Watershed health

July 2018

Winnebago River and Upper Wapsipinicon River Watersheds Monitoring and Assessment Report

MINNESOTA POLLUTION CONTROL AGENCY

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List of acronyms

CD County Ditch

CI Confidence Interval

CLMP Citizen Lake Monitoring Program

CR County Road

CSAH County State Aid Highway

CSMP Citizen Stream Monitoring Program

CWA Clean Water Act

CWLA Clean Water Legacy Act

DNR Minnesota Department of Natural Resources

DOP Dissolved Orthophosphate

E Eutrophic

EQuIS Environmental Quality Information System

EX Exceeds Criteria (Bacteria)

EXP Exceeds Criteria, Potential Impairment

EXS Exceeds Criteria, Potential Severe Impairment

FWMC Flow Weighted Mean Concentration

H Hypereutrophic

HUC Hydrologic Unit Code

IBI Index of Biotic Integrity

IF Insufficient Information

K Potassium

LRVW Limited Resource Value Water

M Mesotrophic

MCES Metropolitan Council Environmental Services

MDA Minnesota Department of Agriculture

MDH Minnesota Department of Health

MINLEAP Minnesota Lake Eutrophication Analysis Procedure

MPCA Minnesota Pollution Control Agency

MSHA Minnesota Stream Habitat Assessment

MTS Meets the Standard

N Nitrogen

Nitrate-N Nitrate Plus Nitrite Nitrogen

NA Not Assessed

NHD National Hydrologic Dataset

NH3 Ammonia

NT No Trend

OP Orthophosphate

P Phosphorous

PCB Poly Chlorinated Biphenyls

PWI Protected Waters Inventory

RNR River Nutrient Region

SWAG Surface Water Assessment Grant

SWCD Soil and Water Conservation District

SWUD State Water Use Database

TALU Tiered Aquatic Life Uses

TKN Total Kjeldahl Nitrogen

TMDL Total Maximum Daily Load

TP Total Phosphorous

TSS Total Suspended Solids

USGS United States Geological Survey

WID Waterbody Identification Number

WPLMN Watershed Pollutant Load Monitoring Network

Executive summary

The Winnebago River and Upper Wapsipinicon River watersheds are two small watersheds in the greater Cedar River watershed. Both the Wapsipinicon River and Winnebago River have their headwaters in Minnesota before flowing into Iowa. Only a small percentage of each watershed is found in Minnesota. The Iowa Department of Natural Resources conducts assessments similar to Minnesota. The Winnebago River and Wapsipinicon River both have impairments in Iowa.

The Upper Wapsipinicon River watershed only covers 13 square miles before crossing into Iowa where the river flows for over 2,000 miles (NRCS, 2007a). Altered hydrology is common throughout the watershed, with 90% of the streams being altered. Watersheds dominated by row crop agriculture often have a high percentage of altered streams. Landuse in the Upper Wapsipinicon River watershed is 91% row crop agriculture (NRCS, 2007a).

The Winnebago River watershed drains 71 square miles in Minnesota before crossing into Iowa (DNR, 2015b). Two lakes, Bear Lake and State Line Lake, are located in the watershed. The DNR has been actively restoring and managing both lakes to create healthy wildlife lakes. There are no sections of natural stream left in the watershed. Landuse is dominated by row crop agriculture with 81% of land in production (NRCS, 2007b).

These watersheds are small and there are no pollutant load monitoring stations. Data was available from watersheds with similar characteristics. Findings from those watersheds show concentrations can vary widely and often follow closely to water runoff and river discharge. Groundwater in this area is relatively good, but vulnerable. Nitrate is a concern.

Examining wetlands in this ecoregion, 42% of them are in poor condition and 40% are in fair condition. Restoring wetlands in the Winnebago River watershed and Upper Wapsipinicon River watershed would increase water storage on the land and contribute to better water quality.

Bear Lake and State Line Lake are both located in the Winnebago River watershed. The lakes were assessed for aquatic recreation. Both were found to be impaired; not meeting standards set for aquatic recreation. There was insufficient data to complete an assessment for aquatic life. Fish contaminants were assessed from Bear Lake using common carp and northern pike. Mercury and PCBs levels were below the standards set for healthy consumption. No impairments resulted from assessment of fish tissue.

One reach on the Wapsipinicon River and one reach on the Winnebago River were assessed for aquatic recreation. Both exceeded standards set for aquatic recreation and are being recommended for impairment. Four stream reaches were assessed for aquatic life on the Winnebago River watershed. All of these are on altered channels that are being assessed using modified use thresholds. All of the reaches assessed for aquatic life were found to be impaired. One reach was assessed for aquatic life in the Upper Wapsipinicon River watershed. Based on the biological data collected, the reach is being listed as impaired for aquatic life.

Introduction

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

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

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

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

This watershed-wide monitoring approach was implemented in the Winnebago River watershed and the Upper Wapsipinicon River watershed beginning in the summer of 2015. This report provides a summary of all water quality assessment results in the Winnebago River watershed and the Upper Wapsipinicon River watershed and incorporates all data available for the assessment process including watershed monitoring, volunteer monitoring and monitoring conducted by local government units.

The watershed monitoring approach

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

Watershed pollutant load monitoring

The Watershed Pollutant Load Monitoring Network (WPLMN) is a long-term statewide river monitoring network initiated in 2007 and designed to obtain pollutant load information from 199 river monitoring sites throughout Minnesota. Monitoring sites span three ranges of scale:

Basin – major river main stem sites along the Mississippi, Minnesota, Rainy, Red, Des Moines, Cedar and St. Croix rivers

Major Watershed – tributaries draining to major rivers with an average drainage area of 1,350 square miles (8-digit HUC scale)

Subwatershed – major branches or nodes within major watersheds with average drainage areas of approximately 300-500 square miles

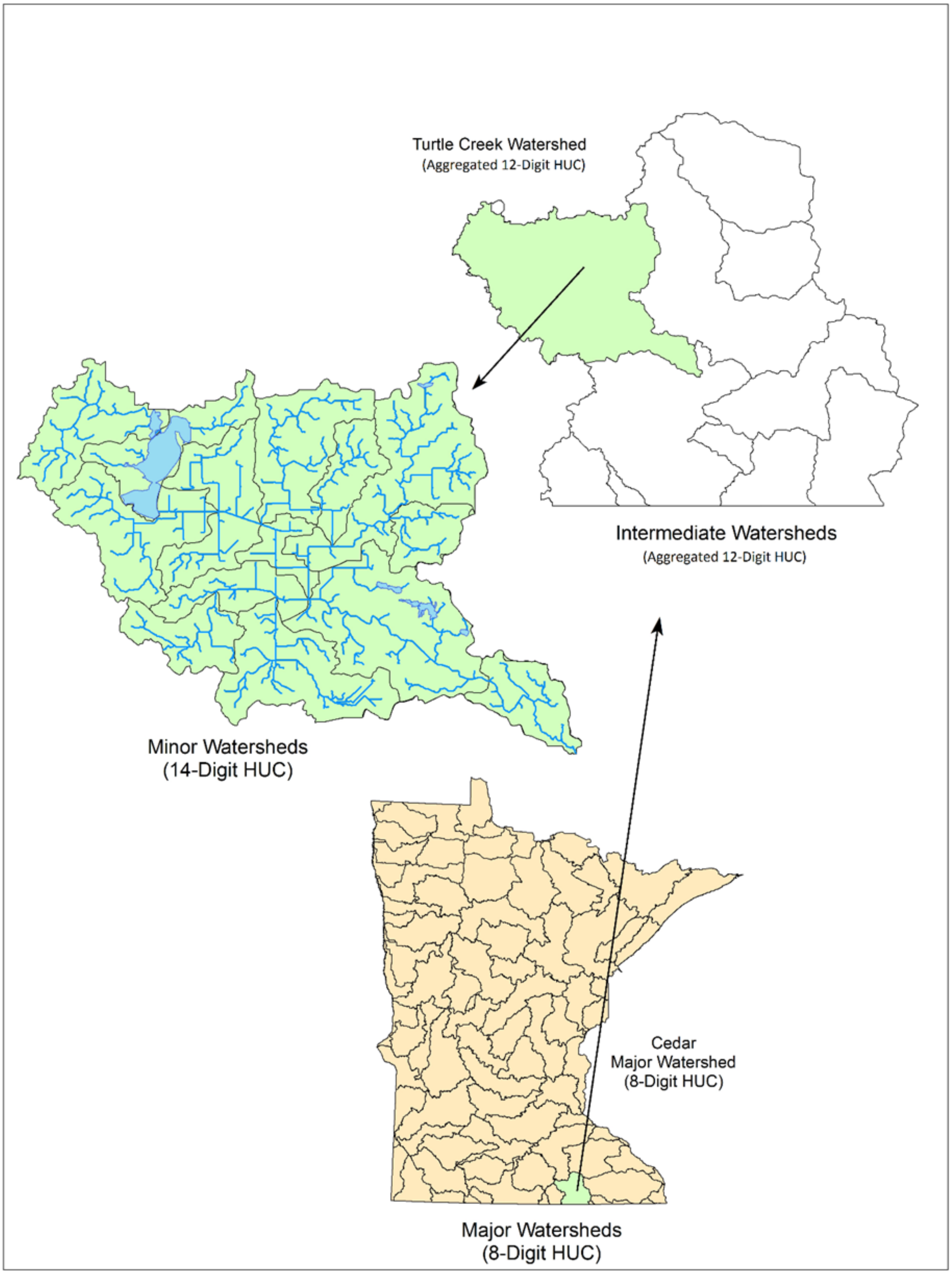
The program utilizes state and federal agencies, universities, local partners, and MPCA staff to collect water quality and flow data to calculate nitrogen, phosphorus, and sediment pollutant loads.

Intensive watershed monitoring

The intensive watershed monitoring strategy utilizes a nested watershed design allowing the sampling of streams within watersheds from a course 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 and Figure 3) is sampled for biology (fish and macroinvertebrates), water chemistry and fish contaminants (in the Winnebago River watershed) 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 mi^2. Each aggregated 12-HUC outlet (green dots in Figure 2 and Figure 3) is sampled for biology and water chemistry for the assessment of aquatic life and aquatic recreation use support. Within each aggregated 12-HUC, smaller watersheds (14 HUCs, typically 10-20 mi^2), are sampled at each outlet that flows into the major aggregated 12-HUC tributaries. Each of these minor subwatershed outlets is sampled for biology to assess aquatic life use support (red dots in Figure 2 and Figure 3).

Figure 1. The Intensive Watershed Monitoring Design.



Lake monitoring

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 Wapsipinicon River and Winnebago River watersheds are shown in Figure 2 and Figure 3 and are listed in Appendices 2.1 and 2.2.

Figure 2. Intensive watershed monitoring sites for streams in the Upper Wapsipinicon River watershed.

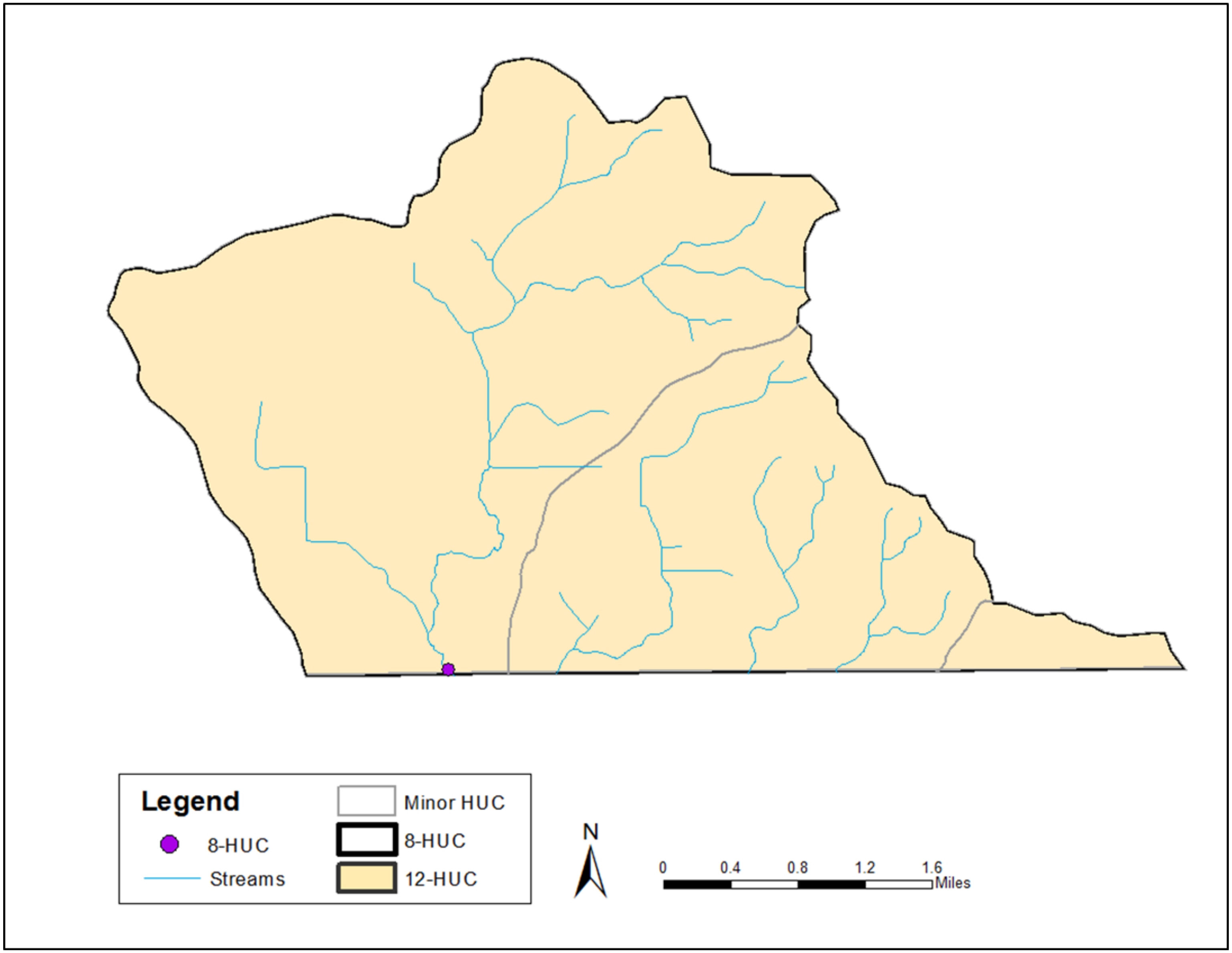
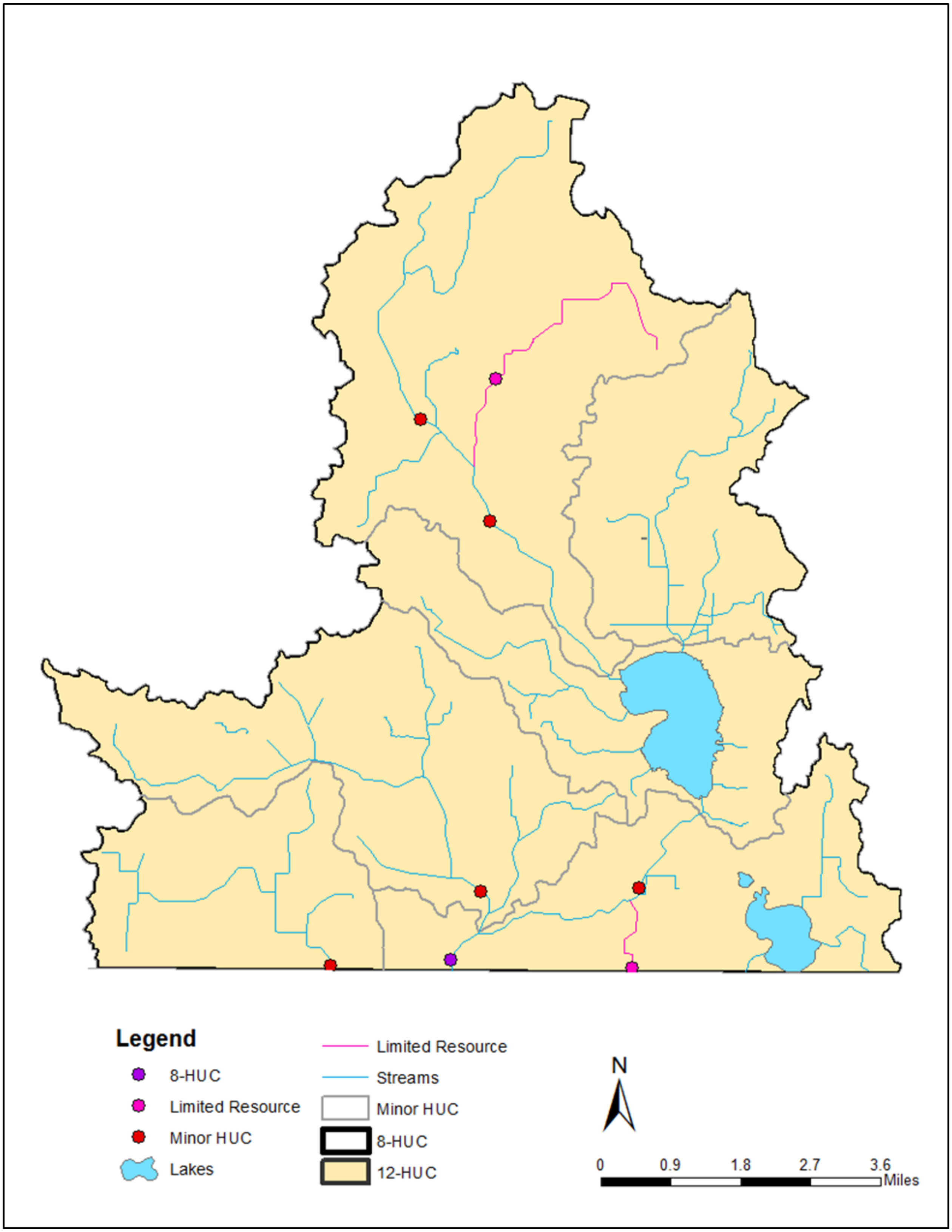


Figure 3. Intensive watershed monitoring sites for streams in the Winnebago River watershed.



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

The MPCA also coordinates two programs aimed at encouraging long term citizen surface water monitoring: the Citizen Lake Monitoring Program (CLMP) and the Citizen Stream Monitoring Program (CSMP). Like the permanent load monitoring network, having citizen volunteers monitor a given lake or stream site monthly and from year to year can provide the long-term picture needed to help evaluate current status and trends. Citizen monitoring is especially effective at helping to track water quality changes that occur in the years between intensive monitoring years. There are no citizen monitoring locations in the Winnebago River watershed or the Upper Wapsipinicon River watershed.

Assessment methodology

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

Water quality standards

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

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

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

Protection of aquatic life means the maintenance of a healthy aquatic community, including fish, 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, dissolved oxygen, un-ionized ammonia nitrogen, chloride, total suspended solids, pesticides, and river eutrophication. For lakes, pesticides and chlorides contribute to the overall aquatic life use assessment.

Protection for aquatic life uses in streams and rivers are divided into three tiers: Exceptional, General, and Modified. Exceptional Use waters support fish and macroinvertebrate communities that have minimal changes in structure and function from the natural condition. General Use waters harbor "good" assemblages of fish and macroinvertebrates that can be characterized as having an overall balanced distribution of the assemblages and with the ecosystem functions largely maintained through redundant attributes. Modified Use waters have been extensively altered through legacy physical modifications which limit the ability of the biological communities to attain the General Use. Currently the Modified Use is only applied to streams with channels that have been directly altered by humans (e.g., maintained for drainage, 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. 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	Coldwater Stream protected for aquatic life and recreation, capable of supporting and maintaining a balanced, integrated, adaptive community of coldwater aquatic organisms that meet or exceed the General Use biological criteria.
Coldwater Exceptional	CWe	2Ae	Coldwater Stream protected for aquatic life and recreation, capable of supporting and maintaining an exceptional and balanced, integrated, adaptive community of coldwater aquatic organisms that meet or exceed the Exceptional Use biological criteria.

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

Assessment units

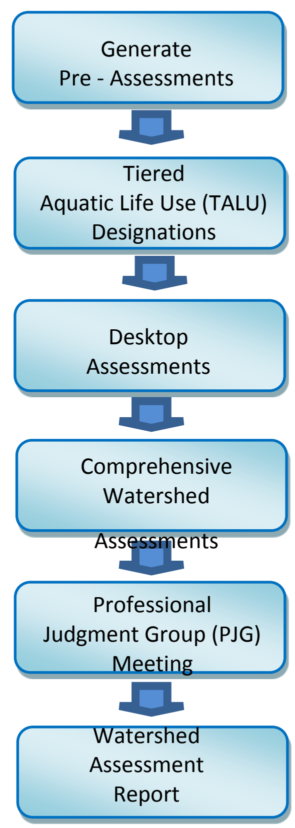
Assessments of use support in Minnesota are made for individual waterbodies. The waterbody unit used for river systems, lakes and wetlands is called the "assessment unit". A stream or river assessment unit usually extends from one significant tributary stream to another or from the headwaters to the first tributary. A stream "reach" may be further divided into two or more assessment reaches when there is a change in use classification (as defined in Minn. R., ch. 7050) or when there is a significant morphological feature, such as a dam or lake, within the reach. Therefore, a stream or river is often segmented into multiple assessment units that are variable in length. The MPCA is using the 1:24,000 scale high resolution National Hydrologic Dataset (NHD) to define and index stream, lake and wetland assessment units. Each river or stream reach is identified by a unique waterbody identifier (known as its WID), comprised of the United States Geological Survey (USGS) 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 WID and are composed of an eight-digit number indicating county, lake and bay for each basin.

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

Determining use attainment

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

Figure 4. Flowchart of aquatic life use assessment process.



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).

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

The last step in the assessment process is the Professional Judgment Group meeting. 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 WID). Waterbodies that do not meet standards and therefore do not attain one or more of their designated uses are considered impaired waters and are placed on the draft 303(d) Impaired Waters List. Assessment results are also included in watershed monitoring and assessment reports.

Watershed overview

Upper Wapsipinicon River

The Upper Wapsipinicon River watershed is located entirely in Mower County in south central Minnesota. Only 13 square miles of the watershed are in Minnesota, before the river and several of its small tributaries flow across the border into Iowa. (DNR, 2015a) These 13 miles are roughly 0.81% of the entire watershed. (NRCS, 2007a). The entire watershed drains 991,980 acres of land across Minnesota and Iowa and flows for 2,158 miles (NRCS, 2007a). The watershed is located in the Western Corn Belt Plains ecoregion. In Minnesota, soils in the watershed are defined as silty and loamy mantled firm till plain. Meaning there is a layer of silty material overlying loamy till before hitting sedimentary bedrock (NRCS, 2007a)

The Upper Wapsipinicon River begins in small drainage ditches and flows south to the Minnesota/Iowa border. Three small ditched tributaries east of the Upper Wapsipinicon River flow across the border before joining the mainstem. The Upper Wapsipinicon River watershed is part of the greater Cedar River watershed.

The Iowa Department of Natural Resources lists the Wapsipinicon River as a Protected Water Area near its confluence with the Mississippi River. A large portion of the river in accessible by canoe. The Iowa Department of Natural Resources says northern pike, walleye, smallmouth bass, largemouth bass, and flathead catfish are popular among anglers on the river. Additionally they monitor the river for assessment, similar to the MPCA. The section of river just below the state border has no impairments. One fish sample was available for assessment and achieved a passing score.

Winnebago River

The Winnebago River watershed primarily located in southwest Freeborn County in south central Minnesota. A small percentage of the watershed flows out of southeast Faribault County. Only 10.4% of the Winnebago River watershed is in Minnesota before the river crosses the border and flows into Iowa. The entire watershed covers 441,604 acres and flows for 600 miles (NRCS, 2007b). In Minnesota, the watershed drains 71 square miles (DNR, 2015b). Like the greater Cedar River watershed, the Winnebago is located in the Western Corn Belt Plains ecoregion. Soils in the eastern part of the watershed are primarily loamy glacial till; categorized as Iowa and Minnesota Rolling Prairie/Forest Moraines (NRCS, 2007b). To the west soils are defined as Iowa and Minnesota Till Prairie and consist of loamy glacial till with areas of lacustrine, potholes, outwash, and flood plains. This region is generally less hilly with more gradual slopes than the moraines.

Bear Lake, located 4 miles south of Conger, is the beginning of the Winnebago River, also called Lime Creek. North of the lake Steward Creek is the largest headwater tributary to the lake. Several tributaries flow into the Winnebago River and Bear Lake. Tributaries in this watershed generally consist of small, ditched subwatersheds. Two tributaries are designated Limited Resource waters, meaning they have a permitted discharger and cannot be assessed as part of this report. According to the DNR, the Winnebago River watershed contains 9 bridge crossings and 110 culverts. Culverts and bridge crossing have the potential to be fish barriers. Of the culverts surveyed 20, were identified as being a barrier to fish passage (DNR, 2018c)

Bear Lake and State Line Lake have undergone several years of intensive management by Minnesota DNR. Bear Lake was established as a Wildlife Management Lake in 1972 and has been managed for waterfowl production and migration since then. The lake does not support a large fishery due to its shallow depths, which lead to frequent winterkills. The Minnesota DNR began work on State Line Lake and Bear Lake in 2013, which included plans for lake draw down in both lakes and rotenone treatment in State Line Lake. More information is available from the Minnesota DNR.

The Iowa Department of Natural Resources assessed the waters of the state. The Winnebago River from the confluence with Pike Run to the state line is impaired for aquatic life. Fish and aquatic macroinvertebrate sampling was conducted in 2000, 2006, and 2012. The IBI scores ranged from fair to poor. The low scores resulted in this reach of the river being impaired for aquatic life. Below this reach the river is listed as impaired due to a fish kill which occurred before 2008. The kill resulted from a discharge from a silage storage tank. Approximately 31,244 fish were killed along a 16.1 mile stretch of the river (Iowa DNR). More information is available from the Iowa Department of Natural Resources on their website https://programs.iowadnr.gov/adbnet/.

Figure 5. The Winnebago River watershed within the Western Corn Belt Plains ecoregion of southern Minnesota.

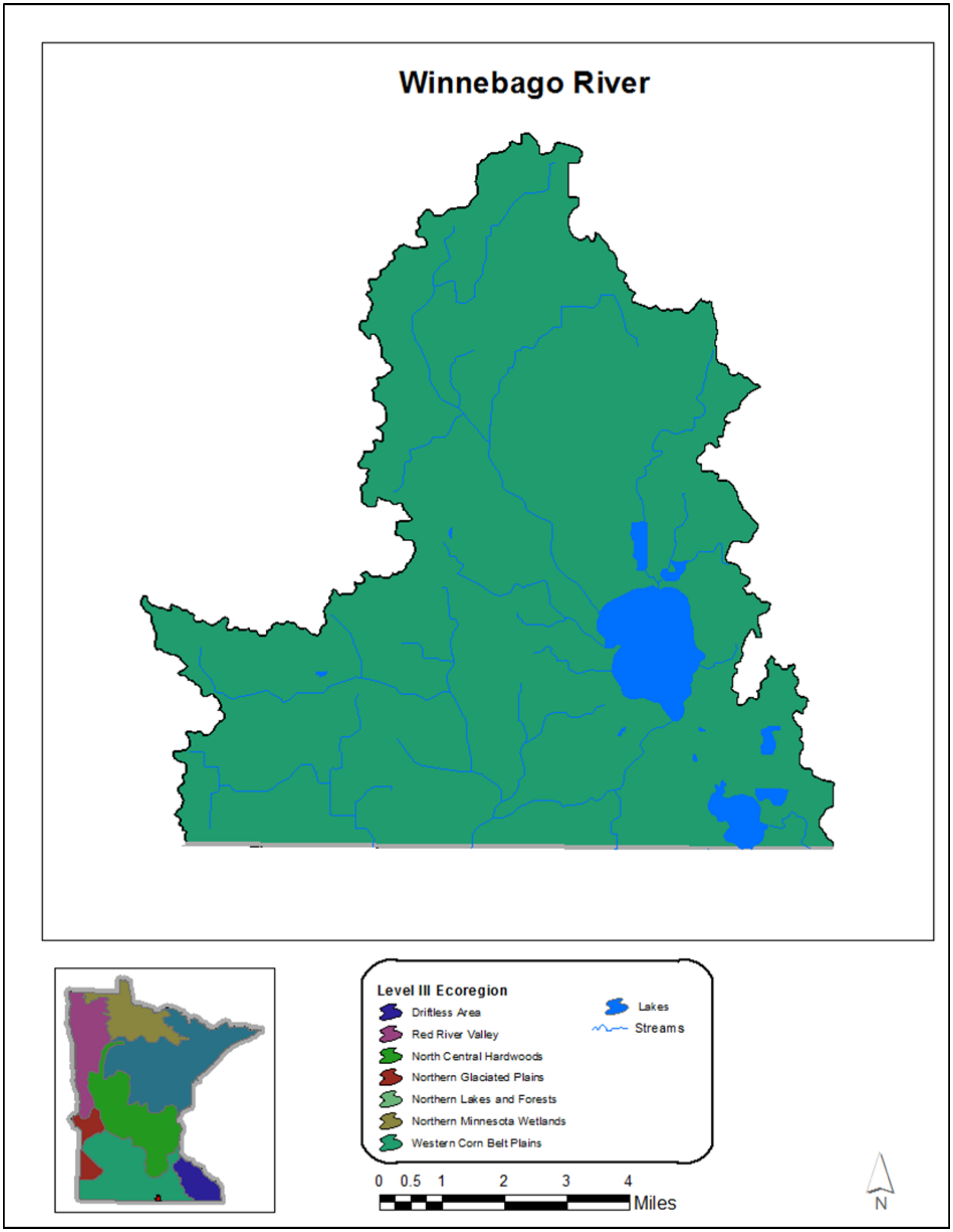


Figure 6. The Upper Wapsipinicon River watershed within the Western Corn Belt Plains ecoregion of southern Minnesota.

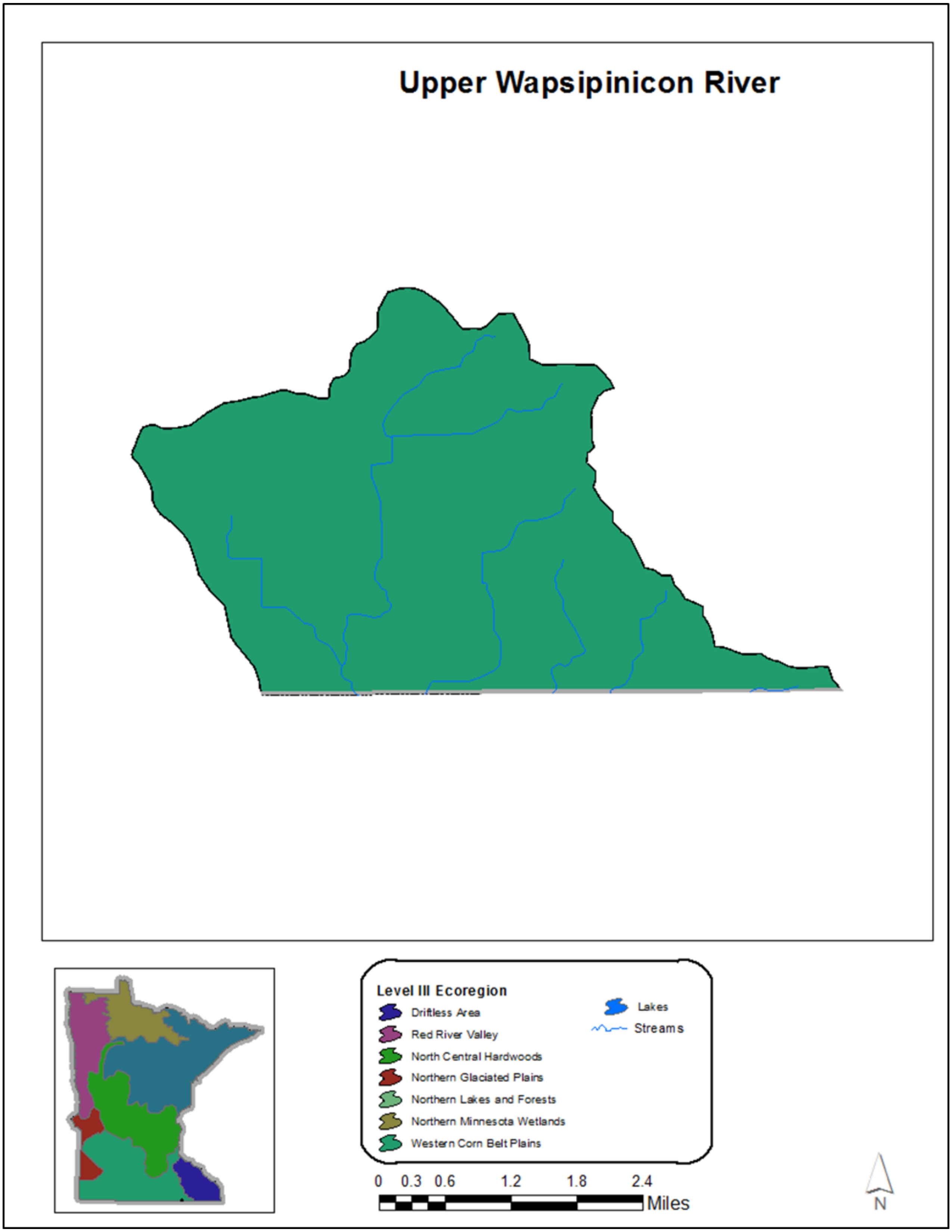


Figure 7. Major Land Resource Areas (MLRA) in the Winnebago River watershed.

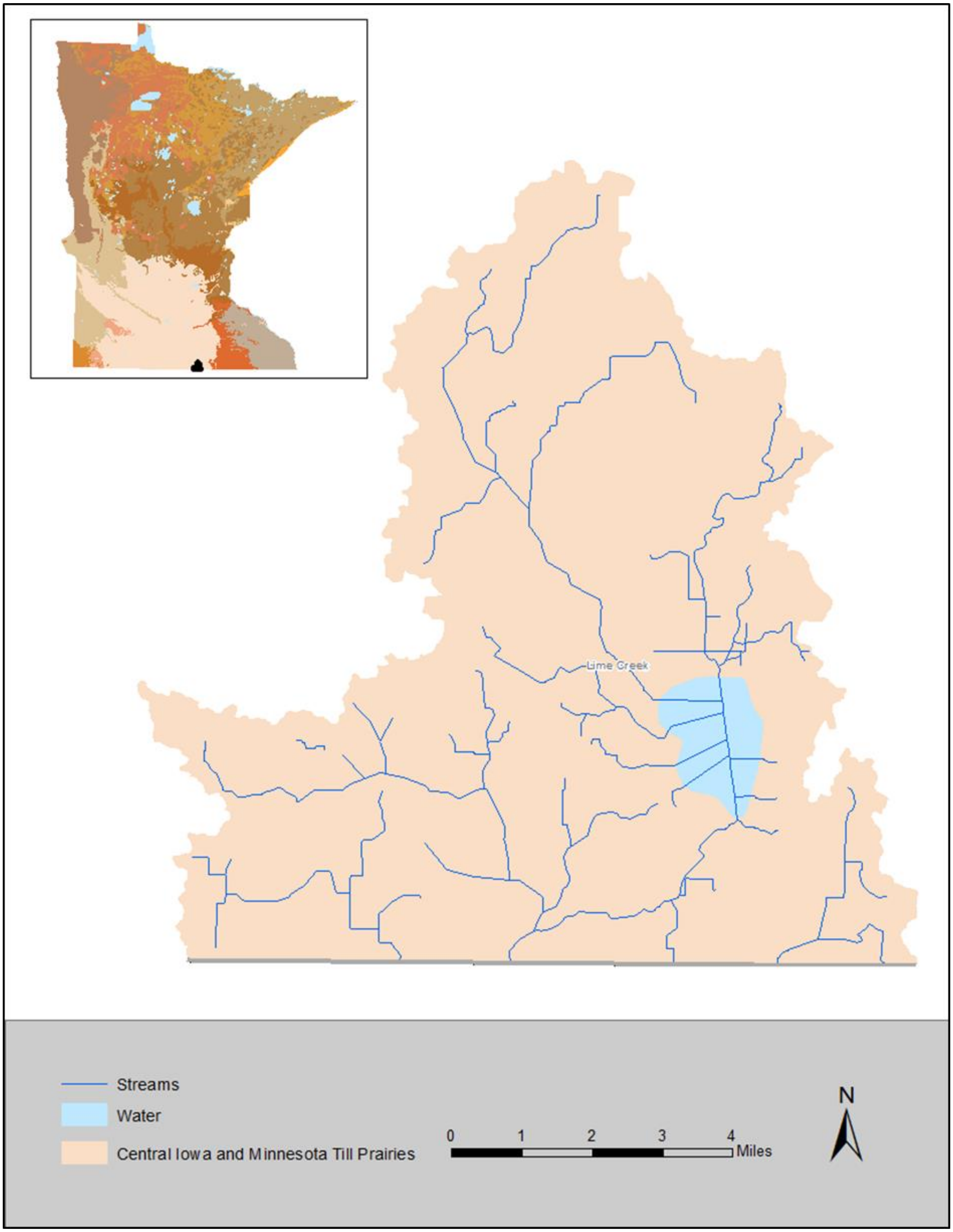
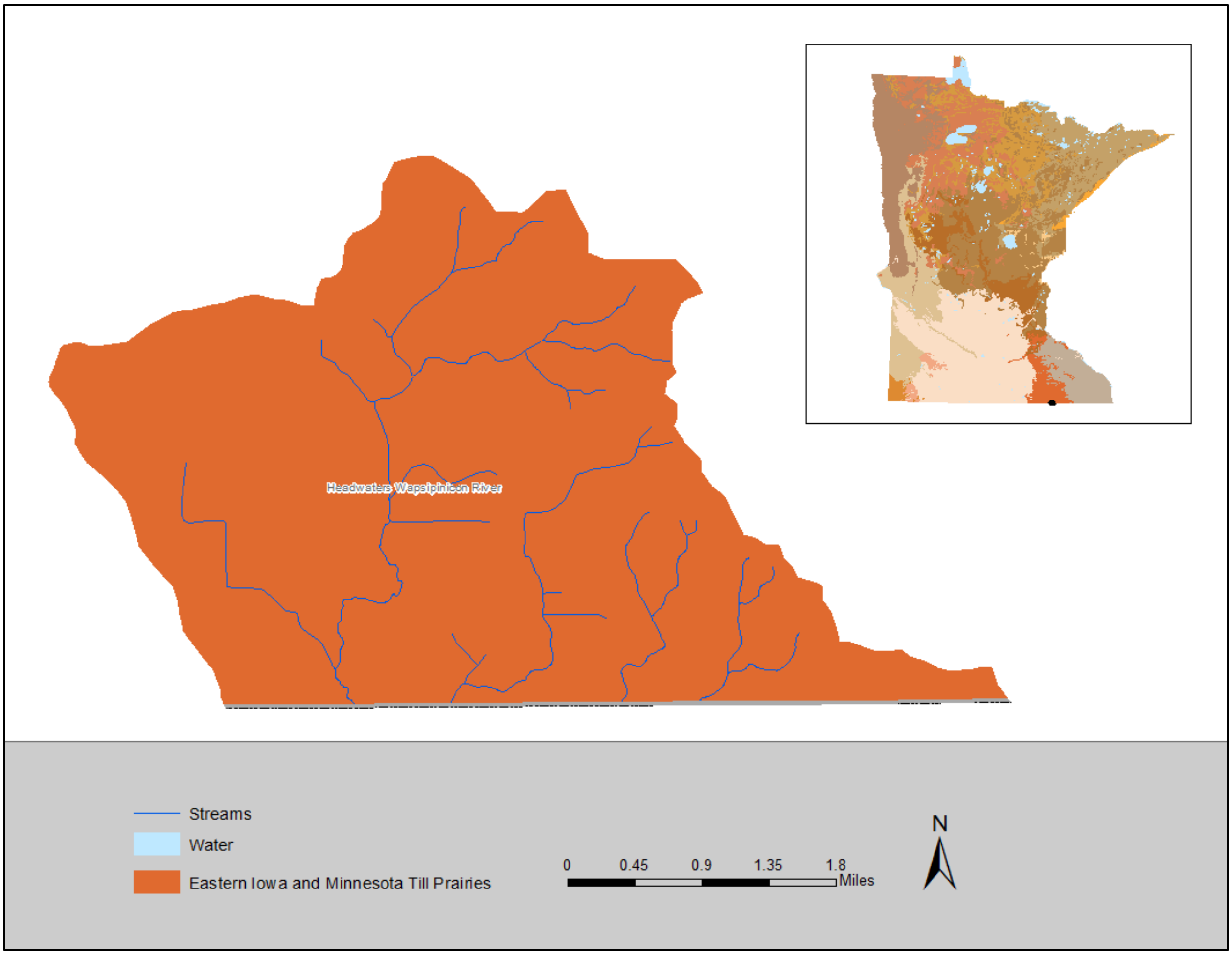


Figure 8. Major Land Resource Areas (MLRA) in the Upper Wapsipinicon River watershed.



Landuse summary

Winnebago River

In Minnesota agriculture makes up 86% of the landuse in the Winnebago River watershed (Homer, 2015), 81% being row crop. Similarly agriculture accounts for 84% of landuse in the entire watershed (NRCS, 2007b). According to Minnesota Department of Agriculture (MDA), Freeborn County (where the Winnebago is located) is eight in the state for crop production and number 10 in the state for hog production. The greater watershed has 1,022 farms and 96% of the land is privately owned (NRCS, 2007b). Census from 2010 show the population of the Winnebago River watershed in Minnesota is 1,143 (DNR, 2015b).

Second to agriculture, in Minnesota, 5.9% of landuse is developed land. Only 0.78% is forested and 3.4% wetland. The lakes in the watershed make up 3.5%.

The Freeborn County SWCD works to promote conservation. According to their 2016 annual report over 9000 acres are enrolled in permanent easements. Another 1,728 acres are farmed using cover crops throughout the entire county. The county started an annual tree program, allowing landowners to purchase native trees at affordable prices. Since the program began over 10,700 trees and shrubs have been planted (Freeborn SWCD, 2016). Throughout the entire watershed 50,663 acres are enrolled in Farmbill programs and another 111,169 acres are being worked with conservation practices (NRCS, 2007b).

The Minnesota DNR scores watersheds on a variety of metrics by major watershed in their Watershed Report Cards. Scores range from 0-100, with 100 being the best and 0 being the worst. According to this report card the Winnebago River watershed has an average score of 11.3 for perennial cover, a score of 11.7 for terrestrial habitat quality, and 21 for non-point source phosphorus risk. Positively the soil erosion potential scores relatively high at 72.4. Impervious cover scores high at 83.7, meaning there is little impervious surface in the watershed. This is likely due to the high percentage of land involved in agriculture and low number of urban areas (DNR, 2015b).

Upper Wapsipinicon River

The Upper Wapsipinicon River watershed was historically prairie land. Currently 93% of the landuse is row crop agriculture (DNR, 2015a). Mower County, where the watershed is located, is ranked number seven in the state for crop production and number five in the state for hog production. Rangeland (pasture) is 3.2% of the landuse. Another 5.5% of land is developed. All other landuse categories are less than 1% of the total landuse in the watershed (Homer, 2015).

The population in the watershed in Minnesota is small, only 68 people reported in the 2010 census (DNR, 2015a). Combining Minnesota and Iowa the watershed has 2,255 farms. Approximately 98% of the land is privately owned. Followed by County ownership with 1.1% (NRCS, 2007a).

The majority of the Upper Wapsipinicon River is located in Iowa. Across the entire watershed there are efforts for conservation. According to the NRCS (2007a) over 50,000 acres are enrolled in the Conservation Reserve Program. Another nearly 24,000 acres are in the Environmental Quality Incentives Program. Mower County is actively working to promote conservation in the watershed. They offer resources to help protect both the land and the water.

Figure 9. Landuse in the Winnebago River watershed

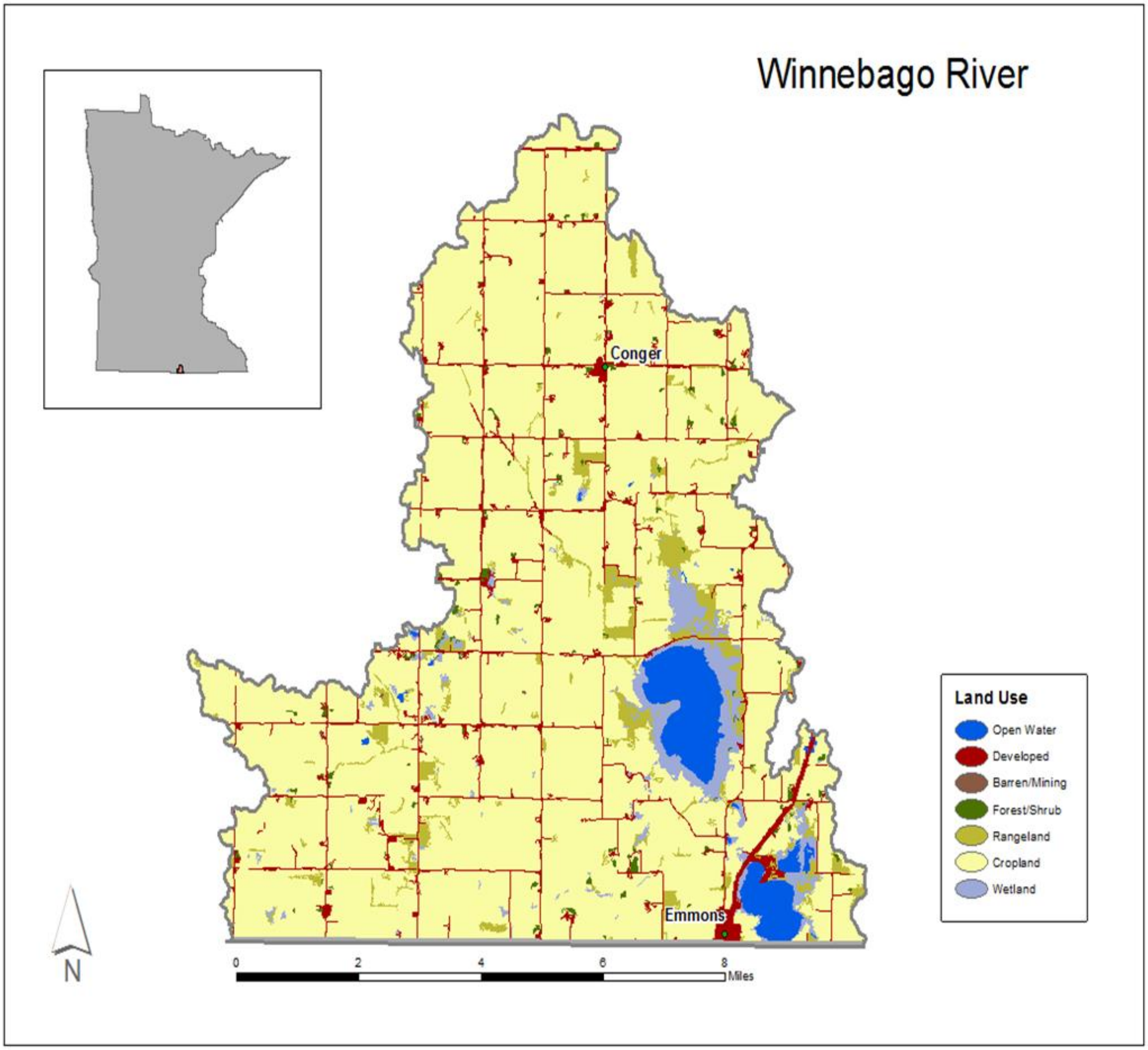
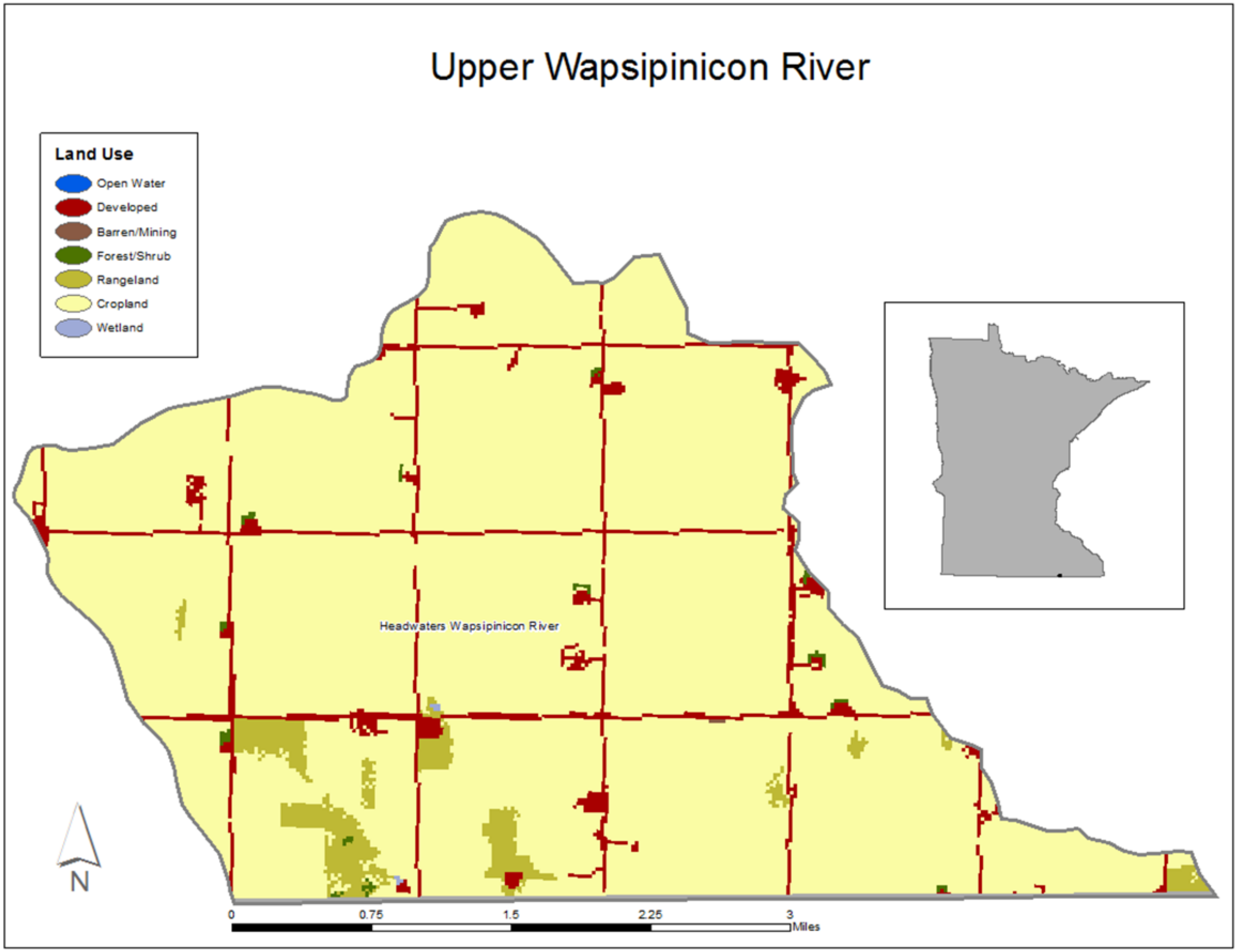


Figure 10. Landuse in the Upper Wapsipinicon River watershed.



Surface water hydrology

The Altered Water Course (AWC), completed by MPCA and MNGeo, maps out the channel condition of streams throughout the state. According to this project the Winnebago River has no natural channel left within the watershed. As seen in Figure 13 below, the impounded channels in the watershed indicate where the lakes are. A small percentage of the streams are classified as no definable channel, which means there had been a channel present but it no longer carries water on an annual basis. Finally nearly 90% of channels in the watershed are altered. All flowing water, not found in the lakes, is found in altered channels. This is likely a result of the large portion of the watershed involved in row crop agriculture. Altered streams often have degraded habitat and channel morphology. Over time streams can begin to re-meander, creating small bends, pools and even riffles. They also begin to establish a small flood plain in the ditch bottom. This is similar to what is referred to as a "two-stage" ditch, a ditch improvement method. Allowing ditched to reach this stage instead of cleaning them out can benefit water quality and even water storage in the ditch.

Also altering hydrology is tiling. The tile lines allow a direct route for water to the streams instead of the water flowing across the land and into the soil. This is a common practice in agriculture areas. While the practice if often beneficial to farmers it can contribute to poor water quality. There are management practices that can be used to clean up tile water before it enters streams. This usually includes removing nutrients and sediment from the water.

The DNR conducted a culvert inventory in the Winnebago River watershed. They found 119 locations where there is a bridge or culvert along the stream, these are called "crossings." (DNR, 2018b). They found at least four perched culverts. Perched culverts can limit fish passage, since the fish cannot pass these culverts until the water level is high enough that the culvert isn't perched, usually during a high water event. Culverts and bridges can be a knick point when flood events happen. Ditches are efficient at removing water from the land, they push a larger than normal volume in a faster period of time into streams. The crossing might not have enough capacity to handle the water suddenly entering the stream and the water backs up behind the structure, often causing erosion. Downstream the water is moving with higher velocity and can scour the banks and increasing sediment load in the water.

Like the Winnebago, the Upper Wapsipinicon River watershed has a high percentage of altered streams at 90%. The watershed does have on small section on natural channel left where the stream flows across the border into Iowa. It was in this small section where the sample location was located. Also like the Winnebago River watershed, this watershed is dominated by row crop agriculture, which is likely why there is a high percentage of altered streams. It is likely a large percentage of the watershed is tiled, resulting in the same problems discussed above.

Figure 11. Map of percent modified streams by major watershed (8-HUC).

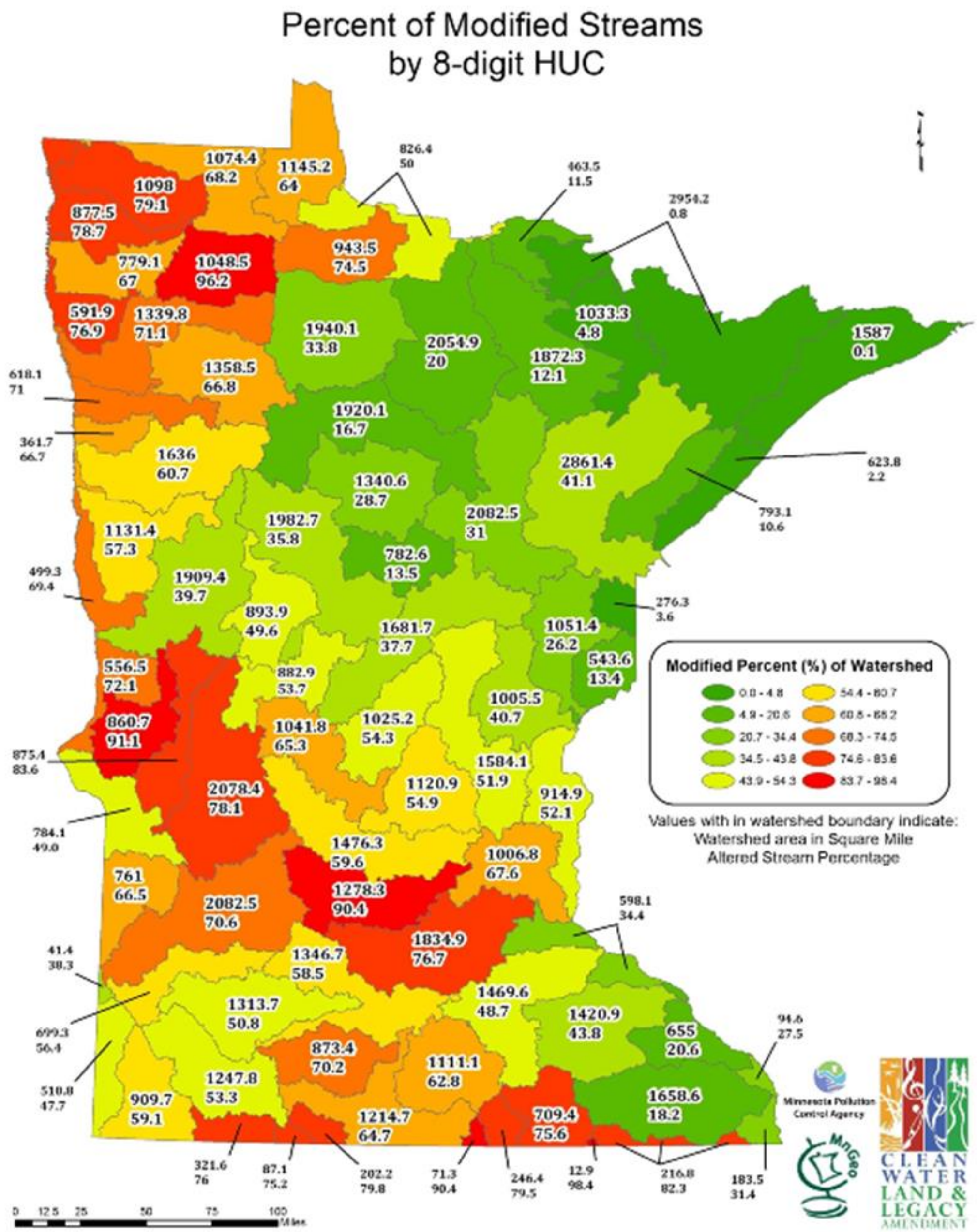


Figure 12. Comparison of natural to altered streams in the Upper Wapsipinicon River watershed (percentages derived from the statewide Altered Water Course project).

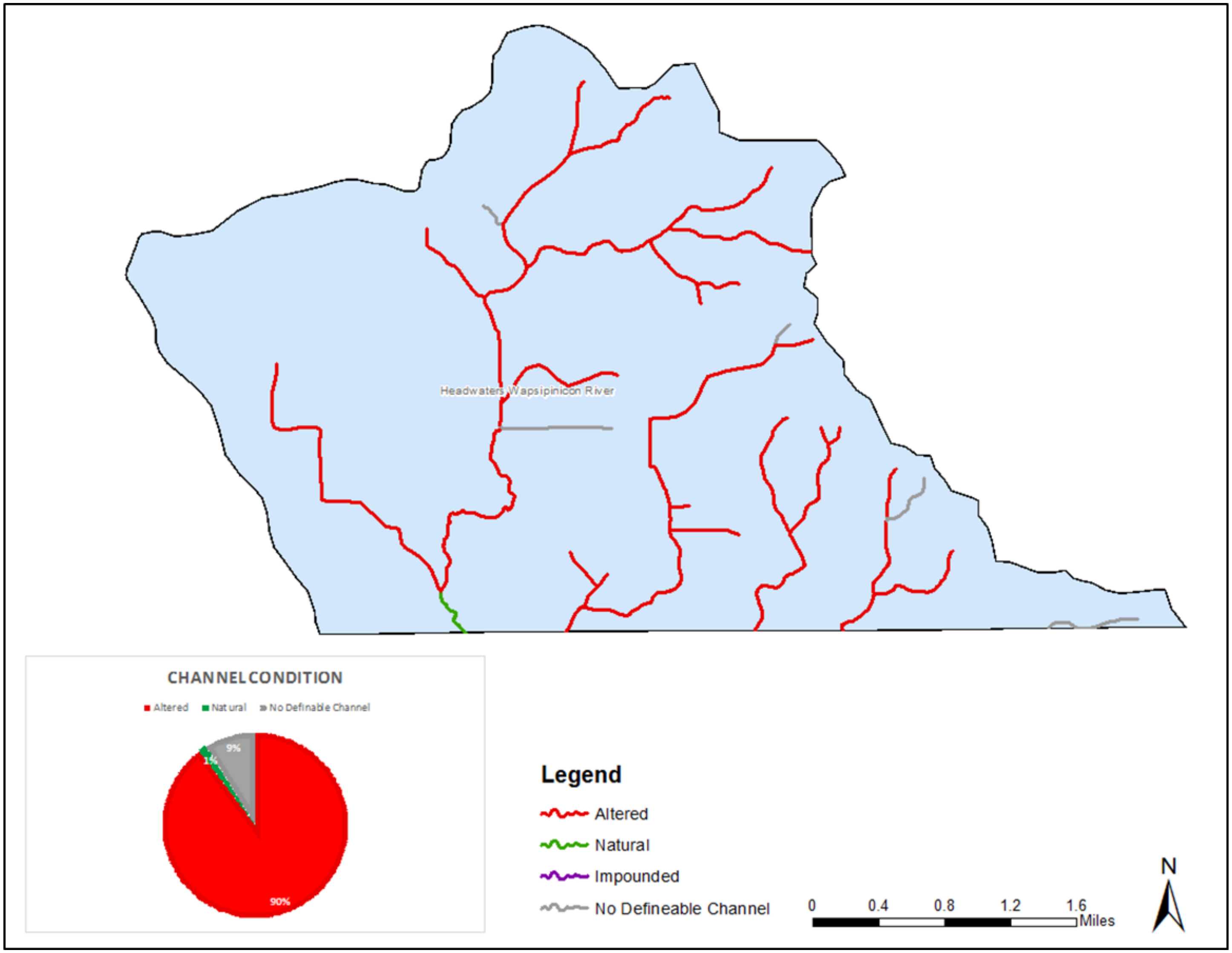
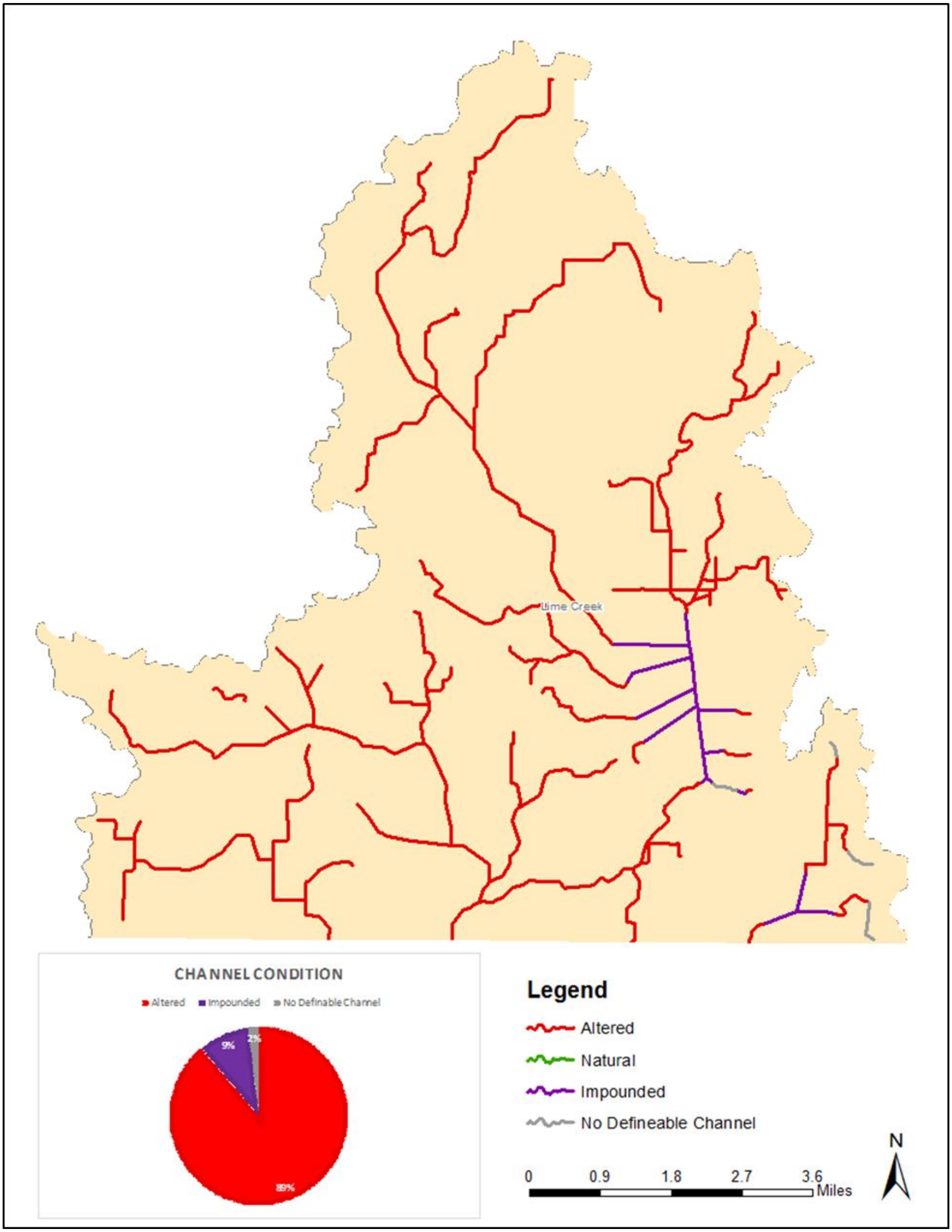


Figure 13. Comparison of natural to altered streams in the Winnebago River watershed (percentages derived from the statewide Altered Water Course project).

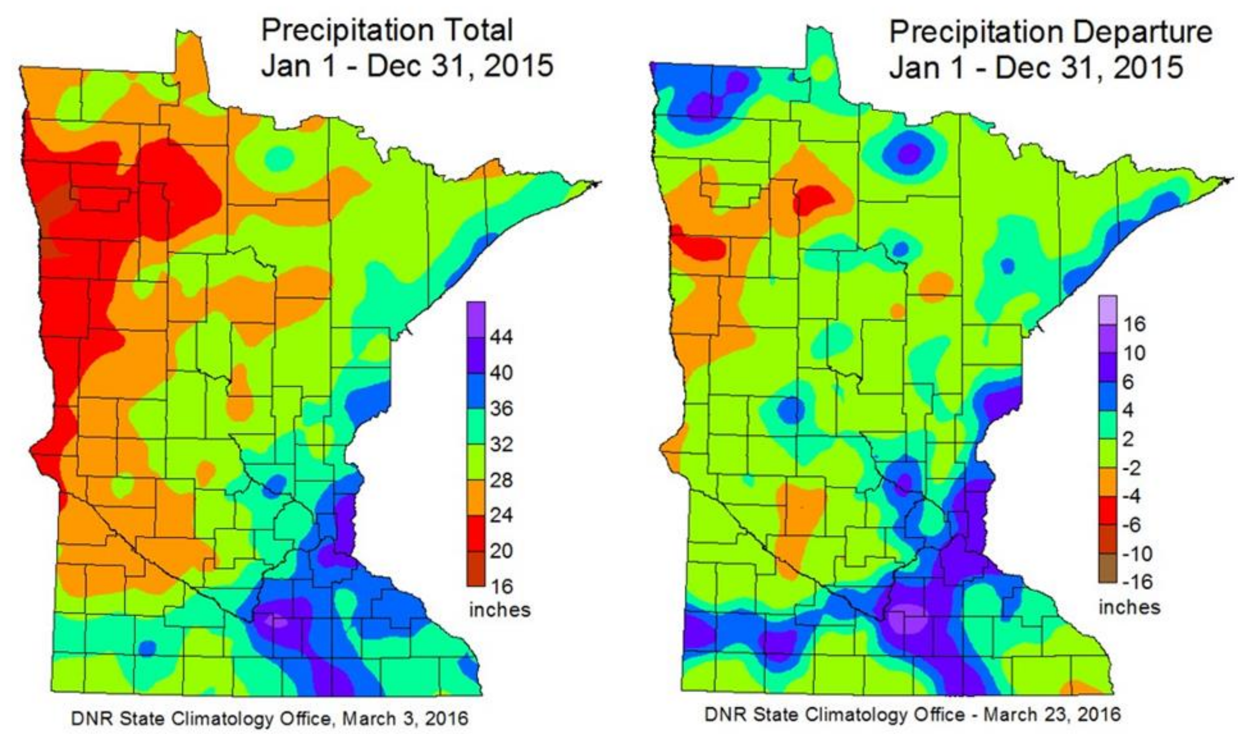


Climate and precipitation

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 (1981-2010) summer (June-August) temperature for Southeast Minnesota around the Upper Wapsipinicon and Winnebago watersheds is 20.55˚C and the mean winter (December-February) temperature is -7.2˚ C (DNR State Climatology Office, 2017b).

Precipitation is an important source of water input to a watershed. Figure 14 displays two representations of precipitation for calendar year 2015. On the left is total precipitation, showing the typical pattern of increasing precipitation toward the eastern portion of the state. According to this figure, these watersheds received anywhere from 32-40 inches of precipitation in 2015. The display on the right shows the amount that precipitation levels departed from normal. Precipitation in these watersheds ranged widely from four inches below normal to four inches above normal in 2015.

Figure 14. Statewide precipitation total (*left*) and precipitation departure (*right*) during 2015 (DNR State Climatology Office, 2017a).



The Upper Wapsipinicon and Winnebago watersheds are located within the Southeast precipitation region. Figure 15 and Figure 16 display the areal average representation of precipitation in Northeast Minnesota for 20 and 100 years, respectively. An aerial 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 Southeast region display no significant trend over the last 20 years. However, precipitation in Southeast 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 15. Precipitation trends in Southeast Minnesota (1996-2015) with five-year running average (WRCC, 2017)

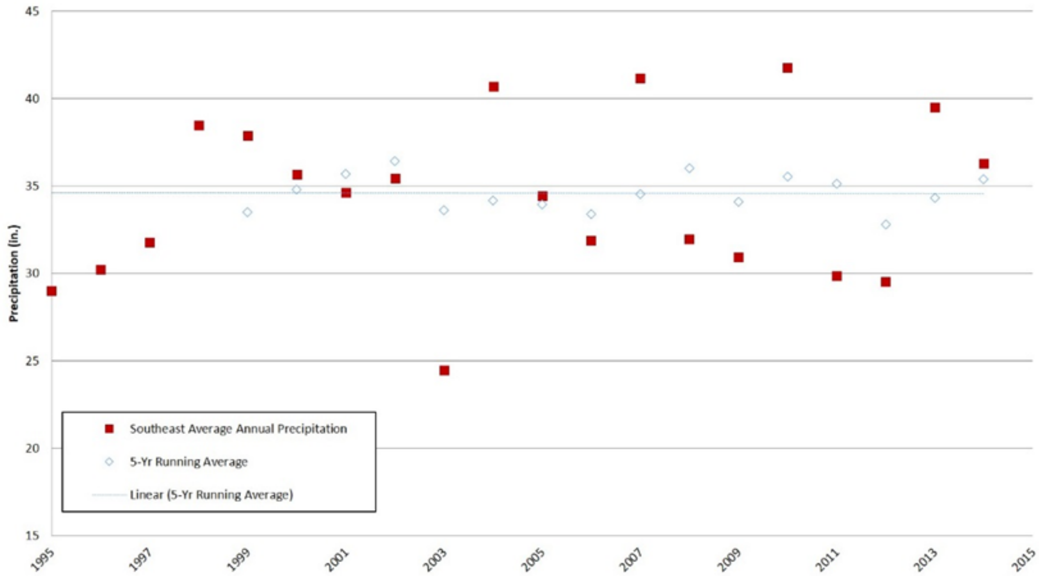
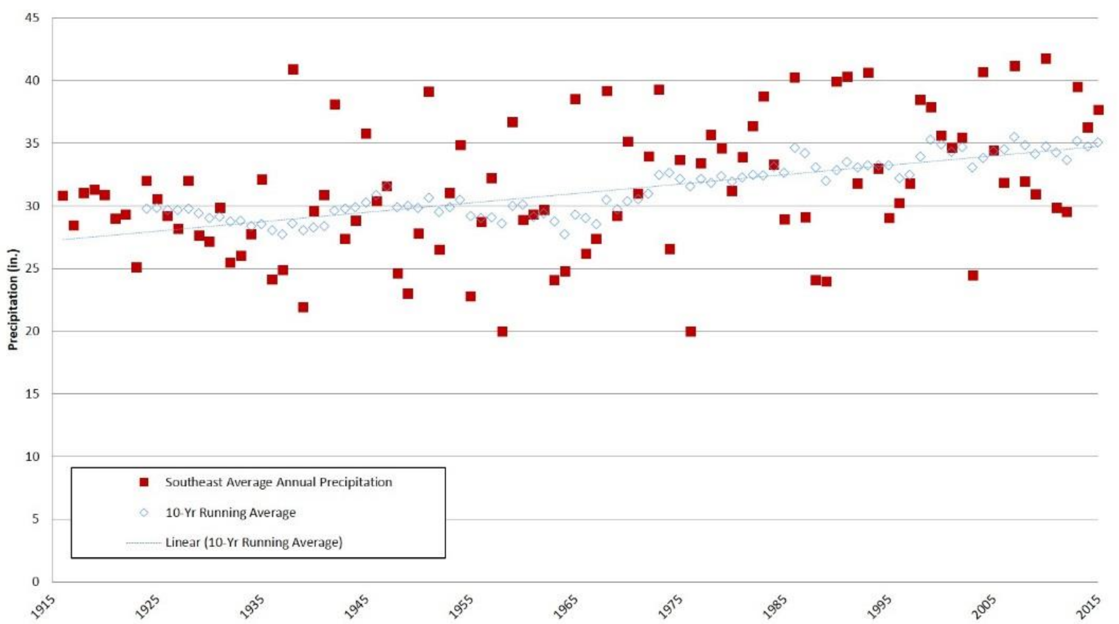


Figure 16 Precipitation trends in Southeast Minnesota (1916-2015) with ten-year running average (WRCC, 2017)



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.

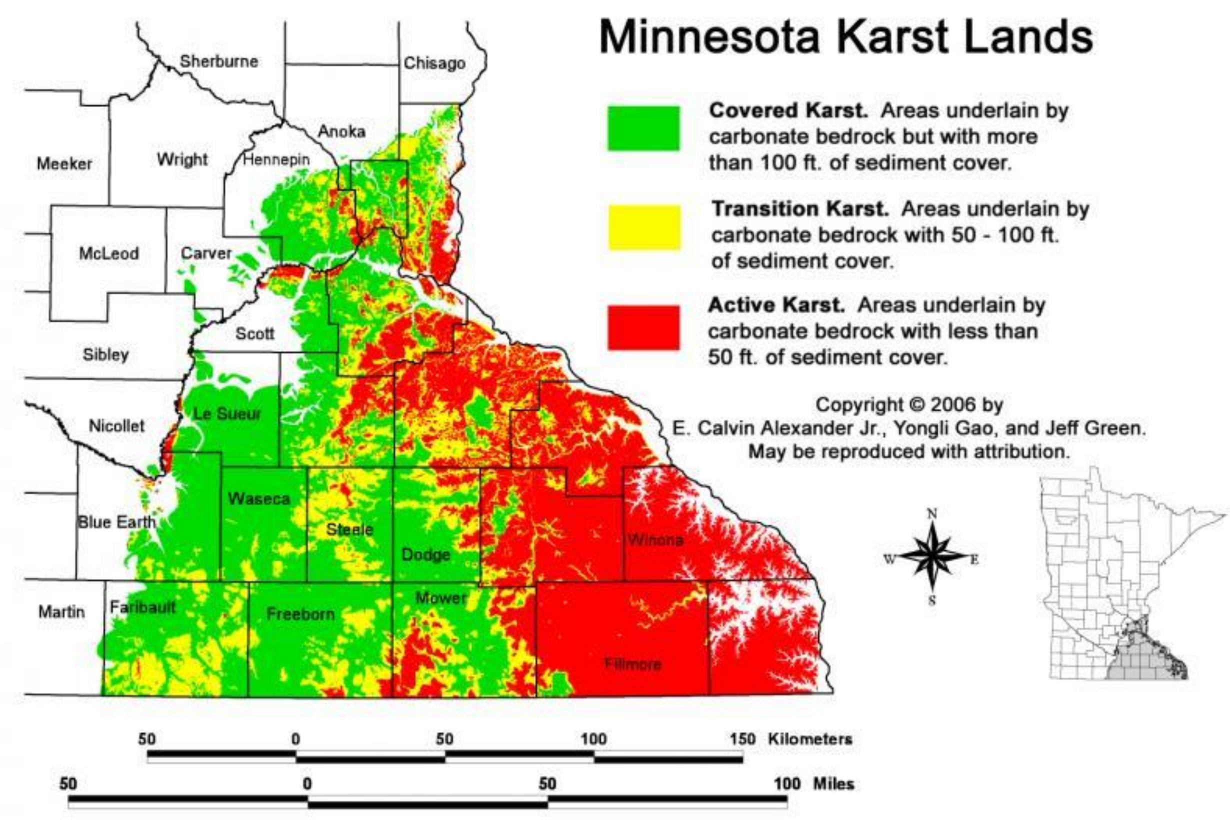
The Upper Wapsipinicon and Winnebago watersheds are located in southeast Minnesota within the Lower Mississippi River Basin. The watershed is found in the eastern area of the Southeast hydrogeologic region (Region 5) and is dominated by glacial landforms and till. Due to the Paleozoic bedrock geology of the area, it is primarily limestone, dolomite and sandstone. The main aquifers include the Upper Carbonate Group (Galena and Cedar Valley carbonate aquifers), St. Peter sandstone, Prairie du Chien Group, Jordan sandstone, and Franconia-Ironton-Galesville aquifers, and the Mt. Simon aquifer (MPCA, 1999).

The Wapsipinicon and Winnebago watersheds fall within Minnesota's South-Central Ground Water Province. The South-Central Province, is characterized by "thick clayey glacial drift overlying Paleozoic sandstone, limestone, and dolostone aquifers." (DNR, 2017c).

Geology in Southeast Minnesota and the Upper Wapsipinicon and Winnebago watersheds is characterized by covered karst features. These geologic features occur where limestone is slowly dissolved by infiltrating rainwater, sometimes forming hidden, rapid pathways from pollution release points to drinking water wells or surface water. Surface water and groundwater are so closely connected in karst areas that the distinction between the two is difficult to determine. Groundwater may emerge as a spring, flow a short distance above ground, only to vanish in a disappearing stream, returning to groundwater conduits and perhaps re-emerge farther downstream again as surface water.

Karst aquifers are very difficult to protect from activities at the ground surface because pollutants can be quickly transported to drinking water wells or surface water. Because of this, the best strategy to protect groundwater in this watershed is pollution prevention from common sources like row-crop agriculture, septic systems, abandoned wells, and animal feedlot operations.

Figure 17. Locations of karst features in southeast Minnesota (Alexander, Yao & Green, 2006)



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 Wapsipinicon and Winnebago Watersheds, the recharge rate to surficial materials ranges from about four to eight inches per year with an average of about 5.5 inches per year. (USGS, 2015)

High capacity withdrawals

The DNR permits all high capacity water withdrawals where the pumped volume exceeds 10,000 gallons/day or one million gallons/year (See Figure 18 for locations of permitted groundwater and surface water withdrawals). Permit holders are required to track water use and report back to the DNR yearly. Information on the program and the program database are found at: http://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/wateruse.html.

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 no MPCA Ambient Groundwater Monitoring wells within the watersheds. However, from 1992 to 1996, the Minnesota Pollution Control Agency conducted baseline water quality sampling and analysis of Minnesota's principal aquifers. The Upper Wapsipinicon and Winnebago watersheds lay entirely within the Southeast Region, where groundwater quality is considered good when compared to other areas with similar aquifers, but with, due to the geology, some high concentrations of trace elements like cadmium, lead and arsenic (MPCA, 1999). Concentrations of chemicals within the Precambrian aquifers were comparable to similar aquifers throughout the state and concentrations of major cations and anions were lower in the surficial and buried drift aquifers when compared to similar aquifers statewide (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 2016 have arsenic levels above the maximum contaminant level (MCL) for drinking water of 10 micrograms per liter. The Winnebago watershed in Minnesota is located nearly completely within Freeborn County where 13.3% of new wells were identified with concentrations exceeding the MCL. The Upper Wapsipinicon watershed in Minnesota is located in southern Mower County where 3.4% of new wells had concentrations exceeding the MCL (MDH, 2018a).

Groundwater Quantity

The Department of Natural Resources 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 DNR 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 2015 are (in order) power generation, public water supply (municipals), and irrigation (DNR, 2017d). According to the most recent DNR Permitting and Reporting System (MPARS), in 2015 the 21 permitted withdrawals within the Upper

Wapsipinicon and Winnebago watersheds are primarily utilized for agricultural and non-crop irrigation (13 of 21). The remaining withdrawals are for livestock watering and public water supplies.

Figure 18 displays total high capacity withdrawal locations within the watershed with active permit status in 2015. Permitted groundwater withdrawals are displayed below as blue triangles and surface water withdrawals as red squares. During 1996 to 2015, groundwater withdrawals within the Upper Wapsipinicon and Winnebago watersheds exhibit a significant increasing withdrawal trend ($p<0.01$) (Figure 19) while surface water withdrawals exhibit no trend (Figure 19).

Figure 18. Locations of active status permitted high capacity withdrawals in the Upper Wapsipinicon and Winnebago watersheds (2015)

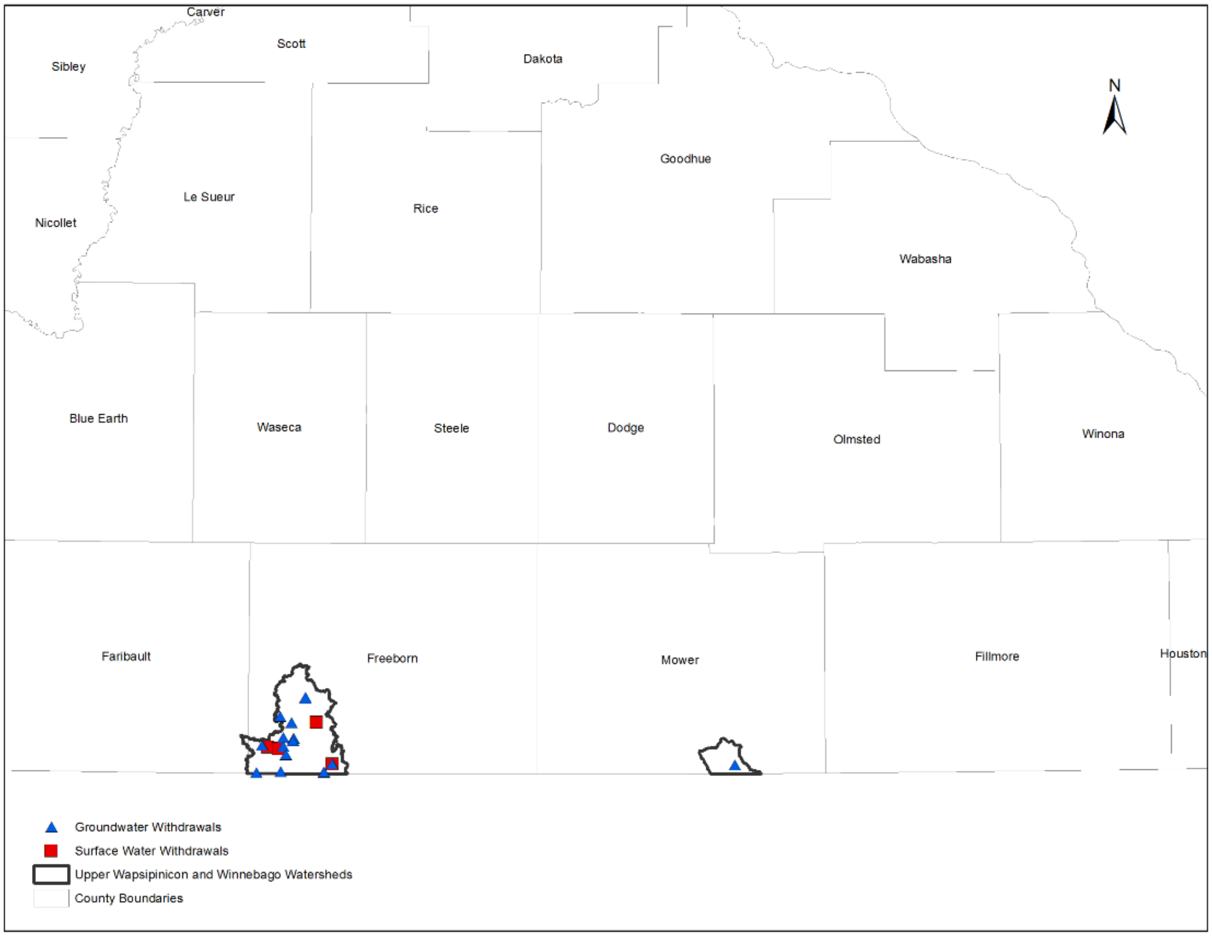
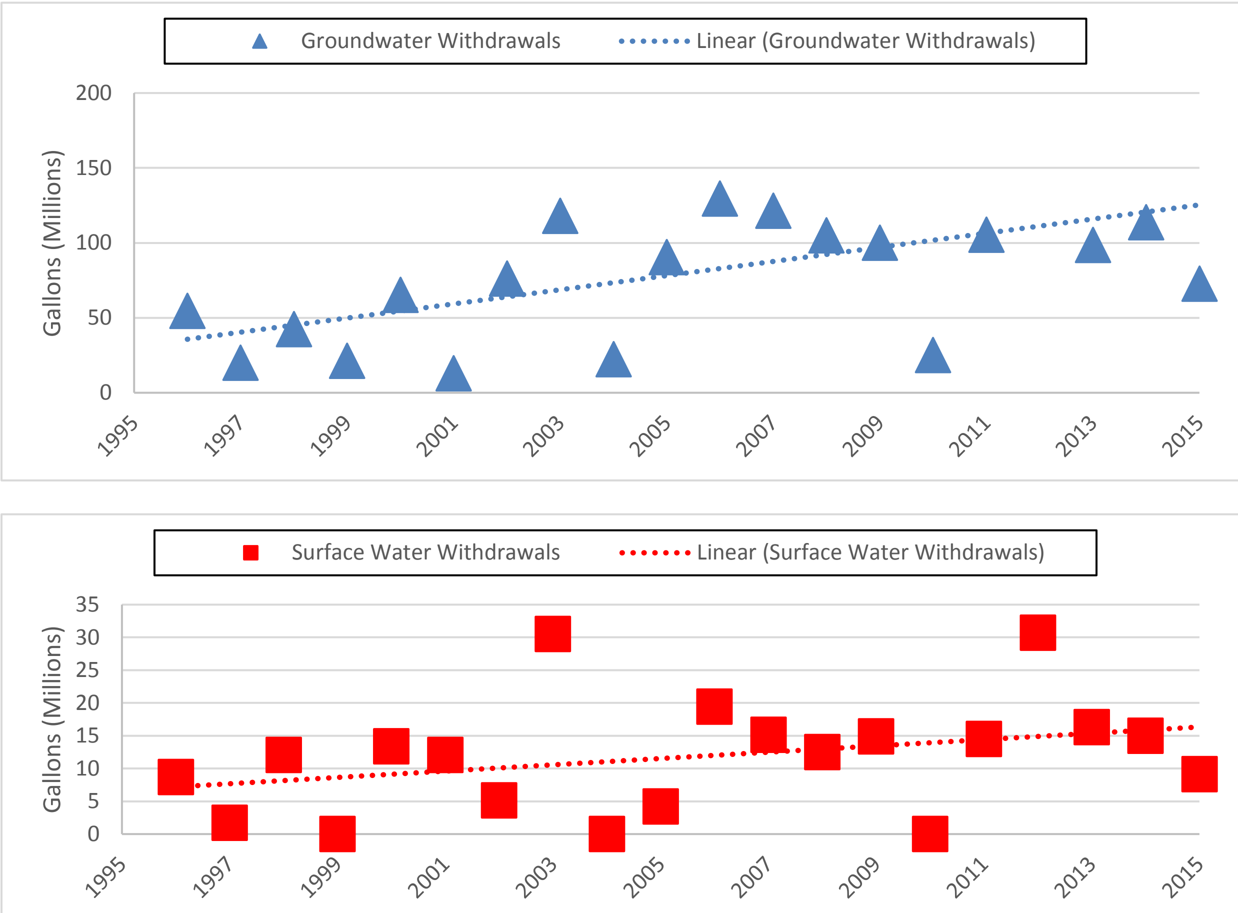


Figure 19. Total annual groundwater (above) and surface water (below) withdrawals in the Wapsipinicon and Winnebago watersheds (1996-2015)



Stream Flow

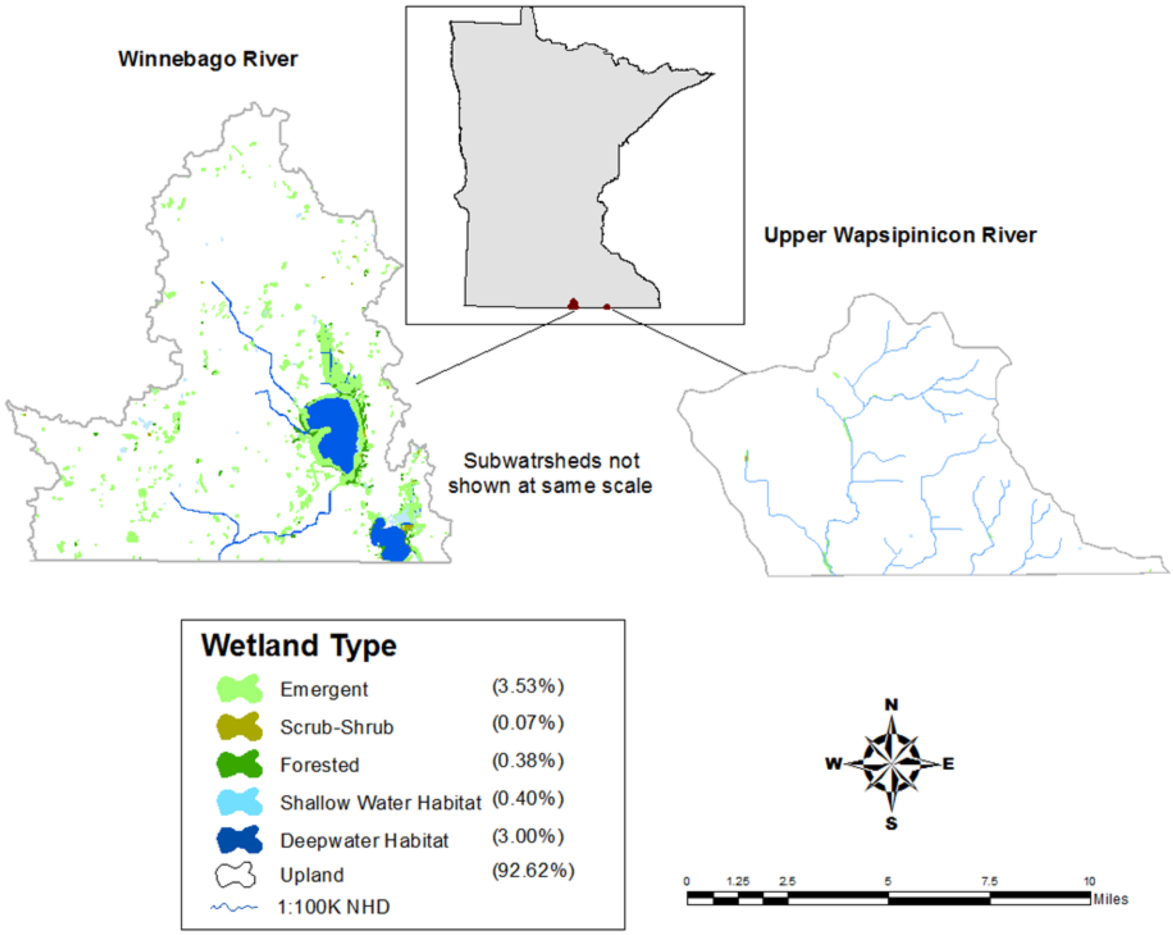
There are no DNR or USGS gages monitoring continuous flow in the Minnesota portions of the Upper Wapsipinicon or Winnebago watersheds.

Wetlands

Wetland Background

Together, the Winnebago River and Upper Wapsipinicon River watersheds support an estimated 2,362 acres of wetland, or 4.4% of these 2 watersheds. This estimate does not include open water portions of lakes, and rivers collectively classed as Deep Water Habitats, which comprise 1,616 acres or 3% of the 2 watersheds combined (Figure 20). Wetlands with herbaceous emergent vegetation comprise over four times the area (3.5%) compared to the other three wetland classes (0.85%) combined. Wetlands in the Winnebago River watershed are somewhat more common in the southeastern region associated with Bear Lake and the State Line Lake complex. In the Upper Wapsipinicon River watershed, the relatively few wetlands are almost exclusively associated with the stream network. These estimates are based on imagery from spring 2011 with wetland mapping published as part of the updated Southern Minnesota phase of the state NWI update that was released in 2015.

Figure 20 Distribution of wetlands according to the Minnesota updated National Wetland Inventory within the Winnebago and Upper Wapsipinicon watersheds.



The Winnebago River watershed surficial geology is dominated by relatively flat moraine complexes especially stagnation and ground moraines originating from the most recent glaciation. The central portion of the Winnebago watershed is outwash influenced moraine. These glacial features in rolling to flat topography were somewhat conductive to formation of wetland. Surface geology of the Upper Wapsipinicon River watershed is classed as undifferentiated grey drift. The drainage network and topography strongly influenced development of wetland features in areas with undifferentiated drift.

Soils data was used to estimate historical wetland extent prior to European settlement, after settlement humans undertook significant actions to drain and convert wetlands. Analysis of Natural Resources Conservation Service digital soil survey (SSURGO) soil map units with drainage classes of either Poorly Drained or Very Poorly Drained suggest approximately 28,700 acres of wetland or 54.9% of the Winnebago watershed and 44.3% of the Upper Wapsipinicon watershed, or a collective percentage of 53.3% occurred prior to European settlement.

Many land use changes have occurred in these watersheds since European settlement. These changes have resulted in conversion of significant percentages of the original wetland resource. Comparing the estimated historic wetland area to current wetland extent finds that wetland conversion in the Winnebago River watershed has resulted in 90.65% of the original wetlands converted to non-wetland. In the Upper Wapsipinicon watershed 99.43% of the wetlands historically present are now non-wetland.

Wetland Hydrogeomorphic Classification

Not all wetlands provide the same functions, e.g. human benefits or services. Position in the watershed and hydrologic connectivity between the wetland and the associated stream network is a major determinant for many individual wetland functions. Plant community types, water source, duration, frequency and magnitude of inundation or saturation and soil properties are also significant determinants of wetland function. Hydrogeomorphic (HGM) classification of wetlands characterizes the hydrologic regime and expected primary water flow paths of individual wetlands (Tiner, 2011). HGM is a hierarchical classification approach based on physical attributes including landscape (River, Stream; Lake and Inland [terrene]; major landform (Fringe, Island, Basin, Floodplain, Flat, Slope, Pond, Lake); water flow path (bi-directional, throughflow, outflow, inflow, isolated, paludified -- organic material deposition as in peatlands) and waterbody type. Several dozen possible combinations occur when the landscape, major landform, and water flow path descriptors were combined hierarchically. Twenty-one unique HGM descriptor combinations ("classes") occurred in analysis of the combined Winnebago and Upper Wapsipinicon watershed. Nine of these 21 unique classes, each made up less than 2% of the total wetland area and were interpreted to be of minimal importance, and are not included in Table 2. The remaining twelve HGM classes each comprising at least 2% of the combined wetland area are presented in Table 2. These predominant wetland HGM classes demonstrate a variety of flow-paths, including flow through, bi-directional, outflow, and isolated. It is likely that in this relatively flat landscape a large portion of the wetlands historically would have exhibited isolated hydrology enabling long retention times prior to discharging to the drainage network. Results in Table 2 illustrate that the remaining wetlands are strongly associated with the river and stream drainage network, and likely shorter retention times during high and moderate flow periods. As a result wetlands in the Winnebago River and Wapsipinicon River watersheds have reduced assimilative and storage capacities. Once saturated they can be expected to freely discharge flow and pollutants downstream.

Table 2. Predominant (> 2.0%) summed area simplified Hydrogeomorphic (HGM) wetland functional classes present in the Winnebago River and Upper Wapsipinicon River watersheds along with percent of the total watershed area (2,364 acres) and the number of polygons of each respective HGM class and the types of simplified plant communities present in each respective HGM class.

HGM Class Code	Wetland HGM landform description	Simplified Wetland Plant Community Classes Present	% of Total Wetland Area	Number of Wetland Polygons	HGM Class Area (ac)
LEBABI	Shallow lake fringing depressional "basin" wetland with bi-directional "ebb and flow"	Shallow Marsh and Hardwood Swamp	15.38	14	363.66
LEFLBI	Shallow lake fringing wetlands in level landscape "flats" with bi-directional "ebb and flow" hydrology	Seasonally Flooded Basin, Hardwood Swamp and Scrub Shrub	7.11	41	168.15
LELKOU	water flowing out via a stream or ditch and no descernable inflows	Shallow Open Water	2.91	1	68.89
LELKTH	Shallow lake, open water community with inlet and outlet "flow through" hydrology	Shallow Open Water	0.59	7	13.98
LRFPTH	River floodplain wetlands with "flow through" hydrology	Seasonally Flooded Basin, Hardwood Swamp, Scrub Shrub and Shallow Marsh	16.22	38	383.51
LSFLTH	Wetlands adjacent "fringing" to streams with inflow and outflow "through flow" hydrology	Hardwood Swamp and Seasonally Flooded Basin	3.14	12	74.2
TEBAOU	Inland wetland basins surrounded by upland with outflow hydrology	Hardwood Swamp, Shallow Marsh and Scrub Shrub	7.16	61	169.33
TEFLIS	Inland wetlands in level landscapes "flats" surrounded by upland "isolated" hydrology	Seasonally Flooded Basin and Hardwood Swamp	2.34	27	55.24
TEFLOU	Inland wetlands in level landscapes "flats" with outflow hydrology	Seasonally Flooded Basin, Hardwood Swamp and Scrub	36.35	372	856.49
TEPDOU	Inland open water basins "ponds" with outflow hydrology	Shallow Open Water, Deep Marsh,	4.28	54	101.07
TESLOU	Inland wetlands situated on slopes with outflow hydrology	Wet Meadow, Hardwood Swamp, and Scrub Shrub	2	45	47.31

Watershed-wide data collection methodology

Lake water sampling

MPCA sampled State Line and Bear Lakes in 2015 and 2016 to complete aquatic recreation use assessments. There are currently no volunteers enrolled in the MPCA's CLMP that are conducting lake monitoring within the watersheds. Sampling methods are similar among monitoring groups and are described in the document entitled "*MPCA Standard Operating Procedure for Lake Water Quality*" found at http://www.pca.state.mn.us/publications/wq-s1-16.pdf. The lake recreation use assessment requires eight observations/samples within a 10-year period (June to September) for phosphorus, chlorophyll-a and Secchi depth. Chloride, sulfate, and nitrates are sampled at a subset of waters that have been identified as being impacted by chloride inputs, are designated wild rice waters, or have a designated drinking water use.

Stream water sampling

Two water chemistry stations were sampled from May thru September in 2015, and again June thru August of 2016, 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 in Figure 2 and Figure 3. (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).

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

Stream biological sampling

The biological monitoring component of the intensive watershed monitoring in the Upper Wapsipinicon River watershed and the Winnebago River watershed was completed during the summers of 2015 and 2016. A total of nine sites were newly established across the watersheds and sampled. These sites were located near the outlets of most minor HUC-14 watersheds. No existing biological monitoring stations within the watershed were revisited. While data from the last 10 years can contribute to the watershed assessments, the data utilized for the 2017 assessment was collected in 2015 and 2016. One WID was sampled for biology in the Upper Wapsipinicon River watershed and six in the Winnebago River watershed. Waterbody assessments to determine aquatic life use support were conducted for one WID in the Upper Wapsipinicon River watershed and four WIDs in the Winnebago River watershed. 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 coldwater 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

Minnesota Department of Natural Resource (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 near the HUC8 pour point, as part of the Intensive Watershed Monitoring. All fish collected by the MPCA are analyzed for mercury and the two largest individual fish of each species are analyzed for polychlorinated biphenyls (PCBs).

Captured fish were wrapped in aluminum foil and frozen until they were thawed, scaled (or skinned), filleted, and ground to a homogenized tissue sample. Homogenized fillets were placed in 60 mL glass jars with Teflon™ lids and frozen until thawed for lab analysis. The Minnesota Department of Agriculture Laboratory analyzed the samples for mercury and PCBs. If fish were tested for 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. 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 90^{th} percentile) exceed 0.2 mg/kg of mercury. At least five fish samples of the same species are required to make this assessment and only the last 10 years of data are used for the assessment. MPCA's Impaired Waters List includes waterways that were assessed as impaired prior to 2006 as well as more recent impairments.

Pollutant load monitoring

Intensive water quality sampling occurs at all WPLMN sites. Thirty-five samples per year are allocated for basin and major watershed sites and 25 samples per season (ice out through October 31) for subwatershed sites. Because concentrations typically rise with streamflow for many of the monitored pollutants, and because of the added influence elevated flows have on pollutant load estimates, sampling frequency is greatest during periods of moderate to high flow. All major snowmelt and rainfall events are sampled. Low flow periods are also sampled although sampling frequency is reduced as pollutant concentrations are generally more stable when compared to periods of elevated flow.

Water sample results and daily average flow data are coupled in the $FLUX_{32}$ pollutant load model to estimate the transport (load) of nutrients and other water quality constituents past a sampling station over a given period of time. Loads and flow weighted mean concentrations (FWMCs) are calculated for total suspended solids (TSS), total phosphorus (TP), dissolved orthophosphate (DOP), nitrate plus nitrite nitrogen (NO_3+NO_2-N), and total Kjeldahl nitrogen (TKN).

More information can be found at the WPLMN website.

Groundwater monitoring

Groundwater Quality

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

Groundwater Quantity

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

Groundwater/Surface Water Withdrawals

The Department of Natural Resources permits all high capacity water withdrawals where the pumped volume exceeds 10,000 gallons/day or 1 million gallons/year. Permit holders are required to track water use and report back to the DNR yearly. Information on the program and the program database are found at: http://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/wateruse.html

Stream Flow

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

Wetland monitoring

The MPCA is actively developing methods and building capacity to conduct wetland quality monitoring and assessment. Our primary approach is biological monitoring—where changes in biological communities may be indicating a response to human-caused impacts. The MPCA has developed IBIs to monitor the macroinvertebrate condition of depressional wetlands that have open water and the Floristic Quality Assessment (FQA) to assess vegetation condition in all of Minnesota's wetland types. For more information about the wetland monitoring (including technical background reports and sampling procedures) please visit the MPCA Wetland monitoring and assessment webpage.

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.

As few open water depressional wetlands exist in the watershed, the focus will be on vegetation quality results of all wetland types.

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 Winnebago River and Upper Wapsipinicon River. 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 2015 Assessment Cycle as well as any impairment listings from previous assessment cycles. Discussion of assessment results focuses primarily on the 2015 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 U.S. Environmental Protection Agency [EPA] reporting cycle); however, impairments from previous assessment cycles are also included and are distinguished from new impairments via cell shading (see footnote section of each table). These tables also denote the results of comparing each individual aquatic life and aquatic recreation indicator to their respective criteria (i.e., standards); determinations made during the desktop phase of the assessment process (see Figure 4). Assessment of aquatic life is derived from the analysis of biological (fish and invert IBIs), dissolved oxygen, total suspended solids, chloride, pH, total phosphorus, chlorophyll-a, biochemical oxygen demand and un-ionized ammonia (NH_3) data, while the assessment of aquatic recreation in streams is based solely on bacteria (Escherichia coli) data. Included in each table is the specific aquatic life use classification for each stream reach: coldwater 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.

Headwaters Wapsipinicon River Aggregated 12-HUC HUC 0708010202-01

The Headwaters Wapsipinicon River subwatershed is located entirely in Mower County on the Minnesota/Iowa border. The majority of the watershed is found in Iowa, with only 8.5mi2 in Minnesota. Over 90% of the landuse in the subwatershed is cropland. The Upper Wapsipinicon River is the main waterbody in the subwatershed with one small ditched tributary flowing in before the Wapsipinicon River crosses the border. All other tributaries in the subwatershed meet the Wapsipinicon River in Iowa. This subwatershed is the only Wapsipinicon River watershed in Minnesota, but is part of the greater Cedar River watershed.

Table 3. Aquatic life and recreation assessments on stream reaches: Headwaters Wapsipinicon River Aggregated 12-HUC.

				Aquatic life indicators:											
WID ***Reach name,*** *Reach description*	**Biological station ID**	**Reach length (miles)**	**Use class**	**Fish IBI**	**Invert IBI**	**Dissolved oxygen**	**TSS**	**Secchi Tube**	**Chloride**	**pH**	**Ammonia -NH_3**	**Pesticides**	**Eutrophication**	**Aquatic life**	**Aquatic rec. (Bacteria)**
07080102-503 **Judicial Ditch 6,** Headwaters to Wapsipinicon River	--	2.11	WWg	--	--	IF	--	--	--	IF	--	--	--	IF	--
07080102-506 **Wapsipinicon River,** Headwaters to -92.6732, 43.5073	--	2.40	WWg	--	--	IF	--	--	--	MTS	--	--	--	IF	--
07080102-507 **Wapsipinicon River,** -92.6732, 43.5073 to MN/IA border	15CD012	0.61	WWg	EXS	EXS	IF	IF	MTS	MTS	MTS	MTS	--	IF	IMP	IMP

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

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

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

Summary

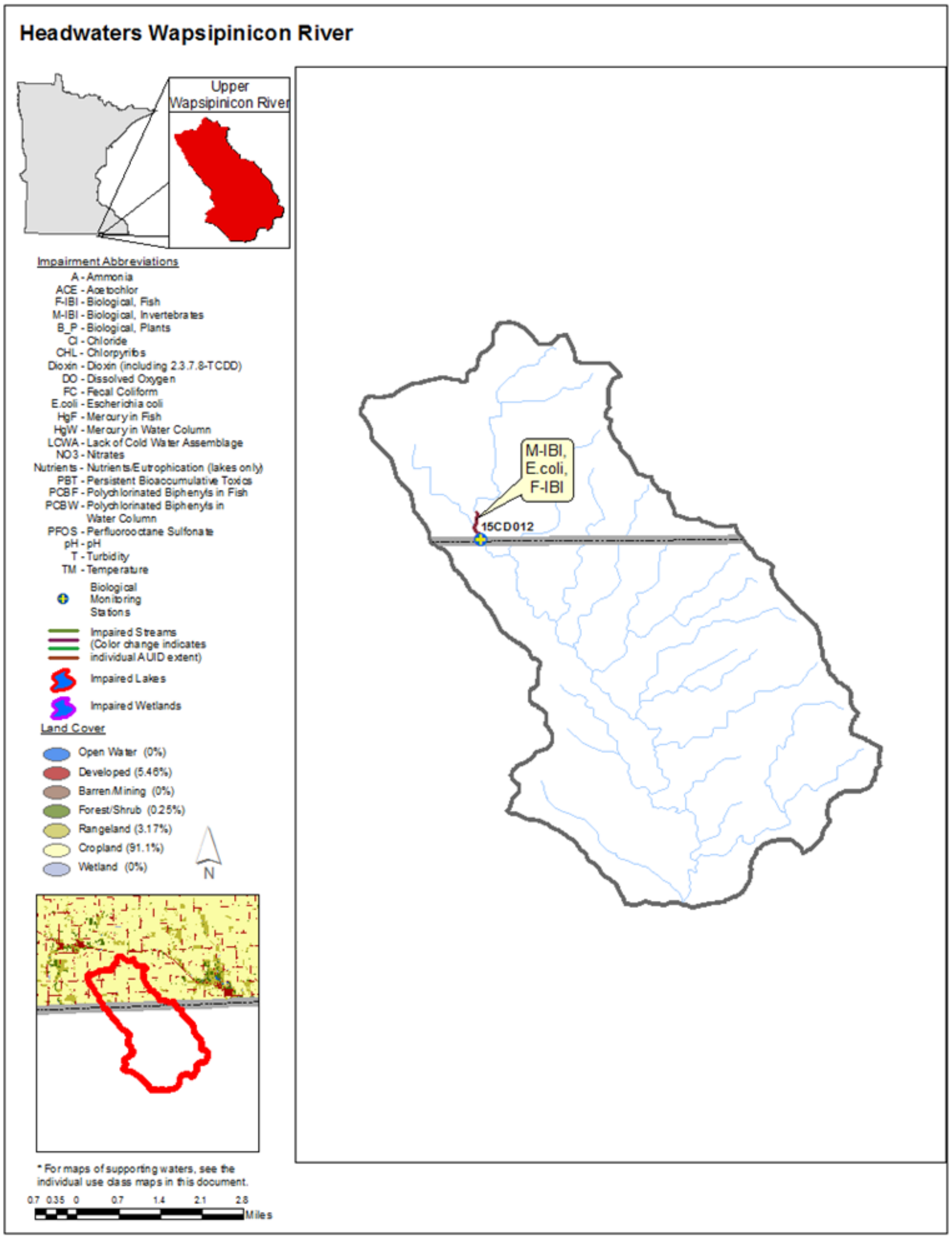
One biological station (15CD012) was sampled twice for fish, once in 2015 and once in 2016. The 2015 sample scored four points below the general use threshold, while the 2016 sample scored above the threshold and upper confidence interval. During the 2016 sample two adult rainbow trout were captured. These fish are a sensitive species and an anomaly in this part of the Wapsipinicon River. It is believed the fish moved upstream into Minnesota from Iowa, where they are stocked by Iowa DNR. Part of the Wapsipinicon River is coldwater in Iowa and stocked for several kinds of trout. Excluding the rainbow trout, the fish species samples from 2015 and 2016 were very similar. One additional darter species found in 2016, Iowa darter, is also sensitive. The addition of these two sensitive species likely resulted in the 14 point difference in IBI scores. However, rainbow trout are an anomaly in warm water streams and they probably moved back downstream as water temperatures rose through the summer. The most abundant fish from both samples were blacknose dace, creek chubs and white suckers, all tolerant species. This suggests the fish would likely have scored at or below the general use threshold in 2016 if the trout had not been found. An impairment for aquatic life use resulted from the fish assessment on the furthest downstream reach of the Upper Wapsipinicon River (07080102-507).

Similarly, station 15CD012 was sampled twice for macroinvertebrates, once in 2015 and 2016. The 2015 sample scored seven points below the GU threshold, within the confidence interval. The 2016 sample scored three points above the general use threshold, within the confidence interval. When the 2016 sample was collected, coarse substrate (gravel) was sampled, despite this site being a low gradient site in which coarse substrates were not sampled in 2015. The additional taxa associated with this habitat were likely responsible for the boost in the IBI score above the low gradient threshold. As this site is accurately considered low gradient due to habitat conditions present at both visits, this higher score was disregarded for the purpose of assessment, and the lower score from 2015 provided the guidance for assessment for this reach. Both samples had very high numbers of nitrogen tolerant taxa (above 90th percentile values for similar stream- southern, low gradient, forested streams), which corroborates the very high nitrogen values collected during fish sampling. Both visits were also dominated by macroinvertebrates tolerant of general stress. The low MIBI score from 2015, along with strong signals related to overall stress in the watershed, resulted in an aquatic life impairment based on macroinvertebrate assessment.

The final mile of the Wapsipinicon River in Minnesota had sufficient data for TSS, chloride, pH, and un-ionized ammonia; these parameters are meeting aquatic life standards. Though TSS dataset was light, Secchi tube data suggests sediment is not adversely affecting aquatic life. Dissolved oxygen concentrations met the standard in 2015; limited data was available for other years of sampling. Phosphorus data were limited, but the average was below the water quality standard indicating that eutrophication is not likely occurring on this reach. Bacteria data suggests this reach is impaired for aquatic recreation use. In the months of June, July, and August over the assessment period, bacteria levels were extremely elevated.

Judicial Ditch 6 and the headwaters reach of the Wapsipinicon River lack sufficient data to assess for aquatic life use.

Figure 21. Currently listed impaired waters by parameter and land use characteristics in the Headwaters Wapsipinicon River Aggregated 12-HUC.



Lime Creek Aggregated 12-HUC HUC 0708020301-04

Lime Creek subwatershed is the headwaters to the Winnebago River. This is the only subwatershed in Minnesota. Steward Creek begins in the far northern region of the subwatershed and flows south into Bear Lake. The lake is the headwaters to the Winnebago River. From Bear Lake the river flows south and into Iowa. Several small, ditched tributaries flow into the lakes and the Winnebago River. State Line Lake, located in the southeast corner of the watershed just east of Emmons, is the only other lake in the subwatershed. Conger is the only other town in the Lime Creek subwatershed and is located in the northern region.

Table 4. Aquatic life and recreation assessments on stream reaches: Lime Creek Aggregated 12-HUC.

WID ***Reach name,*** *Reach description*	Biological Station ID	Reach length (miles)	Use class*	Aquatic life indicators: Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Pesticides	Eutrophication	Aquatic life	Aquatic rec. (Bacteria)
07080203-501 **Lime Creek,** Bear Lake to MN/IA border	15CD001 15CD002	4.42	WWm	EXS	EXS	EXS	IF	IF	MTS	MTS	MTS	--	EXS	IMP	IMP
07080203-503 **Unnamed creek,** MN/IA border to Lime Creek	--	1.16	LRVW	--	--	MTS	--	--	--	MTS	IF	--	--	--	IF
07080203-504 **Steward Creek (County Ditch 23),** Headwaters to Bear Lake	15CD003 15CD009	10.42	WWm	MTS	EXS	EXS	IF	IF	MTS	MTS	MTS	--	MTS	IMP	IF
07080203-505 **County Ditch 48,** Headwaters to Steward Creek (CD 23)	--	4.79	LRVW	--	--	MTS	--	--	--	MTS	IF	--	--	--	IF
07080203-506 **Unnamed creek,** Headwaters to Bear Lake	--	5.21	WWg	--	--	IF	--	IF	--	MTS	--	--	--	IF	--

07080203-507 **Unnamed creek,** Unnamed creek to Bear Lake	--	0.93	WWg	--	--	IF	--	IF	--	IF	--	--	--	IF	--
07080203-508 **Unnamed creek,** State Line Lake to MN/IA border	--	0.31	WWg	--	--	IF	--	IF	--	IF	--	--	--	IF	--
07080203-509 **Unnamed creek,** JD 26 to MN/IA border	15CD004	0.70	WWm	MTS	MTS	EXS	IF	IF	IF	MTS	IF	--	IF	IMP	--
07080203-510 **Unnamed creek,** Headwaters to Unnamed creek	--	2.76	WWg	--	--	IF	IF	IF	--	IF	--	--	IF	IF	--
07080203-512 **Judicial Ditch 26,** Unnamed ditch to Unnamed ditch	--	2.19	WWg	--	--	IF	--	IF	--	IF	--	--	--	IF	--
07080203-514 **Judicial Ditch 25,** Unnamed ditch to Unnamed ditch	--	1.51	WWg	--	--	IF	IF	IF	IF	MTS	IF	--	IF	IF	--
07080203-515 **Judicial Ditch 25,** Unnamed ditch to unnamed creek	15CD005	2.15	WWm	EXS	MTS	IF	IF	IF	IF	IF	IF	--	IF	IMP	--

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information
Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)
Key for Cell Shading: = existing impairment, listed prior to 2016 reporting cycle; = new impairment; = full support of designated use; = insufficient information.
Abbreviations for Use Class: **WWg** = warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = limited resource value water
*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 5. Lake water aquatic recreation assessments Lime Creek 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		
Bear	24-0028-00	1504	4	Shallow Lake	WCBP	NT	**NA**	**MTS**	--	**EXS**	**EXS**	**EXS**	**IF**	**NS**
State Line	24-0030-00	470	5	Shallow Lake	WCBP	NT	**NA**	**MTS**	--	**EXS**	**EXS**	**EXS**	**IF**	**NS**

Abbreviations for Ecoregion: **DA** = Driftless Area, **NCHF** = North Central Hardwood Forest, **NGP** = Northern Glaciated Plains, **NLF** = Northern Lakes and Forests, **NMW** = Northern Minnesota Wetlands, **RRV** = Red River Valley, **WCBP** = Western Corn Belt Plains
Abbreviations for Secchi Trend: **D** = decreasing/declining trend, **I** = increasing/improving trend, **NT** = no detectable trend, **--** = not enough data
Abbreviations for Indicator Evaluations: **--** = No Data, **MTS** = Meets Standard; **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 2016 reporting cycle; ☐ = new impairment; ☐ = full support of designated use; ☐= insufficient information.

Summary

There are four stream reaches with assessable biological data. The reach on Winnebago River (07080203-501), at the state boarder, has two biological stations (15CD001, 15CD002) that were sampled for fish once in 2015 and once in 2016. Habitat is limited and the reach is being suggested for modified use. Three of the four fish samples scored below the modified use threshold. No sensitive fish species were collected during any samples. The one score that was above the modified use threshold was dominated by black bullhead, with 285 collected. Three invertebrate samples were collected in this reach; 15CD001 was sampled in 2015 and 2016, and 15CD002 was sampled in 2016. One of the three invertebrate samples scored below the modified use threshold, with the other scores being above the threshold but within the upper confidence limit. Invertebrate samples had very high abundances of DO tolerant organisms (90^{th} percentile of similar streams in the region). Both sample reaches had very poor habitat scores, were dominated by fine sediment, and lacked riffles and pools. Station 15CD001 was noted as having green water during both samples. The failing fish and invertebrate scores will result in an aquatic life use impairment.

Data available over the assessment period on Lime Creek from Bear Lake to the Minnesota-Iowa border indicated that chemical parameters chloride, pH, and un-ionized ammonia are meeting aquatic life standards. Total phosphorus and DO flux data suggested that river eutrophication is not meeting standards, warranting a new aquatic life impairment. Continuous and spot-sample data also suggests the reach is not meeting standards for dissolved oxygen. Data was lacking to assess TSS. Lime Creek will also be listed for an aquatic recreation impairment as indicated by the bacteria data.

The reach above Bear Lake on Steward Creek (County Ditch 23) (07080203-504) had two biological stations with assessable data. The reach is recommended for modified use due to limited habitat. Two stations (15CD003, 15CD009) were sampled for fish once in 2015 and once in 2016. All fish samples scored above the modified use threshold. These stations were sampled similarly for invertebrates, with an additional duplicate sampled collected at 15CD003 in 2015. All invertebrate samples collected at 15CD009 scored below the modified use threshold, while all samples collected at 15CD003 scored above the threshold. While fish scores indicate a condition supportive of aquatic life uses, failing invertebrate scores at site 15CD009 will result in this reach having an aquatic life use impairment.

Steward Creek from its headwaters to Bear Lake is meeting aquatic life standards for chloride, pH, and unionized ammonia. Dissolved oxygen is not meeting aquatic life standards on this reach, 50% of samples over the assessment period exceeded the standard. Total phosphorus and DO flux were compared to river eutrophication standards. TP was meeting standards, yet DO flux data was insufficient, so river eutrophication is being met on this reach. While TSS data was limited; available samples met the standard.

Judicial Ditch 24 (Unnamed Creek) (07080203-509) has one site (15CD004) with assessable biological data. The stream is habitat limited and being assessed against modified use standards. One fish sample was collected in 2015 and scored above the modified use threshold. Tolerant fish taxa made up 88% of the fish collected with white sucker and brook stickleback being the most abundant species. This station was sample twice for invertebrates once in 2015 and 2016, both samples scored above the modified use threshold. Tolerant invertebrate taxa made up nearly 90% of individuals at both visits. Despite both fish and invertebrate samples being dominated by tolerant taxa, this reach meets the modified use standard and will not be listed as impaired for aquatic life.

Judicial Ditch 25 (07080203-515) flows into the Winnebago River before crossing the state border. There is one site (15CD005) with biological data. The reach is being assessed against modified use standards. This station was sample three times for invertebrates, once in 2015 and twice in 2016 (duplicate sample). All invertebrate sample scored above the modified use threshold. The station was sampled once for fish in 2015. Less than 25 fish were collected during the sample and the IBI score was 0, well below the modified use standard. Only four species of fish were found during the sample. Choking vegetation and algae mats in the stream could be indicative of a nutrient problem, which could contribute to the poor fish community. The thick vegetation, along with very low late-summer flows are creating a condition similar to a wetland, with the invertebrate community dominated by wetland taxa, and taxa tolerant of low dissolved oxygen. Due to the low fish IBI score, the reach is being suggested for an aquatic life us impairment.

Judicial Ditch 25 from its confluence with an unnamed ditch upstream of 120th St to its confluence with an unnamed creek downstream of 110th St did not have any chemical parameters that exceeded aquatic life use. SS is meeting standards and all other parameters lacked the sufficient number of samples to assess.

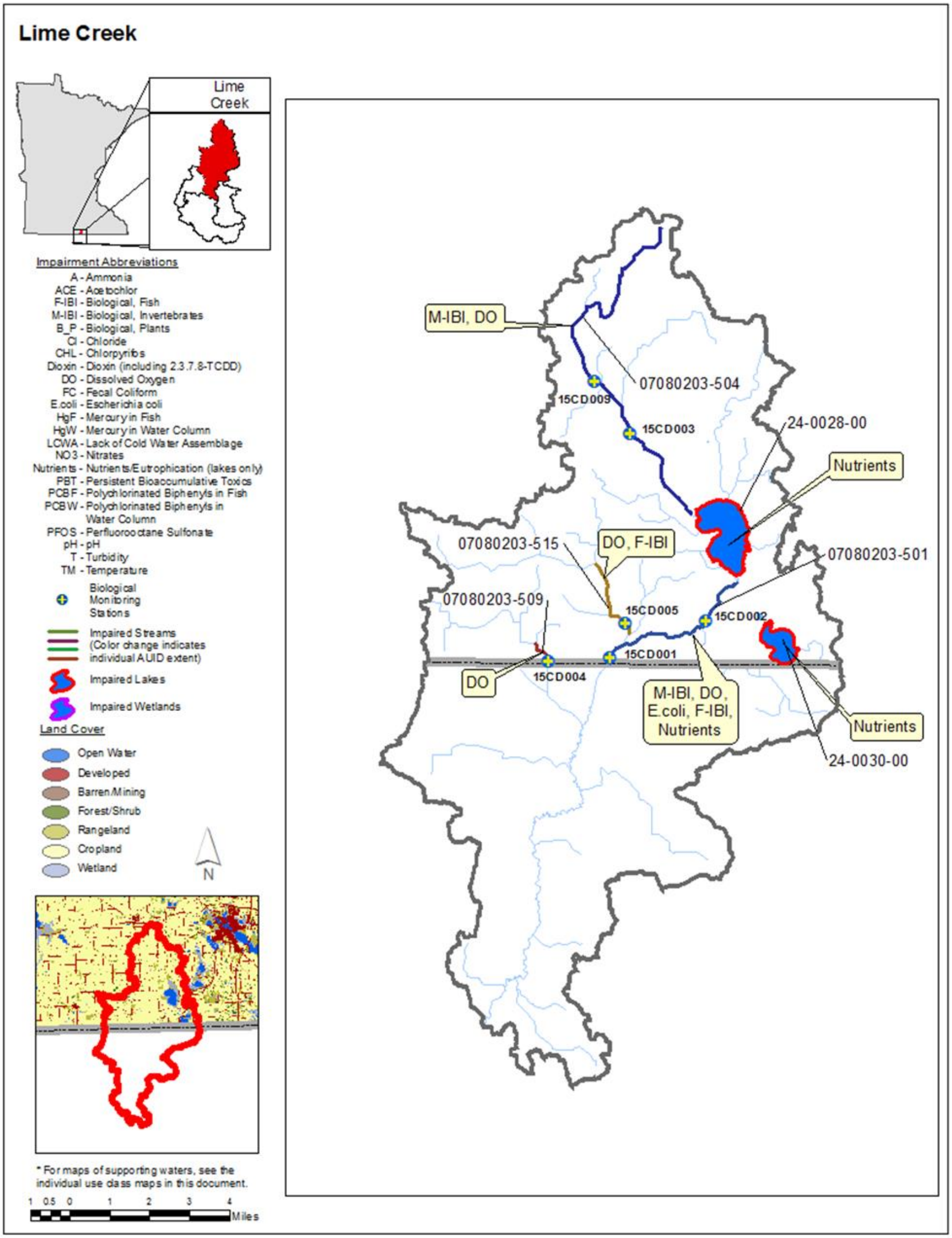
The unnamed creek from Judicial Ditch 26 to the Minnesota-Iowa border was found to be impaired for dissolved oxygen, 65% of the samples exceeded the aquatic life standard over the assessment period. pH was found to be meeting aquatic life standards, all other parameters measured lacked the sufficient numbers of samples.

Six other reaches had chemical parameters to compare to aquatic life use standards, however insufficient numbers of samples were available to assess.

Two limited resource value waters had data available to compare to standards, County Ditch 48 from its headwaters the Steward Creek and the unnamed creek from the Minnesota-Iowa border to its confluence with Lime Creek just south of 110th St. Both met standards for dissolved oxygen and pH.

Two lakes, Bear and State Line, had data available over the assessment period to compare to water quality standards. Both of these lakes are relatively shallow, less than5 feet deep, and are primarily managed for waterfowl and wildlife, secondarily as sport fisheries for northern pike and panfish. TP, Secchi depth, and chlorophyll-a far exceeded aquatic recreation standards on both lakes, they will be listed for eutrophication. State Line Lake was noted to have severe algal blooms in the summer months of 2015 and 2016.

Figure 22. Currently listed impaired waters by parameter and land use characteristics in the Lime 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 Wapsipinicon River and the Winnebago River watersheds, grouped by sample type. Summaries are provided for lakes, streams, and rivers in the watershed for the following: aquatic life and recreation uses, aquatic consumption results, load monitoring data results, transparency trends, and remote sensed lake transparency. Waters identified as priorities for protection or restoration work were also identified. Additionally, groundwater and wetland monitoring results are included where applicable.

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

Stream water quality

Fifteen of the 22 stream WIDs were assessed (Table 6). Of the assessed streams, none of the streams were considered to be fully supporting of aquatic life and no streams were fully supporting of aquatic recreation. Two WIDs were classified as limited resource waters and assessed accordingly.

Throughout the watersheds, five WIDs are non-supporting for aquatic life and/or recreation. Of those WIDs, five are non-supporting for aquatic life and two are non-supporting for aquatic recreation.

Table 6. Assessment summary for stream water quality in the Winnebago River watershed and Upper Wapsipinicon River watershed.

				Supporting		Non-supporting				
Watershed	**Area (acres)**	**# Total WIDs**	**# Assessed WIDs**	**# Aquatic life**	**# Aquatic recreation**	**# Aquatic life**	**# Aquatic recreation**	**Insufficient data**	**# Delistings**	**# Assessed LRV Water**
07080203 07080102	**53913**	**22**	**15**	**0**	**0**	**5**	**2**	**8**	**0**	**2**
0708020301-04	45649	16	12	0	0	4	1	6	0	2
0708010202-01	8264	6	3	0	0	1	1	2	0	0

Lake water quality

Only the Winnebago River watershed contained lakes. Both are shallow, wildlife managed lakes that greatly exceeded water quality standards.

Table 7. Assessment summary for lake water chemistry in the Winnebago River watershed and Upper Wapsipinicon River watershed.

			Supporting		Non-supporting		Insufficient data		
Watershed	**Area (acres)**	**Lakes >10 acres**	**# Aquatic life**	**# Aquatic recreation**	**# Aquatic life**	**# Aquatic recreation**	**# Aquatic life**	**# Aquatic recreation**	**# Delistings**
07080203 07080102	**53913**	**2**	**0**	**0**	**0**	**0**	**2**	**0**	**0**
0708020301-04	45649	2	0	0	0	2	2	0	0
0708010202-01	8264	0	0	0	0	0	0	0	0

Fish contaminant results

No fish contaminant have been collected from the Winnebago or Upper Wapsipinicon rivers. Mercury and polychlorinated biphenyls (PCBs) were analyzed in fish tissue samples collected from Bear Lake (24-0028) in 1995, by the DNR fisheries staff (Table 8). The concentrations of mercury in common carp and northern pike were very low; well below the 0.2 mg/kg water quality standard for mercury in fish tissue and, therefore, not impaired. PCBs were tested in composite samples of the largest fish of each species and all were was less than the 0.01 mg/kg reporting limit.

Table 8. Fish contaminants table.

								Length (in)			Mercury (mg/kg)			PCBs (mg/kg)			
HUC8	WID	Waterway	Species	Year	Anatomy[1]	Total Fish	Number Samples	Mean	Min	Max	Mean	Min	Max	N	Mean	Max	< RL
07080203	24002800	BEAR	Common carp	1995	FILSK	16	3	21.8	18.5	26.0	0.027	0.022	0.038	1	0.01	0.01	Y
			Northern pike	1995	FILSK	19	5	26.8	20.6	34.1	0.067	0.035	0.093	1	0.01	0.01	Y

1 Anatomy codes: FILSK – edible fillet, skin-on.

Pollutant load monitoring

Due to the small proportion of total watershed drainage area contained within Minnesota, the Upper Wapsipinicon River and Winnebago River watersheds are not monitored by the WPLMN. However, neighboring watersheds of similar land cover and land use should have water quality characteristics not unlike those of the ungaged watersheds.

Average annual FWMCs of TSS, TP, and NO_3+NO_2-N by major watershed are presented below, with the Upper Wapsipinicon River and Winnebago River watersheds highlighted. Water runoff, a significant factor in pollutant loading, is also shown. Water runoff is the portion of annual precipitation that makes it to a river or stream and can be expressed in inches.

As a general rule, elevated levels of TSS and NO_3+NO_2-N are regarded as "non-point" source derived pollutants originating from many small diffuse sources such as urban or agricultural runoff. Excess TP can be attributed to both non-point as well as point sources such as industrial or wastewater treatment plants. Major "non-point" sources of phosphorus include dissolved phosphorus from fertilizers and phosphorus adsorbed to and transported with sediment during runoff.

Excessive TSS, TP, and NO_3+NO_2-N in surface waters impacts fish and other aquatic life, as well as fishing, swimming and other recreational uses. High levels of NO_3+NO_2-N is a concern for drinking water.

When compared with watersheds throughout the state, Figure 23, Figure 24, Figure 25 and Figure 26 show average annual TSS, TP, and NO_3+NO_2-N FWMCs to be several times higher for southeastern watersheds than those of north central and northeast Minnesota but in line with the agriculturally rich watersheds found in the northwest and southern regions of the state.

More information, including results for subwatershed stations, can be found at the WPLMN website.

Substantial year-to-year variability in water quality occurs for most rivers and streams, These rivers are no exception and pollutant concentrations often follow closely to water runoff and river discharge.

Figure 23. 2007-2015 Average annual NO_3-NO_2-N flow weighted mean concentrations by major watershed.

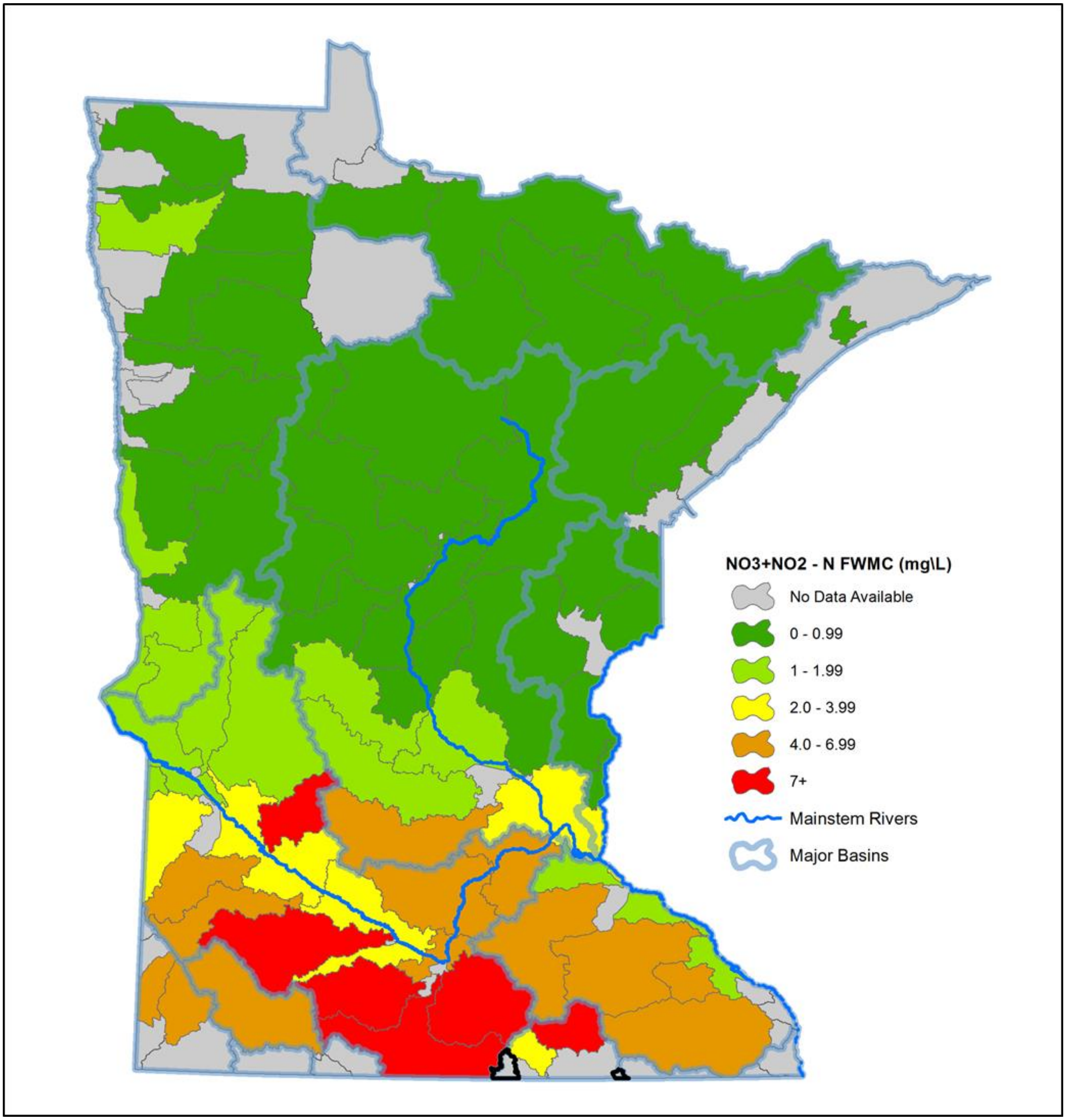


Figure 24. 2007-2015 Average annual runoff by major watershed.

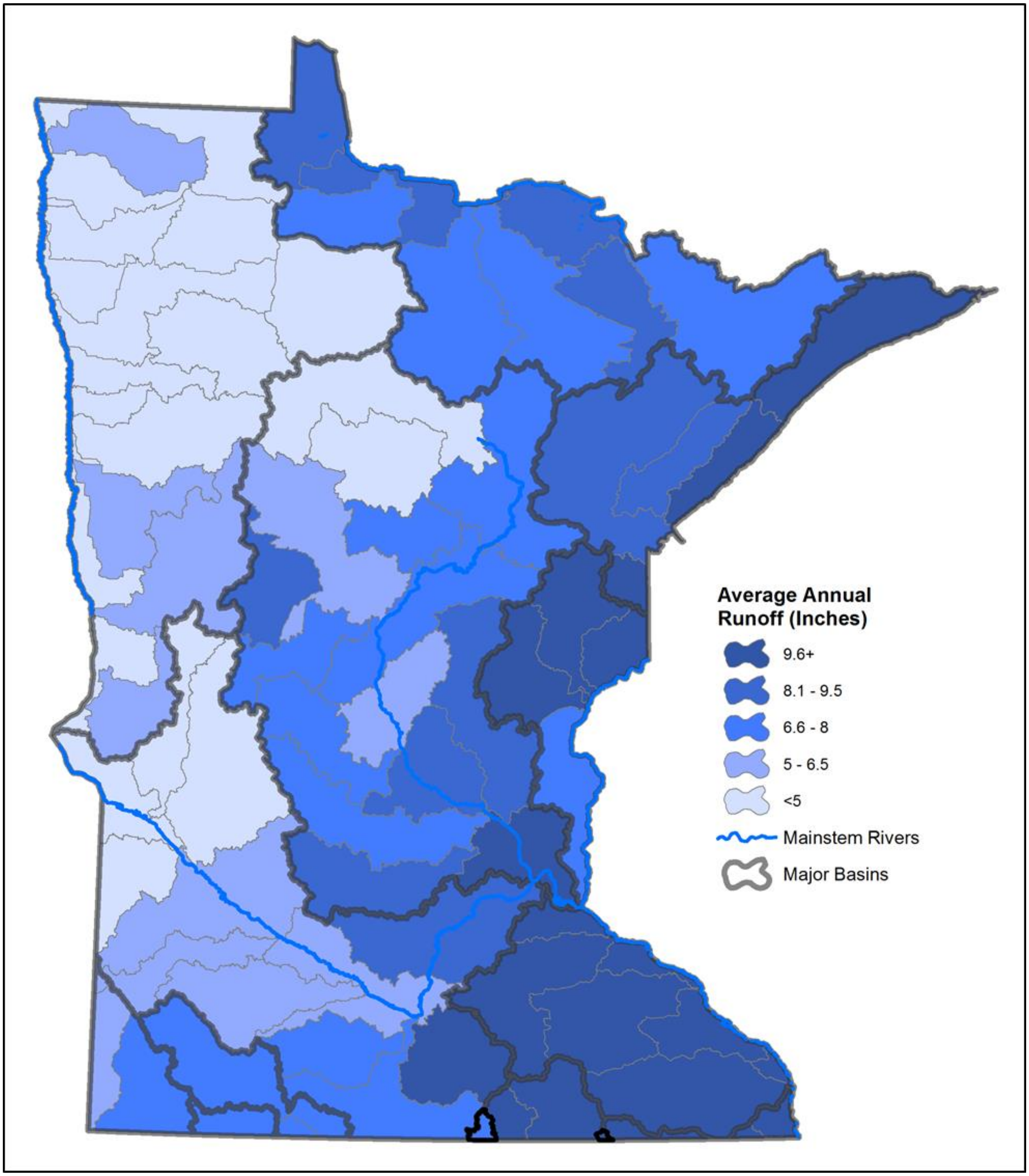


Figure 25. 2007-2015 Average annual TP flow weighted mean concentrations by major watershed.

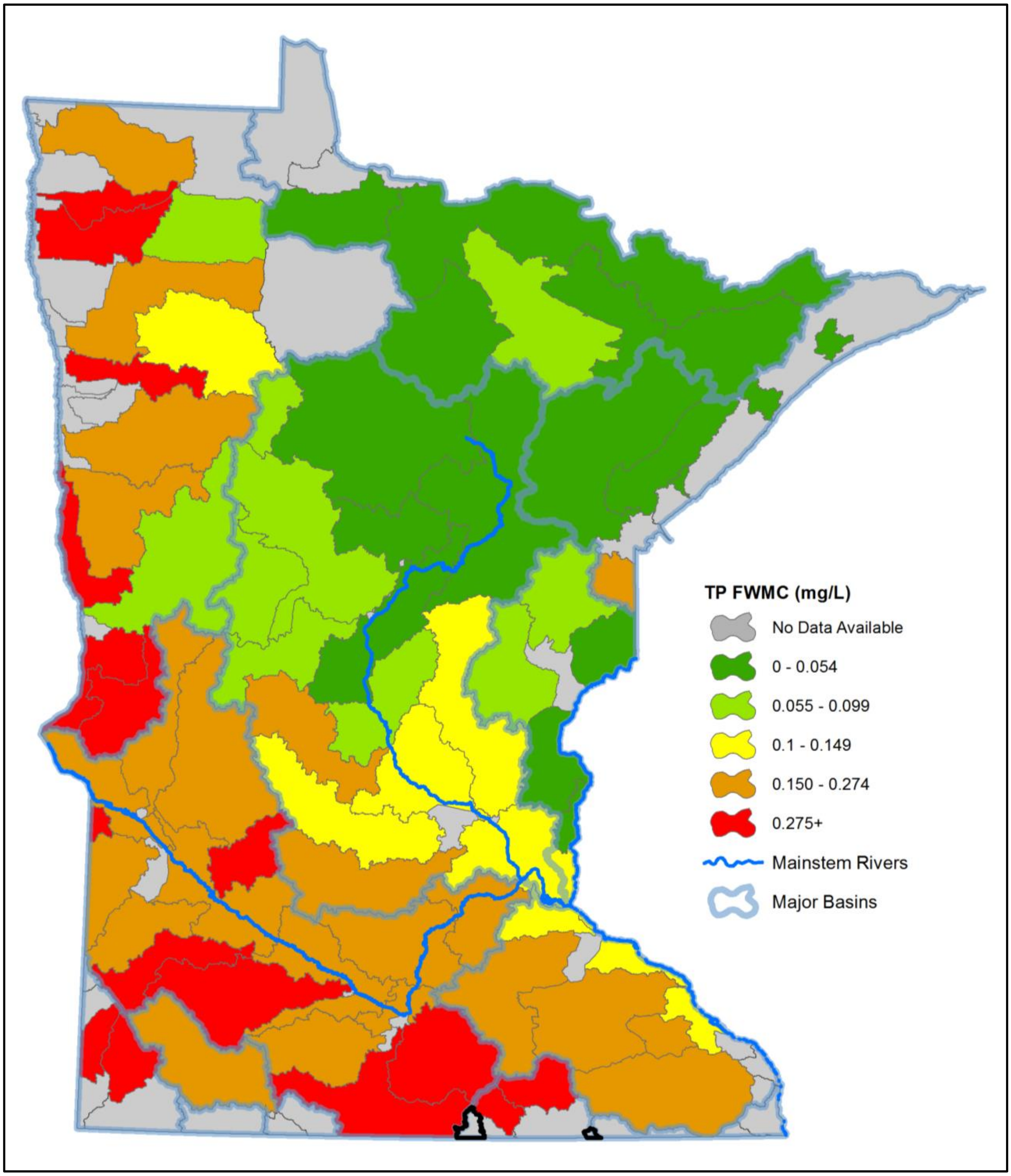
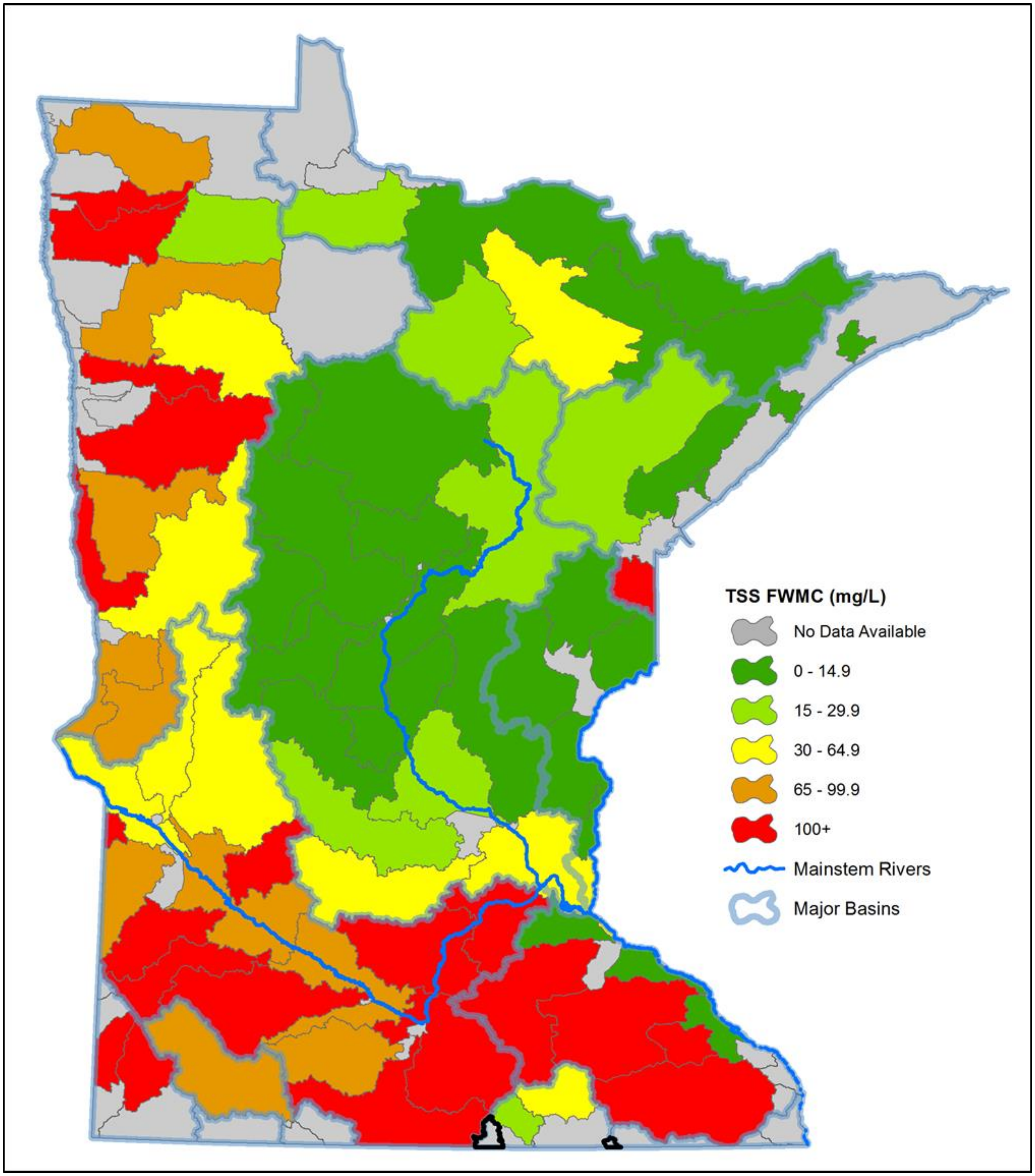


Figure 26. 2007-2015 Average annual TSS flow weighted mean concentrations by major watershed.



Groundwater monitoring

Groundwater quality in the Upper Wapsipinicon and Winnebago watersheds is generally good, but vulnerable to anthropogenic impacts due to the geology of the region. Drinking water may contain elevated concentrations of trace elements from the mineralogy of the region. Nitrate is a contaminant of particular concern in these watersheds due to the rapid transfer to groundwater of surficial contaminants in areas where karst features are present. Pollution prevention from identified sources is the most effective method for groundwater protection in these areas.

Stream flow

There are no DNR or USGS gages monitoring continuous flow in the Minnesota portions of the Upper Wapsipinicon or Winnebago watersheds.

Wetland condition

The Winnebago River and Upper Wapsipinicon watersheds occur entirely within the Temperature Prairies Ecoregion. Wetland condition, in this ecoregion is poor, especially when compared to the Mixed Wood Shield. Based on plant community floristic quality, 42% of the wetlands in the Temperate Prairies Ecoregion are estimated to be poor condition and an estimated 40% are in fair condition, while 7% are estimated to be exceptional condition. (Table 9). Wetland condition results In the Mixed Wood Plains Ecoregion are similar to the Temperate Prairies Ecoregion. In both of these ecoregions significant extents of wetland area are dominated by invasive plants, particularly narrow-leaf cattail (Typha angustifolia), hybrid cattail (Typha X glauca), and reed canary grass (Phalaris arundinacea). These invasive plants often outcompete native species due to their tolerance of nutrient enrichment, hydrologic alterations and toxic pollutants such as chlorides (Galatowisch, 2012) and thus strongly influence the composition and structure of the wetland plant community. Restoring wetlands in these two watersheds will increase the amount of water retained on the landscape and contribute to improved water quality downstream in lakes and streams as well as in the remaining wetlands in these watersheds.

Table 9 Wetland biological condition by major ecoregions based on floristic quality. Results are expressed as an extent (i.e., percentage of wetland acres) and include essentially all wetland types (MPCA, 2015).

Vegetation Condition in All Wetlands

Condition Category	Mixed Wood Shield	Mixed Wood Plains	Temperate Prairies
Exceptional	64%	6%	7%
Good	20%	12%	11%
Fair	16%	42%	40%
Poor		40%	42%

Figure 27. Stream Tiered Aquatic Life Use Designations in the Upper Wapsipinicon River watershed.

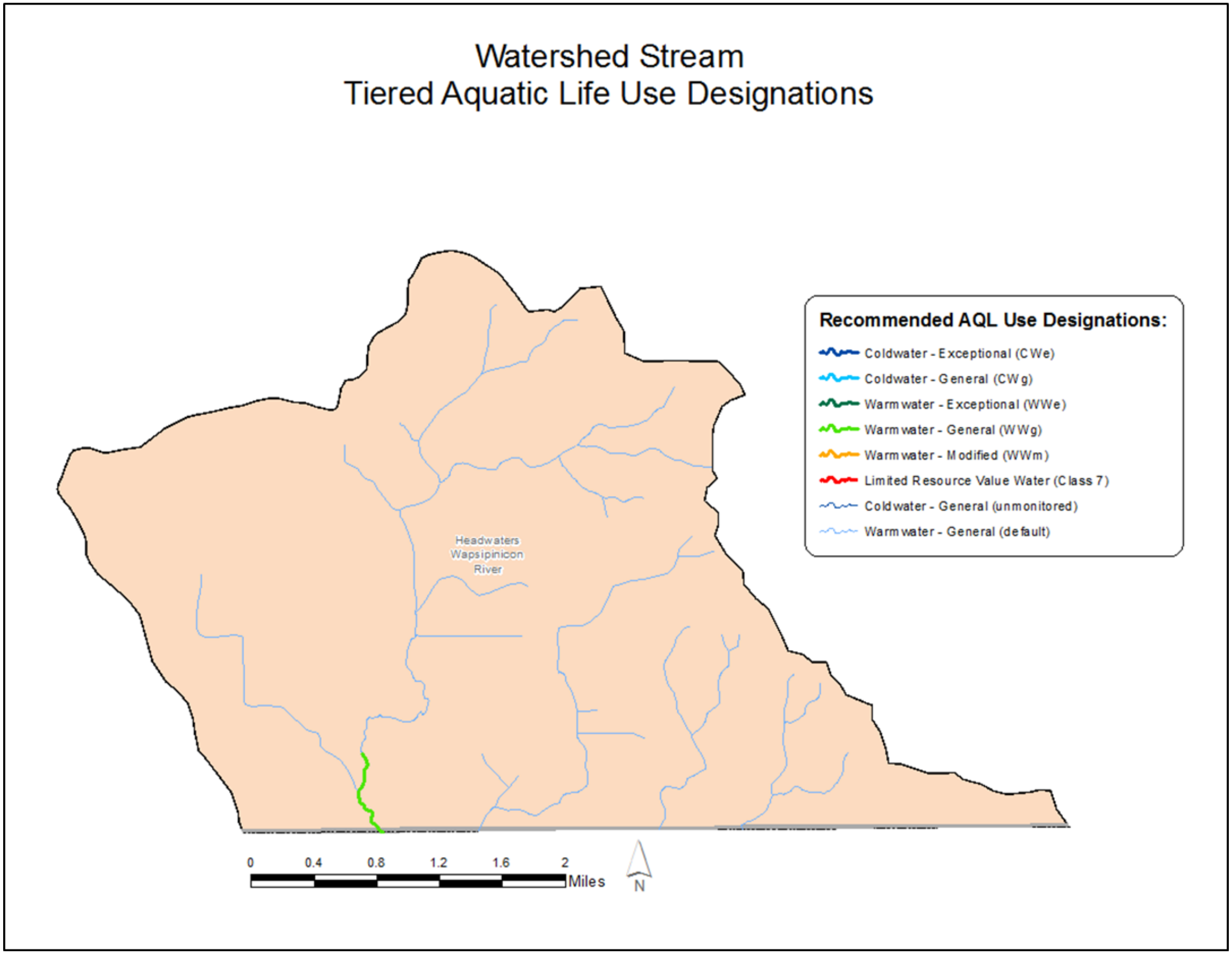


Figure 28. Stream Tiered Aquatic Life Use Designations in the Winnebago River watershed.

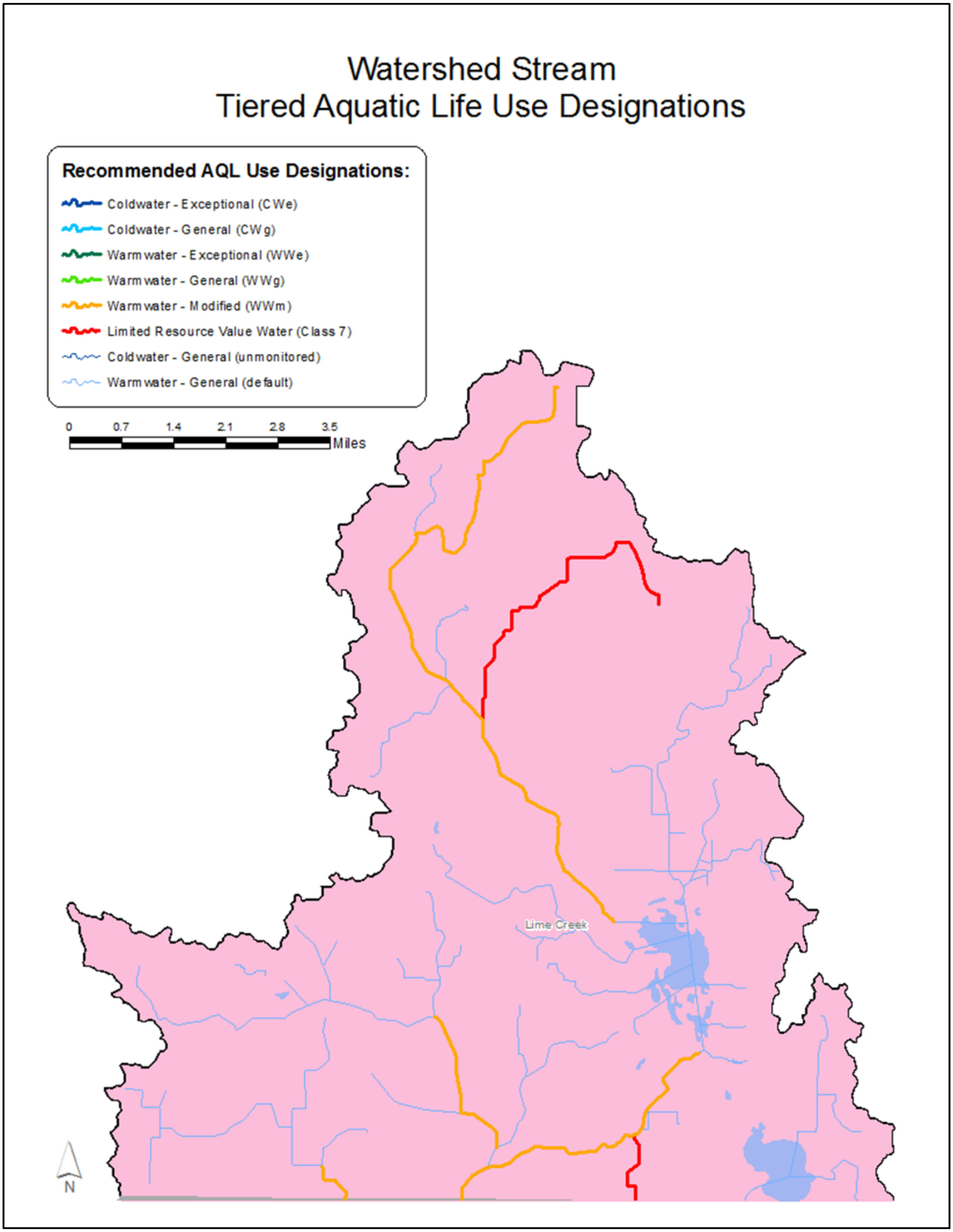


Figure 29. Fully supporting waters by designated use in the Upper Wapsipinicon River watershed.

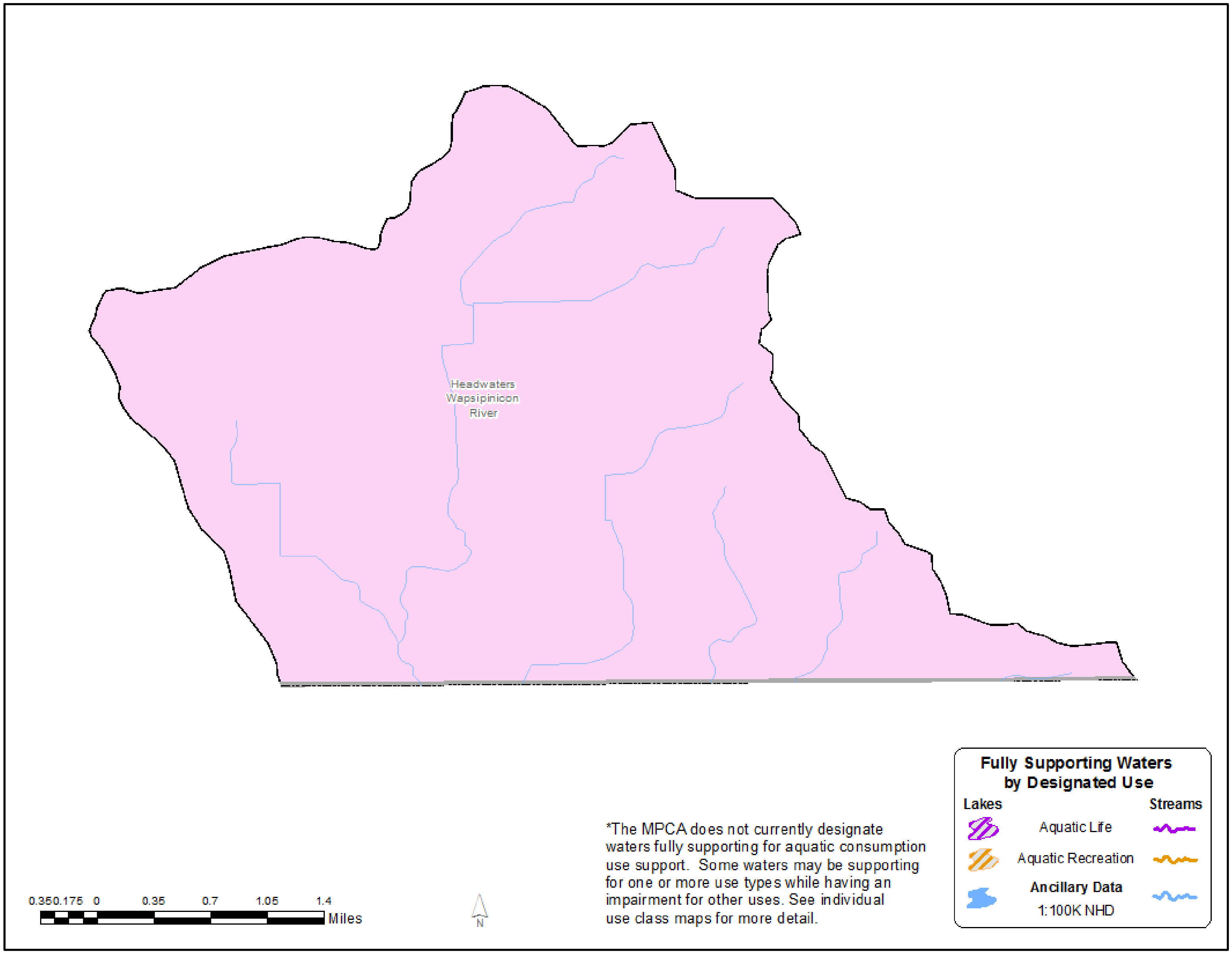


Figure 30. Fully supporting waters by designated use in the Winnebago River watershed.

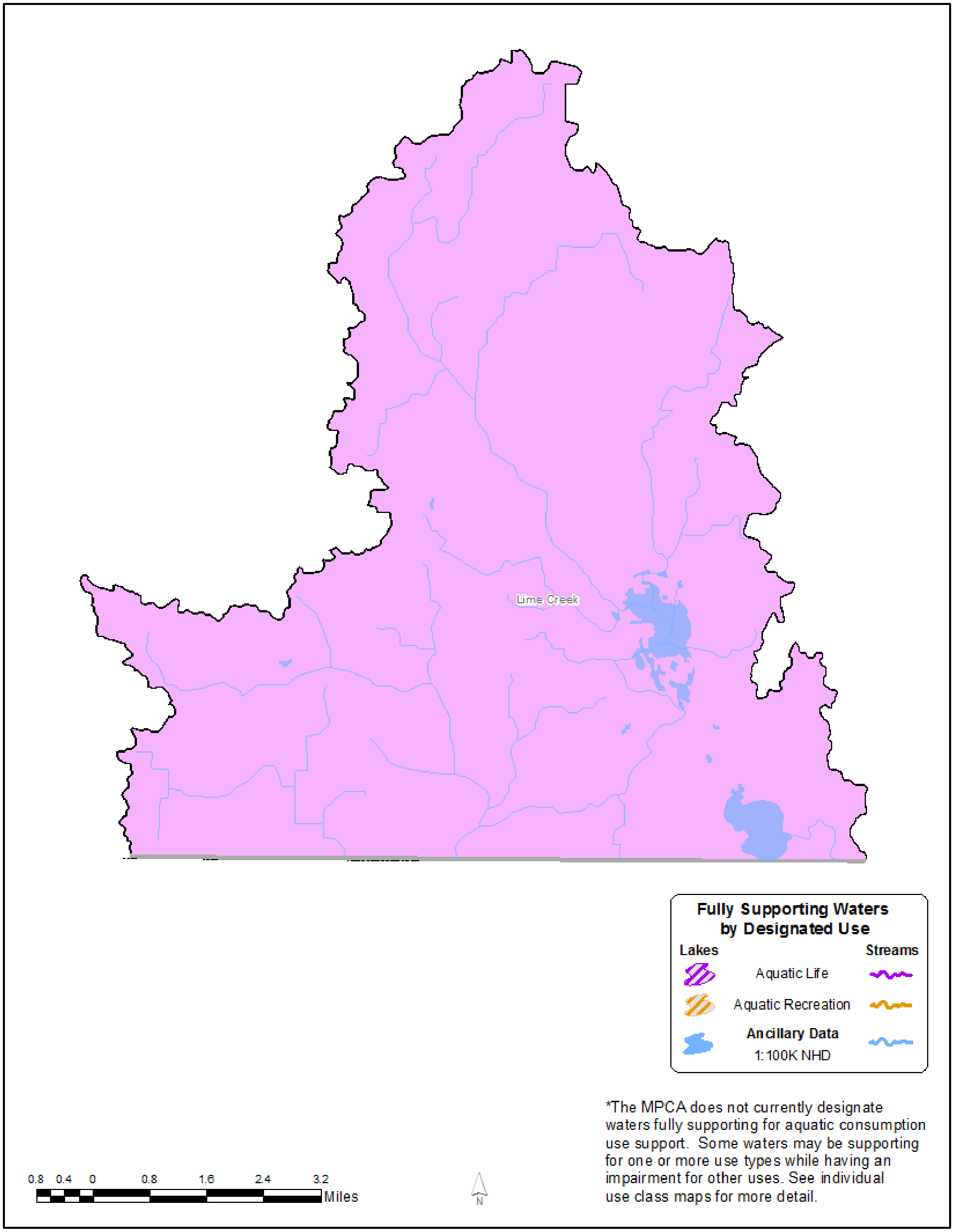


Figure 31. Impaired waters by designated use in the Upper Wapsipinicon River.

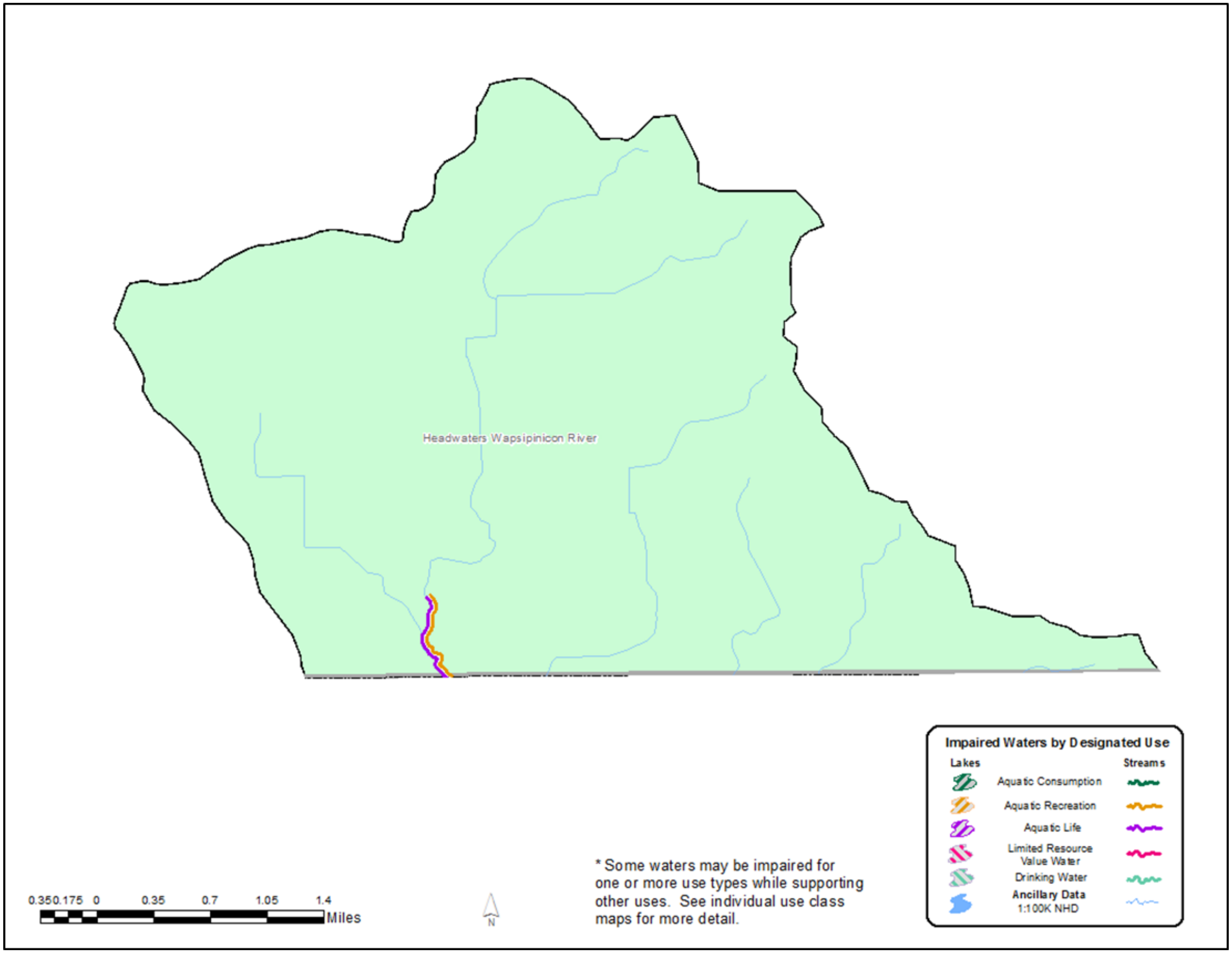


Figure 32. Impaired waters by designated use in the Winnebago River.

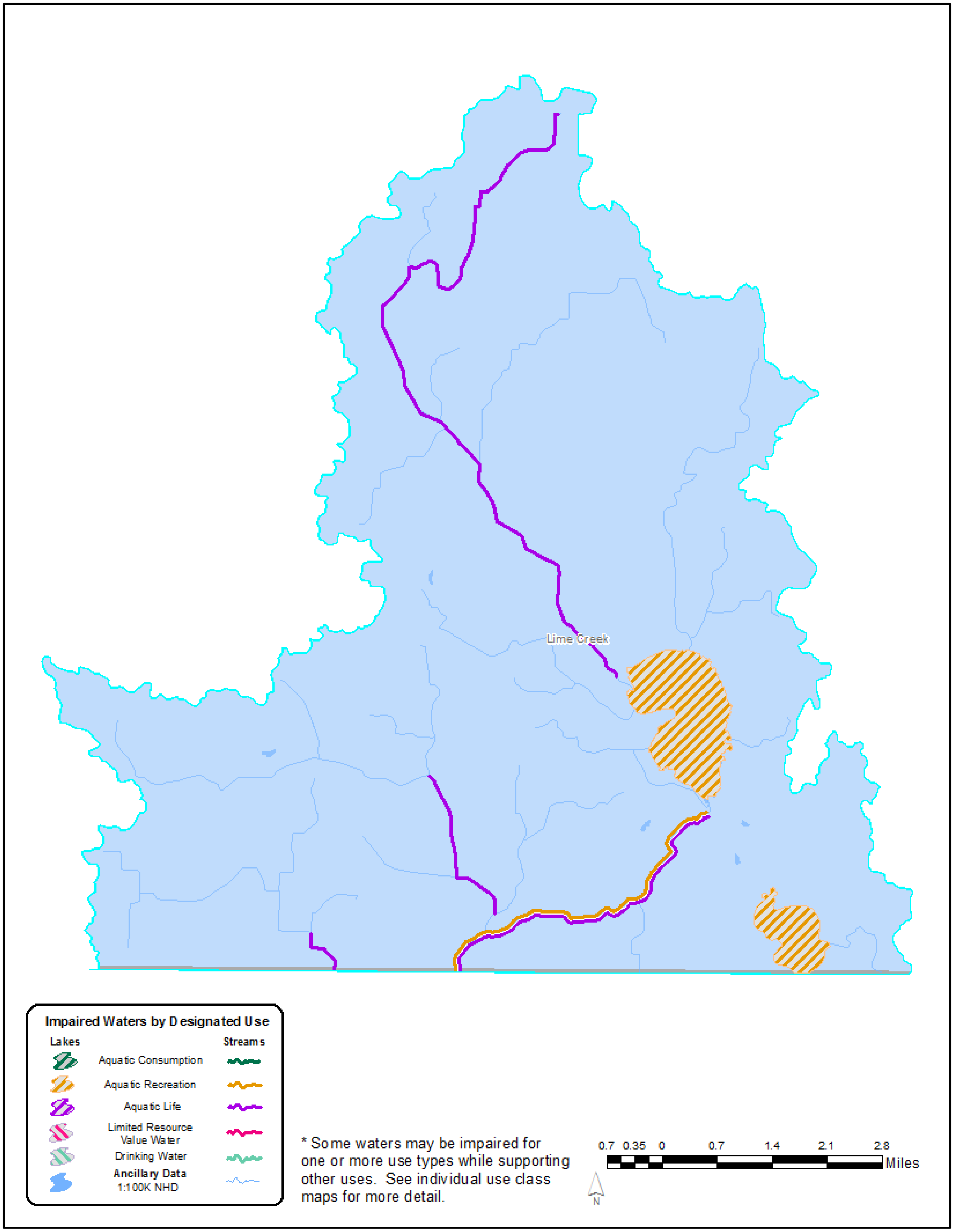


Figure 33. Aquatic consumption use support in the Upper Wapsipinicon River watershed.

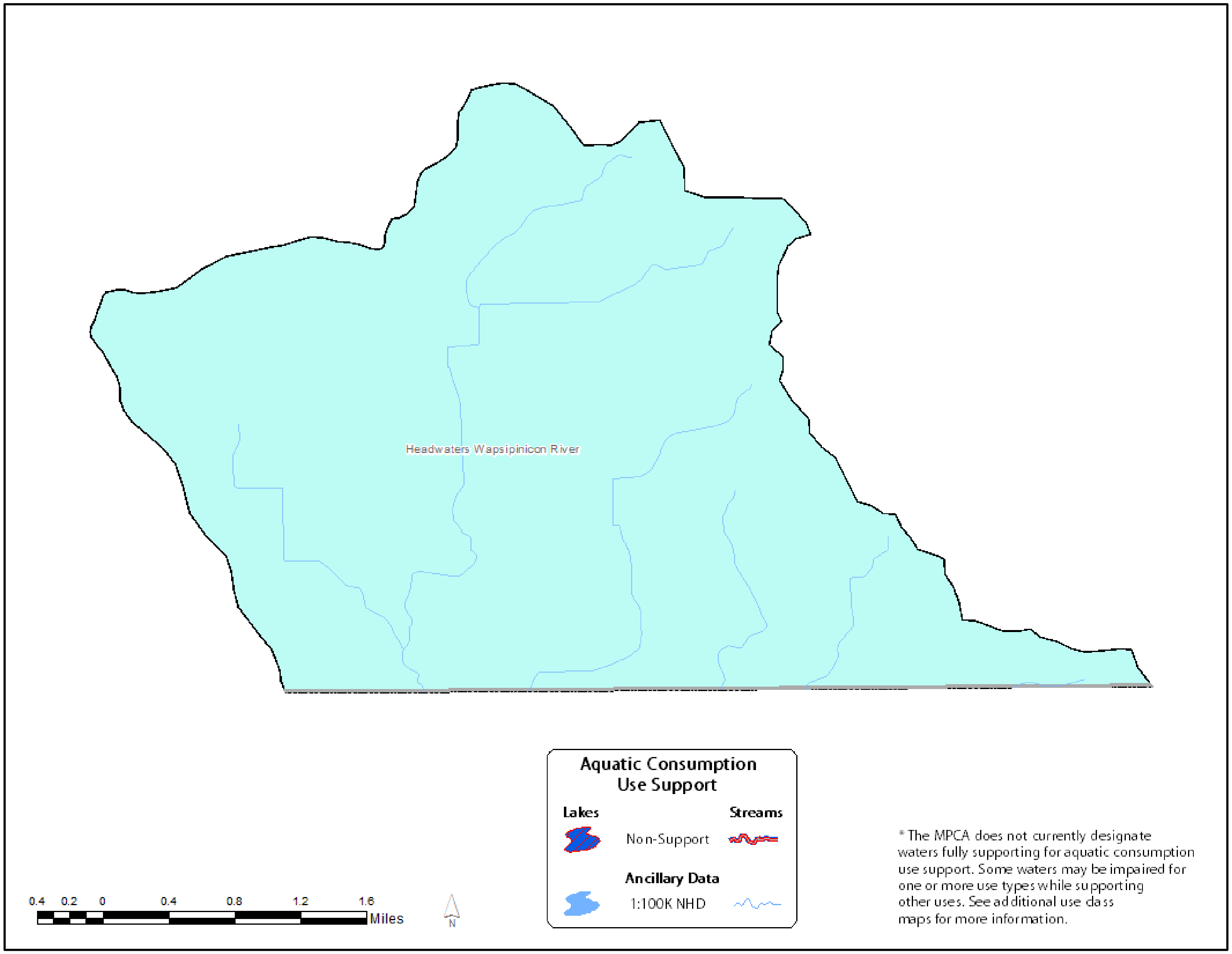


Figure 34. Aquatic consumption use support in the Winnebago River watershed.

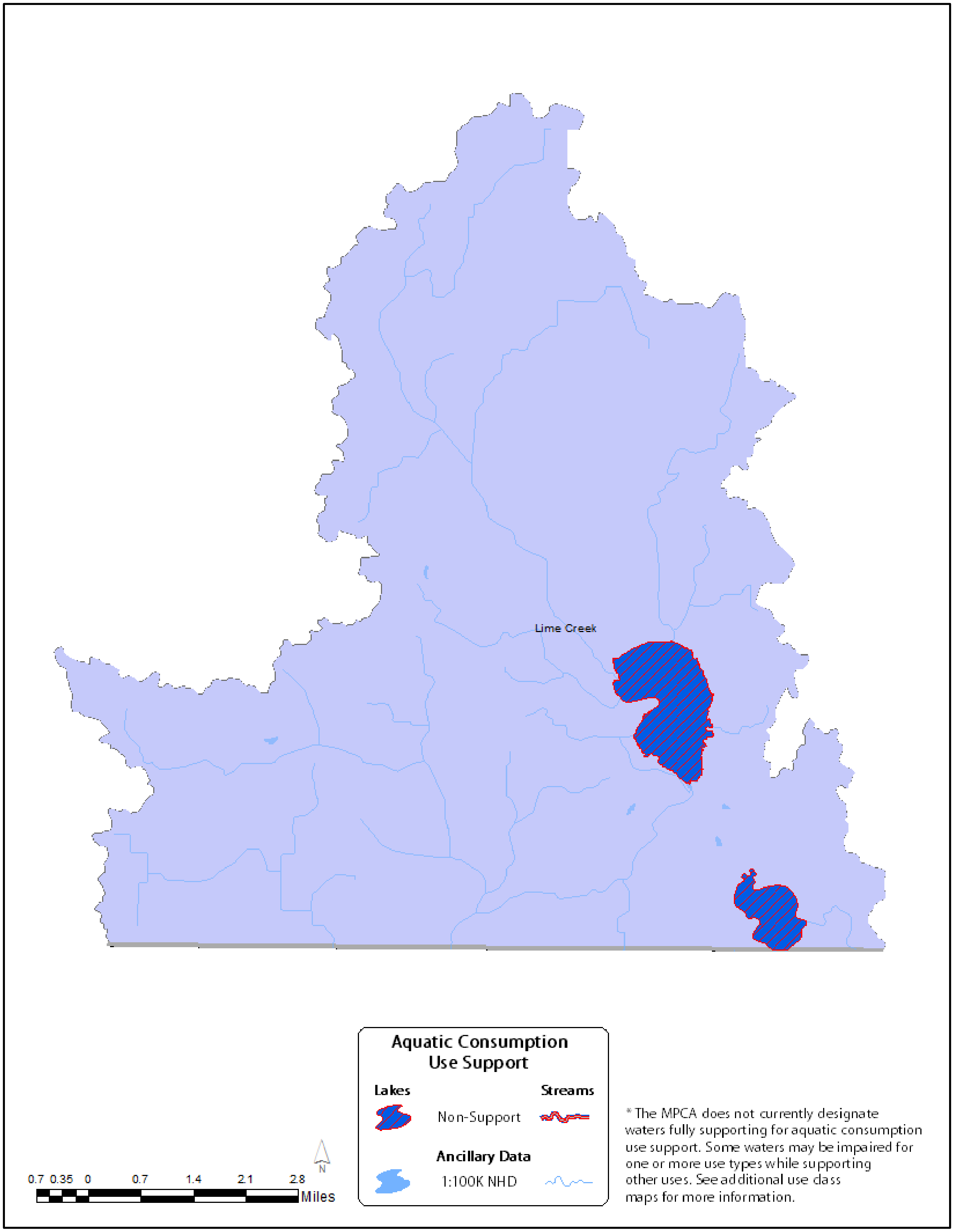


Figure 35. Aquatic life use support in the Upper Wapsipinicon River watershed.

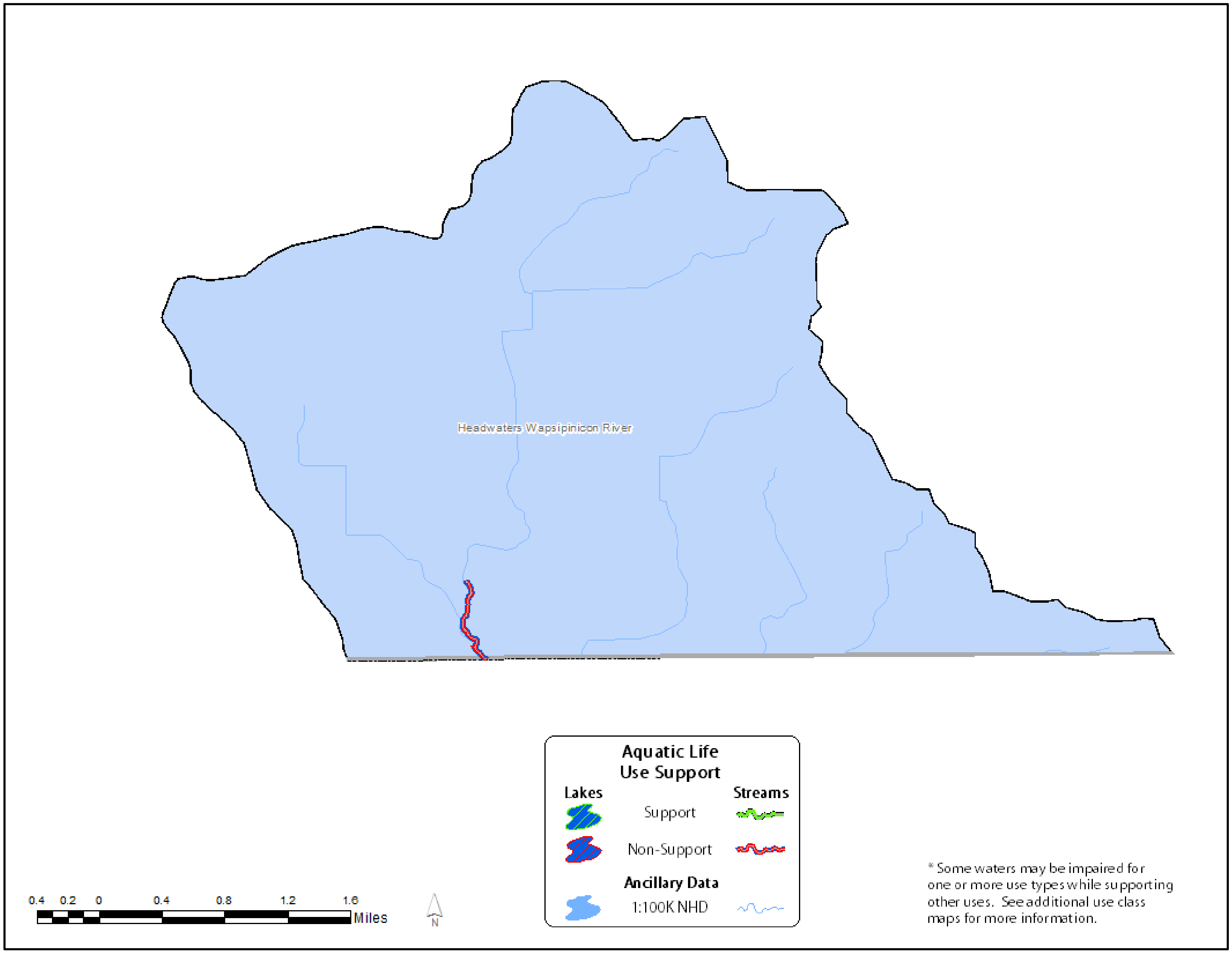


Figure 36. Aquatic life use support in the Winnebago River watershed.

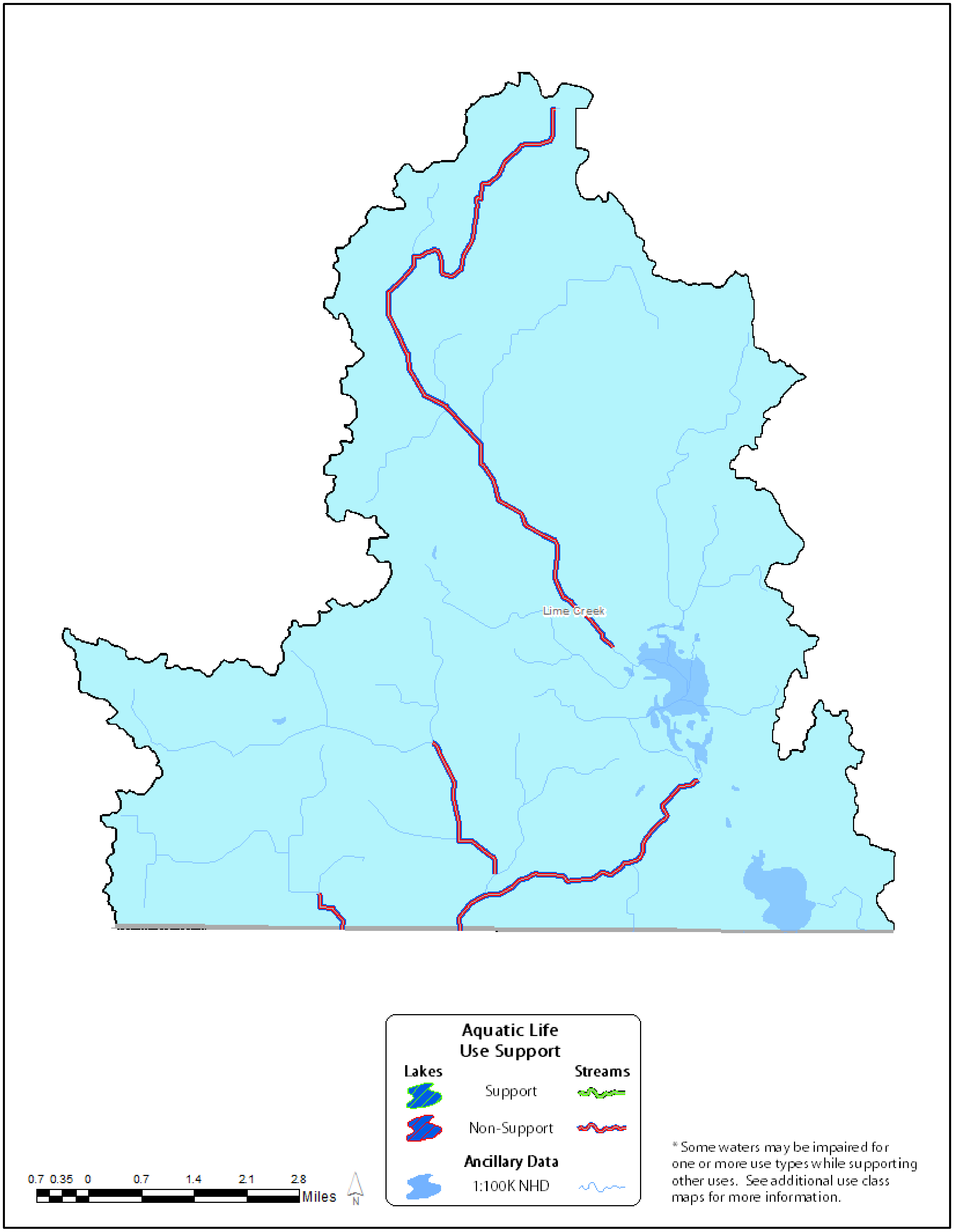


Figure 37. Aquatic recreation use support in the Upper Wapsipinicon River watershed.

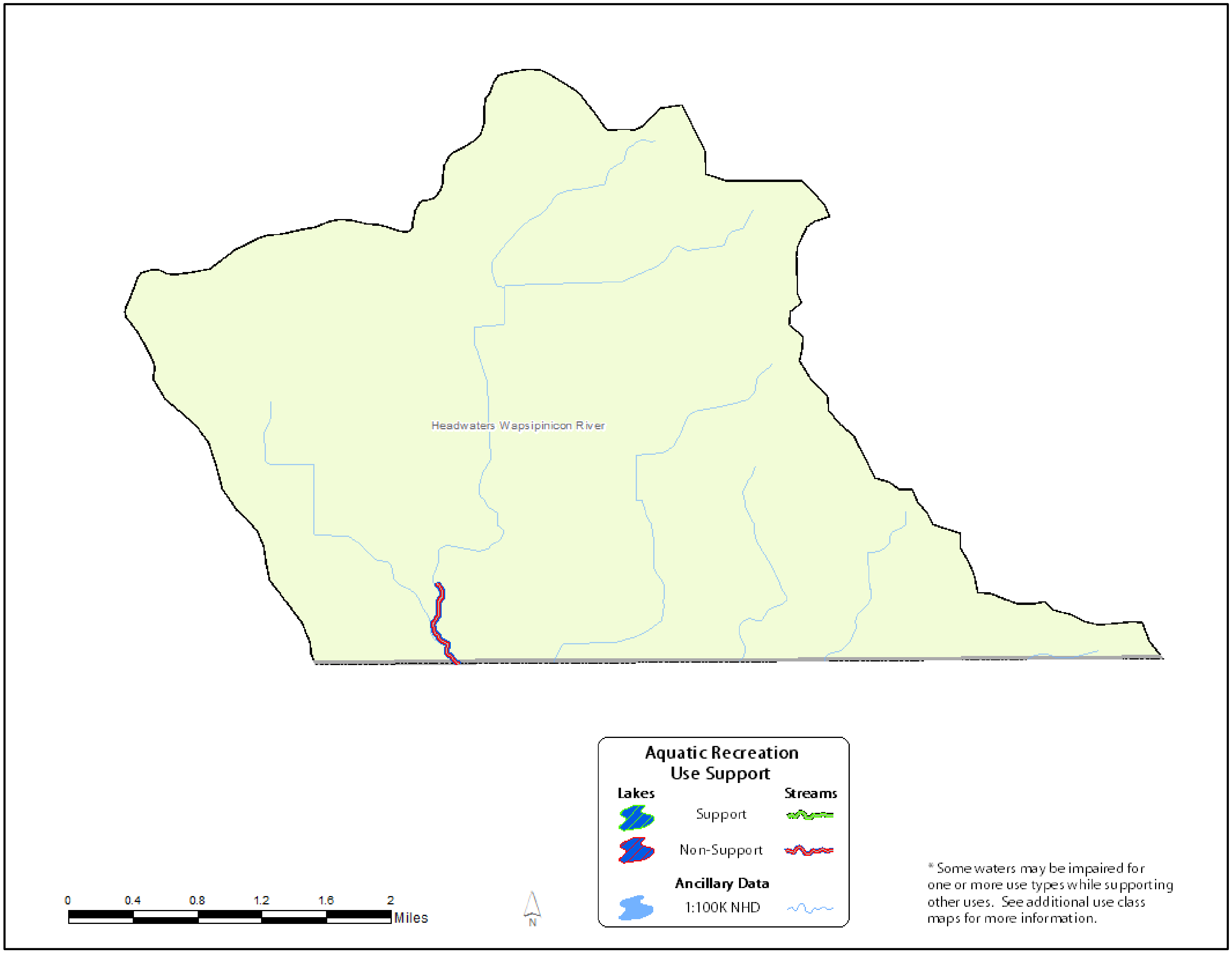
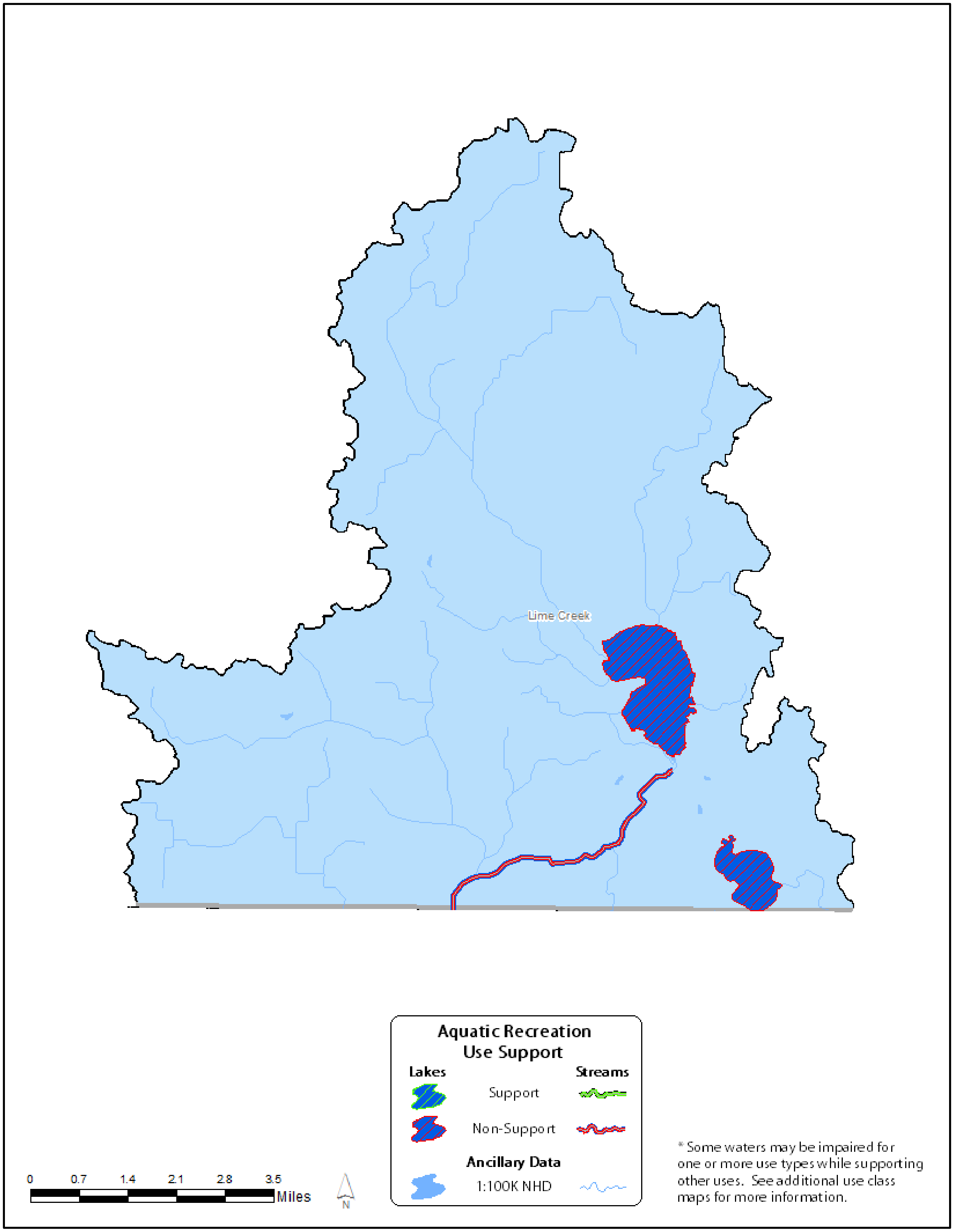


Figure 38. Aquatic recreation use support in the Winnebago River watershed.



Summaries and recommendations

The Winnebago River and Upper Wapsipinicon River watersheds are two small watersheds in the greater Cedar River watershed. They were sampled from 2015-2016 to be assessed for aquatic life and aquatic recreation. They are small watersheds and had limited locations for sites. Both have the majority of their area in Iowa and only their headwaters in Minnesota before crossing the border. Iowa DNR does assessments of streams similar to Minnesota. The Winnebago River watershed and Wapsipinicon River watershed have been assessed on several reaches and have impairments at or near the Minnesota border. To find more information about these assessments do the Iowa DNR webpage.

No pollutant load monitoring stations are in the watersheds. Data was available from similar watersheds. Findings show concentrations can vary widely and often follow closely to water runoff and river discharge. Groundwater in this area is generally good, but vulnerable. Nitrate is a concern when there is a rapid transfer of surface water to groundwater. Karst features contribute to quick movement of water from the surface to underground. With groundwater prevention of contamination is the most effective approach.

Wetland loss is seen throughout the state and these watersheds are no exception. Due to the size of these watersheds there is limited data available about the watersheds here. Looking at wetlands in this ecoregion, 42% of them are in poor condition and 40% are in fair condition. Restoring wetlands in the Winnebago River watershed and Upper Wapsipinicon River watershed would increase water storage on the land and contribute to better water quality.

There was no assessment of fish tissue from any of the streams in these watersheds. There was an assessment made for tissue from Bear Lake using common carp and northern pike. Mercury and PCBs levels were below the standards set for healthy consumption. No impairments resulted from assessment of fish tissue.

Bear Lake and State Line Lake are both located in the Winnebago River watershed. There are no lakes in the Upper Wapsipinicon River watershed. The lakes were assessed for aquatic recreation. Both were found to be impaired; not meeting standards set for aquatic recreation. There was insufficient data to complete an assessment for aquatic life in the lakes.

One reach in each watershed was assessed for aquatic recreation. The data for this assessment came from sites located where the mainstem streams crossed the state border. Both exceeded standards set for aquatic recreation and are being recommended for impairment.

Two reaches in the Winnebago River watershed are limited resource streams. While they have biological data, they cannot be assessed for aquatic life. Four stream reaches were assessed for aquatic life in the Winnebago River watershed. All four reaches met criteria for modified use and were assessed using modified use thresholds. None of the reaches assessed for aquatic life passed, all are being recommended for listing as impaired. One reach was assessed for aquatic life in the Upper Wapsipinicon River. The sample location was on a natural section of stream and cannot be changed to modified use. The reach is recommended to be listed as impaired based on the biological samples.

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Appendix 1 – Water chemistry definitions

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

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

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

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

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

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

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

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

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

Unionized ammonia (NH_3) - Ammonia is present in aquatic systems mainly as the dissociated ion NH_4^+, 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 NH_4^+ 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 Winnebago River watershed Upper Wapsipinicon River watershed

EQuIS ID	Biological station ID	WID	Waterbody name	Location	Aggregated 12-digit HUC
S007-338	15CD001	07080203-501	Lime Creek	State Line Road, 3.7 miles west of Emmons	0708020301-04
S008-409	15CD012	07080102-507	Wapsipinicon River	State Line Road, 5 miles east of Johnsberg	0708010202-01

Appendix 2.2 – Intensive watershed monitoring biological monitoring stations in the Winnebago River watershed and Wapsipinicon River watershed

WID	Biological station ID	Waterbody name	Biological station location	County	Aggregated 12-digit HUC
07080102-507	15CD012	Wapsipinicon River	Upstream of State Line Rd, 5 mi. E of Johnsberg	Mower	0708010202-01
07080203-501	15CD001	Lime Creek (Winnebago River)	Upstream of CR 60 (510th St), 3 mi. W of Emmons	Freeborn	0708020301-04
07080203-501	15CD002	Lime Creek (Winnebago River)	Upstream of 110th St, 1.5 mi. SW of Emmons	Freeborn	0708020301-04
07080203-503	15CD011	Trib. to Lime Creek (Winnebago River)	Upstream of CSAH 4 (State Line Rd), 1 mi. SW of Emmons	Freeborn	0708020301-04
07080203-504	15CD003	Steward Creek (County Ditch 23)	Upstream of 660th Ave, 2.5 mi. S of Conger	Freeborn	0708020301-04
07080203-504	15CD009	Steward Creek (County Ditch 23)	Downstream of CR 4, 1.5 mi. SW of Conger	Freeborn	0708020301-04
07080203-506	15CD007	County Ditch 48	Upstream of 660th Ave, 1.5 mi. SE of Conger	Freeborn	0708020301-04
07080203-509	15CD004	Judicial Ditch 26	Upstream of State Line Rd (CSAH A14), 6 mi. SE of Kiester	Freeborn	0708020301-04
07080203-515	15CD005	Judicial Ditch 25	Upstream of 110th St, 3 mi. W of Emmons	Freeborn	0708020301-04

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 WID	Biological station ID	Stream segment name	Drainage area Mi^2	Fish class	Threshold	FIBI	Visit date
HUC 12: 0708010202-01 (Headwaters Upper Wapsipinicon River)							
07080102-507	15CD012	Wapsipinicon River	8.59	3	55	51.0	7/21/15
07080102-507	15DC012	Wapsipinicon River	8.59	3	55	65.2	6/29/16
HUC 12: 0708020301-04 (Lime Creek)							
07080203-501	15CD001	Lime Creek (Winnebago River)	68.69	2	35	28.5	8/25/15
07080203-501	15CD001	Lime Creek (Winnebago River)	68.69	2	35	34.6	8/9/16
07080203-501	15CD002	Lime Creek (Winnebago River)	40.99	2	35	55.8	8/17/15
07080203-501	15CD002	Lime Creek (Winnebago River)	40.99	2	35	28.7	6/23/16
07080203-504	15CD009	Steward Creek (County Ditch 23)	7.09	3	33	55.7	7/21/15
07080203-504	15CD009	Steward Creek (County Ditch 23)	7.09	3	33	43	8/9/16
07080203-504	15CD003	Steward Creek (County Ditch 23)	16.96	7	15	36.7	8/25/15
07080203-504	15CD003	Steward Creek (County Ditch 23)	16.96	7	15	27.4	6/30/16
07080203-509	15CD004	Judicial Ditch 26	8.32	3	33	43.6	7/21/15
07080203-515	15CD005	Judicial Ditch 25	11.57	7	15	0	7/21/15

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

National Hydrography Dataset (NHD) Assessment Segment WID	Biological station ID	Stream segment name	Drainage area Mi^2	Invert class	Threshold	MIBI	Visit date
HUC 12: 0708010202-01 (Headwaters Upper Wapsipinicon River)							
07080102-507	15CD012	Wapsipinicon River	8.59	6	43	36.24	12-Aug-15
07080102-507	15CD012	Wapsipinicon River	8.59	6	43	47.42	04-Aug-16
HUC 12: 0708020301-04 (Lime Creek)							
07080203-501	15CD001	Lime Creek (Winnebago River)	68.69	7	22	19.58	03-Aug-16
07080203-501	15CD001	Lime Creek (Winnebago River)	68.69	7	22	33.14	12-Aug-15
07080203-501	15CD002	Lime Creek (Winnebago River)	40.99	7	22	0.00	12-Aug-15
07080203-501	15CD002	Lime Creek (Winnebago River)	40.99	7	22	32.22	03-Aug-16
07080203-504	15CD003	Steward Creek (County Ditch 23)	16.96	7	22	26.90	12-Aug-15
07080203-504	15CD003	Steward Creek (County Ditch 23)	16.96	7	22	33.53	12-Aug-15
07080203-504	15CD003	Steward Creek (County Ditch 23)	16.96	7	22	43.59	03-Aug-16
07080203-509	15CD004	Judicial Ditch 26	8.32	7	22	27.51	03-Aug-16
07080203-509	15CD004	Judicial Ditch 26	8.32	7	22	39.44	12-Aug-15
07080203-515	15CD005	Judicial Ditch 25	11.57	7	22	34.84	03-Aug-16
07080203-515	15CD005	Judicial Ditch 25	11.57	7	22	37.05	03-Aug-16
07080203-515	15CD005	Judicial Ditch 25	11.57	7	22	46.99	12-Aug-15

Appendix 4.1 – Fish species found during biological monitoring surveys

Common name	Quantity of stations where present	Quantity of individuals collected
Upper Wapsipinicon River		
Bigmouth shiner	1	38
Black bullhead	1	2
Blacknose dace	1	159
Bluntnose minnow	1	56
Brook stickleback	1	8
Central stoneroller	1	56
Common shiner	1	72
Creek chub	1	156
Fantail darter	1	20
Fathead minnow	1	3
Iowa Darter	1	2
Johnny darter	1	57
Rainbow trout	1	2
Southern redbelly dace	1	85
White sucker	1	89
Lime Creek (Winnebago River)		
Bigmouth buffalo	2	54
Bigmouth shiner	1	2
Black bullhead	7	496
Black crappie	2	7
Blacknose dace	5	181
Bluegill	2	29
Bluntnose minnow	2	5
Brassy minnow	3	34
Brook stickleback	6	113
Central mudminnow	2	8
Common carp	4	71
Common shiner	3	55
Creek chub	6	165
Fathead minnow	8	1519
Golden shiner	4	8
Green sunfish	6	221
Hornyhead chub	1	5
Hybrid sunfish	2	3
Iowa darter	3	231
Johnny darter	6	57

Common name	Quantity of stations where present	Quantity of individuals collected
Northern pike	2	28
Orangespotted sunfish	2	149
Quillback	1	9
Shorthead redhorse	1	1
Spotfin shiner	4	17
Stonecat	1	1
Tadpole madtom	2	9
White sucker	7	389
Yellow bullhead	2	28
Yellow perch	4	118

Appendix 4.2 – Macroinvertebrate species found during biological monitoring surveys

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
Upper Wapsipinicon River		
Ablabesmyia	1	1
Acari	1	36
Acentrella	1	2
Aeshna	1	3
Baetis	1	1
Brillia	1	24
Caenis	1	1
Calopterygidae	1	1
Calopteryx	1	5
Cheumatopsyche	1	15
Cladotanytarsus	1	8
Coenagrionidae	1	4
Cricotopus	1	16
Cryptochironomus	1	2
Cryptotendipes	1	1
Dicrotendipes	1	5
Dixella	1	1
Dubiraphia	1	66
Enchytraeus	1	2
Ephydridae	1	1
Ferrissia	1	10
Fridericia	1	1
Helichus	1	5
Hemerodromia	1	2
Hirudinea	1	6

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
Hyalella	1	65
Hydropsychidae	1	1
Hydroptila	1	1
Hydroptilidae	1	1
Labiobaetis	1	12
Labrundinia	1	43
Limnophyes	1	4
Lymnaeidae	1	1
Micropsectra	1	5
Microtendipes	1	2
Naididae	1	1
Nais	1	4
Nectopsyche	1	15
Ophidonais	1	1
Optioservus	1	1
Orconectes	1	2
Paracladopelma	1	1
Parakiefferiella	1	5
Parametriocnemus	1	1
Paratanytarsus	1	6
Paratendipes	1	2
Phaenopsectra	1	8
Physella	1	63
Pisidiidae	1	5
Polypedilum	1	81
Pristina	1	1
Rheocricotopus	1	1
Rheotanytarsus	1	6
Saetheria	1	1
Simulium	1	1
Tabanidae	1	2
Tanypodinae	1	1
Tanytarsus	1	4
Thienemanniella	1	22
Thienemannimyia Gr.	1	19
Tubificinae	1	11
Tvetenia	1	6
Zavrelimyia	1	3
Lime Creek (Winnebago River)		
Ablabesmyia	2	11
Acari	6	29

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
Aeshnidae	2	2
Anax	2	1
Anisoptera	1	1
Atrichopogon	1	1
Baetis	1	1
Belostoma	4	8
Branchiobdellida	1	1
Bratislavia	1	1
Brillia	2	6
Caecidotea	2	8
Caenis	6	369
Callibaetis	3	34
Calopteryx	1	1
Ceratopogonidae	1	1
Cheumatopsyche	3	24
Chironomini	3	3
Chironomus	1	7
Cladopelma	2	6
Cladotanytarsus	1	2
Coenagrionidae	6	279
Conchapelopia	4	6
Corixidae	4	9
Corynoneura	4	10
Crambidae	1	1
Cricotopus	5	316
Cryptochironomus	2	2
Dicrotendipes	6	257
Dineutus	1	2
Dubiraphia	6	107
Dytiscidae	1	1
Empididae	1	1
Enchytraeus	3	3
Endochironomus	4	214
Ephydridae	4	10
Eukiefferiella	1	1
Ferrissia	2	39
Fossaria	1	2
Fridericia	1	1
Gerridae	1	1
Glyptotendipes	2	48
Gyraulus	3	46

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
Gyrinus	3	7
Haliplus	6	65
Heptagenia	1	1
Hirudinea	4	9
Hyalella	6	631
Hydroptila	6	80
Hydroptilidae	3	6
Ischnura	2	14
Labiobaetis	4	14
Labrundinia	5	113
Leptoceridae	2	2
Limnophyes	1	3
Lymnaeidae	1	1
Mesovelia	1	3
Micropsectra	5	63
Nais	6	51
Nanocladius	5	16
Nectopsyche	2	6
Nemata	1	1
Neoplasta	1	1
Neoplea	2	20
Neoporus	1	3
Oecetis	5	16
Ophidonais	2	2
Orconectes	6	3
Orthocladiinae	3	6
Orthocladius	2	3
Oxyethira	1	4
Parachironomus	2	36
Parakiefferiella	2	4
Paratanytarsus	6	130
Paratendipes	6	29
Peltodytes	2	2
Phaenopsectra	5	49
Physa	1	2
Physella	6	289
Pisidiidae	5	23
Planorbella	3	61
Planorbidae	2	13
Polypedilum	6	71
Procladius	5	33

Taxonomic name	Quantity of stations where present	Quantity of individuals collected
Procloeon	1	1
Ranatra	1	
Rheotanytarsus	3	16
Sciomyzidae	1	1
Sigara	2	10
Simulium	1	4
Stagnicola	4	18
Stenacron	1	1
Stenelmis	1	1
Stictochironomus	1	1
Tanypodinae	3	6
Tanypus	1	1
Tanytarsini	1	10
Tanytarsus	3	18
Thienemanniella	4	17
Thienemannimyia Gr.	6	193
Trepaxonemata	1	1
Triaenodes	3	5
Trichocorixa	1	1
Tricorythodes	1	1
Tropisternus	2	2
Tubificinae	4	21
Zavrelimyia	5	45

Appendix 5 – Minnesota Stream Habitat Assessment results

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

# Visits	Biological station ID	Reach name	Land use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish cover (0-17)	Channel morph. (0-36)	MSHA score (0-100)	MSHA rating
4	15CD012	Wapsipinicon River	0	8.25	14.63	10.25	14.25	47.38	Fair
Average Habitat Results: Headwaters Wapsipinicon River *Aggregated 12 HUC*			**0**	**8.25**	**14.63**	**10.25**	**14.25**	**47.38**	**Fair**
4	15CD001	Lime Creek (Winnebago River)	0	6.625	5.5	3.25	5	20.375	Poor
4	15CD002	Lime Creek (Winnebago River)	0	8	6	3.75	4	21.75	Poor
4	15CD009	Steward Creek (County Ditch 23)	0	9.625	6	10.75	5.5	31.875	Poor
4	15CD003	Steward Creek (County Ditch 23)	0	8.125	12.5	8.25	9	37.875	Poor
2	15CD011	Trib. to Lime Creek (Winnebago River)	0	8	13.675	11.5	15.5	48.675	Fair
3	15CD005	Judicial Ditch 25	0	7.33	6.67	8	8	30	Poor
2	15CD007	County Ditch 48	0	9	6	10.5	6.5	32	Poor
3	15CD004	Judicial Ditch 26	0	9.83	6.67	11.33	7.67	35.5	Poor
Average Habitat Results: *Lime Creek Aggregated 12 HUC*			**0**	**8.32**	**7.88**	**8.42**	**7.65**	**32.26**	**Poor**

Qualitative habitat ratings

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

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

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