Cannon River Watershed Monitoring and Assessment Report

Minnesota Pollution Control Agency

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List of acronyms

AUID Assessment Unit Identification Determination

CCSI Channel Condition and Stability Index

CD County Ditch

CI Confidence Interval

CLMP Citizen Lake Monitoring Program

CR County Road

CSAH County State Aid Highway

CSMP Citizen Stream Monitoring Program

CWA Clean Water Act

CWLA Clean Water Legacy Act

DOP Dissolved Orthophosphate

E Eutrophic

EQuIS Environmental Quality Information System

EPT Ephemeroptera, Plecoptera, Tricoptera

EX Exceeds Criteria (Bacteria)

EXP Exceeds Criteria, Potential Impairment

EXS Exceeds Criteria, Potential Severe Impairment

FS Full Support

FWMC Flow Weighted Mean Concentration

H Hypereutrophic

HUC Hydrologic Unit Code

IBI Index of Biotic Integrity

IF Insufficient Information

K Potassium

LRVW Limited Resource Value Water

M Mesotrophic

MCES Metropolitan Council Environmental Services

MDA Minnesota Department of Agriculture

MDH Minnesota Department of Health

MDNR Minnesota Department of Natural Resources

MINLEAP Minnesota Lake Eutrophication Analysis Procedure

MPCA Minnesota Pollution Control Agency

MSHA Minnesota Stream Habitat Assessment

MTS Meets the Standard

N Nitrogen

Nitrate-N Nitrate Plus Nitrite Nitrogen

NA Not Assessed

NHD National Hydrologic Dataset

NH3 Ammonia

NS Not Supporting

NT No Trend

OP Orthophosphate

P Phosphorous

PCB Polychlorinated Biphenyls

PWI Protected Waters Inventory

RNR River Nutrient Region

SWAG Surface Water Assessment Grant

SWCD Soil and Water Conservation District

SWUD State Water Use Database

TALU Tiered Aquatic Life Uses

TKN Total Kjeldahl Nitrogen

TMDL Total Maximum Daily Load

TP Total Phosphorous

TSS Total Suspended Solids

USGS United States Geological Survey

WPLMN Water Pollutant Load Monitoring Network

Contents

Executive summary

This assessment report is the first in a series of reports for watershed work being conducted in the Cannon River Watershed. The results of surface water monitoring activities in the Cannon River Watershed are reported here. Subsequent reports will explain stressor identification, Total Maximum Daily Loads (TMDLs), and Watershed Restoration and Protection Strategies (WRAPS) for the watershed.

The Cannon River Watershed (07040002) lies in southeast Minnesota and covers portions of nine counties for approximately 941,000 acres. Larger cities include Northfield, Faribault, and Owatonna. The topography varies across the watershed, from flat and undulating hills in the Straight River lobe, the lake-rich headwaters to the Cannon River, to flat headwater land and steep forested hills in the Middle and Lower Cannon River lobes of the watershed.

Historically, the Cannon River Watershed was home to Native American villages that used the Cannon and Straight Rivers for navigation and fishing. Fur trading, logging, and rich tillable soil brought European settlers to the region. Cities grew along the rivers and railroad corridors. Since immigrants arrived in the 1860s, the Cannon River Watershed has undergone considerable land use modification, including the plowing of its native prairies, harvesting of its hardwood forests, draining of its wetlands, and modifications to its natural stream courses. Many dams were placed along the Cannon and Straight Rivers to harvest the energy of flowing water for operating saw mills and grist mills to supply the growing Minneapolis and St. Paul areas. Additionally, many smaller dams were placed to maintain lake levels and control flooding.

Today, land is predominantly used for growing crops such as corn and soybeans, with some urban and forested land. Numerous parks associated with lakes, rivers, and streams provide recreational opportunities for fishing, canoeing, swimming, hiking, bicycling, geocaching, and bird watching. Drinking water quality and the recreational enjoyment of lakes and streams are valuable assets to the health of its citizens and the wealth of local economies throughout the watershed.

In 2011, the Minnesota Pollution Control Agency (MPCA) undertook an intensive watershed monitoring effort of the Cannon River Watershed's surface waters. One hundred and two (102) sites were sampled for biology at the outlets of variable sized subwatersheds. These locations included: the outlet of the Upper, Middle, and Lower Cannon River; the Upper and Lower Straight River; and several tributaries such as Belle Creek, Little Cannon River, Prairie Creek, Maple Creek, Wolf Creek, Turtle Creek, Heath Creek, Crane Creek, and many smaller headwater streams. Also sampled were a number of trout streams including Trout Brook, Pine Creek, Spring Creek, Little Cannon River, and Spring Brook (also known as Rice Creek). As part of this effort, MPCA also contracted with the Cannon River Watershed Partnership (CRWP) who completed stream water chemistry sampling at the outlets of the Cannon River's 13 major subwatersheds. Over the course of the 10-year assessment window (2002 – 2012), 125 biological stations were sampled for fish and 116 stations were sampled for macroinvertebrates, while water chemistry data was collected on numerous lakes and stream stations by agencies, local watershed groups, and volunteer citizen monitors. In 2013, a holistic approach was taken to assess all of the watershed's surface water bodies for support of drinking water, aquatic life, aquatic recreation, and fish consumption uses where sufficient data were available. During this process, 45 lakes and 70 stream reaches were assessed for aquatic recreation and/or aquatic life. (Not all lake and stream reaches were able to be assessed due to insufficient data and modified channel condition).

Historic flooding occurred in 2010 and is partially responsible for high nutrient and sediment loads observed that year at pollutant load monitoring stations on the Straight and Cannon Rivers. Increased drainage in the watershed along with global climate changes may increase the frequency and magnitude of these types of events in the future. However, the added loads observed may not reflect a recent change in land management practices as data from other years are also indicating that sediment and nutrients derived within this watershed are elevated and may be a cause of impairments.

Across the watershed, four coldwater streams have elevated nitrates which may make drinking water unsafe: Pine Creek and Little Cannon River in Goodhue County, Spring Brook (a.k.a. Rice Creek) in Rice County, and Trout Brook in Dakota County. The only coldwater stream not impaired due to elevated levels of nitrates in drinking water is Spring Creek in Goodhue County.

For aquatic consumption, only five lakes are fully supporting while 18 lakes and the Cannon River between Faribault and Lake Byllesby are impaired due to high levels of mercury in fish, while the Cannon River below the Byllesby Reservoir to the Mississippi River has high levels of polychlorinated biphenyls (PCBs). Fish consumption advisories have been recommended for lakes across the watershed. Many additional lakes have not yet been assessed. The five lakes that are fully supporting aquatic consumption are Beaver, Dora, German, Jefferson, and Roberds.

Thirty-six lakes do not support aquatic recreation use due to elevated nutrients that may cause unsightly algae blooms that could make swimming in them undesirable or unsafe. Most of the impaired lakes are located west of Faribault where agricultural land use dominates lake watersheds. Due to a number of projects aimed at managing nutrients, Lake Volney has declining nutrient levels and is showing an improving trend in water clarity. While many of the lakes in the Cannon River Watershed are highly eutrophic (nutrient rich), five lakes stand out as high quality resources for recreation: Roemhildts, Fish, Dudley, Kelly, and Beaver. These lakes generally benefit from being in relatively intact, small watersheds and from their depth. Protection efforts should be put in place to keep the quality of these lakes high.

Excessive bacteria that may make activities in or on the water unsafe were found in rivers and streams across the watershed including the Straight River, Cannon River, and many smaller streams for a total of 41 impairments. Bacteria issues are widespread not only in the Cannon River Watershed, but much of the Lower Mississippi River Basin. A regional TMDL and implementation plan has been developed and projects are underway to better manage bacteria sources.

Fish and macroinvertebrate communities across the watershed are showing a loss of sensitive species due to water pollution and habitat issues. Biological indices (F-IBI and M-IBI) were compared between pre and post flooding (2004 and 2011) and no significant difference in scores was observed indicating that the 2010 flood was not a driver in the fish and macroinvertebrate impairments found. Currently, there are 38 stream reaches that are not supporting aquatic life with one or more impairments, while only 14 stream reaches are supporting. In addition, 12 stream segments were not assessed for aquatic biology because the stream at the biological station is greater than 50% channelized. (Channelized reaches are currently not being assessed until new biological standards can be applied.) Channelized streams ranged from good to poor across the watershed based on their fish and macroinvertebrate assemblages.

While many streams are impaired for aquatic life use, there are other streams that were assessed as fully supporting or have special concern species with specific habitat requirements. For example, the Little Cannon River subwatershed was the only location where the redside dace was collected. The Middle and Lower Cannon River subwatersheds also have a number of beautiful coldwater streams that support brook and brown trout communities, including Trout Brook, Pine Creek, Spring Brook, Belle Creek, Spring Creek (a.k.a. Rice Creek) and the Little Cannon River. However, many of these coldwater streams have macroinvertebrate impairments. For warmwater streams, Maple Creek, Falls Creek, Turtle Creek, Mud Creek, and the Lower Cannon River were supporting aquatic life of both fish and macroinvertebrates with many pollution sensitive species collected. These streams and others should be considered for additional protection to prevent additional aquatic life impairments in the future.

Land use changes in vegetation, loss of wetlands, ditching, urban development, and over application of fertilizers have all likely contributed to algal blooms, potentially unsafe swimming conditions, fishing advisories, drinking water impairments, and loss of sensitive aquatic species. Increased bacteria levels, nutrients in surface and groundwater, and flashy stream flows are threats to the quality of the water resources in much of the watershed today. This watershed has a diverse landscape and the main sources and drivers of water quality issues may vary between regions. A number of pollution source studies and remediation projects have been implemented or are in development that target reductions in nutrients, turbidity, bacteria, and mercury in fish. Additional measures are needed in order to improve and protect water quality throughout the Cannon River Watershed.

Urban expansion into rural/agricultural areas has heightened concern for groundwater in this watershed where the karst geology allows contaminants to transfer rapidly from the surface directly to groundwater. Two particular contaminants of concern are chloride, which is a concern due to the surface application of deicers, and nitrate, a well-documented contaminant of concern primarily from agricultural fertilizer application in the Cannon River Watershed. Pollution prevention from identified sources is the most effective method for groundwater protection in these areas.

The concept of groundwater-surface water interaction and potential effects on waterbodies is an area of new and growing concern for the watershed. The direct correlation of increasing groundwater withdrawals and decreasing surficial water quantity has been documented in other areas of Minnesota, such as Little Rock Creek due to irrigation in north central Minnesota, and White Bear Lake in the city of White Bear Lake, a suburb of St. Paul. To provide a detailed cause and effect between withdrawals and water quantity is beyond the scope of this report. However, further groundwater review would be justified due to the statistically significant increases in groundwater withdrawals and Karst geology of this watershed.

Through the collaboration of state and local agencies, landowners, and citizens, improvements in water quality will protect drinking water and provide scenic and recreational opportunities that enhance the quality of life and economic vitality of the Cannon River Watershed.

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 support the restoration and protection 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 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 Cannon River Watershed beginning in the summer of 2011. This report provides a summary of all water quality assessment results in the Cannon River Watershed and incorporates all data available for the assessment process including watershed monitoring, volunteer monitoring and monitoring conducted by local government units.

I. The watershed monitoring approach

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

Watershed Pollutant Load Monitoring Network

Funded with appropriations from Minnesota's Clean Water Legacy Fund, the Watershed Pollutant Load Monitoring Network (WPLMN) is a long-term program designed to measure and compare regional differences and long-term trends in water quality among Minnesota's major rivers including the Red, Rainy, St. Croix, Mississippi, and Minnesota, and the outlets of the major tributaries (8 digit HUC scale) draining to these rivers. Since the program's inception in 2007, the WPLMN has adopted a multi-agency monitoring design that combines site specific stream flow data from United States Geological Survey (USGS) and Minnesota Department of Natural Resources (MDNR) flow gaging stations with water quality data collected by the Metropolitan Council Environmental Services (MCES), local monitoring organizations, and Minnesota Pollution Control Agency WPLMN staff to compute annual pollutant loads at 79 river monitoring sites across Minnesota. Data will also be used to assist with: TMDL studies and implementation plans; watershed modeling efforts; and watershed research projects.

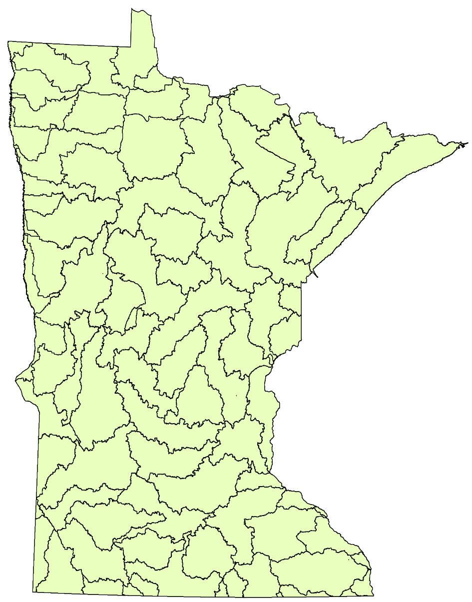

Figure 1. Major watersheds within Minnesota (8-Digit HUC).

Between the years of 2008 and 2011, intensive water quality sampling occurred throughout the year at all WPLMN sites. Sampling frequency is greatest during periods of moderate to high flow. Low flow sampling occurs at a lesser frequency as concentrations of monitored parameters are generally more stable during these periods. Despite discharge related differences in sample collection frequency, this staggered approach to sampling generally results in samples being well distributed over the entire range of flows.

Intensive watershed monitoring

The intensive watershed monitoring (IWM) strategy utilizes a nested watershed design allowing the sampling of streams within watersheds from a coarse to a fine scale. Each watershed scale is defined by a hydrologic unit code (HUC). These HUCs define watershed boundaries for water bodies within a similar geographic and hydrologic extent. The foundation of this approach is the 81 major watersheds (8-HUC) within Minnesota. Using this approach many of the smaller headwaters and tributaries to the main stem river are sampled in a systematic way so that a 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: major watershed (i.e., Cannon River), subwatersheds (e.g., Belle Creek), and minor subwatersheds (e.g., Tributary to Belle Creek). 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 watershed (designated with purple dot in Figure 2) is sampled for biology (fish and macroinvertebrates), water chemistry and fish contaminants to allow for the assessment of aquatic life, aquatic recreation and aquatic consumption use support. The subwatershed is the next smaller watershed scale which generally consists of major tributary streams with drainage areas ranging from 75 to 150 mi^2. Each subwatershed outlet (designated with green dots in Figure 2) is sampled for biology and water chemistry for the assessment of aquatic life and aquatic recreation use support. Within each subwatershed, smaller minor subwatersheds (typically 10-20 mi^2), are sampled at each outlet that flows into the tributary subwatersheds. Each of these minor subwatershed outlets is sampled for biology to assess aquatic life use support (designated with red dots in Figure 2).

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

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

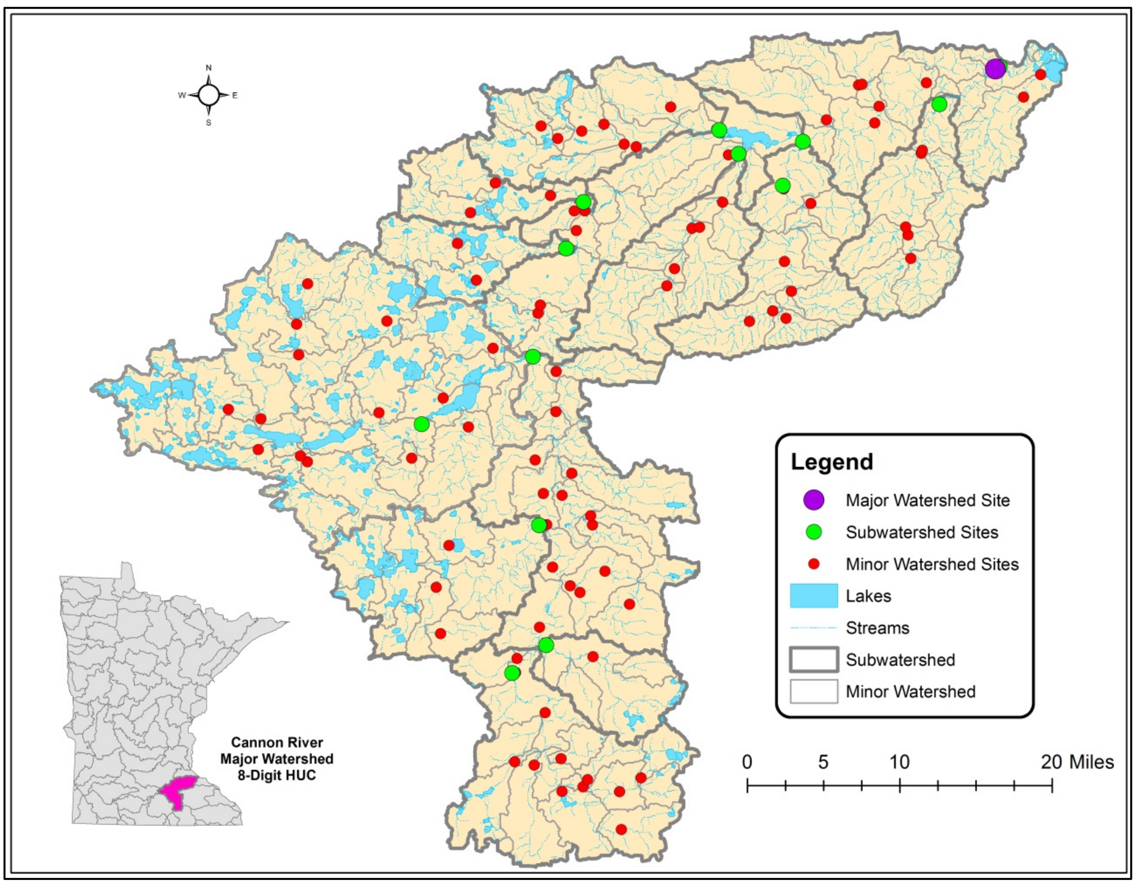

Figure 2. Intensive watershed monitoring sites for streams in the Cannon River Watershed.

Citizen and local group monitoring

Citizen and local monitoring is an important component of the watershed approach. The MPCA and its local partners jointly select the stream sites and lakes to be included in the IWM process. Funding passes from MPCA through Surface Water Assessment Grants (SWAGs) to local groups such as counties, soil and water conservation districts (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. For the Cannon River Watershed, CRWP received SWAG funding to organize citizen monitors to assist in collecting water chemistry data at the outlets of 13 subwatersheds (10x monitoring, Figure 3) and four lakes.

The MPCA also coordinates two programs aimed at encouraging long term citizen surface water monitoring: the Citizen Lake Monitoring Program (CLMP) and the Citizen Stream Monitoring Program (CSMP). Like the permanent load monitoring network, having citizen volunteers monitor a given lake or stream site monthly and from year to year can provide the long-term picture needed to help evaluate current status and trends. Citizen monitoring is especially effective at helping to track water quality changes that occur in the years between intensive monitoring years. Figure 3 provides an illustration of the locations where citizen monitoring data were used for assessment in the Cannon River Watershed. Locations depicted were active in the 2012 monitoring year.

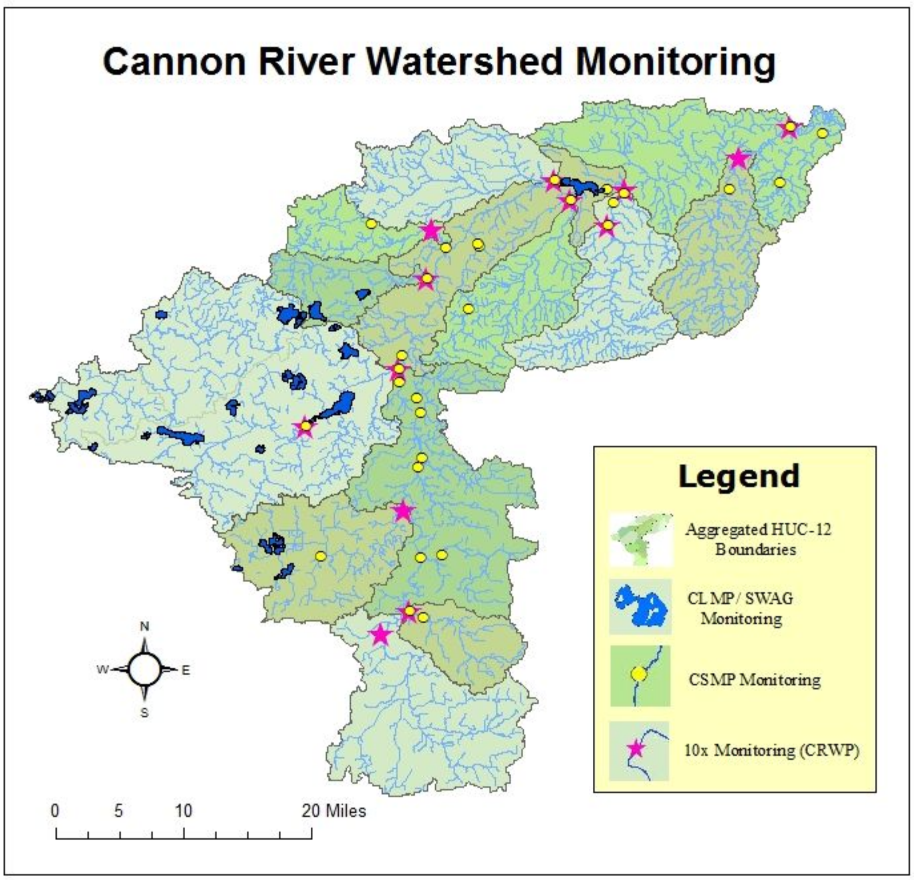

Figure 3. Monitoring locations of local groups and citizen volunteers in the Cannon River Watershed.

II. Assessment methodology

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

Water quality standards

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

Protection of aquatic life means the maintenance of a healthy aquatic community, including fish, invertebrates and plants. The sampling of aquatic organisms for assessment is called biological monitoring. Biological monitoring is a direct means to assess aquatic life use support, as the aquatic community tends to integrate the effects of all pollutants and stressors over time. Interpretations of narrative criteria for aquatic life in streams are based on multi-metric biological indices including the Fish Index of Biological Integrity (F-IBI), which evaluates the health of the fish community, and the Macroinvertebrate Index of Biological Integrity (M-IBI), which evaluates the health of the aquatic invertebrate community. Additionally, chemical parameters are measured and assessed against numeric standards developed to be protective of aquatic life, including pH, dissolved oxygen (DO), un-ionized ammonia nitrogen, chloride, and turbidity.

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

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

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

Assessment units

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

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

Determining use attainment

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

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

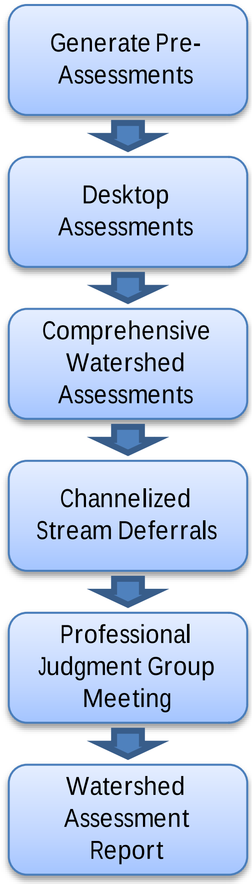

Figure 4. Flowchart of aquatic life use assessment process.

The next step in the process is a Comprehensive Watershed Assessment meeting where reviewers convene to discuss the results of their desktop assessments for each individual waterbody. Implementing a comprehensive approach to water quality assessment requires a means of organizing and evaluating information to formulate a conclusion utilizing multiple lines of evidence. Occasionally, the evidence stemming from individual parameters are not in agreement and would result in discrepant assessments if the parameters were evaluated independently. However, the overall assessment considers each piece of evidence to make a use attainment determination based on the preponderance of information available. See *the Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment 305(b) Report and 303(d) List* (MPCA 2012) http://www.pca.state.mn.us/index.php/view-document.html?gid=21258 for guidelines and factors considered when making such determinations.

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

The last step in the assessment process is the Professional Judgment Group (PJG) meeting. For the Cannon River Watershed, this meeting was held on April 2013 in Northfield. At this meeting, initial assessment determinations 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. Attendees for the Cannon River Watershed PJG meeting included staff from MPCA, MDNR, county SWCDs (Goodhue, Rice, and Steele), St Olaf College, and the CRWP. Information obtained during this meeting may be used to revise previous use attainment decisions (e.g., sampling events that may have been uncharacteristic due to annual climate or flow variation, local factors such as impoundments that do not represent the majority of conditions on the AUID). Waterbodies that do not meet standards and therefore do not attain one or more of their designated uses are considered impaired waters and are placed on the draft 303(d) Impaired Waters List. Assessment results are also included in watershed monitoring and assessment reports.

Data management

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

Period of record

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

III. Watershed overview

The Cannon River Watershed drains 946,440 acres (1460 mi^2) in southeastern Minnesota and consists of two river systems: the Cannon River and the Straight River (Figure 5). From west to east, the Cannon River travels 112 miles between Shields Lake and the Mississippi River north of Redwing. From south to north, the Straight River flows 56 miles through the cities of Owatonna and Medford before connecting with the Cannon River downstream of the dam in Faribault.

The Cannon River Watershed spans a portion of nine counties (Figure 6). The six counties with the largest land area in the watershed include Steele, Rice, Goodhue, Dakota, LeSueur, and Waseca while small portions of Scott, Blue Earth, and Freeborn dot the periphery of the watershed.

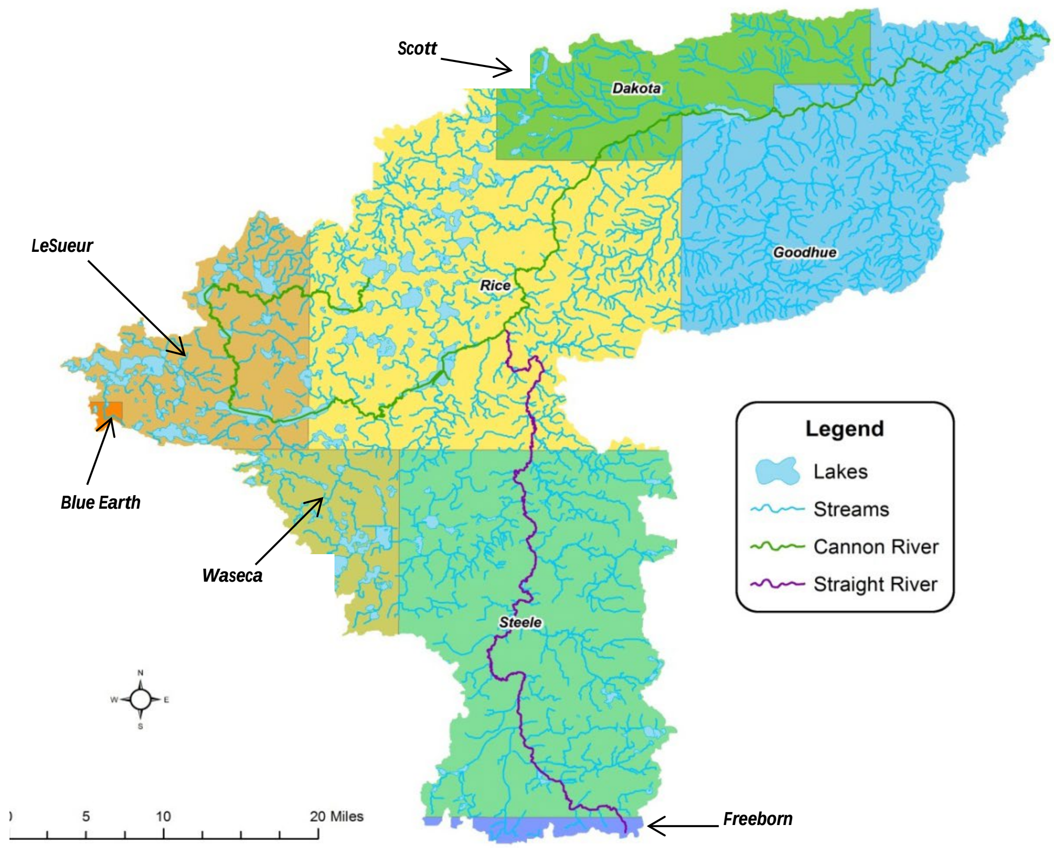

Figure 5. Counties and river courses within the Cannon River Watershed.

The waters of the watershed provide drinking water for households and industry, habitat for aquatic life, riparian corridors for wildlife, and many recreational opportunities. The Cannon River is designated as a Wild and Scenic River starting downstream of its confluence with the Straight River in Faribault. Both the Cannon and Straight River are managed by the MDNR as state water courses that are navigable by canoe and kayak. These rivers pass through scenic landscapes of variable terrain, from the flat wooded floodplains along the Straight River to sandstone, limestone, and dolomite blufflands in the Driftless Area in the lower reaches of the Cannon River. The watershed has numerous lakes that are managed for game fish recreation and a number of trout streams with Brook, Brown, and Rainbow trout that bring local and many Twin Cities residents to the area for fly fishing. Other natural areas for recreational enjoyment include state parks such as Nerstrand Big Woods and Sakata Lake, scenic and natural areas, county parks, and bike trails which provide opportunities for fishing, hiking, cross-country skiing, biking, snowmobiling, birdwatching, geocaching, morel hunting, and viewing of rare and endemic plants such as the Minnesota Dwarf Trout-Lilly (*Erythronium populans*) and Prairie Bush- Clover (*Lespedeza leptostachya*), among others.

The Cannon River Watershed is comprised of three Level III ecoregions (Figure 6): North Central Hardwoods (NCH), Western Cornbelt Plains (WCBP) and Driftless Area (Omernik and Gallant 1988). The ecosystem framework attempts to characterize broad regional differences in geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology (Omernik 1995) and consequent ecosystem responses to disturbance (Bryce et al. 1999) in order to assist agencies and organizations in design and implementation of effective management strategies (Omernik et al. 2000).

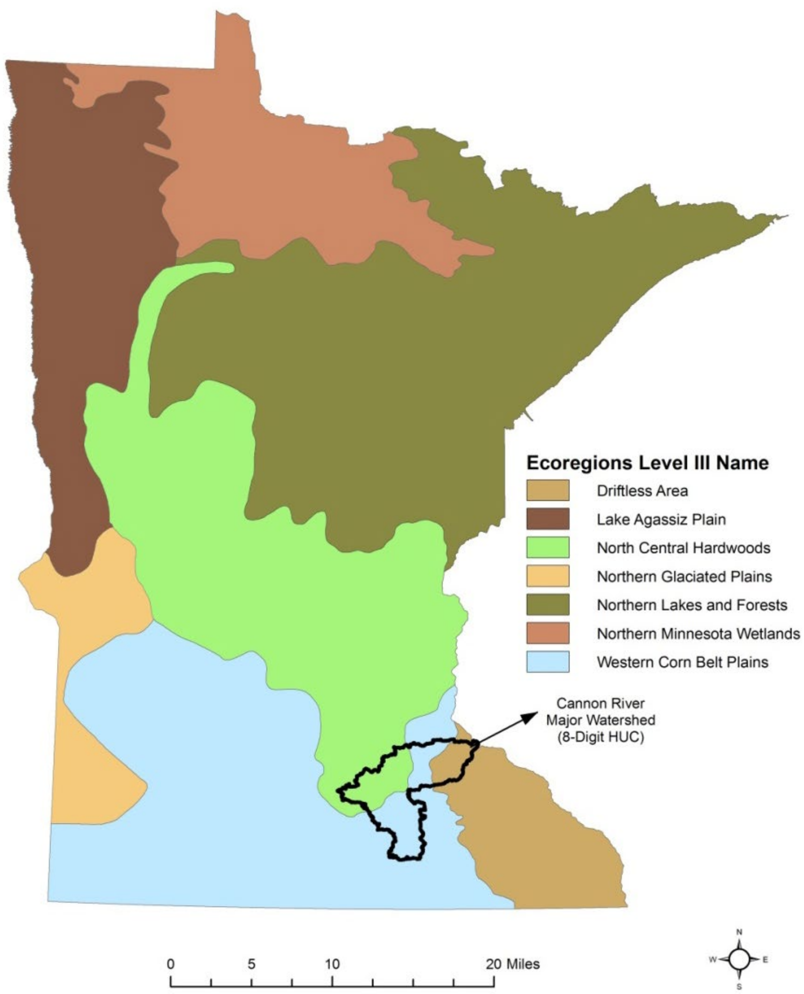

Figure 6. The Cannon River Watershed within the Level III ecoregions of Minnesota.

The Level III ecoregions were recently further subdivided into Level IV ecoregions (EPA 2007). In the northwest corner of the watershed lies the southern extent of the NCH and includes the Big Woods (51i). This region was once hardwood forests covering rolling plains dotted with lakes. Today the hardwood forests have largely been removed and the region is dominated by row-crop agriculture and residential development. The northern lobe of the WCBP runs through the south and central regions of the watershed, which includes the headwaters of the Straight River and central portion of the Cannon River. The portion along the Straight River lies within the eastern Iowa and Minnesota Drift Plains (47c) which is described as an “older glacial till plain with mostly row crops and some pasture” while the Cannon River portion falls within the Lower St Croix and Vermillion Valleys (49j) which is described as a “dissected till plain and outwash valleys with a mix of row crops and pasture” (EPA 2007). On the eastern side lies the Blufflands and Coulees (51i) region of the Driftless Area. This region has steep hills and plateaus and was densely forested. For a time, these steep hills were intensely farmed; however, today, many acres are now managed as forest with cropland and pasture in the valleys.

Geology/soils

Overall, the geology of the Cannon River Watershed has soil topped plateaus of loess that are deeply dissected by river valleys (NRCS 2007). Loess is very fine glacial material that is easily erodible. Loess thickness is variable across the watershed with deposits ranging from 30 feet thick on broad ridgetops, to less than a foot on valley walls (NRCS 2007) with less erodible sedimentary rock such as sandstone and limestone exposed along rivers and road cuts.

The Cannon River Watershed has three major land resource areas (Figure 7). The central Iowa and Minnesota Till Prairies covers the largest portion of the western and southern extent of the watershed including almost all of the Straight River Watershed, and all of the Upper Cannon, Wolf Creek, Heath Creek, and western side of the Middle Cannon Watershed. Part of the Des Moines Lobe of the Wisconsin ice sheet, the land is mostly a rolling glaciated plain of sand and gravel with higher hills formed by glacial meltwaters with lake plains in some areas. Consequently, the geology is predominantly glacial till, outwash and glacial lake deposits with clay, silt, sand, and gravel fill the bottoms of most of the major river valleys (NRCS 2006). Soils are generally very deep, loamy, and range from well drained to very poorly drained. The eastern Iowa and Minnesota Till Prairies encompasses land near Northfield and Cannon Falls and including the Byllesby Reservoir with small portions on the eastern side of the

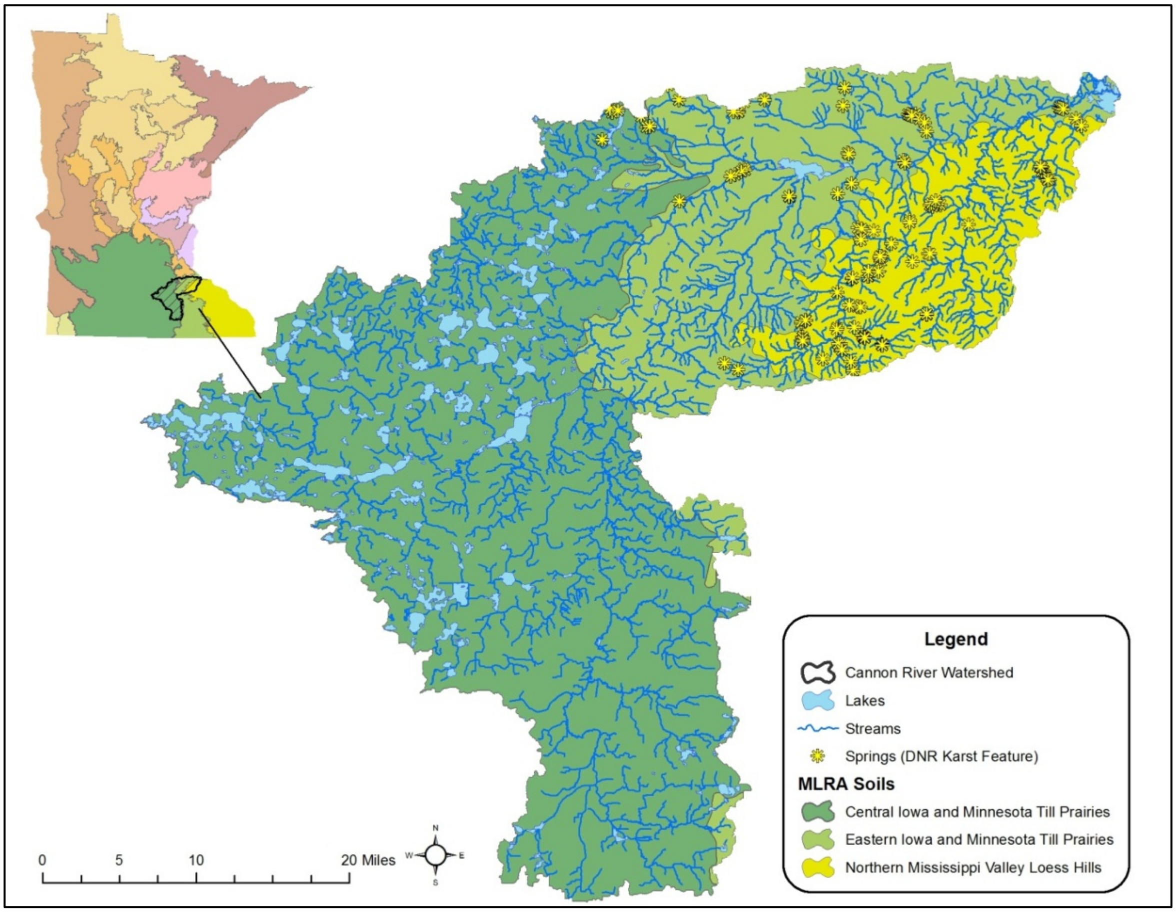

Figure 7. Major land resource areas and springs in the Cannon River Watershed.

Straight River Watershed, lower Middle Cannon River, Prairie Creek, Chub Creek, and northern half of the Lower Cannon River subwatersheds. The topography is gently rolling with few lakes and ponds. The geology is a mix of glacial till and outwash deposits with clay, silt, sand, and gravel fills the major river valleys. Karst features exist in this area with shallow depth of soils and glacial material covering limestone. Soils are classified as well drained to very poorly drained. Subsurface drain tile is commonly used to lower water tables and increase crop production (NRCS 2006). Northern Mississippi Valley Loess Hills lies on the far eastern extent of the watershed and includes Belle Creek, the Little Cannon, and Spring Creek watersheds. This region is part of what is known as the "Driftless Area" because it underwent limited landscape formation by glacial ice. The resulting landscape is mostly gently sloping to rolling summits that create scenic landscapes of deep valleys, abundant rock outcrops, high bluffs, caves, crevices, and sinkholes (NRCS 2006). Limestone and sandstone outcrops are observed along some streams and rivers in the area. Loess deposits cover bedrock in many areas. Some karst areas exist where carbonate rocks are near the surface. Soils are generally moderately deep to very deep, loamy, and well drained to moderately well drained.

Land use summary

Historically, the Cannon River was used as a navigation corridor by the Oneota, a tribe of Native Americans who lived in large villages along the Cannon River (MDNR 1979), and by fur traders who traveled between the Mississippi River and inland. When French fur traders arrived in the area, they saw a great number of canoes along the river banks and so named the river "La Riviere aux Canots" meaning "the river of canoes". As new immigrants moved westward, they saw great opportunities in logging the hardwood forests. Dams were built along the Cannon River to harvest the energy of flowing water to operate saw mills that were springing up along the railroad corridor and along the Mississippi River. As the woodlands fell to the ax, the fertile soils brought another wave of newcomers to area that planted wheat and converted the timber mills to grist mills (MDNR 1979). By 1887, there were 15 flour mills along the Cannon River between Faribault and Northfield alone (http://www.dnr.state.mn.us/watertrails/cannonriver/more.html). During this early era of farming, horses were used to pull plows up and down the newly denuded and steep hills of the Driftless Area, and as a consequence heavy rains washed the fine loess soil down to streams where deep layers of soil buried streams, including the Little Cannon River and Belle Creek. During the 1930s, an era of conservation farming began, and various strategies were adopted to limit soil loss from uplands and greatly reduce excess sedimentation in streams (Trimble and Lund 1982). However, during the same time period, canning operations discharged directly into the Straight and Cannon Rivers causing fish kills (CRWP and MSU 2011), while untreated sewage polluted these rivers as well as many other streams in the watershed.

Also since the early 1900s, many wetlands were drained (see section on wetlands below), stream courses were straightened, and tile lines were laid in order to increase the amount of land that could be cultivated. However, these actions also greatly changed the hydrology (amount and speed of water moving through land to waterbodies) of the watershed which has led to increased bank erosion, turbidity impairments, excess sedimentation, and reduced habitat quality in many streams throughout the watershed, but especially in the Middle and Lower Cannon River lobes.

In the early 1900s, the Cannon River supported a high diversity and abundance of mussels. During the 1940s, mussel beds were harvested heavily to supply the shell button industry. Over extraction, land use, and dams, caused many species of mussels to disappear and it became a rare experience to find any mussels along the Cannon River (CRWP and MSU 2011). Since then, mussel populations have partially rebounded. An MDNR mussel survey during the 1980s (Davis 1987) found 15 species of mussels at 61 locations throughout the watershed. During 2011 and 2012, the MDNR resurveyed many of the same locations and added other survey sites (Secrist and Davis, *unpublished*). Two additional live mussel species were found, bringing the number of live species collected in recent decades in the Cannon River

Watershed to 17. The abundance of many mussel species was also greater during the more recent survey, suggesting that mussels are continuing to recover. This recovery is likely aided by water pollution control measures implemented under the CWA of the 1970s. However, several challenges for mussel populations still exist. For example, dams limit the range of host fish species that carry mussel larvae, often blocking their upstream migration. More erosive stream flow has resulted from draining of wetlands, ditching, and tile drainage. With more volume and power, these flows scour stream banks and disturb and bury mussel beds. These alterations to the stream system continue to limit the occurrence and abundance of many species.

Today, the Cannon River Watershed is comprised of a variable mix of agriculture, forest, and developed land (Figure 8). Agriculture is the dominant land use (76.3%), consisting of cropland (60.5%) and rangeland (15.7%). Cropland is used predominantly for growing corn and soybeans. Forest (9.4%) and wetland (3.1%) comprise 12.5%. Developed land (e.g., industrial land use, urban and rural housing, roads) is 8.4%. Open water (e.g., lakes, rivers, streams, ditches) accounts for 2.9%.

The total watershed population is approximately 194,000 people (NRCS 2007). The three largest cities stretch along the banks of the Straight and Cannon Rivers: Owatonna, Faribault, and Northfield. Smaller cities line the river banks and are scattered throughout agricultural areas: Waseca, Ellendale, Medford, Waterville, Morristown, Kilkenny, Lonsdale, Dundas, Cannon Falls, New Trier, Miesville, Randolph, Dennison, Nerstrand, and Welch. Several unincorporated communities dot the watershed as well.

As of 2008, there were 20 small communities in the watershed identified as needing wastewater management improvements. The wastewater treatment concerns ranged from outdated septic systems to individual and community straight pipe connections to lakes and streams. Since that time, many communities (e.g., Hope, Bixby, Beaver Lake, Meriden) have completed several types of wastewater management improvements, including installation of new individual and cluster subsurface sewage treatment systems, connection to existing treatment facilities, and construction of new community wide wastewater treatment facilities. County ordinances, inspections, and enforcement actions continue to make significant progress toward resolving wastewater issues.

There are 3,172 farms in the watershed, with 65% owning <180 acres, 22% owning 180 to 500 acres, 8% owning 500 to 1,000 acres, and 5% owning >1,000 acres (NRCS 2007). Cropland is used predominantly for growing corn and soybeans. Feedlots are scattered throughout the watershed with over 1,400 containing >20 animal units consisting of pigs, birds (chicken, turkey), bovines (beef, dairy), goats, deer/elk, and llamas. Eight feedlots manage over 1,500 animal units, the largest of which manages over 2,880 animal units; these larger operations manage primary pigs, birds, and bovines.

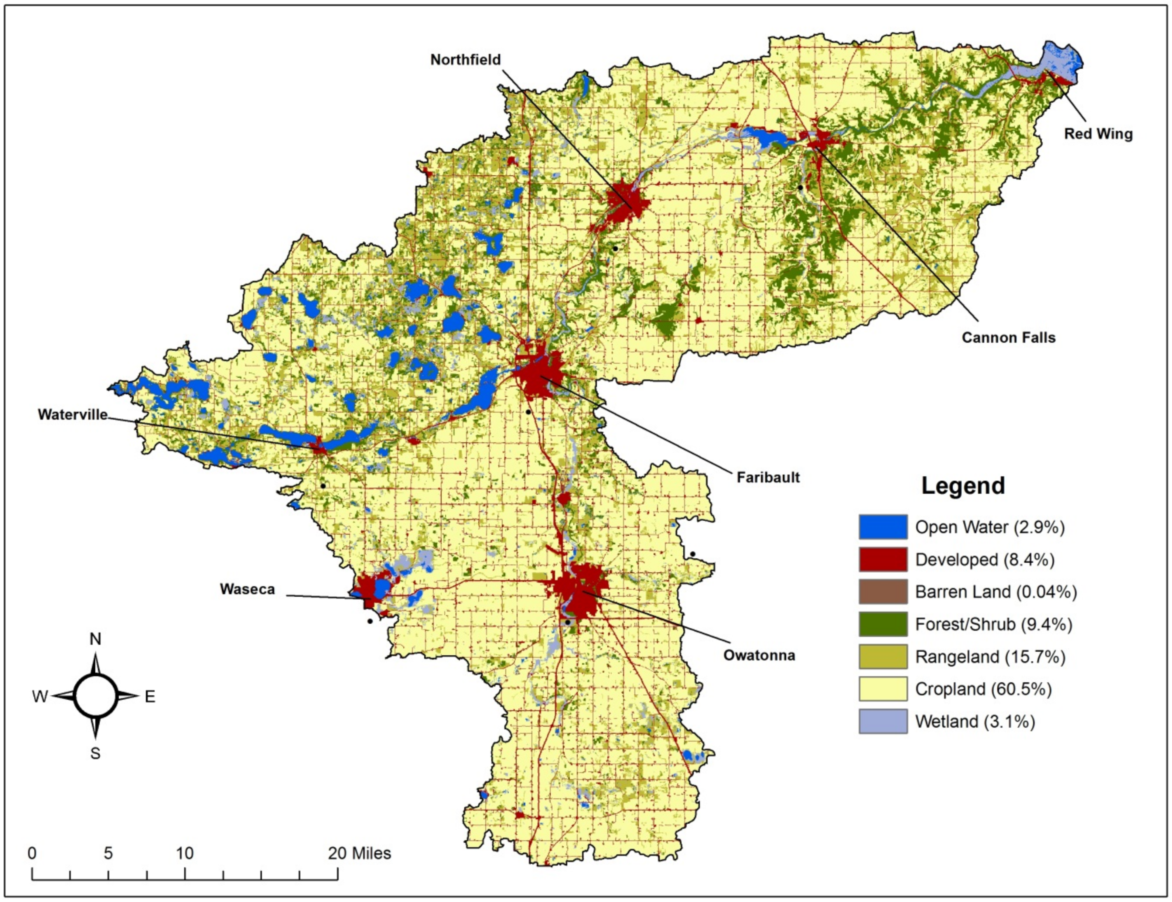

Figure 8. Land use in the Cannon River Watershed.

According to the NRCS (2007) report, the top resource concerns in the watershed include: soil quality/surface water quality – excessive sheet and rill erosion; animal waste management; stormwater management; sediment and erosion control; groundwater protection; water quality; nutrient management; and wetland management. While erosion due to overland water transport has been greatly reduced in recent years, wind erosion has increased (NRCS 2007); this erosion can contribute to turbidity and nutrient impairments. Animal waste has the potential to enter streams and lakes when placed near waterbodies without adequate containment or run-off control. Increases in urban development have led to increases in stormwater volume which can erode stream banks and surpass treatment facility storage capacity. Excess sediment derived from overland erosion on unprotected cropland, urban lands, and increased stormwater volume can exacerbate eroding stream banks and stream bottoms thereby reducing water quality and limiting suitable habitat conditions for aquatic organisms. The Cannon River Watershed is susceptible to groundwater contamination due to geology and soil characteristics, shallow groundwater aquifers, abandoned wells, aging septic systems, and historical tiling practices (NRCS 2007). Excess nutrients (e.g., phosphorus, nitrogen) derived from fertilizer for lawns and cropland, undermanaged waste (e.g., aging septic systems, basic water treatment technology, unsewered communities) and manure runoff from feedlots and cropland can contribute to unsightly and sometimes toxic algae conditions in lakes and rivers. Loss of wetlands and plowing in periodically flooded riparian areas has led to increases in stormwater volume and nutrients entering lakes and streams.

Wetlands

Historically, 294,000 acres of wetlands (~31% of watershed area) covered the Cannon River Watershed prior to European settlement (soil survey staff, NRCS 2013), including a >10,000 acre wetland complex in the headwaters of the Straight River. This estimation of historical wetland acres is based on the Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, and is a summation of “all hydric” map units. In contrast, according the National Wetlands Inventory (NWI) identification of wetland acreage, the Cannon River Watershed presently has only a fraction of its original wetland acreage (~56,000 acres of wetlands, or ~6% of the watershed area). Therefore, a comparison of these two time periods (i.e., pre-settlement vs early 1980s) yields an estimate of 81% wetland loss for the Cannon River Watershed.

Wetlands with herbaceous emergent (i.e., marsh) vegetation are the most predominant wetland type in the watershed (Figure 9). The distribution of wetlands across the watershed is not uniform with the majority of wetland area occurring in the west-central region, corresponding to the Upper Cannon River, Wolf Creek, Heath Creek, Chub Creek, and Crane Creek subwatersheds. In addition, an extensive corridor of floodplain wetlands (forested, emergent, and shallow open) occurs along the lower reaches of the Cannon River as it empties into the Mississippi River. It should be noted that these estimates represent a snapshot of the location, type, and extent of wetlands occurring in the early 1980s, which is the time period that aerial imagery was acquired to develop NWI maps in this part of the state. Updated NWI maps are currently available for select counties in the watershed (Dakota, Scott, Rice, and Goodhue) that were included in a recent update of wetland spatial data for the east-central region of Minnesota based on 2010 and 2011 aerial imagery. Soil data can be used to estimate the extent of historic or pre-settlement wetlands that can serve as a baseline against which current wetland acreage can be compared.

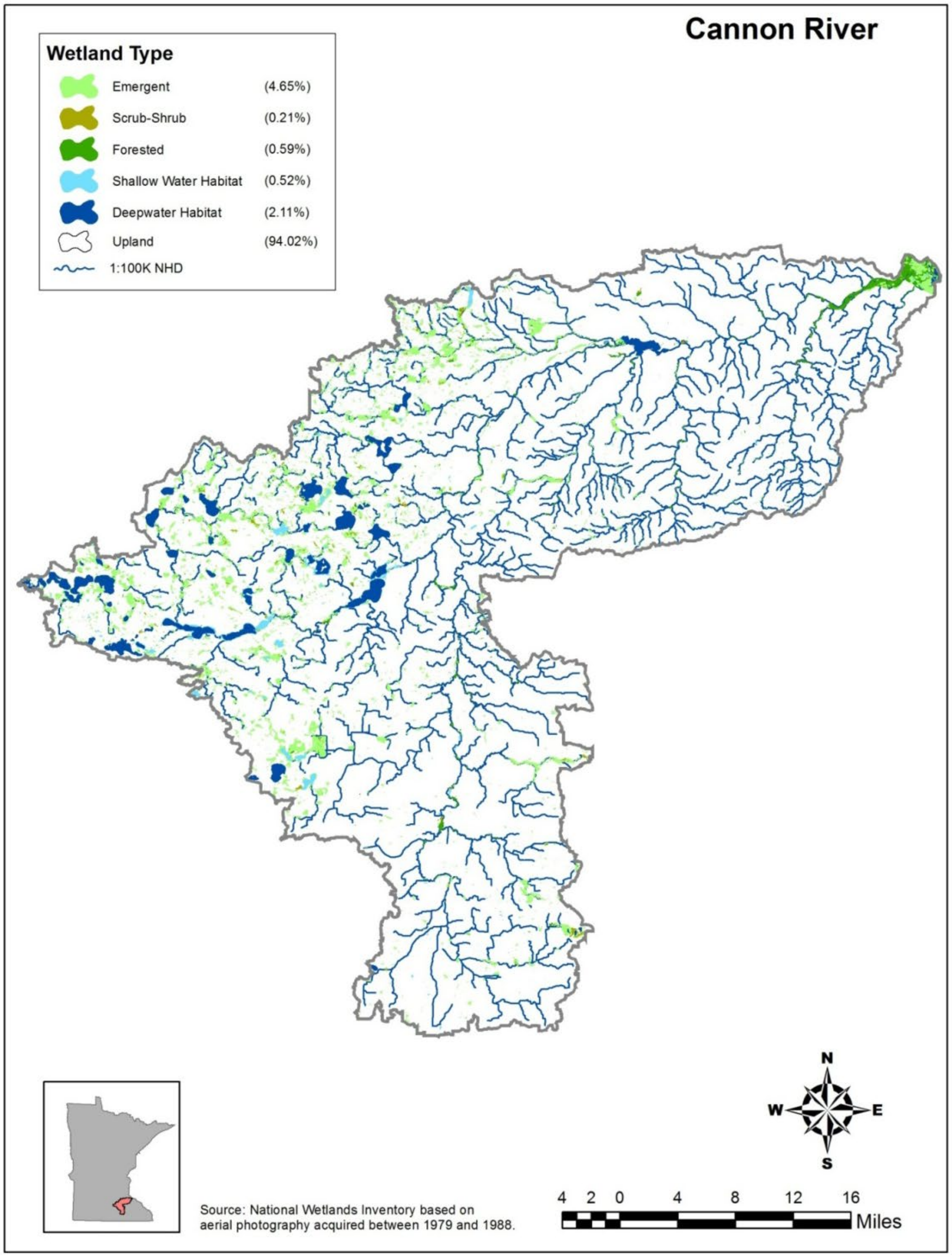

Figure 9. Wetland types and their distribution across the Cannon River Watershed.

Wetland loss is not uniformly distributed across the watershed with the greatest rates of loss occurring in the Upper Straight River (96%), Lower Straight River (94%), Turtle Creek (94%), and Little Cannon River (90%) subwatersheds (Figure 10). Due in large part to its topographic relief, the Lower Cannon River subwatershed had one of the lowest pre-settlement wetland acreage estimates and the lowest rate of wetland loss (43%) in the watershed.

Some efforts to restore wetland acreage in the Cannon River Watershed have occurred over the last few decades (See information on the Straight River Marsh Project at http://www.steeleswcd.org/ProSerRIM.htm). Approximately, 2,300 acres of a 10,000 acre wetland have been set-aside as wetland acres through conservation easements and acquisition of public lands.

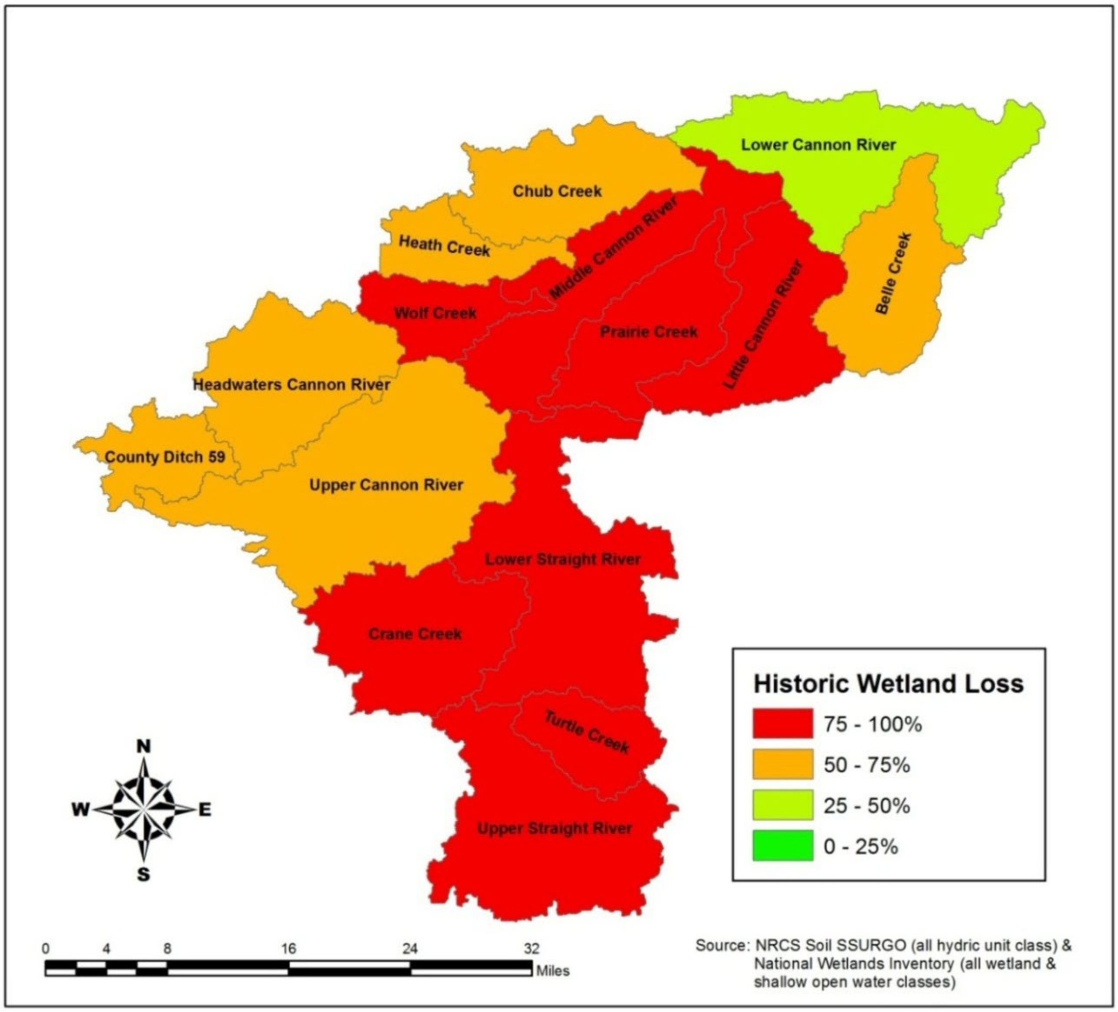

Figure 10. Estimated historic wetland loss in each subwatershed based on a comparison of "all hydric" soil types (SSURGO database) to wetland extent in the early 1980s (NWI).

Surface water hydrology

The Cannon River Watershed consists of two river systems: the Cannon River and the Straight River (Figure 11). From the south, the Straight River headwaters begin as a fan of smaller stream and ditches stretching from Ellendale to north of Blooming Prairie. Along its way, it connects with Turtle Creek, Maple Creek, and Crane Creek before flowing into the Cannon River in Faribault. The headwaters of the Cannon River begin as the outflow of Shields Lake on the western side of the watershed. The mainstem of the Cannon River then curves west and south through an alternating chain of streams and lakes north of Waterville before heading east through lakes Tetonka and Sakata. The Cannon River then flows east until it enters the Cannon Lake Reservoir in Faribault. From there the combined stream flow of the Straight and Cannon River travels east and picks up outlow from Wolf Creek, Heath Creek, Chub Creek, and Prairie Creek before passing through Dundas and Northfield and entering the Byllesby Reservoir west of Cannon Falls. From the Byllesby Reservoir, the Cannon River flows east past scenic limestone bluffs in the Driftless Area near Welch. The Driftless Area has many coldwater springs that feed tributary streams to the Cannon River such as Trout Brook, Pine Creek, Spring Creek, Belle Creek, and the Little Cannon River. Finally, the Cannon River empties into the Mississippi River north of Red Wing.

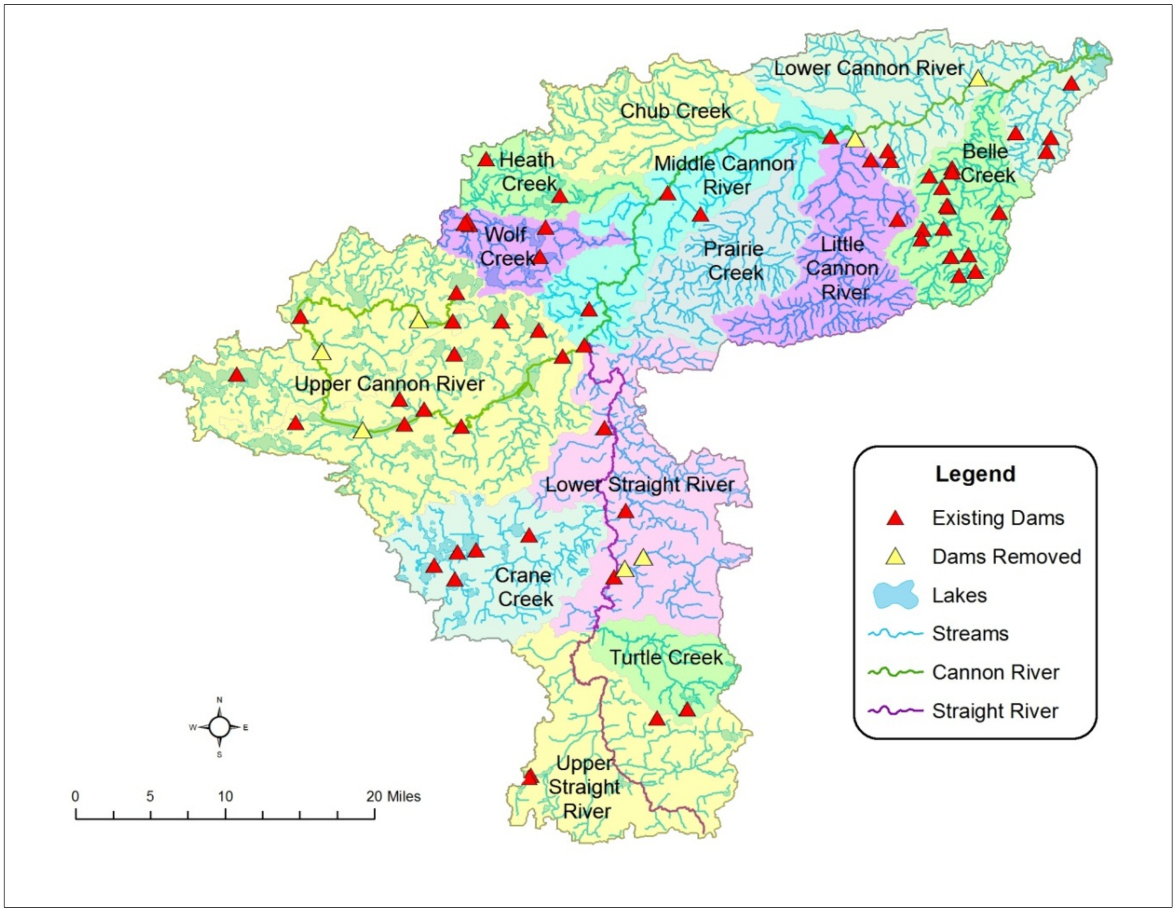

Figure 11. Subwatersheds of the Straight and Cannon Rivers with locations of dams (existing and removed).

Historically, a number of dams were built along the Straight and Cannon Rivers and tributary streams in order to harness the energy of flowing water for operating mills, control flooding, and manage water levels of recreational lakes and reservoirs. Many of these dams act as fish barriers, preventing fish migration between spring spawning areas and refugia during winter months and large flooding events. In addition, many species of mussels have disappeared or have had numbers greatly reduced in association with land use changes, over extraction, and dams that limit mussel dispersal since certain species of migratory fish are hosts for mussel larvae. During the last 30 years, three larger dams have been removed -- on the Cannon River at Welch in 1994 and at Cannon Falls in 2001, and the Morehouse dam on the Straight River in Owatonna in 2006. According to MDNR, many species of fish that previously were only collected downstream of the dam in Welch are now found along the Cannon River further upstream.

Climate and precipitation

Recent precipitation trends in Minnesota for IWM calendar years 2011 and 2012 are shown in Figures 12 and 13. On the left is total precipitation, showing the typical pattern of increasing precipitation toward the southeast portion of the state. On the right is a map showing how precipitation totals have strayed from normal. According to the Precipitation Departure maps, the Cannon River Watershed was slightly drier than normal in 2011. In 2012, a single heavy storm event on June 14th dropped 8.83 inches of rain over a 24-hour period at Cannon Falls (http://www.dnr.state.mn.us/climate/journal/flood14_150612.html). This fairly localized event is evident in both maps in Figure 13.

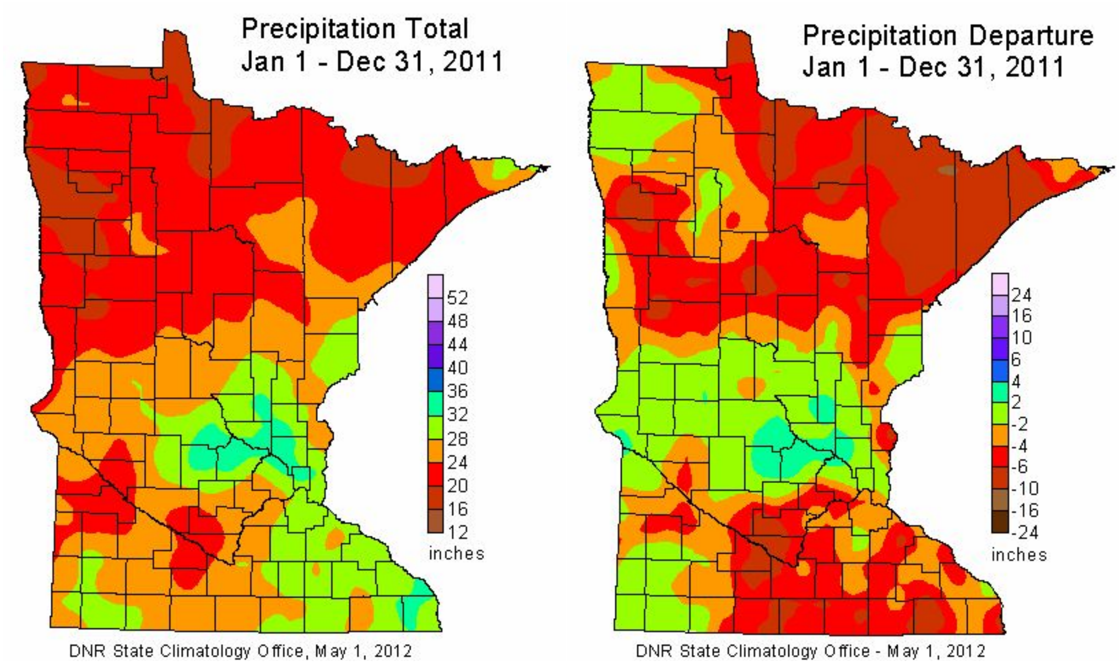

Figure 12. State-wide precipitation levels 2011.

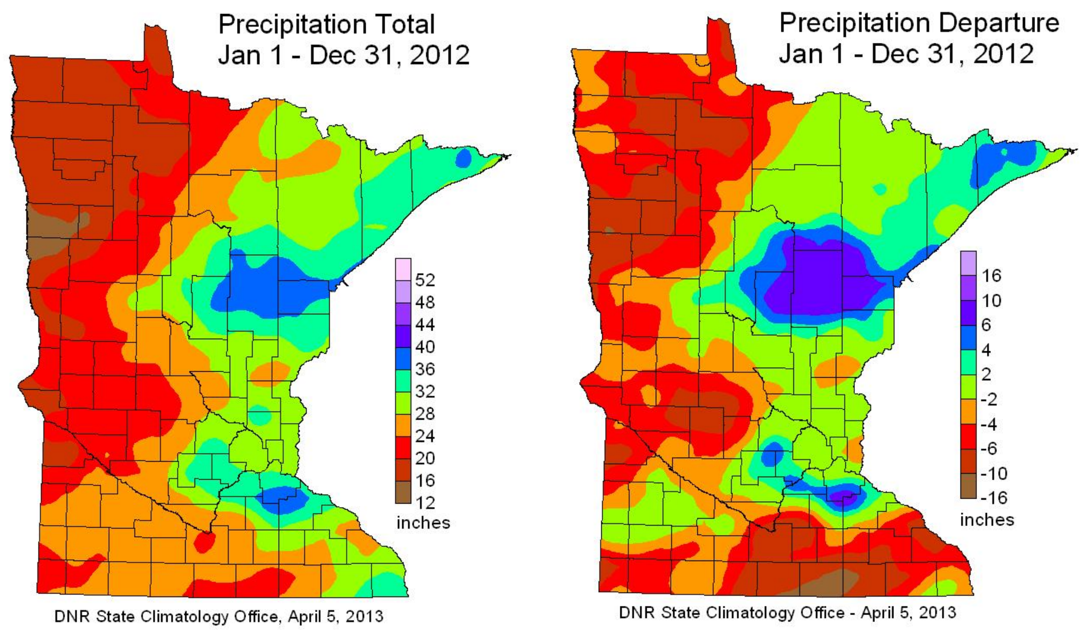

Figure 13. State-wide precipitation levels 2012.

During the 10-year assessment window, there were a few other notable climate and precipitation extremes. In 2003, a severe statewide drought occurred. Rainfall totals were at historic lows across the state, but particularly in southeastern Minnesota (http://climate.umn.edu/doc/journal/dry_mid_summer_2003.htm). In fall 2010, there was a large precipitation event that caused flooding in much of southern Minnesota (http://pubs.usgs.gov/sir/2011/5045/)

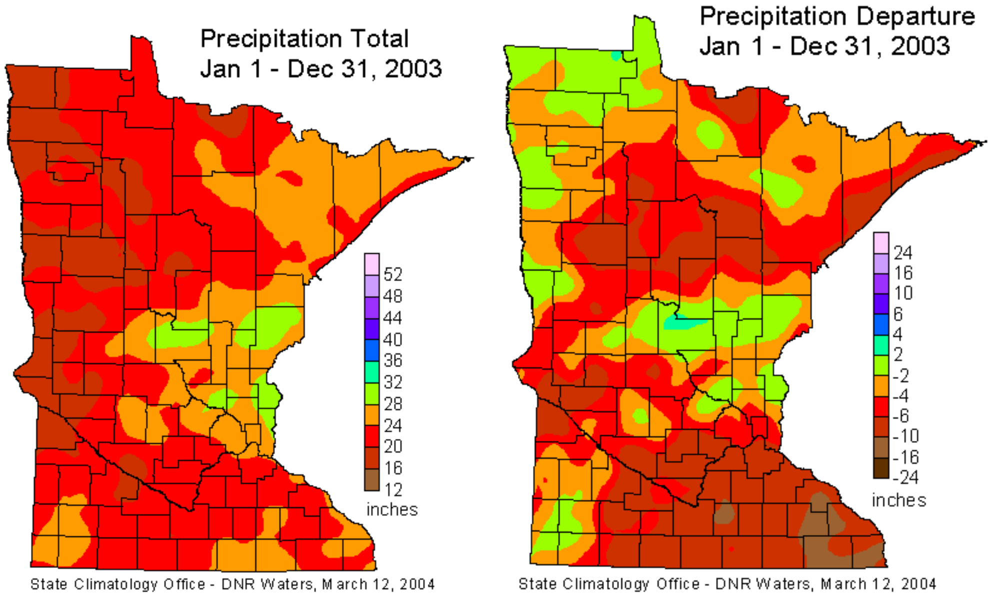

Figure 14. State-wide precipitation levels 2003.

Figure 15 displays the areal average precipitation in southeast Minnesota. An areal average is a spatial average of all the precipitation data collected within an area presented as a single dataset. These data are taken from the Western Regional Climate Center, available at the University of Minnesota Climate website: http://www.wrcc.dri.edu/spi/divplot1map.html. Though it can vary in intensity and time of year, rainfall in the southeast region has not risen significantly over the last 20 years.

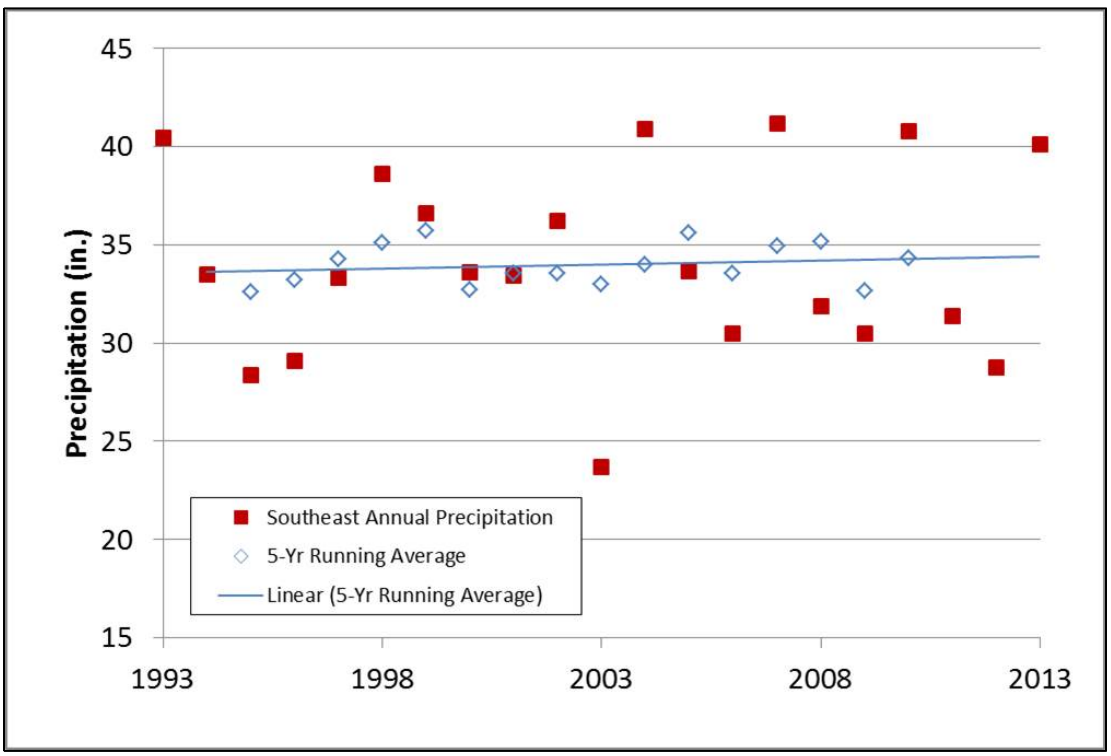

Figure 15. Precipitation trends in southeast Minnesota (1993-2013) with five-year running average.

In contrast, precipitation in southeast Minnesota exhibits a statistically significant rising trend over the past 100 years (p=0.001, Figure 16). This is a strong trend and matches similar trends throughout Minnesota.

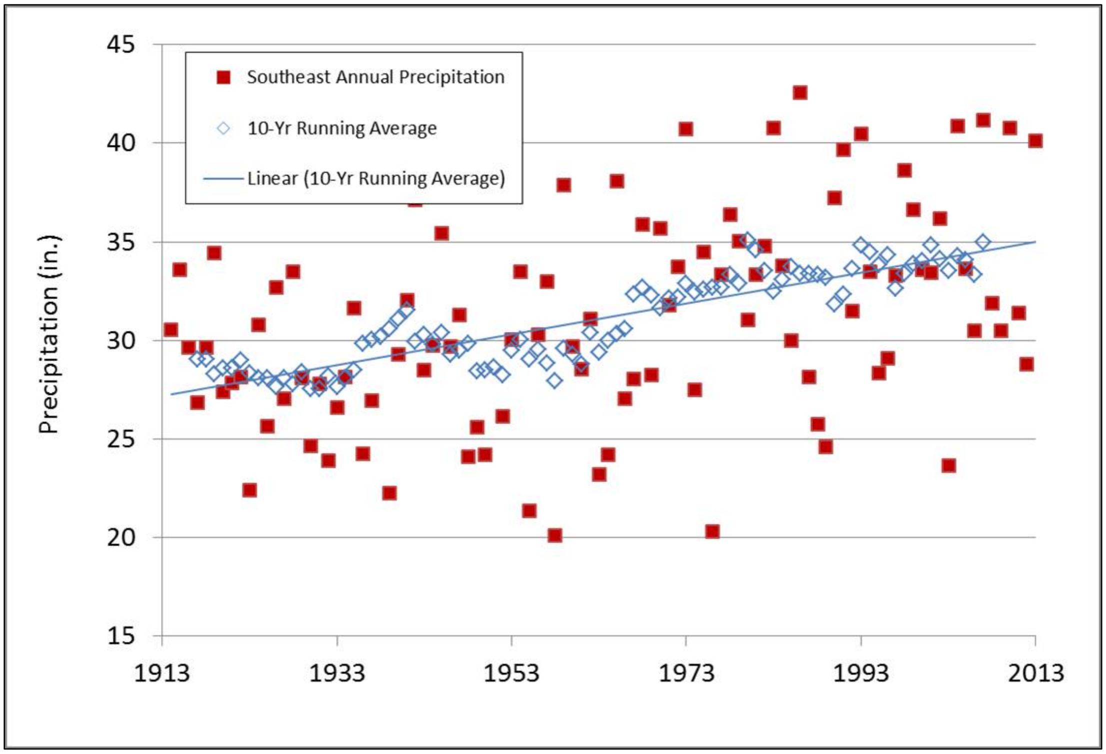

Figure 16. Precipitation trends in southeast Minnesota (1913-2013) with 10-year running average.

Hydrogeology

Geology in southeast Minnesota and the Cannon River Watershed is characterized by karst features (Figure 17). These geologic features occur where limestone is slowly dissolved by infiltrating rainwater, sometimes forming hidden, rapid pathways from pollution sources 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 sometimes 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, like those commonly used in the Cannon River Watershed, 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.

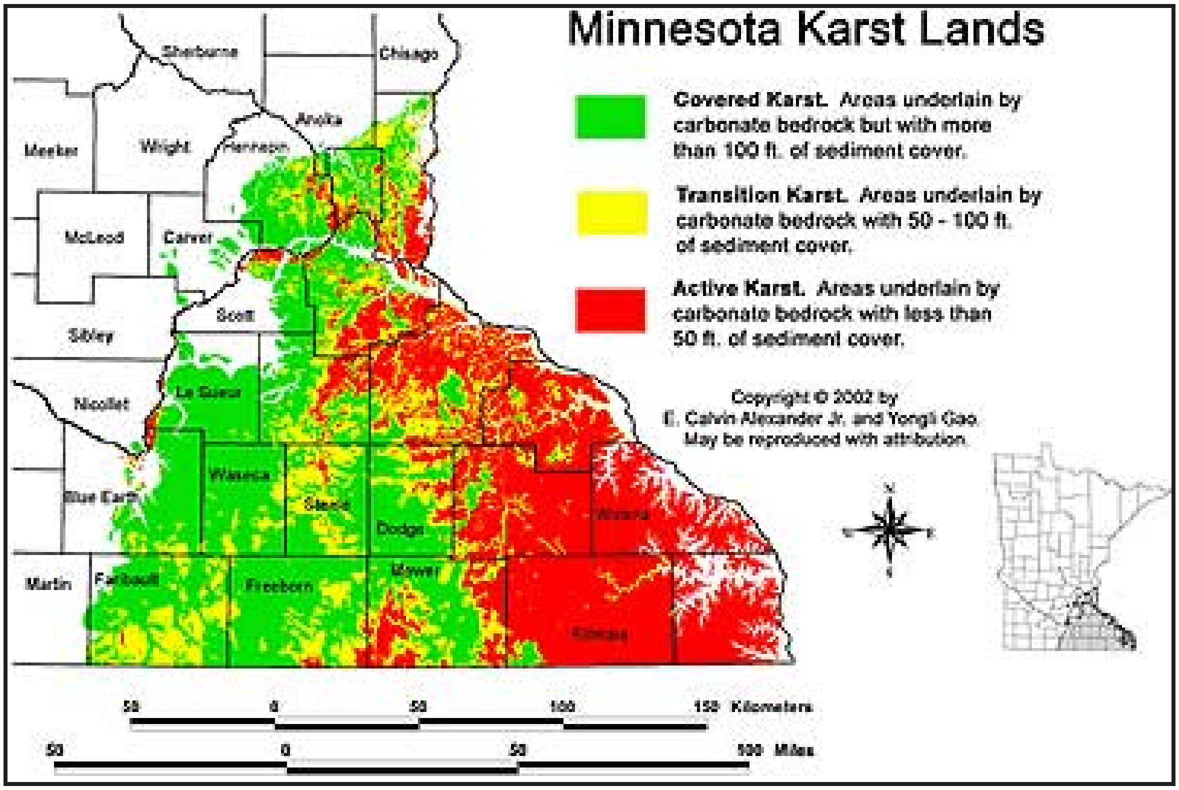

Figure 17: Locations of karst features in southeast Minnesota (E. Calvin Alexander, University of Minnesota).

IV. Watershed-wide data collection methodology

Load monitoring

There are two pollutant load monitoring stations within the Cannon River Watershed -- on the Cannon River at Welch and the Straight River near Faribault. The Straight River is a major tributary to the Cannon River that accounts for approximately 35% of the Cannon River's annual flow volume. The Straight River station is located is at 227th Street East, upstream of Faribault. This station is approximately 9 river miles above the confluence with the Cannon River. The Cannon River station at Welch is located approximately 13 river miles above the confluence with the Mississippi River near Redwing.

Water quality monitoring at the Straight River near Faribault is conducted by MPCA staff according to WPLMN protocols, which include the requirement that only samples collected during the flow monitoring period be used in annual pollutant load calculations (Figure 18). The Cannon River near Welch (Figure 19) is monitored by the MCES Stream Monitoring Program. MCES stream loads are calculated according to slightly different protocols that use a combination of auto sampler collected composite samples and instantaneous grab samples collected during the annual loading period along with samples collected during the two years period prior to the current load calculation period.

Between 27 and 35 mid-stream grab samples were collected per year at the Straight River monitoring site. Annual water quality and daily average discharge data are coupled in the "Flux32," pollutant load model, originally developed by Dr. Bill Walker and recently upgraded by the U.S. Army Corp of Engineers and the MPCA. Flux32 allows the user to create seasonal or discharge constrained concentration/flow regression equations to estimate pollutant concentrations and loads on days when samples were not collected. Primary output include annual and daily pollutant loads and flow weighted mean concentrations (pollutant load/total flow volume). Loads and flow weighted mean oncentrations are calculated for total suspended solids (TSS), total phosphorus (TP), dissolved orthophosphate (DOP), and nitrate plus nitrite nitrogen (nitrate-N).

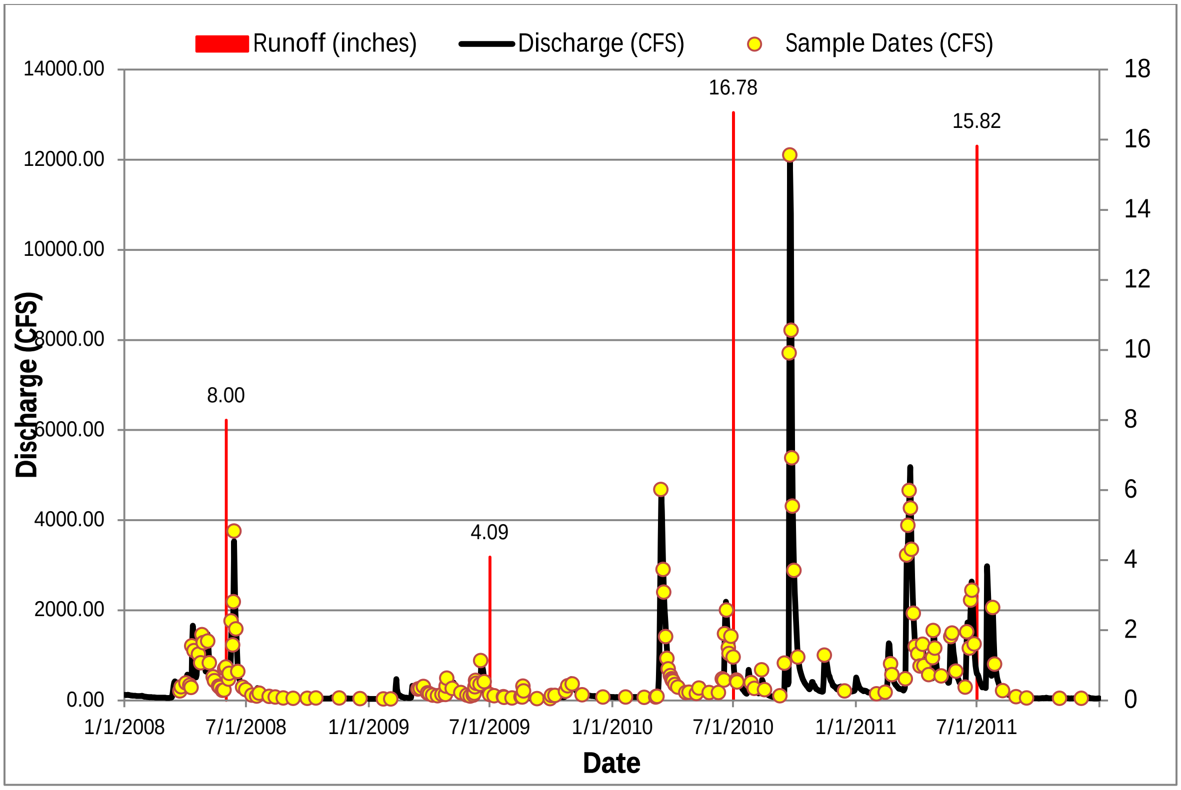

Figure 18. 2008-2011 hydrograph, sampling regime and annual runoff (annual discharge/watershed area) for the Straight River near Faribault, MN

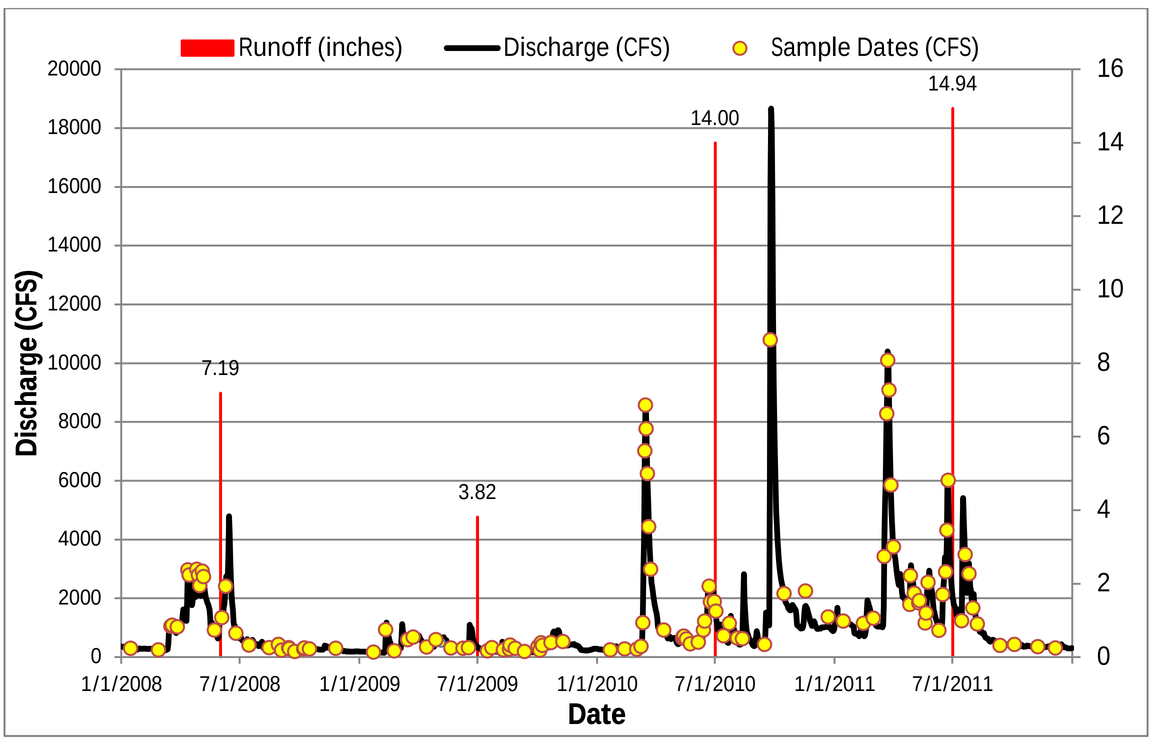

Figure 19. 2008-2011 hydrograph, sampling regime and annual runoff (annual discharge/watershed area) for the Cannon River at Welch, MN

Stream water chemistry sampling

During the 2013 assessment cycle, there were 86 stream reaches that had sufficient chemistry data to assess against current water quality standards. Water chemistry data were collected by locals and volunteers at many locations throughout the watershed over a number or sampling seasons. A SWAG was awarded to the CRWP for collecting water chemistry samples at all 13 designated subwatershed outlet stations during 2011 and 2012. Those water chemistry stations were sampled by local volunteers coordinated by CRWP from May through September in 2011, and again June through August of 2012, to provide sufficient water chemistry data to assess against components of the aquatic life and recreation use standards. Following the IWM design, water chemistry stations were placed at the outlet of each major subwatershed that was >40 mi^2 in area (pink stars in Figure 3). Local volunteers enrolled in the CSMP measured physical water characteristics at 29 stream stations throughout the same two-year span. See Appendix 1 for definitions of stream chemistry analytes monitored in this study. See Appendix 2 for locations of stream water chemistry monitoring sites. Sampling methods are similar among monitoring groups and are described in the document entitled *Standard Operating Procedures (SOP): Intensive Watershed Monitoring – Stream Water Quality Component* found at http://www.pca.state.mn.us/index.php/view-document.html?gid=16141.

Stream biological sampling

The biological monitoring component of the IWM in the Cannon River Watershed was completed during the summer of 2011. A total of 102 stations were sampled and included stations newly established for IWM and others previously established for various projects. The IWM sites were placed near the outlets of most subwatersheds. In addition, data from 43 existing biological monitoring stations that were sampled in previous years within the 10-year assessment window were included in the assessment process. These monitoring stations were initially established for biocriteria development, stressor identification of aquatic life impairments identified in previous assessment cycles, or as part of a 2007 survey which investigated the quality of channelized streams with intact riparian zones.

While data from the last 10 years contributed to the watershed assessments, the majority of data utilized for the 2013 assessment was collected in 2011 as part of the biological monitoring component of the IWM in the Cannon River Watershed. In 2011, 102 biological stations were selected and sampled using the IWM design where stations were located near the outlets of most minor (HUC-14) subwatersheds, with additional sites sampled to determine the condition and extent of coldwater streams. During the 2013 assessment, data from 143 biological stations throughout the watershed were reviewed which included the 102 IWM sites sampled in 2011 along with 42 stations sampled in previous years. These monitoring stations were sampled as part of random Lower Mississippi River Basin wide surveys in 2004 and 2010 or as part of a 2007 survey which investigated the quality of channelized streams with intact riparian zones. A total of 82 AUIDs were sampled for biology in the Cannon River Watershed. Waterbody assessments to determine aquatic life use support were conducted for 55 AUIDs. Waterbody assessments were not conducted for 14 AUIDs because criteria for channelized reaches had not been developed prior to the assessments. Nonetheless, the biological information that was not used in the assessment process will be crucial to the stressor identification process and will also be used as a basis for long term trend results in subsequent reporting cycles. Qualitative ratings for non-assessed reaches area included in Appendix 5.1.

To measure the health of aquatic life at each biological monitoring station, indices of biological integrity (IBIs), specifically Fish and Invertebrate IBIs, were calculated based on monitoring data collected for each of these communities. A fish and macroinvertebrate classification framework was developed to account for natural variation in community structure which is attributed to geographic region, watershed drainage area, water temperature and stream gradient. As a result, Minnesota's streams and rivers were divided into seven distinct warm water classes and two cold water classes, with each class having its own unique Fish IBI and Invertebrate IBI. Each IBI class uses a unique suite of metrics, scoring functions, impairment thresholds, and confidence intervals (CIs) (For IBI classes, thresholds and CIs, see Appendix 4.1). IBI scores higher than the impairment threshold and upper CI indicate that the stream reach supports aquatic life. Contrarily, scores below the impairment threshold and lower CI indicate that the stream reach does not support aquatic life. When an IBI score falls within the upper and lower confidence limits additional information may be considered when making the impairment decision such as the consideration of potential local and watershed stressors and additional monitoring information (e.g., water chemistry, physical habitat, observations of local land use activities). For IBI results for each individual biological monitoring station, see Appendix 4 and Appendix 5.

Lake water sampling

The Cannon River Watershed has 191 lakes of at least 10 acres in size. Twenty-four lakes were monitored by local groups and citizens enrolled in the CLMP in partnership with MPCA. SWAGs were awarded to CRWP and Rice County SWCD to conduct water chemistry monitoring on lakes within the watershed. Forty-seven lakes monitored by MPCA and local partners had enough data to assess against aquatic recreation use standards. Sampling methods are similar among monitoring groups and are described in the document "*MPCA Standard Operating Procedure for Lake Water Quality*" found at http://www.pca.state.mn.us/publications/wq-s1-16.pdf.

Fish contaminants

Mercury was analyzed in fish tissue samples collected from the Cannon River, Trout Brook, and 23 lakes in the watershed. Polychlorinated biphenyls (PCBs) were analyzed in fish from the Cannon River and 19 lakes. MPCA biomonitoring staff collected the fish from Trout Brook in 2011 while MDNR fisheries staff collected all other fish.

In 2010, four fish species from the Cannon River, downstream of Northfield Dam, were tested for perfluorochemicals (PFCs). The PFC that bioaccumulates in fish and is a known health concern for human consumption is perfluorooctane sulfonate (PFOS). Therefore, it is the only PFC concentration reported here for fish tissue. PFCs became a contaminant of emerging concern in 2004 when high concentrations of PFOS were measured in fish from the Mississippi River, Pool 2. Extensive statewide monitoring of lakes and rivers for PFCs in fish was continued through 2010. More focused monitoring for PFCs have continued in known contaminated waters, such as the Mississippi River Pool 2.

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

For PFCs, the MPCA shipped whole fish to AXYS Analytical Services Ltd in Sidney, British Columbia, Canada. AXYS did the fish measurements and processing before analyzing the tissue samples for 13 PFCs. The detection limit for PFOS was approximately 4.8 ng/g.

The Impaired Waters List is submitted every even year to the EPA for the agencies approval. MPCA has included waters impaired for contaminants in fish on the Impaired Waters List since 1998. Impairment assessment for PCBs and PFOS in fish tissue is based on the fish consumption advisories prepared by the Minnesota Department of Health (MDH, See link for site specific guidelines for Minnesota lakes and rivers at http://www.health.state.mn.us/divs/eh/fish/eating/sitespecific.html). If the consumption advice is to restrict consumption of a particular fish species to less than a meal per week because of PCBs or PFOS, the MPCA considers the lake or river impaired. The threshold concentration for impairment (consumption advice of one meal per month) is an average fillet concentration of 0.22 mg/kg for PCBs and 0.200 mg/kg (200 ppb) for PFOS.

Prior to 2006, mercury concentrations in fish tissue were assessed for water quality impairment based on MDH's fish consumption advisory. An advisory more restrictive than a meal per week was classified as impaired for mercury in fish tissue. Since 2006, a waterbody has been classified as impaired for mercury in fish tissue if 10% of the fish samples (measured as the 90th percentile) exceed 0.2 mg/kg of mercury, which is one of Minnesota's water quality standards for mercury. At least five fish samples per species are required to make this assessment and only the last 10 years of data are used for statistical analysis. MPCA's Impaired Waters List includes waterways that were assessed as impaired prior to 2006 as well as more recent impairments.

PCBs in fish have not been monitored as intensively as mercury in the last three decades due to monitoring completed in the 1970s and 1980s. These earlier studies identified that high concentrations of PCBs were only a concern downstream of large urban areas in large rivers, such as the Mississippi River and in Lake Superior. The current watershed monitoring approach includes screening for PCBs in representative predator and forage fish collected at the pour point stations in each major watershed.

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 (See http://www.pca.state.mn.us/index.php/water/water-types-and-programs/groundwater/groundwater-monitoring-and-assessment/index.html). These ambient wells represent a mix of deeper domestic wells and shallow monitoring wells. The shallow wells interact with surface waters and exhibit impacts from human activities more rapidly. Available data from federal, state and local partners are used to supplement reviews of groundwater quality in the region.

Groundwater/surface water withdrawals

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

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

Groundwater quantity

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

Stream flow

The USGS maintains real-time streamflow gaging stations across the United States. Measurements can be viewed at: http://waterdata.usgs.gov/nwis/rt

Wetland monitoring

The MPCA began developing biological monitoring methods for wetlands in the early 1990s, focusing on wetlands with emergent vegetation (i.e., marshes) in a depressional geomorphic setting. This work has resulted in the development of plant and macroinvertebrate (aquatic bugs, snails, leeches, and crustaceans) IBIs for the Temperate Prairies, Mixed Wood Plains and the Mixed Wood Shield level II ecoregions in Minnesota. These IBIs are suitable for evaluating the ecological condition or health of depressional wetland habitats. All of the wetland IBIs are scored on a 0 to 100 scale with higher scores indicating better condition. Wetland sampling protocols can be viewed at: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/wetlands/wetland-monitoring-and-assessment.html. Today, these indicators are used in a statewide survey of wetland condition where results can be summarized statewide and for each of Minnesota's three level II ecoregions (Genet 2012).

V. Individual subwatershed results

Major subwatersheds

Assessment results for aquatic life and recreation use are presented for each major subwatershed within the Cannon River. The primary objective is to portray all the full support and impairment listings within a subwatershed resulting from the complex and multi-step assessment and listing process. (A summary table of assessment results for the entire 8-HUC watershed including aquatic consumption, and drinking water assessments (where applicable) is included in Appendix 3). This scale provides a robust assessment of water quality condition at a practical size for the development, management, and implementation of effective TMDLs and protection strategies. The graphics presented for each of the subwatersheds contain the assessment results from the 2013 Assessment Cycle as well as any impairment listings from previous assessment cycles. Discussion of assessment results focuses primarily on the 2011-2012 IWM effort, but also considers available data from the last 10 years.

The proceeding pages provide an account of each major subwatershed. Each account includes a brief description of the subwatershed, and summary tables of the results for each of the following: a) stream aquatic life and aquatic recreation assessments, b) biological condition of channelized streams and ditches, c) stream habitat quality d) channel stability, and where applicable e) water chemistry for the subwatershed outlet, and f) lake aquatic recreation assessments. Following the tables is a narrative summary of the assessment results and pertinent water quality projects completed or planned for the subwatershed. A brief description of each of the summary tables is provided below.

Stream assessments

A table is provided in each section summarizing aquatic life and aquatic recreation assessments of all assessable stream reaches within the subwatershed (i.e., where sufficient information was available to make an assessment). Primarily, these tables reflect the results of the 2013 assessment process (2014 EPA reporting cycle); however, impairments from previous assessment cycles are also included and are distinguished from new impairments via cell shading (see footnote section of each table). These tables also denote the results of comparing each individual aquatic life and aquatic recreation indicator to their respective criteria (i.e., standards); determinations made during the desktop phase of the assessment process (see Figure 4). Assessment of aquatic life is derived from the analysis of biological (fish and invert IBIs), DO, turbidity, chloride, pH and un-ionized ammonia (NH3) data, while the assessment of aquatic recreation in streams is based solely on bacteria (Escherichia coli or fecal coliform) data. Included in each table is the specific aquatic life use classification for each stream reach: cold water community (2A); cool or warm water community (2B); or indigenous aquatic community (2C). Stream reaches that do not have sufficient information for either an aquatic life or aquatic recreation assessment (from current or previous assessment cycles) are not included in these tables, but are included in Appendix 5.2 and Appendix 5.3. Where applicable and sufficient data exists, assessments of other designated uses (e.g., class 7, drinking water, aquatic consumption) are discussed in the summary section of each major subwatershed as well as in the Watershed-wide results and discussion section.

Channelized stream evaluations

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

Stream habitat results

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

Stream stability results

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

Subwatershed outlet water chemistry results

These summary tables display the water chemistry results for the monitoring station representing the outlet of each major subwatershed. This data along with other data collected within the 10 year assessment window can provide valuable insight on water quality characteristics and potential parameters of concern within the watershed. Parameters included in these tables are those most closely related to the standards or expectations used for assessing aquatic life and recreation.

Lake assessments

A summary of lake water quality is provided in each major subwatershed section where available data exist. Assessment results for all lakes in the watershed are also available in Appendix 3.2. For lakes with sufficient data, basic modeling was also completed. Lake models and corresponding morphometric inputs can be found in Appendix 6.2.

Upper Cannon River Subwatershed HUC 0704000201

The Upper Cannon River Subwatershed is the largest subwatershed in this report at 332.7 mi^2. Most of the subwatershed is located in Le Sueur and Rice counties, with a small portion of its southern and southwestern regions split between Waseca, Steele and Blue Earth counties. Land use is predominantly agriculture (71.5%), with forest, wetland and open water comprising 22%, and developed land 6.3%. The Upper Cannon River Subwatershed is lake-rich with 71 lake basins >10 acres in size. The longest and most influential stream reach is the Cannon River which flows 52 miles in a counter-clockwise arc from its headwaters at Shields Lake to and through Cannon Lake, 3 mi. west of Faribault. The Jefferson Chain of Lakes and surrounding drainage basin make up the westernmost arm of the subwatershed, which drains east via County Ditch 59 to meet the Cannon River 1 mile upstream of Lake Tetonka near Waterville. This subwatershed was originally maintained as a 10-HUC during development of the new aggregated HUC12 coverage that divides this region into three subwatersheds: Upper Cannon River (0704000201-01), Headwaters Cannon River (0704000201-02), and County Ditch 59 (0704000201-03). The outlet of this 10-HUC subwatershed (STORET/EQuIS station S000-545, biological station 11LM002) is located at the bridge on Hwy 60, upstream of Cannon Lake, 2 miles northeast of Morristown. During the 2013 assessment, 15 stream reaches were assessed for aquatic life and/or aquatic recreation uses (Table 1). A number of stream reaches with biological indicators (fish IBI and invertebrate IBI) were not assessable due to channelization. Biological quality ratings for those stations are included in Table 2. For lakes, 31 were assessed for aquatic recreation and/or aquatic consumption use (Table 6).

Table 1. Aquatic life and recreation assessments on stream reaches: Upper Cannon.

AUID, Reach Name, Reach Description	Reach Length (miles)	Use Class	Biological Station ID	Location of Biological Station	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	Aquatic Life	Aquatic Rec.
07040002-621, County Ditch 63, Unnamed cr to Lk Dora	2.4	2B	11LM050**	Upstream of CR 3 (151st Ave), 4 mi. N of Kilkenny	NA**	NA**	IF	MTS	--	--	--	--	EX	IF	NS
07040002-546, Unnamed ditch, Headwaters to Lk Volney	1.8	2B	--	--	--	--	EXP*	EXP	--	MTS	--	--	--	IF*	NA
07040002-578, Little Cannon River/County Ditch 66 (LeSueur County), Headwaters to Sabre Lk	5.6	2B	11LM051**	Downstream of CR 3 (Kilkenny Rd), 0.5 mi. S of Kilkenny	NA**	NA**	IF	IF	MTS	--	--	--	MTS	IF	FS
07040002-614, Judicial Ditch 15, Headwaters to Lk Jefferson	4.3	2B	--	--	--	--	EXP*	IF	--	MTS	--	--	--	IF*	NA
07040002-711, Unnamed creek, Headwaters to Swede's Bay (Jefferson Lk)	1.0	2B	--	--	--	--	EXP*	MTS	--	MTS	--	--	--	IF*	NA
07040002-610, County Ditch 9, Unnamed ditch to German Lk	0.7	2B	--	--	--	--	EXS*	MTS	--	MTS	--	--	--	IF*	NA
07040002-706, Whitewater Creek, Unnamed cr to Waterville Cr	0.7	2B	11LM057	Upstream of Reed St S, 0.5 mi. S of Waterville	MTS	EXS	EXP	MTS	--	MTS	--	--	EX	NS	NS

07040002-560, Waterville Creek, Hands Marsh to Upper Sakatah Lk	6.4	2B	04LM080	Downstream of 147th Ave, 1 mi. S of Waterville	EXS	EXP	--	EXP	--	--	--	--	EX	NS	NS
07040002-577, Devils Creek, Unnamed cr to Cannon R	2.5	2B	11LM045	Downstream of CSAH 16 (230th St W), 2 mi. NW of Morristown	MTS	EXS	IF	MTS	--	--	--	--	EX	NS	NS
07040002-705, Unnamed creek, Unnamed cr to Cannon R	2.9	2B	11LM058	Upstream of 260th St W, 1.5 mi. SE of Morristown	EXP	IF	EXP	EXP	--	--	--	--	EX	NS	NS
07040002-641, Unnamed creek Unnamed cr to Cannon Lk	1.9	2B	11LM070	Downstream of Fairbanks Ave, 3.5 mi W of Faribault	IF	--	--	--	--	--	--	--	--	IF	NA
07040002-576, MacKenzie Creek, T108 R21W S7, west line to Cannon Lk	12.3	2C	11LM056	Downstream of 240th St W, 5 mi. E of Morristown	MTS	EXP	--	MTS	--	--	--	--	EX	NS	NS
07040002-638, Unnamed creek, Unnamed cr to Cannon R	2.0	2B	11LM078	Adjacent to Bellview Tr, 2.5 mi. NW of Faribault	MTS	EXP	--	--	--	--	--	--	--	NS	NA
07040002-702, Unnamed creek, Unnamed cr to Cannon R	4.2	2B	--	--	--	--	EXS*	MTS	--	MTS	--	--	EX	IF*	NS
07040002-542, Cannon River, Headwaters to Cannon Lk	52.0	2B	11LM082 11LM095 04LM081 11LM083 11LM002	Downstream of 170th St W, 6 mi. NE of Kilkenny Downstream of CR 3 (Kilkenny Rd), 1.5 mi. N of Kilkenny Upstream of County Road 5, 5 mi. N.W. of Waterville 0.25 mi. upstream of CR 12 (Tetonka Lake Rd), 3 mi. NW of Waterville 0.3 mi. upstream of Hwy 60 (Morristown Blvd), 1 mi. SW of Warsaw	MTS	EXS	EXS	MTS	MTS	MTS	MTS	IF	EX	NS	NS
07040002-540, Cannon River, Cannon Lk to Straight R	5.0	2B	--	--	--	--	IF	MTS	MTS	--	--	--	EX	IF	NS

Abbreviations for Indicator Evaluations: -- = No Data, NA = Not Assessed, IF = Insufficient Information, MTS = Meets criteria; EXP = Exceeds criteria, potential impairment; EXS = Exceeds criteria, potential severe impairment; EX = Exceeds criteria (Bacteria).

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

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

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

**Channelized station, biological data currently not assessed for aquatic life until Tiered Aquatic Life Use (TALU) standards are developed.

Table 2. Non-assessed biological stations on channelized reaches or AUIDs: Upper Cannon River Subwatershed.

AUID, Reach Name, Reach Description	Reach length (miles)	Use Class	Biological Station ID	Location of Biological Station	Fish IBI	Invert IBI
07040002-619, County Ditch 63, Unnamed cr to Unnamed cr	0.8	2B	04LM082	Downstream of 140th St W, 4 mi. SE of Montgomery	poor	poor
07040002-621, County Ditch 63, Unnamed cr to Lk Dora	2.4	2B	11LM050	Upstream of CR 3 (151st Ave), 4 mi. N of Kilkenny	fair	good
07040002-578, Little Cannon River/County Ditch 66 (LeSueur County), Headwaters to Sabre Lk	5.6	2B	11LM051	Downstream of CR 3 (Kilkenny Rd), 0.5 mi. S of Kilkenny	fair	poor
07040002-606, County Ditch 59, Unnamed ditch to Cannon R	3.3	2B	11LM081	Upstream of CR 7 (201st Ave), 3.5 mi. N of Elysian	fair	poor
07040002-724, Unnamed creek, Unnamed cr to Tetonka Lk	1.6	2B	11LM052	Upstream of CSAH 14, 2.5 mi. W of Waterville	poor	poor
07040002-542, Cannon River, Headwaters to Cannon Lk	52.0	2B	10EM027	Downstream of Hwy 13, 6 mi. SW of Montgomery	poor	poor

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

Table 3. Minnesota Stream Habitat Assessment (MSHA): Upper Cannon River Subwatershed.

# Visits	Biological Station ID	Reach Name	Channel Condition	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	04LM082	County Ditch 63	channelized	0	8	8	2	10	28	poor
1	11LM050	County Ditch 63	channelized	1.3	8.5	9	7	4	29.8	poor
1	11LM051	Little Cannon River/County Ditch 66	channelized	0	7	9	6	1	23	poor
1	11LM081	County Ditch 59	channelized	1.3	8	10	13	9	41.3	poor
1	11LM052	Unnamed creek	channelized	0	8	9	13	4	34	poor
2	04LM080	Waterville Creek	natural	1.9	12.5	15.9	8.5	23	61.7	fair
1	11LM057	Whitewater Creek	natural	0	9	12.3	16	17	54.3	fair
1	11LM045	Devils Creek	natural	0	7.5	21.8	13	22	64.3	fair
1	11LM058	Unnamed creek	natural	0	6	13.1	12	18	49.1	fair
1	11LM070	Unnamed creek	natural	4	10.5	13.6	4	15	47.1	fair

1	11LM056	Mackenzie Creek	natural	0	8	7.8	5	10	30.8	poor
1	11LM078	Unnamed creek	natural	1.3	9	8	13	19	50.3	fair
1	11LM082	Cannon River	natural	1.3	9	9	12	14	45.3	fair
1	11LM095	Cannon River	natural	2.5	9	16.9	8	16	52.4	fair
1	10EM027	Cannon River	channelized	0	12	7	12	7	38	poor
1	04LM081	Cannon River	natural	0	11	6.6	11	19	47.6	fair
1	11LM083	Cannon River	natural	0	8.5	16	14	19	57.5	fair
1	11LM002	Cannon River	natural	2.5	13.5	16.2	17	23	72.2	fair
Average Habitat Results: *Upper Cannon River Subwatershed*				**0.9**	**9.2**	**11.6**	**10.4**	**13.9**	**45.9**	**fair**

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

Table 4. Channel Condition and Stability Assessment (CCSI): Upper Cannon River Subwatershed.

# Visits	Biological Station ID	Stream Name	Stream Type*	Upper Banks (4-43)	Lower Banks (5-46)	Substrate (3-37)	Channel Evolution (1-11)	CCSI Score (13-137)	CCSI Rating
0	04LM082	County Ditch 63	--	--	--	--	--	--	--
1	11LM050	County Ditch 63	TC	18	13	30	6	67	moderately unstable
1	11LM051	Little Cannon River/ County Ditch 66	TC	15	13	17	5	50	moderately unstable
1	11LM081	County Ditch 59	TC	15	9	21	3	48	moderately unstable
1	11LM052	Unnamed creek	TCR	15	10	22	3	50	moderately unstable
1	04LM080	Waterville Creek	MHL	20	19	10	4	53	moderately unstable
1	11LM057	Whitewater Creek	MHL	22	23	22	7	74	moderately unstable
1	11LM045	Devils Creek	MHL	10	17	4	3	34	fairly stable
1	11LM058	Unnamed creek	MHL	22	21	6	6	55	moderately unstable
0	11LM070	Unnamed creek	--	--	--	--	--	--	--
1	11LM056	Mackenzie Creek	MHL	35	46	42	9	132	extremely unstable
1	11LM078	Unnamed creek	MHL	25	30	17	6	78	moderately unstable

1	11LM082	Cannon River	MHL	4	13	17	3	37	fairly stable
1	11LM095	Cannon River	MHL	14	24	9	3	50	moderately unstable
1	10EM027	Cannon River	LGL	24	13	19	3	59	moderately unstable
0	04LM081	Cannon River	--	--	--	--	--	--	--
1	11LM083	Cannon River	MHL	8	11	19	4	42	fairly stable
1	11LM002	Cannon River	MHL	4	7	6	1	18	stable
Average Stream Stability Results: *Upper Cannon River Subwatershed*				16.7	17.9	17.4	4.4	56.5	**moderately unstable**

*See Appendix 9 for description of stream types.

Qualitative channel stability ratings

= stable: CCSI < 27 = fairly stable: 27 < CCSI < 45 = moderately unstable: 45 < CCSI < 80 = severely unstable: 80 < CCSI < 115 = extremely unstable: CCSI > 115

Table 5. Outlet water chemistry results: Upper Cannon River Subwatershed.

Station Location:	**Cannon River** ; At Sakata Singing Hills Trail, N of Morristown Blvd, 2 mi NE of Morristown						
STORET/ EQuIS ID:	**S000-545**						
Station #:	**11LM002**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	14	0.0001	0.0112	0.0024	< 0.0400	0
Chloride	mg/L	10	16	21	18	< 230	0
Dissolved Oxygen	µg/L	19	3.63	9.05	6.68	> 5.00	3
pH	SU	19	7.5	8.7	7.8	6.5 - 9.0	0
Transparency tube	100 cm	19	40	> 100	94	> 20	0
E. coli (geometric mean)	MPN/100ml	47	98	154	-	< 126	1
Escherichia coli	MPN/100ml	15	78	> 2420	346	< 1260	1
Hardness, carbonate	mg/L	10	172	244	192	-	-
Nitrite-nitrate	mg/L	10	0.23	1.29	0.72	-	-
Kjeldahl nitrogen	mg/L	10	0.38	1.32	0.87	-	-
Phosphorus	µg/L	10	81	287	179	-	-
Specific Conductance	µS/cm	19	363	642	454	-	-
Sulfate	mg/L	10	10.7	23.3	16	-	-
Temperature, water	deg °C	19	15	30.1	23.4	-	-
Total suspended solids	mg/L	10	3	314	35.6	-	-
Total volatile solids	mg/L	10	1	52	8	-	-

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.
[2]Data found in the table above were compiled using the results from data collected at the outlet monitoring station in the Upper Cannon River Subwatershed, a component of the IWM work conducted between May and September from 2011 and 2012. These specific data do not necessarily reflect all data that were used to assess the AUID.

Table 6. Lake water aquatic recreation assessments: Upper Cannon River Subwatershed.

Name	DNR Lake ID	Area (acres)	Trophic Status	Percent Littoral	Max. Depth (meters)	Avg. Depth (meters)	Mean TP (µg/L)	Mean chl-a (µg/L)	Secchi Mean (meters)	CLMP Trend	Aquatic Life Support Status	Aquatic Recreation Support Status	Aquatic Consumption Support Status
Horseshoe	400001	400	E	81	7.9	3.1	87	71	1.3	NT	NA	NS	NA
Upper Sakatah	400002	881	H	100	3.0	1.9	462	32	1.1	- -	IF	NS	NS
Sunfish	400009	116	E	60	9.1	3.4	63	34	0.9	- -	NA	NS	NA
Dora	400010	760	H	100	1.8	1.0*	350	42	0.9	- -	IF	NS	FS
Mabel	400011	103	H	100	2.4*	1.0*	111	82	1.2	- -	NA	NS	NA
Diamond	400013	120	H	100	0.9*	0.5*	111	18	0.7	- -	NA	IF	NA
Sabre	400014	253	H	100	4.0	1.0*	1165	26	1.3	- -	IF	NS	NS
Tetonka	400031	1336	H	39	9.5	5	324	39	1.7	NT	IF	NS	NS
Gorman	400032	590	H	100	4.3	2.1	901	34	1.1	- -	IF	NS	NS
Volney	400033	268	E	46	20.4	6.6	59	12	2.8	I	NA	IF	NS
Roemhildts	400039	88	M	61	18.3	8.5	17	6	3.1	- -	NA	FS	NA
Steele	400044	75	E	77	8.2	2.6	31	16	1.1	- -	IF	IF	NA
Silver	400048	17	H	100		1.0*	110	39	2.2	- -	NA	NS	NA
Fish	400051	84	M	42	16.2	5.5	15	4	4.0	NT	IF	FS	NA
Perch	400054	31	M	100		1.0*	21	6	2.3	- -	NA	IF	NA
Rays	400056	153	E	90	9.7	2.3	55	25	1.2	- -	NA	IF	NA
Round	400059	135	H	100		1.0*	127	51	0.4	- -	NA	IF	NA
Tustin	400061	153	H	100	1.5	1.0*	178	78	0.9	- -	NA	NS	NA
German	400063	975	E	58	15.4	4.1	61	34	1.3	- -	IF	NS	NA
East Jefferson	40009201	646	E	48	11.3	5	73	30	1.5	NT	IF	NS	FS
West Jefferson	40009202	439	E	77	7.3	2.7	70	44	0.9	NT	IF	NS	FS
Swede's Bay	40009203	492	H	100	1.8	0.7	275	72	0.6	NT	NA	NS	NA
Middle Jefferson	40009204	664	H	100	2.4	1.3	137	60	0.8	- -	IF	NS	FS
Cannon	660008	1476	H	100	4.6	2.5	358	61	0.8	- -	NA	NS	NS
Wells	660010	634	H	100	1.2	1.0*	399	63	0.7	- -	NA	NS	NS
Dudley	660014	83	E	43	18.2	4.5	28	14	2.2	NT	IF	FS	NA
Kelly	660015	62	E	79	15.2	2.8	42	14	2.1	NT	NA	FS	NA
Roberds	660018	654	H	77	11.6	3.1	268	879	1.2	NT	IF	NS	FS

French	660038	842	H	43	15.4	5	157	82	1.0	- -	NA	NS	NS
Lower Sakatah	660044	341	H	100	2.1	1.0*	425	58	1.0	- -	IF	NS	NS
Hunt	660047	190	E	84	8.2	3	91	61	1.0	- -	NA	NS	NS
Rice	660048	330	H	100	2.0	1.0*	469	4	1.0	- -	NA	NS	NA
Caron	660050	406	H	100	1.2	1.0*	345	86	0.6	- -	NA	NS	NA
Cedar	660052	927	E	73	12.8	2.8	56	28	1.0	NT	NA	NS	NS
Shields	660055	877	H	74	9.4	3.1	281	66	1.3	NT	IF	NS	NS
Toner's	810058	127	H	100	--	1.0*	202	77	1.3	NT	NA	NS	NA

***- Indicates a depth estimated (in meters) by MPCA staff**

Abbreviations:

Trophic Status	Support Status	CLMP Trend
H -- Hypereutrophic	**FS** -- Full Support	**I** -- Increasing/Improving Trends
E – Eutrophic	**NS** -- Non-Support	**NT** -- No Trend
M -- Mesotrophic	**IF** -- Insufficient Information	
	NA – Not Assessed	

Key for Cell Shading: = existing impairment (prior to 2012); = new impairment; = full support of designated use.

Summary of subwatershed water quality

Water quality impairments span this entire lake-rich subwatershed, with high phosphorus levels fueling green algal blooms in lakes, streams, and wetlands. These conditions may also be stressful for fish and macroinvertebrate communities throughout the watershed. A number of lakes and streams were bright green when sampled (see Images 1 and 2) and have elevated total phosphorus concentrations that are occasionally fueling algal blooms. This condition is not only unsightly for recreational enjoyment of lakes and streams, but may also be potentially toxic and unsafe for swimming. In streams, algal blooms may increase daily highs and lows of DO which can be stressful for sensitive aquatic organisms and only allow the most tolerant to survive. Currently, 26 lakes do not support aquatic recreation due to excess nutrient enrichment and 12 lakes do not support aquatic consumption due to elevated mercury in fish tissue. For streams, nine stream reaches do not support aquatic recreation due to high bacteria levels that can make swimming or wading unsafe. Biological condition on many stream reaches and ditches had few pollution sensitive fish and macroinvertebrates indicating water quality or habitat quality issues. Nine stream reaches are currently not supporting their aquatic life uses; however, many other stream reaches were not assessable at this time but also indicate poor biological conditions for fish and macroinvertebrate communities. Some potential biological stressors include low DO,lack of good quality habitat, and potentially channel instability. Water samples collected at the outlet station on the Cannon River (Table 5) show high bacteria levels that could potentially make swimming and wading unsafe, and a few low DO measurements that may be related to the high phosphorus levels also observed at this location. Water quality leaving this subwatershed may be also impacting water quality on sections of the Cannon River downstream as well.

There are a few lakes and streams that are doing better than others. Five lakes support aquatic consumption (East, Middle, and West Jefferson; Dora; and Roberds), four lakes are fully supporting their aquatic recreation use (Roemhildts, Fish, Dudley, Kelly), and one stream reach on the Little Cannon River is fully supporting aquatic recreation. Unlike many other subwatersheds in the Cannon River Watershed, this subwatershed does not appear to have unusually high nitrite-nitrate concentrations. It also has only one listed turbidity impairment, although newer data indicates that turbidity is now meeting the standard so it is a candidate for delisting.

A 90 acre wetland and riparian buffer restoration project is currently underway in the Devil's Creek watershed in order to increase water storage, reduce stream bank erosion, and improve habitat conditions. Stressor identification is currently underway to determine the cause(s) of the poor biological conditions in the subwatershed. TMDLs have been written for reducing the mercury levels in fish and high phosphorus concentrations in lakes.

Image 1: Green algae on Roberds Lake. (8/9/2004). Photo by CRWP.

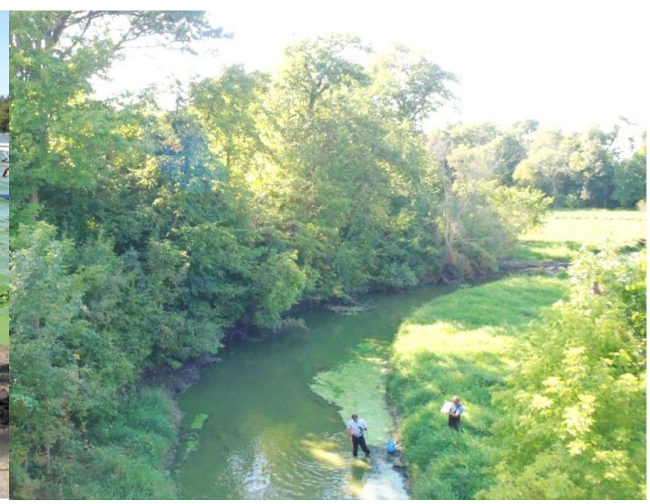

Image 2: Cannon River near the headwaters at station 11LM095. (9/12/2011)

Stream assessments

For aquatic recreation, assessments were conducted on 10 stream reaches and of those, only one reach is supporting aquatic recreation, while nine are not supporting due to elevated bacteria. For aquatic life, assessments were conducted on 15 stream reaches. Of those, 12 were determined to be impaired for one or more aquatic life standards for a total of 14 impairments (two for fish, six for macroinvertebrates, and six due to low DO); however, five of the DO impairments will be deferred until TALU standards can be applied to channelized stream reaches. Three additional reaches received an "IF" categorization for "insufficient information" due to the biological station being channelized or lack of adequate flow conditions during sampling. Additional information is included below.

Impairments due to elevated bacteria levels are widespread throughout the subwatershed, and include the entirety of the Upper Cannon River, County Ditch 63 (2.4 mile stretch) flowing into Dora Lake and downstream of Lake Tetonka (Figures 12 and 13). The only assessment unit fully supporting aquatic recreation use is a stretch of the Little Cannon River (-528) which flows into the east side of Sabre Lake.

Many of the stream reaches that are not supporting aquatic life due to low DO are headwater tributaries to impaired lakes or the Cannon River. Most water chemistry samples indicate that phosphorus is elevated—many values were >300 µg/L and a few were >800 µg/L. For the three reaches which were assessed as IF, two of those reaches did not have enough early morning DO measurements to assess against the standard and one reach had a small drainage area (<5 mi^2) and the perenniality of flow was questioned, given the inability of collecting a macroinvertebrate sample in mid-August due to lack of flowing water.

Numerous tributaries to the Cannon River in this subwatershed such as Devils Creek (-577), Mackenzie Creek (-576), Waterville Creek (-560), and Whitewater Creek (-706) have impaired aquatic life based on assessments of the macroinvertebrate community. In addition to excess nutrients and extreme high and low DO values, instability of the stream channel (i.e., excess erosion and sedimentation) may also be impacting aquatic life in these tributaries. For example, Mackenzie Creek (11LM056) has an intact riparian zone but was rated severely unstable. This station is incised with extreme cutting along both the inside and outside banks. Habitat quality was rated poor with substrates comprised of silt and sand with very little habitat available for fish or macroinvertebrates. For Whitewater Creek, it was mentioned at the PJG meeting that a clean-out occurred upstream of 11LM057 which may have contributed some of the excess sedimentation observed at the sampling station. For Devils Creek, a 90 acre wetland restoration is currently underway which may slow the speed and amount of water entering the stream that will ideally lead to improving channel stability, habitat quality, water quality, and the biological community. This location should be resampled in the future to see if improvements in these conditions are observed.

The 52 mile assessment unit representing the headwaters of the Cannon River (-542) is a series of stream reaches interconnected by several lakes (See Figures 20 and 21), winding its way through a largely agricultural landscape. As indicated by the macroinvertebrate community, aquatic life in this portion of the Cannon River may be impacted by excess nutrients from impaired upstream lakes and local land use activities. Macroinvertebrate IBI scores from five separate monitoring locations are all well below the impairment threshold. At this stage of the process an association between these biological impairments and nutrients can be surmised based on the dense aquatic macrophytes observed in this part of the river and the low DO, high total phosphorus, high chlorophyll-a, and high nitrate (nitrate + nitrite) concentrations measured at numerous monitoring stations. However, the next phase of the IWM process, stressor identification, will evaluate this relationship more closely to confirm or refute the apparent linkage.

Finally, one reach on the Cannon River (-540) that was previously listed due to elevated turbidity in 2004 is proposed for delisting since newer data suggest that this reach is now meeting the turbidity standard. While water clarity appears to be improved, phosphorus concentrations were very high (134 to 599 µg/L, average 326 µg/L). This high loading of phosphorus could impact downstream sections of the Cannon River outside of this subwatershed as well.

Lake assessments

For fish consumption, 19 of 34 lakes have been assessed (Table 6). Three lakes (Roberds, Mabel, Jefferson) fully support aquatic consumption while 12 lakes do not support and are impaired due to elevated mercury in fish tissue (Table 6). The MDH website posts meal limitation recommendations: http://www.health.state.mn.us/divs/eh/fish/eating/safeeating.html.

For aquatic recreation, 36 of the 71 lake basins >10 acres in size have been assessed (Table 6). These lakes are split nearly evenly with 19 shallow and 17 deep lake basins. Three lakes (Roemhildts, Fish, and Perch) have small, mostly forested watersheds and are classified as mesotrophic while all the other lakes are either eutrophic or hypereutrophic. Currently, 28 lakes of the 36 lakes that were assessed are not supporting aquatic recreation due to excess nutrients; 26 lakes were previously listed between 2002 and 2010, and two additional lakes (Silver and Toner's) were assessed in 2013 as not supporting and are proposed to be added to the 2014 Impaired Waters List.

Shallow lakes such as Dora, Swede's Bay, Tustin, and Caron have large upland watersheds and likely receive high nutrient loads from their predominantly agricultural watersheds. Shallow, flow-through lakes like Sabre, Sakatah, Cannon and Wells have high watershed to lake area ratios and receive very high water and nutrient loading and often have very short water residence times. Their shallowness, combined with large surface areas (large fetch) make them susceptible to wind mixing. This mixing serves to keep fine sediments in suspension and may allow for recycling of nutrients from the sediments. This internal nutrient loading typically increases the severity of algal blooms which, in turn, decreases water clarity as the summer progresses.

Deep lakes like Volney, East Jefferson and Shields physically stratify in the summer months. Internal nutrient loading also occurs in deep lakes, but nutrients adsorbed to sediments are more often trapped in the lake's bottom waters (hypolimnion) until fall turnover of the water column. Lakes in a chain may benefit from the sedimentation of phosphorus in the deeper lakes upstream. For example, German Lake benefits from this effect as East Jefferson, a deep lake that stratifies, effectively traps phosphorus adsorbed to sediments in the hypolimnion, which should reduce loads to downstream lakes in the chain. Deep lakes with large upland watersheds that do not have a nutrient sink immediately upstream, such as Roberds and French, typically have much higher nutrient levels in comparison to those that do have upstream sinks. Deep lakes with small, relatively intact watersheds like Fish, Dudley, Kelly, and Roemhildts display better water quality and fully support aquatic recreation uses. Lake Volney is the only lake in the entire Cannon River Watershed that shows an improving water clarity trend over the long term; the MDNR plans to purchase 1000 feet of shoreline on this lake for protection purposes.

Wetland condition

Similar to lakes and streams in this subwatershed, the wetland located within Frank Breen Memorial Wildlife Management Area (WMA) is exhibiting signs of nutrient enrichment. Located in the upper part of this subwatershed about five miles south of Cleveland, this ~30 acre wetland has been monitored by the MPCA since 1999 and has been designated a long-term monitoring site. Wetland plant and macroinvertebrate IBI scores have been variable and can be somewhat explained by sampling location and differing water levels between years. In general, this wetland is characterized as having a poor macroinvertebrate community and a relatively healthy floating-mat plant community. However, total kjeldahl nitrogen concentrations are exhibiting an increasing trend in the water column of this wetland during the summer (Seasonal Kendall Test for Trends). Total phosphorus is not exhibiting a statistically significant trend, though concentrations are high (200 to 750 µg/L) relative to least disturbed reference wetlands in the MWP ecoregion (typically <150 µg/L). Despite having a relatively healthy floating-mat plant community in the interior portions of the wetland, the community may be exhibiting a response to elevated nutrient concentrations in the near shore emergent vegetation zone. Invasive cattails (*Typha* X *glauca* and *T. angustifolia*), reed canary grass (*Phalaris arundinacea*) and duckweed (*Lemna minor*) comprise a large percentage of total plant cover in this area of the wetland (Figure 20). While an increase in algal production (e.g., phytoplankton and filamentous) is typically associated with nutrient enrichment of water bodies, in wetlands a response may also be exhibited by vascular plants adept at taking advantage of the surplus nutrients (e.g., invasive species).

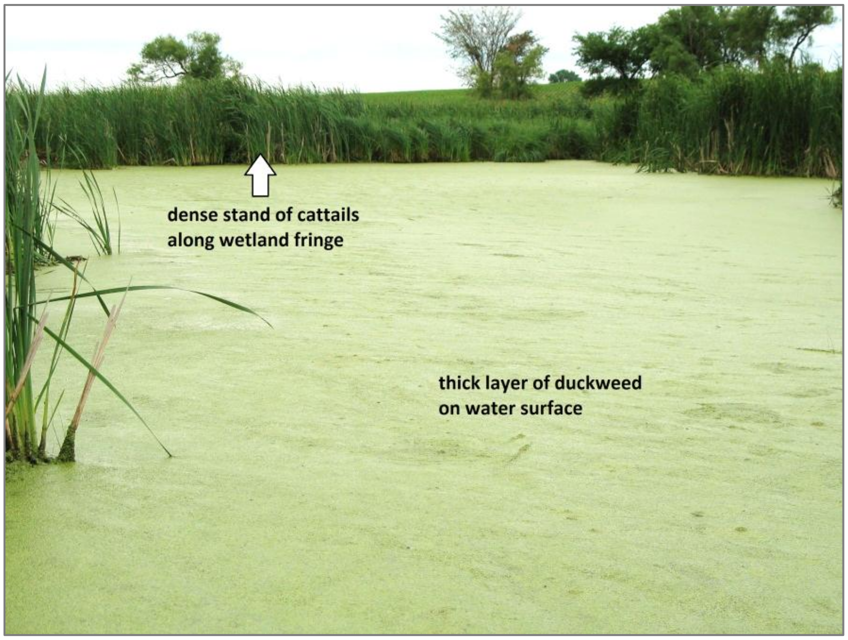

Figure 20. The plant community within the Breen WMA wetland is showing the effects of elevated nutrient concentrations.

Watershed plans, projects, and TMDLs

The 52 mile AUID of the Cannon River is a unique flow-through system of lakes linked with waterbody connectors that have characteristics that are riverine in some regards and lake-like in others. Addressing water quality impairments in this lengthy chain of waterbodies likely will require dividing this reach into manageable segments. However, nutrient levels in water bodies upstream may be contributing to high nutrients and impairments in waterbodies downstream, so the entire chain of waterbodies cannot be completely overlooked. Stressor identification is underway to determine the cause(s) of biological impairments in streams. Some projects have begun to improve water quality conditions. For example, a shoreline restoration project on Lake Volney was completed in 2009 and a 90 acre wetland and riparian buffer restoration project is currently underway in the Devils' Creek Watershed.

For lakes, the fish contaminant listings for excess mercury in fish tissue are being addressed through the Minnesota Statewide Mercury TMDL. Information on this TMDL can be viewed on the MPCA website at: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/special-projects/statewide-mercury-tmdl-pollutant-reduction-plan.html#statewideplan. Mercury levels in fish on Lake Volney were higher than many lakes and will require a separate TMDL. For excess nutrients in lakes, two TMDLs have been drafted for six impaired lakes: The Lake Volney Draft TMDL and the Jefferson –German Lake Chain Draft TMDL (includes West Jefferson Lake, Middle Jefferson Lake, Swede's Bay, East Jefferson Lake and German Lake). These TMDLs have gone through the public comment period (closed on March 3, 2014).The current version of the documents can be found on the MPCA website: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/lower-mississippi-river-basin-tmdl/project-upper-cannon-lakes-excess-nutrients.html.

County water management plans and projects can be found at the following websites:

- LeSueur County - http://www.co.le-sueur.mn.us/environmentalservices/WaterManagementProgram.html
- Rice County - http://www.co.rice.mn.us/node/104860
- Waseca County - http://www.wasecaswcd.org/reports.html
- Blue Earth County - http://www.blueearthcountymn.gov/index.aspx?nid=240
- Steele County - http://www.co.steele.mn.us/departments/environmental_services/water_issues.html

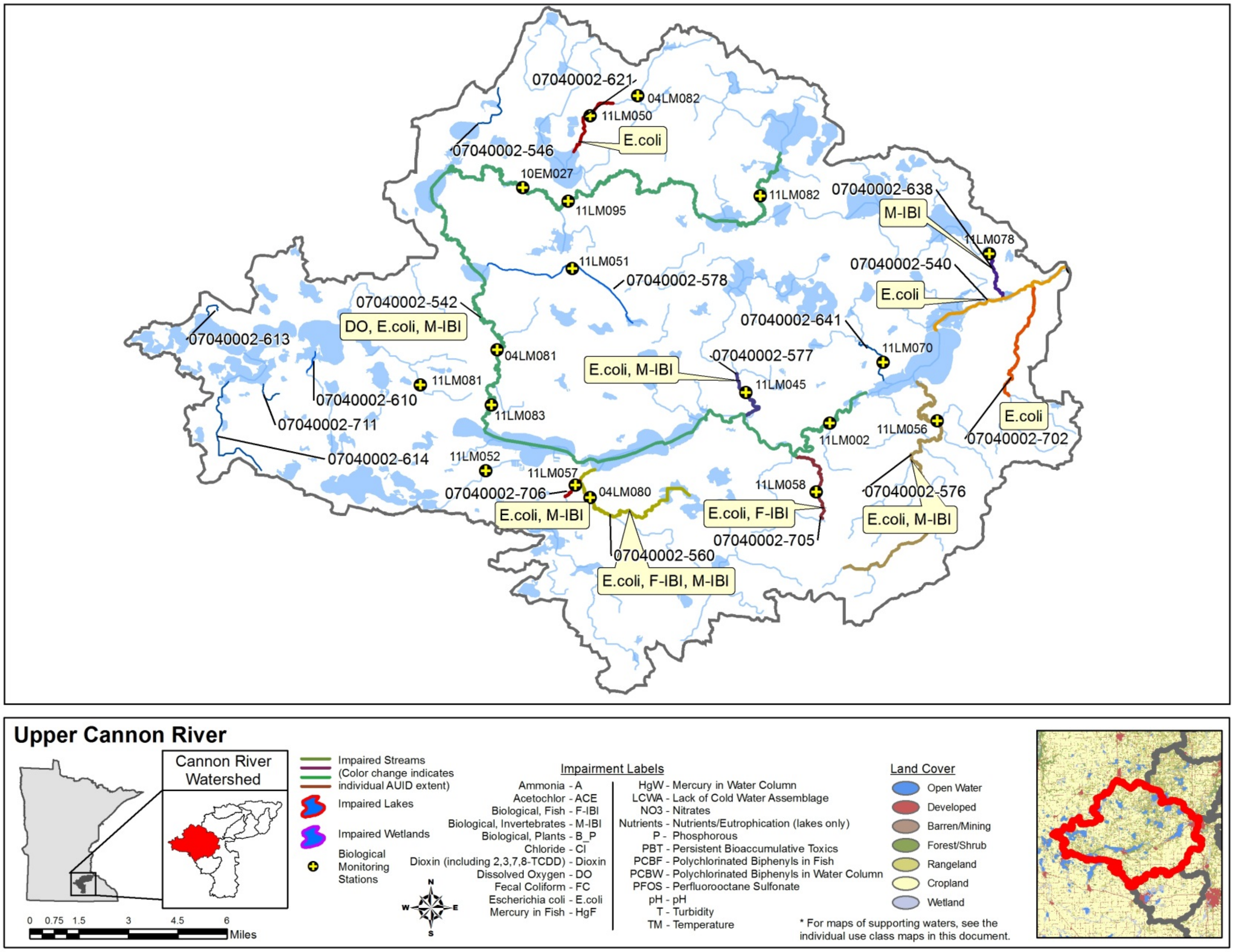

Figure 21. The 2013 assessed stream reaches with impairments and land use characteristics (inset) in the Upper Cannon River Subwatershed. See Figure 22 for lakes.

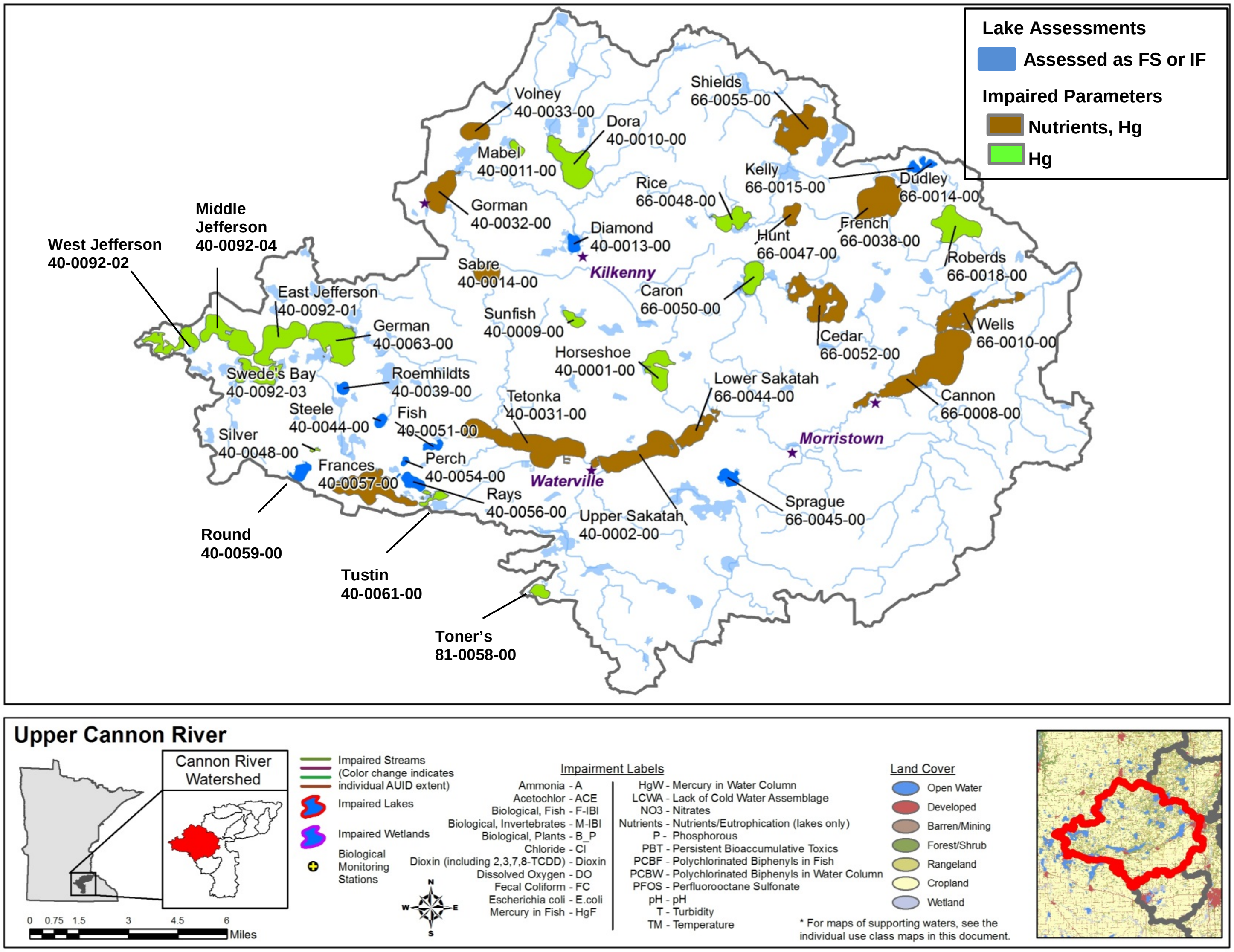

Figure 22. Assessed and listed lakes with impairment parameters and land use characteristics (inset) in the Upper Cannon River Subwatershed. See Figure 21 for streams.

Crane Creek Subwatershed HUC 0704000202-01

The entire Crane Creek subwatershed is located in the WCBP ecoregion and covers just over 105 mi^2. It is divided nearly in half by the Waseca-Steele County line. There are 21 lake basins >10 acres in size. The headwaters of Crane Creek begin near the city of Waseca. Watkins Lake acts as the headwaters for Crane Creek which flows east for 6.5 miles before it turns northeast and flows into the Straight River three miles north of Owatonna. Many headwater streams feed lakes created or maintained by dams (e.g., Goose, Clear, Swan, Watkins, Moonhan Marsh). Land use is predominantly agriculture (81%), comprised mostly of row-crop (74%) with some pastured land (6.6%). Of the remaining land use, 10% is developed land while only a small portion (~9%) of the watershed is forest (2%), wetland (4.6%), and open water (2%). The water chemistry outlet station (STORET/EQuIS station S003-009, biological station 11LM007) is located near the mouth of Crane Creek at the CSAH-22 Bridge, just upstream of the confluence with the Straight River in Clinton Falls. Two stream assessment units were reviewed during the most recent assessment cycle (Table 7). Many stream reaches were currently not assessed against biological standards (F-IBI and M-IBI) due to channelization. Biological quality ratings for these stations are included in Table 8. Two lakes (Clear and Loon) were assessed for aquatic recreation and aquatic consumption use support (Table 12).

Table 7. Aquatic life and recreation assessments on stream reaches: Crane Creek Subwatershed.

AUID, Reach Name, Reach Description	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	**Aquatic Life**	**Aquatic Rec.**
07040002-556, Judicial Ditch 1, Unnamed cr to Crane Cr	4.3	2B	11LM060**	Upstream of Hwy 14, 6 mi. E of Waseca	NA**	NA**	--	EXP	--	--	--	--	--	IF	NA
07040002-516, Crane Creek, Headwaters (Watkins Lk 81-0013-00) to Straight R	15.5	2C	11LM032** 07LM020** 04LM119** 11LM007**	Upstream of NW 52nd Ave, 3.5 mi. W of Owatonna Upstream of NW 26th St, 3 mi. NW of Owatonna Upstream of NW 46th St, 1.3 mi. W of Clinton Falls Downstream of CSAH 22 (E Frontage Rd), N of NW 50th St, in Clinton Falls	NA**	NA**	IF	EXP	MTS	MTS	MTS	IF	EX	IF	NS

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

Table 8. Non-assessed biological stations on channelized reaches or AUIDs: Upper Cannon River Subwatershed.

AUID, Reach Name, Reach Description	**Reach length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Fish IBI**	**Invert IBI**
07040002-727, Unnamed ditch, JD 1 to JD 1	1.1	2B	11LM066	Upstream of CR 62 (NW 85th Ave), 7 mi. NE of Waseca	poor	poor
07040002-593, **Judicial Ditch 1,** Hayes Lk to CD 11	1.5	2B	04LM022	Upstream of Hwy 4, 6 mi. S of Morristown	poor	--
07040002-733, **County Ditch 21,** Unnamed ditch to JD 1	3.0	2B	11LM059	Upstream of CR 33 (SW 92nd Ave), 6.5 mi. SE of Waseca	poor	poor (2)
07040002-556, Judicial Ditch 1, Unnamed cr to Crane Cr	4.3	2B	11LM060	Upstream of Hwy 14, 6 mi. E of Waseca	good	fair
07040002-516, Crane Creek, Headwaters (Watkins Lk 81-0013-00) to Straight R	15.5	2C	11LM032 07LM020 04LM119 11LM007	Upstream of NW 52nd Ave, 3.5 mi. W of Owatonna Upstream of NW 26th St, 3 mi. NW of Owatonna Upstream of NW 46th St, 1.3 mi. W of Clinton Falls Downstream of CSAH 22 (E Frontage Rd), N of NW 50th St, in Clinton Falls	good (5)	good (4)

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

Parentheses behind ratings indicate the quantity of site visits when >1, which may or may not occur in the same year.

Table 9. Minnesota Stream Habitat Assessment (MSHA): Crane Creek Subwatershed.

# Visits	Biological Station ID	Reach Name	Channel Condition	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	11LM066	Unnamed creek	channelized	0	7	4	10	5	26	poor
1	04LM022	Judicial Ditch 1	channelized	2.5	7.5	7.1	13	1	31.1	poor
1	11LM059	County Ditch 21	channelized	2.5	8.5	17.6	12	9	49.6	fair
1	11LM060	Judicial Ditch 1	channelized	0	7	9	5	5	26	poor
1	11LM032	Crane Creek	channelized	2.5	7.5	14	6	4	34	poor
2	07LM020	Crane Creek	channelized	3.4	9	19.1	8.5	24	63.9	fair
1	04LM119	Crane Creek	channelized	0	7	19	6	10	42	poor
1	11LM007	Crane Creek	channelized	0	5.5	13	7	7	32.5	poor
			Average Habitat Results: *Crane Creek Subwatershed*	**2.4**	**7.9**	**16.5**	**8.4**	**13.6**	**48.8**	**fair**

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

Table 10. Channel Condition and Stability Assessment (CCSI): Crane Creek Subwatershed.

# Visits	Biological Station ID	Stream Name	Stream Type*	Upper Banks (4-43)	Lower Banks (5-46)	Substrate (3-37)	Channel Evolution (1-11)	CCSI Score (13-137)	CCSI Rating
1	11LM066	Unnamed creek	TCR	27	19	29	5	80	moderately unstable
0	04LM022	Judicial Ditch 1	TC	--	--	--	--	--	--
1	11LM059	County Ditch 21	TCR	22	5	10	3	40	fairly stable
1	11LM060	Judicial Ditch 1	TC	26	13	9	3	51	moderately unstable
1	11LM032	Crane Creek	TC	18	9	9	3	39	fairly stable
1	07LM020	Crane Creek	TCR	13	15	9	5	42	fairly stable
0	04LM119	Crane Creek	TC	--	--	--	--	--	--
1	11LM007	Crane Creek	TC	13	13	17	3	46	moderately unstable
			Average Stream Stability Results: *Crane Creek Subwatershed*	**19.8**	**12.3**	**13.8**	**3.7**	**49.7**	**moderately unstable**

*See Appendix 9 for description of stream types.
Qualitative channel stability ratings
= stable: CCSI < 27 = fairly stable: 27 < CCSI < 45 = moderately unstable: 45 < CCSI < 80 = severely unstable: 80 < CCSI < 115 = extremely unstable: CCSI > 115

Table 11. Outlet water chemistry results: Crane Creek Subwatershed.

Station Location:	**Crane Creek** ; At CSAH-22, No of NW 50th St, in Clinton Falls						
STORET/ EQuIS ID:	**S003-009**						
Station #:	**11LM007**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	13	0.0002	0.0103	0.0029	< 0.0400	0
Chloride	mg/L	10	18	28	22	< 230	0
Dissolved Oxygen	mg/L	19	5.73	12.00	9.03	> 5.00	0
pH	SU	66	7.0	8.3	7.8	6.5 - 9.0	0
Transparency tube	100 cm	78	5	> 100	51	> 20	8
Turbidity	NRTU	14	2	150	23	25	5
E. coli (geometric mean)	MPN/100ml	91	89	163	-	< 126	2
Escherichia coli	MPN/100ml	61	2	> 2420	255	< 1260	2
Hardness, carbonate	mg/L	10	218	428	280	-	-
Nitrite-nitrate	mg/L	36	0.03	15.60	5.84	-	-
Kjeldahl nitrogen	mg/L	11	0.51	1.80	1.17	-	-
Orthophosphate	µg/L	4	10	120	70	-	-
Phosphorus	µg/L	67	21	560	211	-	-
Specific Conductance	µS/cm	40	420	760	580	-	-
Sulfate	mg/L	10	18.1	80.9	36.5	-	-
Temperature, water	deg °C	66	6.4	30.0	19.6	-	-
Total suspended solids	mg/L	60	2	230	27	-	-
Total volatile solids	mg/L	23	1	46	8	-	-

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.
[2]Data found in the table above were compiled using the results from data collected at the outlet monitoring station in the Crane Creek Subwatershed, a component of the IWM work conducted between May and September from 2011 and 2012. These specific data do not necessarily reflect all data that were used to assess the AUID.

Table 12. Lake water aquatic recreation assessments: Crane Creek Subwatershed.

Name	DNR Lake ID	Area (acres)	Trophic Status	Percent Littoral	Max. Depth (meters)	Avg. Depth (meters)	Mean TP (µg/L)	Mean chl-a (µg/L)	Secchi Mean (meters)	CLMP Trend	Aquatic Life Support Status	Aquatic Recreation Support Status	Aquatic Consumption Support Status
Clear	81001401	648	E	75	7.6	3.0	91	69	0.9	NT	IF	NS	NS
Loon	810015	119	H	100	2.4	1.5	217	66	0.6	NT	NA	NS	NS

Abbreviations:

Trophic Status
H -- Hypereutrophic
E – Eutrophic
M -- Mesotrophic

Support Status
FS -- Full Support
NS -- Non-Support
IF -- Insufficient Information
NA – Not Assessed

CLMP Trend
I -- Increasing/Improving Trends
NT -- No Trend

Key for Cell Shading: = existing impairment (prior to 2012); = new impairment; = full support of designated use.

Summary of subwatershed water quality

Like many other subwatersheds in the Cannon River Watershed, lakes and streams in the Crane Creek Subwatershed are also suffering from excess nutrients. Both Clear Lake and Loon Lake are not supporting aquatic recreation due to excess nutrients that can cause unsightly algae blooms. In addition, both lakes, Clear and Loon, are also impaired for aquatic consumption use due to high mercury levels in fish tissue. Crane Creek --from its headwaters at Watkins Lake to the Straight River—has low water clarity, which may be due to the growth of algae fueled by high phosphorus. This may be impacting fish and macroinvertebrate communities due to daily high and low DO swings, and should be confirmed with additional DO measurements. Biological condition at many headwater stations was rated fair to poor except for the mainstem of Crane Creek where fish and macroinvertebrate communities were generally rated good, although low DO may be a stress that should be investigated. Habitat quality across the watershed was rated fair to poor with reaches often lacking in depth variability, cover for fish, and wide riparian areas—conditions that are often found in channelized streams. Samples collected at the outlet on Crane Creek (Table 11) show that both phosphorus and nitrate values were quite high at times (nitrite-nitrate up to 15 mg/L).The high levels of nutrients leaving this subwatershed may be contributing to poor water quality conditions observed in downstream water bodies such as the Straight River and Cannon River as well. In addition, high bacteria levels were measured on Crane Creek that may make swimming and wading unsafe.

Stream assessments

For aquatic recreation, the bacteria impairment first listed in 2002 was confirmed with newer data on Crane Creek (-516). For aquatic life, many stream reaches are channelized and consequently were not assessed for aquatic life for fish and macroinvertebrates. Two stream reaches that were reviewed using only chemical standards received an IF categorization due to insufficient information to assess for aquatic life. Additional information on those stream reaches and others are included below.

On Crane Creek (-517), DO measurements collected primarily in 2011 ranged from 5.7 mg/L to 17.1 mg/L. The range in values observed (high and low), suggest an excess nutrient issue. Notes from some sampling events indicate that the water was green, so it is possible that the high turbidity values observed may be due to excessive algae in the water column. Phosphorus concentrations ranged from 21 µg/L to 2180 µg/L (average of 222 µg/L). This reach is immediately downstream of a wetland which may, in part, be contributing to the phosphorus values and the low DO measurements observed. Continuous and longitudinal monitoring of DO is recommended in order to determine the severity and extent of the low DO conditions that may be negatively impacting the biological communities and potentially other downstream waterbodies.

Channelized stream stations demonstrated poor biological quality for fish and macroinvertebrate communities in the headwaters and smaller tributaries. Lower in the watershed, Judicial Ditch (JD) 1 and Crane Creek had better biological condition for both fish and macroinvertebrates; the one exception being one macroinvertebrates visit on Crane Creek at station 11LM032 which was rated as poor with only 8 EPT taxa (EPT is short for *Ephemeroptera*, *Plecoptera*, and *Trichoptera*, insect orders with species that are generally intolerant of pollution), as compared to 14 downstream at station 11LM007. Habitat quality across the watershed was rated fair to poor with narrow riparian zones, lack of depth and flow variability and cover-- typical characteristics of channelized reaches in row-crop intensive landscapes. In addition, for Judicial Ditch 1 (-556), limited data indicate that nutrients are likely elevated, with high algae noted with the transparency measurements.

Lake assessments

Clear and Loon are impaired for aquatic consumption use due to high mercury levels in fish tissue. The MDH website posts meal limitation recommendations for individual lakes: http://www.health.state.mn.us/divs/eh/fish/eating/safeeating.html.

Of the 21 lake basins >10 acres in size, only two had sufficient data to assess for aquatic recreation use (Table 12). Other basins had sufficient data but were determined to function more as wetlands than lakes and were not assessed for recreational uses using standards developed for lakes. Clear Lake (listed in 2004) and Loon Lake (listed in 2010) both exceed their respective lake eutrophication standards and are still impaired for excessive nutrients. Both lakes have been subject to a variety of efforts aimed at improving water quality over a long period of time. Data collected by citizen volunteers show no long term trend in water clarity for either lake. Loon Lake is a small, shallow basin with a very small watershed dominated by development within the Waseca city limits. In shallow lakes, wind action can drive internal nutrient loading by re-suspending bottom sediments that hold nutrients such as phosphorus. Clear Lake is a deep basin located on the city of Waseca's eastern fringe and is a focal point for recreation. Its watershed drains much of the city and nearby cultivated lands, both of which contribute to the excess nutrient loads the lake receives. Clear Lake stratifies in the summer months, so while internal nutrient loading does occur, most of the nutrients are detained in the hypolimnion until fall lake turnover.

Watershed plans, projects, and TMDLs

Both Clear and Loon Lakes are included in the Statewide Mercury TMDL: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/special-projects/statewide-mercury-tmdl-pollutant-reduction-plan.html. Stormwater treatment projects have been completed for Clear Lake. The bacteria impairment on Crane Creek is being addressed through the Lower Mississippi River Basin— Regional Fecal Coliform TMDL: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/lower-mississippi-river-basin-tmdl/project-lower-mississippi-river-basin-regional-fecal-coliform.html

County water management plans and projects can be found at the following websites:

- Waseca County - http://www.wasecaswcd.org/reports.html
- Steele County - http://www.co.steele.mn.us/departments/environmental_services/water_issues.html

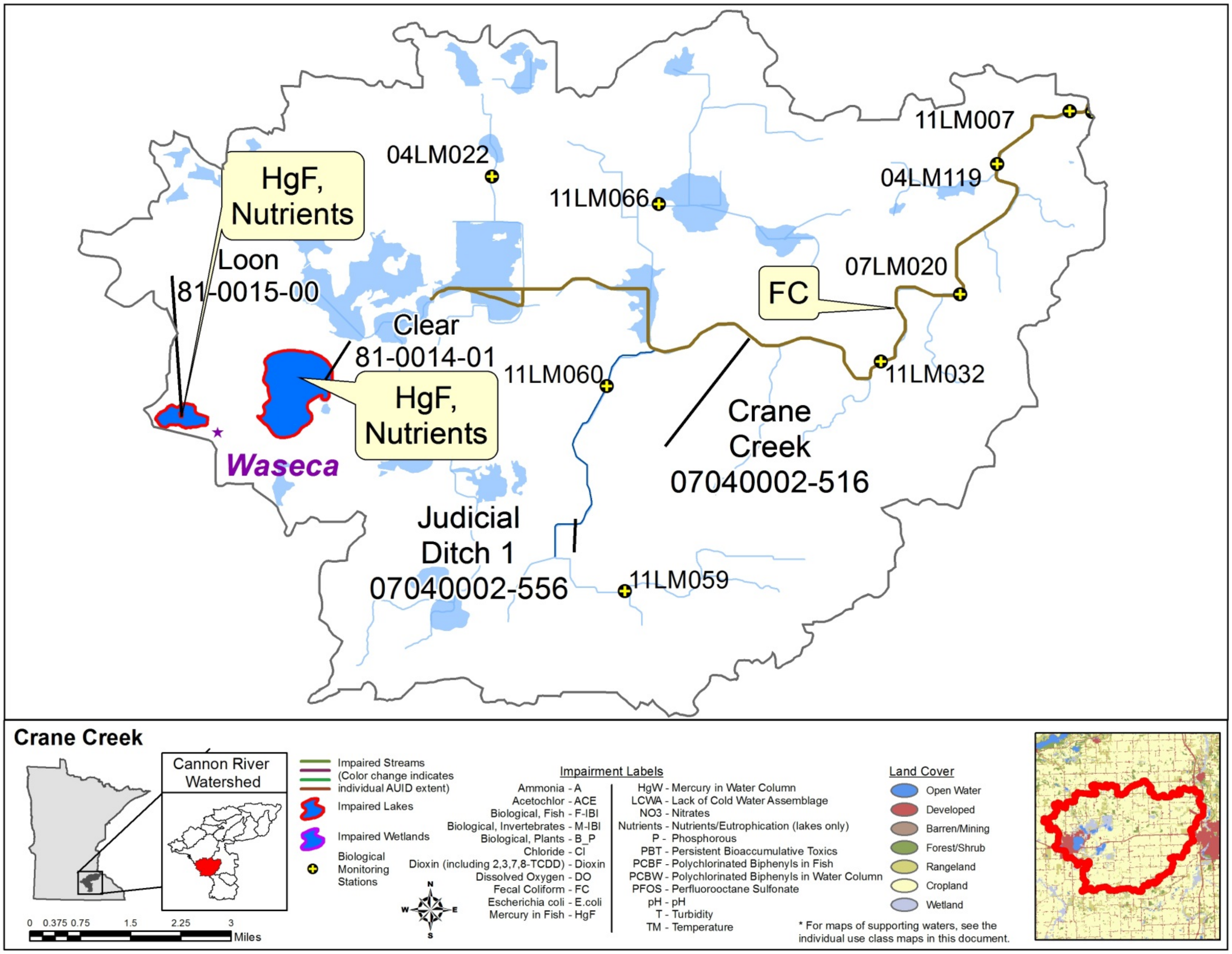

Figure 23. The 2013 assessed stream reaches with impairments and land use characteristics (inset) in the Crane Creek Subwatershed.

Lower Straight River Subwatershed HUC 0701000203-01

This subwatershed is the second largest at 167.8 mi^2, and is split between Rice County in the north and Steele County in the south with a small amount of land found in Dodge County to the east. This portion of the Straight River flows between the confluence with Turtle Creek and the Cannon River in Faribault. Major cities in the subwatershed include Owatonna in the south, Medford in the center, and Faribault in the north. The majority of this subwatershed is located in the WCBP ecoregion with the exception of the area just south and east of Faribault, which is in the NCHF ecoregion. Land use is predominantly row-crop agriculture (66%) with some range land (11%). According to the National Land Cover Dataset (2006), over 15% of the land use is classified as developed land, which includes the cities of Owatonna, Medford, and Faribault, with little forest and wetland remaining (5% and 3%, respectively). The water chemistry outlet station (STORET/EQuIS station S006-527, biological station 11LM010) is located on the Straight River at 14th St. NE in Faribault, just upstream of the wastewater treatment plant. During the 2013 assessment, 13 stream reaches were assessed for aquatic life and/or aquatic recreation use support (Table 13). While there are two lakes >10 acres in size (Kohlmeier 74-0019 and unnamed Lake 74-0015), neither had water chemistry information with which to assess their condition.

Table 13. Aquatic life and recreation assessments on stream reaches: Lower Straight River Subwatershed.

AUID, Reach Name, Reach Description	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	**Bacteria**	**Aquatic Life**	**Aquatic Rec.**
07040002-731, Unnamed creek, Unnamed cr to Unnamed cr	1.9	2B	11LM061	Upstream of Havana Rd, 4.5 mi. SE of Owatonna	MTS	EXP	--	--	--	--	--	--	--	NS	NA
07040002-729, Unnamed creek, Headwaters to Maple Cr	3.5	2B	11LM022	Upstream of Rice Lake St E, in Owatonna	MTS	MTS	--	--	--	--	--	--	--	FS	NA
07040002-519, Maple Creek, Headwaters to Straight R	12.9	2B	11LM011 11LM062	Upstream of Mineral Springs Rd, in Owatonna Downstream of CSAH 35 (Dane Rd), 3 mi. NE of Owatonna	EXP	MTS	IF	MTS	--	MTS	MTS	--	EX	FS	NS
07040002-726, Unnamed creek, Headwaters to Medford Cr	6.7	2B	11LM064	Downstream of CR 77 (NE 24th Ave), 3 mi. SE of Medford	MTS	MTS	--	--	--	--	--	--	--	FS	NA
07040002-547, Medford Creek, Headwaters to Straight R	12.1	2B	11LM063 10EM075 11LM065	Upstream of CSAH 77 (NE 24th Ave), 3.5 mi. SE of Medford Downstream of NE 69th St, 1 mi. NE of Medford Downstream of CR 12 (NW 69th St), 1 mi. E of Medford	EXP	EXP	--	--	--	--	--	IF	--	NS	NA

07040002-604, Unnamed creek, Unnamed cr to Unnamed cr	2.3	2B	--	--	--	--	--	MTS	--	--	--	--	--	IF	NA
07040002-505, Rush Creek, Headwaters to Straight R	15.2	2B	11LM067	Downstream of 270th St E (NW 86th St), 2.5 mi. NE of Medford	MTS	MTS	IF	EXP	--	MTS	MTS	--	EX	NS	NS
07040002-704, Falls Creek, Unnamed cr to Straight R	3.8	2B	11LM069	0.25 mi. upstream of Hwy 60 (Kenyon Blvd), 1 mi. E of Faribault	MTS	MTS	IF	MTS	--	MTS	--	--	EX	FS	NS
07040002-535, Straight River, Turtle Cr to Owatonna Dam	7.4	2B	11LM043	Upstream of CSAH 18 (SW 28th St), 2.5 mi. SW of Owatonna	MTS	MTS	IF	MTS	--	MTS	MTS	IF	EX	FS	NS
07040002-503, Straight River, Maple Cr to Crane Cr	5.8	2B	10EM011 04LM120	Downstream of CSAH 45, 2 mi. S of Medford Upstream CR 34 (26th St NW), North of Owatonna	EXP	EXP	MTS	EXP	MTS	MTS	MTS	MTS	EX	NS	NS
07040002-536, Straight River, Crane Cr to Rush Cr	6.7	2B	11LM088	Upstream of CR 45 (N Main St), in Medford	EXP	EXP	--	EXP	--	--	--	--	--	NS	NA
07040002-515, Straight River, Rush Cr to Cannon R	13.3	2B	04LM014 11LM010 11LM092	Upstream of Hwy 19, 2 mi. N of Medford Downstream of 14th St NE, in Faribault Upstream of 227th St E, 3 mi. SE of Faribault	EXP	EXP	MTS	EXP	MTS	MTS	MTS	MTS	EX	NS	NS
07040002-537, Straight River, Owatonna Dam to Maple Cr	0.9	2B	--	--	--	--	MTS	MTS	MTS	--	--	--	--	FS	NA

Abbreviations for Indicator Evaluations: -- = No Data, NA = Not Assessed, IF = Insufficient Information, MTS = Meets criteria; EXP = Exceeds criteria, potential impairment;
EXS = Exceeds criteria, potential severe impairment; EX = Exceeds criteria (Bacteria).
Abbreviations for Use Support Determinations: NA = Not Assessed, IF = Insufficient Information, NS = Non-Support, FS = Full Support
Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use; = previously impaired, delisting completed or proposed.

Table 14. Non-assessed biological stations on channelized reaches or AUIDs: Lower Straight River Subwatershed.

AUID, Reach Name, Reach Description	Reach length (miles)	Use Class	Biological Station ID	Location of Biological Station	Fish IBI	Invert IBI
07040002-574, Mud Creek, JD 6 to Straight R	8.6	2C	04LM079	Downstream I-35, 5 mi. S of Faribaullt	fair (2)	fair (2)

See Appendix 5.1 for clarification on the good/fair/poor thresholds and Appendix 5.2 and Appendix 5.3 for IBI results.
Parentheses behind ratings indicate the quantity of site visits when >1, which may or may not occur in the same year.

Table 15. Minnesota Stream Habitat Assessment (MSHA): Lower Straight River Subwatershed.

# Visits	Biological Station ID	Reach Name	Channel Condition	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	11LM061	Trib. to Maple Creek	natural	2.5	11	4.3	14	24	55.8	fair
2	11LM022	Trib. to Maple Creek	natural	2.8	11.8	15.2	8	22	59.7	fair
1	11LM011	Maple Creek	natural	2	5.5	17.5	6	22	53.0	fair
1	11LM062	Maple Creek	natural	1.3	8	10.3	14	16	49.6	fair
1	11LM063	Medford Creek	natural	0	10	9	15	15	49	fair
2	10EM075	Medford Creek	natural	2.5	12.3	19.1	8	24	65.9	fair
1	11LM065	Medford Creek	natural	0	11	17.8	9	24	61.8	fair
1	11LM064	Trib. to Medford Creek	natural	0	10	17.4	6	24	57.4	fair
1	11LM067	Rush Creek	natural	2.5	9.5	16.2	12	22	62.2	fair
2	04LM079	Mud Creek	channelized	0	7.5	15.1	8.5	20.5	51.6	fair
2	11LM069	Falls Creek	natural	3.4	9	18.3	12.5	21.5	64.7	fair
1	11LM043	Straight River	natural	2.5	9	17.3	9	19	56.8	fair
2	10EM011	Straight River	natural	1.2	11.8	22.0	9.5	29	73.0	good
2	04LM120	Straight River	natural	5	9.8	15	7.5	6.5	43.8	poor
2	11LM088	Straight River	natural	2.3	6.8	15.8	7	17	48.8	fair
1	04LM014	Straight River	natural	5	10.5	20	12	21	68.5	good
1	11LM010	Straight River	natural	1	6	18	13	24	62	fair
1	11LM092	Straight River	natural	2.5	10.5	20.8	9	28	70.8	good
Average Habitat Results: *Lower Straight River Subwatershed*				**2.1**	**9.4**	**16**	**10**	**21.1**	**58.6**	**fair**

Qualitative habitat ratings

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

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

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

Table 16. Channel Condition and Stability Assessment (CCSI): Lower Straight River Subwatershed.

# Visits	Biological Station ID	Stream Name	Stream Type	Upper Banks (4-43)	Lower Banks (5-46)	Substrate (3-37)	Channel Evolution (1-11)	CCSI Score (13-137)	CCSI Rating
1	11LM061	Trib. to Maple Creek	MHL	6	19	26	3	54	moderately unstable
1	11LM022	Trib. to Maple Creek	MHL	23	19	31	6	81	severely unstable
1	11LM011	Maple Creek	MHL	12	9	6	4	31	fairly stable
1	11LM062	Maple Creek	MHL	19	26	26	3	74	moderately unstable
1	11LM063	Medford Creek	MHL	13	22	21	7	63	moderately unstable
1	10EM075	Medford Creek	MHL	8	22	10	7	47	moderately unstable
0	11LM065	Medford Creek	--	--	--	--	--	--	--
1	11LM064	Trib. to Medford Creek	MHL	23	30	42	6	101	severely unstable
1	11LM067	Rush Creek	MHL	27	28	18	11	84	severely unstable
1	04LM079	Mud Creek	TCR	18	15	8	3	44	fairly stable
1	11LM069	Falls Creek	MHL	21	40	26	7	94	severely unstable
1	11LM043	Straight River	MHL	19	21	20	6	66	moderately unstable
1	10EM011	Straight River	MHL	5	8	7	5	25	stable
1	04LM120	Straight River	MHL	22	19	17	6	64	moderately unstable
1	11LM088	Straight River	MHL	15	15	17	6	53	moderately unstable
0	04LM014	Straight River	--	--	--	--	--	--	--
1	11LM010	Straight River	MHL	15	17	13	5	50	moderately unstable
1	11LM092	Straight River	MHL	10	9	4	3	26	stable
Average Stream Stability Results: *Lower Straight River Subwatershed*				**16.0**	**19.9**	**18.3**	**5.5**	**59.7**	**moderately unstable**

Qualitative channel stability ratings

= stable: CCSI < 27 = fairly stable: 27 < CCSI < 45 = moderately unstable: 45 < CCSI < 80 = severely unstable: 80 < CCSI < 115 = extremely unstable: CCSI > 115

Table 17. Outlet water chemistry results: Lower Straight River Subwatershed.

Station Location:	**Straight River** ; At 14th St NE, in Faribault						
STORET/ EQuIS ID:	**S006-527**						
Station #:	**11LM010**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Chloride	mg/L	10	16	51	32	< 230	0
Dissolved Oxygen	mg/L	17	6.72	11.30	8.30	> 5.00	0
pH	SU	17	7.9	8.4	8.1	6.5 - 9.0	0
Transparency tube	100 cm	30	5	> 100	50	> 20	7
E. coli (geometric mean)	MPN/100ml	15	138	344	-	< 126	3
Escherichia coli	MPN/100ml	15	75	> 2420	393	< 1260	1
Hardness, carbonate	mg/L	10	240	331	286	-	-
Nitrite-nitrate	mg/L	10	2.32	10.80	6.45	-	-
Kjeldahl nitrogen	mg/L	10	0.41	1.36	0.80	-	-
Phosphorus	µg/L	10	67	331	183	-	-
Specific Conductance	µS/cm	17	516	837	675	-	-
Sulfate	mg/L	10	16.5	65.6	39	-	-
Temperature, water	deg °C	18	12	30	23	-	-
Total suspended solids	mg/L	10	3	62	26	-	-
Total volatile solids	mg/L	10	1	10	5	-	-

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.
[2]Data found in the table above were compiled using the results from data collected at the outlet monitoring station in the Lower Straight River Subwatershed, a component of the IWM work conducted between May and September from 2011 and 2012. These specific data do not necessarily reflect all data that were used to assess the AUID.

Summary of subwatershed water quality

High levels of bacteria in streams that may potentially make swimming, wading, and boating unsafe were measured throughout the subwatershed. In total, six stream reaches are not supporting aquatic recreation due to excess bacteria levels. For streams, biological quality varied from good to poor in headwaters and ditches and along the mainstem of the Straight River. Habitat quality was rated good to fair while channel instability varied from stable to severely unstable. Transparency measurements (water clarity) were low and could be related to channel instability issues that may be limiting habitat quality for certain fish and macroinvertebrates. Nutrients were also quite high on the mainstem as well as many ditches and tributaries to the Straight River, and may be contributing to biological stress that is negatively impacting sensitive aquatic organisms throughout this subwatershed as well as potentially downstream waterbodies such as the Straight and Cannon Rivers. Stressor identification is currently underway to pinpoint the likely causes and/or contributors leading to poorer biological condition. Some reaches of the Straight River and tributaries such as Falls Creek are currently supporting aquatic life uses, with many sensitive fish and macroinvertebrates present. However, signs of stress such as channel instability are evident at many stations along these reaches as well. Left unaddressed, high nutrients and habitat issues related to high, erosive flows could potentially lead to additional biological and water quality impairments in the future. The Morehouse dam on the Straight River in Owatonna was recently modified to allow fish passage in 2006 and may be partially responsible for better habitat conditions and the fair fish community present.

Stream assessments

For aquatic recreation, all six of the assessed reaches have bacteria levels exceeding the water quality standard and are impaired for aquatic recreation uses; of those, five are existing impairments and one is a new listing (Falls Creek -704). For aquatic life, 13 stream reaches were assessed. Of those, six are fully supporting, six are not supporting, one reach received an IF for insufficient information, and one is being recommended for a delisting. Of those stream reaches that are impaired, five reaches have existing turbidity impairments. During the recent 2013 assessment, recent data on four reaches support the existing impairment listings, while the Straight River (-535) from its confluence with Turtle Creek to the Owatonna Dam is recommended for delisting of its turbidity impairment. For biological criteria, one new fish and four new macroinvertebrate impairments were found on four stream reaches. Additional information on the biological condition on assessed stream reaches is included below.

Medford Creek (-726) is a tributary to the Straight River found to have impaired fish and macroinvertebrate communities. Three biological stations were sampled in 2010 and 2011. Both fish and macroinvertebrates demonstrate a similar trend. While fish and macroinvertebrate IBIs scored well above threshold at the two downstream stations (10EM075, 11LM065), the fish and macroinvertebrate IBI scores were both well below the threshold of impairment at the upstream station (11LM063). Pictures and CCSI scores from sampling indicate channel incision and overwidening, severe bank erosion, unstable substrates, and excess sedimentation issues. Channel instability also appears to be an issue to some degree at both downstream stations as well as the biological station (11LM064) on the tributary to Medford Creek (-726). Nitrates were also high at all stations (10 to 13 mg/L). The channel instability and high nitrates could potentially be related to row-crop intensification, tiling, and application of nitrogen fertilizer in recent years.

Of the four reaches that have only impaired macroinvertebrates, three reaches are on the Straight River (-503, -536, -515) downstream of Owatonna (Figure 24). This section of river is bounded by the Owatonna Wastewater Treatment Plant (WWTP) at its upper end and the Faribault WWTP at its confluence with the Cannon River, and also includes the Medford WWTP in between. The pattern of macroinvertebrate IBI scores (i.e., departure from impairment threshold) observed along this stretch of river does, however, does suggest that these urban centers are playing some role in the macroinvertebrate impairments as upstream of Owatonna (river miles 30 to 40), the macroinvertebrate community is meeting its biological expectation for a southern, riffle-run stream (Figure 23). Recent upgrades to both the Owatonna and Faribault WWTPs to reduce phosphorus loading were implemented in 2012 and so reductions would not be observed in the water samples collected during the 2013 assessment window. It is not possible at this time to determine whether these facilities contributed to the impaired macroinvertebrate community along this stretch of river or whether the cities themselves and their associated stressors (e.g., impervious surface, stormwater run-off, nutrients, chemical pollutants, etc.) or other watershed land use practices are having an impact on the ecological health of this river. Additional monitoring should occur to see whether the facility upgrades greatly reduced nutrients and improved water quality conditions and whether additional local and watershed wide reductions are needed to improve biological conditions as well.

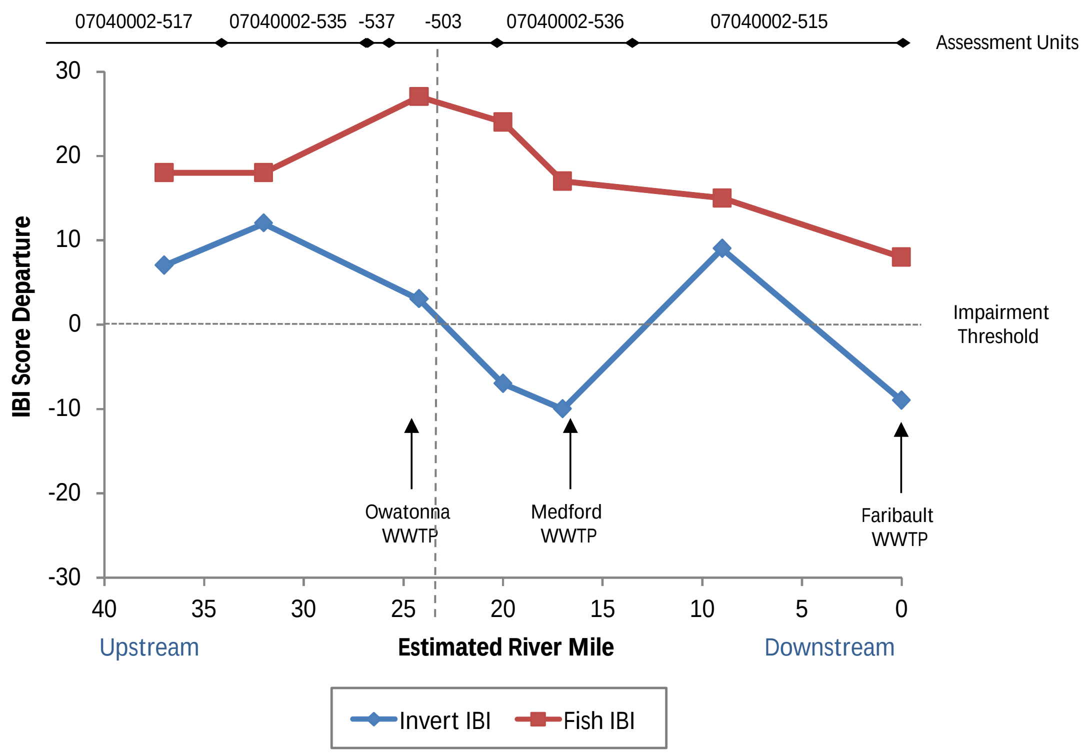

Figure24. Longitudinal pattern of fish and macroinvertebrate IBI scores (2010 & 2011 data) along the Straight River (dotted line divides the reaches into Upper and Lower Straight River Subwatersheds). To standardize the comparison between the two assemblages and among the monitoring locations, scores are depicted as departures from the impairment threshold because multiple IBI classes (each calibrated independently) are represented.

For fish IBIs, the highest performing station is just before Owatonna, and the scores progressively get lower as the Straight River flows through Medford and Faribault. While the fish community was not assessed as impaired, the lower IBI scores near the lower section of the Straight River may be demonstrating a response to some type of biological stress that potentially could lead to impairment in the future. Grab samples from fish sampling indicate that phosphorus was high (0.229 mg/L to 0.372 mg/L) with the highest measurements at stations near the cities of Medford (10EM011, 04LM120) and Faribault (04LM014, 11LM010). Habitat quality varied from poor to fair and channel stability moderately unstable to stable. The station with the poorest habitat quality (04LM120) had silt and sand as the dominant substrates with severe bank erosion and embeddedness; channel stability was rated moderately unstable. At the next station upstream (10EM011) the dominant substrates included cobble, gravel and sand with light to moderate bank erosion and light embeddedness; channel stability was considered stable. Hence, different stages of channel evolution may be occurring along the Straight River. Some stations were overwidened with severe aggradation, while other stations that were rated more stable may have begun to return to a narrower cross-section that is able to maintain some areas of clean coarse substrates. This hypothesis should be verified with channel geomorphology surveys. The MDNR has already completed some of this survey work along the Straight River.

Unnamed creek (-731) is a headwater tributary to Maple Creek near the city of Havana. This was the only reach that was assessed as impaired for macroinvertebrates in the Maple Creek Watershed. The macroinvertebrate community at station 11LM061 had good EPT richness (10 taxa, EPT is short for *Ephemeroptera*, *Plecoptera*, and *Trichoptera*, insect orders with species that are generally intolerant of pollution), but all EPT taxa were tolerant and the sample was comprised of 88% tolerant individuals. Habitat conditions were rated fair with bank erosion and severe embeddedness evident. Nitrates were high (9.5 mg/L) indicating a potential nutrient issue. Land use in the area is intensely managed for row-crops, upstream headwater reaches are channelized, and Havana is an unsewered community with 14 residences, all of which may contribute to higher nutrient levels and unstable stream conditions. Surprisingly, the fish community at station 11LM061 was very diverse (17 species) for a low-gradient stream, with a few sensitive species present (e.g., Iowa darter, hornyhead chub). The macroinvertebrate community may be more responsive to the stressor(s) present on this reach than the fish community, or potentially the mainstem of Maple Creek which is very diverse (>20 species) provides an opportunity to repopulate the headwaters between biologically stressful seasons and years.

Both fully supporting reaches within the Maple Creek watershed (-729, -519) had fish and macroinvertebrate IBI scores above threshold but within the confidence interval of impairment. The fish community was sampled at two locations; at stations 11LM011 upstream of Dartt's Park and at 11LM062 upstream of Mineral Spring Park. Both fish communities contained a high number of pollution sensitive species (e.g., Iowa darter, fantail darter, longnose dace, carmine shiner, northern hogsucker, hornyhead chub) and many gravel spawning species.

While not assessed as impaired, potentially stressful conditions were present on the tributary to Maple Creek (-729). For example, at biological station 11LM022, the invertebrate IBI was only 1 point above threshold with relatively few EPT taxa and no intolerant taxa present. For the fish community, while two pollution sensitive species were present (e.g., Iowa darter, longnose dace), relatively few fish were collected (95 individuals). Habitat was rated fair. Although the riparian area was wide with mature trees, fish cover was sparse with excess sedimentation in runs and pools noted. Channel instability was evident with severely cut banks, an overwidened cross-section, and sedimentation issues which likely contributed to the lack of cover with a loss of pool depth and moderate embeddedness of coarse substrates (image 3). Nitrogen was also high (9.6 mg/L) indicating a potential nutrient issue.

Falls Creek (-704) was sampled twice for fish at station 11LM069 in Falls Creek Park, just east of Faribault. While assessed as fully supporting for fish and invertebrate communities, scores were above but near the threshold of impairment. Similar stressful conditions were observed as within the Maple Creek watershed. Habitat quality was rated fair and good with a wide riparian area of mature trees and light embeddedness of coarse gravels in riffles and runs. However, channel stability was rated severely unstable with some degree of incision, cut banks, lateral and center bar build-up, and excess deposition observed (Image 4). This reach is in the process of returning to a more stable cross-section and channel configuration which allows for some habitat quality to support a few gravel spawning fish species present in the reach, although these species are not considered sensitive to pollution. Nitrogen was also very high (14 mg/L on 8/4/2011).

Image 3: Cut banks and excess sedimentation creating uniformly shallow water depth at 11LM022, a tributary to Maple Creek.

Image 4: Aggradation on point bar causing flow-deflection and erosion on outside bank at 11LM069 on Falls Creek.

Rush Creek (-505) is a 15 mile tributary to the Straight River. One biological station (11LM067) was sampled for fish and macroinvertebrates near the lower end of the reach. Both biological indicators had IBI scores above the threshold of impairment; however, fewer fish species and EPT taxa were collected than would be expected. Habitat conditions were fair with channel instability rated severely unstable, with cut banks and point bar deposition evident. This stream reach has existing turbidity impairment and the recent data confirms the turbidity listing. The one-time grab sample did not indicate that nutrients were high; therefore, it is probable that channel incision and altered watershed hydrology may be contributing to the turbidity impairment and the current biological condition. Left unaddressed, it is possible that this reach could have biological impairments in the future.

Mud Creek was not assessed due to channelization. The biological station (04LM079) rated fair for both biological indicators using the channelized stream rating. This station was sampled in 2004 and 2011. IBI scores were highly variable between years with fish IBI scores much higher in 2004 than 2011, while the opposite occurred for macroinvertebrates. Habitat was fair with coarse substrates and channel stability rated as fairly stable. Nutrients were high (Nitrates: 14 mg/L and 11 mg/L; Phosphorus: 0.234 mg/L and 0.190 mg/L), and there is a possible fish barrier at the station.

Watershed plans, projects, and TMDLs

Many of the bacteria impairments in this subwatershed are being addressed through the Lower Mississippi River Basin— Regional Fecal Coliform TMDL http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/lower-mississippi-river-basin-tmdl/project-lower-mississippi-river-basin-regional-fecal-coliform.html. Addressing the turbidity impairments on the lower Cannon River and Lake Pepin will require also managing sediment and phosphorus loading to the Straight River as well.

County water management plans and projects can be found at the following websites:

- Rice County - http://www.co.rice.mn.us/node/104860
- Steele County - http://www.co.steele.mn.us/departments/environmental_services/water_issues.html
- Dodge County - http://www.dodgeswcd.org

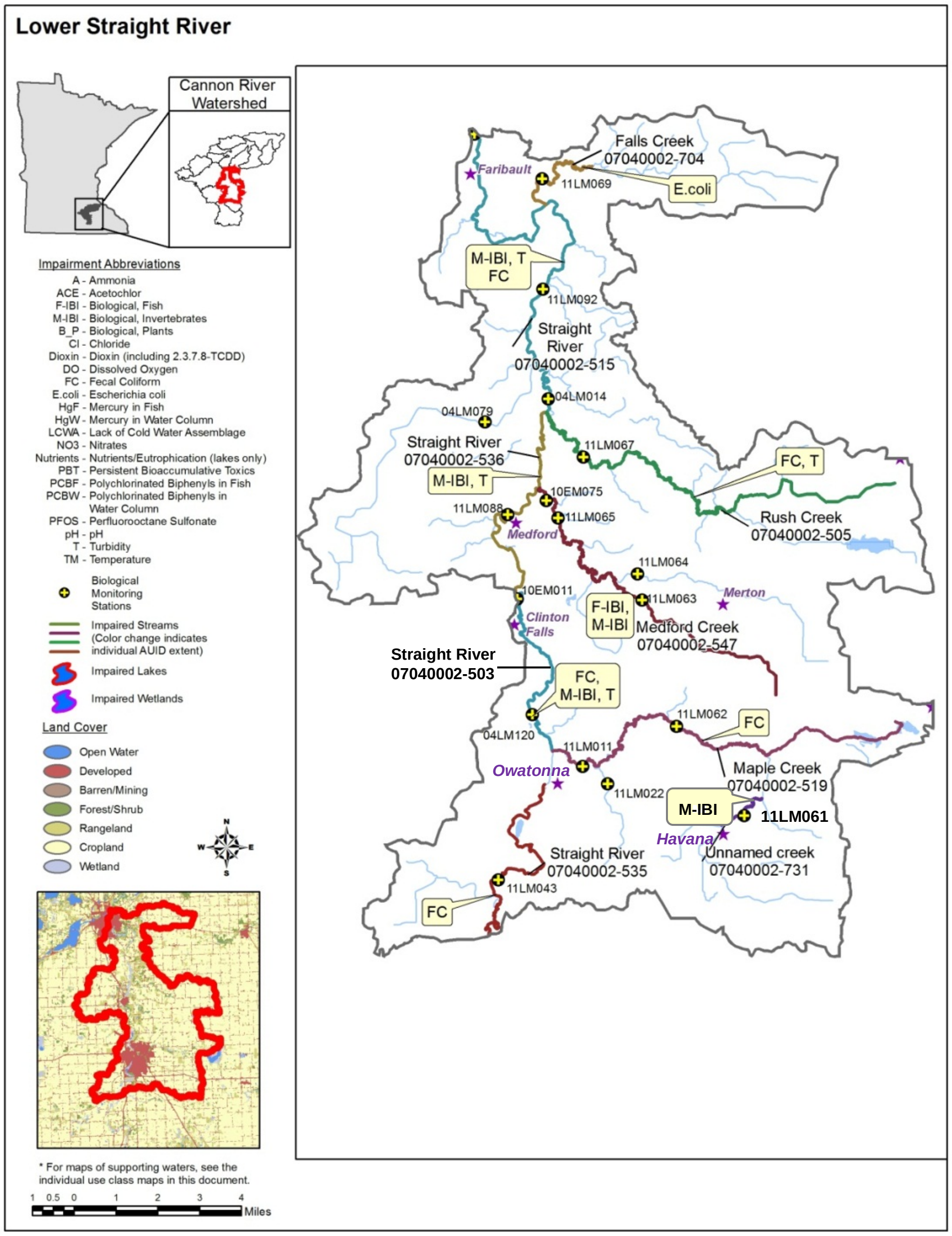

Figure 25. 2013 assessed stream reaches with impairments and land use characteristics (inset) in the Lower Straight River Subwatershed.

Upper Straight River Subwatershed HUC 0704000203-02

The Upper Straight River subwatershed covers nearly 144 mi^2. The majority of the subwatershed is found in Steele County, with a minimal sliver in Dodge County to the west and Freeborn County to the south. The entire subwatershed is located in the WCBP ecoregion. There are 15 lake basins >10 acres in size. Cropland is the dominant land use (78%) followed by range (9%) and developed land (8%). Very little forest (2%) or wetland (2.5%) remains. The Upper Straight River Subwatershed starts in the headwaters near Ellendale and Blooming Prairie in Steele County and ends where Turtle Creek enters the Straight River downstream of Owatonna at Clinton Falls. The Straight River, which flows from the south, is the dominant body of water in the subwatershed and is fed by a series of creek and ditch tributaries as it travels north through farm country. The outlet is represented by STORET/EQuIS station S001-343 and biological station 11LM034 located at the bridge on the western end of SW 58th St/ County Rd 31, 6 miles southwest of Owatonna. During the 2013 assessment, three stream reaches were assessed for aquatic life and/or recreation uses (Table 18). A number of stream reaches were not assessed using biological indicators (F-IBI and M-IBI) due to channelization. Biological quality ratings for those stations are included in Table 18. One lake (Beaver) was assessed for aquatic recreation and aquatic consumption (Table 23).

Table 18. Aquatic life and recreation assessments on stream reaches: Upper Straight River Subwatershed.

AUID, Reach Name, Reach Description	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	**Aquatic Life**	**Aquatic Rec.**
07040002-732, Unnamed creek, Headwaters to Unnamed cr	6.7	2B	11LM038	Downstream of CR 155 (SW 128th St), 6 mi. NE of Ellendale	MTS	EXP*	--	--	--	--	--	--	--	IF*	NA
07040002-525, Unnamed creek, Headwaters to Straight R	11.8	2B	11LM036 11LM008 11LM039	Upstream of SE 128th St, 9 mi. NE of Ellendale Downstream of SE 44th Ave, 8 mi. E of Ellendale Downstream of SE 19th Ave, 5.5 mi. NE of Ellendale	MTS	MTS	--	--	--	--	--	--	--	FS	NA
07040002-517, Straight River, CD 25 to Turtle Cr	11.2	2B	04LM131 04LM033** 11LM034	Upstream of SW 81st St, 6 mi. S of Owatonna Upstream of Hwy 18, 2 mi. S of Owatonna Downstream of CSAH 31 (SW 58th St), 6 mi. SW of Owatonna	MTS	MTS	IF	MTS	MTS	MTS	MTS	--	EX	FS	NS

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

Table 19. Non-assessed biological stations on channelized reaches or AUIDs: Upper Straight River Subwatershed.

AUID, *Reach Name*, *Reach Description*	Reach length (miles)	Use Class	Biological Station ID	Location of Biological Station	Fish IBI	Invert IBI
07040002-524, **County Ditch 64**, Headwaters to Straight River	7.7	2B	11LM041	Upstream of SW 118th St, 4 mi. NE of Ellendale	good	fair
07040002-531, **Unnamed ditch,** Unnamed ditch to CD 64	4.8	2B	11LM042	Upstream of SW 42nd Ave, 3 mi. N of Ellendale	fair	good
07040002-698, **County Ditch 5**, Unnamed ditch to Straight R	4.1	2B	07LM001	Downstream of CR 30, 4 mi. SW of Owatonna	good (2)	poor
07040002-534, **Straight River,** Headwaters to Unnamed cr	10.2	2B	11LM037 04LM139	Downstream of SE 44th Ave, 8 mi. SE of Ellendale Upstream of CR 45, ~4.5 mi. NE of Ellendale	good (3)	fair (3)
07040002-532, **Straight River,** CD 64 to CD 25	2.0	2B	07LM002	Downstream of S 108th St, 5 mi. NE of Ellendale	fair	--
07040002-517, **Straight River,** CD 25 to Turtle Cr	11.2	2B	04LM033	Upstream of Hwy 18, 2 mi. S of Owatonna	fair	--

See Appendix 5.1 for clarification on the good/fair/poor thresholds and Appendix 5.2 and Appendix 5.3 for IBI results.
Parentheses behind ratings indicate the quantity of site visits when >1, which may or may not occur in the same year.

Table 8. Minnesota Stream Habitat Assessment (MSHA): Upper Straight River Subwatershed.

# Visits	Biological Station ID	Reach Name	Channel Condition	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	11LM038	Unnamed creek	channelized	0	0	12.3	9	20	41.3	poor
1	11LM036	Unnamed creek	natural	0	12.5	21.0	8	30	71.5	good
1	11LM008	Unnamed creek	natural	5	9	17.4	9	21	61.4	fair
1	11LM039	Unnamed creek	natural	2.5	12.5	15.8	13	24	67.8	good
1	11LM041	County Ditch 64	channelized	0	8	15.5	7	15	45.5	fair
1	11LM042	Unnamed ditch	channelized	0	8	18	9	10	45	fair
2	07LM001	County Ditch 5	channelized	0	8.5	11.5	6.5	8	34.5	poor
1	11LM037	Straight River	channelized	2.5	9	18.0	11	20	60.5	fair
2	04LM139	Straight River	channelized	5	9.5	6	3	9	32.5	poor

1	07LM002	Straight River	channelized	0	6.5	14	5	16	41.5	poor
2	04LM131	Straight River	natural	3.8	10.3	19.4	10	21.5	64.9	fair
1	11LM034	Straight River	natural	2.5	10	16.1	9	23	60.6	fair
1	04LM033	Straight River	channelized	2.5	9	18	9	18	56.5	fair
Average Habitat Results: *Upper Straight River Subwatershed*				**1.8**	**8.7**	**15.6**	**8.3**	**18.1**	**52.6**	**fair**

Qualitative habitat ratings

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

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

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

Table 21. Channel Condition and Stability Assessment (CCSI): Upper Straight River Subwatershed.

# Visits	Biological Station ID	Stream Name	Stream Type*	Upper Banks (4-43)	Lower Banks (5-46)	Substrate (3-37)	Channel Evolution (1-11)	CCSI Score (13-137)	CCSI Rating
1	11LM038	Unnamed creek	MHL	15	17	18	3	53	moderately unstable
1	11LM036	Unnamed creek	MHL	11	14	10	4	39	fairly stable
1	11LM008	Unnamed creek	MHL	25	25	14	11	75	moderately unstable
1	11LM039	Unnamed creek	MHL	18	23	25	7	73	moderately unstable
1	11LM041	County Ditch 64	TCR	24	7	16	3	50	moderately unstable
1	11LM042	Unnamed ditch	TC	12	11	10	3	36	fairly stable
1	07LM001	County Ditch 5	TC	19	9	17	2	47	moderately unstable
1	11LM037	Straight River	TCR	22	9	10	3	44	fairly stable
1	04LM139	Straight River	TC	26	15	22	4	67	moderately unstable
0	07LM002	Straight River	--	---	--	--	--	--	--
1	04LM131	Straight River	MHL	18	22	9	5	54	moderately unstable
1	11LM034	Straight River	MHL	30	23	26	7	86	severely unstable
0	04LM033	Straight River	--	--	--	--	--	--	--
Average Stream Stability Results: *Upper Straight River Subwatershed*				20	15.9	16.1	4.7	56.7	**moderately unstable**

*See Appendix 9 for description of stream types.

Qualitative channel stability ratings

= stable: CCSI < 27 = fairly stable: 27 < CCSI < 45 = moderately unstable: 45 < CCSI < 80 = severely unstable: 80 < CCSI < 115 = extremely unstable: CCSI > 115

Table 22. Outlet water chemistry results: Upper Straight River Subwatershed.

Station Location:	**Straight River** ; At end of SW 58th St, 6 mi SW of Owatonna						
STORET/ EQuIS ID:	**S001-343**						
Station #:	**11LM034**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	11	0.0001	0.0023	0.0008	< 0.0400	0
Chloride	mg/L	10	14	24	20	< 230	0
Dissolved Oxygen	mg/L	19	5.37	11.36	8.25	> 5.00	0
pH	SU	19	6.6	8.2	7.8	6.5 - 9.0	0
Transparency tube	100 cm	15	7	> 100	61	> 20	1
E. coli (geometric mean)	MPN/100ml	22	321	523	-	< 126	3
Escherichia coli	MPN/100ml	15	150	> 2420	600	< 1260	2
Hardness, carbonate	mg/L	10	224	382	297	-	-
Nitrite-nitrate	mg/L	10	1.19	8.55	4.51	-	-
Kjeldahl nitrogen	mg/L	10	0.30	1.40	0.84	-	-
Phosphorus	µg/L	10	52	270	139	-	-
Specific Conductance	µS/cm	19	425	696	601	-	-
Sulfate	mg/L	10	18.6	82.1	50.3	-	-
Temperature, water	deg °C	19	14.3	28.1	22.0	-	-
Total suspended solids	mg/L	10	4	118	29	-	-
Total volatile solids	mg/L	10	1	20	7	-	-

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.
[2]Data found in the table above were compiled using the results from data collected at the outlet monitoring station in the Upper Straight River Subwatershed, a component of the IWM work conducted between May and September from 2011 and 2012. These specific data do not necessarily reflect all data that were used to assess the AUID.

Table 23. Lake water aquatic recreation assessments: Upper Straight River Subwatershed.

Name	DNR Lake ID	Area (acres)	Trophic Status	Percent Littoral	Max. Depth (meters)	Avg. Depth (meters)	Mean TP (µg/L)	Mean chl-a (µg/L)	Secchi Mean (meters)	CLMP Trend	Aquatic Life Support Status	Aquatic Recreation Support Status	Aquatic Consumption Support Status
Beaver	740023	90	M	45	8.2	4.4	22	9	1.4	- -	IF	FS	FS

Abbreviations:

Trophic Status
H -- Hypereutrophic
E – Eutrophic
M -- Mesotrophic

Support Status
FS -- Full Support
NS -- Non-Support
IF -- Insufficient Information
NA – Not Assessed

CLMP Trend
I -- Increasing/Improving Trends
NT -- No Trend

Key for Cell Shading: = existing impairment (prior to 2012); = new impairment; = full support of designated use.

Summary of subwatershed water quality

Historically, the headwaters of the Straight River was a large >10,000 acre wetland marsh with native plants and abundant wildlife. During the early 1900s, the marsh was drained to advance opportunities for farming. Due to the unstable nature of peat lining the ditch banks, maintenance costs were high. Additionally, the loss of water storage in the headwaters caused more severe flooding and damage in neighboring communities. Today, portions of the historic marsh are being restored through state and federal programs and the work of private landowners and local agencies (http://www.steeleswcd.org/ProSerRIM.htm). In addition to retaining flood waters, it is thought that the marsh may also benefit wildlife and water quality in downstream reaches in the Straight and Cannon Rivers as well.

Today, water quality in this subwatershed appears to be better than others in the Cannon River Watershed. The Straight River and a tributary near Ellendale are considered fully supporting of aquatic life with many sensitive fish and macroinvertebrates collected. Across the subwatershed, habitat quality was generally fair to good with a few areas rated poor at channelized stations, while channel stability varied from fairly stable to severely unstable at stations along the Straight River and tributaries. The Straight River is currently listed as impaired due to turbidity (issues with water clarity) but a delisting may occur since water samples suggest that it is no longer an issue. The improvements in water clarity could be a result of the Straight River Marsh Project that helps to control the speed of water and remove sediment and nutrients before the water flows into the Straight River. In addition, Beaver Lake is fully supporting of both aquatic recreation and aquatic consumption. For streams, fish and macroinvertebrate communities are doing fairly well with a few exceptions where macroinvertebrates on channelized stations were rated poor. Water samples collected at the outlet station on the Straight River show both high and low measurements of DO that may be a stress to the biological communities. Water samples at this and other stations within the subwatershed suggest that although biological communities are doing fairly well, high nutrient (phosphorus and nitrates) levels may be contributing to extremes in high and low DO levels that may be a stress to sensitive fish and macroinvertebrates. Additionally, high levels of bacteria in the Straight River may make swimming or wading unsafe. Excess nutrients and bacteria leaving this subwatershed could be contributing to poor water quality conditions in downstream waterbodies such as the Lower Straight River and Cannon River.

Stream assessments

For aquatic recreation, only the Straight River (-517) was listed as impaired due to elevated bacteria in 2002, and data demonstrate that it is still not supporting aquatic recreation. Three stream reaches were assessed for aquatic life: two reaches are fully supporting and one reach is not supporting aquatic life use. Unnamed creek (-732) was assessed as having impaired aquatic macroinvertebrates, but the impairment is being deferred due to the reach being >50% channelized. Unnamed creek (-525) is fully supporting aquatic life and the Straight River (-517) is proposed to have its turbidity impairment delisted, which would also make it fully supporting of aquatic life. Additional information on individual reaches is included below.

The Straight River (-517—from Turtle Creek to the Owatonna Dam) was listed in 2002 for not supporting aquatic recreation due to excess bacteria and current data support the listing. Some projects to reduce bacteria loading to the Straight River have already occurred. For example, in 2008 the small community of Hope built a plant to treat its raw sewage which was previously routed untreated to the Straight River. Since the upgrade occurred during the 10-year assessment window, it may have been too early to detect whether the new plant is helping to reduce the bacteria levels in the Straight River. Additionally, there could be many other sources that may be contributing to the impairment such as underperforming septic systems, feedlots, manure applied to cropland, pet waste, and wildlife.

This same reach of the Straight River (-517) was also listed for turbidity in 2006 but is now meeting the water quality standard; consequently, a delisting process has been initiated to remove it from the Impaired Waters List. Improvements in water clarity may be attributed to the Straight River Marsh Project (http://www.steeleswcd.org/ProSerRIM.htm) that may now dampen flood peaks that used to excessively erode stream banks and send sediments and nutrients such as phosphorus downstream. When the turbidity listing is removed, this section of the Straight River will be considered fully supporting of aquatic life. A number of fish species were sampled that are considered sensitive to pollution (greater redhorse, northern hogsucker, hornyhead chub, fantail darter, longnose dace, carmine shiner) including a small (19.5 inch) muskellunge (Image 5) sampled ~6 miles upstream of Owatonna. Inquiries by the MDNR determined that this small muskellunge came from a local rearing pond that overflowed during a large storm event. Many of the sensitive fish species sampled on this section of the Straight River are fish that require clean coarse substrates and good water quality conditions to spawn. While this reach was assessed as fully supporting for its aquatic life use, the fish IBI at the downstream station (11LM034) was 18 points above threshold while the fish IBI at the upstream station (04LM131) was two points below threshold, thereby suggesting that stressors may be present at least in the upper portion of this reach that is suppressing the biological community. Habitat quality was rated fair at both station 11LM034 and station 04LM131 with sparse cover and light to moderate bank erosion and embeddedness. Channel stability was rated moderately unstable and severely unstable, respectively. The one-time grab samples during fish sampling show that nitrates were also much higher at the upstream station than the downstream station (7 mg/L on 6/14/2011 and 1.5 mg/L on 8/16/2011, respectively); however, this may be due to the different time of year that the samples were taken, since nitrates can be higher in streams during the spring months before row-crop plants are growing and able to take-up excess nitrates that instead may enter subsurface drain tile and be routed to streams and rivers.

The other reach that is fully supporting aquatic life (unnamed creek -525) is a 12 mile long tributary to the Straight River. There were three biological stations sampled in 2011. The macroinvertebrate community scored above the impairment threshold at all three stations. However, for fish, while the two lower stations (11LM008 and 11LM039) scored well above the impairment threshold with high diversity of species (15 and 29, respectively) and sensitive taxa present, the fish community at the upstream station (11LM036) scored 10 points below threshold with low species diversity (7) and only one sensitive individual (Iowa darter) collected. Habitat was rated good with gravel and cobble riffles and light embeddedness in runs. Channel stability was rated fairly stable with some bank cutting observed. Given the good ratings for macroinvertebrates and that there was nothing noted that would be considered a biological stress to the fish community, the assessment team assessed the reach as fully supporting. Pictures from sampling indicate that although this reach is fully supporting for both fish and macroinvertebrates, some moderate channel instability is occurring at the lower stations (11LM008, 11LM039). CCSI scores and site images from these two stations indicate that the stream is moderately incised with severely cut banks (i.e., flow related bank erosion). This may be a symptom of watershed-wide changes in hydrology that have caused streams to down-cut and concentrate flows within the stream channel during high flow events, thereby scouring substrates and eroding banks (Image 6).

Image 5: Small muskellunge collected on the Straight River upstream of Owatonna. It is suspected that this small muskie escaped from a rearing pond during a large storm event.

Image 6: Evidence of channel instability as bank erosion and mid-channel bars at 11LM008 on unnamed creek.

Many other biological stations along the Straight River and tributaries were sampled but not assessed due to the biological station locations being channelized. The biological quality was rated good to fair for fish and good to generally good to fair for macroinvertebrates with two exceptions where the macroinvertebrates were rated poor— stations 07LM001 on County Ditch 5 and 04LM139 on the Straight River. Habitat quality was rated poor at both stations with silt on the bottom of the channel. For County Ditch 5 (07LM001) south of Owatonna, algae and instream plants were dense and made wading difficult, suggesting that there may be an issue with excess nutrients. Due to the density of plants and algae it is plausible that dissolved oxygen (DO) may be experiencing high daily fluctuations, although DO measured 7.0 mg/L during both fish sampling events. The station on the Straight River (04LM139) EPT taxa count was low (only 2 taxa; EPT is short for *Ephemeroptera*, *Plecoptera*, and *Trichoptera*, insect orders with species that are generally intolerant of pollution) and the tolerant taxa percent was high (90%); whereas, at a different station downstream that rated fair (11LM039), the EPT taxa count was much higher (9 taxa) and tolerant taxa percent was slightly lower (75%). These results mirror the habitat ratings at the two stations, suggesting that degraded habitat conditions may be responsible for the poor macroinvertebrate community at the downstream station (04LM139). Additionally, DO measured during fish sampling at 04LM139 on 6/13/2011 was very high (13.5 mg/L) suggesting high daily fluctuations in DO may be occurring, although plants were sparse.

Lake assessments

Of the 15 lake basins >10 acres in size, only one (Beaver Lake, 74-0023) was assessed for recreation use support. Beaver Lake displays unusually high water quality (Table 23) for the WCBP ecoregion in comparison to similar deep basins in the area. Beaver Lake was selected as one of the reference lakes for the WCBP ecoregion when lake water eutrophication standards were being developed. Beaver Lake fully supports aquatic recreation uses. The overall catchment area for this lake is relatively small with a mix of forested and agricultural land, as well as residential dwellings on the north and south shorelines and a public park with a swimming beach. Nutrients entering the lake are detained in the hypolimnion when the water column stratifies during the summer months; however, algal blooms may occur late in the season when the water column turns over and brings additional nutrients to the surface. Currently there are insufficient water quality data to determine the support status for aquatic life uses; although the chloride levels measured in the lake were low.

Watershed plans, projects, and TMDLs

The bacteria impairment on the Straight River (-517) is being addressed through the Lower Mississippi River Basin— Regional Fecal Coliform TMDL http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/lower-mississippi-river-basin-tmdl/project-lower-mississippi-river-basin-regional-fecal-coliform.html. A few projects have already been implemented to reduce bacteria and phosphorus loading to the Straight River, one example being the Hope-Somerset Township Wastewater Treatment Facility. Additional information on the Straight River Marsh Project can be found on the Steele County SWCD website: http://www.steeleswcd.org/ProSerRIM.htm.

County water management plans and projects can be found on County SWCD website:

- Steele County - http://www.co.steele.mn.us/departments/environmental_services/water_issues.html
- Freeborn County - http://www.freebornswcd.org/

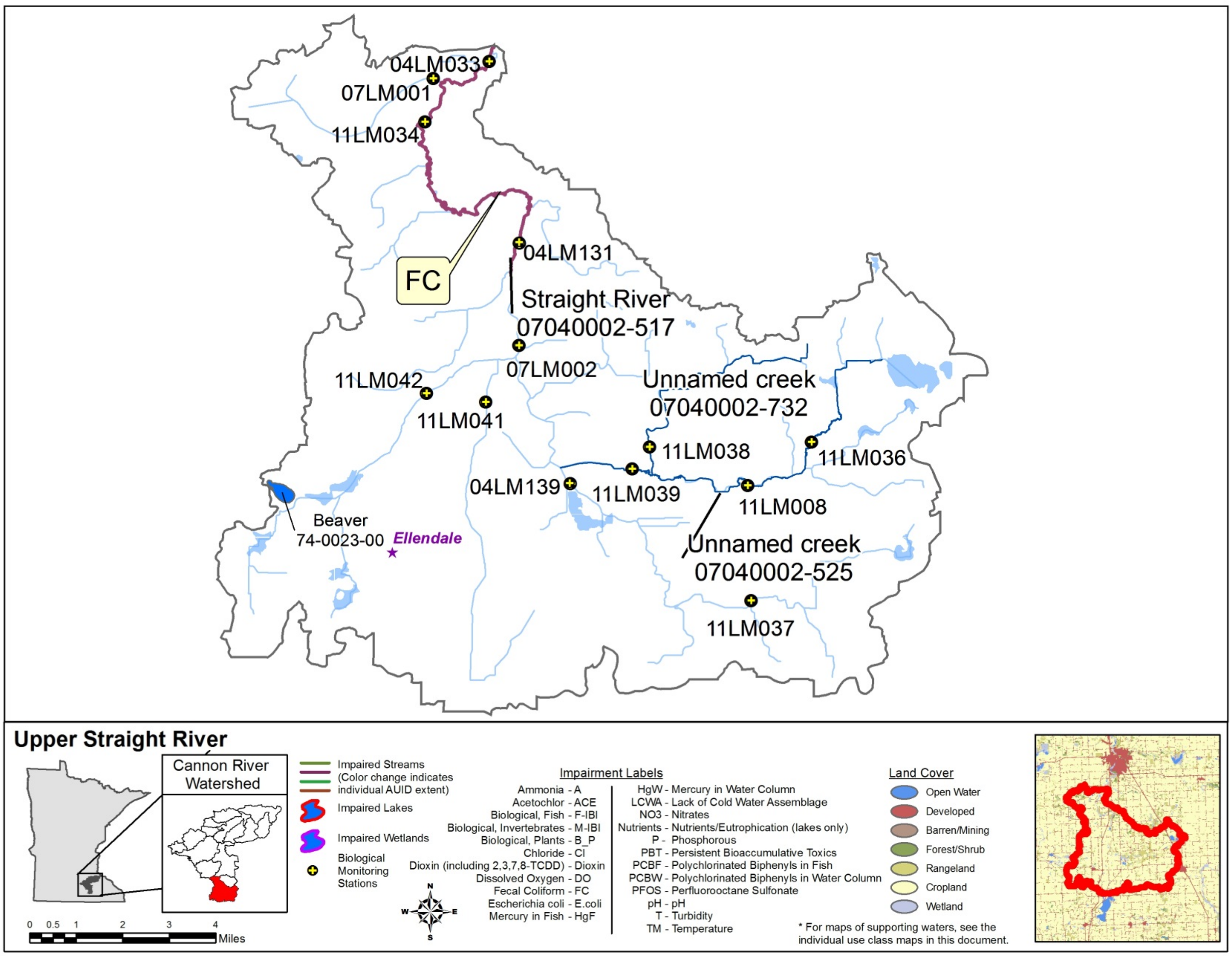

Figure 26. The 2013 assessed stream reaches with impairments and land use characteristics (inset) in the Upper Straight River Subwatershed.

Turtle Creek Subwatershed HUC 0704000203-03

Located in Steele County, the Turtle Creek Subwatershed is the third smallest subwatershed at 44.8 mi^2. Turtle Creek flows from east to west for a total of 19 miles to its confluence with the Straight River, 2 miles southwest of Owatonna. Turtle Creek follows a drainage ditch for much of the first half of its journey through farm country; however, the stream channel becomes more natural shortly after crossing under CSAH-73 one mile southwest of the Town of Pratt where it flows through the Aurora Wildlife Management Area. From there Turtle Creek enters the Straight River south of Owatonna. This subwatershed falls entirely within the WCBP ecoregion. Land use is predominantly cropland (76%) while the remaining land use is a mix of range (11%) and developed land (8%) with very little forest (2%) and wetland (3%). The water chemistry outlet station is located just upstream of the SW 22nd Avenue bridge over Turtle Creek, 3 miles southwest of Owatonna (STORET/EQuIS station S003-628, biological station 11LM004). According to MDNR lake coverage, there are three lake basins >10 acres in size; however, aerial photos show none of them are actual open water lakes and no assessments were made. Only one stream reach on Turtle Creek (-518) was assessed for aquatic life and recreation use support (Table 24).

Table 24. Aquatic life and recreation assessments on stream reaches: Turtle Creek Subwatershed.

AUID, Reach Name, Reach Description	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	**Aquatic Life**	**Aquatic Rec.**
07040002-518, Turtle Creek, Headwaters to Straight R	19.2	2B	11LM035 11LM004	Upstream of SW 22nd Ave, 3 mi. SW of Owatonna Upstream of SE 24th Ave, 4.5 mi. SE of Owatonna	MTS	MTS	IF	MTS	MTS	MTS	MTS	IF	EX	FS	NS

Abbreviations for Indicator Evaluations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **MTS** = Meets criteria; **EXP** = Exceeds criteria, potential impairment; **EXS** = Exceeds criteria, potential severe impairment; **EX** = Exceeds criteria (Bacteria).
Abbreviations for Use Support Determinations: **NA** = Not Assessed, **IF** = Insufficient Information, **NS** = Non-Support, **FS** = Full Support
Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use.

Table 25. Minnesota Stream Habitat Assessment (MSHA): Turtle Creek Subwatershed.

# Visits	Biological Station ID	Reach Name	Channel Condition	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	11LM035	Turtle Creek	natural	2.5	10	21.0	8	22	63.5	good
1	11LM004	Turtle Creek	natural	2.5	12	20.2	11	23	68.7	good
Average Habitat Results: *Turtle Creek Subwatershed*				**2.5**	**11**	**20.6**	**9.5**	**22.5**	**66.1**	**good**

Qualitative habitat ratings

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

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

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

Table 26. Channel Condition and Stability Assessment (CCSI): Turtle Creek Subwatershed.

# Visits	Biological Station ID	Stream Name	Stream Type*	Upper Banks (4-43)	Lower Banks (5-46)	Substrate (3-37)	Channel Evolution (1-11)	CCSI Score (13-137)	CCSI Rating
1	11LM035	Turtle Creek	MHL	23	21	14	7	65	moderately unstable
1	11LM004	Turtle Creek	MHL	20	19	15	4	58	moderately unstable
Average Stream Stability Results: *Turtle Creek Subwatershed*				**21.5**	**20**	**14.5**	**5.5**	**61.5**	**moderately unstable**

*See Appendix 9 for description of stream types.

Qualitative channel stability ratings.

= stable: CCSI < 27 = fairly stable: 27 < CCSI < 45 = moderately unstable: 45 < CCSI < 80 = severely unstable: 80 < CCSI < 115 = extremely unstable: CCSI > 115

Table 27. Outlet water chemistry results: Turtle Creek Subwatershed.

Station Location:	**Turtle Creek** ; Upstream of SW 22nd Ave, 3 mi SW of Owatonna						
STORET/ EQuIS ID:	**S003-628**						
Station #:	**11LM004**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	11	0.0001	0.0038	0.0016	< 0.0400	0
Chloride	mg/L	10	14	23	19	< 230	0
Dissolved Oxygen	mg/L	19	7.05	10.03	8.21	> 5.00	0
pH	SU	19	7.5	8.3	8.0	6.5 - 9.0	0
Transparency tube	100 cm	32	4	> 100	67	> 20	5
Turbidity	NRTU	13	2	190	26	25	3
E. coli (geometric mean)	MPN/100ml	91	170	236	-	< 126	3
Escherichia coli	MPN/100ml	15	93	> 2420	577	< 1260	1
Hardness, carbonate	mg/L	10	184	391	279	-	-
Nitrite-nitrate	mg/L	23	0.03	12.00	5.47	-	-
Kjeldahl nitrogen	mg/L	10	0.36	1.60	0.78	-	-
Phosphorus	µg/L	23	47	510	150	-	-
Specific Conductance	µS/cm	19	397	684	598	-	-
Sulfate	mg/L	10	7.7	25.7	18.3	-	-
Temperature, water	deg °C	19	14.5	27.0	20.6	-	-
Total suspended solids	mg/L	23	3	250	25	-	-
Total volatile solids	mg/L	22	2	50	6	-	-

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.
[2]Data found in the table above were compiled using the results from data collected at the outlet monitoring station in the Turtle Creek Subwatershed, a component of the IWM work conducted between May and September from 2011 and 2012. These specific data do not necessarily reflect all data that were used to assess the AUID.

Summary of subwatershed water quality

Turtle Creek has high bacteria levels that may potentially make swimming and wading unsafe. At present, the diverse fish and macroinvertebrate communities are doing fairly well, although low DO was measured that is a likely stress that should be investigated in order to prevent impairments in the future. Water samples collected on Turtle Creek (Table 27) indicate that nutrients such as phosphorus and nitrates are at times elevated and may be a factor in the low DO and higher percentage of tolerant fish and macroinvertebrates observed. Habitat was good, although channel instability was observed. High nutrients leaving this subwatershed may also impact downstream waterbodies such as the Lower Straight River and Cannon River.

Stream assessments

For aquatic recreation, Turtle Creek was listed due to elevated bacteria levels in 2002 and current data support the existing impairment. For aquatic life, Turtle Creek was assessed as fully supporting for fish and macroinvertebrate communities; however, additional monitoring is recommended to determine if DO levels are a potential stressor to aquatic life. High phosphorus concentrations (>500 µg/L) may be a factor. Nitrates were also high (12 mg/L). Additional information on the biological communities and assessments are included below.

Two stations were sampled on Turtle Creek: 11LM035 and 11LM004. Although assessed as fully supporting aquatic life, both fish and macroinvertebrate IBIs were close to the threshold of impairment. High diversity of fish species were found at both stations (16 and 23, respectively) with sensitive species present; however, both samples were dominated by tolerant fish (68% and 65%, respectively) which may suggests that biological stressful conditions are present and are having a negative impact on the fish community. The macroinvertebrate communities were comprised of a moderate number of EPT taxa (8 taxa at both stations; EPT is short for *Ephemeroptera*, *Plecoptera*, and *Trichoptera*, insect orders with species that are generally intolerant of pollution) and high percentage of tolerant individuals (78% and 89%, respectively). Habitat quality was rated good at both stations with good diversity of cover and only light embeddedness of gravel substrate; however, channel stability was rated moderately unstable with some cutting and bank erosion observed and excess embeddedness in runs. Grab samples of water chemistry during fish sampling indicate that nitrates are high (8.5 mg/L and 9.6 mg/L, respectively). Data collected at the water chemistry outlet station also show water quality standard exceedances for transparency tube and turbidity; however, exceedance rates were <10% and so are considered to be currently meeting their standards. The high nitrates and channel instability observed on Turtle Creek is a symptom of many subwatersheds in this area where land use is predominantly row crop agriculture with extensive networks of tile drainage. A Watershed and Restoration and Protection Strategy (WRAPS) should consider including Turtle Creek in broad regional applications of nutrient and flow management strategies.

Watershed plans, projects, and TMDLs

Stressor identification is underway to determine the candidate causes of biological impairments. The bacteria impairment on Turtle Creek is being addressed through the Lower Mississippi River Basin—Regional Fecal Coliform TMDL http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/lower-mississippi-river-basin-tmdl/project-lower-mississippi-river-basin-regional-fecal-coliform.html.

The county water quality plan and projects can be found at the Steele County SWCD website:

http://www.steeleswcd.org/

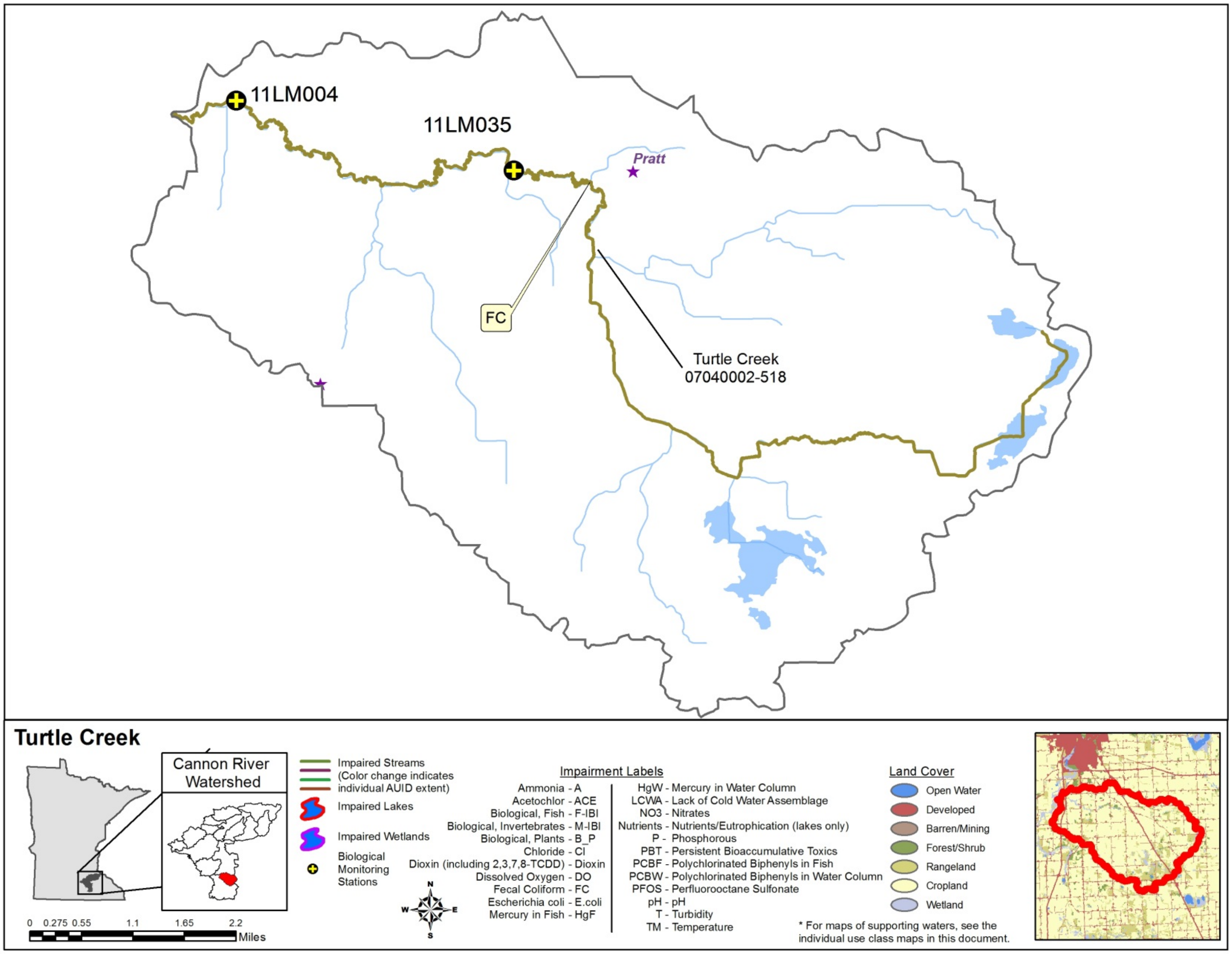

Figure 27. The 2013 assessed stream reaches with impairments and land use characteristics (inset) in the Turtle Creek Subwatershed.

Chub Creek Subwatershed HUC 0704000204-01

Located mostly in Dakota County, the Chub Creek Subwatershed covers just over 85 miles reaching from the cities of Elko New Market in the northwest to the northern outskirts of Northfield in the south and over to Randolph in the east. Chub Creek starts in Chub Lake northwest of Northfield and flows east 25 miles to Randolph before entering the Cannon River near the west side of the Byllesby Reservoir. The subwatershed is split nearly evenly between the NCHF and WCBP ecoregions. Land use is predominantly agriculture (83%) consisting of a mix of cropland (60%) and rangeland (23%). Forest and wetland cover 12% of the watershed with the remaining as developed land (5%). There are two lake basins >10 acres in size. The water chemistry outlet station (STORET/EQuIS station S002-533, biological station 00LM007) is located at the CSAH-83 bridge over Chub Creek, in Randolph. During the 2013 assessment, six stream reaches were assessed for aquatic life and/or recreation uses (Table 28). Three channelized stations were not assessed using biological indicators (F-IBI and M-IBI). Biological quality ratings for those stations are included in Table 29. For lakes, only Chub Lake was assessed for aquatic recreation (Table 33).

Table 28. Aquatic life and recreation assessments on stream reaches: Chub Creek Subwatershed.

AUID, ***Reach Name***, *Reach Description*	Reach Length (miles)	Use Class	Biological Station ID	Location of Biological Station	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	Aquatic Life	Aquatic Rec.
07040002-719, Unnamed creek, Unnamed cr to Unnamed cr	0.8	2B	11LM071	Downstream of Isle Ave, 2.5 mi. SW of Dennison	MTS	MTS	--	--	--	--	--	--	--	FS	NA
07040002-572, Dutch Creek, Headwaters to Chub Cr	9.3	2C	11LM044 04LM143	Upstream of Foliage Ave, 6 mi NW of Northfield Downstream of CR 90 (300th St W), 5 mi. NW of Northfield	EXP	EXP	EXP	--	--	--	--	--	--	IF†	NA
07040002-558, Mud Creek, Unnamed cr to Chub Cr	2.5	2B	11LM017	Downstream of Hwy 3 (Dahomey Ave), 3 mi. N of Northfield	MTS	MTS	EXP	MTS	--	MTS	MTS	--	EX	FS	IF
07040002-566, Chub Creek, North Branch, T113 R19W S19, west line to Chub Cr	7.1	2C	11LM018**	Upstream of CR 86 (280th St), 3.5 mi. NW of Randolph	NA**	NA**	IF	MTS	--	MTS	MTS	--	EX	IF*	NS
07040002-528, Chub Creek, Headwaters to Cannon R	24.7	2B	11LM016 10EM087 00LM006 11LM012 07LM017** 00LM007	Upstream of CSAH 23 (Foliage Ave), 4.5 mi. W of Northfield 0.25 mi. upstream of Arkansas Ave, 4 mi. NE of Northfield Upstream of Hwy 3 (Dahomey Ave), 4 mi. N of Northfield Downstream of Canada Ave, 4 mi. NE of Northfield Upstream of 290th St E, 3 mi. W of Randolph Upstream of CR 83, in Randolph	EXP	EXP	IF	MTS	MTS	MTS	MTS	IF	EX	NS	NS

Abbreviations for Indicator Evaluations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **MTS** = Meets criteria; **EXP** = Exceeds criteria, potential impairment; **EXS** = Exceeds criteria, potential severe impairment; **EX** = Exceeds criteria (Bacteria).
Abbreviations for Use Support Determinations: **NA** = Not Assessed, **IF** = Insufficient Information, **NS** = Non-Support, **FS** = Full Support
Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use.
** Channelized station, biological data currently not assessed for aquatic life until Tiered Aquatic Life Use (TALU) standards are developed.
†Not assessed, additional monitoring recommended.

Table 29. Non-assessed biological stations on channelized reaches or AUIDs: Chub Creek Subwatershed.

AUID, *Reach Name*, *Reach Description*	Reach length (miles)	Use Class	Biological Station ID	Location of Biological Station	Fish IBI	Invert IBI
07040002-720, Unnamed cr, Unnamed cr to Chub Cr	1.4	2B	11LM013	Downstream of 290th St W, 5 mi. N of Northfield	fair	good
07040002-566, Chub Creek, North Branch, T113 R19W S19, west line to Chub Cr	7.1	2C	11LM018	Upstream of CR 86 (280th St), 3.5 mi. NW of Randolph	fair	fair
07040002-528, Chub Creek, Headwaters to Cannon R	24.7	2B	07LM017	Upstream of 290th St E, 3 mi. W of Randolph	fair	--

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

Table 30. Minnesota Stream Habitat Assessment (MSHA): Chub Creek Subwatershed.

# Visits	Biological Station ID	Reach Name	Channel Condition	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	11LM071	Unnamed creek	natural	2.5	9.5	12.7	11	25	60.7	fair
1	11LM044	Dutch Creek	natural	2.5	9	11.2	16	18	56.7	fair
1	04LM143	Dutch Creek	natural	0	11	19	17	19	66	good
1	11LM013	Unnamed ditch	channelized	0	9.5	11.6	11	19	51.1	fair
1	11LM017	Mud Creek	natural	0	4	12.3	8	25	49.3	fair
1	11LM018	Chub Creek, North Branch	channelized	0	8	9	7	14	38	poor
1	07LM017	Chub Creek	channelized	0	8.5	13.9	6	16	44.4	poor
1	11LM016	Chub Creek	natural	0	10	10.3	7	17	44.3	poor
1	10EM087	Chub Creek	natural	0	13	20	13	20	66	good
0	00LM006	Chub Creek	natural	--	--	--	--	--	--	--
1	11LM012	Chub Creek	natural	1	3.5	19.9	13	21	58.4	fair
1	00LM007	Chub Creek	natural	3	13	19.4	13	24	72.4	good
Average Habitat Results: *Chub Creek Subwatershed*				**0.8**	**9.0**	**14.5**	**11.1**	**19.8**	**55.2**	**fair**

Qualitative habitat ratings

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

Table 31. Channel Condition and Stability Assessment (CCSI): Chub Creek Subwatershed.

# Visits	Biological Station ID	Stream Name	Stream Type*	Upper Banks (4-43)	Lower Banks (5-46)	Substrate (3-37)	Channel Evolution (1-11)	CCSI Score (13-137)	CCSI Rating
0	11LM071	Unnamed creek	--	--	--	--	--	--	--
0	11LM044	Dutch Creek	--	--	--	--	--	--	--
0	04LM143	Dutch Creek	--	--	--	--	--	--	--
0	11LM013	Unnamed ditch	--	--	--	--	--	--	--
0	11LM017	Mud Creek	--	--	--	--	--	--	--
0	11LM018	Chub Creek, North Branch	--	--	--	--	--	--	--
0	07LM017	Chub Creek	--	--	--	--	--	--	--
1	11LM016	Chub Creek	MHL	31	34	26	5	96	severely unstable
0	10EM087	Chub Creek	--	--	--	--	--	--	--
0	00LM006	Chub Creek	--	--	--	--	--	--	--
0	11LM012	Chub Creek	--	--	--	--	--	--	--
0	00LM007	Chub Creek	--	--	--	--	--	--	--
Average Channel Stability Results: *Chub Creek Subwatershed*			MHL	**31**	**34**	**26**	**5**	**96**	**severely unstable**

*See Appendix 9 for descriptions of Stream Types.

Qualitative channel stability ratings

= stable: CCSI < 27 = fairly stable: 27 < CCSI < 45 = moderately unstable: 45 < CCSI < 80 = severely unstable: 80 < CCSI < 115 = extremely unstable: CCSI > 115

Table 32. Outlet water chemistry results: Chub Creek Subwatershed.

Station Location:	**Chub Creek** ; Upstream of CR-83 (Dixie Ave), 0.2 mi S of Randolph						
STORET/ EQuIS ID:	**S002-533**						
Station #:	**00LM007**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	23	0.0001	0.0073	0.0016	< 0.0400	0
Chloride	mg/L	11	15	29	22	< 230	0
Dissolved Oxygen	mg/L	29	5.24	10.09	7.93	> 5.00	0
pH	SU	29	7.5	8.2	8.0	6.5 - 9.0	0
Transparency tube	100 cm	31	14	> 100	56	> 20	2
Turbidity	NRTU	12	2	32	9	25	1
E. coli (geometric mean)	MPN/100ml	24	477	1282	-	< 126	3
Escherichia coli	MPN/100ml	25	1	2613	1000	< 1260	4
Hardness, carbonate	mg/L	11	176	298	258	-	-
Nitrite-nitrate	mg/L	11	0.51	7.41	3.97	-	-
Kjeldahl nitrogen	mg/L	23	0.34	1.51	0.82	-	-
Phosphorus	µg/L	23	20	357	122	-	-
Specific Conductance	µS/cm	28	253	655	565	-	-
Sulfate	mg/L	11	6.6	36.0	21.4	-	-
Temperature, water	deg °C	29	11.6	25.8	19.4	-	-
Total suspended solids	mg/L	23	2	44	18	-	-
Total volatile solids	mg/L	20	1	14	5	-	-

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

[2]Data found in the table above were compiled using the results from data collected at the outlet monitoring station in the Chub Creek Subwatershed, a component of the IWM work conducted between May and September from 2011 and 2012. These specific data do not necessarily reflect all data that were used to assess the AUID.

Table 33. Lake water aquatic recreation assessments: Chub Creek Subwatershed.

Name	DNR Lake ID	Area (acres)	Trophic Status	Percent Littoral	Max. Depth (meters)	Avg. Depth (meters)	Mean TP (µg/L)	Mean chl-a (µg/L)	Secchi Mean (meters)	CLMP Trend	Aquatic Life Support Status	Aquatic Recreation Support Status	Aquatic Consumption Support Status
Chub	190020	301	H	100	2.9	1.0*	183	125	0.4	- -	IF	NS	NA

*- Indicates a depth estimated (in meters) by MPCA staff

Abbreviations:

Trophic Status
H -- Hypereutrophic
E – Eutrophic
M -- Mesotrophic

Support Status
FS -- Full Support
NS -- Non-Support
IF -- Insufficient Information
NA – Not Assessed

CLMP Trend
I -- Increasing/Improving Trends
NT -- No Trend

Key for Cell Shading: = existing impairment (prior to 2012); = new impairment; = full support of designated use.

Summary of subwatershed water quality

Excess nutrients appear to be a pervasive issue in this subwatershed. Chub Lake has phosphorus levels almost triple the regional background for shallow lakes. Additionally, phosphorus levels were high in streams throughout the subwatershed as well as in Chub Creek which flows out of the lake. Paired with high nitrates, nutrients in streams may be contributing to conditions that are limiting to sensitive fish and macroinvertebrate communities. Chub Creek is impaired for aquatic life for fish and macroinvertebrates with biological condition worse near the outlet of Chub Lake and becoming better near the mouth. Low DO, low transparency (water clarity), and poor habitat conditions may be factors limiting to sensitive fish and macroinvertebrates in Chub Creek as well as other streams in this subwatershed. While only Chub Creek is listed as impaired for aquatic life use, other streams are also showing signs of stress in their communities. For example, Mud Creek and an unnamed creek in the headwaters had a high number of sensitive fish and macroinvertebrate species. However, bank erosion, high phosphorus and low DO may be stressors that, if not addressed now, could lead to impairments in the future. In addition, Chub Creek and two other stream reaches are not supporting aquatic recreation use due to high levels of bacteria that may make swimming or wading unsafe. Water samples collected at the outlet station near Randolph (Table 32) show high bacteria levels, high phosphorus and nitrates, and occasional issues with water clarity (turbidity and transparency tube); the poor water quality conditions leaving this subwatershed may be contributing to water quality issues downstream on the Cannon River and the Byllesby Reservoir as well. Stressor identification is underway to determine the main cause(s) of biological impairments.

Stream assessments

For aquatic recreation, three reaches have existing bacteria impairments (listed in 2004 and 2006); newer data confirmed impairments on and Chub Creek (-528) and the North Branch of Chub Creek (-566) while no new data were available on Mud Creek (-558). For aquatic life, four stream reaches were assessed in 2013. Of those, two reaches were assessed as fully supporting aquatic life, while one reach was assessed as not supporting of both fish and macroinvertebrate communities, and one reach (Dutch Creek -572) had insufficient information to make an assessment determination. Additional information on individual reaches is included below.

Dutch Creek (-572) had insufficient information to make an assessment due to wetland characteristics present at the two stations sampled for fish and macroinvertebrates. The fish communities were dominated (>85%) by species that are often associated with wetlands (e.g., central mudminnow, fathead minnow) and the macroinvertebrate communities were dominated by taxa that are tolerant of low DO conditions often associated with wetlands. During biological visits at both stations, DO was measured below the 5 mg/L standard (2.9 to 3.5) and phosphorus was elevated (183 and 215 µg/L). During review of the information, the assessment team determined that it would not be appropriate to assess these locations using stream criteria and instead suggested that alternate locations be chosen and sampled for fish and macroinvertebrates. However, upon GIS review, it was determined that there was not a good location within the Dutch Creek watershed to locate a station that would not have predominantly wetland characteristics. The MPCA wetland monitoring team was consulted in order to assess locations within the Dutch Creek watershed using wetland criteria. Additional monitoring may occur in 2014.

The impaired reach on Chub Creek is 24.7 miles in length and starts north of Northfield in Chub Lake and Chub Marsh and then flows east and enters the Cannon River just before the Byllesby Reservoir. Five biological stations were included in the assessment. Fish and invertebrates were determined to both be impaired. Aquatic macroinvertebrate IBI scores indicate impaired conditions in the headwaters that gradually improve downstream. At the furthest upstream monitoring station (11LM016) the macroinvertebrate community is largely comprised of pollution-tolerant taxa, low species richness, and few EPT taxa (EPT is short for *Ephemeroptera*, *Plecoptera*, and *Trichoptera*, insect orders with species that are generally intolerant of pollution). CCSI and MSHA evaluation methods indicate that this section of the creek has severe channel instability and poor habitat conditions. In contrast, the station furthest downstream on Chub Creek (00LM007) has excellent IBI scores (both score above the upper confidence limit) and habitat ratings suggests that problems further upstream may be more related to local habitat conditions (e.g., riparian buffer, shading, substrate composition) than to watershed-wide water quality issues. Additional investigation will be required in order to determine the legitimacy of the presumption. Fish IBI scores were more variable from the headwaters to the mouth with good and poor scores intermixed longitudinally. Dissolved oxygen measurements from earlier years in the upstream section of this reach indicate a possible stressor which may be related to the proximity of wetlands or related to excess nutrient delivery in the watershed. Chub Creek flows out of Chub Lake which is listed for excess nutrients with high phosphorus levels. Hence, Chub Lake may be a source of excess nutrients in Chub Creek as well as other watershed sources.

Two reaches were fully supporting of aquatic life use for fish and macroinvertebrates: Mud Creek (-558) and Unnamed creek (-719). The Mud Creek station 11LM017 had a high diversity of fish species for a headwater stream (18 species) with pollution sensitive species (e.g., hornyhead chub, tadpole madtom, golden redhorse) and many gravel spawning fish. The macroinvertebrate community consisted of 10 EPT for 22% of specimens collected. Habitat quality was fair with some coarse gravels in riffle and run areas, although the stream had moderate bank erosion likely from the cattle access to the stream. Unnamed creek (-719) is a headwater stream of the Dutch Creek Marsh. During 2011, one biological station was sampled (11LM071). For both biological indicators, IBI scores were near the threshold of impairment (F-IBI 6 points above, M-IBI1 point below) but within the confidence interval. The fish community was fairly diverse for a headwater stream (16 species) with no sensitive species but a fair number of gravel spawning fish. The macroinvertebrate community had 7 EPT taxa for 18% of the specimens collected. Habitat quality was fair with gravel in riffles and runs, but with severe bank erosion and embeddedness observed. Dissolved oxygen during fish sampling was below the 5 mg/L standard (3.3 mg/L at 9:45 a.m. on 9/13/2011) with high phosphorus (214 µg/L) indicating a potential biological stress related to excess nutrients, flashy hydrology, or other factors. In addition, the sampling team noted, "First 40m of site had cloudy appearance to water, rest of site was crystal clear" which may warrant some additional investigation. While not assessed as impaired, this location should be considered when drafting the Watershed Restoration and Protection Strategy (WRAPS) in order to maintain and improve biological conditions and potentially prevent an impairment listing in the future.

Lake assessments

Only one of the two lake basins >10 acres in size (Chub Lake, 19-0020) was assessed for aquatic recreation use support during the 2013 assessment; data indicate that this lake has an ongoing nutrient impairment (first listed in 2002) and does not support aquatic recreation use. Chub Lake is a shallow basin covering approximately 300 acres with a long north to south fetch. Chub Lake has a mean nutrient concentration triple that of the NCHF eutrophication standard; internal loading resulting from the shallow, windswept nature of the lake may be contributing to the high concentration (Table 33). Chub Lake is on the fringe of the NCHF and WCBP ecoregions; however, land uses in the lake catchment area represent a good mix of forested to agricultural land and are indicative of the NCHF ecoregion. Chub Lake has not been assessed for aquatic consumption.

Watershed plans, projects, and TMDLs

Stressor identification is currently underway to determine the main cause(s) of biological impairments. The bacteria impairment on Chub Creek (-528) is being addressed through the Lower Mississippi River Basin— Regional Fecal Coliform TMDL http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/lower-mississippi-river-basin-tmdl/project-lower-mississippi-river-basin-regional-fecal-coliform.html.

The Dakota County water quality plan and projects can be found at:

http://www.co.dakota.mn.us/environment/waterquality/pages/default.aspx

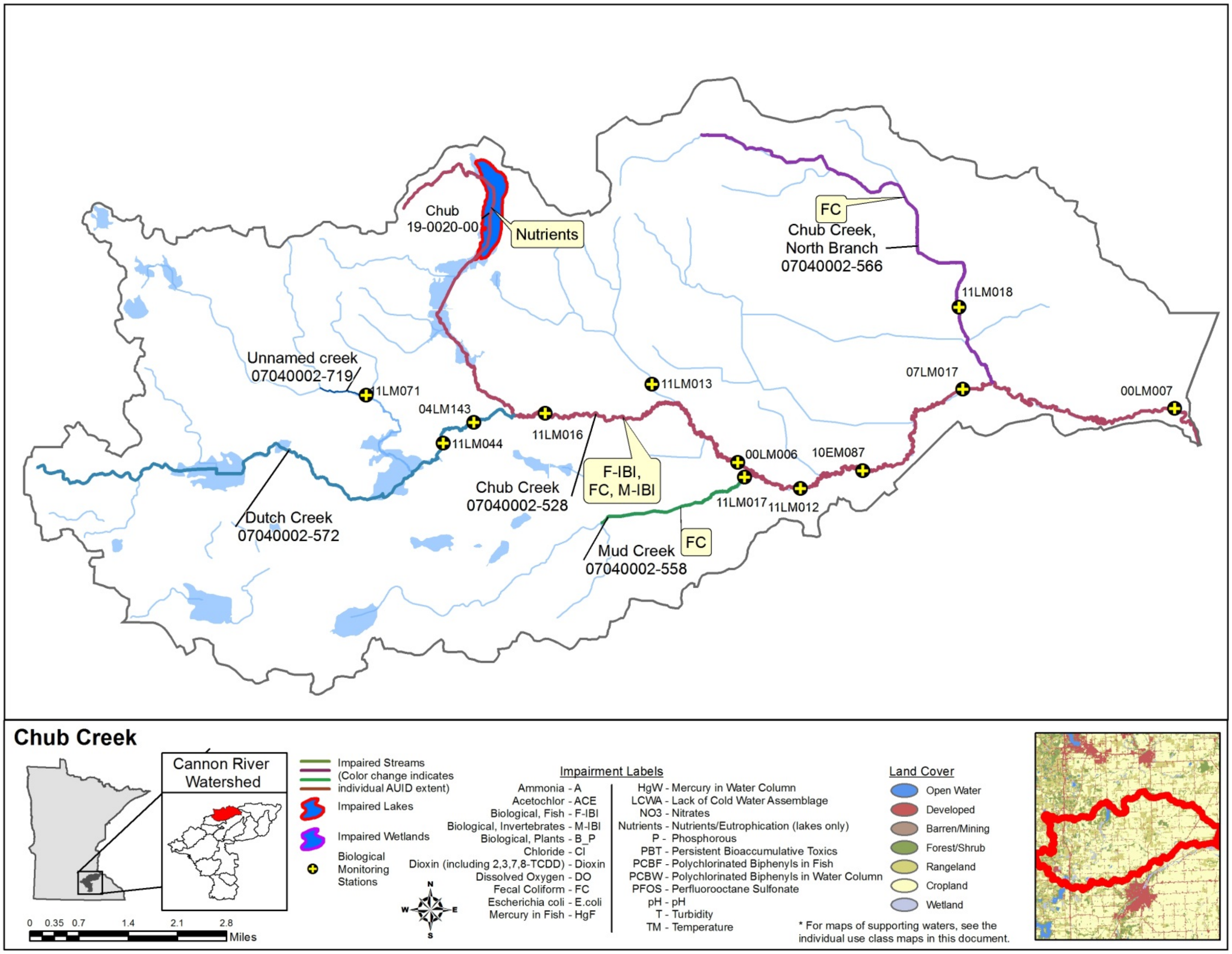

Figure 28. The 2013 assessed stream reaches with impairments and land use characteristics (inset) in the Chub Creek Subwatershed.

Prairie Creek Subwatershed Unit

HUC 0704000205-01

The Prairie Creek Subwatershed drains 79.8 mi2 of predominantly agricultural land in Rice and Goodhue Counties and contains the cities of Northfield and Cannon Falls. Land use is comprised of cropland (72%) with some range (10%) and developed land (6.5%). Forest and wetland make-up the remaining 12%. This subwatershed is located mostly in the WCBP ecoregion but has a sliver of land in the NCHF ecoregion at the headwaters of Prairie Creek northeast of Faribault, and another sliver of land in the Driftless Area ecoregion east and northeast of the town of Dennison. Prairie Creek flows north and east for nearly 29 miles from its headwaters (two miles northeast of Faribault) and flows into the south side of the Byllesby Lake Reservoir. This subwatershed also includes the 2,884 acres Nerstrand Big Woods State Park. The water chemistry outlet station on Prairie Creek is located the bridge on 310th Street (STORET/EQuIS station S001-785, biological station 11LM009) near Randolph, just one mile upstream of the Reservoir. During the 2013 assessment, only Prairie Creek was assessed for aquatic recreation and four stream reaches were assessed for aquatic life use support (Table 34). There are no lake basins are >10 acres in size; hence, no lakes were assessed

Table 34. Aquatic life and recreation assessments on stream reaches: Prairie Creek Subwatershed.

					Aquatic Life Indicators:										
AUID, Reach Name, Reach Description	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	**Aquatic Life**	**Aquatic Rec.**
07040002-513, Unnamed creek, Unnamed cr to Unnamed cr	5.0	2B	--	--	--	--	--	--	--	--	--	--	--	NA	NA
07040002-587, Unnamed creek, Unnamed cr to Unnamed cr	0.8	2B	11LM077	Upstream of 150th St (Jenkins Tr), 2.5 mi. NW of Nerstrand	MTS	EXP	NR	NR	--	NR	NR	--	--	NS	NA
07040002-512, Unnamed creek, Headwaters to Prairie Cr	3.0	2B	11LM075	Downstream of 110th St E, 1.5 mi. N of Dennison	MTS	EXS	--	EXS	--	--	--	--	--	NS	NA
07040002-723, Unnamed creek, Unnamed cr to Prairie Cr	2.1	2B	11LM054	Downstream of 342nd St, 3.5 mi. NE of Dennison	EXP	EXS	--	--	--	--	--	--	--	NS	NA
07040002-504, Prairie Creek, Headwaters to Lk Byllesby	28.8	2C	11LM055 04LM059 11LM009	Downstream of 110th St E, 1.5 mi. NW of Dennison Downstream of Hwy 56, 0.8 miles E of Stanton Upstream of 310th St, 2.5 mi. SE of Randolph	MTS	EXP	IF	EXP	MTS	MTS	MTS	--	EX	NS	NS

Abbreviations for Indicator Evaluations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **MTS** = Meets criteria; **EXP** = Exceeds criteria, potential impairment; **EXS** = Exceeds criteria, potential severe impairment; **EX** = Exceeds criteria (Bacteria).
Abbreviations for Use Support Determinations: **NA** = Not Assessed, **IF** = Insufficient Information, **NS** = Non-Support, **FS** = Full Support
Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use.

Table 35. Non-assessed biological stations on channelized reaches or AUIDs: Prairie Creek Subwatershed.

AUID, Reach Name, Reach Description	Reach length (miles)	Use Class	Biological Station ID	Location of Biological Station	Fish IBI	Invert IBI
07040002-504, Prairie Creek, Headwaters to Lk Byllesby	28.8	2C	11LM033	Downstream of Karlow Tr, 2.5 mi. SW of Dennison	fair	good

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

Table 36. Minnesota Stream Habitat Assessment (MSHA): Prairie Creek Subwatershed.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	11LM077	Unnamed creek	2.5	8.5	16.8	12	21	60.8	fair
1	11LM075	Unnamed creek	1.3	6	10.8	11	19	48.1	fair
1	11LM054	Unnamed creek	1.3	9	16	13	28	67.3	good
1	11LM033	Prairie Creek	2.5	9.5	10.3	14	20	56.3	fair
1	11LM055	Prairie Creek	0	7.5	16.7	10	25	59.2	fair
1	04LM059	Prairie Creek	4.3	7	16	13	16	56.3	fair
2	11LM009	Prairie Creek	0.6	9.8	18.7	11.5	25	65.5	fair
Average Habitat Results: *Prairie Creek Subwatershed*			**1.8**	**8.2**	**15**	**12.1**	**22**	59.1	**fair**

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

Table 37. Channel Condition and Stability Assessment (CCSI): Prairie Creek Subwatershed.

# Visits	Biological Station ID	Stream Name	Stream Type*	Upper Banks (4-43)	Lower Banks (5-46)	Substrate (3-37)	Channel Evolution (1-11)	CCSI Score (13-137)	CCSI Rating
1	11LM077	Unnamed creek	MHL	28	17	22	7	74	moderately unstable
1	11LM075	Unnamed creek	MHL	13	11	31	3	58	moderately unstable
1	11LM054	Unnamed creek	MHL	18	18	22	5	63	moderately unstable
1	11LM033	Prairie Creek	MHL/TCR	16	20	20	3	59	moderately unstable
1	11LM055	Prairie Creek	MHL	20	11	10	3	44	fairly stable
0	04LM059	Prairie Creek	--	--	--	--	--	--	--
1	11LM009	Prairie Creek	MHL	12	17	15	7	51	moderately unstable
Average Stream Stability Results: *Prairie Creek Subwatershed*				**17.8**	**15.7**	**20**	**4.7**	**58.2**	**moderately unstable**

*See Appendix 9 for descriptions of Stream Types

Qualitative channel stability ratings

= stable: CCSI < 27 = fairly stable: 27 < CCSI < 45 = moderately unstable: 45 < CCSI < 80 = severely unstable: 80 < CCSI < 115 = extremely unstable: CCSI > 115

Table 38. Outlet water chemistry results: Prairie Creek Subwatershed.

Station Location:	**Prairie Creek** ; Upstream of 310th St, 2.5 mi SE of Randolph						
STORET/ EQuIS ID:	**S001-785**						
Station #:	**11LM009**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	13	0.0001	0.0122	0.0030	< 0.0400	0
Chloride	mg/L	10	13	21	18	< 230	0
Dissolved Oxygen	mg/L	29	7.34	12.82	8.83	> 5.00	0
pH	SU	29	7.7	8.5	8.2	6.5 - 9.0	0
Transparency tube	100 cm	29	5	> 100	50	> 20	10
E. coli (geometric mean)	MPN/100ml	28	599	891	-	< 126	3
Escherichia coli	MPN/100ml	15	197	12997	1857	< 1260	5
Hardness, carbonate	mg/L	10	132	328	262	-	-
Nitrite-nitrate	mg/L	10	4.20	9.61	6.60	-	-
Kjeldahl nitrogen	mg/L	10	0.34	1.64	0.94	-	-
Phosphorus	µg/L	10	19	334	143	-	-
Specific Conductance	µS/cm	29	396	660	604	-	-
Sulfate	mg/L	10	17.7	40.6	29.1	-	-
Temperature, water	deg °C	29	6.3	25.0	18.8	-	-
Total suspended solids	mg/L	10	5	320	93	-	-
Total volatile solids	mg/L	10	2	40	15	-	-

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.
[2]Data found in the table above were compiled using the results from data collected at the outlet monitoring station in the Prairie Creek Subwatershed, a component of the IWM work conducted between May and September from 2011 and 2012. These specific data do not necessarily reflect all data that were used to assess the AUID.

Summary of subwatershed water quality

Prairie Creek flows through the remnant Big Woods contained within beautiful Nerstrand State Park. Within the park is scenic Hidden Falls (Image 7). While the park is enjoyable to visit, recreating in the water may be unsafe as elevated bacteria have been measured on Prairie Creek and two tributaries. For aquatic life, fish communities in this subwatershed were rated good with many pollution sensitive fish collected in the samples, including the colorful rainbow darter. In contrast, macroinvertebrate communities on Prairie Creek and three tributaries were dominated by pollution tolerant individuals and all four reaches are impaired. Water clarity (transparency) is also poor on Prairie Creek and a tributary. Habitat quality was fair to good although severe bank erosion and embedded substrates was observed. Many reaches had fairly intact riparian zones, so these conditions could be a reflection of altered watershed hydrology instead of local land use conditions. Water samples collected at the outlet of Prairie Creek show that DO during the day is sometimes high (>12 mg/L) which may be related to the higher levels of phosphorus observed at times that is potentially feeding algae. Additional monitoring may show that the high DO during the day is paired with low DO during the night which could be a present stress to sensitive fish and macroinvertebrates. Stressor identification is currently underway to investigate the reason for the poor macroinvertebrate communities.

Image 7: Hidden Falls in Nerstrand State Park. Image from Wikipedia.

Stream assessments

For aquatic recreation, Prairie Creek (-504) was listed as impaired due to excess bacteria in 2002 and recent data confirmed the existing impairment. Two other reaches that are on tributary streams to Prairie Creek (-512 and -513) were previously listed due to excess bacteria in 2002, but there was no new data to assess. For aquatic life, four reaches (Prairie Creek and three unnamed creeks) were assessed as having impaired macroinvertebrates but were found to not have impaired fish. Prairie Creek (-504) and a tributary (-512) have existing turbidity impairments. Additional information on individual reaches is included below.

Prairie Creek (-504) was listed as not supporting aquatic life due to turbidity in 2004 and newer data confirmed the impairment. In addition, a new macroinvertebrate impairment was found in 2013. Macroinvertebrate assessment results from Prairie Creek have been variable between years (2004 & 2011) and stations along the length of this 28 mile assessment unit. The macroinvertebrate communities at stations in the lower part of Prairie Creek appear to be in slightly better condition than communities in the upper reaches; all IBI scores are close to the impairment threshold. However, considering the 2011 macroinvertebrate data (i.e., highest IBI score was from 2004), the extensive erosion this stream is experiencing, and the high nitrate concentrations, it was decided to list aquatic macroinvertebrates as impaired on this stream and to let the stressor identification process determine the primary cause. Addressing the existing turbidity impairment will certainly improve the health of the macroinvertebrate community inhabiting Prairie Creek; however at this stage it could not be determined whether or not turbidity is the principal cause of the biological impairment.

Unnamed creek (-512) was listed as impaired due to turbidity in 2006 and newer data confirmed the impairment. In 2013, macroinvertebrates were assessed as impaired and fish were considered marginally supporting. At station 11LM075, while there were 14 fish species collected with some sensitive taxa present, the sensitive species were represented by only a few individuals, suggesting that these species are experiencing some limitation associated with habitat quality, food sources, or water quality conditions. Site photos, CCSI notes, and the turbidity impairment suggest that sediment may be impacting the aquatic community. Additionally, phosphorus was high (0.188 mg/L) and could also be contributing to biologically stressful conditions.

Two other unnamed creeks (-587, -723) were found to have new aquatic life impairments of macroinvertebrates. Unnamed creek (-587) was not reviewed for many water chemistry parameters due to lack of sufficient data to assess. For macroinvertebrates, low EPT richness (EPT is short for *Ephemeroptera*, *Plecoptera*, and *Trichoptera*, insect orders with species that are generally intolerant of pollution) with a high percentage of tolerant individuals indicated impairment. For fish, while the F-IBI was above threshold and confidence interval, the fish community was skewed with only one sensitive taxa collected (fantail darter) with only five fish, suggesting some limitation is present that could lead to an impaired fish community in the future. Sampling observations and site images indicate that this is an unstable stream channel with bank and bottom instability and excess sedimentation in pools, indicating a potential habitat quality issue. Nitrogen and total suspended solids were also high (8.7 and 54 mg/L respectively) and may be additional factors. At the other unnamed creek (-723) while the macroinvertebrate community was assessed as impaired, the fish community was more balanced and considered unimpaired. Habitat quality was rated good with coarse substrates and an intact riparian zone. However, this stream is incised and overwidened in places with unstable banks and bottom substrates. Site photos and CCSI notes suggest that sediment may be impacting the aquatic macroinvertebrate community of this stream. Nitrogen was also high (4.1 mg/L) and could be an additional stressor.

Watershed plans, projects, and TMDLs

Stressor identification is currently underway to determine the likely cause(s) of the macroinvertebrate and turbidity impairments.

The bacteria impairments on Prairie Creek (-504) and two tributaries (-512, -513) are being addressed through the Lower Mississippi River Basin— Regional Fecal Coliform TMDL Rice County has implemented a number of projects aimed to address the bacteria loadings.

County Water Quality Plan and projects can be found online:

- Rice County - http://www.co.rice.mn.us/node/104860
- Goodhue County - http://www.goodhueswcd.org/#!programs/c10d6

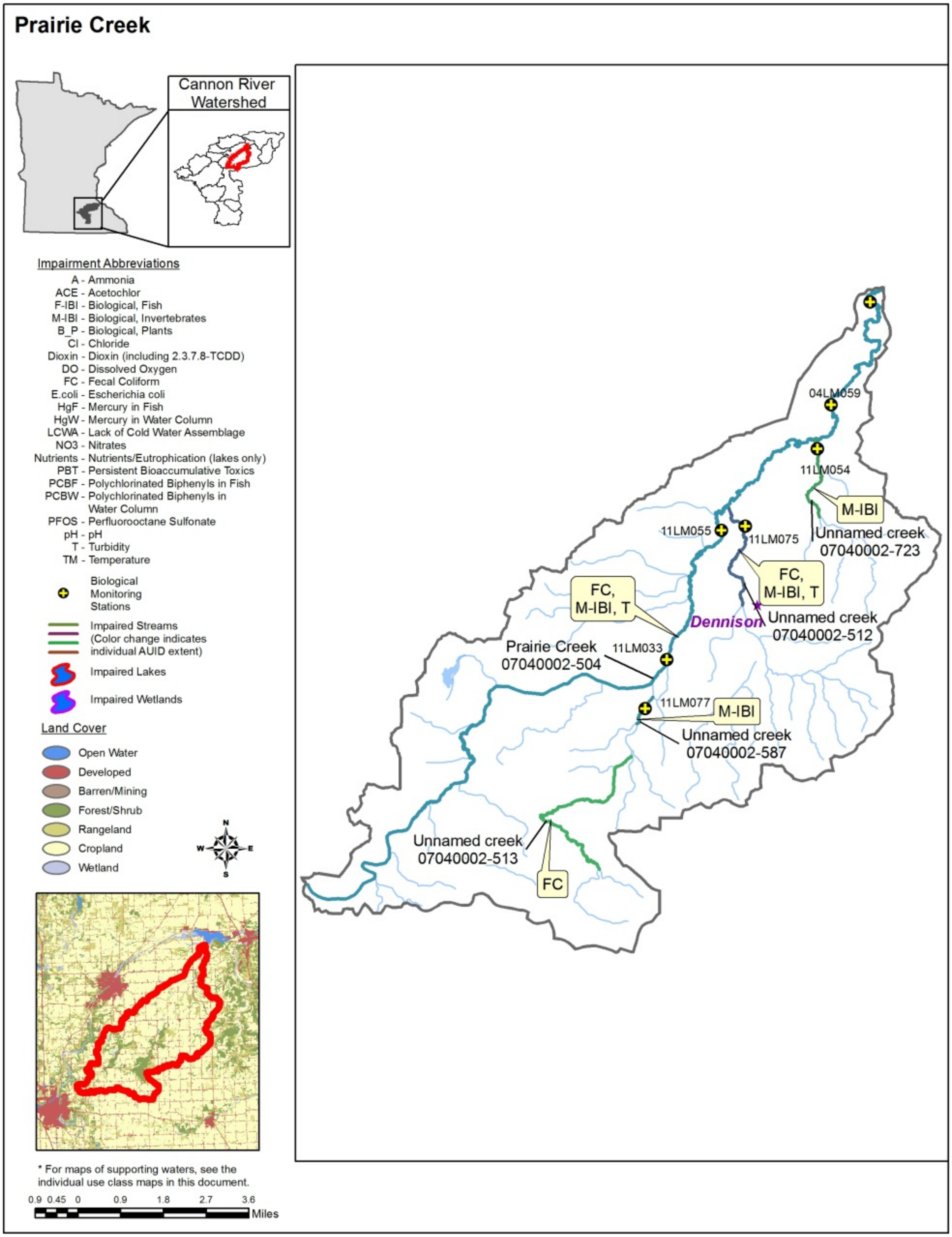

Figure 29. The 2013 assessed stream reaches with impairments and land use characteristics (inset) in the Prairie Creek Subwatershed.

Middle Cannon River Subwatershed HUC 0704000206-01

The Middle Cannon River subwatershed covers nearly 114 mi^2 and is split between Rice, Dakota, and Goodhue Counties. The Cannon River enters this subwatershed at the city of Faribault and flows northeast for 30 miles through the cities of Dundas and Northfield before reaching the Byllesby Reservoir southeast of Randolph. Most of the subwatershed is located in the NCHF and WCBP ecoregions, with only a small portion in the Driftless Area ecoregion to the east and south of Byllesby Reservoir. Land use is predominantly agriculture (71%), followed by developed land (13%), with forest, wetland, and open water at a combined 15%. There are seven lake basins greater than 10 acres in size and 27 established stream assessment units. The water chemistry outlet station (STORET/EQuIS station S003-818, biological monitoring station 00LM002) is located upstream of the Highway 20 bridge in Cannon Falls. During the 2013 assessment, 11 stream reaches were assessed for aquatic life and/or recreation uses (Table 39). Only one lake (Byllesby Reservoir) was assessed for aquatic recreation and aquatic consumption use (Table 43).

Table 39. Aquatic life and recreation assessments on stream reaches: Middle Cannon River Subwatershed.

AUID, Reach Name, Reach Description	Reach Length (miles)	Use Class	Biological Station ID	Location of Biological Station	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	Aquatic Life	Aquatic Rec.
07040002-703, Unnamed creek, Unnamed cr to Cannon R	2.2	2B	11LM096	Upstream of CSAH 3 (Faribault Blvd), 3.5 mi. N of Faribault	MTS	MTS	IF	MTS	--	MTS	--	--	EX	FS	NS
07040002-716, Unnamed creek, Headwaters to Cannon R	1.0	2B	--	--	--	--	--	MTS	--	--	--	--	--	IF	NA
07040002-562, Unnamed creek (Spring Brook/Rice Creek), Headwaters to T111 R20W S9, north line	3.7	2B	--	--	--	--	--	MTS	--	--	--	--	EX	IF	NS
07040002-557, Unnamed creek (Spring Brook/Rice Creek), Unnamed cr to Cannon R	1.9	1B, 2A	04LM077 11LM099	Downstream of Decker Ave, 1 mi. W of Northfield Upstream of Dundas Blvd (Armstrong Rd), 0.5 mi. W of Northfield	MTS	EXP	NR	EXS	--	NR	NR	MTS	EX	NS	NA
07040002-568, Unnamed creek (Spring Creek), Unnamed cr to Cannon R	4.0	2B	--	--	--	--	IF	MTS	--	MTS	--	--	MTS	IF	FS
07040002-591, Spring Creek, Unnamed cr to Unnamed cr	4.1	2B	04LM046 11LM094	Downstream of 320th St E, 6.2 mi. NE of Northfield Upstream of 310th St, 2 mi. SE of Randolph	MTS	EXP	--	--	--	--	--	--	--	NS	NA
07040002-581, Cannon River, Straight R to T110 R20W S19, SE1/4 line	0.9	2B	--	--	--	--	--	--	--	--	--	--	NA	NA	NA

07040002-582, Cannon River, T110 R20W S19, NE1/4 line to Wolf Cr	11.2	2B	11LM068 04LM078	Upstream of CR 29 (158th St E), 4.5 mi. N of Faribault Adjacent to Eaton Ave/124th St E, 5 mi. SW of Northfield	EXP	EXS	IF	MTS	--	EXP	--	--	EX	NS	NS
07040002-507, Cannon River, Wolf Cr to Heath Cr	3.0	2B	11LM086	Upstream of CR 1 (Hester St), in Dundas	MTS	EXP	IF	EXP	MTS	--	--	--	EX	NS	NS
07040002-508, Cannon River, Heath Cr to Northfield Dam	1.6	2B	--	--	--	--	IF	EXS	MTS	MTS	--	--	EX	NS	NS
07040002-509, Cannon River, Northfield Dam to Lk Byllesby inlet	10.5	2B	11LM097	Downstream of Canada Ave, 2.5 mi NE of Northfield	EXP	EXP	IF	EXP	MTS	--	IF	--	IF	NS	IF
07040002-539, Cannon River, Byllesby Dam to Little Cannon R	2.8	2B	00LM002	Upstream of Hwy 20, in Cannon Falls	MTS	EXP	IF	MTS	MTS	MTS	MTS	--	MTS	NS	FS

Abbreviations for Indicator Evaluations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **MTS** = Meets criteria; **EXP** = Exceeds criteria, potential impairment; **EXS** = Exceeds criteria, potential severe impairment; **EX** = Exceeds criteria (Bacteria).
Abbreviations for Use Support Determinations: **NA** = Not Assessed, **IF** = Insufficient Information, **NS** = Non-Support, **FS** = Full Support
Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use.

Table 40. Minnesota Stream Habitat Assessment (MSHA): Middle Cannon River Subwatershed.

# Visits	Biological Station ID	Reach Name	Channel Condition	Land Use (0-5)	Riparian (0-15)	Substrate	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	11LM096	Unnamed creek	natural	5	12.5	18.8	8	29	73.3	good
2	04LM077	Unnamed creek (Spring Brook)	natural	3.5	9.3	17.6	13.5	28	71.8	good
1	11LM099	Unnamed creek (Spring Brook)	natural	0	7	16.2	16	32	71.2	good
1	04LM046	Spring Creek	natural	0	5	8.8	11	14	38.8	poor
1	11LM094	Spring Creek	natural	2.5	13	17.4	11	26	69.9	good
1	11LM068	Cannon River	natural	2.5	9.5	20.2	11	21	64.2	fair
1	04LM078	Cannon River	natural	5	8	15	3	20	51	fair
1	11LM086	Cannon River	natural	1.5	7.5	20.1	11	28	68.1	good
1	11LM097	Cannon River	natural	1.3	10	17.1	9	26	63.3	fair
1	00LM002	Cannon River	natural	1	7	21.8	10	25	64.8	fair
Average Habitat Results: *Middle Cannon River Subwatershed*				**2.2**	**8.9**	**17.3**	**10.4**	**24.9**	**63.6**	**fair**

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

Table 41. Channel Condition and Stability Assessment (CCSI): Middle Cannon River Subwatershed.

# Visits	Biological Station ID	Stream Name	Upper Banks (4-43)	Lower Banks (5-46)	Substrate (3-37)	Channel Evolution (1-11)	CCSI Score (13-137)	Upper Banks (4-43)	CCSI Rating
1	11LM096	Unnamed creek	MHL	12	15	11	3	41	fairly stable
1	04LM077	Unnamed creek (Spring Brook)	MHL	6	9	13	3	31	fairly stable
1	11LM099	Unnamed creek (Spring Brook)	MHL	16	17	18	3	54	moderately unstable
0	04LM046	Spring Creek	--	--	--	--	--	--	--
1	11LM094	Spring Creek	MHL	8	15	28	7	58	moderately unstable
1	11LM068	Cannon River	MHL	16	15	20	5	56	moderately unstable
0	04LM078	Cannon River	--	--	--	--	--	--	--
0	11LM086	Cannon River	--	--	--	--	--	--	--
1	11LM097	Cannon River	MHL	13	17	18	7	55	moderately unstable
1	00LM002	Cannon River	MHL	18	15	10	3	46	moderately unstable
Average Stream Stability Results: *Middle Cannon River Subwatershed*				**12.7**	**14.7**	**16.9**	**4.4**	**48.7**	**moderately unstable**

*See Appendix 9 for descriptions of Stream Types

Qualitative channel stability ratings

= stable: CCSI < 27 = fairly stable: 27 < CCSI < 45 = moderately unstable: 45 < CCSI < 80 = severely unstable: 80 < CCSI < 115 = extremely unstable: CCSI > 115

Table 42. Outlet water chemistry results: Middle Cannon River Subwatershed.

Station Location:	**Cannon River** ; Upstream of Hwy 20, in Cannon Falls						
STORET/ EQuIS ID:	**S003-818**						
Station #:	**00LM002**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	9	0	0.0134	0.0044	< 0.0400	0
Chloride	mg/L	12	20	37	29	< 230	0
Dissolved Oxygen	mg/L	18	5.49	12.40	8.27	> 5.00	0
pH	SU	21	6.0	8.5	7.8	6.5 - 9.0	1
Transparency tube	100 cm	24	13	> 100	52	> 20	1
E. coli (geometric mean)	MPN/100ml	11	16	55	-	< 126	0
Escherichia coli	MPN/100ml	16	1	> 2420	190	< 1260	1
Hardness, carbonate	mg/L	10	192	263	224	-	-
Nitrite-nitrate	mg/L	10	1.19	8.25	3.98	-	-
Kjeldahl nitrogen	mg/L	10	0.66	2.06	1.26	-	-
Phosphorus	µg/L	10	94	553	201	-	-
Specific Conductance	µS/cm	21	344	723	540	-	-
Sulfate	mg/L	12	21.0	40.0	29.1	-	-
Temperature, water	deg °C	24	15.5	28.0	22.6	-	-
Total suspended solids	mg/L	10	6	54	16	-	-
Total volatile solids	mg/L	10	4	10	7	-	-

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.
[2]Data found in the table above were compiled using the results from data collected at the outlet monitoring station in the Middle Cannon River Subwatershed, a component of the IWM work conducted between May and September from 2011 and 2012. These specific data do not necessarily reflect all data that were used to assess the AUID.

Table 43. Lake water aquatic recreation assessments: Middle Cannon River Subwatershed.

Name	DNR Lake ID	Area (acres)	Trophic Status	Percent Littoral	Max. Depth (meters)	Avg. Depth (meters)	Mean TP (µg/L)	Mean chl-a (µg/L)	Secchi Mean (meters)	CLMP Trend	Aquatic Life Support Status	Aquatic Recreation Support Status	Aquatic Consumption Support Status
Byllesby	190006	2255	H	68	15.2	3.2	205	39	0.8	NT	IF	NS	NS

***- Indicates a depth estimated (in meters) by MPCA staff**

Abbreviations:

Trophic Status
H -- Hypereutrophic
E – Eutrophic
M -- Mesotrophic

Support Status
FS -- Full Support
NS -- Non-Support
IF -- Insufficient Information
NA – Not Assessed

CLMP Trend
I -- Increasing/Improving Trends
NT -- No Trend

Key for Cell Shading: = existing impairment (prior to 2012); = new impairment; = full support of designated use

Summary of subwatershed water quality

Spring Brook (a.k.a. Rice Creek) is a rare trout stream in this part of the state as it has a self-sustaining population of brook trout. It has been used by the MDNR as a source of brook trout to stock other streams in the area. While the trout population was in good condition, signs of stress from unstable banks and high nutrients may be contributing to low DO and poor macroinvertebrate conditions on this reach as well as many other reaches. Due to the opportunity for trout fishing and a rare self-sustaining population of brook trout, additional restoration and protection strategies are needed to maintain and improve this valuable resource and prevent further degradation. Only one stream reach north of Faribault (unnamed creek, -503) had good fish and macroinvertebrate communities. Turbidity (water clarity) impairments are mixed throughout, with some reaches on the Cannon River and tributaries doing better than others. Habitat quality was generally good to fair, with one poor rating on Spring Creek where slumping banks and poor substrate conditions were observed. Channel stability was rated fairly stable on a few headwater tributaries, and moderately stable on many other tributaries and the Cannon River. Water samples collected within this subwatershed show that nutrients (phosphorus and nitrates) are high and may be a factor in the poor biological conditions observed. Elevated bacteria was found in many streams which may potentially make swimming and wading unsafe; only two stream reaches were considered fully supporting of aquatic recreation. For lakes, the Byllesby Reservoir is not supporting aquatic recreation due to excess phosphorus that fuels algal blooms. These conditions can not only make recreation such as fishing not enjoyable, but could also make swimming in them unsafe. Stressor identification is currently underway to determine the cause of the impaired fish and macroinvertebrate communities, while the Byllesby Reservoir Excess Nutrient TMDL has been drafted and is awaiting EPA approval. Projects aimed at reducing nutrients have already taken place, but many more are needed in order to improve lake conditions. The high mercury levels found in fish are being addressed through the Statewide Mercury TMDL.

Stream assessments

For aquatic recreation, eight reaches have bacteria impairments--including the Cannon River all the way from Faribault to the Byllesby Reservoir. Only two reaches fully support aquatic recreation: Spring Creek (-568) and the Cannon River below the Byllesby Dam (-539). For aquatic life, only one reach (unnamed creek -703, west of Faribault) is fully supporting, seven are not supporting, while three have insufficient information to make an assessment determination.

Of those that are not supporting, five reaches have existing turbidity impairments, and there is newer data supporting four of those listings; however, newer data for one reach on the Cannon River (-582)--from Faribault to one mile south of Dundas--is now meeting the water quality standard for turbidity and is recommended for removal from the EPA's 2014 Impaired Waters List. This reach on the Cannon River is between two reaches that will remain on the impaired waters list. The reach that is proposed for delisting may have geologic character such as bedrock that contributes to better water clarity in this section of the Cannon River. However, this same reach has a new macroinvertebrate impairment and so will remain on the impaired waters list for not supporting aquatic life. In total, there are six new macroinvertebrate impairments and one fish impairment; four reaches on the Cannon River and two smaller streams, Spring Creek (-591) and Spring Brook (-557).

Spring Creek (-591) is a 2B warmwater stream that flows into the Byllesby Reservoir. Two biological stations were sampled in 2004 (04LM046) and 2011 (11LM094). While only the macroinvertebrate community was assessed as impaired, the fish community was also demonstrating signs of stress with high percentages of tolerant fish (>80%) and few sensitive individuals. Nitrogen was high at both stations (8.1 mg/L and 9.8 mg/L, respectively). Habitat quality rated poor at the upstream station (04LM046) but rated good at the downstream station (11LM094). Images from sampling indicate the upstream station is in a pasture with slumping banks while the downstream station has an intact riparian zone but may be incised with moderate bank instability; excess sediment may be impacting the biological condition of this stream. In addition, a tributary to Spring Creek (-568) had high and low DO values observed, suggesting a potential nutrient issue in this tributary that may be having an effect on the Spring Creek (-591) as well.

Spring Brook (-557), also known locally as Rice Creek, is a 2A cold water stream located southwest of Northfield. It is the only designated coldwater stream in Rice County and brook trout from this stream have been used to stock other streams. The genetic strain has been determined to be more closely related to New England States than other strains in southeast Minnesota (Hoxmeier et al. 2012), supporting the historical lore than this stream was stocked by landowners many decades ago (CRWP 2013). Regardless, this stream has a healthy brook trout population (Image 8) with many age classes represented, indicating that conditions are favorable for brook trout to spawn and grow to adult size. Fish communities on Spring Brook scored well above the southern coldwater IBI impairment threshold at both stations during both years. However, other coolwater and warmwater species were sampled as well (white sucker, creek chub, brook stickleback, Johnny darter, green sunfish) suggesting that the thermal regime may be somewhat marginal for brook trout. Temperature logger data from 2011 and 2012 (CRWP 2013) indicates that summer temperatures often go above the optimal temperature (18.8 °C, Blann, 2002). A project to study seasonal and daily temperature variation, locations of springs, nitrate sources, and food resources available to brook trout was recently completed (http://crwp.net/work/rice-creek/). This was a collaborative project and involved citizen groups, college staff and students, CRWP, and local and state agencies.

Both biological monitoring stations on Spring Creek are located within pasture land. Even though the riparian corridor along the upper station (04LM077) in this assessment unit was not actively being grazed in 2011, macroinvertebrates scored below the impairment threshold for the southern coldwater IBI class. At the other monitoring station (11LM099, ~1 mi downstream) that was being grazed in 2011, the macroinvertebrate IBI was above the threshold. In addition to their grazing status, substrate composition differed between these two reaches. Rocky substrate and riffle habitat was sampled at station 11LM099, whereas coarse substrate suitable for sampling macroinvertebrates was not present at station 04LM077. This difference may account for the discrepancy in IBI scores at these two stations; however, the documentation of other stressors in this stream, notably the previous nitrate and turbidity impairment listings, as well as the observations of extensive periphyton growth led to the decision to list aquatic macroinvertebrates as impaired. Additionally, the possibility that past grazing activities (e.g., animal trampling, bank erosion) at the site as well as erosion issues further upstream could not be ruled out as factors contributing to excess sedimentation, and thus lack of coarse substrates at station 04LM077. Dissolved oxygen was just below the standard for a 2A coldwater stream (6.86 mg/L at 8:15 a.m. on 6/14/2011). Additional early morning DO monitoring will help ascertain whether or not the reach is regularly meeting the DO standard. Grab samples indicate that nitrates were very high during fish sampling at both stations (16 mg/L in 2004 and 10 mg/L in 2011 at 04LM077; 10 mg/L at 11LM099 in 2011), as well as phosphorus, indicating a nutrient issue and potential biological stressor. In addition, nitrate samples collected by local monitoring groups have found many values above the 10 mg/L drinking water standard, up to as high as 71 mg/L (CRWP 2013). The land use in this small watershed is dominated by row crop agriculture (84%) with channelization and extensive tile drainage in the headwaters, with only a few feedlot operations and some residential land near Northfield. Investigation of the largest sources of nitrates suggests that tile drainage and seepage are the largest contributors. This stream is fed by groundwater that has a short residence time (<5 to 10 years) suggesting a shallow aquifer, and many tile outlets drain directly to the Spring Brook and upstream ditches (CRWP 2013).

The reach that was assessed as fully supporting aquatic life, unnamed creek (-703), is a small tributary to the Cannon River just north of Faribault. The F-IBI was above the threshold and confidence interval for impairment with a few sensitive species present (e.g., hornyhead chub, burbot), while the macroinvertebrate IBI was a few points below the threshold of impairment but within the confidence interval. During macroinvertebrate sampling, water chemistry results appeared to suggest favorable conditions for aquatic life although there was a lack of significant flow and sampleable habitat. Habitat quality was rated good with coarse substrates and largely intact riparian areas. Channel stability was also rated fairly stable, unlike many other reaches in this subwatershed. Thus, during the assessment process it was thought that the macroinvertebrate IBI score may be somewhat depressed due to the sampling conditions at that time and not poor water quality conditions. Considering all of this information together (F-IBI, habitat quality, water quality), the assessment for macroinvertebrates was considered also fully supporting for aquatic life.

Image 8: Brook Trout in sampling tub collected on Spring Brook (Rice Creek).

Image 9: Cut banks and filamentous algae in-stream on Spring Brook (Rice Creek) during sampling in 2011.

Lake assessments

Of the seven basins >10 acres in size, only one (Byllesby Reservoir, 19-0006) was assessed for aquatic recreation use support. The Byllesby Reservoir is located in the NCHF ecoregion but has site specific standards more akin to the WCBP ecoregion. The reservoir is a flow-through lake with its deepest parts found in the old channel of the Cannon River just before reaching the dam. Most of the reservoir is shallow and susceptible to internal nutrient loading, driven by wind action mixing the water column and re-suspending nutrients in the bottom sediments which makes it prone to algal blooms (Image 10). The Byllesby Reservoir was listed as impaired for aquatic recreation use due to excessive nutrients in 2002. That impairment is confirmed by the most recently available data (Table 43) showing phosphorous concentrations more than double the site specific eutrophication standard of 90 µg/L. The Byllesby Reservoir is also not supporting aquatic consumption due to elevated mercury in fish tissue. Guidelines for eating fish from this lake can be found on the MDH website: http://www.health.state.mn.us/divs/eh/fish/.

Image 10: Algae bloom on the Byllesby Reservoir (9/5/2008). Image by CRWP.

Watershed plans, projects, and TMDLs

Stressor Identification is currently underway to determine the causes of biological impairments. For the Byllesby Reservoir, a TMDL has been drafted and is awaiting EPA approval: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/lower-mississippi-river-basin-tmdl/project-byllesby-reservoir-excess-nutrients.html. Some implementation projects have already begun, such as upgrading the ability of wastewater treatments plants to capture and reduce the amount of phosphorus discharged into the Cannon River that eventually makes its way to the Reservoir. Upgrades occurred for Northfield in 2001 and more recently in Faribault in 2011 and Owatonna in 2013. Additional measures to manage nutrients for cities and agricultural land will need to occur in order to see improvements in water clarity and recreational conditions. The bacteria impairment on the Cannon River (-509) is being addressed through the Lower Mississippi River Basin— Regional Fecal Coliform TMDL: http://www.pca.state.mn.us/foyp984

County Water Quality Plans and projects can be viewed at the following SWCD websites:

- Goodhue County - http://www.goodhueswcd.org/#!programs/c10d6
- Rice County - http://www.co.rice.mn.us/node/104860
- Dakota County - http://www.dakotaswcd.org/

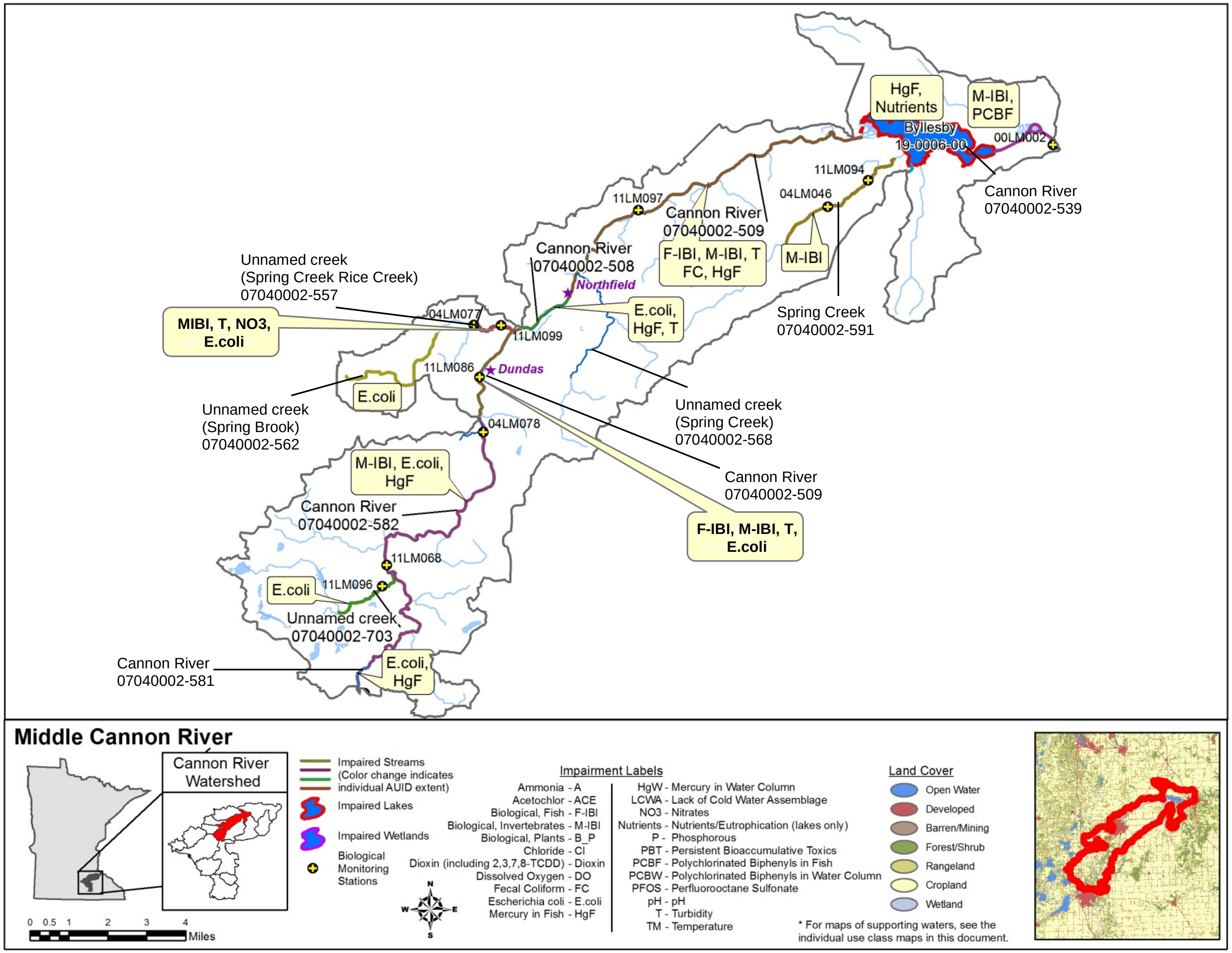

Figure 30. The 2013 assessed stream reaches with impairments and land use characteristics (inset) in the Middle Cannon River Subwatershed.

Heath Creek Subwatershed Unit HUC 0704000206-02

The smallest subwatershed area at 40.8 mi^2, the Heath Creek Subwatershed is located largely in Rice County, with only a small portion located in the southwestern corner of Dakota County. The subwatershed stretches from Lonsdale in the west to the Cannon River on the outskirts of Northfield in the east. There are four lake basins >10 acres in size. Union Lake drains the western half of the subwatershed and acts as the headwaters of Heath Creek, which flows east and meets the Cannon River southwest of Northfield. Located entirely in the NCHF ecoregion, land use is an equal mix of cropland (32%) and rangeland (32%) with the remainder as forest (13.4%), wetland (4.4%), open water (2.6%) and developed land (7.5%). The water chemistry outlet station is located just off Highway 19 at the bridge of Decker Avenue over Heath Creek, roughly two miles northwest of where Heath Creek meets the Cannon River (STORET station S006-521, biological station 11LM005). During the 2013 assessment, four stream reaches were assessed for aquatic life and/or aquatic recreation (Table 44) and one reach was assessed against limited use water quality standards (Class 7). A few stream reaches were not assessed using biological standards (F-IBI and M-IBI) due to channelization. Biological quality ratings are included in Table 45. Union Lake was the only lake assessed for aquatic recreation (Table 49).

Table 44. Aquatic life and recreation assessments on stream reaches: Heath Creek Subwatershed.

AUID, Reach Name, Reach Description	Reach Length (miles)	Use Class	Biological Station ID	Location of Biological Station	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	Aquatic Life	Aquatic Rec.
07040002-603, Knowles Creek, Unnamed cr to Union Lk	2.1	2B	11LM020**	Upstream of 80th St W, 5.5 mi. E of Lonsdale	NA**	NA**	--	MTS	--	--	--	--	--	IF*	NA
07040002-530, Unnamed ditch, Headwaters to T112 R22W S36, south line	2.4	7	11LM031	Downstream of CR 59 (Union Lake Tr), 1.5 mi. S of Lonsdale	NA	NA	IF	--	--	MTS	--	--	--	NA	NA
07040002-555, Unnamed ditch, T111 R22W S1, north line to Unnamed cr	0.6	2B	04LM083	Upstream of Gonvick Ave, 2 mi. SE of Lonsdale	EXS	EXP	--	--	--	--	--	--	--	NS	NA
07040002-529, Unnamed creek, Unnamed cr to Union Lk	6.2	2B	11LM021**	Upstream of CSAH 34 (Clearwater Tr), 10 mi. N of Faribault	--	NA**	--	MTS	--	--	--	--	--	IF*	NA
07040002-521, Heath Creek, Headwaters (Union Lk 66-0032-00) to Cannon R	13.4	2B	04LM076 11LM005	Upstream of CR 59 (90th St), 4 mi W of Northfield Downstream of CR 59 (90th St E), 1.5 mi. W of Northfield	IF†	IF†	MTS	MTS	MTS	MTS	MTS	--	EX	IF†	NS

Abbreviations for Indicator Evaluations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **MTS** = Meets criteria; **EXP** = Exceeds criteria, potential impairment; **EXS** = Exceeds criteria, potential severe impairment; **EX** = Exceeds criteria (Bacteria).

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

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

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

** Channelized station, biological data currently not assessed for aquatic life until Tiered Aquatic Life Use (TALU) standards are developed.

†Not assessed, additional monitoring recommended.

Table 45. Non-assessed biological stations on the Class 7 and channelized reaches or AUIDs: Heath Creek Subwatershed.

AUID, Reach Name, Reach Description	**Reach length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Fish IBI**	**Invert IBI**
07040002-529, Unnamed cr, Unnamed cr to Union Lk	6.2	2B	11LM021	Upstream of CSAH 34 (Clearwater Tr), 10 mi. N of Faribault	--	poor
07040002-603, Knowles Creek, Unnamed cr to Union Lk	2.1	2B	11LM020	Upstream of 80th St W, 5.5 mi. E of Lonsdale	fair	poor
07040002-530, Unnamed ditch, Headwaters to T112 R22W S36, south line	2.4	7	11LM031	Downstream of CR 59 (Union Lake Tr), 1.5 mi. S of Lonsdale	poor	poor

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

Table 46. Minnesota Stream Habitat Assessment (MSHA): Heath Creek Subwatershed.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
2	04LM083	Unnamed ditch	1.1	1.8	11.7	8	20.5	43.1	poor
0	11LM021	Unnamed creek	--	--	--	--	--	--	--
1	11LM020	Knowles Creek	0	12	8.2	8	13	41.2	poor
1	11LM031	Unnamed ditch	2.5	7.5	18	13	21	62	fair
1	04LM076	Heath Creek	0	13	9.9	15	26	63.9	fair
1	11LM005	Heath Creek	1.3	10	18.7	12	25	66.9	good
Average Habitat Results: *Heath Creek Subwatershed*			**1.0**	**8.9**	**13.3**	**11.2**	**21.1**	**55.4**	**fair**

Qualitative habitat ratings

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

Table 47. Channel Condition and Stability Assessment (CCSI): Heath Creek Subwatershed.

# Visits	Biological Station ID	Stream Name	Stream Type	Upper Banks (4-43)	Lower Banks (5-46)	Substrate (3-37)	Channel Evolution (1-11)	CCSI Score (13-137)	CCSI Rating
0	04LM083	Unnamed ditch	--	--	--	--	--	--	--
0	11LM021	Unnamed creek	--	--	--	-	--	--	--
1	11LM020	Knowles Creek	TCR	31	19	28	3	81	severely unstable
0	11LM031	Unnamed ditch	--	--	--	--	--	--	--
0	04LM076	Heath Creek	--	--	--	--	--	--	--
1	11LM005	Heath Creek	MHL	16	13	12	3	44	fairly stable
Average Stream Stability Results: *Heath Creek Subwatershed*				**23.5**	**16**	**20**	**3**	**62.5**	**moderately unstable**

Qualitative channel stability ratings

= stable: CCSI < 27 = fairly stable: 27 < CCSI < 45 = moderately unstable: 45 < CCSI < 80 = severely unstable: 80 < CCSI < 115 = extremely unstable: CCSI > 115

Table 48. Outlet water chemistry results: Heath Creek Subwatershed.

Station Location:	**Heath Creek** ; At 90th St E, 1.5 mi. W of Northfield						
STORET/ EQuIS ID:	**S006-521**						
Station #:	**11LM005**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	11	0.0001	0.0155	0.0061	< 0.0400	0
Chloride	mg/L	10	21	45	29	< 230	0
Dissolved Oxygen	mg/L	20	4.71	9.44	7.21	> 5.00	2
pH	SU	20	6.5	8.5	7.9	6.5 - 9.0	0
Transparency tube	100 cm	20	8	> 100	56	> 20	1
E. coli (geometric mean)	MPN/100ml	35	100	310	-	< 126	2
Escherichia coli	MPN/100ml	15	89	> 2420	454	< 1260	1
Hardness, carbonate	mg/L	10	176	427	234	-	-
Nitrite-nitrate	mg/L	10	0.84	3.17	1.65	-	-
Kjeldahl nitrogen	mg/L	10	0.55	2.55	1.51	-	-
Phosphorus	µg/L	10	155	586	350	-	-
Specific Conductance	µS/cm	20	303	737	477	-	-
Sulfate	mg/L	10	3.0	33.3	18.5	-	-
Temperature, water	deg °C	19	13.5	29.8	21.6	-	-
Total suspended solids	mg/L	10	3	120	33	-	-
Total volatile solids	mg/L	10	2	24	8	-	-

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

[2]Data found in the table above were compiled using the results from data collected at the outlet monitoring station in the Heath Creek Subwatershed, a component of the IWM work conducted between May and September from 2011 and 2012. These specific data do not necessarily reflect all data that were used to assess the AUID.

Table 49. Lake water aquatic recreation assessments: Heath Creek Subwatershed.

Name	DNR Lake ID	Area (acres)	Trophic Status	Percent Littoral	Max. Depth (meters)	Avg. Depth (meters)	Mean TP (µg/L)	Mean chl-a (µg/L)	Secchi Mean (meters)	CLMP Trend	Aquatic Life Support Status	Aquatic Recreation Support Status	Aquatic Consumption Support Status
Union	660032	437	H	100	3	1.0*	428	93	0.4	- -	IF	NS	NA

*- Indicates a depth estimated (in meters) by MPCA staff

Abbreviations:

Trophic Status
H -- Hypereutrophic
E – Eutrophic
M -- Mesotrophic

Support Status
FS -- Full Support
NS -- Non-Support
IF -- Insufficient Information
NA – Not Assessed

CLMP Trend
I -- Increasing/Improving Trends
NT -- No Trend

Key for Cell Shading: = existing impairment (prior to 2012); = new impairment; = full support of designated use.

Summary of subwatershed water quality

The Heath Creek subwatershed appears to be suffering from excess nutrients in the system. Phosphorus was very high in many waterbodies throughout this watershed. Union Lake is not supporting its aquatic recreation use due to excess phosphorus that fuels the growth of algae, thereby creating unsightly conditions for recreational enjoyment. Water flowing out of Union Lake forms the headwaters to Heath Creek; hence, excess nutrients in the lake may be impacting the water quality of Heath Creek. Headwater streams and ditches—as well as biological stations along Heath Creek--are dominated by pollution tolerant fish and macroinvertebrates and are often lacking sensitive species. Biological stressors are likely a combination of nutrient enrichment causing exacerbated daily highs and lows in DO and poor habitat conditions. Channel instability was observed indicated by severe bank cutting (see images below) and loosely deposited sediment covering gravel in areas. The lower portion of Heath Creek near Northfield had better habitat conditions than in the upper reaches of this watershed. Water samples collected at the outlet station (Table 48) show high bacteria levels continue to be an issue that may make swimming and wading unsafe, while fair to poor biological conditions on the lower portion of Heath Creek may be related to the low values of DO and low transparency (water clarity) observed. Phosphorus was also high (>300 µg/L, and some values >500 µg/L) and may be a cause or contributor to the low DO observed on Heath Creek, and potentially contributing to poor water quality conditions on sections of the Cannon River. Compared to other subwatersheds, nitrite-nitrate values were not as high. Stressor Identification is currently underway to investigate the probable causes of biological impairments. A model was recently developed for Union Lake that will aid in identifying nutrient sources and reduction strategies that could be implemented in order to improve lake conditions.

Stream assessments

Only one reach was assessed for aquatic recreation. Heath Creek—from its headwaters to the Cannon River-- was listed as impaired due to elevated bacteria in 2010 and the current data support the listing. Five stream reaches were reviewed for aquatic life during the 2013 assessment. Of those, one reach is newly impaired for fish and macroinvertebrates, one reach was a Class 7 that is not assessed against aquatic life standards, and three reaches had insufficient information for assessment. Of those with insufficient information, two were due to the biological stations being channelized, and for Heath Creek (-521) additional monitoring is recommended before an assessment determination can be made for aquatic life. Additional information on individual reaches is included below.

Heath Creek (-521) is a 13 mile reach just west of Northfield. This reach was listed as impaired due to turbidity and not supporting aquatic life in 2008. However, it was determined that water chemistry data at monitoring station S001-935 were influenced by algal conditions within Union Lake, due to its close proximity to the lake outflow, and were not representative of Heath Creek. As such, those data were removed from the assessment dataset and a new assessment showed that Heath Creek (-521) meets the water quality standard for turbidity and will be removed from the 2014 Impaired Waters List. For biological indicators, additional monitoring for fish and invertebrates is needed to determine an aquatic life use support status. Two biological stations were sampled; one near the headwaters (04LM076) sampled in 2004 and one near the outlet (11LM005) sampled in 2011. At 11LM005, both fish and macroinvertebrate IBIs scored above threshold with sensitive taxa present; however, the opposite occurred at 04LM076 where both IBI scores for both biocriteria were well below the threshold with a high percentage of tolerant individuals (100% for fish, 93.3% for macroinvertebrates). Habitat quality was rated fair at the upstream station (04LM076) with silt and sand substrate and moderate channel instability. Dissolved oxygen was also low (2.95 mg/L), vegetation was dense, and phosphorus was high (0.453 mg/L) suggesting a potential nutrient issue. Heath Creek flows out of Union Lake which is impaired by excess nutrients and may be a potential contributor to the low DO and poor biological conditions. At the downstream station (11LM005), habitat was rated good with cobble riffle habitat and a fairly stable channel. This station was one of only two locations in the Cannon River Watershed where the pollution-sensitive, turtle shell case-maker caddisfly larvae, *Glossosoma sp*., was collected.

Phosphorus was also high (0.301 mg/L). The lower reach appears to be supporting aquatic life and the upstream reach sampled seven years earlier indicates a non-supporting condition. There is the potential that there may have been watershed or local improvements between those two time periods, but with no new data available to confirm improved biological condition or present impairment additional monitoring was recommended by the watershed assessment team. In 2013, biological monitoring was conducted at the upstream station (04LM076) and at a new location in between the two existing stations (13LM001). The fish communities at both stations were dominated by tolerant individuals and the F-IBI scores at both stations were below the threshold, suggesting a potential F-IBI impairment. However, the 2013 biological and water quality data will need to be reviewed during a special assessment in the future before a formal determination is made. One-time field measurement of DO at 04LM076 was still below the standard (4.79 mg/L at 12:30 p.m. on 8/5/2013) while at the downstream station (13LM001) DO was slightly above the standard (5.96 at 2:25 p.m. on 8/5/2013). Site images suggest that the channel at both stations is very incised with bank cutting evident, although the riparian area is in better condition at the downstream station.

Further upstream in the headwaters, impaired reach (-555) is immediately downstream of a Class 7 reach (-530). The fish community below the Class 7 reach was sampled twice at station 04LM083 in 2004 and 2011. Both samples were below threshold. The FIBI score from 2004 was 7 points below threshold and the 2011 score was 19 points below threshold, indicating severe impairment. The drainage area of this biological station is small (3.4 mi^2) and typically not sampled for intensive watershed monitoring; however, this station was sampled as part of a special study that compares all Class 7 biological quality to upstream and downstream conditions. Habitat quality was rated fair in 2004 and good in 2011, although the site is pastured and channel instability was noted. The fish community at the biological station on the Class 7 reach (11LM031) was poor with a one-time measurement of DO at 4.21 mg/L, which is well above the Class 7 standard of 1 mg/L but indicates that DO may be limiting the biological quality at this station. Phosphorus was also high (0.566 mg/L) and total ammonia was detected (0.24 mg/L) suggesting eutrophic conditions. For pH, while the assessment determined that the data met the Class 7 standard (pH 6.0 to 9.0), one exceedance occurred in June 2010 (pH 4.7). At station 04LM083, nutrients were somewhat high (nitrogen: 2 mg/L in 2004, 3.8 mg/L in 2011; phosphorus: 0.356 mg/L in 2004, 0.269 mg/L) also suggesting a potential nutrient issue. In addition, conductivity was noticeably higher in 2011 (1221 µmhos) as compared to 2004 (286 µmhos). This reach is currently being investigated by stressor identification staff to determine if the source and constituents comprising the higher conductivity observed could be a cause or contributor to the biological impairment in the 2B reach(-555).

Image 11: Cut banks and excess deposition indicating an incised and overwidened stream at 04LM076 on Heath Creek (8/5/2013).

Image 12: Incised banks and shallow run filled with silt on Knowles Creek (June 13, 2011).

Two assessment reaches had biological stations that were channelized and the only data available to assess against aquatic life standards was TSS, which is not enough to determine whether or not the stream is meeting its aquatic life standard. Using the channelized stream rating, both reaches rated poor for macroinvertebrates. The biological station on Knowles Creek (11LM020) had 100% tolerant macroinvertebrates and 96.5% tolerant fish. The macroinvertebrate community was dominated by *Rheotanytarsus*, a midge of the bloodworm family, while the fish community was dominated by fathead minnow and green sunfish; all of which are tolerant of low DO conditions. This station also rated poor for habitat and severely unstable for channel stability with severe bank cutting. Substrate was predominantly silt with little cover for fish or macroinvertebrates (Image 12). The biological station on the tributary to Union Lake (11LM021) was only sampled for macroinvertebrates since the site was dry and appeared impounded during fish sampling. This station is also between two large wetland complexes, which may also be a factor influencing the community at this station, which was dominated by low DO tolerant midges (*Chironomimus*) and oligocheate worms.

Lake assessments

Of the four lake basins >10 acres in size, only one (Union Lake, 66-0032-00) was assessed for aquatic recreation use support. Union Lake is a shallow basin with a large surface area and a moderately well protected shoreline. Union Lake is hypereutrophic and greatly exceeds eutrophication standards for shallow lakes in the NCHF ecoregion; it was listed as impaired due to excess nutrients in 2006. Review of the latest data during this assessment cycle confirms the existing nutrient impairment; hence, the lake does not support aquatic recreation use. Insufficient information was available to determine aquatic life use support at this time, but available chloride concentrations were meeting standards. Union Lake has not been assessed for aquatic consumption.

Watershed plans, projects, and TMDLs

Stressor identification is underway to investigate the causes of the biological impairments in streams. A model was recently developed for Union Lake that will aid in identifying nutrient sources and reduction strategies that could be implemented in order to improve lake conditions. Other projects and water quality plans can be found at the following SWCD websites:

- Rice County - http://www.co.rice.mn.us/node/104860
- Dakota County - http://www.co.dakota.mn.us/environment/waterquality/pages/default.aspx

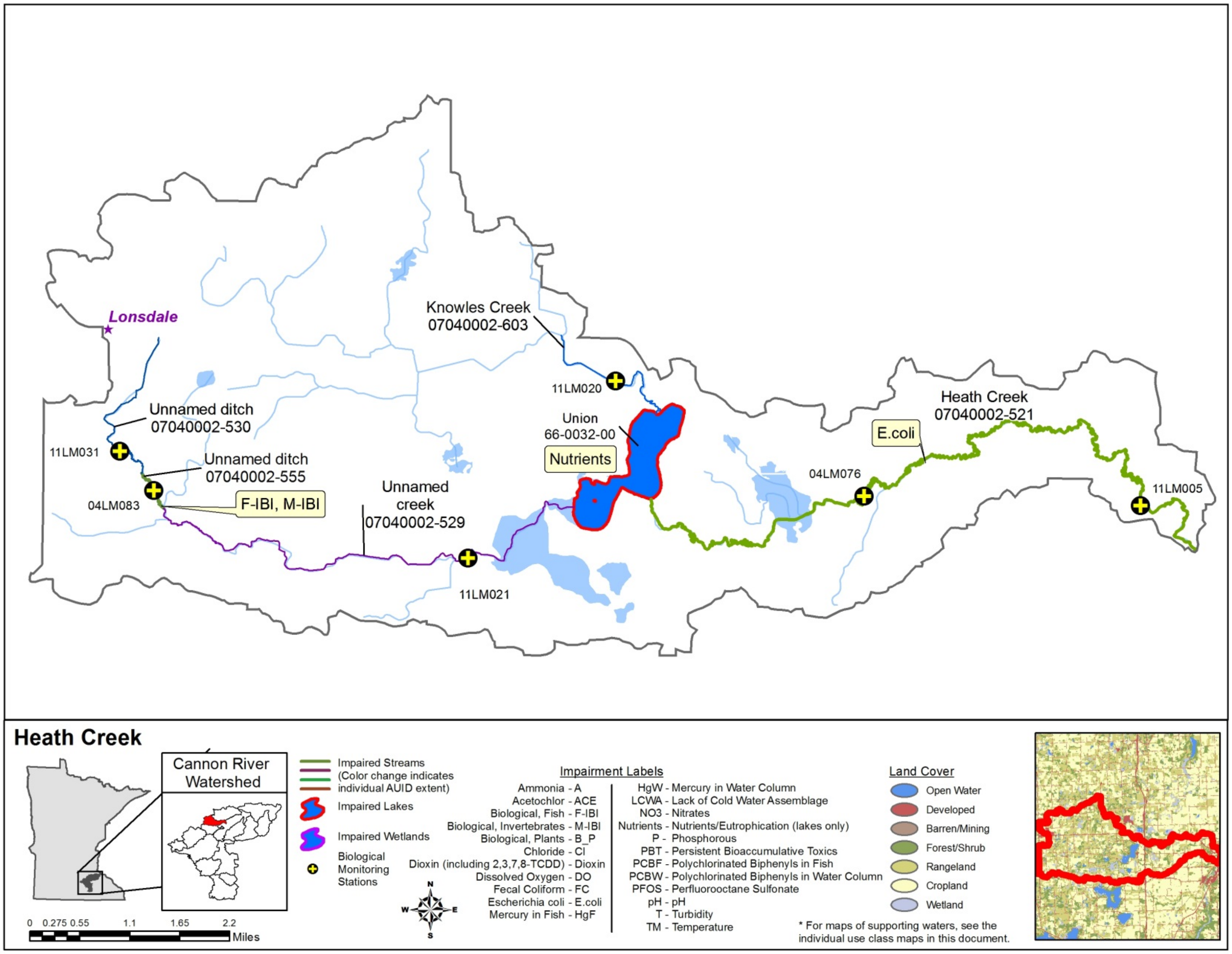

Figure 31. The 2013 assessed stream reaches with impairments and land use characteristics (inset) in the Heath Creek Subwatershed.

Wolf Creek Subwatershed HUC 0704000206-03

The Wolf Creek Subwatershed is west of Northfield and I-35 in Rice County. This 42 mi^2 subwatershed is nestled between the lake dominated Upper Cannon Subwatershed to the west and Heath Creek Subwatershed to the east. Located entirely within the NCHF ecoregion, this subwatershed has a number of lakes, the largest being Circle, Mazaska, and Fox. In total, there are 12 lakes >10 acres in size. Lake Mazaska drains via a series of ditches to the east and north through Fox and Circle lakes. Circle Lake is the catchment basin for more than two-thirds of the subwatershed, and acts as the headwaters of Wolf Creek which flows east out of the lake. Wolf Creek begins at the outflow of Circle Lake and travels 10 miles before entering the Cannon River near Dundas. Agriculture is the dominant land use at 68.7% (cropland: 39.2%, range: 29.5%) while developed land is 5.4%, forest/wetland is 18.6% and 7.2% of land use is classified as open water. The water chemistry outlet station is located on Wolf Creek at the CSAH-8 bridge, 1.5 miles southeast of Dundas (STORET/EQuIS station S001-397, biological station 11LM003). During the 2013 assessment, two reaches were reviewed for meeting aquatic life and recreation use standards (Table 50). Biological quality ratings for channelized stations that were not assessed are included in Table 51. Three lakes (Circle, Fox, and Mazaska), were assessed for aquatic recreation (Table 55), while only Circle and Mazaska have been assessed for aquatic consumption.

Table 50. Aquatic life and recreation assessments on stream reaches: Wolf Creek Subwatershed.

					Aquatic Life Indicators:										
AUID, Reach Name, Reach Description	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	**Aquatic Life**	**Aquatic Rec.**
07040002-628, Unnamed creek, Unnamed cr to Unnamed cr	1.6	2B	04LM084	Downstream of Gilbert Ave, ~3.5 mi. S of Lonsdale	EXS†	EXP†	IF	MTS	--	MTS	MTS	--	--	IF†	NA
07040002-629, Wolf Creek, Unnamed ditch to Fox Lk	1.3	2B	04LM044**	Upstream of Culver Avenue, 6 mi. NW of Faribault	NA**	NA**	--	--	--	--	--	--	--	NA	NA
07040002-522, Wolf Creek, Headwaters (Circle Lk 66-0027-00) to Cannon R	10.1	2B	10EM023** 11LM003	Upstream and downstream of Canby Ave, 6 mi. SW of Lonsdale Upstream of CSAH 8 (Dundas Blvd), 1 mi. SW of Dundas	EXP	MTS	MTS	EXP	MTS	MTS	MTS	IF	EX	NS	NS

Abbreviations for Indicator Evaluations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **MTS** = Meets criteria; **EXP** = Exceeds criteria, potential impairment; **EXS** = Exceeds criteria, potential severe impairment; **EX** = Exceeds criteria (Bacteria).
Abbreviations for Use Support Determinations: **NA** = Not Assessed, **IF** = Insufficient Information, **NS** = Non-Support, **FS** = Full Support
Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use.
†Not assessed, additional monitoring recommended.
** Channelized station, biological data currently not assessed for aquatic life until Tiered Aquatic Life Use (TALU) standards are developed.

Table 51. Non-assessed biological stations on channelized reaches or AUIDs: Wolf Creek Subwatershed.

AUID, Reach Name, Reach Description	Reach length (miles)	Use Class	Biological Station ID	Location of Biological Station	Fish IBI	Invert IBI
07040002-629, Wolf Creek, Unnamed ditch to Fox Lk	1.3	2B	04LM044	Upstream of Culver Avenue, 6 mi. NW of Faribault	fair (2)	fair (3)
07040002-522, Wolf Creek, Headwaters (Circle Lk 66-0027-00) to Cannon R	10.1	2B	10EM023	Upstream and downstream of Canby Ave, 6 mi. SW of Lonsdale	good	poor

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

Table 52. Minnesota Stream Habitat Assessment (MSHA): Wolf Creek Subwatershed.

# Visits	Biological Station ID	Reach Name	Channel Condition	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	04LM084	Unnamed creek	natural	2.5	12	12	13	20	59.5	fair
2	04LM044	Wolf Creek	channelized	1.3	11.5	10.1	12	9.5	44.4	poor
1	10EM023	Wolf Creek	channelized	2	8.5	7.9	8	9	35.4	poor
1	11LM003	Wolf Creek	natural	2.5	12	20.3	12	21	67.8	good
Average Habitat Results: *Wolf Creek Subwatershed*				**2.1**	**11**	**12.6**	**11.3**	**14.9**	**51.8**	**fair**

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

Table 53. Channel Condition and Stability Assessment (CCSI): Wolf Creek Subwatershed.

# Visits	Biological Station ID	Stream Name	Stream Type*	Upper Banks (4-43)	Lower Banks (5-46)	Substrate (3-37)	Channel Evolution (1-11)	CCSI Score (13-137)	CCSI Rating
0	04LM084	Unnamed creek	--	--	--	--	--	--	--
0	04LM044	Wolf Creek	--	--	--	--	--	--	--
0	10EM023	Wolf Creek	--	--	--	--	--	--	--
1	11LM003	Wolf Creek	MHL	19	13	10	3	45	fairly stable
Average Stream Stability Results: *Wolf Creek Subwatershed*				**19**	**13**	**10**	**3**	**45**	**fairly stable**

*See Appendix 9 for descriptions of Stream Types
Qualitative channel stability ratings

= stable: CCSI < 27 = fairly stable: 27 < CCSI < 45 = moderately unstable: 45 < CCSI < 80 = severely unstable: 80 < CCSI < 115 = extremely unstable: CCSI > 115

Table 54. Outlet water chemistry results: Wolf Creek Subwatershed.

Station Location:	**Wolf Creek** ; At CSAH-8, 1 mi SW of Dundas						
STORET/ EQuIS ID:	**S001-397**						
Station #:	**11LM003**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	11	0.0001	0.0099	0.0046	< 0.0400	0
Chloride	mg/L	10	13	19	16	< 230	0
Dissolved Oxygen	mg/L	8	5.72	9.96	7.94	> 5.00	0
pH	SU	8	7.6	8.3	7.9	6.5 - 9.0	0
Transparency tube	100 cm	8	19	74	35	> 20	2
E. coli (geometric mean)	MPN/100ml	15	237	846	-	< 126	3
Escherichia coli	MPN/100ml	15	126	3873	774	< 1260	2
Hardness, carbonate	mg/L	10	140	343	213	-	-
Nitrite-nitrate	mg/L	10	0.92	3.92	2.32	-	-
Kjeldahl nitrogen	mg/L	10	0.37	3.09	1.42	-	-
Phosphorus	µg/L	10	60	539	255	-	-
Specific Conductance	µS/cm	7	294	605	442	-	-
Sulfate	mg/L	10	14.6	32.0	21.2	-	-
Temperature, water	deg °C	7	21	29	25	-	-
Total suspended solids	mg/L	10	1	81	32	-	-
Total volatile solids	mg/L	10	1	29	11	-	-

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

[2]Data found in the table above were compiled using the results from data collected at the outlet monitoring station in the Wolf Creek Subwatershed, a component of the IWM work conducted between May and September from 2011 and 2012. These specific data do not necessarily reflect all data that were used to assess the AUID.

Table 55. Lake water aquatic recreation assessments: Wolf Creek Subwatershed.

Name	DNR Lake ID	Area (acres)	Trophic Status	Percent Littoral	Max. Depth (meters)	Avg. Depth (meters)	Mean TP (µg/L)	Mean chl-a (µg/L)	Secchi Mean (meters)	CLMP Trend	Aquatic Life Support Status	Aquatic Recreation Support Status	Aquatic Consumption Support Status
Circle	660027	976	H	100	4.3	1.6	323	70	0.7	- -	NA	NS	NS
Fox	660029	330	E	48	14	5.9	88	31	1.3	D	NA	NS	NA
Mazaska	660039	687	H	49	15.2	5.1	189	138	1.0	NT	IF	NS	NS

Abbreviations:

Trophic Status
H -- Hypereutrophic
E – Eutrophic
M -- Mesotrophic

Support Status
FS -- Full Support
NS -- Non-Support
IF -- Insufficient Information
NA – Not Assessed

CLMP Trend
I -- Increasing/Improving Trends
NT -- No Trend

Key for Cell Shading: = existing impairment (prior to 2012); = new impairment; = full support of designated use.

Summary of subwatershed water quality

Excess nutrients are a pervasive issue in lakes and streams across this subwatershed. All three lakes (Circle, Fox, Mazaska) are impaired for aquatic recreation use due to excess phosphorus and a lack of water clarity. Wolf Creek, which flows out of Circle Lake, is often bright green with algae during the summer and has high phosphorus. The algae may be impacting fish and macroinvertebrate communities by creating high and low DO conditions that are stressful to pollution sensitive species. Other streams sampled also have very high phosphorus, and channel instability issues indicated by severe bank erosion which may be impacting habitat quality. Additionally, Circle and Mazaska lakes are not supporting fish consumption due to high levels of mercury in fish tissue. Water samples collected at the outlet station (Table 54) on Wolf Creek show high bacteria levels, low transparency tube (water clarity) measurements, and elevated phosphorus, all which may be impacting not only the poor water quality conditions on Wolf Creek, but may also be adding to the poor water quality conditions on downstream waterbodies such as the Cannon River and the Byllesby Reservoir. Stressor identification is currently underway to determine the causes of poor biological condition in streams. For lakes, the high levels of mercury in fish found on Circle Lake are being addressed with the Statewide Mercury TMDL. However, the mercury levels in fish on Mazaska were too high to be included in the statewide TMDL and will require a TMDL to be written for it in the future.

Stream assessment results

Only one reach on Wolf Creek was assessed for aquatic recreation. Samples were collected in 2011 and 2012 and for all dates sampled, the bacteria levels were above 126 MPN/100 ml resulting in geometric means for all months above the chronic standard. Consequently, this reach was determined to be impaired for aquatic recreation use due to elevated bacteria in 2013 and will be added to the impaired waters list in 2014. For aquatic life, only two reaches had data that were reviewed against standards, while one reach was not assessable using biocriteria standards due to the station being channelized. Of those that were assessed, Wolf Creek (-522) met biocriteria standards for fish and macroinvertebrates but is listed as impaired for aquatic life use due to an existing turbidity impairment, while another reach on Wolf Creek (-629) had insufficient information and additional monitoring is recommended before an aquatic life assessment can be made. Information on individual stream reaches is included below.

Wolf Creek (-522)-- from Circle Lake to the Cannon River-- was listed as impaired for aquatic life use due to turbidity in 2006, and this impairment was confirmed with more recent data. At the outlet station (11LM003), the water typically has a very green cast, especially during late summer (Image 13), indicating a potential nutrient issue. There are two water chemistry stations on Wolf Creek, one upstream and one on the downstream end of the reach. When sampled on the same date, transparency (water clarity) was typically less at the upstream reach than at the downstream station which may be due to the proximity to Circle Lake to the upstream site, which is impaired due to excess phosphorus which may be fueling algae growth in Wolf Creek. Some phosphorus may have been attenuated in the downstream site or it has less light for algae growth. Currently, the fish and macroinvertebrate communities in the lower section of Wolf Creek (below Circle Lake) are meeting their expectations for a healthy stream. However, a comparison of IBI scores to each assemblage's impairment threshold reveals that both communities are only barely meeting these expectations. Except for dominance by one species, the common shiner, the fish community was fairly well balanced with good numbers of individuals representing sensitive species (e.g., hornyhead chub, longnose dace). For macroinvertebrates, Wolf Creek is one of only two locations in the Cannon River Watershed where the pollution-sensitive, turtle shell case-maker caddisfly larvae, *Glossosoma sp.,* was collected. Due to the IBI scores for both biological assemblages being near the threshold of impairment, it will be important to address existing impairments in both the creek itself (turbidity) and the lake immediately upstream (Circle Lake – excess nutrients & fish tissue mercury impairments) to maintain and improve the aquatic life of Wolf Creek.

Image 13: Green cast to water due to algae observed on Wolf Creek (8/6/ 2011).

Image 14: Cut banks on Wolf Creek at 04LM084 in 2011.

One additional reach in the headwaters of Wolf Creek (-629) was sampled for fish and macroinvertebrates in 2004 and 2011; however, this reach is channelized and will not be assessed until TALU standards are developed. The fish community was rated poor in 2004 and good in 2011 while the macroinvertebrate community was rated fair in both years. Notes during fish sampling in 2004 indicate that in-stream vegetation was dense and made sampling difficult; only two species with 15 fish were collected (13 blackbullheads and 2 yellow bullheads). In contrast, 11 species were collected in 2011, including sensitive taxa such as logperch and bluegill; sampling notes indicate that vegetation was still dense, suggesting a potential nutrient issue. Phosphorus was somewhat high in 2004 (0.24 mg/L) but within regional expectations in 2011 (0.11mg/L). Another possibility that may explain the difference in the fish communities collected between the two years is the severe drought conditions during 2003.

For unnamed creek (-628), additional monitoring was recommended. The biological station (04LM084) was sampled once in 2004 for fish and macroinvertebrates. Fish were sampled in June and macroinvertebrates were sampled in August. Only 11 fish were collected and the F-IBI score was 0 suggesting severe impairment for fish. In contrast, aquatic macroinvertebrates scored above threshold but within the confidence interval; hence the assessment decision was that this reach supports aquatic life for macroinvertebrates. The macroinvertebrate community had good overall taxa richness and an even distribution of species abundances, although with only moderate EPT richness (EPT is short for *Ephemeroptera*, *Plecoptera*, and *Trichoptera*, insect orders with species that are generally intolerant of pollution) and no sensitive taxa. This part of the watershed experienced a severe drought during 2003 and so it was unclear if water quality issues or drought may have been the reason for the low number of fish collected, and so additional monitoring was recommended before a formal assessment for fish could be made. However, the 2013 fish visit also collected relatively few individuals (29 fish) in this small headwater stream (7.4 mi^2 drainage area). The F-IBI score for 2013 was 47 (threshold 55, +/-7), suggesting that this reach may potentially be impaired for aquatic life for fish. A future assessment will determine whether or not this reach is impaired for aquatic life. Phosphorus was high in 2004 and 2013 (430 and 330 µg/L, respectively) so additional monitoring during the early hours of the day could potentially uncover a DO issue. Channel instability may be an additional stressor. This station has intact riparian zone, but from sampling images (Image 14) appears to be incised with moderate bank erosion that may be associated with a change in flow conditions related to a change in watershed hydrology.

Lake assessment results

Three of the 12 lakes >10 acres in size (Mazaska, Fox and Circle) were assessed for aquatic recreation use (Table 55). Circle Lake receives water from a series of ditches to its west and from Fox Lake via Wolf Creek to the south, and in total drains more than 21,000 acres of mostly agricultural/pastured uplands. All three lakes exceed their respective eutrophication standards and are listed as not supporting aquatic recreation due to excessive nutrients. Mazaska and Fox Lakes are deep basins and remain stratified during the summer months. Fox Lake is one mile upstream of Circle Lake and acts as a nutrient sink which lessens the cumulative impact of nutrients on Circle Lake's shallow basin. Circle Lake is a shallow lake with a large fetch and is highly susceptible to internal nutrient loading from wind action re-suspending bottom sediments that hold nutrients. Additionally, Circle and Mazaska are not supporting fish consumption due to high levels of mercury in fish tissue. The MDH has lake specific fish eating guidelines: http://www.health.state.mn.us/divs/eh/fish/eating/sitespecific.html.

Watershed plans, projects, and TMDLs

Stressor identification of biological impairments is presently underway. The high mercury in fish for Circle Lake is being addressed through the Statewide Mercury TMDL. Information and the TMDL can be found on the MPCA website:
http://www.pca.state.mn.us/index.php/water/waterhttp://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/special-projects/statewide-mercury-tmdl-pollutant-reduction-plan.html. Due to the high mercury levels in fish, Mazaska is not included in the Statewide Mercury TMDL and will require its own TMDL in the future.

County water quality plans and projects can be found on the Rice County SWCD website:
http://www.riceswcd.org/

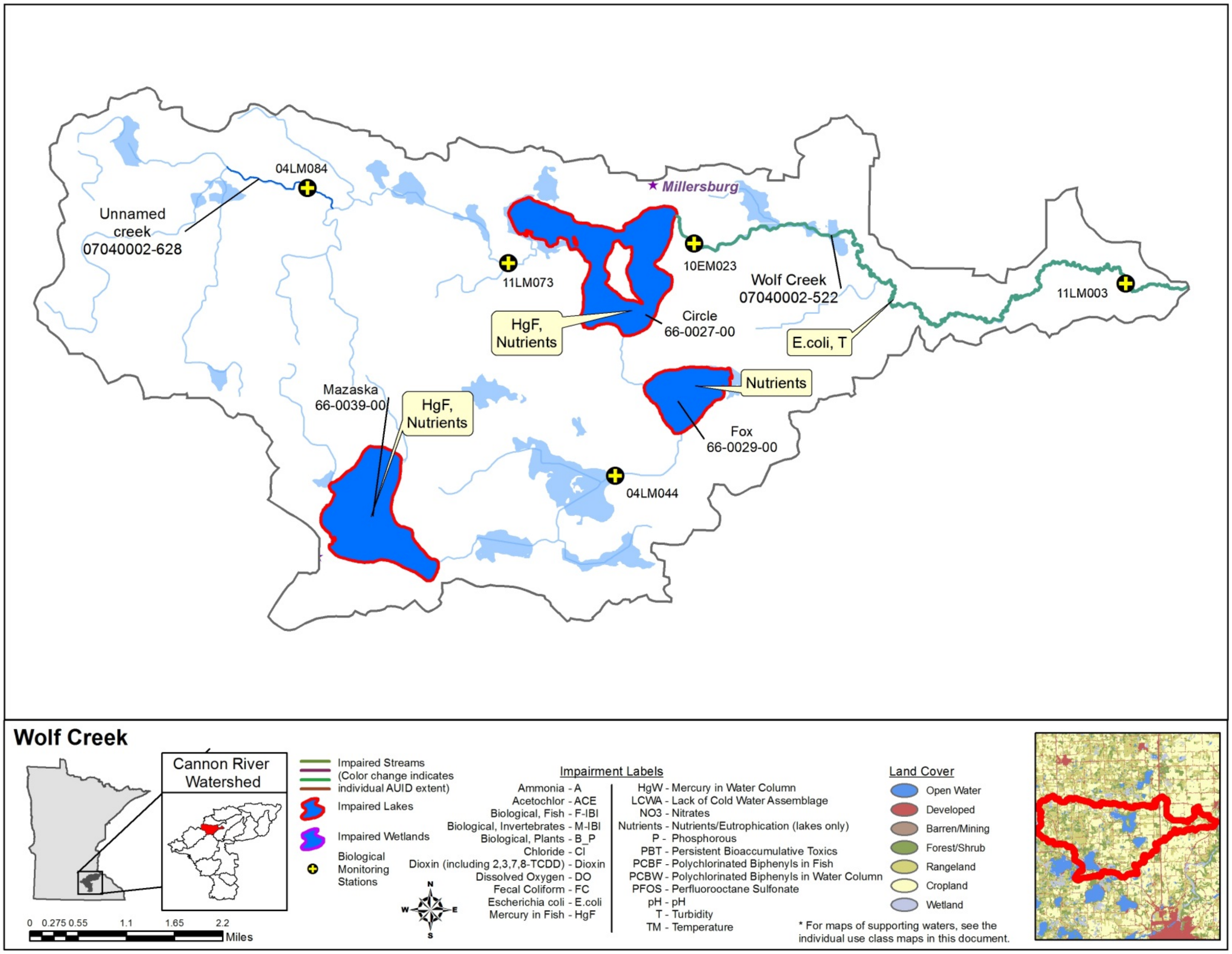

Figure 32. 2013 assessed stream reaches with impairments and land use characteristics (inset) in the Wolf Creek Subwatershed.

Little Cannon River Subwatershed HUC 0704000207-01

The headwaters of this 95 mi^2 subwatershed begin near the city of Nansen. From there, the Little Cannon River flows north through Sogn and completes its journey in the city of Cannon Falls where it enters the Cannon River west of the Byllesby Reservoir. The area immediately surrounding the most upstream two miles of the Little Cannon River's headwaters are located in Rice County, while the rest of the subwatershed is located in Goodhue County. Most of subwatershed is in the Driftless Area ecoregion, with only a small part of the headwaters region, south of the town of Nerstrand, in the WCBP ecoregion. Land use is a mix of forest land (22%), agriculture (70% cropland and rangeland), and developed land (7.6%). There are no lake basins >10 acres in size. The water chemistry outlet station (STORET/EQuIS station S004-512, biological station 11LM089) is located on the Little Cannon River at the CSAH-24 Bridge, 3 miles south-southeast of Cannon Falls. During the 2013 assessment, six stream reaches were reviewed against aquatic life and/or aquatic recreation standards (Table 56).

Table 56. Aquatic life and recreation assessments on stream reaches: Little Cannon Subwatershed.

AUID, Reach Name, Reach Description	Reach Length (miles)	Use Class	Biological Station ID	Location of Biological Station	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	Aquatic Life	Aquatic Rec.
07040002-670, Unnamed creek (Little Cannon River Tributary), T110 R18W S12, south line to Unnamed cr	0.4	1B, 2B*	11LM023	Downstream of CSAH 14, 7 mi. E of Nerstrand	MTS	EXP†	--	--	--	--	--	--	--	IF†	NA
07040002-639, Unnamed creek (Little Cannon River Tributary), T110 R18W S1, east line to Little Cannon R	0.6	1B, 2B*	11LM027	Upstream of CSAH 49 Blvd, 6.5 mi. SE of Dennison	MTS	EXP†	--	--	--	--	--	--	--	IF†	NA
07040002-590, Butler Creek, Unnamed cr to Little Cannon R	2.1	2B	04LM085	Upstream of Hwy 52, 3.5 mi. S of Cannon Falls	MTS	EXP	IF	IF	MTS	MTS	MTS	--	EX	NS	NS
07040002-553, Little Cannon River (Goodhue County), Headwaters to T110 R10W S9, east line	6.7	2B	--	--	--	--	--	MTS	--	--	--	--	--	IF	NA
07040002-589, Little Cannon River (Goodhue County), T110 R18W S10, west line to T111 R18W S13, east line	12.1	1B, 2A	11LM025 11LM024 04LM086	Downstream of Hwy 56, 4 mi. W of Nerstrand Downstream of CSAH 44, 6 mi. W of Nerstrand Leon Township, ~7.5mi. S of Cannon Falls	EXS	EXS	IF	EXS	--	MTS	IF	--	EX	NS	NA
07040002-526, Little Cannon River (Goodhue County), T111 R17W S18, west line to Cannon R	11.9	2B	04LM038 11LM089	Downstream of CR 57, 6 mi. S of Cannon Falls Upstream of CSAH 24 (Felton Ave), 3 mi. SW of Cannon Falls	EXP	EXP	MTS	EXS	MTS	MTS	MTS	MTS	EX	NS	NS

Abbreviations for Indicator Evaluations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **MTS** = Meets criteria; **EXP** = Exceeds criteria, potential impairment; **EXS** = Exceeds criteria, potential severe impairment; **EX** = Exceeds criteria (Bacteria).

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

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

†Reach was assessed based on use class included in table (2B) and existing use class as defined in Minn. Rule 7050 is different (2A). MPCA is currently in the process of changing the existing use class for this AUID in rule based on an analysis of the biological community and temperature data.

Table 57. Minnesota Stream Habitat Assessment (MSHA): Little Cannon River Subwatershed.

# Visits	Biological Station ID	Reach Name	Channel Condition	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	11LM023	Unnamed creek	natural	1.3	9.5	20	13	25	68.8	good
1	11LM027	Unnamed creek	natural	3.8	10.5	16.9	12	25	68.2	good
2	04LM085	Butler Creek	natural	2.5	9.8	17.7	7.5	24	61.5	fair
1	11LM025	Little Cannon River	natural	0	6	21.4	13	29	69.4	good
1	11LM024	Little Cannon River	natural	2.5	6.5	20.4	8	20	57.4	fair
2	04LM086	Little Cannon River	natural	1.3	6.8	14.1	13	25.5	60.6	fair
1	04LM038	Little Cannon River	natural	0	9	18.3	13	25	65.3	fair
1	11LM089	Little Cannon River	natural	2.5	9.5	12.4	16	22	62.4	fair
Average Habitat Results: *Little Cannon River Subwatershed*				**1.7**	**8.4**	**17.6**	**11.9**	**24.4**	**64.2**	**fair**

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

Table 58. Channel Condition and Stability Assessment (CCSI): Little Cannon River Subwatershed.

# Visits	Biological Station ID	Stream Name	Stream Type*	Upper Banks (4-43)	Lower Banks (5-46)	Substrate (3-37)	Channel Evolution (1-11)	CCSI Score (13-137)	CCSI Rating
1	11LM023	Unnamed creek	MHL	13	27	10	5	55	moderately unstable
1	11LM027	Unnamed creek	MHL	30	40	19	7	96	severely unstable
1	04LM085	Butler Creek	MHL	40	34	32	11	117	extremely unstable
1	11LM025	Little Cannon River	MHL	20	17	10	5	52	moderately unstable
1	11LM024	Little Cannon River	MHL	33	19	12	5	69	moderately unstable
1	04LM086	Little Cannon River	MHL	38	46	26	11	121	extremely unstable
1	04LM038	Little Cannon River	--	--	--	--	--	--	--
1	11LM089	Little Cannon River	MHL	40	46	42	11	139	extremely unstable
Average Stream Stability Results: *Little Cannon River Subwatershed*				**30.6**	**32.7**	**21.6**	**7.9**	**92.7**	**severely unstable**

*See Appendix 9 for descriptions of Stream Types
Qualitative channel stability ratings
= stable: CCSI < 27 = fairly stable: 27 < CCSI < 45 = moderately unstable: 45 < CCSI < 80 = severely unstable: 80 < CCSI < 115 = extremely unstable: CCSI > 115

Table 59. Outlet water chemistry results: Little Cannon River Subwatershed.

Station Location:	**Little Cannon River** ; At CSAH-24 (Felton Ave), 3 mi. SW of Cannon Falls						
STORET/ EQuIS ID:	**S004-512**						
Station #:	**11LM089**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	11	0.0001	0.0079	0.0026	< 0.0400	0
Chloride	mg/L	10	18	33	21	< 230	0
Dissolved Oxygen	mg/L	29	7.73	11.96	8.88	> 5.00	0
pH	SU	29	7.8	8.4	8.1	6.5 - 9.0	0
Transparency tube	100 cm	38	1	> 100	57	> 20	12
E. coli (geometric mean)	MPN/100ml	-	-	-	-	< 126	-
Escherichia coli	MPN/100ml	15	100	29090	2662	< 1260	4
Hardness, carbonate	mg/L	10	188	362	284	-	-
Nitrite-nitrate	mg/L	10	3.76	9.48	5.96	-	-
Kjeldahl nitrogen	mg/L	10	0.37	10.50	1.89	-	-
Phosphorus	µg/L	10	45	415	157	-	-
Specific Conductance	µS/cm	29	274	697	625	-	-
Sulfate	mg/L	10	17.8	32.6	25.9	-	-
Temperature, water	deg °C	29	6.4	25.0	18.4	-	-
Total suspended solids	mg/L	26	3	3580	412	-	-
Total volatile solids	mg/L	10	2	184	27	-	-

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.
[2]Data found in the table above were compiled using the results from data collected at the outlet monitoring station in the Little Cannon River Subwatershed, a component of the IWM work conducted between May and September from 2011 and 2012. These specific data do not necessarily reflect all data that were used to assess the AUID.

Summary of subwatershed water quality

The Little Cannon River is considered a popular fly fishing destination due to the fairly large rainbow and brown trout that can be captured. The MDNR stocks adult rainbow trout and fingerling brown trout to maintain adequate fishing conditions; however, few trout were sampled and natural reproduction appears non-existent or rare. Many stream reaches show high eroding banks and unstable substrates that may be limiting the spawning success of trout (Image 15). Additionally, a few low DO measurements were recorded and current water temperatures are not considered the best for trout to thrive. Five reaches have poor macroinvertebrate communities in this subwatershed. Low water clarity (high turbidity and low transparency), high nutrients, and poor habitat conditions related to severe bank erosion and excess sedimentation were observed at many stations throughout. The Little Cannon River is also impaired for drinking water use due to high nitrates, which may also be a stress to fish and macroinvertebrates. Water samples collected at the outlet of the Little Cannon River show water clarity issues (turbidity and transparency tube) and elevated nutrients (phosphorus and nitrates). Dissolved oxygen during the day was also high (12 mg/L), suggesting that conditions of low DO could be occurring during the nighttime that would be a stress to sensitive fish and macroinvertebrates. The high nutrients and sediment leaving this watershed could also be impacting the Lower Cannon River as well. Stressor Identification is currently underway to determine the cause of the biological impairments, while the low water clarity is being addressed through a TMDL and local implementation plan.

Image 15 : Severely cut banks along outside bend on the Little Cannon River.

Image 16: Redside dace, a special concern species.

The Little Cannon River subwatershed is home to a special concern species, the redside dace (*Clinostomus elongatus*). This colorful minnow was collected at multiple stations throughout the Little Cannon River and tributaries. One of its unique attributes is the upturned mouth (Image 16) that allows this fish to jump out of water to capture flying insects. This species prefers smaller streams with cool, clear water and clean gravel or bedrock substrates (Becker 1983, Eddy and Underhill 1974, Phillips et al. 1982). Due to the presence of this special concern species, additional restoration and protection measures should be considered to maintain and restore sensitive fish habitat and a cool thermal regime.

Stream assessment results

For aquatic recreation, two reaches were assessed and both are impaired due to excess bacteria. Both the Little Cannon River reach (-526) and Butler Creek (-590) were listed in 2010 and these impairments were confirmed by the most recent data set. For aquatic life, six reaches were assessed. Of those, three reaches had TSS and t-tube data to confirm existing turbidity impairments, five reaches had impaired biota including the Little Cannon River and tributaries, and one reach had insufficient information to determine aquatic life use support status. Of the five that have impaired biota, one reach has a new impairment of fish (F-IBI) while five reaches were newly assessed as having impaired macroinvertebrate communities (M-IBI). However, the aquatic life use designations of the Little Cannon River tributaries

(-639 and -670) are being proposed to change from cold water (Class 2A) to warm water (Class 2B) in Minnesota's water quality standards, based on an analysis of the thermal regime and aquatic communities which lack a coldwater assemblage for both fish and macroinvertebrates. Consequently, the M-IBI listings on these two reaches are being deferred until a proposed change in use class can occur. Additional information on individual reaches is included below.

For the coldwater (2A) designated reach of the Little Cannon River (-589) both macroinvertebrate and fish samples collected in 2011 from three monitoring stations resulted in coldwater IBI scores well below the impairment threshold. This AUID was first designated a trout stream in 1946 but removed in 1950, and then redesignated a coldwater stream in 1988. Currently, this section of the Little Cannon River is stocked heavily by the MDNR with catchable rainbow trout and fingerling brown trout for recreational fishing. Temperature logger data and MDNR management notes indicate that the thermal regime and habitat conditions are marginal at best for trout, although many springs in the watershed may provide suitable temperatures in isolated pools for brown trout to carry over. At station 04LM086, both large adult brown and rainbow trout were captured as well as brown trout fingerlings (smallest 7.7 cm) but the number of individuals collected was very low (e.g., 5 brown trout in 2004 and only 2 brown trout in 201). Since the MDNR stock fingerling brown trout, it is probable that the younger age classes were from stocking and not natural reproduction. However, the adult brown trout collected (e.g., 41 cm) suggest that some of the stocked fingerlings experience a sufficient thermal regime (probably in isolated areas near springs or deep pools) to carry over each year to grow to adult size. However, community samples were dominated by cool and warmwater taxa with few coldwater taxa (brown trout and rainbow trout) present; hence, it is considered impaired for a coldwater F-IBI. The fish community included a number of sensitive taxa (e.g., American brook lamprey, fantail darter, redside dace) which may suggest that temperature or habitat quality is limiting, although DO was measured below the 7.0 mg/L standard for coldwater streams which may also be a stressor worth investigating. Images from sampling as well as a Rosgen geomorphology training indicate that the Little Cannon River is experiencing channel instability that may be limiting favorable flow and substrate conditions--especially in the spring-- when many sensitive fish species spawn. Since the stream is downcut, more powerful erosive flows are contained within the channel and can disturb gravel spawning beds and scour away newly deposited eggs, thereby limiting spawning success. Such highly dynamic conditions (e.g., shifting substrate, channel migration) are likely impacting the macroinvertebrate and fish communities of these reaches, although additional analysis is required to determine if channel instability or other stressors are most limiting to the biological communities. Addressing the previously listed (2006) turbidity impairments should lead to improvements in substrate quality, water clarity, and channel stability, as well as the condition of the fish and macroinvertebrate communities that are dependent on the quality of these habitat characteristics. Additional protections should also be considered to maintain the presence of special concern species such as the redside dace and improve conditions for the recreational trout fishery on the Little Cannon River.

A few brown trout were also collected on Butler Creek which is a small warmwater (2B) tributary to the Little Cannon River. This reach has an existing turbidity impairment and was also assessed in 2013 as impaired for warmwater macroinvertebrates (M-IBI). The M-IBI was just above the impairment threshold in 2004 but well below threshold in 2011. Compared to the 2004 macroinvertebrate sample, the 2011 sample exhibited lower total taxa richness, fewer EPT taxa, and a decreased percentage of EPT individuals. Sampling notes and the CCSI indicate that this reach is extremely unstable. The reach has downcut and is overwidened with areas of severe bank erosion observed along the outside bends where the riparian zone is planted in row-crop. Due to the unstable nature of the channel, more recent storm flows in 2012 have exacerbated the already unstable conditions of this stream. Addressing the previously listed (2006) turbidity impairment on Butler Creek and the Little Cannon River should lead to improvements in substrate quality, water clarity, and channel stability as well as the condition of the macroinvertebrate and fish communities.

Watershed plans, projects, and TMDLs

Stressor identification is currently underway to determine the cause of the biological impairments. The turbidity impairments in the Little Cannon River subwatershed are being addressed through the Lower Cannon River Turbidity TMDL and Implementation Plan. These documents can be viewed at: http://www.pca.state.mn.us/index.php/view-document.html?gid=7989 and http://www.pca.state.mn.us/index.php/view-document.html?gid=7991. The bacteria impairment on the Little Cannon River and tributaries are being worked on through the Little Cannon River Watershed E. coli Assessment and Harvestable Buffer Program. A fact sheet on this program can be found on CRWP's website at: http://crwp.net/wp-content/uploads/2013/01/Little-Cannon-River-Watershed-E.coli-Assessment.pdf .

County water quality plans and projects can also be found on the SWCD websites for:

- Rice County - http://www.riceswcd.org/
- Goodhue County - http://www.goodhueswcd.org/#

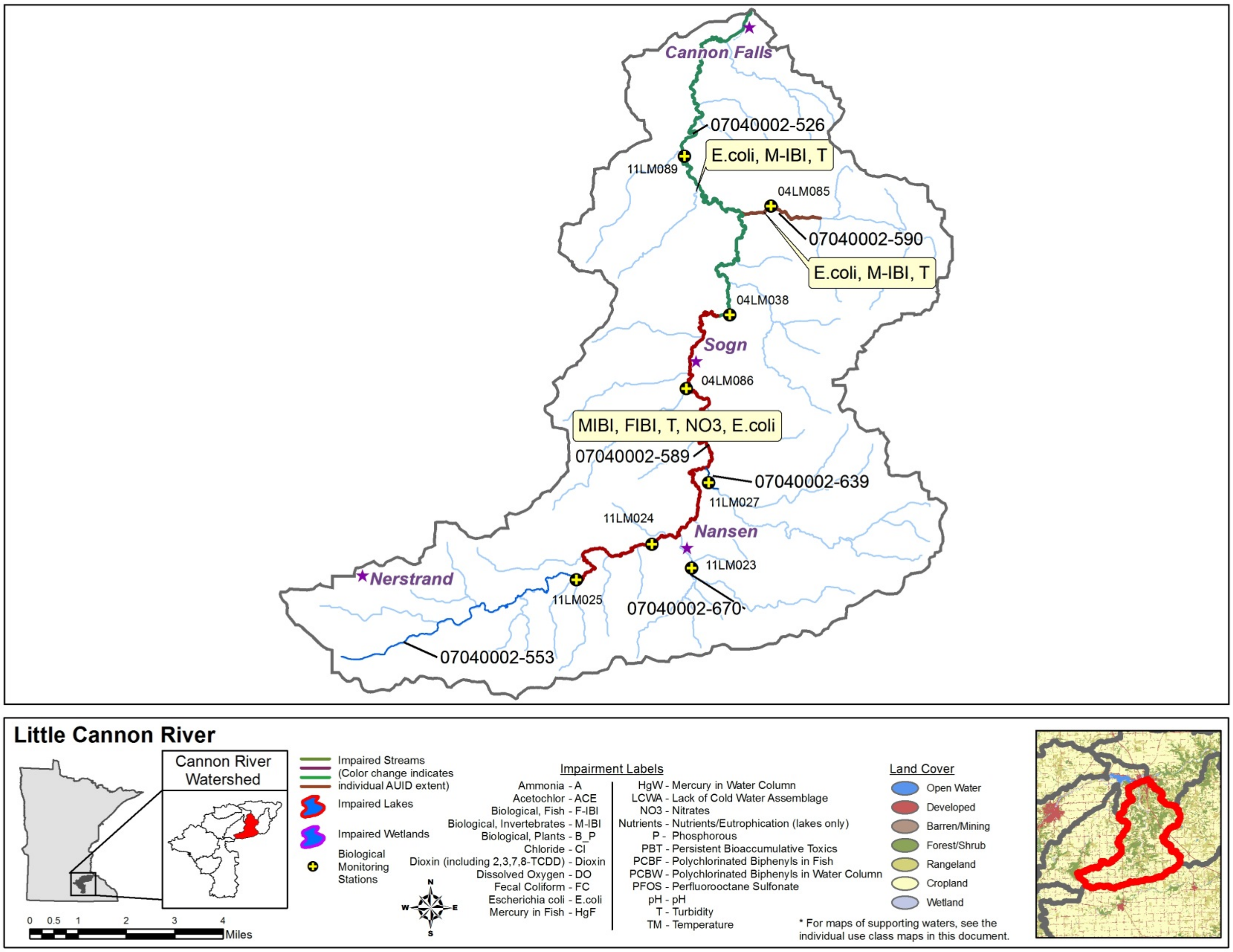

Figure 33. The 2013 Assessed streams with currently listed impaired waters by parameter and land use characteristics (inset) in the Little Cannon River Subwatershed.

Belle Creek Subwatershed HUC 0704000208-01

Located entirely in Goodhue County, there are no major cities within the boundaries of this 78.4 mi^2 subwatershed, although historic townships and villages are scattered throughout. The headwaters of Belle Creek start near Hader. Belle Creek then flows north through White Rock and meanders through the scenic Driftless Area within the Richard J. Dorer Memorial Hardwood State Forest before flowing into the Cannon River two miles southeast of Welch Village. Located in the Driftless Area ecoregion, this subwatershed has a fair amount of forest cover (12%), although the predominant land use is agriculture (83%). The water chemistry outlet station is located adjacent to CSAH-7 (east side) 1.5 miles south of Welch Village (STORET station S002-532, biological station 11LM006). During the 2013 assessment, four stream reaches were assessed to determine a support status for aquatic life and/or recreation use (Table 60). According to the MDNR lake inventory, there are five lake basins >10 acres in size. However, a review of aerial photos shows that all five lake basins are retention ponds in agricultural settings, none of which are assessable with aquatic recreation use support standards developed for lakes.

Table 60. Aquatic life and recreation assessments on stream reaches: Belle Creek Subwatershed.

AUID, Reach Name, Reach Description	Reach Length (miles)	Use Class	Biological Station ID	Location of Biological Station	Aquatic Life Indicators: Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	Aquatic Life	Aquatic Rec.
07040002-721, Unnamed creek, Unnamed cr to Belle Cr	1.2	2B	11LM028	Downstream of CSAH 8 Blvd, 8.5 mi. SE of Cannon Falls	MTS	EXP*	--	--	--	--	--	--	--	IF*	NA
07040002-699, Unnamed creek, Unnamed cr to Belle Cr	0.6	2B	--	--	--	--	IF	MTS	MTS	MTS	MTS	--	EX	IF	NS
07040002-735, Belle Creek, Headwaters to Hwy 19	18.6	2B	11LM026 11LM029 11LM030 04LM090	Upstream of CSAH 8, 6.5 mi. W of Goodhue Upstream of 362nd St, 9 mi. SE of Cannon Falls Upstream of White Rock Tr, 4.5 mi. S of Welch Village Upstream of Hwy 19, 1.5 mi. W of Vasa	MTS	EXP	IF	EXP	--	--	--	--	EX	NS	NS
07040002-734, Belle Creek, Hwy 19 to Cannon R	7.9	2A+	11LM006	Upstream of ATV bridge adjacent to CSAH 7, 1.5 mi. S of Welch Village	EXP†	EXP†	IF	EXP	MTS	MTS	MTS	--	EX	NS	NS

Abbreviations for Indicator Evaluations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **MTS** = Meets criteria; **EXP** = Exceeds criteria, potential impairment; **EXS** = Exceeds criteria, potential severe impairment; **EX** = Exceeds criteria (Bacteria).

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

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

†Reach was assessed based on use class included in table (2A) and existing use class as defined in Minn. Rule 7050 is different (2B). MPCA is currently in the process of changing the existing use class for this AUID in rule based on an analysis of the biological community and temperature data.

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

†Reach was assessed based on use class included in table (2B) and existing use class as defined in Minn. Rule 7050 is different (2A). MPCA is currently in the process of changing the existing use class for this AUID in rule based on an analysis of the biological community and temperature data.

Table 61. Minnesota Stream Habitat Assessment (MSHA): Belle Creek Subwatershed.

# Visits	Biological Station ID	Reach Name	Channel Condition	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	11LM028	Unnamed creek	natural	1.3	2	19.6	12	25	59.9	fair
1	11LM026	Belle Creek	natural	1.3	9.5	16.9	12	26	65.6	fair
1	11LM029	Belle Creek	natural	1.3	7	16.9	11	26	62.2	fair
1	11LM030	Belle Creek	natural	4.5	9	19.9	14	25	72.4	good
2	04LM090	Belle Creek	natural	5	12.3	21.1	12.5	27	77.9	good
1	11LM006	Belle Creek	natural	5	9	21.5	14	25	74.5	good
Average Habitat Results: *Belle Creek Subwatershed*				**3.0**	**8.1**	**19.3**	**12.6**	**25.7**	**68.7**	**good**

Qualitative habitat ratings

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

Table 62. Channel Condition and Stability Assessment (CCSI): Belle Creek Subwatershed.

# Visits	Biological Station ID	Stream Name	Stream Type*	Upper Banks (4-43)	Lower Banks (5-46)	Substrate (3-37)	Channel Evolution (1-11)	CCSI Score (13-137)	CCSI Rating
1	11LM028	Unnamed creek	MHL	33	30	30	7	100	severely unstable
1	11LM026	Belle Creek	MHL	16	15	16	3	50	moderately unstable
1	11LM029	Belle Creek	MHL	26	25	33	11	95	severely unstable
1	11LM030	Belle Creek	MHL	29	21	15	7	72	moderately unstable
1	04LM090	Belle Creek	MHL	15	15	8	3	41	fairly stable
1	11LM006	Belle Creek	MHL	25	19	19	7	70	moderately unstable
Average Stream Stability Results: *Belle Creek Subwatershed*				**24.0**	**20.8**	**20.2**	**6.3**	**71.3**	**moderately unstable**

*See Appendix 9 for descriptions of Stream Types.

Qualitative channel stability ratings

= stable: CCSI < 27 = fairly stable: 27 < CCSI < 45 = moderately unstable: 45 < CCSI < 80 = severely unstable: 80 < CCSI < 115 = extremely unstable: CCSI > 115

Table 63. Outlet water chemistry results: Belle Creek Subwatershed.

Station Location:	**Belle Creek** ; Adjacent to CSAH-7, 1.5 mi S of Welch Village						
STORET/ EQuIS ID:	**S002-532**						
Station #:	**11LM006**						
Parameter	**Units**	**# of Samples**	**Minimum**	**Maximum**	**Mean**	**WQ Standard[1]**	**# of WQ Exceedances[2]**
Ammonia-nitrogen	mg/L	10	0.0000	0.0124	0.0033	< 0.0160	0
Chloride	mg/L	10	21	27	23	< 230	0
Dissolved Oxygen	mg/L	21	7.78	11.63	9.43	> 7.00	0
pH	SU	21	7.4	8.9	8.1	6.5 - 8.5	0
Transparency tube	100 cm	40	1	> 100	51	> 20	14
E. coli (geometric mean)	MPN/100ml	36	240	351	-	< 126	3
Escherichia coli	MPN/100ml	15	20	11533	1412	< 1260	5
Hardness, carbonate	mg/L	10	229	311	275	-	-
Nitrite-nitrate	mg/L	10	0.50	6.45	4.60	-	-
Kjeldahl nitrogen	mg/L	10	0.30	1.85	0.71	-	-
Phosphorus	µg/L	10	13	531	161	-	-
Specific Conductance	µS/cm	21	360	677	574	-	-
Sulfate	mg/L	10	15.0	22.0	18.9	-	-
Temperature, water	deg °C	21	14.2	27.0	19.5	-	-
Total suspended solids	mg/L	26	1	6600	535	-	-
Total volatile solids	mg/L	10	1	32	9	-	-

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.
[2]Data found in the table above were compiled using the results from data collected at the outlet monitoring station in the Belle Creek Subwatershed, a component of the IWM work conducted between May and September from 2011 and 2012. These specific data do not necessarily reflect all data that were used to assess the AUID.

Summary of subwatershed water quality

During the early 1900s, the rolling hills of the Belle Creek Subwatershed were largely denuded of forest cover and the loess soil was plowed for farming. Also active in the watershed were industries and small towns that discharged waste directly into the stream. A cheese factory in the headwaters near Hader led to a pollution investigation by the MDH in 1936. At that time 10,000 gallons/day of whey was being discharged to Belle Creek causing anoxic conditions in the stream rendering downstream areas practically devoid of aquatic life. The memo also comments on additional stress to the stream: "The character of the stream, especially in the lower portion, is such that it has been considered a fine trout stream in years past. Now that the surrounding country is well cultivated and marginal land is grazed extensively, the character of the stream has changed. Erosion of cultivated soil has silted the stream, and grazing has reduced the cover, especially in the upper reaches of the stream. In spite of these changes the stream is still suitable to trout in certain sections, and trout had been planted in the stream for a number of years." Since then, industries have ceased discharging untreated waste to Belle Creek and conservation practices have reduced soil erosion on the steep hills surrounding the lower reach. Today, this lower section of Belle Creek has clean riffles of coarse gravels and deep pools that provide suitable habitat for many sensitive macroinvertebrate and fish species, including trout; habitat in the upper reaches may be still recovering from legacy impacts, evidenced by the silt still in the headwaters of Belle Creek. Additionally, damaging floods in the 1960s propelled locals to find ways to control future flooding and multiple impoundments were placed within the Belle Creek Subwatershed. Today, these impoundments may be limiting to fish that migrate between downstream larger waterbodies to the headwaters in order to spawn.

Since there are no lakes in this subwatershed, water quality impairments are limited to streams. Impairments include high bacteria levels potentially making swimming and wading unsafe on Belle Creek and a tributary. Turbidity and biotic impairments indicate non-support for aquatic life on Belle Creek and tributaries. Fish and macroinvertebrate communities are also showing signs of stress. Habitat quality was rated good to fair with channel instability rated moderately to extremely unstable at most sampling locations. A few high DO measurements (>11 mg/L) were recorded on Belle Creek, which may indicate excess nutrients such as phosphorus are promoting the growth of algae which can cause high DO during the day and low DO during the night, although this should be investigated with additional monitoring. Stressor identification is currently underway to determine the main cause of the biological impairments. TMDLs have been drafted to address the bacteria and turbidity impairments.

A special concern species, the suckermouth minnow (*Phenacobius mirabilis*), was collected in a tributary to Belle Creek. This small insectivore inhabits gravel and cobble riffles and runs of clear to turbid waters from small creeks to large rivers.

The loss of historic wetlands (74%), current land use practices (predominantly agriculture), and the relatively steep topography have resulted in the altered hydrology and erosion problems currently impacting this subwatershed. While these issues may have originated with land management practices in the early 1900s, additional land use pressures continue to maintain the less than optimal habitat and water quality conditions found today. Additional restoration and protection measures may be needed to maintain and improve biological quality that would enhance the fishing and recreational enjoyment of Belle Creek and protect special concern species such as the suckermouth minnow.

Stream assessments

For aquatic recreation, three stream reaches are impaired for elevated bacteria; a tributary to Belle Creek (-699) will be added to the impaired waters list in 2014 and two reaches on Belle Creek. The original 26 mile reach of Belle Creek is being split into two AUIDs to accommodate a proposed use class change; therefore, the existing bacteria impairment for Belle Creek (-527) is being assigned to two newly assigned reaches (-734, -735). For aquatic life, four stream reaches were assessed. Of those, three were assessed as impaired for aquatic life use and one was assessed as "IF" for "insufficient information". The aquatic life impairments include two existing turbidity impairments, one fish impairment, and two macroinvertebrate impairments; however, the biotic impairments are being deferred. Additional information on individual reaches is included below.

The tributary to Belle Creek (-699) received an "IF" since no biological monitoring data were available and not enough early morning DO measurements were available to determine if this reach is fully meeting aquatic life standards.

Unnamed Creek (-721), which is also a tributary to Belle Creek, was assessed as not supporting aquatic life based on macroinvertebrates; however, this impairment is being deferred due to the AUID being >50% channelized and will not be assessed until TALU standards are developed.

Belle Creek is currently designated as a Class 2B warmwater stream according to Minnesota Water Quality Standards (Minn. R. ch. 7050), meaning that for aquatic life it has the expectation of a warm water community. This section of Belle Creek is currently managed with a MDNR special regulation of catch and release only. In the past, this section of Belle Creek was managed by the MDNR as a coldwater trout stream; however, in 1976, due to higher thermal temperatures that were too warm for trout (upper 70F) and excess siltation of coarse spawning gravels from upland farming practices and heavily grazed riparian vegetation, the MDNR discontinued the trout stream designation following a 1975 electofishing survey that did not capture any trout. In recent years, likely in part due to conservation measures to reduce upland erosion and increase riparian cover, brown trout have greatly increased in numbers and natural reproduction appears to be occurring, since fish of various age classes are present and the stream has not been stocked by the MDNR during the last 15 years. Based on recent analysis of the fish community, macroinvertebrate community, and water temperature data, the MPCA is proposing that the aquatic life classification of Belle Creek (below Hwy 19) (-734) should be changed to a cold water (Class 2A) expectation.

Due to the proposed use class change and dividing the former reach into two sections, the previous turbidity listing for Belle Creek (-527) is being given two new reach assignments (-734, -735). Since most of the turbidity data was collected on the downstream reach (-734), additional data collection is recommended to confirm whether the turbidity impairment extends to the upper half of Belle Creek (-735). For biological indicators, IBI scores for both fish and macroinvertebrates were close to the impairment threshold, with the assessment of marginal support for fish and impairment for macroinvertebrates, although a listing is not being pursued at this time.

The macroinvertebrate IBI within the proposed coldwater section of Belle Creek (-734) was sampled twice in 2011. M-IBI scores at station 11LM006 were just above and just below the impairment threshold for the Southern Cold Water Stream IBI class. Cold water macroinvertebrate taxa such as the mayfly *Baetis tricaudatus* and the caddisfly *Brachycentrus occidentalis* were present in the samples. Rather than list aquatic macroinvertebrates as impaired on this stream (necessitating a stressor identification) based on borderline assessment results, the watershed assessment team decided to refrain from listing at this point, with the idea that addressing the existing turbidity impairment would protect (and hopefully improve) Belle Creek's aquatic macroinvertebrate assemblage. Upstream of highway 19, the Belle Creek (-735) is proposed to remain a Class 2B warm water aquatic life stream. This assessment unit would be over 18 miles long. Macroinvertebrate IBI scores were both above and below the impairment threshold at monitoring stations located at the downstream end of this reach as well as near the upper extent of the assessment unit. Given the existing turbidity impairment, the borderline macroinvertebrate IBI results, and the erosion/sedimentation observed at the monitoring stations, the watershed assessment team decided that the focus for the time being should remain on addressing the turbidity (i.e., erosion) issues in this subwatershed. High nitrates may also be an additional stress to the aquatic community.

Except for one sample from 2004 at biological station 04LM090, all other fish collections on Belle Creek and tributaries were from 2011. Fish communities at all stations sampled were well above the threshold of impairment. Many brown trout (Image 17) and other game fish (e.g., walleye, smallmouth bass, largemouth bass, freshwater drum, black crappie) and sensitive species (fantail darter, logperch, northern hogsucker, hornyhead chub) were sampled at stations near the lower reach of Belle Creek (e.g., 11LM006, 04LM090) while numbers in samples in the upper reach (11LM030, 11LM029) had fewer brown trout and sensitive species. However, channel stability was rated moderately to severely unstable at many reaches along Belle Creek and tributaries, although conditions appear to be more stable at station 04LM090. Lateral riffles were observed at station 11LM0006 which suggest an incised stream in the process of channel migration and may explain the shifting substrates and highly eroded banks observed (Image 18). The high flows in 2011 eroded away banks and destabilized a newly constructed ATV bridge.

Minnesota Department of Natural Resources (MDNR) records indicate that the lower reach of Belle Creek has a naturally reproducing population of brown trout and that this reach has not been stocked with trout by the MDNR in over 15 years. During 2011, 59 brown trout of various age classes (76 to 521 mm) were captured during fish sampling at station 11LM006; however, no young-of-year or fingerling sized trout were collected in the samples. This may mean that potentially the younger age classes avoided capture or that water quality or flow conditions have not been favorable for brown trout reproduction during recent years—especially during the high flows of fall 2010 during the time of year when brown trout spawn. Since Belle Creek appears to be incised, higher flows will be contained and more erosive currents have the ability to scour away gravel substrates. If the erosive flows are timed during the spawning and incubation period, that year's recruitment can fail. While the F-IBI scores do not currently indicate impairment, the unstable habitat conditions and possibly check dams placed throughout the watershed may be a potential stress to the fish community that could eventually lead to an impairment. The turbidity listing and TMDL plan should target watershed and local restoration projects that aim to reduce erosive stream power and regrade/restabilize the stream banks to regain some floodplain connectivity.

Image 17: an adult brown trout collected on Belle Creek by MPCA in 2011.

Image 18: Lateral riffle deflecting flow into the outer bank by new ATV bridge on Belle Creek. Image taken on August 4, 2011 before large storm event and high flows caused more severe bank erosion in fall 2011 and 2012.

Watershed plans, projects, and TMDL

Stressor identification is currently underway to determine the cause of the poor macroinvertebrate conditions. Turbidity impairments are being addressed through the Lower Cannon River Turbidity TMDL and Implementation Plan. These documents can be viewed at: http://www.pca.state.mn.us/index.php/view-document.html?gid=7989 and http://www.pca.state.mn.us/index.php/view-document.html?gid=7991. The Goodhue County water quality plans and projects can also be found on the SWCD website: http://www.goodhueswcd.org/#. Belle Creek also has a watershed district that manages the dams in this subwatershed: http://www.goodhueswcd.org/#!belle-creek-watershed-district/cot2

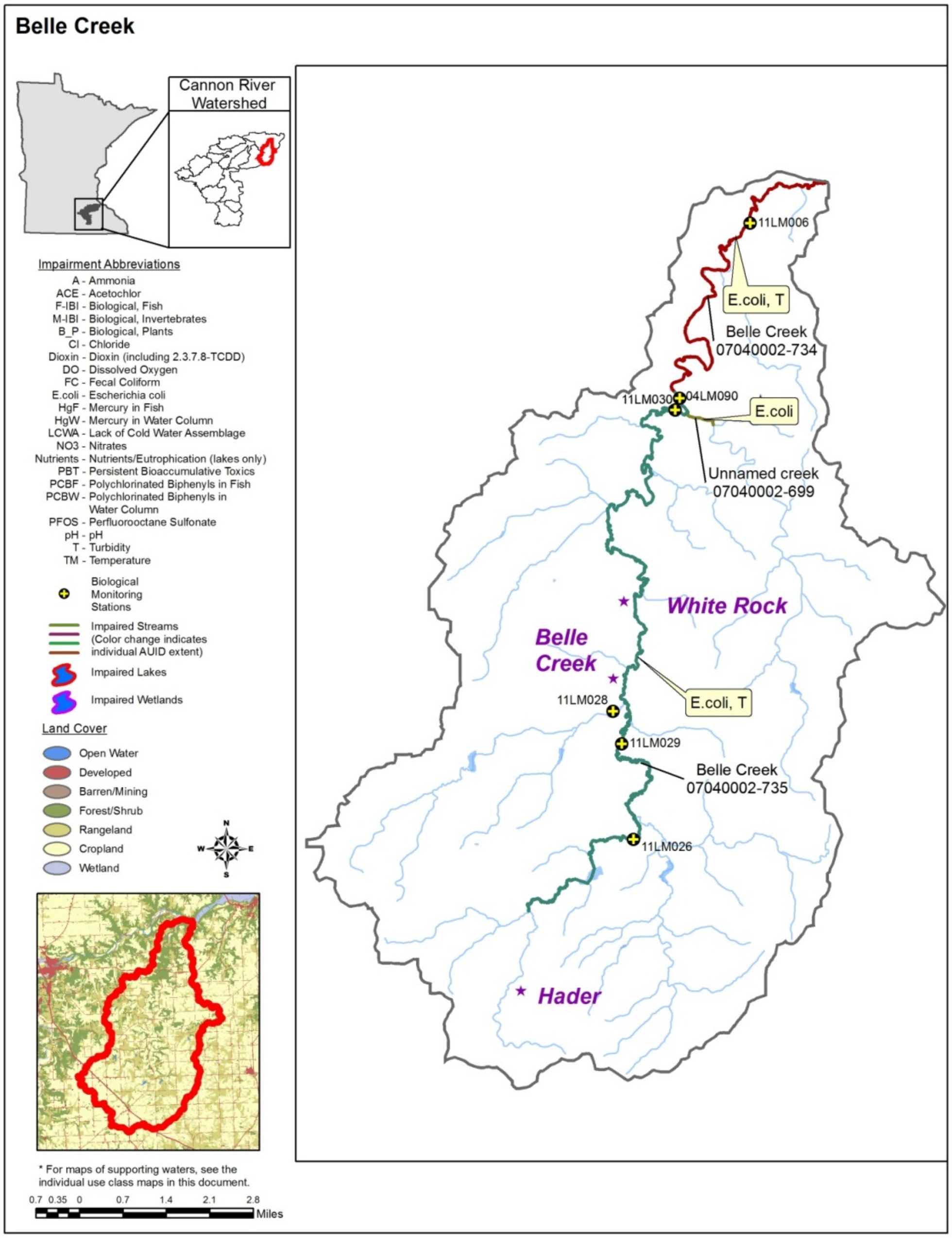

Figure 34. The 2013 assessed stream reaches with impairments and land use characteristics (inset) in the Belle Creek Subwatershed.

Lower Cannon River Subwatershed HUC 0704000209-01

The Lower Cannon River Subwatershed is nested east of Cannon Falls and west of Red Wing and encompasses the Cannon River between the Byllesby Reservoir and the Mississippi River. The southeastern most area of the watershed is drained by Spring Creek which also empties into the Mississippi River upstream of Red Wing. Split between Dakota and Goodhue Counties, this 140 mi^2 subwatershed is well known for its prized trout fishing streams that are in close proximity to the Twin Cities, as well as excellent game fishing and recreational opportunities including canoeing and tubing along the Cannon River at Welch Village and hiking and skiing in parks. Miesville Ravine Park Preserve maintains ~1600 acres of biologically diverse land and beautiful spring fed streams such as Trout Brook. Other trout fishing destinations include Pine Creek and Spring Creek within the Richard Dorer Memorial Hardwood State Forest. The northwestern region of the subwatershed, including most of the area in Dakota County, is located in the WCBP ecoregion, while the central and eastern regions are located in the Driftless Area ecoregion. With a mix of agricultural land in the uplands and hardwood forests in the valleys of the Driftless Area, almost 25% of the land is undeveloped as forest (18.6%), wetland (4.3%), and open water (1.2%), with the rest in cropland (55%) and range land (15%). The water chemistry outlet station on the Cannon River is located on an abandoned road bridge downstream of Hwy-61, just north of Redwing (STORET station S001-766, biological stations 11LM098 and 02LM017). For aquatic life and aquatic recreation, nine stream reaches were assessed (Table 67). There are no lakes basins >10 acres in size so no lakes were assessed.

Table 64. Aquatic life and recreation assessments on stream reaches: Lower Cannon River Subwatershed.

AUID, Reach Name, Reach Description	**Reach Length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Aquatic Life Indicators:** Fish IBI	Invert IBI	Dissolved Oxygen	Turbidity	Chloride	pH	NH_3	Pesticides	Bacteria	**Aquatic Life**	**Aquatic Rec.**
07040002-520, Pine Creek, T113 R18W S26, west line to Cannon R	6.0	1B, 2A	04LM004** 07LM018** 99LM002	Upstream of 280th St, 1.5 mi. N of Cannon Falls Upstream of CR 20, 2 mi. N of Cannon Falls Upstream of County 17 Blvd, 2.5. mi. NE of Cannon Falls	MTS	MTS	EXS*	MTS	--	MTS	MTS	MTS	IF	IF*	IF
07040002-580, Unnamed creek (Trib to Trout Brook), Unnamed cr to Unnamed cr	0.5	1B, 2A	99LM005	Upstream of CSAH 19 (Miesville Tr), 2.5 mi. SW of Miesville	MTS	EXP	EXS	MTS	--	MTS	MTS	--	IF	NS	IF
07040002-573, Unnamed creek (Trout Brook), T113 R17W S27, west line to Unnamed cr	1.6	1B, 2A	04LM144	Upstream of CR 91, 6 mi. NE of Cannon Falls	MTS	EXS	IF	MTS	--	MTS	MTS	--	IF	NS	IF
07040002-567, Unnamed creek (Trout Brook), Unnamed cr to Cannon R (trout stream portion)	3.0	1B, 2A	99LM001	Upstream of 280th St E (Orlando Tr), in Dakota County Park, 4 mi. S of Miesville	MTS	MTS	IF	MTS	--	MTS	MTS	MTS	IF	FS	IF
07040002-569, Spring Creek, T112 R15W S18, west line to T113 R15W S34, north line	8.9	1B, 2A	11LM014 04LM037	Upstream of Peaceful Ridge Rd, 6 mi. E of Welch. Downstream of CR 6, 5 mi. WSW of Red Wing	MTS	MTS	IF	EXS	MTS	MTS	MTS	--	EX	NS	NS

07040002-571, Spring Creek, T113 R15W S27, south line to Spring Creek Lk	3.5	2B	11LM015	Downstream of Industrial Park Rd (Tyler Rd N), in Redwing	MTS	MTS	--	EXP	--	--	--	--	--	NS	NA
07040002-502, Cannon River, Pine Cr to Belle Cr	11.5	2B	04LM055 11LM090 10EM175	Adjacent to Sunset Trail, 4 mi. E of Cannon Falls Upstream of CSAH 7, in Welch. 0.25 mi. downstream of CSAH 7, 8 mi. NE of Cannon Falls	MTS	MTS	IF	EXP	MTS	MTS	MTS	MTS	EX	NS	NS
07040002-501, Cannon River, Belle Cr to split near mouth	8.6	2B	11LM098 02LM017	Downstream of Hwy 61, 1 mi. N of Redwing 0.3 mi. downstream of Hwy 61, 1 mi. N of Redwing	MTS	MTS	IF	EXP	MTS	MTS	MTS	--	EX	FS	NS
07040002-646, Cannon River, North branch of split to Vermillion R	1.7	2B	--	--	--	--	IF	EXP	--	--	--	--	--	NS	NA

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

Table 65. Non-assessed biological stations on channelized reaches or AUIDs: Lower Cannon River Subwatershed.

AUID, Reach Name, Reach Description	**Reach length (miles)**	**Use Class**	**Biological Station ID**	**Location of Biological Station**	**Fish IBI**	**Invert IBI**
07040002-520, Pine Creek, T113 R18W S26, west line to Cannon R	6.0	1B, 2A	04LM004 07LM018	Upstream of 280th St, 1.5 mi. N of Cannon Falls Upstream of CR 20, 2 mi. N of Cannon Falls	good (2)	fair

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

Parentheses behind ratings indicate the quantity of site visits when >1, which may or may not occur in the same year.

Table 66. Minnesota Stream Habitat Assessment (MSHA): Lower Cannon River Subwatershed.

# Visits	Biological Station ID	Reach Name	Channel Condition	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	04LM004	Pine Creek	channelized	0	6	16	11	10	43	poor
1	07LM018	Pine Creek	channelized	0	13	18	14	27	72	good
1	99LM002	Pine Creek	natural	2.5	14.5	18.2	10	29	74.2	good
1	99LM005	Unnamed creek (Trib. to Trout Brook)	natural	2.5	14.5	21.2	13	28	79.2	good
3	04LM144	Unnamed creek (Trout Brook)	natural	4.2	13.7	19.1	11.3	25.7	73.9	good
2	99LM001	Unnamed creek (Trout Brook)	natural	2.9	13	18.2	14.5	32	80.6	good
1	11LM014	Spring Creek	natural	4.3	11.5	17.6	7	24	64.4	fair
1	04LM037	Spring Creek	natural	2.5	12.5	6.15	3	16	40.2	poor
1	11LM015	Spring Creek	natural	1.3	13	19.1	11	35	79.3	good
2	04LM055	Cannon River	natural	2.5	9.5	21.9	8.5	23.5	65.9	fair
1	11LM090	Cannon River	natural	2.5	8.5	22	10	29	72	good
1	10EM175	Cannon River	natural	3	11	20.8	8	30	72.8	good
1	11LM098	Cannon River	natural	5	9	19.4	13	24	70.4	good
0	02LM017	Cannon River	natural	--	--	--	--	--	--	--
Average Habitat Results: *Lower Cannon River Subwatershed*				**2.5**	**11.5**	**18.3**	**10.3**	**25.6**	**68.3**	**good**

Qualitative habitat ratings

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

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

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

Table 67. Channel Condition and Stability Assessment (CCSI): Lower Cannon River Subwatershed.

# Visits	Biological Station ID	Stream Name	Stream Type*	Upper Banks (4-43)	Lower Banks (5-46)	Substrate (3-37)	Channel Evolution (1-11)	CCSI Score (13-137)	CCSI Rating
0	04LM004	Pine Creek	--	--	--	--	--	--	--
0	07LM018	Pine Creek	--	--	--	--	--	--	--
1	99LM002	Pine Creek	HBC	14	11	12	3	40	fairly stable
1	99LM005	Unnamed creek (Trib. to Trout Brook)	MHL	12	7	6	3	28	fairly stable
1	04LM144	Unnamed creek (Trout Brook)	MHL	14	15	16	6	51	moderately unstable
1	99LM001	Unnamed creek (Trout Brook)	MHL	17	22	22	5	66	moderately unstable
1	11LM014	Spring Creek	HBC	11	11	8	3	33	fairly stable
0	04LM037	Spring Creek	--	--	--	--	--	--	--
1	11LM015	Spring Creek	MHL	23	22	19	7	71	moderately unstable
1	04LM055	Cannon River	MHL	16	11	10	3	40	fairly stable
1	11LM090	Cannon River	MHL	16	17	13	3	49	moderately unstable
1	10EM175	Cannon River	MHL	5	10	7	3	25	stable
0	11LM098	Cannon River	--	--	--	--	--	--	--
1	02LM017	Cannon River	MHL	15	18	22	7	62	moderately unstable
Average Stream Stability Results: *Lower Cannon River Subwatershed*				**14.3**	**14.4**	**13.5**	**4.3**	**46.5**	**moderately unstable**

*See Appendix 9 for stream types.

Qualitative channel stability ratings

= stable: CCSI < 27 = fairly stable: 27 < CCSI < 45 = moderately unstable: 45 < CCSI < 80 = severely unstable: 80 < CCSI < 115 = extremely unstable: CCSI > 115

Table 68. Outlet water chemistry results: Lower Cannon River Subwatershed.

Station Location:	**Cannon River** ; Downstream of Hwy 61, 5 mi E of Welch Village
STORET/ EQuIS ID:	**S001-766**
Station #:	**02LM017**

Parameter	Units	# of Samples	Minimum	Maximum	Mean	WQ Standard[1]	# of WQ Exceedances[2]
Ammonia-nitrogen	mg/L	11	0.0001	0.0045	0.0026	< 0.0400	0
Chloride	mg/L	10	17	30	24	< 230	0
Dissolved Oxygen	mg/L	7	6.89	9.00	7.90	> 5.00	0
pH	SU	7	7.8	8.2	8.0	6.5 - 9.0	0
Transparency tube	100 cm	7	5	96	40	> 20	2
E. coli (geometric mean)	MPN/100ml	41	95	242	-	< 126	2
Escherichia coli	MPN/100ml	15	31	10860	1488	< 1260	4
Hardness, carbonate	mg/L	10	219	274	247	-	-
Nitrite-nitrate	mg/L	10	3.07	7.24	4.51	-	-
Kjeldahl nitrogen	mg/L	10	0.62	2.10	1.03	-	-
Phosphorus	µg/L	10	72	938	223	-	-
Specific Conductance	µS/cm	7	336	631	512	-	-
Sulfate	mg/L	10	16.1	30.3	24.6	-	-
Temperature, water	deg °C	7	17.3	26.0	22.3	-	-
Total suspended solids	mg/L	10	8	688	103	-	-
Total volatile solids	mg/L	10	3	92	17	-	-

[1]Secchi Tube/Transparency tube standards are surrogate standards derived from the turbidity standard of 25.
[2]Data found in the table above were compiled using the results from data collected at the outlet monitoring station in the Lower Cannon River Subwatershed, a component of the IWM work conducted between May and September from 2011 and 2012. These specific data do not necessarily reflect all data that were used to assess the AUID.

Summary of subwatershed water quality

Located in the Driftless Area, streams within the Lower Cannon River Subwatershed are scenic and enjoyable and provide many recreational opportunities. This subwatershed contains three trout streams (Trout Brook, Pine Creek, and Spring Creek) with catchable brook and brown trout, while the Cannon River supports aquatic life including a high diversity of sensitive macroinvertebrates and fish—including game fish such as smallmouth bass, walleye, channel catfish, flathead catfish, white bass, and freshwater drum. However, past and present land use is degrading the water quality throughout the subwatershed. The Cannon River is not supporting aquatic recreation due to high levels of bacteria that may make swimming, wading, and canoeing unsafe, as well as not supporting aquatic consumption due to elevated PCBs in fish tissue. Two tributaries to Trout Brook are impaired due to a lack of sensitive macroinvertebrates. High nitrates on Pine Creek and Trout Brook are higher than acceptable for drinking water, but are currently meeting standards on Spring Creek. Other streams also have high nitrates, which may indicate that nitrate levels are potentially high in groundwater used for drinking. High nitrates observed in streams may be a stress to pollution sensitive fish and macroinvertebrates. Water clarity (turbidity) impairments are spread throughout, indicating that too much sediment is moving through the system which may impact habitat quality and potentially carry excess phosphorus that fuels the growth of algae. This could cause daily highs and lows in DO that could be a stress to sensitive fish and macroinvertebrates—as well as mussels and other aquatic life. High nutrients such as phosphorus and nitrates leaving this subwatershed indicate the nutrient loading of the entire Cannon Watershed. Poor water quality conditions leaving the Cannon River Watershed may be contributing to poor water quality conditions downstream on Lake Pepin and further downstream on the Mississippi River to the Gulf of Mexico.

Stream assessments

For aquatic consumption, the Cannon River--from Byllesby Dam to the Mississippi River--was placed on the impaired waters list in 2012 due to PCBs in fish tissue. For aquatic recreation, three stream reaches were assessed as impaired due to high bacteria levels, while four reaches had insufficient data. Of the three impaired reaches, two reaches are on the Cannon River between Pine Creek and Belle Creek, east of Cannon Falls, while the other reach is on Spring Creek, east of Welch. The four other reaches did not have enough samples collected in the summer months to calculate the geometric mean used as one of the standards. At these same stations, a few high values were observed which seemed to correspond with large rain events; the geometric mean is used to determine whether or not there is a chronic issue with a range of flow conditions. For aquatic life, nine stream reaches were assessed in 2013. Of those, two reaches were assessed as fully supporting and seven reaches on streams throughout the watershed are not supporting; however, the DO impairment on Pine Creek (-520) will be deferred due to the AUID being >50% channelized. Of those that are impaired, two coldwater (2A) reaches (Trout Brook and Tributary to Trout Brook) were newly assessed as having impaired macroinvertebrates. Trout Brook and Pine Creek are impaired for drinking water use due to high nitrates (standard >10 mg/L), while nitrate levels on Spring Creek are not exceeding the drinking water standard. In addition, five stream reaches throughout the watershed were previously assessed as impaired due to turbidity and current data confirms the impairment listings on four of those, while newer data suggests that one reach that is currently listed for turbidity (Trout Brook) appears to be meeting the standard and a delisting could be proposed if supported with additional data. Additional information on individual stream reaches is included below.

Trout Brook, as the name implies, is a coldwater (2A) stream located in the Miesville Ravine Park Preserve. This reach was listed as impaired for drinking water use in 2010 (high nitrates) and aquatic life use in 2006 (turbidity) and 2013 (M-IBI). High nitrate concentrations (>10 mg/L) were consistently observed during both stormflow and baseflow conditions. During three biological visits at station 04LM144 in 2004 and 2011, nitrates ranged from 13 to 19 mg/L, although, during sampling at a station

(99LM005) on an adjacent tributary, nitrates were slightly lower at 11 mg/L. This difference in nitrate concentrations in these two branches of Trout Brook is puzzling. Biological monitoring data collected from both stations on the western branch (04LM144) and eastern branch (99LM005) yielded M-IBI scores below the impairment threshold for southern coldwater streams. While both branches of Trout Brook have extremely high nitrate concentrations, the eastern branch is showing signs of eutrophication (i.e., dense filamentous algae, Image 19) to a much greater extent than the western branch. This is likely due to the relatively sparse forest canopy along the eastern branch's riparian corridor allowing more sunlight to reach the water's surface. Recent flooding in 2012 has further degraded the riparian canopy (Image 20). Both of these upper stream reaches had significantly fewer mayfly and caddisfly species collected compared to the station further downstream (99LM001) where the M-IBI score was above the impairment threshold. Since nitrate concentrations are equally high in the unimpaired downstream reach, it appears that macroinvertebrate impairments in the upper reaches are not exclusively due to the toxic effects of this pollutant. This reach on Trout Brook was also listed due to turbidity in 2006 although more recent data suggest that this stream is now meeting the standard; however, additional data are needed with which to propose a delisting for turbidity.

Image 19 : Dense algae in 2011 at station 99LM005 (tributary to Trout Brook).

Image 20: Station 99LM005 after severe flooding in 2012.

In contrast, the F-IBI scores on Trout Brook and tributaries were all well above the threshold of impairment; communities were comprised of high numbers of pollution sensitive brook trout at the headwater stations (99LM005, 04LM144) and a combination of brook trout and brown trout with a few other coolwater species at the lower station (99LM001). Habitat quality at all three stations was rated good while channel stability varied from fairly stable at 99LM005 to moderately unstable at the other two stations. The biological station 99LM005 is located on a small tributary with large fractured rocks of sandstone/limestone in the reach, while the other two reaches are mostly sand and gravel dominated, making them more susceptible to channel adjustment. Some degree of channel instability was also noted at these stations indicting that these streams may still experience additional bank erosion and substrate movement during high flows. Although channel instability was observed, the present habitat quality was good with many deep pools and unembedded gravel in riffles. However, it is not known whether or not the large flood during the late fall of 2010 may have disturbed the spawning beds of trout and limited the presence of a new young-of-year age class. While not having impaired fish communities, additional protection and restoration strategies instream and in the watershed may help to maintain this popular and beautiful recreational trout fishery.

Pine Creek (-520) is a coldwater trout stream north of Cannon Falls. This 6.0 mile stream reach was assessed as impaired due to low DO; however, the impairment is being deferred until TALU criteria are developed because the reach is channelized in the upstream section. Habitat varies between the upstream and downstream sections. In the headwaters, the stream is low-gradient and substrate is dominated by sand; whereas, in the lower reaches, where the stream flows through the Richard J. Memorial Hardwood State Forest, the stream is high gradient and the substrate is dominated by bedrock and cobble. Dissolved oxygen measurements fell below the threshold (7.0 mg/L for 2A) in the low-gradient headwaters. Surprisingly, although the upper reach on Pine Creek is channelized and the substrate is dominated by sand, a fair number of brown trout of various age classes were collected at both upstream stations. At station 04LM004, sampled in 2004, 47 brown trout were collected, ranging in size from 2.5 to 18.5 inches. At station 07LM017 sampled in 2007, 93 brown trout were collected, ranging from 3.5 to 11 inches. At the lower station (99LM002) sampled in 2011, 183 brown trout of various age classes(3 in. to 13.5 in.) were collected. It is possible that trout are migrating up and down Pine Creek, using spawning habitat where found during spring while foraging all along Pine Creek at other times of the year. Nitrates were high at all stations (~10 mg/L) along Pine Creek indicating a potential nutrient issue. The remarkable number of brown trout captured demonstrates that Pine Creek --from the headwaters to the mouth—should be considered for restoration and protection measures to address the low DO and high nitrate conditions.

Spring Creek is a small tributary stream to the Cannon River located west of Red Wing. The headwater reach (-569) of Spring Creek is classified as coldwater (2A); whereas, the lower reach (-571) is classified as warmwater (2B). While both reaches were assessed as supporting aquatic life for fish, the 2004 visit at 04LM037 captured <25 fish. Notes from sampling suggested that the low fish catch (only 9 brown trout) was impairment related and not due to sampling issues. From site photos, the stream appears to have a good riparian zone, but is overwidened and shallow throughout much of the reach; habitat quality was rated poor with cover nearly absent and clay and silt the dominant substrates. Nitrogen was moderately high 5.4 mg/L. One additional station on this coldwater AUID was sampled in 2011 (11LM011) and 60 brown trout and a few other cool and warmwater species were collected (e.g., northern pike, creek chub, white sucker, Johnny darter). Habitat quality was fair with some channel stability issues and lack of cover indicated; substrate is cobble, gravel and sand. Nitrogen was also moderately high (6.8 mg/L). Without additional information, the assessment team inferred that the few brown trout collected in 2004 may have been related to the nature of the clay substrate and almost non-existent pool habitat, and considered the 2011 data more representative of the current state of a majority of the AUID, and so assessed this coldwater reach as supporting fish communities. For the lower warmwater reach, brown trout were also collected along with other coolwater/warmwater species (e.g., northern pike, largemouth bass, central mudminnow, yellow bullhead, Johnny darter). While adult brown trout were collected, no young-of-year age classes were sampled. Discussion with DNR staff and management reports indicate that the water temperature is warmer in the lower reach making it marginal for trout, and so this location is not considered for trout management. This reach also flows into the floodplain of the Mississippi River, and hence is likely to experience backwater flooding. Temploggers were placed in both sections during 2011 and 2012 but were lost both years due to flooding. Nitrogen was moderately high (5.7 mg/L) on this warmwater reach as well. The flood in 2012 also severely altered the habitat on Spring Creek at the upstream stations. Although not assessed as impaired, Spring Creek should be considered in the Watershed Restoration and Protection Strategy (WRAPS) for measures to address the habitat quality and high nitrate issues.

Macroinvertebrate and fish IBI scores indicate that the lower reaches of the Cannon River (-501 and -502) are fully supporting aquatic life. All scores from 2010 and 2011 meet the biocriteria; although, a turbidity impairment exists on (-502) and current data support the listing. The fish community on the lower Cannon River is comprised of a number of game fish (e.g., walleye, smallmouth bass, flathead catfish, freshwater drum, and white bass) and pollution sensitive species (e.g., northern hogsucker, logperch, banded darter, and stonecat). The dam on the Cannon River at Welch was removed in 1994. The presence of flathead catfish collected at station 10EM075 on the Cannon River upstream of Welch (Image 21) is one indicator that active fish migration is indeed occurring on the Cannon River upstream of the old dam site. According to the MDNR (Carlson et al. 2004), additional species are being reportedly found upstream of the former dam site that had not been seen in decades (e.g., muskellunge, bowfin, longnose gar, mooneye, and gizzard shad).

Image 21: Flathead catfish collected on the Cannon River upstream of Welch.

Watershed plans, projects, and TMDLs

Stressor identification is currently underway to determine the cause(s) of biological impairments. The turbidity impairments on Pine Creek, Trout Brook, and Spring Creek are being addressed through the Lower Cannon River Turbidity TMDL and Implementation Plan. These documents can be viewed at: http://www.pca.state.mn.us/index.php/view-document.html?gid=7989 and http://www.pca.state.mn.us/index.php/view-document.html?gid=7991 . Sources of the high nitrates in trout streams are being investigated by staff at the University of Minnesota and Minnesota Geological Survey. The bacteria impairment on the Cannon River is being addressed through the Lower Mississippi River Basin— Regional Fecal Coliform TMDL http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/lower-mississippi-river-basin-tmdl/project-lower-mississippi-river-basin-regional-fecal-coliform.html.

County water quality plans and projects can be found at the SWCD websites:

- Dakota - http://www.dakotaswcd.org/
- Goodhue - http://www.goodhueswcd.org/

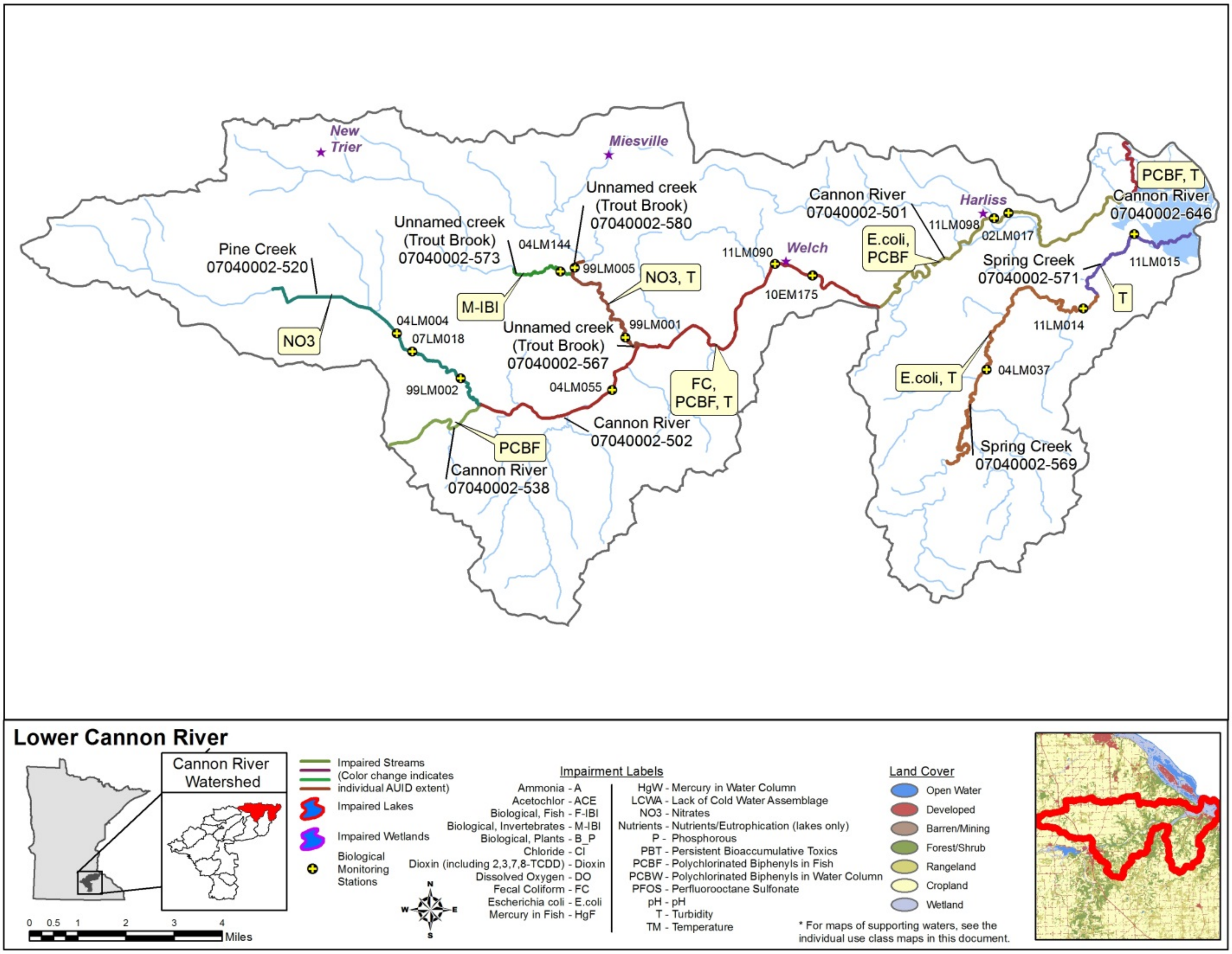

Figure 35. The 2013 assessed stream reaches with impairments and land use characteristics (inset) in the Lower Cannon River Subwatershed.

VI. Watershed-wide results and discussion

Assessment results and data summaries are included below for the entire HUC-8 watershed unit of the Cannon River, grouped by sample type. Summaries are provided for load monitoring data results near the mouth of the river, aquatic life and recreation uses in streams and lakes throughout the watershed, and for aquatic consumption results at select river and lake locations along the watershed. Additionally, groundwater monitoring results and long-term monitoring trends are included where applicable.

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

Pollutant load monitoring

Many years of water quality data from throughout Minnesota combined with the previous analysis of Minnesota's ecoregion patterns have resulted in the development of three "River Nutrient Regions" (RNR), each with unique nutrient standards (MPCA 2008b). Of the state's three RNRs (North, Central, South), the Cannon River's monitoring station is located within the Central RNR and the Straight River is within the South RNR.

Annual flow weighed mean concentrations (FWMCs) were calculated and compared for years 2008 through 2011 (Figures 36 to 39) and compared to RNR "draft" standards (only TP and TSS draft standards are available at the time of this report for the RNR). It should be noted that while a FWMC exceeding given water quality standard is generally a good indicator that the water body is out of compliance with the RNR standard, the rule does not always hold true. Waters of the state are listed as impaired based on the percentage of individual samples exceeding the numeric standard, generally 10% and greater, over the most recent 10-year period and not based on comparisons with FWMCs (MPCA, 2012). A river with a FWMC above a water quality standard, for example, would not be listed as impaired if less than 10% the individual samples collected over the assessment period were above the standard.

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

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

Total suspended solids

Water clarity refers to the transparency of water. Turbidity is a measure of the lack of transparency or "cloudiness" of water due to the presence of suspended and colloidal materials such as clay, silt, finely divided organic and inorganic matter, and plankton or other microscopic organisms. By definition, turbidity is caused primarily by suspension of particles that are smaller than one micron in diameter in the water column.

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

During the monitoring period for this watershed report, Minnesota's TSS standards were considered draft standards. Within the South and Central RNRs, a river would be considered impaired when greater than 10% of individual samples exceed the TSS draft standard of 65 mg/L and 30mg/L respectively (MPCA 2011). At the Cannon River near Welch, samples exceeded the Central RNR draft standard (30 mg/L) 26% to 45% of the time between 2008 and2012. The Straight River near Faribault exceeded the South RNR draft standard (65 mg/L) 12% to 18% of the time during the same time period. Interestingly, the computed Straight River FWMCs did not exceed the 65 mg/L draft standard as shown in Figure 34, which suggests periods of elevated flow carried less sediment per unit volume. The Cannon River, on the other hand, had FWMCs that exceeded the 35 mg/L (Central) draft standard three of the four years monitored (Figure 36).

A review of Tables 69 and 70 also show Cannon River TSS loads as consistently higher than those measured in the Straight. If between-year differences in FWMCs are insignificant, annual difference in pollutant loads can be attributed to the differences in annual runoff volume. On the other hand, if annual runoff volumes are similar, between-years differences in annual pollutant loads can be attributed to differences in annual FWMCs (water quality). Figures 17 and 18 show runoff volumes during 2008 and 2009 of approximately 50% and 25% of volumes measured in 2010 and 2011 for both the Cannon and Straight Rivers. In 2010, the majority of the annual TSS load is assumed to be from a late September high flow event during which the highest daily flow volumes as well as the highest TSS concentrations occurred. Concentrations were estimated to be as high as 1,050 mg/L and believed to have carried a significant portion of the TSS load for that year. Figure 34 shows a similar trend with 2008 and 2009 TSS FWMCs for both the Straight and Cannon much lower than those recorded in 2010 and 2011. As a result, between-year differences in measured TSS loads can be attributed to both differences in annual flow volume, and between-year differences in water quality (TSS FWMCs).

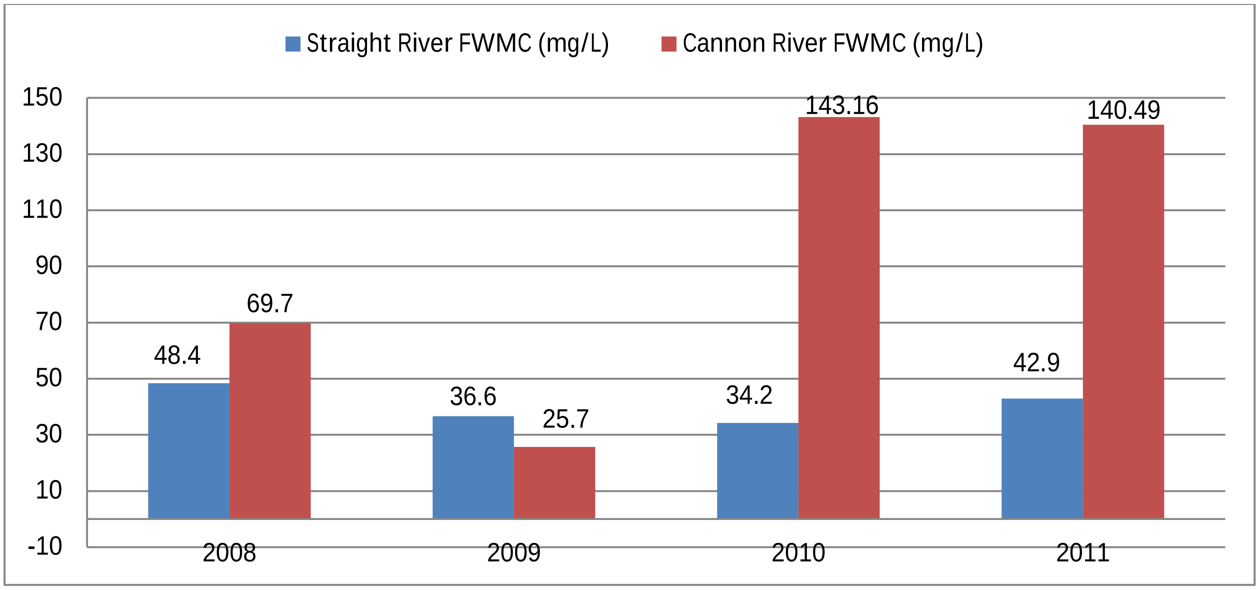

Figure 36. Total Suspended Solids (TSS) flow weighted mean concentrations for the Straight and Cannon Rivers.

Total phosphorus

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

Total phosphorus standards for Minnesota's rivers are also considered "draft" until approved. Total phosphorous draft standards of 0.10 mg/L and 0.15 mg/L, as a summer average, have been proposed for the Central RNR and South RNR respectively. Summer average violations of one or more "response" variables (pH, biological oxygen demand, DO flux, chlorophyll-a) must also occur along with the numeric TP violation for the water to be listed. In comparison of the summer data collected at the Cannon River near Welch between 2008 and 2011, TP exceedences occurred over 80% of the time with concentration estimates reaching 0.933 mg/L during the September 2010 high flow event. During the same time period (2008-2011), the Straight River near Faribault monitoring location had only one summer sample that did not exceed the 0.15 mg/L (South) draft standard. Figure 37 illustrates FWMCs greater than the draft standard; this includes all data throughout the year (not just summer values).

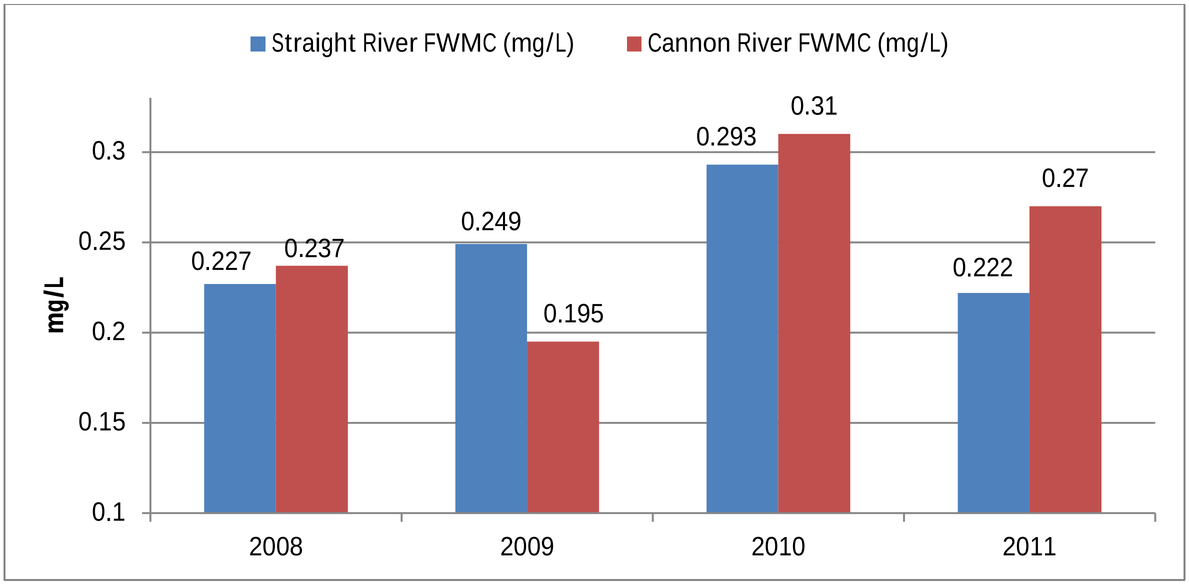

Figure 37. Total Phosphorus (TP) flow weighted mean concentrations for the Straight River and Cannon Rivers.

Dissolved orthophosphate

Dissolved orthophosphate is a water soluble form of phosphorus that is readily available for plant uptake (MPCA and MSUM, 2009). While orthophosphates occur naturally in the environment, river and stream concentrations may become elevated with additional inputs from wastewater treatment plants, noncompliant septic systems, and fertilizers in urban and agricultural runoff. The DOP:TP ratio of FWMCs in the Cannon River (Figure 38) from the four years were 56, 71, 45, and 52%, respectively. The Straight River ratios from the four years were 62, 73, 83, and 70%, respectively.

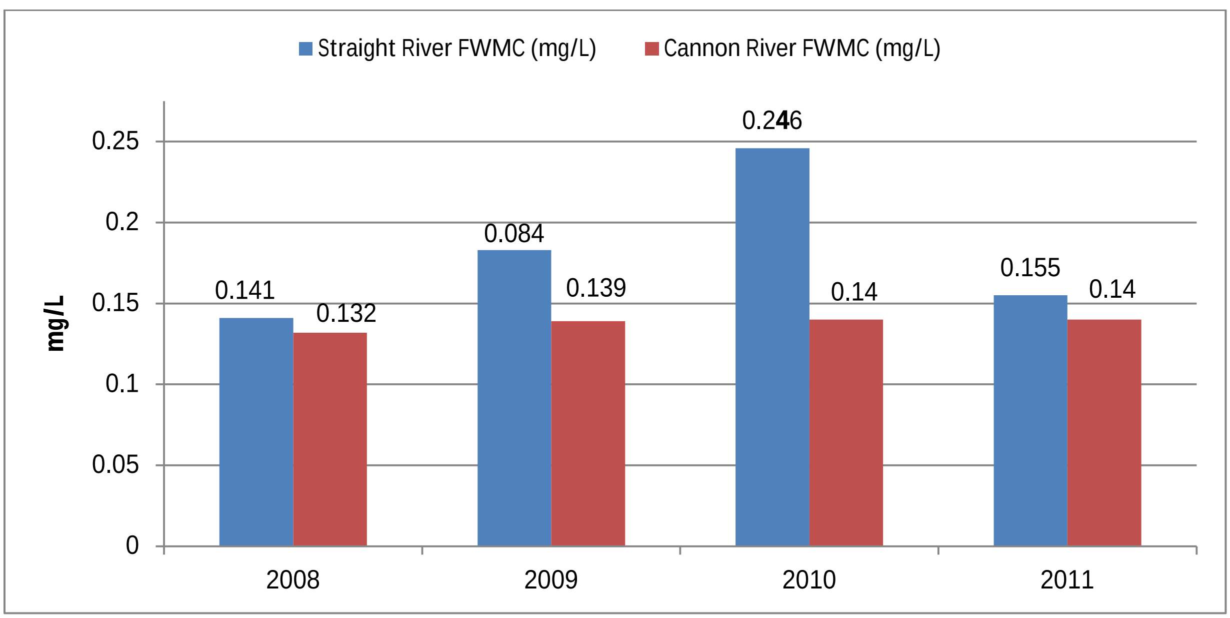

Figure 38. Dissolved Orthophosphate (DOP) flow weighted mean concentrations for the Straight and Cannon Rivers.

Nitrate plus nitrite - nitrogen

Nitrate and nitrite-nitrogen are inorganic forms of nitrogen present within the environment that are formed through the oxidation of ammonia-nitrogen by nitrifying bacteria (nitrification). Ammonia-nitrogen is found in fertilizers, septic systems, and animal waste. Once converted from ammonia-nitrogen to nitrate and nitrite-nitrogen, they too, like phosphorus, can stimulate excessive levels of some algae species in streams (MPCA, 2008). Because nitrate and nitrite-nitrogen are water soluble, transport to surface waters is enhanced through agricultural drainage. The ability of nitrite-N to be readily converted to nitrate-nitrogen is the basis for the combined laboratory analysis of nitrate plus nitrite-nitrogen, with nitrite-nitrogen typically making up a small proportion of the combined total concentration. These and other forms of nitrogen exist naturally in aquatic environments; however concentrations can vary drastically depending on season, biological activity, and anthropogenic inputs. Environmentally, studies have shown that the elevated nitrate-nitrogen levels in the Mississippi River basin contribute to hypoxia (low levels of DO) in the Gulf of Mexico. This occurs by nitrate-nitrogen stimulating the growth of algae which, through death and biological decomposition, consume large amounts of DO and thereby threaten aquatic life (MPCA and MSUM, 2009).

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

Figure 39 shows the nitrate-N FWMCs over the four-year period for the Cannon River and Straight River monitoring sites. The nitrate-N FWMC for the Cannon River was above the draft Class 2B chronic nitrate-N standard two of the four years and the Straight River three out of four years. There were no exceedances of the draft acute value at either site over the monitoring period.

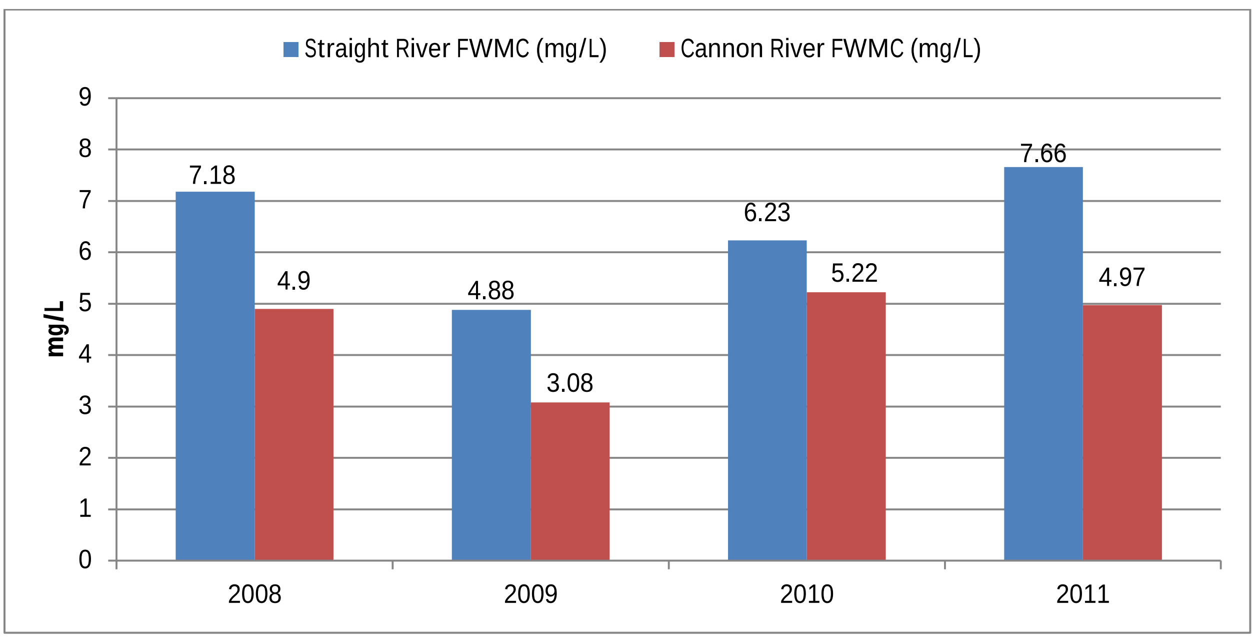

Figure 39. Nitrate + Nitrite Nitrogen (Nitrate-N) Flow Weighted Mean Concentrations for the Straight and Cannon Rivers.

Table 69. Annual pollutant loads by parameter calculated for the Straight River.

Straight River	2008	2009	2010	2011
Parameter	Mass (kg)	Mass (kg)	Mass (kg)	Mass (kg)
Total Suspended Solids	11,122,368	4,295,502	16,442,020	19,489,070
Total Phosphorus	52,246	29,215	140,941	100,683
Ortho Phosphorus	32,334	21,449	118,212	70,292
Nitrate + Nitrite Nitrogen	1,649,483	573,172	2,999,458	3,477,619

Table70. Annual pollutant loads by parameter calculated for the Cannon River.

Cannon River	2008	2009	2010	2011
Parameter	Mass (kg)	Mass (kg)	Mass (kg)	Mass (kg)
Total Suspended Solids	44,159,780	8,476,983	192,417,600	185,029,200
Total Phosphorus	150,215	65,581	416,128	360,093
Ortho Phosphorus	83,745	46,687	189,724	185,408
Nitrate + Nitrite Nitrogen	3,105,365	1,037,723	7,009,447	6,545,763

Stream water quality

During the 2013 assessment, 82 of the 231 assigned stream reaches (stream reaches are not assigned a unique AUID until they are assessed) had data that were reviewed against standards for one or more uses (see Table 71). Of those, 70 were assessed for drinking water, aquatic recreation and/or aquatic life uses (not all reaches had sufficient data for assessment, or were determined to be inappropriate to assess against current stream water quality standards).

Table 71. Assessment summary for stream water quality in the Cannon River Watershed.

				Supporting		Non-supporting			
Watershed	Area (acres)	Total AUIDs	Assessed AUIDs	Aquatic Life	Aquatic Recreation	Aquatic Life	Aquatic Recreation	Insufficient Data	Delistings/ (Corrections)
7040002 HUC-8	**1,929,849**	**231**	**82**	**14**	**3**	**38**	**41**	**35**	**4+1*, (1)**
704000201-01, -02,-03	956,359	40	16	0	1	7	9	9	1
0704000202-01	303,064	18	2	0	0	0	1	2	- - -
0704000203-01	482,647	22	13	6	0	6	6	1	1
0704000203-02	413,465	12	3	2	0	0	1	1	1
0704000203-03	128,762	3	1	1	0	0	1	0	- - -
0704000204-01	245,799	9	5	2	0	1	3	2	- - -
0704000205-01	229,670	9	5	0	0	4	3	2	- - -
0704000206-01	327,846	27	11	1	2	7	8	4	1
0704000206-02	117,125	6	5	0	0	1	1	3	(1)
0704000206-03	122,098	7	2	0	0	1	1	1	- - -
0704000207-01	273,678	32	6	0	0	3	3	3	- - -
0704000208-01	225,584	4	4	0	0	2	3	2	- - -
0704000209-01	403,768	42	9	2	0	6	3	5	1*

*a delisting could be proposed if sufficient data were available that demonstrated support of the water quality standard.

Of the assessed reaches, four are not supporting their drinking water use (coldwater streams) due to elevated nitrates, while 64 stream reaches are non-supporting of aquatic recreation and/or aquatic life uses with 41 non-supporting of aquatic recreation due to excessive bacteria levels and 42 are non-supporting of aquatic life for one or more standards (e.g., fish, macroinvertebrates, DO, turbidity, pH, un-ionized ammonia, pesticides). Of those, five turbidity impairments are proposed to be removed from the 2014 impaired waters list (four are delistings, one is a list correction) while one additional reach could be removed if sufficient data were available to confirm that the reach is now meeting the turbidity standard (Trout Brook -567).

Many of the non-supporting reaches were previous listings where newer data confirmed the existing impairments (e.g., 21 turbidity impairments) or additional criteria were found to not be meeting one or more aquatic life standards. However, a number of new impairments were identified during the 2013 assessment (Appendix 3.1). For aquatic recreation, 8 new reaches are not supporting due to elevated bacteria. For aquatic life, 26 new reaches were found to be not supporting for one or more standards (32 macroinvertebrate bioassessments, 7 fish bioassessments, and 7 DO). Included in this number are

7 stream reaches where 10 aquatic life listings are being deferred (4 macroinvertebrate bioassessments, 6 DO) until TALU standards can be applied to channelized reaches or a use class change occurs. Biological indices (F-IBI and M-IBI) were compared between pre and post flooding (2004 and 2011) and no significant difference in scores was observed, indicating that the flood in late September s2010 was not a significant factor in the fish and macroinvertebrate impairments found. In total, there are 72 aquatic life impairments that have been found in the Cannon River Watershed (Appendix 3.1). This number includes potentially five turbidity delistings where newer data demonstrate that the standard is now being met.

Across the watershed, only three assessed reaches are fully supporting of aquatic recreation and 14 reaches are considered to be fully supporting of aquatic life. The three reaches that are fully supporting aquatic recreation include the headwaters of the Cannon River in LeSueur County, Spring Creek, and the Cannon River between the Byllesby Reservoir and the Little Cannon River (Figure 55). Many stream reaches that are fully supporting aquatic life (Table 72, Figure 54) are showing signs of stress, such as a loss of sensitive species, less than optimal habitat quality and/or water quality conditions. These streams should be considered in development of WRAPS in order to prevent additional impairments in the future as well as to protect special concern species such as the redside dace and suckermouth minnow. The Little Cannon River subwatershed was the only location where the redside dace was found. This colorful minnow requires clear, cool water and unembedded gravel substrates for spawning. Channel stability indicators suggest that the Little Cannon is incised (unstable). This condition may be causing the severe bank erosion and deposition observed along many stream reaches. Only one suckermouth minnow was collected in the entire Cannon River Watershed. This fish was sampled in a small tributary in the Belle Creek subwatershed which also appears to be unstable as well.

Table 72. Stream reaches fully supporting aquatic life in the Cannon River Watershed.

Subwatershed	Assessment Unit ID	Waterbody Name	Reach Description
Lower Straight River	07040002-729	Unnamed creek	Headwaters to Maple Cr
	07040002-519	Maple Creek	Headwaters to Straight R
	07040002-726	Unnamed creek	Headwaters to Medford Cr
	07040002-704	Falls Creek	Unnamed cr to Straight R
	07040002-537	Straight River	Owatonna Dam to Maple Cr
Upper Straight River	07040002-525	Unnamed creek	Headwaters to Straight R
	07040002-517	Straight River	CD 25 to Turtle Cr
Turtle Creek	07040002-518	Turtle Creek	Headwaters to Straight R
Chub Creek	07040002-719	Unnamed creek	Unnamed cr to Unnamed cr
	07040002-558	Mud Creek	Unnamed cr to Chub Cr
Middle Cannon River	07040002-703	Unnamed creek	Unnamed cr to Cannon R
Lower Cannon River	07040002-501	Cannon River	Belle Cr to split near mouth

Finally, data collected on a number of reaches were not used to assess their condition for various reasons (35 reaches with “IF” for “insufficient data”). Twelve reaches were not assessed for aquatic life use support due to channelization. For three reaches, additional monitoring was recommended due to uncertainty regarding drought effects in 2003 or potential wetland influence. For two of those reaches, additional biological monitoring occurred during 2013 and they will be assessed in the near future while for one reach, wetland monitoring will be conducted during 2014.

Stream biological monitoring: macroinvertebrates

Aquatic macroinvertebrate stream communities in the Cannon River Watershed not only reflect the land use of the upland area contributing to each monitoring location but the diversity of the watershed's stream habitats as well. From the high gradient, cold water streams in the eastern portion of the basin to the low gradient, warm water streams in the west, the Cannon River Watershed is rivaled by few others in the state when it comes to its variety of rivers and streams. This is also reflected in the number of distinct M-IBIs required to accurately assess all waterway types present in the Cannon Watershed: Southern Cold Water Stream IBI; Southern Forest Stream (Glide/Pool Habitat) IBI; Southern Stream (Riffle/Run Habitats) IBI; and Prairie Forest River IBI. Having options in terms of which IBI to use for assessing macroinvertebrate communities, depending on characteristics of the monitoring station, allows natural variability to be accounted for and therefore increases the resolution of the anthropogenic or human disturbance "signal" provided by the IBI results. Within each IBI class, there are examples of streams that meet the aquatic life macroinvertebrate criteria (e.g., Pine Creek, Maple Creek, Wolf Creek, and Cannon River--below Cannon Falls) as well as streams that are below the impairment threshold set for each IBI (e.g., Trout Brook, Devils Creek, Prairie Creek, and the Cannon River above Cannon Falls).

Overall, a total of 273 genera in 82 families of macroinvertebrates were collected in the Cannon River Watershed based on 141 qualitative multi-habitat samples taken primarily in years 2004, 2010, and 2011. The most commonly collected macroinvertebrates in low gradient streams (i.e., glide/pool habitat) included midges in the genera *Polypedilum, Rheotanytarsus*, and *Thienemannimyia Gr*., mayflies in the genera *Caenis* and *Baetis*, riffle beetles in the genus *Dubiraphia*, snails in the genus *Physa*, and side-swimmers in the genus *Hyalella*. A total of 229 macroinvertebrate genera were collected from low gradient, warm water streams. In high gradient (i.e., riffle/run habitat) warm water streams, the list of most commonly collected taxa included mayflies in the genus *Baetis*, caddisflies in the genera *Ceratopsyche* and *Cheumatopsyche*, midges in the genera *Polypedilum, Rheotanytarsus*, and *Thienemannimyia Gr.,* and riffle beetles in the genera *Stenelmis, Optioservus*, and *Dubiraphia*. A total of 182 genera were collected from high gradient, warm water streams. Mayflies in the genus *Baetis*, side-swimmers in the genus *Gammarus,* blackflies in the genus *Simulium*, midges in the genera *Tvetenia*, *Eukiefferiella*, and *Polypedilum*, and caddisflies in the genus *Ceratopsych*e were the most frequently collected invertebrates in cold water streams. Though a much lower number of cold water streams were sampled in the watershed (14 samples), a total of 113 macroinvertebrate genera were collected.

Stream biological monitoring: fish

Similar to the macroinvertebrate communities, fish communities in the Cannon River Watershed reflect both the natural watershed variation in topography, geology, and resulting stream size, stream gradient, and thermal temperature regimes, as well as current water quality conditions resulting from past and present local and watershed-wide land use practices. Consequently, five F-IBI classes were used to assess the variety of stream types and fish communities found in this watershed: Low-gradient IBI, Southern Headwater IBI, Southern Stream IBIs, Southern Rivers IBI, and Southern Coldwater IBI.

In total, 70 species from 16 families were collected in the Cannon River Watershed (Appendix 8) from 149 visits at 125 stations sampled during 2004, 2007, 2010, and 2011.The most species diverse families included: *Cyprinidae* (22 species, e.g., minnows, dace, chubs), *Percidae* (11 species, e.g., darters, walleye), *Catostomidae* (9 species, e.g., redhorse, suckers), *Ictaluridae* (7 species, e.g., bullheads, catfish), and *Centrarchidae* (8 species, e.g., sunfish, bass). Twenty-four (24) pollution sensitive species were collected, 10 of which are considered intolerant to pollution (see Appendix 9). The most commonly occurring species (>100 stations) included the white sucker, creek chub and Johnny darter. The least commonly occurring species (<4 stations) included: muskellunge (muskie), flathead catfish, bigmouth buffalo, pearl dace, rainbow darter, banded darter, silver redhorse, and brown bullhead. Two special concern fish species were collected: the Redside dace (*Clinostomus elongatus*) which was only found on the Little Cannon River and its tributaries, and the suckermouth minnow (*Phenacobius mirabilis*) which was only collected at one tributary to Bell Creek.

Lake water quality

Forty-five of the 142 lakes >10 acres in size found in the Cannon River Watershed were assessed (Table 73). Of the 45 assessed lakes, only five (Beaver, Dudley, Fish, Kelly, Roemhildts) are considered fully supporting of aquatic recreation uses. For aquatic life, chloride was currently the only standard assessed, for some of the lakes, as IBIs for lakes are presently in development. No lakes exceeded the chloride standard. Twenty-seven lakes had insufficient information to determine a support status for either aquatic recreation use or aquatic life use (based on chloride data meeting the standard). Watershed-wide, 36 lakes have been identified that do not support aquatic recreation use; 34 have been listed as impaired for excess nutrients since 2002 while two additional lakes (Toner's and Silver) were recommended to be added to the2014 impaired waters list.

Table 73. Assessment summary for lake water chemistry in the Cannon River Watershed.

				Supporting		Non-supporting			
Watershed	Area (acres)	# Lakes >10 Acres	# Lakes Assessed	# Aquatic Life	# Aquatic Recreation	# Aquatic Life	# Aquatic Recreation	# Insufficient Data	# Delistings
7040002 HUC-8	1,929,849	142	45	0 *	5	0 *	36	27	0
704000201	956,359	71	36	0 *	4	0 *	28	21	0
0704000202-01	303,064	21	2	0 *	0	0 *	2	1	0
0704000203-01	482,647	2	0	- - -	- - -	- - -	- - -	- - -	0
0704000203-02	413,465	15	1	0 *	1	0 *	0	1	0
0704000203-03	128,762	3	0	0 *	- - -	0 *	- - -	- - -	0
0704000204-01	245,799	2	1	0 *	0	0 *	1	1	0
0704000205-01	229,670	0	0	- - -	- - -	- - -	- - -	- - -	0
0704000206-01	327,846	7	1	0 *	0	0 *	1	1	0
0704000206-02	117,125	4	1	0 *	0	0 *	1	1	0
0704000206-03	122,098	12	3	0 *	0	0 *	3	1	0
0704000207-01	273,678	0	0	- - -	- - -	- - -	- - -	- - -	0
0704000208-01	225,584	5	0	- - -	- - -	- - -	- - -	- - -	0
0704000209-01	403,768	0	0	- - -	- - -	- - -	- - -	- - -	0

* Lake IBIs are currently in development for the assessment of aquatic life use; until those tools are available, the only standard with which to assess lakes is chloride in order to determine if chloride toxicity is impacting aquatic life. If a lake exceeds the chloride standard, NS is assigned for aquatic life use. All other assessments are IF, until the IBIs are implemented.

Wetland monitoring results

Portions of the Cannon River Watershed lie within the Mixed Wood Plains and Temperate Prairie Level II ecoregions (Figure 40) of the regional classification system used to develop depressional wetland IBIs. For depressional wetlands in the Mixed Wood Plains ecoregion, macroinvertebrate IBI scores ranged from 38 to 68 with a mean of 49 (3 sites). Generally speaking, these results indicate that depressional wetland macroinvertebrate communities are in fair ecological condition in the Mixed Wood Plains portion of the watershed (Figure 38). For the Temperate Prairie portion of the watershed, macroinvertebrate IBI scores ranged from 54 to 89 with a mean of 75 (5 sites). These higher IBI scores, in comparison to those within the Mixed Wood Plains ecoregion, suggest that Temperate Prairie depressional wetlands in the Cannon River Watershed are in relatively good condition compared to wetlands in other parts of this ecoregion. However, it should be noted that two of the wetlands in the Temperate Prairie ecoregion were selected as monitoring sites during the IBI development project due to their relatively undisturbed, natural surroundings. Therefore, this limited sample of sites may not be representative of Temperate Prairie depressional wetlands in the watershed.

Plant IBI scores ranged from 17 to 66 with a mean of 46 (3 sites) for depressional wetlands in the Mixed Wood Plains portion of the watershed. Similar to the wetland macroinvertebrate IBI, these scores are indicative of fair ecological condition (Figure 38). In the Temperate Prairie portion of the watershed, plant IBI scores ranged from 51 to 98 with a mean score of 73 (5 sites). Again, these relatively high scores suggest that Temperate Prairie depressional wetlands are in good condition relative to other parts of the ecoregion, but the sample of sites is likely a biased representation.

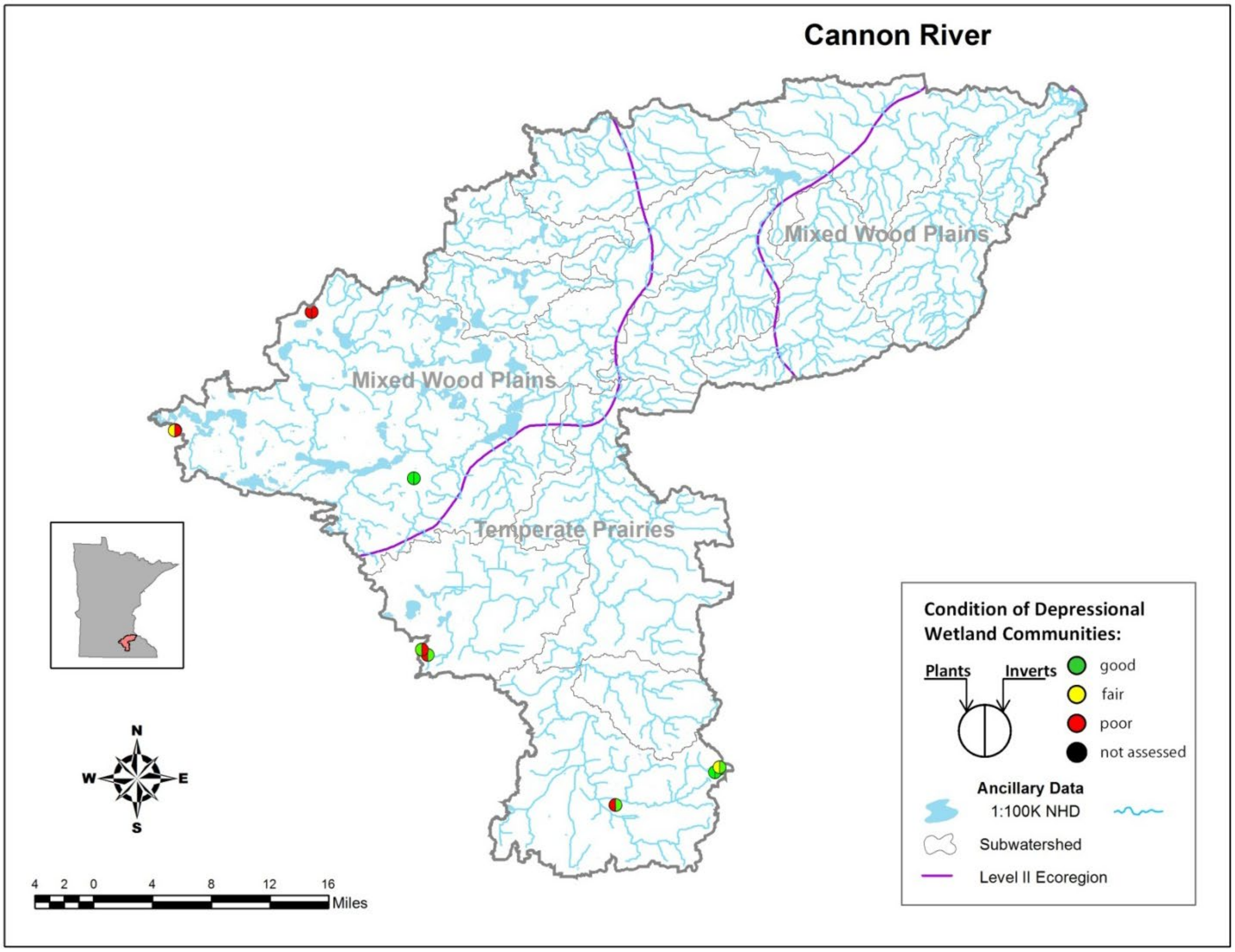

Figure 40. Depressional wetland condition in the Cannon River Watershed.

Fish contaminants

Overall watershed summary of Aquatic Consumption Use Support

Throughout the watershed, mercury in fish tissue remains a concern for the Cannon River and 18 of the 21 (86%) lakes tested (Table 74). Although PCBs have generally declined in fish over the last three decades, the most recent measured concentrations in carp from the Cannon River indicate that PCBs remain a concern as well. PFOS concentrations were detectable in the Cannon River and in three lakes tested (Byllesby, Upper Sakatah, and Tetonka), but at very low levels that do not cause fish consumption advisories. Common carp in the Cannon River (from river mile 22) may have migrated upstream from the Mississippi River which is also currently impaired for PCBs in fish tissue as well. Fish from the Cannon River should be tested for PCBs again in the near future. All 14 lakes impaired for mercury in fish, as well as the Cannon River above the Byllesby Reservoir, should be tested again for mercury in the near future.

Fish contaminant assessment results

The Cannon River was tested for fish contaminants in five years between 1978 and 2011. Lakes in the watershed were tested in 21 years between 1970 and 2012. A total of 1,552 fish were tested in the lakes and 122 fish were tested from the Cannon River. For the Cannon River, mercury was measured in six fish species, PCBs in five species, and PFCs in four species. In the lakes, mercury has been measured in 21 fish species, PCBs in nine species, and PFCs in six species.

Table 74 shows which waterways are impaired for aquatic consumption (i.e., fish contaminants). Cannon River was listed as impaired for mercury in fish in 1998 for the reach from Faribault to the Byllesby Reservoir. The lower reach of the Cannon River, downstream of Byllesby Dam, was listed as impaired for PCBs in fish in 2012, because of a composite of three carp collected in 2010 that had a PCB concentration of 0.353 mg/kg (parts per million, ppm) with a standard of 0.22 mg/kg. The fish were collected at river mile 22, which is about three miles downstream of Cannon Falls. Eighteen of the 23 lakes (86%) are listed as impaired for mercury in fish while none of the lakes in the Cannon River Watershed are impaired for PCBs in fish. All but 3 of the lakes are included in the Statewide Mercury TMDL (MPCA 2007). The other 3 lakes, Mazaska (Lake ID 66-0039), Sabre (Lake ID 40-0014), and Volney (40-0033) had mercury levels that were too high to be included in the statewide TMDL and, therefore, require separate TMDLs.

Appendices 7.1 and 7.2 are a summary of contaminant concentrations by waterway, fish species, and year. These tables show which contaminants are listed, fish species, and years sampled within a given lake. "No. Fish" indicates the total number of fish analyzed and "N" indicates the number of samples. The number of fish exceeds the number of samples when fish are combined into a composite sample. This was typically done for panfish, such as bluegill sunfish (BGS) and yellow perch (YP). Since 1989, most of the samples have been skin-on fillets (FILSK) or for fish without scales (catfish and bullheads), skin-off fillets (FILET). In the early testing (i.e., before 1980), whole fish (WHORG) were compared to samples of dorsal muscle (PLUG). These comparisons showed higher concentrations in the muscle samples and homogenizing the whole fish caused a dilution of the mercury concentration.

The highest mercury concentration was 1.09 mg/kg in a walleye (WE) collected from Mazaska Lake (Lake ID 66-0039) in 2002 (Appendix 7.1). The lake was tested again in 2012 and the maximum mercury concentration in walleye had dropped to 0.63 mg/kg, which is still a high mercury concentration (compare to the fish tissue water quality standard of 0.2 mg/kg). An interesting result of the testing is the comparison to northern pike (NP), which were also tested in 2002 and 2012. The mean mercury concentrations for 2002 and 2012 were 0.17 mg/kg and 0.11 mg/kg for northern pike, while walleye had mean concentrations for the two years of 0.53 mg/kg and 0.45 mg/kg. Typically, northern pike and walleye parallel each other in mercury concentrations and have a nearly one-to-one correlation of mercury concentrations when standardized for body length. The other fish species tested in Mazaska had very low mercury concentrations, which is typical of eutrophic or hypereutrophic lakes, such as

Mazaska. These results indicate the high mercury concentrations in walleye are not caused by a mercury source that is affecting all fish, but rather there is something about the walleye population that is causing high bioaccumulation of mercury. The MDNR's latest Fishery Survey Summary (7/23/2012) noted that catch rates of walleye have steadily increased since the early 2000s.

Perfluorooctane sulfonate (PFOS) was detected in fish from the Cannon River and 3 lakes: Byllesby, Upper Sakatah, and Tetonka (Appendix 7.2). Note that the PFOS concentrations are reported in nanograms per gram (ng/g) or parts per billion (ppb), rather than as parts per million (ppm). The Byllesby Reservoir was first tested for PFOS in 2007. A composite of five bluegill sunfish (BGS) in one sample had a PFOS concentration of 1.4 ng/g, which is below the current reporting limit for PFOS. Since 2009, the reporting limit for PFOS has been approximately 4.8 ng/g (AXYS Analytical laboratory). Many of the fish tested in Upper Sakatah and Tetonka were below this reporting limit. This was the case for northern pike (NP) and yellow perch (YP) from Upper Sakatah; and for bluegill sunfish (BGS), black crappie (BKS), and walleye (WE) in Tetonka. In the Cannon River, all but one fish—a common carp—had PFOS concentrations above the reporting limit. All detectable PFOS concentrations were low and well below the threshold for listing as impaired (species mean of 200 ng/g PFOS). The mean PFOS concentration for a fish species less than 40 ng/g do not warrant a fish consumption advisory by MDH.

Table 74. Waterways having fish contaminant data, showing impairments caused by contaminants in fish tissue and number of fish tested by species

Waterway	AUID	Aquatic Consumption Use Support[1]	Impair-ment[2]	BBU	BGS	BKB	BKS	BRB	C	CHC	CPS	CPY	FWD	LMB	NP	RHS	RKB	SMB	WE	WHB	WHS	WSU	YEB	YP
CANNON R	07040002 -539, -538, -502, -501, -646 (downstream of Byllesby Dam)	NS	PCBs						19							15		6	28		21			
	-581, -582, -507, -508, -509 (Fairbault to L. Byllesby)	NS	Hg (4a)						27							15	5	12	31		21			
BEAVER	74002300	FS			9		8							1	1				8					
BYLLESBY	19000600	NS	Hg (4a)		9		1		11	4	4	9			2			11	10	7	1			
CANNON	66000800	NS	Hg (4a)		2	9	22		17	5			11		11				9	7				12
CEDAR	66005200	NS	Hg (4a)				9								2				6					
CIRCLE	66002700	NS	Hg (4a)		10				7						5				6					7
CLEAR	81001400	NS	Hg (4a)		8	8	8												12					
DORA	40001000	FS		10		10	10																	
FRANCES	40005700	NS	Hg (4a)		25	3	25	12	4				8	2	10				24	3				
FRENCH	66003800	NS	Hg (4a)		10		20		1				12		6				9		1			10
GERMAN	40006300	FS			10				4						5									
GORMAN	40003200	NS	Hg (4a)		10				5					2	10				5			3		
HUNT	66004700	NS	Hg(4a)		10		9		3						7				2					
JEFFERSON	40009200	FS		45		40	50		75						95				55					
LOON	81001500	NS	Hg(4a)		8	8	8							4										
LOWER SAKATAH	66004400	NS	Hg (4a)												8				1	9				8
MAZASKA	66003900	NS	Hg (5)		12		24		5						57				48					3
ROBERDS	66001800	FS					10		8						9									
SABRE	40001400	NS	Hg (5)						5						13					9				4
SHIELDS	66005500	NS	Hg (4a)		20	5	10		8						8				11				5	10
TETONKA	40003100	NS	Hg (4a)		18	8	9		21						12				36	8		11		4
UPPER SAKATAH	40000200	NS	Hg (4a)		8	7	10		4						12				6	11				6
VOLNEY	40003300	NS	Hg(5)	1			10		1										5					
WELLS	66001000	NS	Hg (4a)																1	8				

[1]Aquatic consumption use support: NS = non-support, FS = full support.

[2]Impairment for mercury is categorized as either Hg (4a) for waters covered by the Statewide Mercury TMDL or Hg (5) not covered by the Statewide Mercury TMDL.

Species codes: BBU = bigmouth buffalo; BGS = bluegill sunfish; BKB = black bullhead; BKS = black crappie; BRB = brown bullhead; C = common carp; CHC = channel catfish; CPS = river carpsucker; CPY = crappie, unknown species; FWD = freshwater drum; LMB = largemouth bass; NP = northern pike; RHS = redhorse, unknown species; RKB = rock bass; SMB = smallmouth bass; WE = walleye; WHB = white bass; WHS = white crappie; WSU = white sucker; YEB = yellow bullhead; YP = yellow perch

Groundwater quality

Karst geology in the Cannon River Watershed allows for rapid transfer of groundwater to surface water, and vice-versa. These conditions are beneficial when groundwater serves as a component of baseflow for surface water bodies like trout streams. However, that same rapid transfer can be detrimental to the receiving water body when the source water is contaminated. Studies by Dakota County (Hastings Area Nitrate Study 2003), the Dakota County Soil and Water Conservation District (2010) and by the University of Minnesota (Groten and Alexander 2013) have all identified nitrate as the primary contaminant of concern for groundwater in this watershed. Sources of nitrate contamination include row crop agriculture, septic systems, municipal sewer infrastructure and animal feedlot operations.

The Minnesota Department of Agriculture (MDA) annually monitors pesticides and nitrate in groundwater through a network of monitoring wells statewide. Southeast Minnesota, including the Cannon River Watershed, is one of two areas MDA monitors more intensively due to the vulnerable geology. In 2012, no pesticide detections exceeded any established health risk limit for drinking water. Nitrate was detected in every sample from the southeast Minnesota region in 2012. The health risk limit for nitrate set by MDH is 10.00 mg/L. Of the samples the MDA collected that year, 71% ranged in concentration from 3.01 mg/L to 10.00 mg/L, while 26% were above 10.00 mg/L. Results from each year of pesticide monitoring are available on the MDA website at
http://www.mda.state.mn.us/en/chemicals/pesticides/maace.aspx

The MPCA's Ambient Groundwater Monitoring Program also sampled five domestic wells within the Cannon River Watershed (Figure 41). Results from these wells did not exceed drinking water standards for the 101 substances analyzed, including nitrate.

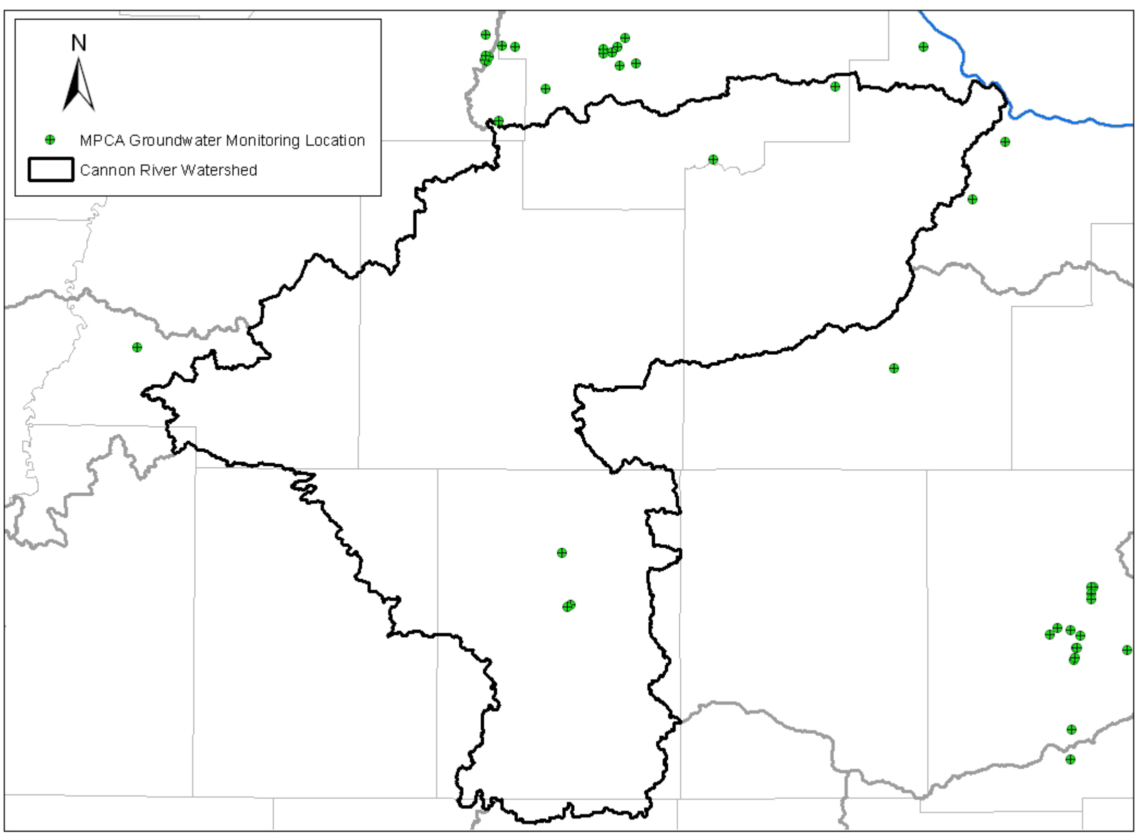

Figure 41. MPCA Ambient Groundwater Monitoring Program wells in and around the Cannon River Watershed.

Groundwater/surface water withdrawals

Figure 42 displays locations of permitted groundwater and surface water withdrawals from within the Cannon River Watershed. Blue symbols are groundwater withdrawals and red are surface water, taken from lake, stream or other surface water feature. The three largest permitted consumers of water in the state (in order) are municipalities, industry and irrigation. The withdrawals within the Cannon River Watershed are mostly irrigation and municipal use.

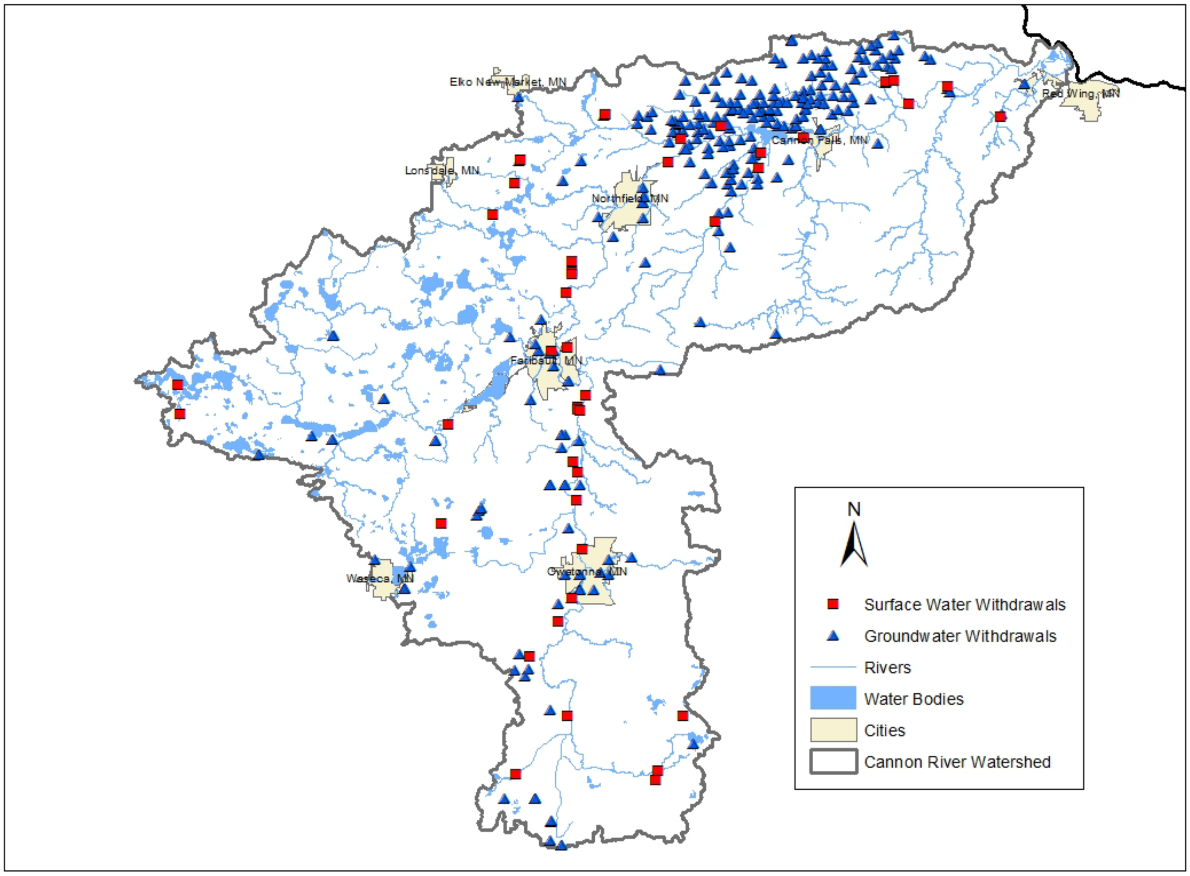

Figure 42. Locations of 2011 permitted groundwater and surface water withdrawals in the Cannon River Watershed.

Over the 20-year period from 1991-2011 (Figure 43), total groundwater withdrawals have increased significantly ($p=0.001$). Surface water withdrawals have increased as well ($p=0.05$).

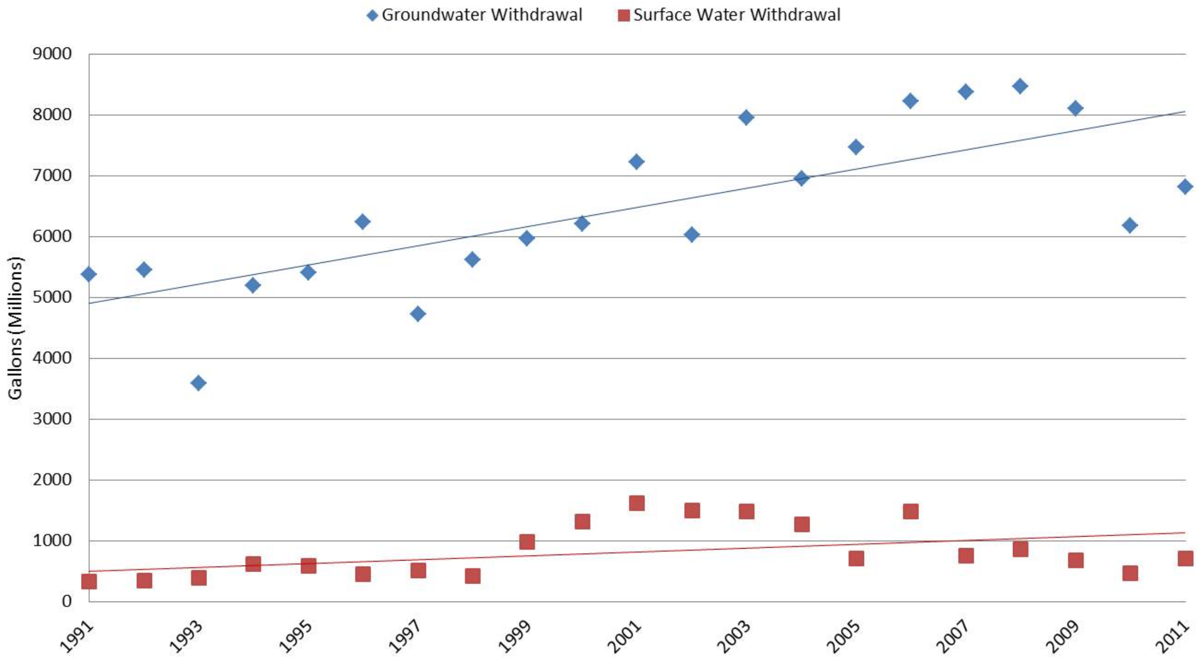

Figure 43. Total annual groundwater & surface water withdrawals located within the Cannon River Watershed (1991-2011)

More specifically, groundwater withdrawals from the Prairie du Chien aquifer – which interacts quickly with surficial water bodies and is most easily impacted by anthropogenic activities, have increased significantly (p=0.001, Figure 44). Withdrawals from the surficial water table aquifer have also increased (p=0.05, Figure 45).

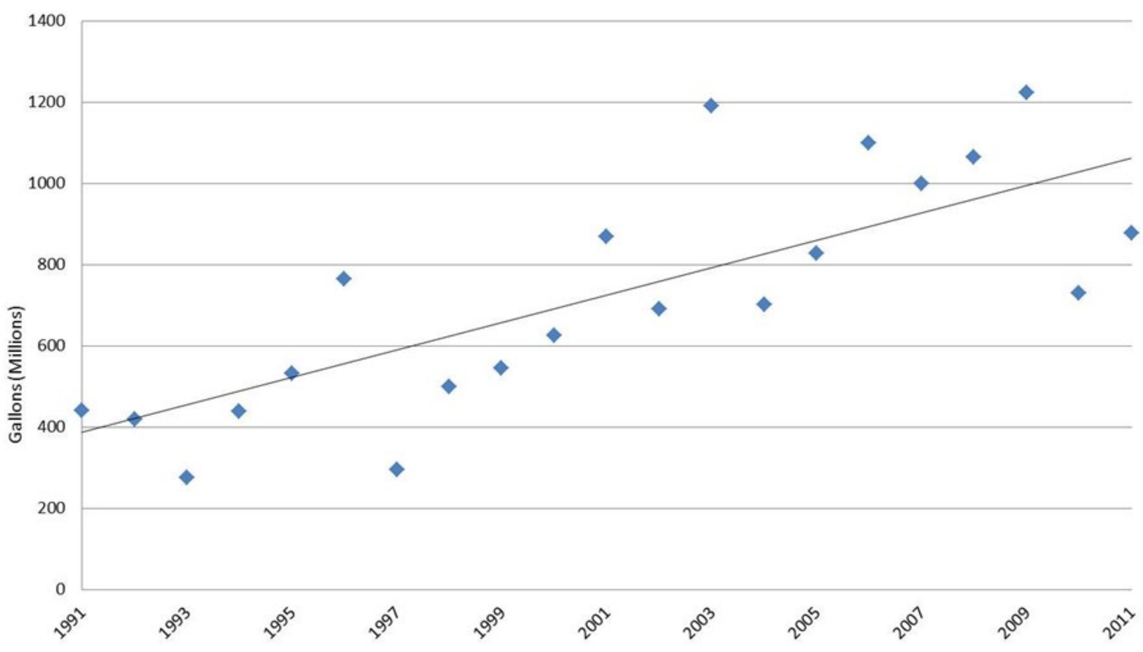

Figure 44. Annual groundwater withdrawals from the Prairie du Chien aquifer within the Cannon River Watershed (1991-2011)

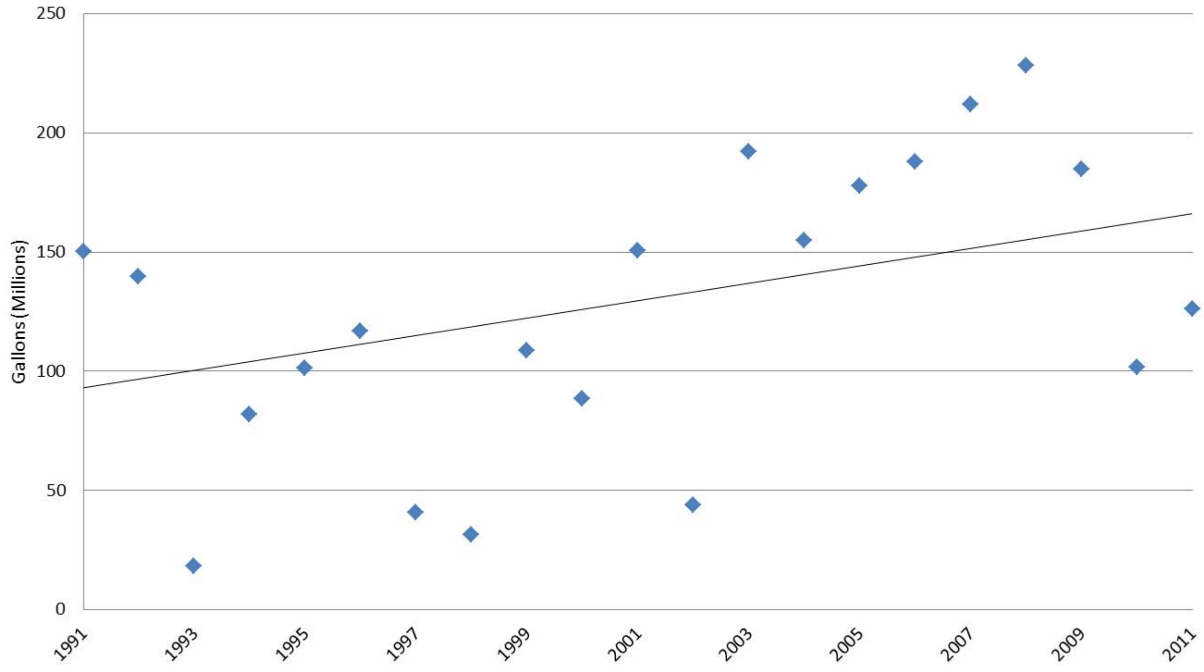

Figure 45. Annual groundwater withdrawals from surficial water table aquifers within the Cannon River Watershed (1991-2011)

Groundwater quantity

One observation well (19006) within the Cannon River Watershed was chosen based on data availability and geologic location. This observation well exhibits no statistically significant trend in groundwater elevation change (Figure 46).

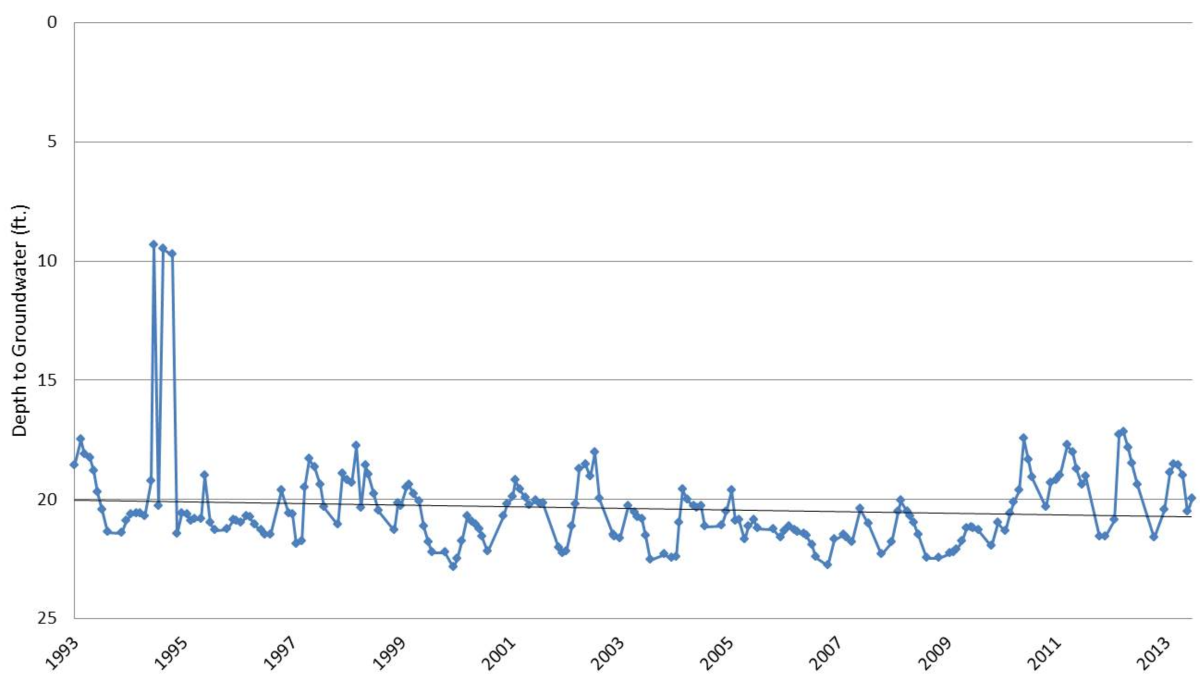

Figure 46. Observation Well 19006, located in the northern area of Cannon River Watershed near Randolph, MN in Dakota County (1993-2013).

Stream flow

Stream flow for two rivers in the Cannon River Watershed was analyzed for annual mean discharge and summer monthly mean discharge (July and August). Figure 47 is a display of the annual mean discharge for Cannon River at Welch from 1992 to 2012. Figure 46 displays July and August mean flows for the last 20 years for the same water body. The data shows that there is a decrease in stream flow over time, both monthly and annually, but there is no statistically significant trend. Similar trends can be seen in Figures 49 and 50 of the Straight River near Faribault during the same time period, however, that decrease in monthly mean discharge exhibits a small statistical significance (p=0.1). By way of comparison, flows during July and August have declined at a statistically significant rate at a majority of streams selected randomly for a study of statewide trends.

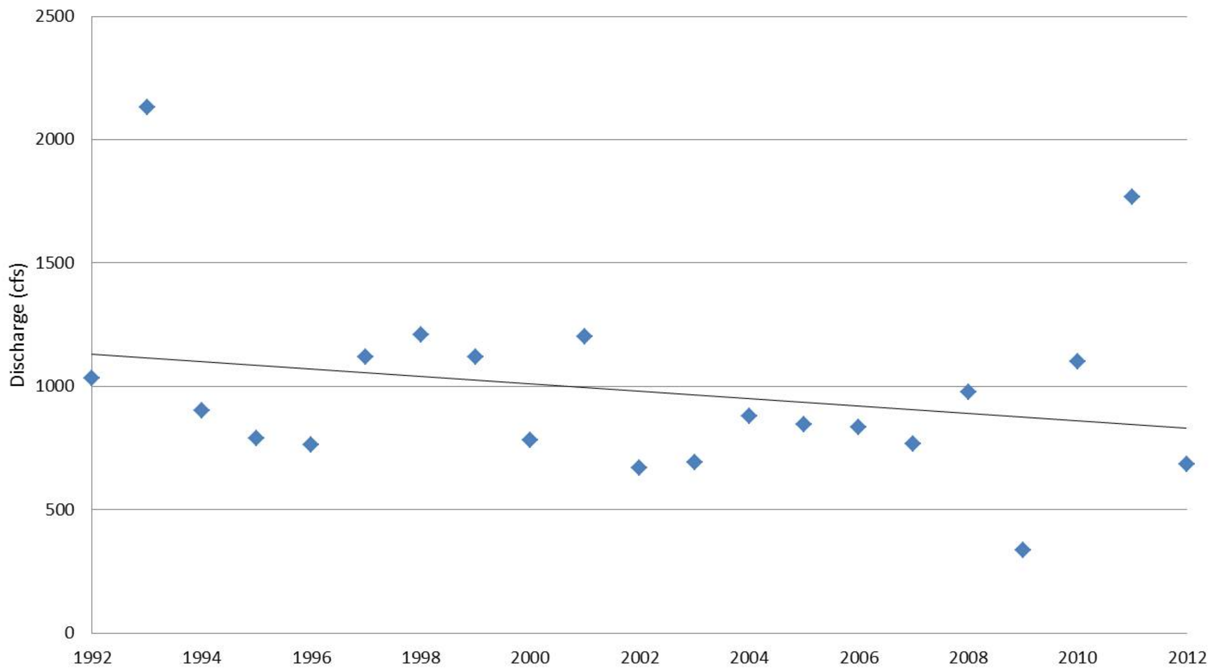

Figure 47. Annual mean discharge for the Cannon River at Welch, MN (1992-2012).

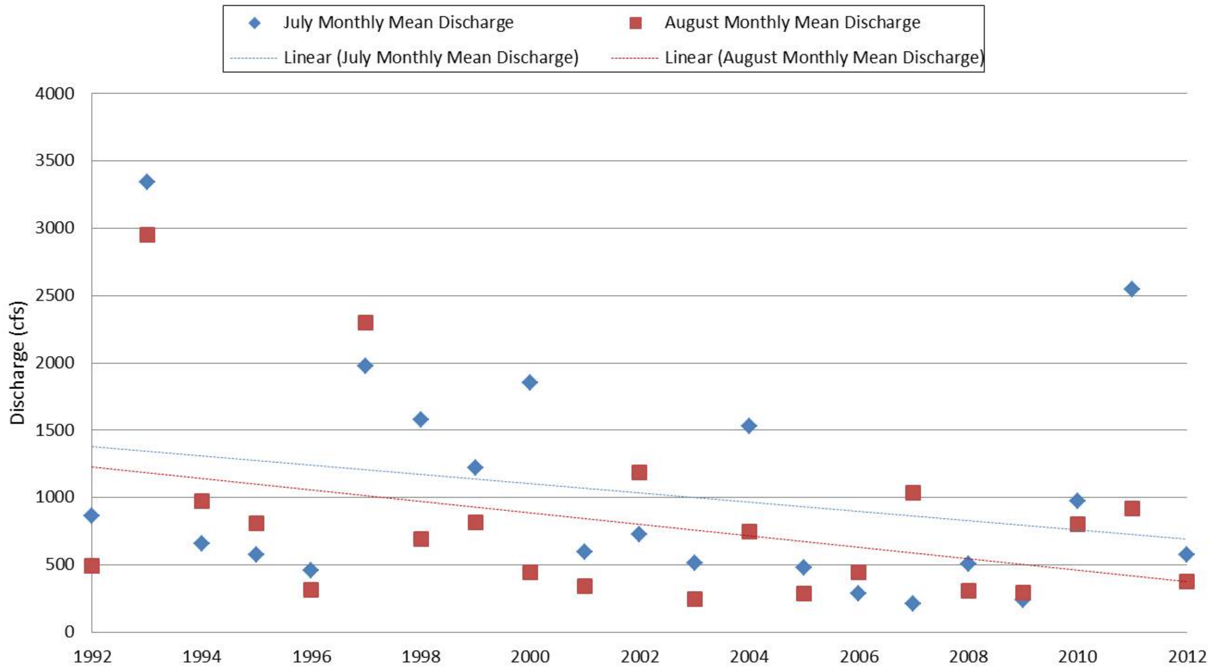

Figure 48. Mean monthly discharge measurements for July and August flows for the Cannon River at Welch, MN (1992-2012).

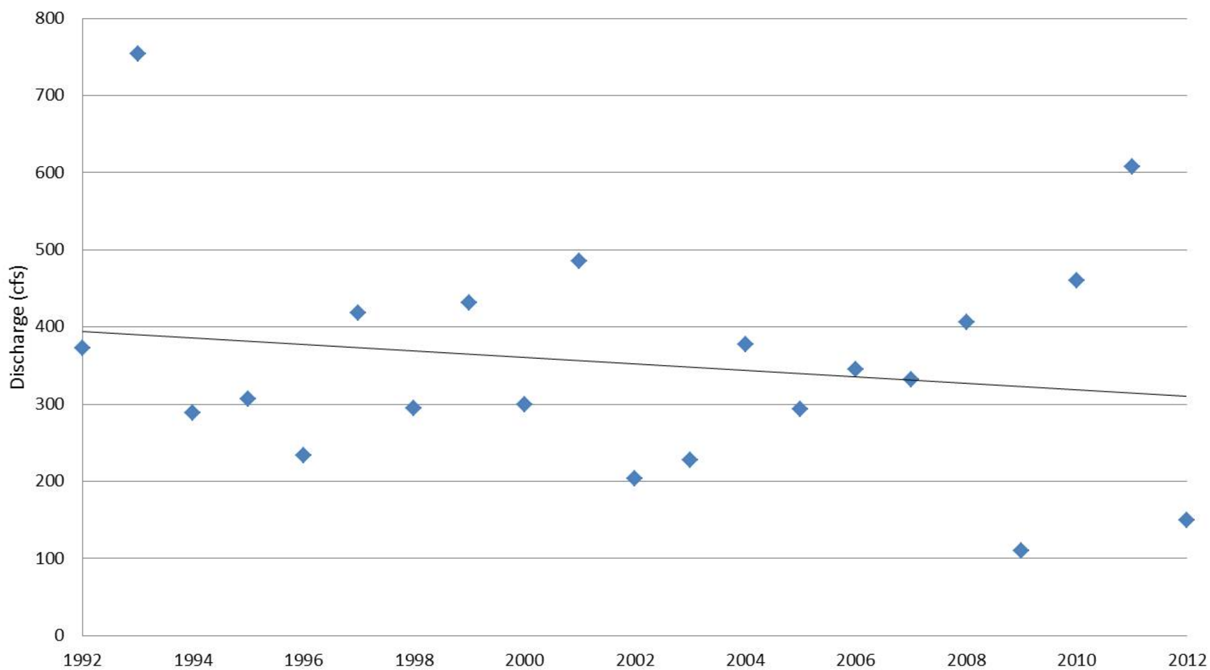

Figure 49. Annual Mean Discharge for the Straight River near Faribault, MN (1992-2012).

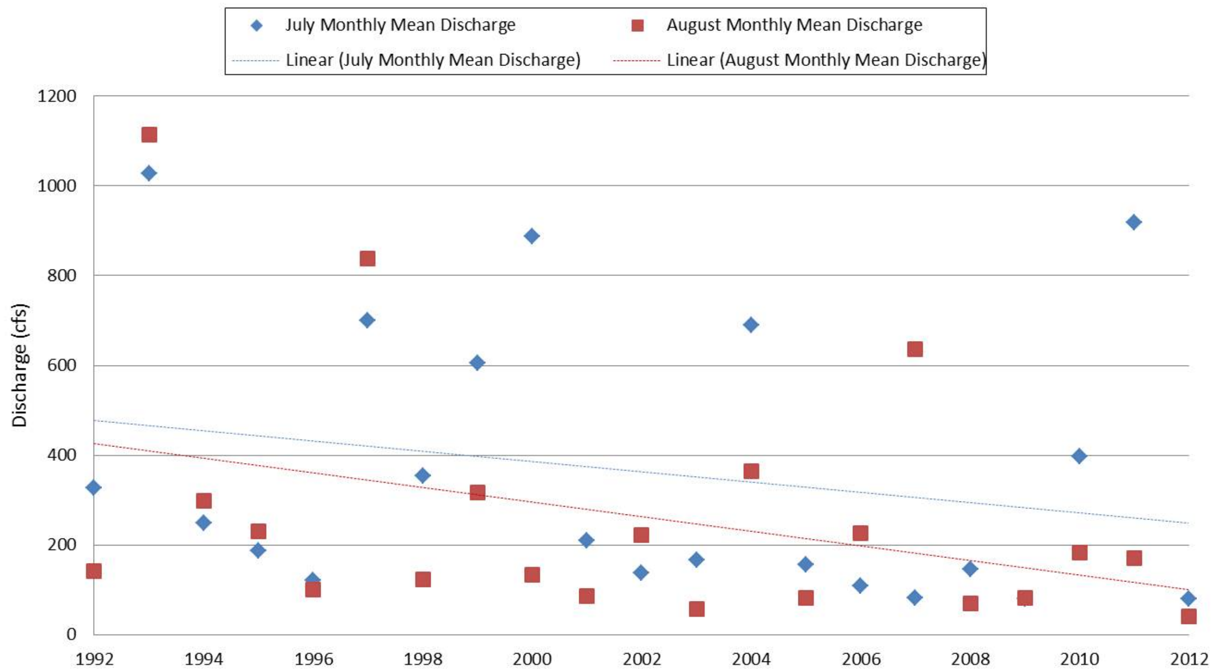

Figure 50. Mean monthly discharge measurements for July and August flows for the Straight River near Faribault, MN (1992-2012).

Pollutant trends for the Cannon River

Water quality trends at long-term monitoring stations

Water chemistry data from MPCA's milestone monitoring stations on the Cannon River and Straight River were analyzed for trends (Table 75) for a long term period of record and a near term period of record. For the Cannon River, there were significant increases in nitrite/nitrates and chloride during the long term period of record (1953-2008) and for only nitrite/nitrates for the near term period of record (1999-2009). For the Straight River, there were only significant increases in chloride during the long-term period of record (1955-2009); however, the median concentration of nitrite/nitrate was higher during the last 10-year period of record (4 mg/L) than the median concentration of the first 10-year period of record (1 mg/L) which were the same measurements observed for each period on the Cannon River as well. Conversely, there were significant decreases in total suspended solids, total phosphorus, ammonia, and biological oxygen demand for the long term periods of record for both the Cannon River and Straight River, while there were no trends with the near term periods.

Table 75. Trends in the Cannon River Watershed

	Total Suspended Solids	Total Phosphorus	Nitrite/ Nitrate	Ammonia	Biochemical Oxygen Demand	Chloride
Cannon River at Br on CSAH-7 at Welch (CA-13) (period of record 1953 - 2009)						
overall trend (1953-2009)*	decrease	decrease	increase	decrease	decrease	increase
average annual change	-2.6%	-2.3%	1.4%	-7.0%	-0.8%	1.8%
total change	-77%	-69%	105%	-97%	-37%	178%
recent trend (1995 – 2009)*	no trend	no trend	increase	no trend	no trend	little data
average annual change			1.9%			
total change			31%			
median concentrations first 10 years	26	0.3	1	0.20	3.6	11
median concentrations recent 10 years	14	0.2	4	<.05	2.3	28
Straight River near CSAH-1, 1 Mi SE of Clinton Falls (ST-18) (period of record 1955 - 2009)						
overall trend (1955 – 2009)*	decrease	decrease	no trend	decrease	decrease	increase
average annual change	-1.9%	-1.0%		-7.4%	-3.5%	1.4%
total change	-64%	-43%		-98%	-85%	114%
recent trend (1995 – 2009)*	no trend	no trend	no trend	no trend	no trend	little data
average annual change						
total change						
median concentrations first 10 years	38	0.7	1	0.44	6.8	17
median concentrations recent 10 years	23	0.3	4	<.05	1.1	30

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

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

Water clarity trends at lake and stream monitoring sites

Historical water clarity data (minimum of eight years) were used to identify long term water clarity trends (Table 76) for lake and stream monitoring sites in the Cannon River Watershed. Many of the sites with sufficient data for trend analysis are sampled by volunteers through the Citizen Lake or Citizen Stream Monitoring Programs. That data identified one stream monitoring location (STORET/EQuIS station S001-396 on Cannon River in Dundas) and two lakes (Volney and Middle Jefferson in the Upper Cannon River Subwatershed) with evidence of increasing water clarity trends. Decreasing water clarity trends were identified on two lakes (Fox and Upper Sakatah) and zero streams. Fox Lake is located in the Wolf Creek subwatershed and Upper Sakatah in the Upper Cannon River subwatershed. The data also show that 41 streams and 24 lakes have no identifiable trends in water clarity.

Table 76. Water clarity trends: lake and stream monitoring sites

Cannon River Watershed HUC 07040002	Stream Sites	Lakes
number of sites w/ increasing trend	1	2
number of sites w/ decreasing trend	0	2
number of sites w/ no trend	41	24

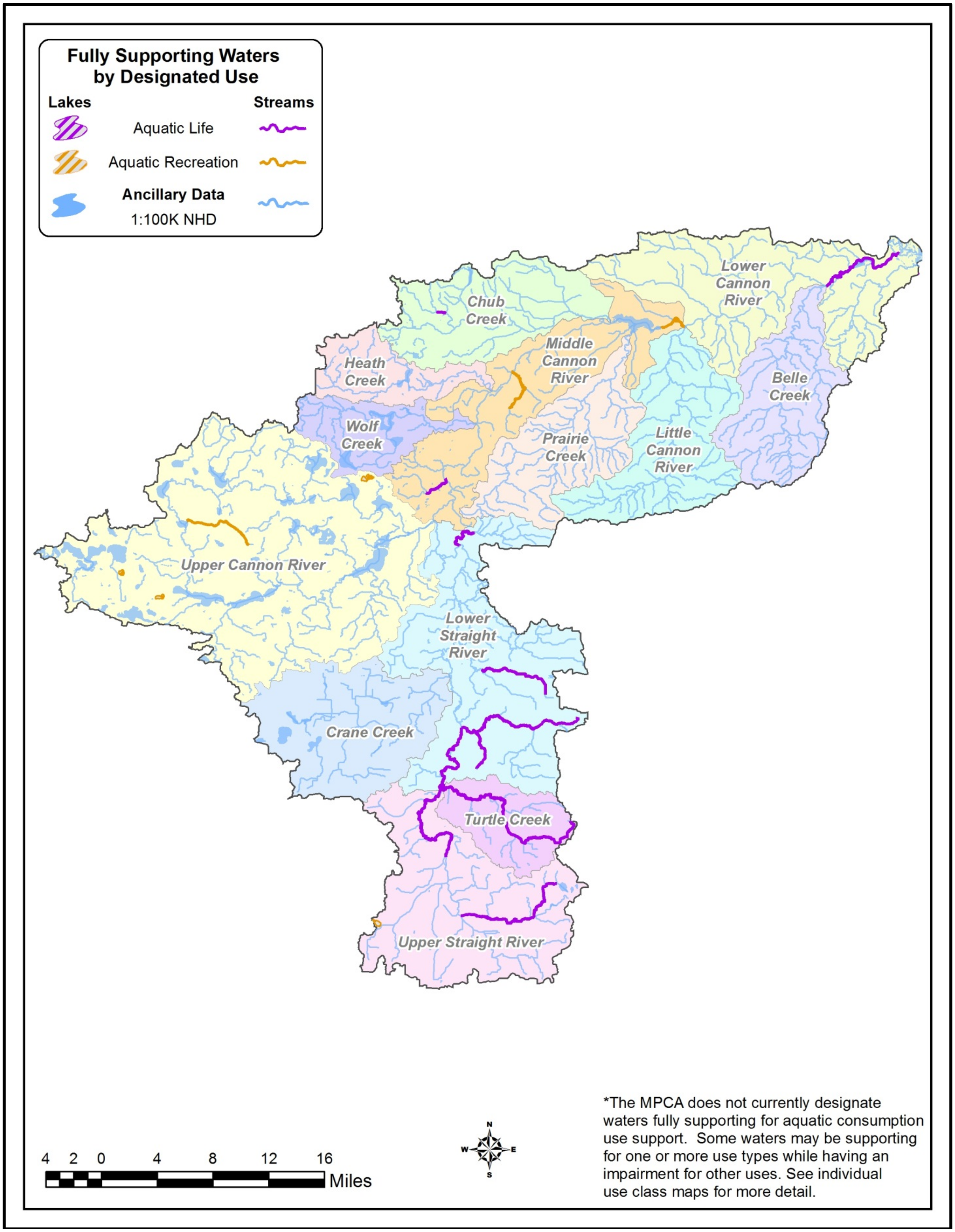

Figure 51. Fully supporting waters by designated use in the Cannon River Watershed.

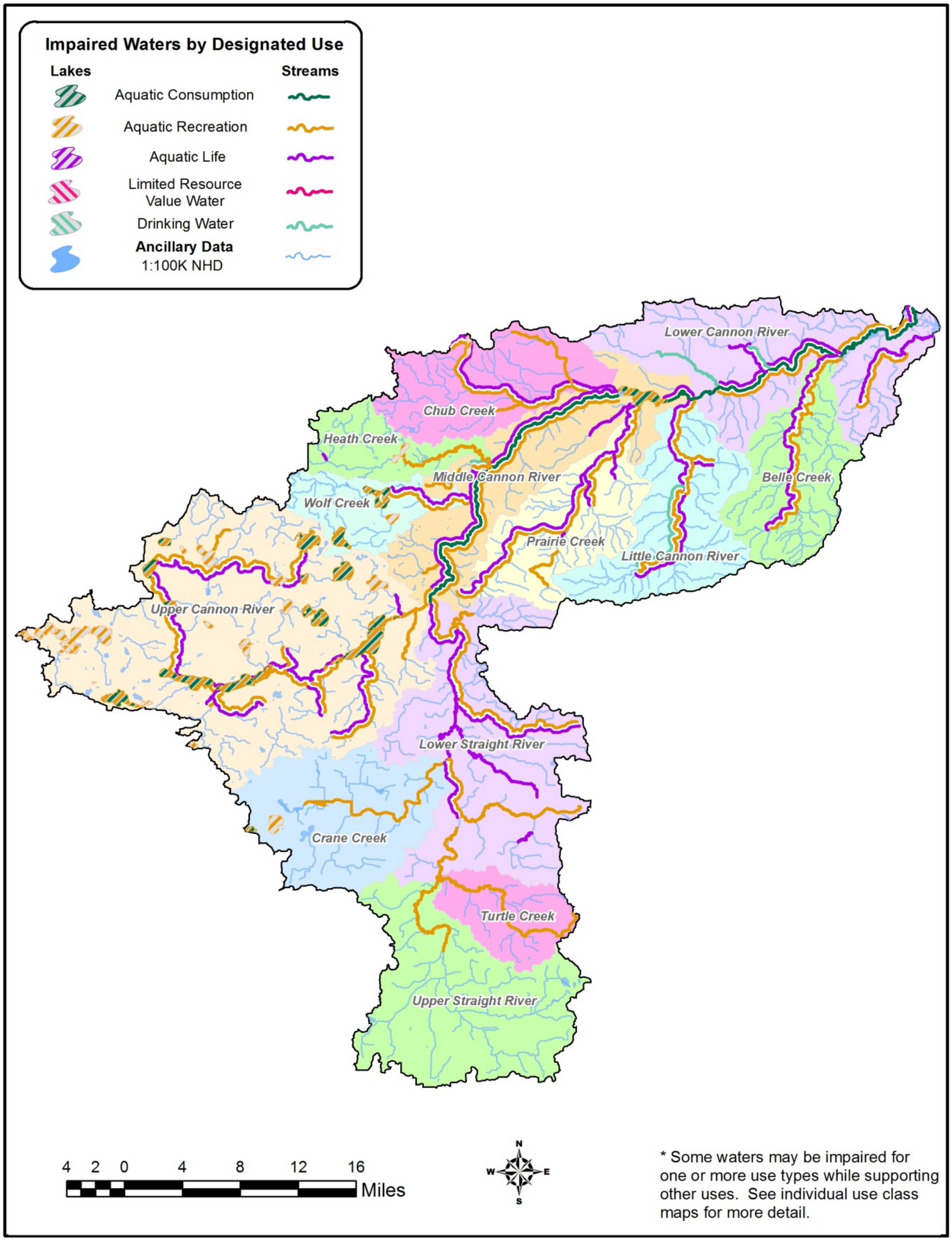

Figure 52. Impaired waters by designated use in the Cannon River Watershed.

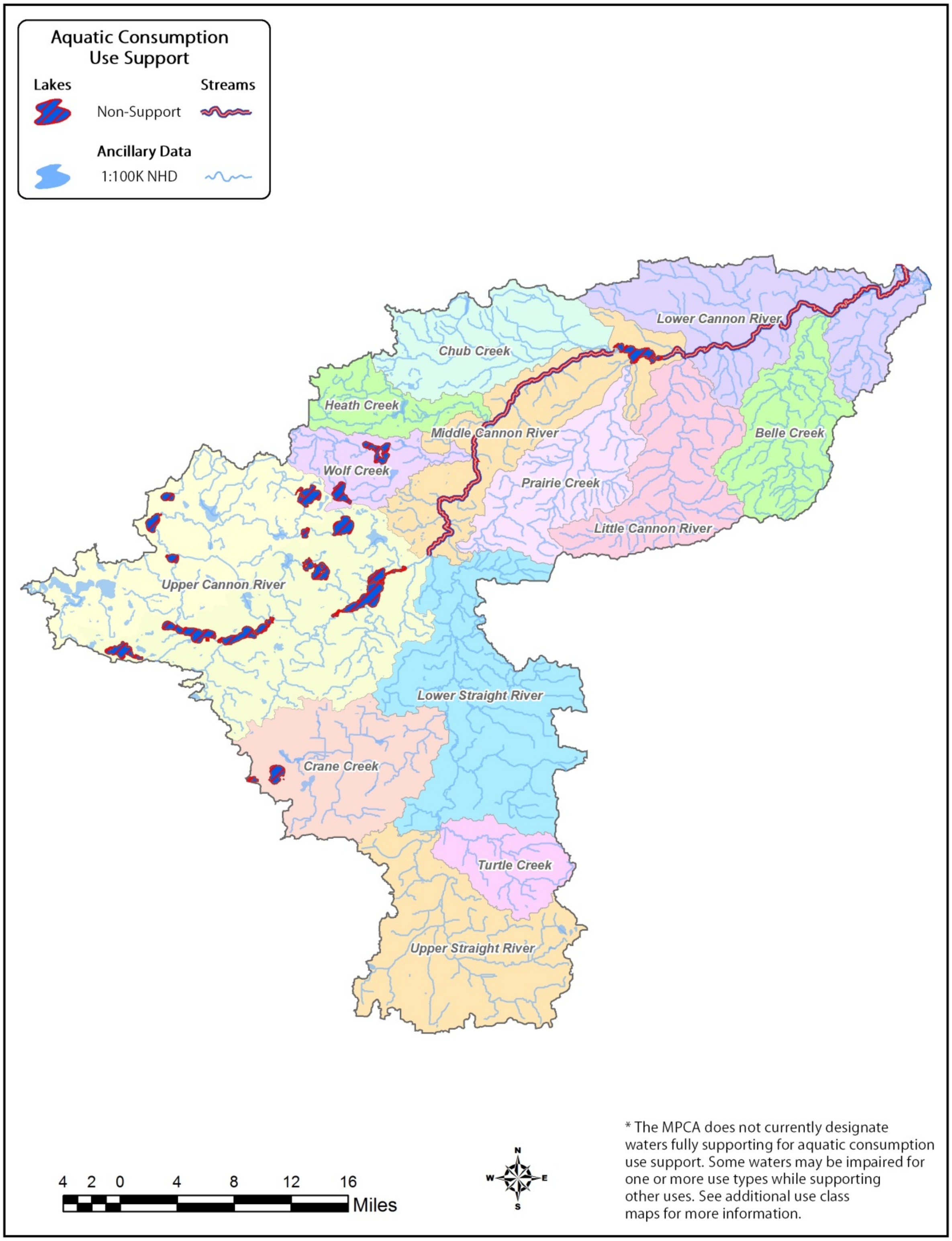

Figure 53. Aquatic consumption use support in the Cannon River Watershed.

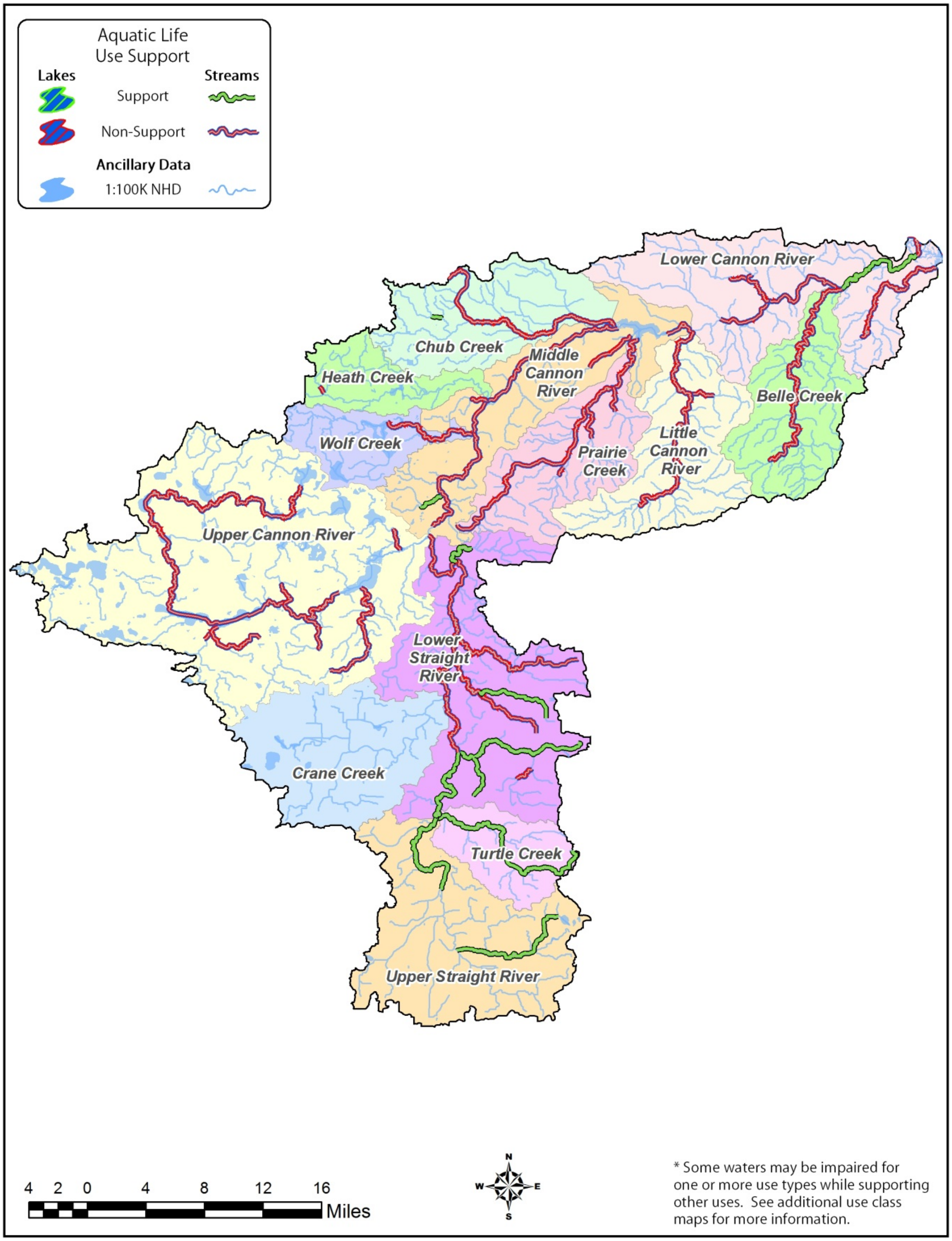

Figure 54. Aquatic life use support in the Cannon River Watershed.

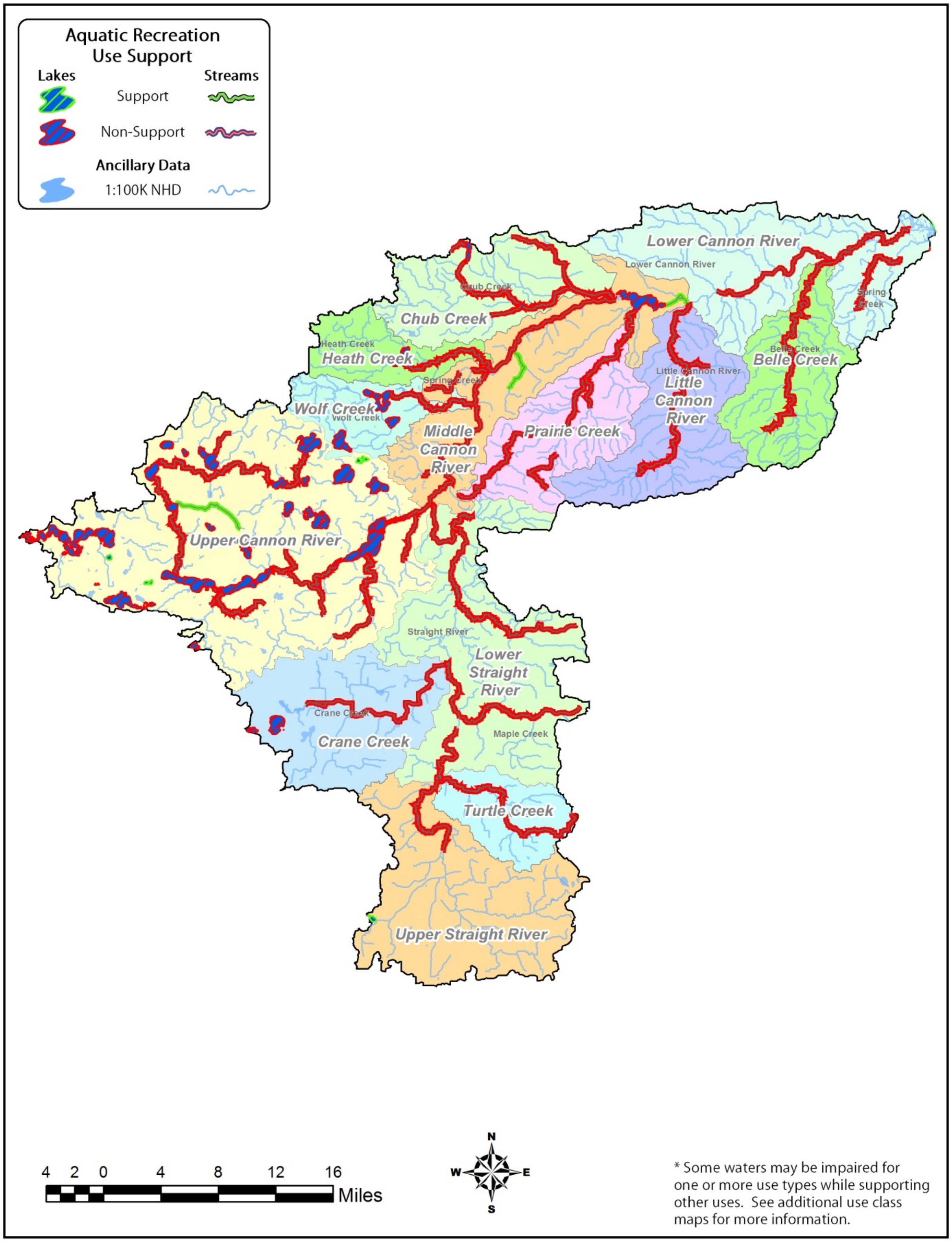

Figure 55. Aquatic recreation use support in the Cannon River Watershed.

VII. Summaries and recommendations

Overall findings

While great improvements have been made to the water quality of the Cannon River Watershed over the last 30 years with regards to many point source discharges, many waterbodies struggle to maintain adequate water quality for drinking, fish consumption, recreation, and supporting the living conditions for sensitive fish and insects. Numerous conservation measures have been implemented in the watershed that aim to reduce the loading of phosphorus, nitrates, sediment, and bacteria in lakes, rivers, and streams such as conservation tillage, wetland restoration, water treatment upgrades, and improving shoreland buffer compliance on streams and ditches, among others. However, conservation measures have not been implemented uniformly across the watershed, with some cities and counties working on water quality projects and monitoring and enforcing shoreland buffer rules more often than others. Additional measures adopted and applied in targeted regions and throughout the watershed have the potential to further enhance and protect downstream waterbodies from further degradation and additional impairment listings. In combination with the findings of this report, additional monitoring may be needed to determine the extent, causes, and nature of existing and new impairments. This information should better inform where to target implementation strategies to best address the sources and causes identified.

Historic flooding occurred the year prior to the IWM launch (October 2010) and during the last year of subwatershed outlet sampling (June 2012). These large rain events and high waters added an increased volume of sediment and nutrient loads carried by the Straight River and Cannon River, as was seen at the load monitoring stations. Increased drainage in the watershed along with global climate changes may increase the frequency and magnitude of these types of events in the future. Therefore, the added loads observed may not reflect a recent change in land management practices, as other years are also indicating that sediment and nutrients derived within this watershed are at times elevated. During the 10-year window of data that was used for assessment, other years also indicated sediment and nutrients derived within this watershed are high and may be a cause of water quality impairments related to high nitrates in drinking water, phosphorus causing algae blooms in lakes, and macroinvertebrate and fish impairments found at many locations throughout the watershed. Across the watershed, four coldwater streams have elevated nitrate levels that may make drinking the water unsafe, so they do not support their drinking water use. For aquatic consumption, 86% (18 of 21) of lakes and the Cannon River between Faribault to the Byllesby Reservoir do not support aquatic consumption use due to elevated mercury in fish, while the Cannon River below the Byllesby Reservoir is non-supporting of fish consumption due to elevated PCBs. For aquatic life for streams, 50% (40 out of 80) of stream reaches are non-supporting with a total of 63 impairments (7 for fish bioassessments, 32 for macroinvertebrate bioassesments, 7 for DO, and 27 for turbidity). For aquatic life in lakes, no lakes in the watershed currently show a chloride toxicity issue; however, biotic standards are in development, which, when applied, may identify additional impairments. For aquatic recreation, 80% (36 out of 45) of lakes are non-supporting due to elevated nutrients, while 45% (36 out of 80) of streams are not supporting due to elevated bacteria levels.

Specific pollutants and conditions

Bacteria

Excessive levels of bacteria in streams can indicate conditions that are unsafe for swimming or wading, and secondary body contact such as fishing from a boat or shore. Bacteria impairments are widespread, similar to other watersheds that are part of the Lower Mississippi River Basin regional Fecal Coliform TMDL. Within the Cannon River Watershed, roughly half of the Straight River upstream of the city of Owatonna (and nearly all of it downstream to Faribault) is impaired due to bacteria. All but three assessment units (totaling seven miles in length) of the Cannon River (downstream of Cannon Lake) are also impaired due to bacteria. Sources of bacteria that have the potential to cause water borne illnesses in streams--and lakes--include outdated or underperforming septic systems and animal waste (e.g., livestock, pets, wildlife). Actions such as upgrading underperforming septic systems, minimizing runoff from animal feedlots and agricultural fields fertilized with manure, and picking up pet wastes can help to mitigate the widespread bacteria problems within the watershed.

Aquatic life conditions

Aquatic life impairments in streams were indicated by low percentages of pollution sensitive fish and macroinvertebrates and/or poor water quality conditions (e.g., turbidity, low DO) that may be stressful to aquatic communities. The Cannon River Watershed saw both extremes in precipitation during the 10 year assessment window -- historic drought conditions and historic flooding—that could potentially effect the composition of the biological communities collected. In 2003, drought conditions may have caused many headwater streams to go dry which could potentially explain the low numbers of fish collected at some stations during early summer 2004. However, additional monitoring at these same stations in 2011 and 2013 indicates biological stress that may be related to excess nutrients or habitat limitations. In order to determine whether the historic rainfalls and flooding could have negatively impacted the biological communities that were sampled in 2011, MPCA staff compared results at biological stations that were sampled both during 2004 (at non-drought impacted sites) and 2011 and found no significant difference in the F-IBI or M-IBI scores, indicating that the floods are not a main factor in the new aquatic life impairments. Stressor Identification is looking into the potential causes of biological stress throughout the watershed.

Potential stressors in the watershed that may directly or indirectly affect aquatic biota include: channelization, flashier stream flows, erosion and embedded substrates, turbidity, excess nutrients fueling algae blooms that can cause extreme fluctuations in DO levels, high water temperatures, and dams that prevent fish from migrating between habitats used for spawning, foraging, and refuge. The next step in the watershed management process is Stressor Identification that will list candidate causes and identify the most likely ones for prioritizing in-stream, near-stream, and/or watershed-wide projects.

While many streams are impaired for aquatic life use, there are other streams that were assessed as fully supporting or have special concern species with specific habitat requirements. For example, the Little Cannon River subwatershed was the only location where the redside dace was collected. The Middle and Lower Cannon River subwatersheds also have a number of beautiful coldwater streams that support healthy brook and brown trout communities, including Trout Brook, Pine Creek, Spring Brook, Belle Creek, Spring Creek (a.k.a. Rice Creek), and the Little Cannon River. However, many of these coldwater streams have macroinvertebrate impairments that when the stressors present are addressed should also maintain and improve habitat and water quality conditions for the fish communities as well. For warm water streams, Maple Creek, Falls Creek, Turtle Creek, Mud Creek, and the lower Cannon River support aquatic life for both fish and macroinvertebrates with many pollution sensitive species collected. These streams and others should be considered for additional protection to prevent additional aquatic life impairments in the future.

Nitrates

Drinking water standards for nitrates and other constituents apply to coldwater (2A) streams in Minnesota since nitrate levels measured in groundwater dominated trout streams are likely to indicate the level of nitrates in groundwater that could be used for drinking as well. Impaired streams and the counties where they are located include: Trout Brook in Dakota, Pine Creek which flows from Dakota to Goodhue, Little Cannon River in Goodhue, and Spring Brook (a.k.a. Rice Creek) in Rice. Nitrate is a well-documented contaminant of concern for drinking water sources in the Cannon River Watershed and other karst regions in Minnesota, due to the porous nature of karst geology that allows rapid transfer of pollutants, like nitrate, between surface water and groundwater. Groundwater quality can best be preserved by protecting groundwater recharge zones and preventing contamination from identified sources.

Mercury and PCBs

High levels of mercury and PCBs in fish may make eating them unsafe. For the Cannon River Watershed, 18 lakes and the Cannon River between Faribault to the Byllesby Reservoir do not support aquatic consumption use due to elevated mercury in fish, while the Cannon River below the Byllesby Reservoir is non-supporting due to elevated PCBs. Fish consumption advisories have been posted (http://www.health.state.mn.us/divs/eh/fish/eating/sitespecific.html). While a number of lakes are impaired, there are five lakes in the watershed that are fully supporting aquatic consumption (Beaver, Dora, German, Jefferson, and Roberds). High levels of mercury in fish tissue are almost entirely from atmospheric deposition from sources within and outside the state and the county. Some sources of mercury include: coal fired power plants, taconite mining, dental fillings, fluorescent light bulbs, cosmetics, and ash from erupting volcanos http://www.pca.state.mn.us/index.php/view-document.html?gid=288. The Statewide Mercury TMDL was approved by the EPA in 2007 and includes all lakes in the Cannon River Watershed except for three lakes (Mazaska, Sabre, and Volney) that had much higher concentrations of mercury in fish than most other lakes. Separate TMDLs for these three lakes will need to be written in the future.

Nutrients

Excess nutrients such as too much phosphorus can cause unsightly and sometimes toxic algal blooms and reduced water clarity. The nutrient impairments in lakes are mostly concentrated in the Upper Cannon River Subwatershed (28 lakes) west of Faribault, with an additional eight lakes outside of that subwatershed that are also impaired. Most of the impaired lakes are in the NCHF ecoregion and agriculture dominates the surrounding land use for most of the individual lake watersheds. A number of larger cities have recently upgraded their wastewater treatment facilities (e.g., Northfield, Owatonna, and Faribault) to reduce phosphorus loading that contributes to downstream waterbody impairments (e.g., Byllesby Reservoir Excess Nutrients TMDL). In addition, there are many smaller cities and communities that have recently upgraded (e.g., Hope) or are in the process of building water treatment facilities. Inspections are also occurring to identify underperforming septic systems. However, other sources will also need to be identified and additional prevention measures applied to greatly improve water quality in lakes, rivers, streams—and wetlands--throughout the watershed. Measures such as mitigating overland run-off from agricultural fields and feedlots, use of lawn-care products free of phosphates, and sweeping grass clippings and leaves off of sidewalks and street curbs are among some of the steps that can be taken. Leaving standing tree lines or planting new windbreaks on the windward shoreline of lakes, as well as property owners using best management practices (such as leaving a natural buffer strip between lawn space and shorelines) can help mitigate the effects of internal nutrient loading in lakes and reduce the duration and severity of summer algal blooms. While many of the lakes in the Cannon River Watershed are highly eutrophic (nutrient rich), five lakes stand out as high quality resources for recreation; Roemhildts, Fish, Dudley, Kelly, and Beaver. These lakes generally benefit from being in relatively intact, small watersheds and from their depth. Protection efforts should be in place to keep the quality of these lakes high.

The draft Minnesota Nutrient Reduction Strategy (MPCA 2013) outlines key measures that could be implemented in urban and agricultural areas in the Mississippi River Basin in Minnesota where phosphorus and nitrogen reductions are needed in order to reduce nutrient loading to Lake Pepin and the Mississippi River. Some best management practices highlighted include: increasing fertilizer use efficiencies through soil testing and application via subsurface banding; increasing living (perennial) cover by using cover crops, increasing riparian buffers and conservation reserve acres; controlling field erosion by using conservation tillage; managing stormwater volume and velocity through wetland restoration and controlled drainage practices; and continued and improved waste management for waste water treatment facilities, septic systems, and feedlots, among others.

Groundwater withdrawals

Another area of emerging concern is the rate and timing of groundwater extraction and the potential effects on the quantity and quality of surface waters. The direct correlation of increasing groundwater withdrawals and decreasing surficial water quantity has been documented in other areas of Minnesota such as Little Rock Creek and White Bear Lake. To provide a detailed a cause and effect between withdrawals and water quantity is beyond the scope of this report. However, statistically significant increases in withdrawals may justify further groundwater review given the unique groundwater and surface water interactions in this predominantly karst watershed.

Through the collaboration of state and local agencies, landowners, and citizens, improvements in water quality will protect drinking water and provide scenic and recreational opportunities that enhance the quality of life and economic vitality of the Cannon River Watershed.

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Appendix 1 - Water chemistry definitions

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

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

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

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

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

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

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

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

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

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

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

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

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

Appendix 2 - Intensive watershed monitoring water chemistry stations in the Cannon River Watershed

Biological Station ID	STORET/ EQuIS ID	Reach Name	Location	Subwatershed
11LM006	S002-532	Belle Creek	Adjacent to CSAH-7, 1.5 mi S of Welch Village	0704000208-01
11LM002	S000-545	Cannon River	At Sakata Singing Hills Trail, N of Morristown Blvd, 2 mi NE of Morristown	704000201-01, -02, -03
00LM002	S003-818	Cannon River	At Hwy 20, in Cannon Falls	0704000206-01
02LM017	S001-766	Cannon River	At Hwy 61, 5 mi E of Welch Village	0704000209-01
00LM007	S002-533	Chub Creek	At CR-83 (Dixie Ave), 0.2 mi S of Randolph	0704000204-01
11LM007	S003-009	Crane Creek	At CSAH-22, No of NW 50th St, in Clinton Falls	0704000202-01
11LM005	S006-521	Heath Creek	At 90th St E, 1.5 mi. W of Northfield	0704000202-02
11LM089	S004-512	Little Cannon River	At CSAH-24 (Felton Ave), 3 mi. SW of Cannon Falls	0704000207-01
11LM009	S001-785	Prairie Creek	At 310th St, 2.5 mi SE of Randolph	0704000205-02
11LM034	S001-343	Straight River	At end of SW 58th St, 6 mi SW of Owatonna	0704000203-02
11LM010	S006-527	Straight River	At 14th St NE, in Faribault	0704000203-01
11LM004	S003-628	Turtle Creek	At SW 22nd Ave, 3 mi SW of Owatonna	0704000203-03
11LM003	S001-397	Wolf Creek	At CSAH-8, 1 mi SW of Dundas	0704000206-03

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

AUID DESCRIPTIONS					USES					BIOLOGICAL CRITERIA		WATER QUALITY STANDARDS						
Assessment Unit ID (AUID)	Stream Reach Name	Reach Description	Reach Length (Miles)	Use Class	Aquatic Life	Aquatic Recreation	Aquatic Consumption	Drinking Water	Class 7	Fish	Macroinvertebrates	Dissolved Oxygen	Turbidity	Chloride	pH	NH3	Pesticides	Bacteria (Aquatic Recreation)
Upper Cannon River Subwatershed																		
07040002-619	County Ditch 63	Unnamed cr to Unnamed cr	0.8	2B	NA*	NA	NA	NA	-	NA*	NA*	--	--	--	--	--	--	--
07040002-621	County Ditch 63	Unnamed cr to Lk Dora	2.4	2B	IF*	NS	NA	NA	-	NA*	NA*	IF	MTS	--	--	--	--	EX
07040002-546	Unnamed ditch	Headwaters to Lk Volney	1.8	2B	IF*	NA	NA	NA	-	--	--	EXP*	EXP	--	MTS	--	--	--
07040002-578	Little Cannon River/ County Ditch 66 (LeSueur County)	Headwaters to Sabre Lk	5.6	2B	IF*	FS	NA	NA	-	NA*	NA*	IF	IF	MTS	--	--	--	MTS
07040002-606	County Ditch 59	Unnamed ditch to Cannon R	3.3	2B	NA*	NA	NA	NA	-	NA*	NA*	--	--	--	--	--	--	--
07040002-614	Judicial Ditch 15	Headwaters to Lk Jefferson	4.3	2B	IF*	NA	NA	NA	-	--	--	EXP*	IF	--	MTS	--	--	--
07040002-711	Unnamed creek	Headwaters to Swede's Bay (Jefferson Lk)	1.0	2B	IF*	NA	NA	NA	-	--	--	EXP*	MTS	--	MTS	--	--	--
07040002-610	County Ditch 9	Unnamed ditch to German Lk	0.7	2B	IF*	NA	NA	NA	-	--	--	EXS*	MTS	--	MTS	--	--	--
07040002-706	Whitewater Creek	Unnamed cr to Waterville Cr	0.7	2B	NS	NS	NA	NA	-	MTS	EXS	EXP	MTS	--	MTS	--	--	EX
07040002-724	Unnamed creek	Unnamed creek to Tetonka Lk	1.6	2B	NA*	NA	NA	NA	-	NA*	NA*	--	--	--	--	--	--	--
07040002-560	Waterville Creek	Hands Marsh to Upper Sakatah Lk	6.4	2B	NS	NS	NA	NA	-	EXS	EXP	--	EXP	--	--	--	--	EX
07040002-577	Devils Creek	Unnamed cr to Cannon R	2.5	2B	NS	NS	NA	NA	-	MTS	EXS	IF	MTS	--	--	--	--	EX
07040002-705	Unnamed creek	Unnamed cr to Cannon R	2.9	2B	NS	NS	NA	NA	-	EXP	IF	EXP	EXP	--	--	--	--	EX
07040002-641	Unnamed creek	Unnamed cr to Cannon Lk	1.9	2B	IF	NA	NA	NA	-	IF	--	--	--	--	--	--	--	--
07040002-576	MacKenzie Creek	T108 R21W S7, west line to Cannon Lk	12.3	2C	NS	NS	NA	NA	-	MTS	EXP	--	MTS	--	--	--	--	EX
07040002-638	Unnamed creek	Unnamed cr to Cannon R	2.0	2B	NS	NA	NA	NA	-	MTS	EXP	--	--	--	--	--	--	--
07040002-702	Unnamed creek	Unnamed cr to Cannon R	4.2	2B	IF*	NS	NA	NA	-	--	--	EXS*	MTS	--	MTS	--	--	EX
07040002-542	Cannon River	Headwaters to Cannon Lk	52.0	2B	NS	NS	NA	NA	-	MTS	EXS	EXS	MTS	MTS	MTS	MTS	IF	EX
07040002-540	Cannon River	Cannon Lk to Straight R	5.0	2B	IF	NS	NA	NA	-	--	--	IF	MTS	MTS	--	--	--	EX

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

AUID DESCRIPTIONS					USES						BIOLOGICAL CRITERIA		WATER QUALITY STANDARDS						
Assessment Unit ID (AUID)	Stream Reach Name	Reach Description	Reach Length (Miles)	Use Class	Aquatic Life	Aquatic Recreation	Aquatic Consumption	Drinking Water	Class 7		Fish	Macroinvertebrates	Dissolved Oxygen	Turbidity	Chloride	pH	NH3	Pesticides	Bacteria (Aquatic Recreation)
Crane Creek Subwatershed																			
07040002-727	Unnamed ditch	JD1 to JD1	1.1	2B	NA*	NA	NA	NA	-		NA*	NA*	--	--	--	--	--	--	--
07040002-593	Judicial Ditch 1	Hayes Lake to CD11	1.5	2B	NA*	NA	NA	NA	-		NA*	--	--	--	--	--	--	--	--
07040002-733	County Ditch 21	Unnamed ditch to JD1	3.0	2B	NA*	NA	NA	NA	-		NA*	NA*	--	--	--	--	--	--	--
07040002-556	Judicial Ditch 1	Unnamed cr to Crane Cr	4.3	2B	IF*	NA	NA	NA	-		NA*	NA*	--	EXP	--	--	--	--	--
07040002-516	Crane Creek	Headwaters (Watkins Lk 81-0013-00) to Straight R	15.5	2C	IF*	NS	NA	**NA**	-		NA*	NA*	IF	EXP	MTS	MTS	MTS	IF	EX
Lower Straight River Subwatershed																			
07040002-731	Unnamed creek	Unnamed cr to Unnamed cr	1.9	2B	NS	NA	NA	NA	-		MTS	EXP	--	--	--	--	--	--	--
07040002-729	Unnamed creek	Headwaters to Maple Cr	3.5	2B	FS	NA	NA	NA	-		MTS	MTS	--	--	--	--	--	--	--
07040002-519	Maple Creek	Headwaters to Straight R	12.9	2B	FS	NS	NA	NA	-		EXP	MTS	IF	MTS	--	MTS	MTS	--	EX
07040002-726	Unnamed creek	Headwaters to Medford Cr	6.7	2B	FS	NA	NA	NA	-		MTS	MTS	--	--	--	--	--	--	--
07040002-547	Medford Creek	Headwaters to Straight R	12.1	2B	NS	NA	NA	NA	-		EXP	EXP	--	--	--	--	--	IF	--
07040002-604	Unnamed creek	Unnamed cr to Unnamed cr	2.3	2**B**	IF	NA	NA	NA	-		--	--	--	MTS	--	--	--	--	--
07040002-505	Rush Creek	Headwaters to Straight R	15.2	2B	NS	NS	NA	NA	-		MTS	MTS	IF	EXP	--	MTS	MTS	--	EX
07040002-704	Falls Creek	Unnamed cr to Straight R	3.8	2B	FS	NS	NA	NA	-		MTS	MTS	IF	MTS	--	MTS	--	--	EX
07040002-574	Mud Creek	JD6 to Straight River	8.6	2C	NA*	NA	NA	NA	-		NA*	NA*	--	--	--	--	--	--	--
07040002-535	Straight River	Turtle Cr to Owatonna Dam	7.4	2B	FS	NS	NA	NA	-		MTS	MTS	IF	MTS	--	MTS	MTS	IF	EX
07040002-503	Straight River	Maple Cr to Crane Cr	5.8	2B	NS	NS	NA	NA	-		EXP	EXP	MTS	EXP	MTS	MTS	MTS	MTS	EX
07040002-536	Straight River	Crane Cr to Rush Cr	6.7	2B	NS	NA	NA	NA	-		EXP	EXP	--	EXP	--	--	--	--	--
07040002-515	Straight River	Rush Cr to Cannon R	13.3	2B	NS	NS	NA	NA	-		EXP	EXP	MTS	EXP	MTS	MTS	MTS	MTS	EX
07040002-537	Straight River	Owatonna Dam to Maple Cr	0.9	2B	FS	NA	NA	NA	-		--	--	MTS	MTS	MTS	--	--	--	--

AUID DESCRIPTIONS					USES						BIOLOGICAL CRITERIA		WATER QUALITY STANDARDS						
Assessment Unit ID (AUID)	Stream Reach Name	Reach Description	Reach Length (Miles)	Use Class	Aquatic Life	Aquatic Recreation	Aquatic Consumption	Drinking Water	Class 7		Fish	Macroinvertebrates	Dissolved Oxygen	Turbidity	Chloride	pH	NH3	Pesticides	Bacteria (Aquatic Recreation)
Upper Straight River Subwatershed																			
07040002-732	Unnamed creek	Headwaters to Unnamed cr	6.7	2B	IF*	NA	NA	NA	-		MTS	EXP*	--	--	--	--	--	--	--
07040002-524	County Ditch 64	Headwaters to Straight R	7.7	2B	NA*	NA	NA	NA	-		NA*	NA*	--	--	--	--	--	--	--
07040002-531	Unnamed ditch	Unnamed ditch to CD 64	4.8	2B	NA*	NA	NA	NA	-		NA*	NA*	--	--	--	--	--	--	--
07040002-698	County Ditch 5	Unnamed ditch to Straight R	4.1	2B	NA*	NA	NA	NA	-		NA*	NA*	--	--	--	--	--	--	--
07040002-534	Straight River	Headwaters to unnamed cr	10.2	2B	NA*	NA	NA	NA	-		NA*	NA*	--	--	--	--	--	--	--
07040002-532	Straight River	CD 64 to CD 25	2.0	2B	NA*	NA	NA	NA	-		NA*	--	--	--	--	--	--	--	--
07040002-525	Unnamed creek	Headwaters to Straight R	11.8	2B	FS	NA	NA	NA	-		MTS	MTS	--	--	--	--	--	--	--
07040002-517	Straight River	CD 25 to Turtle Cr	11.2	2B	FS	NS	NA	NA	-		MTS	MTS	IF	MTS	MTS	MTS	MTS	--	EX
Turtle Creek Subwatershed																			
07040002-518	Turtle Creek	Headwaters to Straight R	19.2	2B	FS	NS	NA	NA	-		MTS	MTS	IF	MTS	MTS	MTS	MTS	IF	EX
Chub Creek Subwatershed																			
07040002-719	Unnamed creek	Unnamed cr to Unnamed cr	0.8	2B	FS	NA	NA	NA	-		MTS	MTS	--	--	--	--	--	--	--
07040002-572	Dutch Creek	Headwaters to Chub Cr	9.3	2C	IF†	NA	NA	NA	-		EXP	EXP	EXP	--	--	--	--	--	--
07040002-558	Mud Creek	Unnamed cr to Chub Cr	2.5	2B	FS	IF	NA	NA	-		MTS	MTS	EXP	MTS	--	MTS	MTS	--	EX
07040002-566	Chub Creek, North Branch	T113 R19W S19, west line to Chub Cr	7.1	2C	NA*	NA	NA	NA	-		NA*	NA*	--	--	--	--	--	--	--
07040002-528	Chub Creek	Headwaters to Cannon R	24.7	2B	NS	NS	NA	NA	-		EXP	EXP	IF	MTS	MTS	MTS	MTS	IF	EX

Full Support (FS); Not Supporting (NS); Insufficient Data (IF); Not Assessed (NA); Meets standards or ecoregion expectations (MT/MTS), Potential Exceedence (EXP), Exceeds standards or ecoregion expectations (EX/EXS). Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use; previous impairment, delisting proposed. *Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream. †Not assessed, additional monitoring recommended.

AUID DESCRIPTIONS					USES						BIOLOGICAL CRITERIA		WATER QUALITY STANDARDS						
Assessment Unit ID (AUID)	Stream Reach Name	Reach Description	Reach Length (Miles)	Use Class	Aquatic Life	Aquatic Recreation	Aquatic Consumption	Drinking Water	Class 7		Fish	Macroinvertebrates	Dissolved Oxygen	Turbidity	Chloride	pH	NH3	Pesticides	Bacteria (Aquatic Recreation)
Prairie Creek Subwatershed																			
07040002-513	Unnamed creek	Unnamed cr to Unnamed cr	5	2B	NA	NA	NA	NA	-		--	--	--	--	--	--	--	--	--
07040002-587	Unnamed creek	Unnamed cr to Unnamed cr	0.8	2B	NS	NA	NA	NA	-		MTS	EXP	NR	NR	--	NR	NR	--	--
07040002-512	Unnamed creek	Headwaters to Prairie Cr	3.0	2B	**NS**	NA	NA	NA	-		MTS	EXS	--	EXS	--	--	--	--	--
07040002-723	Unnamed creek	Unnamed cr to Prairie Cr	2.1	2B	**NS**	NA	NA	NA	-		EXP	EXS	--	--	--	--	--	--	--
07040002-504	Prairie Creek	Headwaters to Lk Byllesby	28.8	2C	NS	NS	NA	NA	-		MTS	EXP	IF	EXP	MTS	MTS	MTS	--	EX
Middle Cannon River Subwatershed																			
07040002-703	Unnamed creek	Unnamed cr to Cannon R	2.2	2B	FS	NS	NA	NA	-		MTS	MTS	IF	MTS	--	MTS	--	--	EX
07040002-716	Unnamed cree,	Headwaters to Cannon R	1.0	2B	IF	NA	NA	NA	-		--	--	--	MTS	--	--	--	--	--
07040002-562	Unnamed creek (Spring Brook)	Headwaters to T111 R20W S9, north line	3.7	2B	IF	NS	NA	NA	-		--	--	--	MTS	--	--	--	--	EX
07040002-557	Unnamed creek (Spring Brook)	Unnamed cr to Cannon R	1.9	1B, 2A	NS	NA	NA	NS	-		MTS	EXP	NR	EXS	--	NR	NR	M TS	EX
07040002-568	Unnamed creek (Spring Creek)	Unnamed cr to Cannon R	4.0	2B	IF	FS	NA	NA	-		--	--	IF	MTS	--	MTS	--	--	M TS
07040002-591	Spring Creek	Unnamed cr to Unnamed cr	4.1	2B	NS	NA	NA	NA	-		MTS	EXP	--	--	--	--	--	--	--
07040002-581	Cannon River	Straight R to T110 R20W S19, SE1/4 line	0.9	2B	NA	NA	NS	NA	-		--	--	--	--	--	--	--	--	NA
07040002-582	Cannon River	T110 R20W S19, NE1/4 line to Wolf Cr	11.2	2B	NS	NS	NS	NA	-		EXP	EXS	IF	MTS	--	EXP	--	--	EX
07040002-507	Cannon River	Wolf Cr to Heath Cr	3.0	2B	NS	NS	NS	NA	-		MTS	EXP	IF	EXP	MTS	--	--	--	EX
07040002-508	Cannon River	Heath Cr to Northfield Dam	1.6	2B	NS	NS	NS	NA	-		--	--	IF	EXS	MTS	MTS	--	--	EX
07040002-509	Cannon River	Northfield Dam to Lk Byllesby inlet	10.5	2B	NS	IF	NS	NA	-		EXP	EXP	IF	EXP	MTS	--	IF	--	IF
07040002-539	Cannon River	Byllesby Dam to Little Cannon R	2.8	2B	NS	FS	NS	NA	-		MTS	EXP	IF	MTS	MTS	MTS	MTS	--	M TS

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Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use; = previous impairment, delisting proposed.*Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream. #Reach was assessed based on use class included in table and existing use class as defined in Minn. Rule 7050 is different. MPCA is currently in the process of changing the existing use class for this AUID in rule based on an analysis of the biological community and temperature data. †Not assessed, additional monitoring recommended.

AUID DESCRIPTIONS					USES						BIOLOGICAL CRITERIA		WATER QUALITY STANDARDS							
Assessment Unit ID (AUID)	Stream Reach Name	Reach Description	Reach Length (Miles)	Use Class	Aquatic Life	Aquatic Recreation	Aquatic Consumption	Drinking Water	Class 7		Fish	Macroinvertebrates	Dissolved Oxygen	Turbidity	Chloride	pH	NH3	Pesticides	Bacteria (Aquatic Recreation)
Heath Creek Subwatershed																			
07040002-603	Knowles Creek	Unnamed cr to Union Lk	2.1	2B	IF*	NA	NA	NA	-		NA*	NA*	--	MTS	--	--	--	--	--
07040002-530	Unnamed ditch	Headwaters to T112 R22W S36, south line	2.4	7	NA*	NA	NA	NA	IF		NA*	NA*	IF	--	--	MTS	--	--	--
07040002-555	Unnamed ditch	T111 R22W S1, north line to Unnamed cr	0.6	2B	NS	NA	NA	NA	-		EXS	EXP	--	--	--	--	--	--	--
07040002-529	Unnamed creek	Unnamed cr to Union Lk	6.2	2B	IF*	NA	NA	NA	-		NA*	NA*	--	MTS	--	--	--	--	--
07040002-521	Heath Creek	Headwaters (Union Lk 66-0032-00) to Cannon R	13.4	2B	IF†	NS	NA	NA	-		IF†	IF†	MTS	MTS	MTS	MTS	MTS	--	EX
Wolf Creek Subwatershed																			
07040002-628	Unnamed creek	Unnamed cr to Unnamed cr	1.6	2B	IF†	NA	NA	NA	--		EXS	EXP	IF	MTS	--	MTS	MTS	--	
07040002-522	Wolf Creek	Headwaters (Circle Lk 66-0027-00) to Cannon R	10.1	2B	NS	NS	NA	NA	--		EXP	MTS	MTS	EXP	MTS	MTS	MTS	IF	EX
Little Cannon River Subwatershed																			
07040002-670	Unnamed creek (Little Cannon River Tributary)	T110 R18W S12, south line to Unnamed cr	0.4	2B#	NS#	NA	NA	NA	-		MTS	EXP#	--	--	--	--	--	--	--
07040002-639	Unnamed creek (Little Cannon River Tribuatry)	T110 R18W S1, east line to Little Cannon R	0.6	2B#	NS#	NA	NA	NA	-		MTS	EXP#	--	--	--	--	--	--	--
07040002-590	Butler Creek	Unnamed cr to Little Cannon R	2.1	2B	NS	NS	NA	NA	-		MTS	EXP	IF	IF	MTS	MTS	MTS	--	EX
07040002-553	Little Cannon River (Goodhue County)	Headwaters to T110 R10W S9, east line	6.7	2B	IF	NA	NA	NA	-		--	--	--	MTS	--	--	--	--	--
07040002-589	Little Cannon River (Goodhue County)	T110 R18W S10, west line to T111 R18W S13, east line	12.1	1B, 2A	NS	NA	NA	NS	-		EXS	EXS	IF	EXS	--	MTS	IF	--	EX
07040002-526	Little Cannon River (Goodhue County)	T111 R17W S18, west line to Cannon R	11.9	2B	NS	NS	NA	NA	-		EXP	EXP	MTS	EXS	MTS	MTS	MTS	M TS	EX
Belle Creek Subwatershed																			
07040002-721	Unnamed creek	Unnamed cr to Belle Cr	1.2	2B	IF*	NA	NA	NA	-		MTS	EXP*	--	--	--	--	--	--	--
07040002-699	Unnamed creek	Unnamed cr to Belle Cr	0.6	2B	IF	NS	NA	NA	-		--	--	IF	MTS	MTS	MTS	MTS	--	EX
07040002-735	Belle Creek	Headwaters to Hwy 19	18.6	2B	NS	NS	NA	NA	-		MTS	EXP	IF	EXP	--	--	--	--	EX
07040002-734	Belle Creek	Hwy 19 to Cannon R	7.9	2A #	NS	NS	NA	NA	-		EXP#	EXP#	IF	EXP	MTS	MTS	MTS	--	EX

Full Support (FS); Not Supporting (NS); Insufficient Data (IF); Not Assessed (NA); Meets standards or ecoregion expectations (MT/MTS), Potential Exceedence (EXP), Exceeds standards or ecoregion expectations (EX/EXS).
Key for Cell Shading: = existing impairment, listed prior to 2012 reporting cycle; = new impairment; = full support of designated use; = previous impairment, list correction proposed. *Aquatic Life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream. #Reach was assessed based on use class included in table and existing use class as defined in Minn. Rule 7050 is different. MPCA is currently in the process of changing the existing use class for this AUID in rule based on an analysis of the biological community and temperature data. †Not assessed, additional monitoring recommended.

AUID DESCRIPTIONS				USES						BIOLOGICAL CRITERIA		WATER QUALITY STANDARDS						
Assessment Unit ID (AUID)	Stream Reach Name	Reach Description	Reach Length (Miles)	Use Class	Aquatic Life	Aquatic Recreation	Aquatic Consumption	Drinking Water	Class 7	Fish	Macroinvertebrates	Dissolved Oxygen	Turbidity	Chloride	pH	NH3	Pesticides	Bacteria (Aquatic Recreation)
Lower Cannon River Subwatershed																		
07040002-520	Pine Creek	T113 R18W S26, west line to Cannon R	6.0	1B, 2A	IF*	IF	NA	NS	-	MTS	MTS	EXS*	MTS	--	MTS	MTS	MTS	IF
07040002-580	Unnamed creek (Trib to Trout Brook)	Unnamed cr to Unnamed cr	0.5	1B, 2A	NS	IF	NA	NA	-	MTS	EXP	EXS	MTS	--	MTS	MTS	--	IF
07040002-573	Unnamed creek (Trout Brook)	T113 R17W S27, west line to Unnamed cr	1.6	1B, 2A	NS	IF	NA	NA	-	MTS	EXS	IF	MTS	--	MTS	MTS	--	IF
07040002-567	Unnamed creek (Trout Brook)	Unnamed cr to Cannon R (trout stream portion)	3.0	1B, 2A	FS	IF	NA	NS	-	MTS	MTS	IF	MTS	--	MTS	MTS	MTS	IF
07040002-569	Spring Creek	T112 R15W S18, west line to T113 R15W S34, north line	8.9	1B, 2A	NS	NS	NA	NA	-	MTS	MTS	IF	EXS	MTS	MTS	MTS	--	EX
07040002-571	Spring Creek	T113 R15W S27, south line to Spring Creek Lk	3.5	2B	NS	NA	NA	NA	-	MTS	MTS	--	EXP	--	--	--	--	--
07040002-538	Cannon River	Little Cannon R to Pine Cr	2.6	2B	NA	NA	NS	NA	-	--	--	--	--	--	--	--	--	--
07040002-502	Cannon River	Pine Cr to Belle Cr	11.5	2B	NS	NS	NS	NA	-	MTS	MTS	IF	EXP	MTS	MTS	MTS	MTS	EX
07040002-501	Cannon River	Belle Cr to split near mouth	8.6	2B	FS	NS	NS	NA	-	MTS	MTS	IF	EXP	MTS	MTS	MTS	--	EX
07040002-646	Cannon River	North branch of split to Vermillion R	1.7	2B	NS	NA	NS	NA	-	--	--	IF	EXP	--	--	--	--	--

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

Appendix 3.2 - Assessment results for lakes in the Cannon River Watershed

Lake ID	Lake Name	County	Subwatershed	Ecoregion	Lake Area (acres)	Max Depth (m)	Watershed Area (acres)	% Littoral	Mean depth (m)	Aquatic Recreation Support Status	Aquatic Consumption Support Status
190006	Byllesby	Dakota	70400020605	WCBP	2255	15.2	733,166	68	3.2	NS	NS
190020	Chub	Dakota	70400020402	NCHF	301	2.9	1,487	100	1.0*	NS	NA
400001	Horseshoe	Le Sueur	70400020106	NCHF	400	7.9	3,032	81	3.1	NS	NA
400002	Upper Sakatah	Le Sueur	70400020106	NCHF	881	3.0	131,907	100	1.9	NS	NS
400009	Sunfish	Le Sueur	70400020104	NCHF	116	9.1	471	60	3.4	NS	NA
400010	Dora	Le Sueur	70400020102	NCHF	760	1.8	11,788	100	1.0*	NS	FS
400011	Mabel	Le Sueur	70400020104	NCHF	103	2.4*	834	100	1.0*	NS	NA
400013	Diamond	Le Sueur	70400020104	NCHF	120	0.9*	2,164	100	0.5*	IF	NA
400014	Sabre	Le Sueur	70400020104	NCHF	253	4.0	56,166	100	1.0*	NS	NS
400031	Tetonka	Le Sueur	70400020106	NCHF	1336	9.5	105,585	39	5.0	NS	NS
400032	Gorman	Le Sueur	70400020104	NCHF	590	4.3	44,099	100	2.1	NS	NS
400033	Volney	Le Sueur	70400020104	NCHF	268	20.4	2,017	46	6.6	IF	NS
400039	Roemhildts	Le Sueur	70400020103	NCHF	88	18.3	171	61	8.5	FS	NA
400044	Steele	Le Sueur	70400020103	NCHF	75	8.2	823	77	2.6	IF	NA
400048	Silver	Le Sueur	70400020106	NCHF	17	--	125	100	1.0*	NS	NA
400051	Fish	Le Sueur	70400020106	NCHF	84	16.2	841	42	5.5	FS	NA
400054	Perch	Le Sueur	70400020106	NCHF	31	--	266	100	1	NS	NA
400056	Rays	Le Sueur	70400020106	NCHF	153	9.7	424	90	2.3	IF	NA
400057	Frances	Le Sueur	70400020106	NCHF	870	18.3	4,107	63	--	IF	NS
400059	Round	Le Sueur	70400020106	NCHF	135	--	1,002	100	1.0*	IF	NA
400061	Tustin	Le Sueur	70400020106	NCHF	153	1.5	4,868	100	1.0*	NS	NA
400063	German	Le Sueur	70400020103	NCHF	975	15.4	19,355	58	4.1	NS	FS
40009201	East Jefferson	Le Sueur	70400020103	NCHF	646	11.3	10,404	48	5.0	NS	FS
40009202	West Jefferson	Le Sueur	70400020103	NCHF	439	7.3	1,028	77	2.7	NS	FS
40009203	Swede's Bay	Le Sueur	70400020103	NCHF	492	1.8	5,776	100	0.7	NS	NA
40009204	Middle Jefferson	Le Sueur	70400020103	NCHF	664	2.4	2,781	100	1.3	NS	FS

Lake ID	Lake Name	County	Subwatershed	Ecoregion	Lake Area (acres)	Max Depth (m)	Watershed Area (acres)	% Littoral	Mean depth (m)	Aquatic Recreation Support Status	Aquatic Consumption Support Status
660007	Faribault	Rice	70400020109	NCHF	57	--	212,733	--	--	NA	NA
660008	Cannon	Rice	70400020109	NCHF	1476	4.6	189,163	100	2.5	NS	NS
660010	Wells	Rice	70400020109	NCHF	634	1.2	205,160	100	1.0*	NS	NS
660014	Dudley	Rice	70400020108	NCHF	83	18.2	220	43	4.5	FS	NA
660015	Kelly	Rice	70400020108	NCHF	62	15.2	703	79	2.8	FS	NA
660018	Roberds	Rice	70400020108	NCHF	654	11.6	9,564	77	3.1	NS	FS
660027	Circle	Rice	70400020602	NCHF	976	4.3	21,414	100	1.6	NS	NS
660029	Fox	Rice	70400020602	NCHF	330	14.0	8,752	48	5.9	NS	NA
660032	Union	Rice	70400020603	NCHF	437	3.0	19,009	100	1.0*	NS	NA
660038	French	Rice	70400020108	NCHF	842	15.4	4,300	43	5.0	NS	NS
660039	Mazaska	Rice	70400020602	NCHF	687	15.2	2,980	49	5.1	NS	NS
660044	Lower Sakatah	Rice	70400020106	NCHF	341	2.1	139,383	100	1.0*	NS	NS
660045	Sprague	Rice	70400020107	NCHF	161	--	533	--	--	NA	NA
660047	Hunt	Rice	70400020101	NCHF	190	8.2	645	84	3.0	NS	NS
660048	Rice	Rice	70400020101	NCHF	330	2.0	12,898	100	1.0*	NS	NA
660050	Caron	Rice	70400020107	NCHF	406	1.2	8,484	100	1.0*	NS	NA
660052	Cedar	Rice	70400020107	NCHF	927	12.8	4,722	73	2.8	NS	NS
660055	Shields	Rice	70400020101	NCHF	877	12.8	7,196	74	3.1	NS	NS
660057	Logue	Rice	70400020602	NCHF	100	11.6	895	100	--	NA	NA
740023	Beaver	Steele	70400020304	WCBP	90	8.2	295	45	4.4	FS	FS
810013	Watkins	Waseca	70400020201	WCBP	148	8.2	20,101	--	--	NA	NA
810014	Clear	Waseca	70400020201	WCBP	648	7.6	3,051	75	3.0	NS	NS
810015	Loon	Waseca	70400020201	WCBP	119	2.4	272	100	1.5	NS	NS
810016	Goose	Waseca	70400020201	WCBP	370	7.3	6,914	100	--	NA	NA
810022	Rice	Waseca	70400020201	WCBP	412	2.7	12,186	--	--	NA	NA
810058	Toner's	Waseca	70400020105	NCHF	127	--	298	100	1.0*	NS	NA

Abbreviations: **FS** – Full Support **NS** – Non-Support **IF** – Insufficient Information **NA** – Not Assessed

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

*These depths were created by MPCA Staff.

Appendix 4.1 - Minnesota statewide IBI thresholds and confidence limits

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

Appendix 4.2 - Biological monitoring results – fish IBI for natural (non-channelized) reaches

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Threshold	FIBI	Visit Date
Upper Cannon River Subwatershed (0704000201, -02, -03)							
07040002-641	11LM070	Unnamed creek	4.4	3	51	42	03-Aug-11
07040002-705	11LM058	Unnamed creek	6.3	3	51	40	03-Aug-11
07040002-542	11LM082	Cannon River	15.4	3	51	63	10-Aug-11
07040002-638	11LM078	Unnamed creek	15.7	3	51	58	16-Aug-11
07040002-706	11LM057	Whitewater Creek	15.8	3	51	66	10-Aug-11
07040002-577	11LM045	Devils Creek	18.6	3	51	59	09-Aug-11
07040002-560	04LM080	Waterville Creek	19.4	3	51	35	05-Aug-04
07040002-560	04LM080	Waterville Creek	19.4	3	51	55	09-Aug-11
07040002-576	11LM056	MacKenzie Creek	23.1	3	51	76	11-Aug-11
07040002-542	11LM095	Cannon River	51.3	2	45	63	12-Sep-11
07040002-542	04LM081	Cannon River	96.1	2	45	53	17-Aug-04
07040002-542	11LM083	Cannon River	142.0	2	45	69	12-Sep-11
07040002-542	11LM002	Cannon River	256.8	2	45	77	13-Sep-11
Crane Creek Subwatershed (0704000202)							
NONE							
Lower Straight River Subwatershed (0704000203-01)							
07040002-547	10EM075	Medford Creek	0.2	3	51	70	14-Jul-10
07040002-547	10EM075	Medford Creek	0.2	3	51	73	25-Aug-10
07040002-729	11LM022	Unnamed creek	6.1	3	51	56	02-Aug-11
07040002-729	11LM022	Unnamed creek	6.1	3	51	66	22-Aug-11
07040002-547	11LM063	Medford Creek	6.5	3	51	39	02-Aug-11
07040002-726	11LM064	Unnamed creek	7.1	3	51	65	03-Aug-11
07040002-704	11LM069	Falls Creek	12.0	3	51	60	04-Aug-11
07040002-704	11LM069	Falls Creek	12.0	3	51	57	16-Aug-11
07040002-731	11LM061	Unnamed creek	12.5	3	51	62	02-Aug-11
07040002-731	11LM061	Unnamed creek	12.5	3	51	72	22-Aug-11
07040002-547	11LM065	Medford Creek	21.1	3	51	69	02-Aug-11

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi²	Fish Class	Threshold	FIBI	Visit Date
07040002-505	11LM067	Rush Creek	21.4	3	51	75	16-Aug-11
07040002-519	11LM062	Maple Creek	26.3	3	51	56	13-Sep-11
07040002-519	11LM011	Maple Creek	37.9	2	45	49	15-Aug-11
07040002-535	11LM043	Straight River	195.1	2	45	63	16-Aug-11
07040002-503	04LM120	Straight River	247.0	2	45	40	29-Jun-04
07040002-503	04LM120	Straight River	247.0	2	45	72	16-Aug-11
07040002-503	10EM011	Straight River	250.9	2	45	45	21-Jul-10
07040002-503	10EM011	Straight River	250.9	2	45	69	17-Aug-11
07040002-536	11LM088	Straight River	361.6	1	46	46	17-Aug-11
07040002-536	11LM088	Straight River	361.6	1	46	63	13-Sep-11
07040002-515	04LM014	Straight River	412.0	1	46	39	13-Sep-04
07040002-515	11LM092	Straight River	435.8	1	46	61	17-Aug-11
07040002-515	11LM010	Straight River	461.8	1	46	54	18-Aug-11
Upper Straight River Subwatershed (0704000203-02)							
07040002-732	11LM038	Unnamed creek	5.8	3	51	70	27-Jul-11
07040002-525	11LM036	Unnamed creek	8.3	3	51	41	27-Jul-11
07040002-525	11LM008	Unnamed creek	17.9	3	51	62	27-Jul-11
07040002-525	11LM039	Unnamed creek	29.1	3	51	74	13-Jun-11
07040002-517	04LM131	Straight River	117.2	2	45	43	29-Jun-04
07040002-517	04LM131	Straight River	117.2	2	45	48	14-Jun-11
07040002-517	11LM034	Straight River	133.1	2	45	63	16-Aug-11
Turtle Creek Subwatershed (0704000203-03)							
07040002-518	11LM035	Turtle Creek	28.2	3	51	71	14-Jun-11
07040002-518	11LM004	Turtle Creek	41.4	2	45	44	14-Jun-11
Chub Creek Subwatershed (0704000204)							
07040002-719	11LM071	Unnamed creek	7.4	3	51	57	13-Sep-11
07040002-558	11LM017	Mud Creek	9.9	3	51	71	10-Aug-11
07040002-572	11LM044	Dutch Creek	23.9	7	40	17	11-Aug-11
07040002-572	04LM143	Dutch Creek	24.4	3	51	36	04-Aug-04
07040002-528	11LM016	Chub Creek	32.0	2	45	39	13-Sep-11

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Threshold	FIBI	Visit Date
07040002-528	11LM012	Chub Creek	53.4	2	45	56	11-Aug-11
07040002-528	10EM087	Chub Creek	54.8	2	45	36	02-Aug-10
07040002-528	00LM007	Chub Creek	84.0	2	45	65	10-Aug-11
Prairie Creek Subwatershed (0704000205)							
07040002-723	11LM054	Unnamed creek	8.4	3	51	57	18-Aug-11
07040002-587	11LM077	Unnamed creek	10.4	3	51	70	04-Aug-11
07040002-512	11LM075	Unnamed creek	16.7	3	51	68	10-Aug-11
07040002-504	11LM055	Prairie Creek	45.3	2	45	50	07-Sep-11
07040002-504	04LM059	Prairie Creek	77.3	2	45	49	06-Jul-04
07040002-504	11LM009	Prairie Creek	79.7	2	45	55	10-Aug-11
07040002-504	11LM009	Prairie Creek	79.7	2	45	57	14-Sep-11
Middle Cannon River Subwatershed (0704000206-01)							
07040002-557	04LM077	Unnamed creek (Spring Brook)	5.9	10	45	80	12-Jul-04
07040002-557	04LM077	Unnamed creek (Spring Brook)	5.9	10	45	68	14-Jun-11
07040002-557	11LM099	Unnamed creek (Spring Brook)	6.5	10	45	65	14-Jun-11
07040002-703	11LM096	Unnamed creek	8.1	3	51	62	11-Aug-11
07040002-591	04LM046	Spring Creek	9.2	3	51	63	06-Jul-04
07040002-591	11LM094	Spring Creek	11.3	3	51	70	18-Aug-11
07040002-582	11LM068	Cannon River	812.0	1	46	47	20-Sep-11
07040002-582	04LM078	Cannon River	831.7	1	46	26	23-Aug-04
07040002-507	11LM086	Cannon River	876.6	1	46	80	15-Sep-11
07040002-509	11LM097	Cannon River	944.7	1	46	42	06-Sep-11
07040002-539	00LM002	Cannon River	1156.8	1	46	76	06-Sep-11
Health Creek Subwatershed (0704000206-02)							
07040002-530	11LM031	Unnamed ditch	3.1	3	51	25	04-Aug-11
07040002-555	04LM083	Unnamed ditch	3.4	3	51	44	18-Jun-04
07040002-555	04LM083	Unnamed ditch	3.4	3	51	32	15-Aug-11
07040002-521	04LM076	Heath Creek	34.2	2	45	12	04-Aug-04
07040002-521	11LM005	Heath Creek	40.1	2	45	58	07-Sep-11

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Threshold	FIBI	Visit Date
Wolf Creek Subwatershed (0704000206-03)							
07040002-628	04LM084	Unnamed creek	7.4	3	51	0	18-Jun-04
07040002-625	11LM073	Unnamed creek	14.7	3	51	29	09-Aug-11
07040002-522	11LM003	Wolf Creek	42.0	2	45	50	13-Sep-11
Little Cannon River Subwatershed (0704000207)							
07040002-670	11LM023	Unnamed creek	6.7	3	51	83	17-Aug-11
07040002-590	04LM085	Butler Creek	9.6	3	51	66	24-Jun-04
07040002-590	04LM085	Butler Creek	9.6	3	51	78	08-Aug-11
07040002-639	11LM027	Unnamed creek	11.3	3	51	74	17-Aug-11
07040002-589	11LM025	Little Cannon River	12.3	3	51	65	14-Sep-11
07040002-589	11LM024	Little Cannon River	20.0	3	51	77	10-Aug-11
07040002-589	04LM086	Little Cannon River	50.5	2	45	58	01-Jul-04
07040002-589	04LM086	Little Cannon River	50.5	2	45	54	19-Aug-04
07040002-589	04LM086	Little Cannon River	50.5	2	45	57	09-Aug-11
07040002-526	04LM038	Little Cannon River	58.0	2	45	58	29-Jul-04
07040002-526	11LM089	Little Cannon River	80.9	2	45	47	09-Aug-11
Belle Creek Subatershed (0704000208)							
07040002-735	11LM026	Belle Creek	9.6	3	51	50	17-Aug-11
07040002-721	11LM028	Unnamed creek	10.8	3	51	73	17-Aug-11
07040002-735	11LM029	Belle Creek	24.4	3	51	82	08-Sep-11
07040002-735	11LM030	Belle Creek	56.1	2	45	57	08-Aug-11
07040002-735	04LM090	Belle Creek	69.6	2	45	70	26-Jul-04
07040002-735	04LM090	Belle Creek	69.6	2	45	65	08-Aug-11
07040002-734	11LM006	Belle Creek	76.8	10	45	57	09-Aug-11
Lower Cannon River Subwatershed (0704000209)							
07040002-580	99LM005	Unnamed creek (Trout Brook)	10.4	10	45	94	15-Jun-11
07040002-573	04LM144	Unnamed creek (Trout Brook)	15.1	10	45	98	24-Jun-04
07040002-573	04LM144	Unnamed creek (Trout Brook)	15.1	10	45	97	18-Aug-04
07040002-573	04LM144	Unnamed creek (Trout Brook)	15.1	10	45	98	15-Jun-11

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Threshold	FIBI	Visit Date
07040002-569	04LM037	Spring Creek	16.0	10	45	72	18-Aug-04
07040002-569	11LM014	Spring Creek	21.6	10	45	59	25-Aug-11
07040002-520	99LM002	Pine Creek	21.8	10	45	73	08-Aug-11
07040002-571	11LM015	Spring Creek	24.4	3	51	82	08-Sep-11
07040002-567	99LM001	Unnamed creek (Trout Brook)	28.1	10	45	82	15-Jun-11
07040002-567	99LM001	Unnamed creek (Trout Brook)	28.1	10	45	84	25-Aug-11
07040002-502	04LM055	Cannon River	1296.0	1	46	67	30-Aug-04
07040002-502	04LM055	Cannon River	1296.0	1	46	66	20-Sep-11
07040002-502	11LM090	Cannon River	1340.2	1	46	72	21-Sep-11
07040002-502	10EM175	Cannon River	1341.4	1	46	56	26-Aug-10
07040002-501	11LM098	Cannon River	1436.7	1	46	77	21-Sep-11

Appendix 4.3 - Biological monitoring results-macroinvertebrate IBI for natural (non-channelized) reaches

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Invert Class	Threshold	M-IBI	Visit Date
Upper Cannon River Subwatershed (0704000201, -02, -03)							
07040002-705	11LM058	Unnamed creek	6.3	6	46.8	35.8	16-Aug-11
07040002-542	11LM082	Cannon River	15.4	6	46.8	14.8	17-Aug-11
07040002-638	11LM078	Unnamed creek	15.7	6	46.8	38.2	17-Aug-11
07040002-706	11LM057	Whitewater Creek	15.8	6	46.8	27.5	09-Aug-11
07040002-577	11LM045	Devils Creek	18.6	6	46.8	20.4	17-Aug-11
07040002-577	11LM045	Devils Creek	18.6	6	46.8	29.8	17-Aug-11
07040002-560	04LM080	Waterville Creek	19.4	5	35.9	18.0	25-Aug-04
07040002-560	04LM080	Waterville Creek	19.4	5	35.9	39.6	16-Aug-11
07040002-576	11LM056	MacKenzie Creek	23.1	6	46.8	42.4	15-Aug-11
07040002-542	11LM095	Cannon River	51.3	6	46.8	12.1	16-Aug-11
07040002-542	04LM081	Cannon River	96.1	6	46.8	9.4	25-Aug-04
07040002-542	11LM083	Cannon River	142.0	6	46.8	9.3	09-Aug-11
Crane Creek Subwatershed (0704000202)							
NONE							
Lower Straight River Subwatershed (0704000203-01)							
07040002-547	10EM075	Medford Creek	0.2	5	44.7	35.9	10-Aug-10
07040002-729	11LM022	Unnamed creek	6.1	6	47.9	46.8	10-Aug-11
07040002-547	11LM063	Medford Creek	6.5	6	30.8	46.8	10-Aug-11
07040002-726	11LM064	Unnamed creek	7.1	6	48.4	46.8	11-Aug-11
07040002-704	11LM069	Falls Creek	12.0	5	38.6	35.9	16-Aug-11
07040002-731	11LM061	Unnamed creek	12.5	6	43.5	46.8	10-Aug-11
07040002-547	11LM065	Medford Creek	21.1	5	37.1	35.9	11-Aug-11
07040002-547	11LM065	Medford Creek	21.1	5	38.6	35.9	11-Aug-11
07040002-505	11LM067	Rush Creek	21.4	5	40.5	35.9	11-Aug-11
07040002-519	11LM062	Maple Creek	26.3	6	54.1	46.8	10-Aug-11
07040002-519	11LM011	Maple Creek	37.9	5	38.1	35.9	10-Aug-11
07040002-535	11LM043	Straight River	195.1	5	48.1	35.9	03-Aug-11

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Threshold	FIBI	Visit Date
07040002-503	04LM120	Straight River	247.0	5	46.1	35.9	03-Sep-04
07040002-503	04LM120	Straight River	247.0	5	35.3	35.9	10-Aug-11
07040002-503	10EM011	Straight River	250.9	5	29.3	35.9	10-Aug-10
07040002-536	11LM088	Straight River	361.6	6	37.1	46.8	11-Aug-11
07040002-515	04LM014	Straight River	412.0	5	40.2	35.9	07-Sep-04
07040002-515	11LM092	Straight River	435.8	5	45.1	35.9	15-Aug-11
07040002-515	11LM010	Straight River	461.8	5	26.8	35.9	16-Aug-11
Upper Straight River Subwatershed (0704000203-02)							
07040002-732	11LM038	Unnamed creek	5.8	6	31.6	46.8	01-Aug-11
07040002-525	11LM036	Unnamed creek	8.3	5	38.8	35.9	01-Aug-11
07040002-525	11LM008	Unnamed creek	17.9	6	48.8	46.8	01-Aug-11
07040002-525	11LM039	Unnamed creek	29.1	6	63.9	46.8	01-Aug-11
07040002-517	04LM131	Straight River	117.2	6	37.5	46.8	03-Sep-04
07040002-517	04LM131	Straight River	117.2	6	37.9	46.8	02-Aug-11
07040002-517	11LM034	Straight River	133.1	5	43.0	35.9	02-Aug-11
Turtle Creek Subwatershed (0704000203-03)							
07040002-518	11LM035	Turtle Creek	28.2	5	35.9	36.3	02-Aug-11
07040002-518	11LM004	Turtle Creek	41.4	6	46.8	48.8	02-Aug-11
Prairie Creek Subwatershed (0704000204)							
07040002-723	11LM054	Unnamed creek	8.4	6	46.8	23.2	03-Aug-11
07040002-587	11LM077	Unnamed creek	10.4	5	35.9	31.5	11-Aug-11
07040002-512	11LM075	Unnamed creek	16.7	6	46.8	16.6	03-Aug-11
07040002-504	11LM055	Prairie Creek	45.3	5	35.9	29.7	11-Aug-11
07040002-504	04LM059	Prairie Creek	77.3	6	46.8	63.0	17-Aug-04
07040002-504	11LM009	Prairie Creek	79.7	5	35.9	30.8	11-Aug-11
07040002-504	11LM009	Prairie Creek	79.7	5	35.9	45.4	11-Aug-11
Middle Cannon River Subwatershed (0704000206-01)							
07040002-557	04LM077	Unnamed creek (Spring Brook)	5.9	9	46.1	47.9	18-Aug-04
07040002-557	04LM077	Unnamed creek (Spring Brook)	5.9	9	46.1	38.3	03-Aug-11
07040002-557	11LM099	Unnamed creek (Spring Brook)	6.5	9	46.1	56.1	03-Aug-11

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Threshold	FIBI	Visit Date
07040002-703	11LM096	Unnamed creek	8.1	5	35.9	32.1	17-Aug-11
07040002-591	04LM046	Spring Creek	9.2	6	46.8	39.3	18-Aug-04
07040002-591	11LM094	Spring Creek	11.3	6	46.8	36.8	11-Aug-11
07040002-582	11LM068	Cannon River	812.0	2	30.7	17.0	01-Sep-11
07040002-507	11LM086	Cannon River	876.6	2	30.7	22.8	16-Aug-11
07040002-509	11LM097	Cannon River	944.7	2	30.7	22.8	01-Sep-11
07040002-539	00LM002	Cannon River	1156.8	2	30.7	28.6	01-Sep-11
Heath Creek Subwatershed (0704000206-02)							
07040002-530	11LM031	Unnamed ditch	3.1	5	35.9	20.2	17-Aug-11
07040002-555	04LM083	Unnamed ditch	3.4	6	46.8	44.8	18-Aug-04
07040002-521	04LM076	Heath Creek	34.2	6	46.8	26.0	18-Aug-04
07040002-521	11LM005	Heath Creek	40.1	5	35.9	43.2	03-Aug-11
Wolf Creek Subwatershed (0704000206-03)							
07040002-628	04LM084	Unnamed creek	7.4	6	46.8	47.8	18-Aug-04
07040002-522	11LM003	Wolf Creek	42.0	5	35.9	36.2	16-Aug-11
07040002-522	11LM003	Wolf Creek	42.0	5	35.9	39.4	16-Aug-11
Little Cannon River Subwatershed (0704000207)							
07040002-670	11LM023	Unnamed creek (Little Cannon River Tributary)	6.7	5	35.9	29.0	16-Aug-11
07040002-590	04LM085	Butler Creek	9.6	5	35.9	39.9	17-Aug-04
07040002-590	04LM085	Butler Creek	9.6	5	35.9	22.3	15-Aug-11
07040002-639	11LM027	Unnamed creek (Little Cannon River Tribuatry)	11.3	5	35.9	36.3	16-Aug-11
07040002-589	11LM025	Little Cannon River (Goodhue County)	12.3	5	35.9	28.1	16-Aug-11
07040002-589	11LM024	Little Cannon River (Goodhue County)	20.0	5	35.9	22.2	15-Aug-11
07040002-589	04LM086	Little Cannon River (Goodhue County)	50.5	5	35.9	31.7	17-Aug-04
07040002-589	04LM086	Little Cannon River (Goodhue County)	50.5	5	35.9	51.2	07-Sep-04
07040002-589	04LM086	Little Cannon River (Goodhue County)	50.5	5	35.9	24.0	15-Aug-11
07040002-526	04LM038	Little Cannon River (Goodhue County)	58.0	5	35.9	45.8	17-Aug-04
07040002-526	11LM089	Little Cannon River (Goodhue County)	80.9	6	46.8	42.1	16-Aug-11

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Threshold	FIBI	Visit Date
Belle Creek Subwatershed (0704000208)							
07040002-735	11LM026	Belle Creek	9.6	5	35.9	39.8	04-Aug-11
07040002-721	11LM028	Unnamed creek	10.8	5	35.9	28.0	15-Aug-11
07040002-735	11LM029	Belle Creek	24.4	5	35.9	29.0	04-Aug-11
07040002-735	11LM030	Belle Creek	56.1	5	35.9	35.9	15-Aug-11
07040002-735	04LM090	Belle Creek	69.6	5	35.9	32.1	17-Aug-04
07040002-735	04LM090	Belle Creek	69.6	5	35.9	33.8	08-Aug-11
07040002-735	04LM090	Belle Creek	69.6	5	35.9	37.5	08-Aug-11
07040002-734	11LM006	Belle Creek	76.8	9	46.1	41.3	04-Aug-11
07040002-734	11LM006	Belle Creek	76.8	9	46.1	47.5	04-Aug-11
Lower Cannon River Subwatershed (0704000209)							
07040002-580	99LM005	Unnamed creek (Trout Brook)	10.4	9	46.1	33.3	04-Aug-11
07040002-573	04LM144	Unnamed creek (Trout Brook)	15.1	9	46.1	37.4	17-Aug-04
07040002-573	04LM144	Unnamed creek (Trout Brook)	15.1	9	46.1	23.2	07-Sep-04
07040002-573	04LM144	Unnamed creek (Trout Brook)	15.1	9	46.1	30.1	04-Aug-11
07040002-569	04LM037	Spring Creek	16.0	9	46.1	75.5	30-Aug-04
07040002-569	11LM014	Spring Creek	21.6	9	46.1	63.0	11-Aug-11
07040002-520	99LM002	Pine Creek	21.8	9	46.1	59.8	04-Aug-11
07040002-571	11LM015	Spring Creek	24.4	6	46.8	40.1	01-Sep-11
07040002-567	99LM001	Unnamed creek (Trout Brook)	28.1	9	46.1	60.2	04-Aug-11
07040002-502	04LM055	Cannon River	1296.0	2	30.7	16.3	17-Aug-04
07040002-502	04LM055	Cannon River	1296.0	2	30.7	35.8	01-Sep-11
07040002-502	11LM090	Cannon River	1340.2	2	30.7	44.7	01-Sep-11
07040002-502	10EM175	Cannon River	1341.4	2	30.7	45.2	09-Aug-10
07040002-501	02LM017	Cannon River	1436.8	2	30.7	36.1	01-Sep-11

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

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

Class #	Class Name	Good	Fair	Poor
Fish				
1	Southern Rivers	>38	38-24	<24
2	Southern Streams	>44	44-30	<30
3	Southern Headwaters	>50	50-36	<36
4	Northern Rivers	>34	34-20	<20
5	Northern Streams	>49	49-35	<35
6	Northern Headwaters	>39	39-25	<25
7	Low Gradient Streams	>39	39-25	<25
10	Southern Coldwater	>43	43-17	<17
11	Northern Coldwater	>36	36-22	<22
Invertebrates				
1	Northern Forest Rivers	>51	52-36	<36
2	Prairie Forest Rivers	>31	31-16	<16
3	Northern Forest Streams RR	>50	50-35	<35
4	Northern Forest Streams GP	>52	52-37	<37
5	Southern Streams RR	>36	36-21	<21
6	Southern Forest Streams GP	>47	47-32	<32
7	Prairie Streams GP	>38	38-23	<23
8	Northern Coldwater	>23	23-11	<11
9	Southern Coldwater	>44	44-18	<18

Appendix 5.2 - Channelized stream reach and AUID IBI scores - fish

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Good	Fair	Poor	FIBI	Visit Date
Upper Cannon River (070400020101, -02, -03)									
07040002-619	04LM082	County Ditch 63	2.5	3	>50	50-36	<36	0	12-Jul-04
07040002-621	11LM050	County Ditch 63	5.6	3	>50	50-36	<36	31	03-Aug-11
07040002-578	11LM051	Little Cannon River/County Ditch 66 (LeSueur County)	11.0	7	>39	39-25	<25	32	03-Aug-11
07040002-724	11LM052	Unnamed creek	11.8	3	>50	50-36	<36	48	09-Aug-11
07040002-606	11LM081	County Ditch 59	40.6	2	>44	44-30	<30	41	12-Sep-11
07040002-542	10EM027	Cannon River	57.2	2	>44	44-30	<30	0	21-Jul-10
Crane Creek (0704000202)									
07040002-593	04LM022	Judicial Ditch 1	4.0	3	>50	50-36	<36	25	24-Jun-04
07040002-727	11LM066	Unnamed ditch	9.3	7	>39	39-25	<25	11	02-Aug-11
07040002-733	11LM059	County Ditch 21	9.9	3	>50	50-36	<36	65	02-Aug-11
07040002-556	11LM060	Judicial Ditch 1	17.9	3	>50	50-36	<36	58	02-Aug-11
07040002-516	11LM032	Crane Creek	89.0	2	>44	44-30	<30	54	22-Aug-11
07040002-516	07LM020	Crane Creek	94.9	2	>44	44-30	<30	61	13-Aug-07
07040002-516	07LM020	Crane Creek	94.9	2	>44	44-30	<30	79	22-Aug-11
07040002-516	04LM119	Crane Creek	103.3	2	>44	44-30	<30	31	28-Jun-04
07040002-516	11LM007	Crane Creek	105.2	2	>44	44-30	<30	50	15-Aug-11
Lower Straight River (0704000203-01)									
07040002-574	04LM079	Mud Creek	12.1	3	>50	50-36	<36	61	05-Aug-04
07040002-574	04LM079	Mud Creek	12.1	3	>50	50-36	<36	50	02-Aug-11
Upper Straight River (0704000203-02)									
07040002-534	11LM037	Straight River	8.4	3	>50	50-36	<36	68	01-Aug-11
07040002-698	07LM001	County Ditch 5	8.4	3	>50	50-36	<36	64	13-Aug-07
07040002-698	07LM001	County Ditch 5	8.4	3	>50	50-36	<36	51	01-Aug-11
07040002-531	11LM042	Unnamed ditch	16.8	3	>50	50-36	<36	43	01-Aug-11
07040002-524	11LM041	County Ditch 64	16.9	3	>50	50-36	<36	51	01-Aug-11

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Fish Class	Good	Fair	Poor	FIBI	Visit Date
07040002-534	04LM139	Straight River	25.5	3	>50	50-36	<36	46	30-Jun-04
07040002-534	04LM139	Straight River	25.5	3	>50	50-36	<36	52	13-Jun-11
07040002-532	07LM002	Straight River	105.6	2	>44	44-30	<30	43	14-Aug-07
07040002-517	04LM033	Straight River	143.7	2	>44	44-30	<30	43	07-Oct-04
Turtle Creek (0704000203-03)									
NONE									
Chub Creek (0704000204)									
07040002-720	11LM013	Unnamed creek	5.5	3	>50	50-36	<36	50	13-Jun-11
07040002-566	11LM018	Chub Creek, North Branch	11.9	3	>50	50-36	<36	49	25-Aug-11
07040002-528	07LM017	Chub Creek	60.6	2	>44	44-30	<30	44	13-Aug-07
Prairie Creek (0704000205)									
07040002-504	11LM033	Prairie Creek	34.8	2	>44	44-30	<30	32	14-Sep-11
(0704000206-01)									
NONE									
Heath Creek (0704000206-01)									
07040002-603	11LM020	Knowles Creek	41.2	3	>50	50-36	<36	37	13-Jun-11
Wolf Creek (0704000206-03)									
07040002-629	04LM044	Wolf Creek	10.7	3	>50	50-36	<36	32	04-Aug-04
07040002-629	04LM044	Wolf Creek	10.7	3	>50	50-36	<36	77	09-Aug-11
07040002-522	10EM023	Wolf Creek	33.8	2	>44	44-30	<30	54	07-Sep-10
Little Cannon River (0704000207)									
NONE									
Belle Creek (0704000208)									
NONE									
Lower Cannon River (0704000209)									
07040002-520	04LM004	Pine Creek	17.9	10	>43	43-17	<17	62	06-Jul-04
07040002-520	07LM018	Pine Creek	20.5	10	>43	43-17	<17	63	16-Aug-07

Appendix 5.3 - Channelized stream reach and AUID IBI scores - macroinvertebrates

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Invert Class	Good	Fair	Poor	M-IBI	Visit Date
Upper Cannon River Subwatershed (0704000201, -02, -03)									
07040002-619	04LM082	County Ditch 63	2.5	6	>47	47-32	<32	25.9	18-Aug-04
07040002-621	11LM050	County Ditch 63	5.6	6	>47	47-32	<32	47.9	09-Aug-11
07040002-578	11LM051	Little Cannon River/County Ditch 66 (LeSueur County)	11.0	6	>47	47-32	<32	33.6	09-Aug-11
07040002-724	11LM052	Unnamed creek	11.8	6	>47	47-32	<32	7.1	09-Aug-11
07040002-606	11LM081	County Ditch 59	40.6	6	>47	47-32	<32	15.6	16-Aug-11
07040002-606	11LM081	County Ditch 59	40.6	6	>47	47-32	<32	14.8	16-Aug-11
07040002-542	10EM027	Cannon River	57.2	6	>47	47-32	<32	5.0	31-Aug-10
Crane Creek Subwatershed (0704000202)									
07040002-727	11LM066	Unnamed ditch	9.3	6	>47	47-32	<32	28.4	03-Aug-11
07040002-733	11LM059	County Ditch 21	9.9	6	>47	47-32	<32	27.4	03-Aug-11
07040002-733	11LM059	County Ditch 21	9.9	6	>47	47-32	<32	21.9	03-Aug-11
07040002-556	11LM060	Judicial Ditch 1	17.9	6	>47	47-32	<32	38.1	03-Aug-11
07040002-516	11LM032	Crane Creek	89.0	6	>47	47-32	<32	35.0	11-Aug-11
07040002-516	07LM020	Crane Creek	94.9	5	>36	36-21	<21	36.3	08-Aug-11
07040002-516	04LM119	Crane Creek	103.3	6	>47	47-32	<32	45.1	25-Aug-04
07040002-516	11LM007	Crane Creek	105.2	6	>47	47-32	<32	48.6	11-Aug-11
Lower Straight River Subwatershed (070400020301)									
07040002-574	04LM079	Mud Creek	12.1	6	>47	47-32	<32	24.7	02-Sep-04
07040002-574	04LM079	Mud Creek	12.1	6	>47	47-32	<32	45.1	15-Aug-11
Upper Straight River Subwatershed (070400020302)									
07040002-534	11LM037	Straight River	8.4	5	>36	36-21	<21	47.2	02-Aug-11
07040002-534	11LM037	Straight River	8.4	5	>36	36-21	<21	38.9	02-Aug-11
07040002-698	07LM001	County Ditch 5	8.4	6	>47	47-32	<32	30.0	02-Aug-11
07040002-531	11LM042	Unnamed ditch	16.8	6	>47	47-32	<32	36.0	02-Aug-11
07040002-524	11LM041	County Ditch 64	16.9	6	>47	47-32	<32	37.9	02-Aug-11
07040002-534	04LM139	Straight River	25.5	6	>47	47-32	<32	32.0	02-Sep-04

National Hydrography Dataset (NHD) Assessment Segment AUID	Biological Station ID	Stream Segment Name	Drainage Area Mi^2	Invert Class	Good	Fair	Poor	M-IBI	Visit Date
07040002-534	04LM139	Straight River	25.5	6	>47	47-32	<32	36.3	02-Aug-11
Turtle Creek Subwatershed (070400020303)									
NONE									
Chub Creek Subwatershed (0704000204)									
07040002-720	11LM013	Unnamed creek	5.5	6	>47	47-32	<32	44.5	17-Aug-11
07040002-566	11LM018	Chub Creek, North Branch	11.9	6	>47	47-32	<32	38.8	16-Aug-11
Prairie Creek Subwatershed (0704000205)									
07040002-504	11LM033	Prairie Creek	34.8	6	>47	47-32	<32	44.8	11-Aug-11
Middle Cannon River Subwatershed (070400020601)									
NONE									
Heath Creek Subwatershed (070400020602)									
07040002-529	11LM021	Unnamed creek	11.9	6	>47	47-32	<32	7.3	17-Aug-11
07040002-603	11LM020	Knowles Creek	12.8	6	>47	47-32	<32	24.9	17-Aug-11
Wolf Creek Subwatershed (070400020603)									
07040002-629	04LM044	Wolf Creek	10.7	6	>47	47-32	<32	43.1	18-Aug-04
07040002-629	04LM044	Wolf Creek	10.7	6	>47	47-32	<32	34.4	17-Aug-11
07040002-522	10EM023	Wolf Creek	33.8	6	>47	47-32	<32	17.7	19-Aug-10
Little Cannon River Subwatershed (0704000207)									
NONE									
Belle Creek Subwatershed (0704000208)									
NONE									
Lower Cannon River Subwatershed (0704000209)									
07040002-520	04LM004	Pine Creek	17.8	9	>44	44-18	<18	38.3	18-Aug-04

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

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

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

Lake ID	Lake Name	Obs TP (µg/L)	MINLEAP TP (µg/L)	Obs Chl-a (µg/L)	MINLEAP Chl-a (µg/L)	Obs Secchi (m)	MINLEAP Secchi (m)	Avg. TP Inflow (µg/L)	TP Load (kg/yr)	%P Retention	Outflow (hm3/yr)	Residence Time (yrs)	Areal Load (m/yr)	Trophic Status
190006	**Byllesby**	205	329	39	313	0.8	0.3	570	220130	42	386.26	0.1	42.33	H
190020	**Chub**	183	58	125	25	0.4	1.2	183	152	68	0.83	1.5	0.68	H
400001	**Horseshoe**	87	42	71	15	1.3	1.6	171	285	76	1.66	3.0	1.03	E
400002	**Upper Sakatah**	462	103	32	57	1.1	0.7	149	10377	31	69.54	0.1	19.50	H
400009	**Sunfish**	63	33	34	11	0.9	1.9	190	51	83	0.27	6.0	0.57	E
400010	**Dora**	350	75	42	36	0.9	0.9	160	1010	53	6.32	0.5	2.06	H
400011	**Mabel**	111	65	82	29	1.2	1.1	170	77	62	0.46	0.9	1.09	H
400013	**Diamond**	111	93	18	49	0.7	0.8	158	183	41	1.16	0.2	2.38	H
400014	**Sabre**	1165	118	26	70	1.3	0.6	149	4404	21	29.59	0.0	28.90	H
400031	**Tetonka**	324	72	39	34	1.7	1	150	8383	52	55.76	0.5	10.31	H
400032	**Gorman**	901	89	34	46	1.1	0.8	150	3505	41	23.30	0.2	9.76	H
400033	**Volney**	59	30	12	10	2.8	2.1	172	190	82	1.10	6.5	1.02	E
400039	**Roemhildts**	17	20	6	5	3.1	3	230	24	91	0.10	22.9	0.29	M
400044	**Steele**	31	49	16	20	1.1	1.3	164	73	70	0.50	1.8	1.47	E
400048	**Silver**	110	63	39	28	2.2	1.1	172	12	63	0.07	1.0	1.00	H
400051	**Fish**	15	36	4	12	4.0	1.8	166	76	78	0.46	4.1	1.34	M
400054	**Perch**	21	66	6	30	2.3	1	169	24	61	0.14	0.9	1.16	M
400056	**Rays**	55	36	25	12	1.2	1.8	208	52	83	0.25	5.7	0.40	E
400059	**Round**	127	64	51	58	0.4	1.1	172	94	63	0.55	1.0	1.00	H
400061	**Tustin**	178	88	78	46	0.9	0.8	154	398	43	2.58	0.2	4.18	H
400063	**German**	61	51	34	20	1.3	1.3	157	1625	68	10.34	1.6	2.62	E
40009201	**East Jefferson**	73	44	30	17	1.5	1.5	159	888	72	5.58	2.3	2.13	E
40009202	**West Jefferson**	70	32	44	10	0.9	2	218	133	85	0.61	7.8	0.34	E
40009203	**Swede's Bay**	275	79	72	39	0.6	0.9	163	509	52	3.12	0.4	1.57	H
40009204	**Middle Jefferson**	137	50	60	20	0.8	1.3	189	297	73	1.57	2.2	0.58	H
660008	**Cannon**	358	95	61	51	0.8	0.8	149	14908	36	99.76	0.1	16.70	H
660010	**Wells**	399	123	63	74	0.7	0.6	149	16051	17	108.04	9 DAYS	42.11	H
660014	**Dudley**	28	28	14	9	2.2	2.2	211	27	86	0.13	9.6	0.38	E
660015	**Kelly**	42	48	14	19	2.1	1.4	164	62	70	0.38	1.9	1.51	E
660018	**Roberds**	268	51	879	21	1.2	1.3	160	824	68	5.14	1.6	1.94	H
660027	**Circle**	323	71	70	34	0.7	1	156	1786	54	11.42	0.6	2.89	H
660029	**Fox**	88	49	31	19	1.3	1.4	155	722	68	4.66	1.7	3.49	E
660032	**Union**	428	93	93	50	0.4	0.8	152	1533	39	10.07	0.2	5.69	H
660038	**French**	157	30	82	9	1.0	2.1	182	437	84	2.40	7.1	0.70	H
660039	**Mazaska**	189	28	138	9	1.0	2.2	188	315	86	1.68	8.4	0.60	H
660044	**Lower Sakatah**	425	125	58	49	1.0	0.6	148	10894	16	73.38	7 DAYS	53.18	H
660045	**Sprague**	68	55	6	23	1.0	1.2	199	61	72	0.31	1.9	0.47	E
660047	**Hunt**	91	33	61	11	1.0	1.9	198	73	83	0.37	6.2	0.48	E
660048	**Rice**	469	92	4	48	1.0	0.8	153	1044	40	6.84	0.2	5.12	H
660050	**Caron**	345	81	86	40	0.6	0.9	157	710	49	4.53	0.4	2.76	H
660052	**Cedar**	56	39	28	14	1.0	1.7	182	480	79	2.63	4.0	0.70	E
660055	**Shields**	281	43	66	16	1.3	1.5	170	667	75	3.93	2.8	1.11	H
740023	**Beaver**	22	52	9	21	1.4	1.3	561	99	91	0.18	9.1	0.49	M
81001401	**Clear**	91	74	69	35	0.9	0.9	564	994	87	1.76	4.5	0.67	E
810015	**Loon**	217	76	66	37	0.6	0.9	558	96	86	0.17	4.2	0.36	H
810022	**Rice**	334	236	73	192	0.6	0.3	569	3704	59	6.51	0.3	3.91	H
810058	**Toner's**	202	50	77	20	1.3	1.3	218	39	77	0.18	2.9	0.35	H

Trophic Status Abbreviations: E – Eutrophic H – Hypereutrophic M – Mesotrophic

Appendix 7.1 – Summary statistics of mercury and PCBs by waterway-species-year-anatomy

WATERWAY	AUID	LOCATION	SPECIES[1]	YEAR	ANATOMY[2]	No. fish	Length (in)			Mercury (mg/kg)				PCBs (mg/kg)		
							Mean	Min	Max	N	Mean	Min	Max	N	Mean	Max
CANNON R.*, #, $	07040002 - 581, -582, -507, -508, -509, -539, -538, -502, -501, -646	RM 41.5, BELOW NORTHFIELD*	C	1989	FILSK	3	17.0			1	0.083			1	0.044	
			WE	1978	PLUG	5	12.9			1	0.150			1	0.02	
					WHORG	5	12.9			1	0.110			1	0.07	
			WSU	1978	PLUG	5	14.5			1	0.220			1	0.09	
					WHORG	10	13.6	12.7	14.5	2	0.100	0.080	0.120	2	0.125	
				1989	FILSK	3	17.3			1	0.082			1	< 0.01	
		RM 38, BELOW NORTHFIELD**	C	1989	FILSK	3	18.1			1	0.160			1	0.047	
			RHS	1978	PLUG	5	16.3			1	0.210			1	0.04	
					WHORG	10	15.2	14.0	16.4	2	0.095	0.070	0.120	2	0.25	0.29
			WE	1978	PLUG	5	15.8			1	0.290			1	0.03	
					WHORG	5	15.8			1	0.090			1	0.3	
				1989	FILSK	3	16.1			1	0.270			1	< 0.01	
			WSU	1989	FILSK	3	12.2			1	0.100			1	< 0.01	
		RM 22, BELOW CANNON FALLS#	C	2010	FILSK	3	23.1			1	0.174			1	0.353	
			RKB	2010	FILSK	5	7.3			1	0.148					
			SMB	2010	FILSK	6	12.7	10.9	15.5	6	0.156	0.130	0.205	1	< 0.025	
			WE	2010	FILSK	3	14.3	12.9	15.6	3	0.105	0.088	0.132	1	< 0.025	
		RM 18, W OFHIGHWAY 52#	C	1992	FILSK	18	17.0	12.4	20.9	3	0.125	0.094	0.140	2	0.0715	0.075
			SMB	1992	FILSK	6	11.2	10.4	12.0	2	0.100	0.069	0.130	1	< 0.01	
			WE	1992	FILSK	2	14.6			1	0.120			1	0.032	
		RM 7: 02LM017#	WE	2011	FILSK	3	15.7	15.2	16.3	3	0.211	0.131	0.322	2	0.029	0.033
BYLLESBY*	19000600		BGS	1983	FILSK	4	4.5			1	0.070			1	0.05	
				2007	FILSK	5	5.6			1	0.010					
			BKS	2004	FILSK	1	8.3			1	0.086					
			C	1983	FILSK	5	17.8			1	0.160			1	0.058	
				1989	FILSK	3	17.3			1	0.100			1	0.11	
				2004	FILSK	3	22.9			1	0.155			1	0.04	
			CHC	1987	FILET	3	24.3			1	0.240			1	0.24	
				1989	FILET	1	26.3			1	0.190			1	0.052	
			CPS	2004	FILSK	4	17.9			1	0.124			1	0.03	

WATERWAY	AUID	LOCATION	SPECIES[1]	YEAR	ANATOMY[2]	No. fish	Length (in)			Mercury (mg/kg)				PCBs (mg/kg)		
							Mean	Min	Max	N	Mean	Min	Max	N	Mean	Max
			CPY	1989	FILSK	9	8.3			1	0.040			1	< 0.01	
			NP	1989	FILSK	2	27.8			1	0.082			1	0.022	
			SMB	2004	FILSK	1	10.2			1	0.201			1	< 0.01	
				2007	FILSK	10	9.9	7.7	14.6	10	0.012	0.010	0.025			
			WE	1983	FILSK	7	17.7			1	0.040			1	0.181	
				1989	FILSK	3	19.3			1	**0.400**			1	0.032	
			WHB	2004	FILSK	2	11.1	11.1	11.1	2	0.182	0.180	0.183	2	< 0.01	
				2007	FILSK	5	12.0	10.4	13.1	5	0.192	0.094	0.307			
			WHS	2004	FILSK	1	9.0			1	0.153					
UPPER SAKATAH*	40000200		BGS	1999	FILSK	8	6.8			1	0.060					
			BKB	1999	FILET	7	10.6			1	0.050					
			BKS	1999	FILSK	10	8.3			1	0.040					
			C	1999	FILSK	4	21.3			1	0.080			1	0.015	
			NP	1999	FILSK	4	21.1	18.1	25.1	4	0.090	0.050	0.140	1	< 0.01	
				2009	FILSK	8	25.0	21.3	31.1	3	**0.285**	**0.232**	**0.328**			
			WE	1999	FILSK	6	15.5	12.4	22.9	6	0.088	0.060	0.140	1	< 0.01	
			WHB	2009	FILSK	11	13.3	11.8	15	6	**0.271**	0.194	**0.365**	2	0.025	
			YP	2009	FILSK	6	8.8			1	0.073					
DORA	40001000		BBU	1990	FILSK	10	15.0	13.9	16	2	0.025	0.020	0.030	2	< 0.01	
			BKB	1990	FILET	10	7.6			1	0.055			1	< 0.01	
			BKS	1990	FILSK	10	8.2			1	0.072			1	< 0.01	
SABRE*	40001400		C	1978	WHORG	5	23.5			1	0.080			1	0.025	
			NP	1978	WHORG	5	25.0			1	0.130			1	0.041	
				2009	FILSK	8	24.6	19.6	29.1	8	**0.290**	**0.254**	**0.333**			
			WHB	2009	FILSK	9	14.4	13	15.9	9	**0.500**	0.210	**0.808**	3	0.025	
			YP	2009	FILSK	4	8.5			1	0.099					
TETONKA*	40003100		BGS	1990	FILSK	8	7.3			1	0.077			1	< 0.01	
				2009	FILSK	10	7.8	7.4	8.3	2	0.158	0.131	0.184			
			BKB	1990	FILET	8	8.0			1	0.064			1	< 0.01	
			BKS	2009	FILSK	9	8.7			1	0.154					
			C	1970	PLUG	2	16.6	16.4	16.7	2	0.020	0.020	0.020			
				1984	FILSK	5	16.8			1	0.120			1	0.05	
				1990	FILSK	14	15.4	14.2	16.6	2	0.020	0.020	0.020	2	< 0.01	

WATERWAY	AUID	LOCATION	SPECIES[1]	YEAR	ANATOMY[2]	No. fish	Length (in)			Mercury (mg/kg)				PCBs (mg/kg)		
							Mean	Min	Max	N	Mean	Min	Max	N	Mean	Max
			NP	1971	PLUG	4	25.3	21.5	31	4	0.173	0.100	**0.300**			
				1990	FILSK	2	25.8	24.4	27.2	2	**0.275**	0.210	**0.340**	2	0.021	
				2009	FILSK	6	26.0	21.7	35.3	3	**0.360**	**0.320**	**0.398**			
			WE	1970	PLUG	2	17.8	17.1	18.5	2	**0.395**	**0.330**	**0.460**			
				1971	PLUG	6	16.2	14.7	17.5	6	0.207	0.130	**0.270**			
				1979	WHORG	7				1	0.130			1	0.025	
				1984	FILSK	5	14.3			1	0.210			1	0.05	
				1990	FILSK	9	19.5	18.3	20.7	2	**0.355**	**0.230**	**0.480**	2	0.011	
				2009	FILSK	7	21.7	18.5	27.5	4	**0.485**	**0.388**	**0.595**			
			WHB	2009	FILSK	8	14.7	13.6	15.5	3	**0.410**	**0.309**	**0.467**	2	0.025	
			WSU	1970	PLUG	1	20.8			1	**0.230**					
				1979	WHORG	5				1	0.150			1	0.025	
				1984	FILSK	5	18.1			1	0.170			1	0.05	
			YP	2009	FILSK	4	9.1			1	0.086					
GORMAN*	40003200		BGS	2009	FILSK	10	7.6	7.6	7.6	2	0.113	0.112	0.113			
			C	1978	WHORG	5	17.8	13.5	22	2	0.045	0.020	0.070	2	0.025	
			LMB	2009	FILSK	2	14.7	13.8	15.5	2	**0.371**	**0.308**	**0.434**			
			NP	1978	WHORG	2	25.5			1	0.160			1	< 0.025	
				2009	FILSK	8	30.4	26.3	35.1	8	**0.316**	**0.247**	**0.434**			
			WE	2009	FILSK	5	20.4	17	25.2	5	**0.430**	**0.270**	**0.536**			
			WSU	1978	WHORG	3	19.2			1	0.050			1	< 0.025	
VOLNEY*	40003300		BBU	1996	FILSK	1	20.8			1	0.080			1	< 0.01	
			BKS	1996	FILSK	10	8.9			1	0.090					
			C	1996	FILSK	1	16.5			1	0.070					
			WE	1996	FILSK	5	21.6	19.4	23.8	2	**0.615**	**0.510**	**0.720**	1	< 0.01	
FRANCES*	40005700		BGS	1991	FILSK	15	6.2			1	0.030					
				2012	FILSK	10	8.0	7.8	8.2	2	0.066	0.062	0.069			
			BKB	1991	FILET	3	10.1			1	0.100					
			BKS	1991	FILSK	15	7.4			1	0.028			1	< 0.01	
				2012	FILSK	10	9.8	9.2	10.3	2	0.064	0.062	0.065			
			BRB	1991	FILET	12	10.1			1	0.120			1	0.011	
			C	1991	FILSK	4	25.6	22.3	28.8	2	0.065	0.048	0.081	2	0.0325	
			FWD	1991	FILSK	8	13.1			1	0.020					

WATERWAY	AUID	LOCATION	SPECIES[1]	YEAR	ANATOMY[2]	No. fish	Length (in)			Mercury (mg/kg)				PCBs (mg/kg)		
							Mean	Min	Max	N	Mean	Min	Max	N	Mean	Max
			LMB	2012	FILSK	2	11.9	11.8	12	2	0.164	0.141	0.187			
			NP	1991	FILSK	8	19.6	18.2	20.9	2	0.105	0.100	0.110	1	< 0.01	
				2012	FILSK	2	22.9	19.6	26.1	2	**0.203**	0.167	**0.239**			
			WE	1991	FILSK	16	17.8	14.2	23.7	3	**0.231**	0.094	**0.490**	2	0.012	
				2012	FILSK	8	18.0	15.4	22.8	8	0.211	0.102	**0.404**			
			WHB	1991	FILSK	3	12.4			1	0.160			1	0.027	
GERMAN	40006300		BGS	2008	FILSK	10	7.3			1	0.067					
			C	2008	FILSK	4	23.8			1	0.022					
			NP	2008	FILSK	5	23.3	19.6	28.6	5	0.088	0.050	0.158			
JEFFERSON	40009200		BBU	1992	FILSK	45	13.4	11.4	15.3	10	0.042	0.015	0.069	5	< 0.01	
			BKB	1992	FILET	40	9.8	9.8	9.8	5	0.048	0.048	0.048			
			BKS	1992	FILSK	50	7.8	7.8	7.8	5	0.055	0.055	0.055			
			C	1992	FILSK	75	17.6	14	22.4	15	0.029	0.010	0.042	10	0.0105	
			NP	1992	FILSK	95	22.6	19.3	26.5	15	0.051	0.038	0.070	5	< 0.01	
			WE	1992	FILSK	55	15.3	13.9	16.7	10	0.078	0.065	0.090	5	< 0.01	
CANNON*	66000800		BGS	2009	FILSK	2	7.1			1	0.105					
			BKB	1984	FILET	9	8.0			1	0.020			1	< 0.05	
			BKS	1984	FILSK	10	8.0			1	0.060			1	< 0.05	
				2009	FILSK	2	9.1			1	0.048					
			C	1979	WHORG	5				1	0.050			1	< 0.025	
				1984	FILSK	6	16.6			1	0.030			1	< 0.05	
			CHC	1979	WHORG	5				1	0.050			1	0.1	
			FWD	1984	FILSK	11	10.0			1	0.090			1	< 0.05	
			NP	1979	WHORG	5				1	0.060			1	< 0.025	
				2009	FILSK	6	26.0	22.2	31.3	6	0.150	0.097	0.197			
			WE	1979	WHORG	2				1	0.120	0.120	0.120	1	0.046	
				2009	FILSK	7	20.2	17.1	22.9	7	0.220	0.125	**0.282**			
			WHB	2009	FILSK	7	16.9	16	18.1	7	**0.315**	**0.289**	**0.337**	2	< 0.025	
			YP	1984	FILSK	12	10.0			1	0.070			1	< 0.05	
WELLS*	66001000		WE	2009	FILSK	1	21.0			1	**0.287**					
			WHB	2009	FILSK	8	16.0	14.7	18	8	**0.255**	0.196	**0.332**	2	< 0.025	
ROBERDS	66001800		BKS	1993	FILSK	10	7.2			1	0.044					
			C	1993	FILSK	8	22.1			1	0.055			1	< 0.01	

WATERWAY	AUID	LOCATION	SPECIES[1]	YEAR	ANATOMY[2]	No. fish	Length (in)			Mercury (mg/kg)				PCBs (mg/kg)		
							Mean	Min	Max	N	Mean	Min	Max	N	Mean	Max
			NP	1993	FILSK	9	24.9	23.2	26.6	2	0.070	0.065	0.074	1	< 0.01	
CIRCLE*	66002700		BGS	2007	FILSK	10	7.4			1	0.062					
			C	2007	FILSK	7	13.6			1	0.035					
			NP	2007	FILSK	5	20.9	18.4	26.2	5	0.099	0.045	**0.235**			
			WE	2007	FILSK	6	14.2	12.4	16.5	6	0.114	0.097	0.138			
			YP	2007	FILSK	7	8.5			1	0.037					
FRENCH*	66003800		BGS	2012	FILSK	10	7.8	7.6	7.9	2	0.046	0.045	0.047			
			BKS	1996	FILSK	10	9.0			1	0.180					
				2012	FILSK	10	9.6	8.7	10.5	2	0.129	0.067	0.190			
			C	2012	FILSK	1	25.3			1	0.051					
			FWD	1996	FILSK	12	17.9	16.7	19	2	0.230	0.190	**0.270**	1	< 0.01	
			NP	1996	FILSK	5	30.7	28.4	33	2	0.260	**0.230**	**0.290**	1	< 0.01	
				2012	FILSK	1	25.1			1	0.127					
			WE	1996	FILSK	1	24.5			1	0.370					
				2012	FILSK	8	16.8	12.8	19.1	8	0.341	0.202	**0.423**			
			WHS	2012	FILSK	1	13.8			1	0.495					
			YP	2012	FILSK	10	8.5	8.2	8.7	2	0.031	0.029	0.032			
MAZASKA*	66003900		BGS	2007	WHORG	7	4.7			1	0.043					
				2012	FILSK	5	8.4			1	0.035					
			BKS	1992	FILSK	10	9.3			1	0.057					
				2002	FILSK	9	8.2			1	0.140					
				2012	FILSK	5	9.0			1	0.079					
			C	1992	FILSK	5	21.9	17	27.1	3	0.065	0.010	0.097	2	0.0155	
			NP	1996	FILSK	6	18.3	8.9	26.5	6	0.152	0.074	**0.257**			
				2002	FILSK	24	21.8	15.6	30.9	24	0.169	0.071	**0.315**			
				2007	FILSK	19	20.9	16.2	25	19	0.140	0.088	0.193			
				2012	FILSK	8	19.6	13.8	24.6	8	0.106	0.088	0.135			
			WE	1992	FILSK	8	21.6	16	25.2	3	**0.286**	0.099	**0.450**	1	0.02	
				1996	FILSK	5	22.0	19.3	26.1	5	**0.370**	**0.223**	**0.823**			
				2002	FILSK	20	18.2	10.2	26.5	20	**0.528**	0.190	**1.090**			
				2012	FILSK	15	20.5	17.3	25.6	15	**0.446**	**0.240**	**0.633**			
			YP	2007	WHORG	3	5.6			1	0.054					
LOWER	66004400		NP	2009	FILSK	8	27.4	24.7	29.2	8	**0.222**	0.156	**0.253**			

WATERWAY	AUID	LOCATION	SPECIES[1]	YEAR	ANATOMY[2]	No. fish	Length (in)			Mercury (mg/kg)				PCBs (mg/kg)		
							Mean	Min	Max	N	Mean	Min	Max	N	Mean	Max
SAKATAH*			WE	2009	FILSK	1	19.1			1	**0.278**					
			WHB	2009	FILSK	9	14.3	12.3	15.7	9	**0.246**	0.010	**0.458**	2	< 0.025	
			YP	2009	FILSK	8	9.4	9.3	9.5	2	0.059	0.057	0.060			
HUNT*	66004700		BGS	2001	FILSK	10	7.1			1	0.025					
			BKS	2001	FILSK	9	12.7	9.2	16.1	2	0.123	0.050	0.196			
			C	2001	FILSK	3	26.5			1	0.025			1	< 0.01	
			NP	2001	FILSK	7	24.2	19.7	28.8	7	0.082	0.059	0.117			
			WE	2001	FILSK	2	23.5	22.2	24.8	2	**0.445**	**0.383**	**0.507**			
CEDAR*	66005200		BKS	2008	FILSK	9	7.8	7.2	8.4	2	0.056	0.051	0.061			
			NP	2008	FILSK	2	20.8	20	21.6	2	0.053	0.034	0.072			
			WE	2008	FILSK	6	19.7	17.3	22.3	6	0.140	0.031	**0.266**			
SHIELDS*	66005500		BGS	2001	FILSK	10	8.1			1	0.090					
				2012	FILSK	10	7.0	6.7	7.2	2	0.041	0.041	0.041			
			BKB	2012	FILET	5	9.3			1	0.048					
			BKS	2001	FILSK	10	10.5			1	0.161					
			C	2001	FILSK	4	27.0			1	0.080			1	< 0.01	
				2012	FILSK	4	20.9			1	0.029					
			NP	2001	FILSK	7	25.6	19	32	7	0.170	0.106	**0.254**			
				2012	FILSK	1	23.7			1	0.114					
			WE	2001	FILSK	8	16.3	13.7	18.7	8	0.160	0.122	0.188			
				2012	FILSK	3	15.3	15.2	15.5	3	0.146	0.136	0.161			
			YEB	2012	FILET	5	10.1			1	0.045					
			YP	2012	FILSK	10	8.3	7.6	9	2	0.047	0.037	0.056			
BEAVER	74002300		BGS	2012	FILSK	9	7.8	7.5	8.1	2	0.038	0.030	0.046			
			BKS	2012	FILSK	8	8.4	7.8	9	2	0.054	0.043	0.065			
			LMB	2012	FILSK	1	15.8			1	0.102					
			NP	2012	FILSK	1	30.4			1	**0.464**					
			WE	2012	FILSK	8	18.9	17.1	23.5	8	0.143	0.104	0.208			
CLEAR*	81001400		BGS	1990	FILSK	24	5.6	5.6	5.6	3	0.055	0.055	0.055	3	0.012	
			BKB	1990	FILET	24	9.6	9.6	9.6	3	0.020	0.020	0.020	3	0.015	
			BKS	1990	FILSK	24	5.3	5.3	5.3	3	0.091	0.091	0.091	3	< 0.01	
			WE	1990	FILSK	12	17.0			3	**0.230**	**0.230**	**0.230**	3	0.027	

LOON*	81001500	BGS	1990	FILSK	8	6.0			1	0.039			1	0.019	
		BKB	1990	FILET	8	8.9			1	0.020			1	0.049	
		BKS	1990	FILSK	8	6.9			1	0.035			1	0.036	
		LMB	1990	FILSK	4	13.2			1	**0.300**			1	< 0.01	

1 Impairment codes: Mercury = *, PFOS = #, PCBs = $
2 Species codes: BBU = bigmouth buffalo; BGS = bluegill sunfish; BKB = black bullhead; BKS = black crappie; BRB = brown bullhead; C = common carp; CHC = channel catfish; CPS = river carpsucker; CPY = crappie, unknown species; FWD = freshwater drum; LMB = largemouth bass; NP = northern pike; RHS = redhorse, unknown species; RKB = rock bass; SMB = smallmouth bass; WE = walleye; WHB = white bass; WHS = white crappie; WSU = white sucker; YEB = yellow bullhead; YP = yellow perch
3 Anatomy codes: FILSK – fillet skin-on; FILET – fillet skin-off; WHORG – whole
4 In red are results that are above the impairment threshold: Mercury = 0.2 mg/kg, PCBs = 0.22 mg/kg, PFOs = 200 ng /kg

Appendix 7.2 PFOS concentrations[1] in fish from the Cannon River and three lakes

Waterway	YEAR	Species[1]	No. Fish	No. Samples	Mean (ng/g)	Min (ng/g)	Max (ng/g)
Cannon R. - above Northfield	2010	C	2	2	6.1	< 4.93	7.24
		RKB	5	5	18.4	8.69	32
		SMB	2	2	12.9	9.71	16
		WE	2	2	27.1	13.0	41.2
BYLLESBY	2007	BGS	5	1	1.42		
UPPER SAKATAH	2009	NP	5	5	< 4.8		
		WHB	5	5	5.81	< 4.9	8.4
		YP	6	2	< 4.8		
TETONKA	2009	BGS	4	1	< 4.61		
		BKS	5	1	< 4.78		
		NP	3	3	6.22	< 4.8	8.37
		WE	3	3	< 4.8		
		WHB	5	5	6.04	< 4.8	7.27

1 Impairment threshold = 200 ng/g.
2 Species codes: BBU = bigmouth buffalo; BGS = bluegill sunfish; BKB = black bullhead; BKS = black crappie; BRB = brown bullhead; C = common carp; CHC = channel catfish; CPS = river carpsucker; CPY = crappie, unknown species; FWD = freshwater drum; LMB = largemouth bass; NP = northern pike; RHS = redhorse, unknown species; RKB = rock bass; SMB = smallmouth bass; WE = walleye; WHB = white bass; WHS = white crappie; WSU = white sucker; YEB = yellow bullhead; YP = yellow perch

Appendix 8 – Fish species found during biological monitoring surveys

Common Name	Pollution Tolerance	Quantity of Stations Where Present	Quantity of Individuals Collected
American brook lamprey	Intolerant	5	81
banded darter	Sensitive	4	79
bigmouth buffalo	Very Tolerant	3	3
bigmouth shiner	Very Tolerant	65	2830
black bullhead	Very Tolerant	52	940
black crappie	Moderate	17	59
blacknose dace	Tolerant	82	3835
blackside darter	Moderate	58	857
bluegill	Moderate	40	628
bluntnose minnow	Very Tolerant	76	2201
bowfin	Moderate	8	58
brassy minnow	Tolerant	21	372
brook stickleback	Tolerant	64	908
brook trout	Intolerant	9	939
brown bullhead	Moderate	1	4
brown trout	Sensitive	23	783
carmine shiner	Sensitive	24	348
central mudminnow	Very Tolerant	63	1490
central stoneroller	Tolerant	68	3214
channel catfish	Moderate	12	74
common carp	Very Tolerant	64	582
common shiner	Moderate	79	3546
creek chub	Tolerant	100	5729
emerald shiner	Moderate	11	2436
fantail darter	Sensitive	35	1551
fathead minnow	Very Tolerant	94	3086
flathead catfish	Moderate	3	3
freshwater drum	Moderate	20	106
Gen: redhorses	NA	6	84
gizzard shad	Moderate	4	238
golden redhorse	Moderate	38	595
golden shiner	Moderate	18	69
greater redhorse	Intolerant	12	40
green sunfish	Very Tolerant	99	1897
hornyhead chub	Sensitive	44	927
hybrid minnow	NA	3	4
hybrid sunfish	Tolerant	10	22
Iowa darter	Sensitive	21	181

Common Name	Pollution Tolerance	Quantity of Stations Where Present	Quantity of Individuals Collected
johnny darter	Moderate	108	3041
largemouth bass	Moderate	42	272
logperch	Intolerant	17	200
longnose dace	Intolerant	44	699
mimic shiner	Intolerant	4	9
mooneye	Sensitive	2	6
muskellunge	Intolerant	1	1
northern hogsucker	Sensitive	42	604
northern pike	Moderate	49	166
orangespotted sunfish	Very Tolerant	11	36
pearl dace	Sensitive	3	6
pumpkinseed	Moderate	3	3
quillback	Moderate	7	67
rainbow darter	Sensitive	3	32
rainbow trout	Sensitive	5	13
redside dace*	Intolerant	10	158
river redhorse	Intolerant	1	3
rock bass	Sensitive	24	153
sand shiner	Tolerant	38	2876
sauger	Moderate	5	12
shorthead redhorse	Moderate	13	209
silver redhorse	Moderate	2	3
slenderhead darter	Sensitive	4	11
smallmouth bass	Intolerant	30	422
southern redbelly dace	Moderate	27	263
spotfin shiner	Moderate	34	745
spottail shiner	Moderate	8	85
stonecat	Sensitive	16	25
suckermouth minnow*	Moderate	1	4
tadpole madtom	Moderate	38	359
walleye	Moderate	18	39
white bass	Moderate	5	11
white sucker	Tolerant	128	7920
yellow bullhead	Moderate	24	135
yellow perch	Moderate	35	476

*Designated special concern by MDNR.

Appendix 9 - Stream types associated with Channel Condition and Stability Index (CCSI) ratings

HBC	**Higher-Gradient, Boulder/Cobble**	Uncommon. Mostly found in Lake Superior Basin. Higher gradient streams with bedrock/boulder/cobble stream banks and/or bottom. Step-pool or plunge pool morphology in bedrock streams or long riffles (>50% of reach) in boulder/cobble dominated streams. Tend to be very stable, although increases in discharge from changes in watershed land use or uncharacteristically large rain events can make conditions unfavorable for fish eggs and YOY fish and certain macroinvertebrates taxa that are poorly equipped to cling on rocks or woody debris under high velocity conditions.
MHL	**Moderate-Gradient, High/Low Banks**	Common. Moderate gradient, meandering, alluvial channels where the outside bend may have a higher bank than the depositional inside bend. Typically pool-riffle-run morphology with substrates comprised of cobble, gravel, sand or silt. Riffles typically present (5% -40% of reach).
LGL	**Low-Gradient, Low Banks**	Fairly common. Meandering wetland or low-gradient stream with no or very low banks typically comprised of organic material (muck, detritus) or silt. Often lack riffle habitat (0 – 5% of reach). Substrate typically sand, silt or muck.
TC	**Trapezoidal Channel**	Common. Streams that are mechanically channelized, typically with high banks on both sides of channel. Typically lack depth variability, no riffle habitat.
TCR	**Trapezoidal Channel, Recovering**	Somewhat common. Streams that are mechanically channelized, but may not have been re-dredged in recent years allowing some habitat recovery. Stream may have a slightly meandering thalweg with inner berms and point bars present, or, at least some depth variability forming with the potential of riffle (0-15%) or pool habitat providing some flow variability.
CLGL	**Channelized, Low-Gradient, Low Banks**	Fairly common. Streams that are mechanically channelized through a wetland or low-gradient stream with no or low banks. Banks typically comprised of organic material (detritus, muck) or silt. Often do not have riffle habitat (0-5%).