Oecetis	2	2

Taxonomic Name	Quantity of Stations Where Present	Quantity of Individuals Collected
Oecetis avara	9	17
Oecetis furva	2	2
Oecetis testacea	4	9
Oxyethira	4	25
Phryganeidae	4	9
Polycentropodidae	4	8
Polycentropus	2	4
Protoptila	3	14
Psychomyiidae	1	1
Ptilostomis	11	20
Pycnopsyche	2	5
Triaenodes	3	15
Trichoptera	2	2
Uenoidae	1	6
Unclassified		
Acari	25	186
Hirudinea	17	36
Hydrozoa	1	1
Nemata	3	3
Veneroida		
Pisidiidae	25	125

Appendix 5 – Minnesota Stream Habitat Assessment results

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

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
2	14RD100	Sandy River	5	12	15.5	13	13	58.5	Fair
2	14RD102	Sandy River	3.5	9.3	17.8	12.5	18.5	61.6	Fair
2	14RD103	North Fork River	4.3	11	19.8	14	23.5	72.6	Good
Average Habitat Results: *Sandy River Aggregated 12 HUC*			**4.4**	**11.1**	**16.8**	**13.1**	**19.3**	**64.7**	**Fair**
2	14RD109	Hay Creek	5	9.5	11.5	10.5	12.5	49	Fair
2	14RD126	Pike Creek	4.3	11	8.4	13	13.5	50.1	Fair
2	14RD153	Pike Creek	5	9.5	10.7	12	15.5	52.6	Fair
Average Habitat Results: *Lower Red Lake Frontal Aggregated 12 HUC*			**4.8**	**10**	**10.2**	**11.8**	**13.8**	**50.6**	**Fair**
2	14RD106	Mud River	3.5	12	17.8	12	19.5	64.8	Fair
3	14RD107	Mud River	4.7	11	20.6	13.7	22	71.9	Good
3	14RD157	Mud River	3.3	10.3	19.2	13	17.3	63.2	Fair
Average Habitat Results: *Mud River Aggregated 12 HUC*			**3.8**	**11.1**	**19.2**	**12.9**	**19.6**	**66.7**	**Good**
2	14RD110	O'Brien Creek	4.5	11.3	19.5	14.5	24.5	74.2	Good
3	14RD112	Darrigans Creek	1.2	7.3	20.3	14.3	21	64.1	Fair
3	14RD114	Blackduck River	4.7	11.2	17.8	14	21.3	68.9	Good
1	14RD122	Blackduck River	5	11	8	7	16	47	Fair
2	14RD158	Blackduck River	4.5	10.3	14.2	13	8.5	50.5	Fair
Average Habitat Results: *Blackduck River Aggregated 12 HUC*			**3.9**	**10.2**	**15.9**	**12.6**	**18.3**	**60.9**	**Fair**
2	14RD115	South Cormorant River	4	10.5	10.9	8.5	10	43.9	Fair
1	14RD116	Perry Creek	5	13	21.5	16	26	81.6	Good

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
2	14RD117	South Cormorant River	4.8	10	17.9	11.5	15	59.2	Fair
2	14RD119	South Cormorant River	4	10.3	19.1	13.5	23.5	70.3	Good
2	14RD121	Spring Creek	5	10.5	14.9	13	20	63.4	Fair
Average Habitat Results: *South Cormorant River Aggregated 12 HUC*			**4.6**	**10.9**	**16.9**	**12.5**	**18.9**	**63.7**	**Fair**
2	14RD124	North Cormorant River	4.5	10	12.6	11	17.5	55.6	Fair
1	14RD127	North Cormorant River	5	10	19	13	15	62	Fair
2	14RD128	North Cormorant River	1.6	10.5	18.8	12	23	65.9	Fair
2	14RD141	Meadow Creek	4	11	18.7	14	24	71.7	Good
Average Habitat Results: *North Cormorant River Aggregated 12 HUC*			**3.8**	**10.4**	**17.3**	**12.5**	**19.9**	**63.8**	**Fair**
1	09RD064	Battle River, South Branch	4	11.5	19.9	16	17	68.4	Good
2	14RD129	Battle River, South Branch	4	11	8	11.5	11	45.5	Fair
3	14RD130	Battle River, North Branch	4.7	12	14.1	13	18.7	62.4	Fair
2	14RD132	Armstrong Creek	3.5	7.5	19	14	12.5	56.5	Fair
2	14RD134	Trib. to Battle River, South	4.3	10.8	13.1	13	12	53.0	Fair
Average Habitat Results: *Battle River Aggregated 12 HUC*			**4.1**	**10.6**	**14.8**	**13.5**	**14.2**	**57.2**	**Fair**
2	14RD136	Shotley Brook	5	11.5	15.5	10	14	56	Fair
2	14RD137	Hoover Creek	4.5	10	14.3	13.5	18.5	60.8	Fair
Average Habitat Results: *Shotley Brook Aggregated 12 HUC*			**4.8**	**10.8**	**14.9**	**11.8**	**16.3**	**58.4**	**Fair**
2	14RD138	Little Tamarac River	5	9.5	11.5	7	7	40	Poor
Average Habitat Results: *Little Tamarac River Aggregated 12 HUC*			**5**	**9.5**	**11.5**	**7**	**7**	**40**	**Poor**
3	14RD142	Lost River	5	12	18.7	11.7	16.3	63.7	Fair
4	14RD148	Lost River	5	11.4	14.8	13	16	60.2	Fair
Average Habitat Results: *Lost River Aggregated 12 HUC*			**5**	**11.7**	**16.8**	**12.3**	**16.2**	**61.9**	**Fair**
2	14RD139	Tamarac River	4	11.5	7.9	11	12.5	46.9	Fair
4	14RD143	Tamarac River	5	10.9	15.5	10	14.8	56.1	Fair
Average Habitat Results: *Tamarac River Aggregated 12 HUC*			**4.5**	**11.2**	**11.7**	**10.5**	**13.6**	**51.5**	**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)