COMMUNITY ASSISTANCE
PLANNING REPORT NO. 321

Preliminary Draft

MASON CREEK WATERSHED PROTECTION PLAN

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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PRELIMINARY DRAFT

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MASON CREEK WATERSHED PROTECTION PLAN

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The preparation of this publication was financed in part through a grant from the Wisconsin Department of Natural Resources River Planning Grant Program.

February 2017

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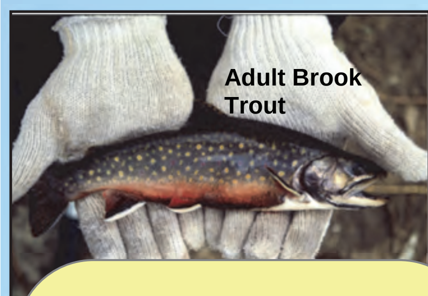
Mason Creek Watershed Protection Plan
Executive Summary

The Mason Creek watershed which is located within Washington, Waukesha, and Dodge Counties, is an 8.2-square mile sub-basin within the upper part of the Oconomowoc River watershed. Mason Creek discharges to North Lake along with the Oconomowoc and Little Oconomowoc Rivers. Several lakes (Friess, Loews, Keesus, Beaver, and Pine) also contribute flow to North Lake. Discharge from North Lake flows through Okauchee Lake, Oconomowoc Lake, Fowler Lake, and Lac La Belle before the Oconomowoc River flows into the Rock River. Historically, Native Americans were attracted to the area for its deep maple and basswood forests, wetlands, clear lakes and wild game. Europeans began to settle in the area in the early to mid-1800s, primarily where the Towns of Erin and Merton are now located, due to the area's lakes and rivers and to experience a rural lifestyle. The settlers quickly began farming the high-quality soil, which resulted in the clearing of forests and natural areas and building homes along the shorelines of the lakes. Over time, farming and associated stream channelization has greatly impacted the water quality and wildlife in this ecosystem.

The Mason Creek watershed has been identified as an important contributor of sediment and phosphorus to both the Oconomowoc and Rock Rivers. Mason Creek has been listed as an impaired waterway by the U.S. Environmental Protection Agency (USEPA) and Wisconsin Department of Natural Resources (WDNR). Excessive sediment and nutrient loading to North Lake have led to unnatural conditions such as increased algal blooms, deep water oxygen depletion, and water clarity issues. North Lake has been listed as impaired for high phosphorus loads.

Target Annual Nonpoint Source Load Reduction Goals for Mason Creek:
92% or 5,355 (lbs) Total Phosphorus and
93% or 883 (tons) Total Suspended Solids

A significant amount of the nonpoint source loads of phosphorus and sediment to North Lake were found to be coming from the Mason Creek watershed. This fact, along with low dissolved oxygen, elevated water temperature, and degraded habitat prompted local units of government and organizations to partner with State and Federal agencies to improve the water quality in the Lake and watershed. Although these efforts have had had some success, the water quality in North Lake and Mason Creek continues to be a cause for concern. In response, the North Lake Management District and Tall Pines Conservancy worked with the Southeastern Wisconsin Regional Planning Commission to develop the Mason Creek Watershed Protection Plan in cooperation with the City of Oconomowoc, Towns of Erin and Merton, Washington and Waukesha Counties, the WDNR, USEPA, and the Natural Resources Conservation Service (NRCS).



Mason Creek is home to a small population of self-sustaining brook trout.
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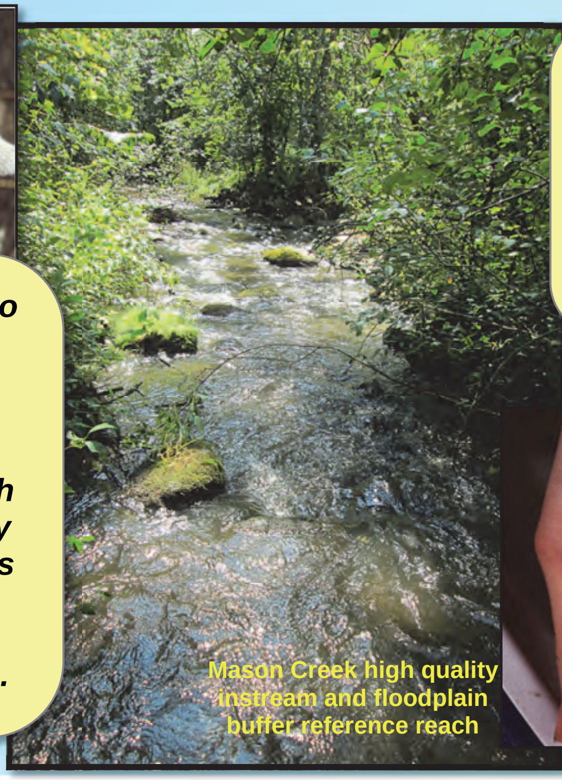
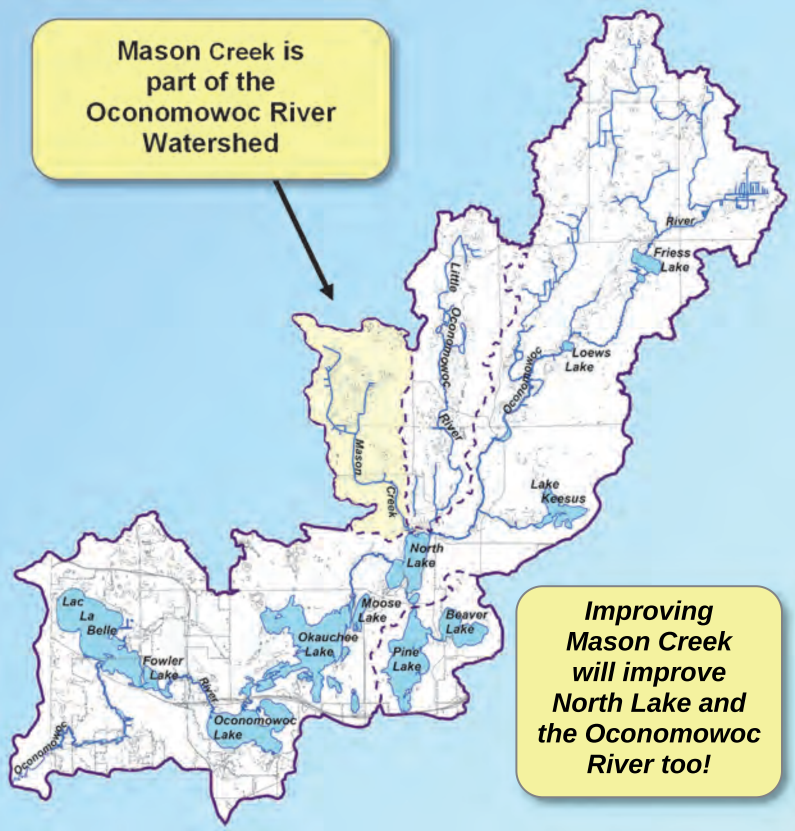
This sensitive gamefish species is like a canary in the coal mine, so it is an indicator of good water quality & fish community conditions.


Mason Creek high quality instream and floodplain buffer reference reach

Mason Creek serves as an important nursery area that supports the fishery within North Lake

Strategy for Improvement

In addition to establishing recommended pollutant load reductions, this plan focuses on reducing instream water temperature and protecting/preserving groundwater discharge to mitigate against a warming climate and/or reduced precipitation and to promote the "resistance" and "resilience" of the Mason Creek system. "*Resistance*" is the ability of a system to remain unchanged in the face of external forces. "*Resilience*" is the ability of a system to recover from disturbance. The overall strategy of this plan is to identify adaptation approaches that promote *resistance* and build ecological *resilience* to reduce the impacts of climate change and other stressors. More specifically, adaptation strategies can be applied in the Mason Creek watershed to increase landscape connectivity and corridors among habitats, restore degraded habitats, and remove other threats and stressors such as invasive species or upland erosion. The goals of the strategies are to enable Mason Creek to meet water quality criteria and maintain a sustainable naturally reproducing brook trout population and the associated coldwater biotic assemblage for future generations .



The Mason Creek Watershed Protection Plan provides a framework for communities to work together on a common mission to protect and improve land and water resources and meet the assigned TMDL load and wasteload allocations. The protection plan is designed to be a practical guide for the improvement of water quality within the Mason Creek watershed, addressing the management of land surfaces that drain directly and indirectly to streams—and consequently to downstream reaches including North Lake, the Oconomowoc River, the Rock River, and ultimately, the Mississippi River.

Challenges and Pollution Sources in the Mason Creek Watershed

Since at least the early 1900s, the Mason Creek system has been substantially altered through channelization, ditching, agricultural and urban development, road construction, placement of fill, construction of stormwater conveyance systems, and other actions related to these land use changes. These changes have physically, chemically, and hydrologically degraded aquatic habitat and impaired water quality and the associated aquatic community (particularly brook trout). As the dominant land use in the area, agriculture is responsible for nearly 82 percent of the phosphorus loading and 92 percent of the sediment loading to Mason Creek, so a major focus of the plan addresses load reductions from these areas. In addition, streambed load was found to be a significant source of sediment and impairment within Mason Creek, particularly in the channelized reaches and ditched reaches. Channelization is extensive throughout the watershed and is a major determinant of limited instream habitat, degraded water quality, and impaired biological conditions. Therefore, a major focus of this plan is to address these problem areas through wetland restoration, improved floodplain connectivity, and/or re-meandering stream reaches.

Example of flocculent sediment filling in streambed within the channelized reaches of Mason Creek. ***September, 2014***

Mason Creek (looking upstream) after a storm event before entering North Lake. ***July, 2014***

Partnership and Participation is Key

One challenge is helping farm operators and landowners to recognize the value of Mason Creek and to become more aware of the water quality issues and the need for conservation practices and sustainable land use management. Although some of the landowners in the watershed have worked with and are aware of County and Federal conservation programs and best management practices (BMPs), significantly greater pollutant load reductions are still needed to meet water quality criteria. To accomplish this, implementation of BMPs needs to be expanded to address a greater proportion of the agricultural land area. The challenge in this watershed is threefold: to develop more opportunities for conservation projects, to install more BMPs, and to ensure the longevity and effectiveness of these projects and practices once they are implemented.

Funding is Available

Fortunately, there is great potential for funding to implement agricultural and urban BMPs within the Mason Creek watershed through the City of Oconomowoc Wastewater Utility's recently established "Adaptive Management Program (AMP)." Under the AMP, a total phosphorus concentration of 0.075 mg/L is to be achieved at the confluence of the Rock and Oconomowoc Rivers in the next 15 years. This led to the formation of the Oconomowoc Watershed Protection Program (OWPP) to address the AMP and achievement of water quality criteria. This approach allows point and nonpoint sources (e.g., agricultural producers, wastewater and stormwater utilities, and developers) to work together to improve water quality in those waters not meeting phosphorus standards throughout the Oconomowoc River watershed. This option recognizes that the excess phosphorus accumulating in lakes and streams comes from a variety of sources, and that reductions in both point and nonpoint sources are frequently needed to achieve water quality goals. This partnership allows combinations of funding from the NRCS, the City of Oconomowoc, and other project partners to be used to offer incentives and matching funding for implementation actions. Hence, the Oconomowoc AMP offers a flexible and robust cost-share funding program to assist landowners with the installation of upgraded conservation practices in agricultural and urban landscapes.

The challenge in this watershed is developing more opportunities for conservation projects, installing more best management practices (BMPs), and ensuring the longevity and effectiveness of practices once BMPS are installed.

Demonstration Projects-Effectively Reduce Pollutant Loads and Improve Water Quality

(Funded in Partnership by the City of Oconomowoc Wastewater Utility and the North Lake Management District)

Riparian buffer/filter strip BMPs are being installed to protect Mason Creek from excessive sediment and nutrient loads from cropland.

Streambank is being restored to prevent severe erosion within Mason Creek

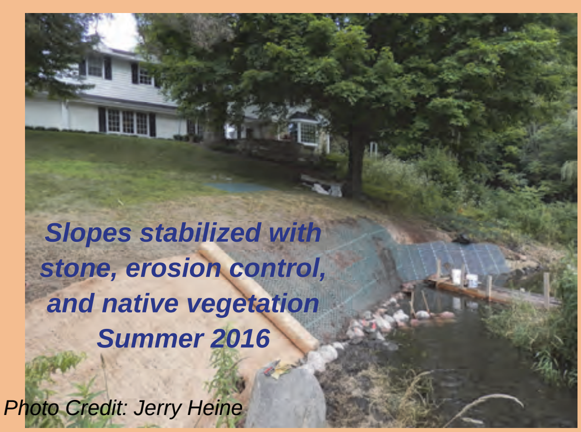


Photo Credit: Jerry Heine

Watershed Protection Plan Elements

A 10-year implementation plan was developed to meet water quality goals for the watershed. The plan recommends best management practices, information and education activities, and restoration practices, and lists the estimated costs, potential funding sources, agencies responsible for implementation, and measures to gauge success.

Recommended Priority Management Practices

Agricultural BMPs Applied to Cropland
- No till
- Cover crops
- Nutrient management planning
- Grassed waterways/filter strips
- Harvestable buffers; wetland buffers; wetland restoration, including ditch plugs to stop sediments

Urban BMPs
- Stormwater runoff management
- Ditch checks/check dams along roadway ditches
- Green infrastructure/Low Impact Development

Key Management Objectives to Improve Mason Creek:

- ***Reduce the loads of sediment and phosphorus from upland sources to improve water quality and enhance and restore stream form and function;***
- ***Reduce the volume and velocity of runoff from upland areas to streams, increase soil infiltration, and enhance groundwater recharge;***
- ***Maintain and expand wetland habitats and fish and wildlife habitats and populations;***
- ***Increase public awareness of water quality issues and participation in watershed conservation activities.***

Instream Fish and Wildlife Habitat Recommendations

Improve instream flows (i.e., floodwater detention, enhance groundwater recharge)

Protect existing high quality components (i.e., brook trout spawning areas)

Restore degraded stream channels, wetlands, and riparian buffer areas

Reconnect all portions of Mason Creek to North Lake by removing aquatic organism passage barriers to restore latent ecological value to North Lake

Education and Information Recommendations

- Provide educational workshops and tours, demonstration projects, and share information on emerging crop BMPs
- Engage landowners in implementing conservation practices and provide information, technical tools, and financial support
- Promote engagement by the farming community in decision making and equip farmers with monitoring tools and methods
- Target action-oriented messages about water quality and conservation practices to key groups
- Produce and distribute newsletters, exhibits, fact sheets, and/or web content to improve communication

Conclusion: Mason Creek has Great Potential for Improvement

The Mason Creek watershed currently embodies significant aesthetic and ecological values and has the potential to be a more diverse and resilient aquatic and terrestrial ecosystem. The attributes that make Mason Creek and its watershed unique are the same attributes that attract residents, businesses, and supporting infrastructure to the watershed and which are necessary for a healthy local economy. Therefore, meeting the goals of the Mason Creek Watershed Protection Plan will lead to improved water quality and quantity for human needs and will help improve and preserve the hydrologic and ecological integrity of the water resources. This will also lead to a healthier and more resilient local economy.

Meeting the goals for the Mason Creek watershed will be challenging. Watershed planning and implementation is primarily a voluntary effort. The effort will need to be supported with targeted technical and financial assistance. It will require a commitment of the ***entire community*** in the Mason Creek, North Lake, and Oconomowoc River areas to improve the water quality and the condition of the watershed. The plan must be adaptable to the challenges, changes, and lessons learned by all.

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SEWRPC Community Assistance Planning Report No. 321

MASON CREEK WATERSHED PROTECTION PLAN

Chapter I

WATERSHED SETTING AND CHARACTERISTICS

WATERSHED SETTING

Mason Creek is an 8.2-square mile (5,275-acre) watershed situated within Washington, Waukesha, and Dodge Counties. Mason Creek discharges directly into North Lake, which is a 440-acre drainage lake, and then flows into the Oconomowoc River, which is a major subwatershed of the Rock River watershed. Mason Creek is about six miles long and has several small (perennial and intermittent) tributaries that flow into it. Due to its proximity and connection with North Lake, this watershed offers a variety of water-based recreational opportunities and has been a focus of the community surrounding the Lake. The watershed includes portions of the Towns of Ashippun, Erin, and Merton as shown on Map I-1.

PURPOSE OF THE PLAN

The North Lake Management District received Wisconsin Department of Natural Resources (WDNR) funding through the Chapter NR 195 River Planning and Management Grant Program to complete this Protection Plan for the Mason Creek watershed. This planning effort was conducted cooperatively and involved the U.S. Environmental Protection Agency (USEPA), the Natural Resources Conservation Service (NRCS), WDNR, University of Wisconsin-Extension, Washington County Planning and Parks Department, Waukesha County Dept. of Parks & Land Use, City of Oconomowoc, the Towns of Erin and Merton, Tall Pines Conservancy, and the Southeastern Wisconsin Regional Planning Commission (SEWRPC).

This plan was also prepared in cooperation with representatives from the ad hoc Mason Creek Watershed Protection Plan Advisory Group (see Appendix A). The Advisory Group was comprised of self-nominated individuals representing a range of stakeholders with interests in the Mason Creek watershed who volunteered their time to meet and review portions of the plan. The Advisory Group represents a diversity of interests and perspectives both within and downstream of the watershed, including stream and lake residents, and County and local government staff as shown in Figure I-1. From 2013 through 2016, participants in the Advisory Group either attended one or more of the several meetings or provided electronic mail correspondence to define issues, develop goals, and establish recommendations for this plan. It is important to note that the plan goals, which were based upon the feedback provided by the Advisory Group, form the foundation for generating and evaluating the alternative and recommended plan elements, and for establishing a sound framework within which to implement the recommendations.

The purpose of this plan is to provide a framework to enable communities in the area to work together with a common mission: *to protect and improve the land and water resources of the Mason Creek watershed*. This watershed protection plan focuses on what can be done to continue to *protect* the existing high-quality resources from human impacts and *prevent* future water pollution or resource degradation from occurring by implementing the following general goals:

- Minimize the further degradation of surface water and preserve, restore, and maintain the high quality of all waterbodies within the watershed.
- Identify opportunities to improve the quality of the land and water (including groundwater) resources within the watershed by reducing both nonpoint agricultural and urban runoff.
- Manage and develop lands in a manner that is consistent with the protection of living resources: avoid habitat fragmentation and encourage the preservation and enhancement of wetlands and wildlife corridors including providing and preserving connections with upland habitats and through sensitive landscaping practices.
- Promote active stewardship among residents, farmers, landowners, businesses, community associations, as well as governmental and non-governmental organizations.

Excessive sediment and nutrient loading to North Lake has led to increased algal blooms, oxygen depletion, and water clarity issues, which has been documented since the 1970s as part of watershed planning efforts by the WDNR and SEWRPC staff. In the 1980s it was substantiated that a significant amount of the nonpoint source loads (i.e., phosphorus and sediment) to North Lake were coming from the inlets to North Lake, which included the Mason Creek subwatershed. This prompted the need for action to be taken by local units of government and organizations in partnership with State and Federal agencies to improve water quality in both North Lake and in the Mason Creek watershed. This current planning effort to complete a watershed protection plan for Mason Creek was initiated as part of the ongoing efforts to identify and prioritize projects to improve water quality conditions in this basin.

More recently, excessive sediment and nutrient loading to the Rock River has led to increased algal blooms, oxygen depletion, water clarity issues, and degraded habitat. Algal blooms can be toxic to humans and costly to a local economy. Estimated annual economic losses due to eutrophication in the United States are as follows: recreation ($1 billion), waterfront property value ($0.3-2.8 million), recovery of threatened and endangered species ($44 million), and drinking water ($813 million).[1] Mason Creek was listed as an impaired waterway by the USEPA and WDNR in 2012 (see Map I-2). In addition, North Lake was added to WDNR's year 2014 impaired waters list for excessive total phosphorus. Due to the impairments of the Rock River Basin, a TMDL (Total Maximum Daily Load) study for phosphorus and sediment was developed for the Rock River basin and its tributaries and was approved in 2011.[2] Under that study, the Mason Creek subwatershed was identified as a significant contributor of sediment and phosphorus to the Rock River. Hence, this plan is designed with a 10-year timeframe and is intended to address phosphorus and sediment load reductions consistent with the TMDL load and wasteload allocations established for Mason Creek and the Rock River. The Rock River TMDL requires that any tributaries to Mason Creek meet a median summer total phosphorus limit of 0.075 mg/l or less and a median summer total suspended solids concentration of 26 mg/l or less. According to the Rock River TMDL, achieving those instream concentrations will require substantial reductions in loading from municipal separate storm sewer systems (MS4s) and nonpoint agricultural sources. For the Mason Creek watershed, this will require average percent reductions from baseline loads of total phosphorus of 11 percent and 39 percent for MS4s and nonpoint sources, respectively. It will also require average percent reductions from baseline loads of suspended solids of 12 percent and 43 percent for MS4s and nonpoint sources, respectively.[3]

This watershed protection plan has been prepared to meet the USEPA nine minimum elements for a watershed based plan (see "*USEPA Watershed Plan Requirements*" section below). This protection plan is also designed to serve as a practical guide for the management of water quality within the Mason Creek watershed and for the management of the land surfaces that drain directly and indirectly to the stream, and downstream reaches including North Lake, Oconomowoc River, and, ultimately, the Rock River.

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[1]*Dodds, W.K., W.W. Bouska, J.L. Eitzman, T.J. Pilger, K.L. Pitts, A.J. Riley, J.T. Schoesser, and D.J. Thornbrugh., Eutrophication of U. S. freshwaters: analysis of potential economic damages, Environmental Science and Technology 43: 12-19, 2009.*

[2]*USEPA and WDNR*, Total Maximum Daily Loads for Total Phosphorus and Total Suspended Solids in the Rock River Basin Columbia, Dane, Dodge, Fond du Lac, Green, Green Lake, Jefferson, Rock, Walworth, Washington, and Waukesha Counties, Wisconsin*, prepared by the CADMUS Group, July 2011.*

[3]Ibid.

USEPA Watershed Plan Requirements

In 1987, Congress enacted the Section 319 of the Clean Water Act which established a national program to control nonpoint sources of water pollution. Section 319 grant funding is available to states, tribes, and territories for the restoration of impaired waters and to protect unimpaired/high quality waters. Watershed plans funded by Clean Water Act section 319 funds must address nine key elements that the USEPA has identified as critical for achieving improvements in water quality.[4] In addition, projects implemented using Federal funds provided under Section 319 of the Clean Water Act must directly implement a watershed-based plan that USEPA has determined to be consistent with the nine elements. Thus, a finding of consistency with the nine elements is a significant benefit to implementation of the plan in that it would make projects recommended under the plan eligible for Federal funding. The nine elements from the USEPA Nonpoint Source Program and Grants Guidelines for States and Territories are as follows:

1. Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan. Sources that need to be controlled should be identified at the significant subcategory level along with estimates of the extent to which they are present in the watershed.

2. Estimates of the load reductions expected from management measures.

3. Descriptions of the nonpoint source management measures that will need to be implemented to achieve load reductions in element 2, and a description of the critical areas in which those measures will be needed to implement this plan.

4. Estimates of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.

5. An information and education component used to enhance public understanding of the plan and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented.

6. A reasonably expeditious schedule for implementing the nonpoint source management measures identified in this plan.

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[4] *U.S. Environmental Protection Agency (USEPA),* Handbook for Developing Watershed Plans to Restore and Protect Our Waters, *USEPA 841-B-08-002, March 2008.*

7. A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.

8. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.

9. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under element 8.

PRIOR STUDIES, PROJECTS, AND EXISTING RESOURCE MANAGEMENT AND COMPREHENSIVE PLANS

Various studies have already been completed describing and analyzing conditions in the Mason Creek watershed and nearby areas, and including management and comprehensive plans and monitoring programs.

Priority Watershed Study

- ***Nonpoint Source Control Plan for the Oconomowoc River Priority Watershed Project***, WDNR, 1986;
- ***Upper Rock River Basin Areawide Water Quality Management Plan***, WDNR, Wisconsin Water Quality Management Program, May 1989;
- ***Upper Rock River Basin Water Quality Management Plan***, A Five-Year Plan to Protect and Enhance our Water Resources, WDNR, December 1995; and
- **The State of the Rock River Basin,** Your River Neighborhood ~ The Rock River Basin, WDNR, PUBL # WT-668-2002, April 2002.

These plans identified the original goals for nutrient reduction and set the stage for implementation of management measures within the Rock River basin, which included North Lake and lands discharging to North Lake among the subwatersheds of the Oconomowoc River, Little Oconomowoc River, and Mason Creek. The highest priorities in the Rock River basin were identified as: surface water quality; groundwater aquifers; wetland, shoreland, and habitat protection; recreation, including hunting and fishing; rural development concerns; and storm water runoff.

North Lake Management Plans and Studies

- ***A Water Quality Management Plan for North Lake, Waukesha County***, Wisconsin, Community Assistance Planning Report No. 54, 1982, SEWRPC.

- ***North Lake and Tributary Limnological Survey 2011-2012, prepared by*** Jerry Kaster, Aquatic Environmental Consulting, for the North Lake Management District , 2012.
- ***A Water Resources Management Plan for the Village of Chenequa, Waukesha County, Wisconsin,*** Community Assistance Planning Report No. 315, 2014, SEWRPC.

North Lake is the second of six major lakes in a chain connected by the Oconomowoc River. North Lake is a 440 acre lake located in Waukesha County. It has a maximum depth of 78.4 feet and over half of the Lake is more than 40 feet deep. During 1976-1977, a hydrologic budget was determined that 70 percent of the inflow came from the Oconomowoc River, which receives flow from Friess Lake, Flynn Creek, and the Little Oconomowoc River before entering North Lake. Mason Creek provides seven percent of the inflow, and the intermittent outlet from Cornell Lake provides five percent of the inflow. The remaining surface water inflow provides eight percent of the hydrologic budget to North Lake, and come from overland flow and precipitation. Groundwater accounts for 10 percent of the inflow to the lake and occurs primarily along the northern portion of the west shore, which demonstrates the importance of the Mason Creek subwatershed in protecting groundwater recharge to North Lake. The eastern shore is a groundwater flow transition zone, where flows into and out of the Lake alternate, and the south and southwest shores are areas where the groundwater is recharged from the lake. The residence time of water in the Lake is approximately 9.5 months during a year of normal precipitation, meaning that the Lake is flushed about 1.3 times per year.

North Lake has transitioned from a mesotrophic (moderately enriched) to eutrophic (highly enriched) condition over time that is consistent with decreased clarity, oxygen-depleted bottom waters during the summer, and excessive aquatic plant overgrowth.[5] Total phosphorus concentrations remain excessive and water clarity measurements are often 25 to 50 percent less than historic observations, and both conditions largely contribute to its impairment classification as described above. In addition, recent dissolved oxygen measurements taken in the lake indicate that total oxygen depletion occurs in the bottom waters during the period of summer (June-August) stratification. This condition was also recorded in the lake during the early 1900s,[6] and there appears to have been little change (i.e. no improvement) in the dissolved oxygen characteristics of North Lake over this more than 110-year period of record. This is likely also associated with the dramatic reduction in the abundance of the two-story Cisco (*Coregonus artedii*

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[5]*Wisconsin Department of Natural Resources, Citizen Lake Monitoring data, website accessed April 2016 at http://dnr.wi.gov/lakes/waterquality/Station.aspx?id=683137*

[6]*Wisconsin Department of Natural Resources,* A Nonpoint Source Control Plan for the Oconomowoc River Priority Watershed Project*, Publication WR-194-86, 1986.*

or Lake Herring) coldwater fishery in North Lake, which was observed in July 29, 2013, to be low (see "*Fish Species Diversity*" section in Chapter II of this report for more details).[7]

Concerns among lake residents also have been raised regarding the aesthetic degradation of the resource and deteriorating water quality conditions, particularly in the northern portions of North Lake, primarily related to sediment deposition from tributary streams. As previously mentioned above, North Lake was added to WDNR's year 2014 impaired waters list due to excessive total phosphorus loads. These concerns have led to a concerted effort to identify sources of sedimentation and work towards preventing or mitigating these sources with other local partners from discharging into the Lake.[8] These plans have identified that rural nonpoint source loads are the biggest sources of pollution to North Lake from the Oconomowoc River, Little Oconomowoc River, and Mason Creek sub-basins. The Mason Creek sub-basin has been and continues to be one of the highest priority watersheds identified (i.e. greatest potential on a per acre basis) to reduce rural nonpoint source loads for phosphorus and sediment to North Lake, which has prompted the development of this watershed protection plan by the North Lake Management District and its local partners.

Comprehensive and Land and Water Resource Management Plans

- ***Dodge County Year 2030 Comprehensive Plan Inventory and Trends Report, Prepared by Foth & Van Dyke and Assoc., Inc., Amended June 21, 2011;*** and ***Dodge County Land and Water Resource Management Plan (3rd Revision 2013-2022),*** **March 2012**, Dodge County Land Conservation Committee***;***
- ***A Multi-Jurisdictional Comprehensive Plan for Washington County: 2035***, Community Assistance Planning Report No. 287, April 2008, SEWRPC and Washington County Planning and Parks Department; and ***Washington County Land and Water Resource Management Plan (2nd Revision 2011-2020),*** **June 2010**, Washington County Land Conservation Committee; and
- ***A Comprehensive Development Plan for Waukesha County***, Waukesha County Department of Parks and Land Use Land Resources Division, February 2009; and, ***Waukesha County Land and Water Resource Management Plan 2012 Update,*** Waukesha County Department of Parks and Land Use Land Resources Division.

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[7] *Wisconsin Department Natural Resources*, The Whitefishes Of Wisconsin's Inland Lakes: The 2011-2014 Wisconsin Department of Natural Resources Cisco and Lake Whitefish Survey*, Fisheries and Aquatic Research Section, February 2015.*

[8] *Rock River Reflections*, "The City of Oconomowoc Steps out of its Boundaries to Work in the Entire Watershed*," A publication of the Rock River Coalition in cooperation with the Rock River Stormwater Group, Volume 19, No. 1, Winter 2016.*

These plans serve a number of functions. Most importantly, they provide a basis for decision-making on land use-related matters by County and town officials and they guide the land and water quality programs, activities and priorities within Dodge, Waukesha, and Walworth Counties. In addition, the comprehensive plans serve to increase the awareness and understanding of County and town planning goals and objectives by landowners, developers, and other private interests. With the adopted comprehensive plans in place, private sector interests and residents can proceed with greater assurance that proposals developed in accordance with these plans should receive required approvals. These Plans include current and projected land use conditions of both counties as well as natural resource base inventories to prioritize resource issues and concerns and identify opportunities to achieve land and water resource management goals.

- **Rock River Basin TMDL Study:** Total Maximum Daily Loads for Total Phosphorus and Total Suspended Solids in the Rock River Basin: Columbia, Dane, Dodge, Fond du Lac, Green, Green Lake, Jefferson, Rock, Walworth, Washington, and Waukesha Counties, Wisconsin
- **Oconomowoc Watershed Protection Program**, City Of Oconomowoc, Waukesha County, Wisconsin, prepared by Ruekert & Mielke, Inc., February 2016

The TMDL study for the Rock River Basin was prepared by the Cadmus Group for the USEPA and WDNR and was approved in 2011. This plan established TMDLs for the Rock River and certain tributaries and estimated current pollutant loadings and loading reductions needed to meet the TMDL for subwatersheds in the Rock River Basin (see "*TMDL Requirements*" section in Chapter II of this report for more details).

More recently the City of Oconomowoc is embarking on an innovative program called *Adaptive Management* to improve the water quality of the many lakes and rivers in the Oconomowoc River watershed. The City of Oconomowoc and its partners developed the Oconomowoc Watershed Protection Program (OWPP), which refined pollutant loads, load reduction goals, priority projects, and recommended Best Management Practices (BMPs) to achieve the load reductions throughout the entire basin.[9] This plan includes the Mason Creek sub-basin area as a high priority area to achieve load reduction goals within a projected 15-year timeframe for implementation.

[9] *see more details at website http://oconomowocwatershed.com/*

WATERSHED JURISDICTIONS, DEMOGRAPHICS, AND TRANSPORTATION NETWORK

Watershed Jurisdictions

The Mason Creek watershed lies almost entirely within Washington and Waukesha Counties (see Map I-1, and Figure I-2). The largest portion of the watershed is in the Town of Erin with 51 percent, followed by the Town of Merton with 41 percent. The remaining eight percent of the watershed lies within the Town of Ashippun in Dodge County.

Jurisdictional Roles and Responsibilities

Natural resources in the United States are protected to some extent under Federal, state, and local law. The Clean Water Act regulates surface water quality at the national level. In Wisconsin, the WDNR has the authority to administer the provisions of the Clean Water Act. The US EPA, U.S. Army Corps of Engineers, Natural Resources Conservation Service, and the U.S. Fish and Wildlife Service work with the WDNR to protect natural areas, wetlands, and threatened and endangered species. The Federal Safe Drinking Water Act also protects surface and groundwater resources.

Counties and other local governments in the watershed area have ordinances regulating land development and protecting surface waters. The comprehensive zoning ordinance represents one of the most important and significant tools available to local units of government in directing the proper use of lands within their jurisdictions. Local zoning regulations include general, or comprehensive, zoning regulations and special-purpose regulations governing floodplain and shoreland areas. General zoning and special-purpose zoning regulations may be adopted as a single ordinance or as separate ordinances; they may or may not be contained in the same document. Any analysis of locally proposed land uses must take into consideration the provisions of both general and special-purpose zoning. The ordinances administered by the units of government within the watershed are summarized in Table I-1. In addition, since State laws governing County and local zoning regulations are often revised, the SEWRPC staff provides periodic summaries of the most up-to-date changes that can be read and downloaded at the following website location: http://www.sewrpc.org/SEWRPCFiles/CommunityAssistance/Smartgrowth/fact_sheet_implementation_of_comp_plans.pdf.

Other governmental entities with watershed jurisdictional or technical advisory roles include: the Wisconsin Department of Agriculture, Trade, and Consumer Protection; the University of Wisconsin-Extension; Dodge County Land Conservation Department, Washington County Planning and Parks Department, Waukesha County Department of Parks and Land Use; and SEWRPC.

Floodland Zoning

Section 87.30 of the *Wisconsin Statutes* requires that counties, with respect to their unincorporated areas; cities; and villages adopt floodplain zoning to preserve the floodwater conveyance and storage capacity of floodplain areas and to prevent the location of new flood-damage-prone development in flood hazard areas. The minimum standards that such ordinances must meet are set forth in Chapter NR 116, “Wisconsin’s Floodplain Management Program,” of the *Wisconsin Administrative Code*. The required regulations govern filling and development within a regulatory floodplain, which is defined as the area that has a 1 percent annual probability of being inundated. The one-percent-annual-probability (100-year recurrence interval) floodplains within the Mason Creek watershed are shown on Map I-3. Under Chapter NR 116, local floodland zoning regulations must prohibit nearly all forms of development within the floodway, which is that portion of the floodplain required to convey the one-percent-annual-probability peak flood flow. Local regulations must also restrict filling and development within the flood fringe, which is that portion of the floodplain located outside the floodway that would be covered by floodwater during the one-percent-annual-probability flood. Allowing the filling and development of the flood fringe area, however, reduces the floodwater storage capacity of the natural floodplain, and may, thereby, increase downstream flood flows and stages. Map I-3 shows that there are no mapped floodplains within Dodge County. The floodplains designated as “Zone A” is where the extent of the floodplain was based upon an approximate study that did not calculate specific flood stage elevations. The majority of these areas are associated with the middle reaches of Mason Creek between CTH CW and extends northward up to the Washington and Waukesha County line as shown on Map I-3.

The Washington and Waukesha Counties ordinances related to floodplain zoning recognize existing uses and structures and regulate them in accordance with sound floodplain management practices while protecting the overall water quality of stream systems. These ordinances are intended to: 1) regulate and diminish the proliferation of nonconforming structures and uses in floodplain areas; 2) regulate reconstruction, remodeling, conversion and repair of such nonconforming structures—with the overall intent of lessening the public responsibilities attendant to the continued and expanded development of land and structures inherently incompatible with natural floodplains; and 3) lessen the potential danger to life, safety, health, and welfare of persons whose lands are subject to the hazards of floods. Floodplain zoning is in place for each of the towns in Washington and Waukesha Counties (see Table I-1).

TRANSPORTATION

The major road within the Mason Creek watershed is Interstate Highway (IH) 83, which runs from north-south along the eastern edge of the basin (see Map I-1). County Trunk Highway CW/Mapleton Road crosses Mason Creek and bisects the middle of watershed runs from an east-west direction. County Trunk Highway Q is located in the northeast portion of the watershed and runs from a northwest-southeast direction. There is only one railroad line, which is part of the Canadian Pacific Railroad System that passes through the southern portion of the watershed and just north of North Lake. There are no biking or hiking recreational trails within the watershed.

POPULATION AND HOUSEHOLDS

Data on population and numbers of households in the Mason Creek watershed from 1960 to 2010 is shown in Figure I-3. Over that time period, the resident population grew from about 130 to 1,150 individuals and the number of households grew from about 40 to 420. The greatest increase in both population and the number of households occurred between 1990 and 2000, however, there has been a steady growth in both population and households since 2000 as shown in Figure I-3. Based upon the adopted regional land use plan, the population and number of resident households in the Mason Creek watershed are projected to continue to increase through the year 2035, which is consistent with the planned land use as shown in Table I-2.[10]

HISTORICAL URBAN GROWTH

Historical urban growth within the Mason Creek watershed is summarized on Map I-4. Much of the early growth (pre-1963) in the watershed was focused within the shoreline of North Lake. Between 1963 and 1970, growth continued to emanate from North Lake into the lower reaches of Mason Creek. In the 1980s and 1990s growth continued to expand within the lower reaches of Mason Creek as well as in the northeast portion of the watershed in the Town of Erin, Washington County. From 1995 to 2010 growth was focused in the north and northeast portion of the watershed. If population growth continues at the same rate of growth, urban runoff may have more of an impact in the watershed, and measures to mitigate that impact would need to be considered.

LAND USE

Existing year 2010 and planned year 2035 land use data for the watershed were developed by the SEWRPC staff.[11] [12]

Changes in Land Use Over Time

Historically, before European settlement in the mid-1800s, the landscape within the Mason Creek watershed consisted largely of Maple - Basswood Forest, which could be characterized by continuous, often dense, canopies of deciduous trees and understories of shade adapted shrubs and herbs. Other natural habitats included large

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[10]*SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035*, June 2006.*

[11]*Ibid.*

[12]*The existing land use data for this study area is based upon 12-inch pixel color year 2010 orthophotography and cadastral mapping. SEWRPC has over 60 land cover classifications and a spatial resolution scale of 1 inch equals 200 feet, which is equivalent to the National Map Accuracy Standards (NMAS) of 90 percent of the positions of well-defined points as determined from the orthophotographs to be within 6.6 feet of their correct position as determined by field measurement.*

expanses of wetland and conifer swamp, with small pockets of oak forest along the northeast edge of the watershed, oak savanna (oak opening) transitional habitat between forest and grassland containing prairie grasses and forbs beneath widely spaced trees in the north, and lowland hardwood forest in the south. The extent of these natural habitat types in the Mason Creek watershed, derived from the original land survey records, is shown on Map I-5.

Following European settlement, large portions of the landscape were converted to agricultural use. Natural vegetation was cleared to make way for crops. Efforts were made to open up wetlands to cultivation through ditching and draining of wet soils. Steeply sloped lands that were spared the plow were often opened up to grazing by livestock. This land conversion had significant consequences on water quality, water quantity, and wildlife habitat. For example, water quality has been compromised through increases in erosion leading to siltation of surface waters, particularly in North Lake. Natural waterways have been dredged and straightened to facilitate rapid runoff bypassing natural functions of adjacent wetlands including absorbing nutrients and storing flood waters.

Agricultural land use continues to dominant the landscape in the watershed, comprising about 58 percent of the watershed area under 2010 land use conditions (Map I-6 and Table I-2). Cultivated crops consist of about 80 percent and pasture/hay accounts for 20 percent of the agricultural land use. Urban land uses accounted for about 16 percent of the watershed area in 2010. The majority of the urban development is in the northeastern and southern portions of the watershed, but there are significant smaller pockets of residential lands between these areas. Wetlands comprise nearly 21 percent and forested land covers about 5 percent of the watershed, followed by surface water which covers 0.3 percent.

Under planned 2035 land use conditions (see Table I-2 and Map I-7), agricultural land is only expected to be reduced by about two percent, or 71 acres. Urban development, primarily residential land use, is planned to increase by about 70 percent, comprising about 13 percent of the watershed by 2035 as shown in Table I-2. Map I-7 graphically depicts the agricultural land, open land, and woodland that would be expected to be converted to urban uses under planned year 2035 conditions. Agricultural land will still be the largest land use overall in the watershed and will continue to be the dominant land use among each of the four main sub-basins (MC-1, MC-2, MC-3, and MC-4) and the internally drained areas (MC-1B and MC-2B) as shown in Figure I-4. Based upon this planned land use scenario urban runoff is not anticipated to have much more of an impact in the watershed in the future (see "*Pollutant Loading Model*" section in Chapter II of this report).

When urban development in a watershed increases, the amount of impervious surface area increases. Many researchers throughout the United States, including researchers at the WDNR, report that the amount of *connected* impervious surface is the best indicator of the level of urbanization in a watershed.[13] Directly connected impervious area is area that discharges directly to the stormwater drainage system, and, ultimately, to a stream without the potential for infiltration through discharge to pervious surfaces or facilities specifically designed to infiltrate runoff. Impervious surfaces:[14]

- Contribute to the hydrologic changes that degrade waterways;
- Are a major component of the intensive land uses that generate pollution;
- Prevent natural pollutant attenuation or removal in the soil by preventing infiltration; and
- Serve as an efficient conveyance system transporting pollutants into waterways.

Research over the last 20 years shows a strong relationship between the imperviousness of a drainage basin and the health of receiving streams.[15] Studies have found that relatively low levels of urbanization—8 to 12 percent connected impervious surface—can cause subtle changes in physical (increased temperature and turbidity) and chemical (reduced dissolved oxygen and increased pollutant levels) properties of a stream, leading to a decline in the biological integrity of the stream. For example, each 1 percent increase in watershed imperviousness can lead to an increase in water temperature of nearly 2.5°F.[16] While this temperature increase may appear to be small in magnitude, this small increase can have significant impacts on fish, such as trout and other biological communities that have a low tolerance to temperature fluctuations or require specific thermal ranges.

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[13]*L. Wang, J. Lyons, P. Kanehl, and R. Bannerman, "Impacts of Urbanization on Stream Habitat and Fish across Multiple Spatial Scales,"* Environmental Management, *Vol. 28, 2001, pp. 255-266.*

[14]*Dane County Regional Planning Commission,* Dane County Waterbody Classification Study-Phase I, *March 2007.*

[15]*Wang, L., J. Lyons, P. Kanehl, R. Bannerman, and E. Emmons. 2000. Watershed Urbanization and Changes in Fish Communities in Southeastern Wisconsin Streams. Journal of the American Water Resources Association 36(5):1173-1189; Wang, L., J. Lyons, P. Kanehl, and R. Gatti. 1997. Influences of Watershed Land Use on Habitat Quality and Biotic Integrity in Wisconsin Streams. Fisheries 22(6):6-12; Arnold, C., and C.J. Gibbons. 1996. Impervious Surface Coverage. The Emergence of a Key Environmental Indicator. Journal of the American Planning Association 62(2):243-258; Schueler, T. 1995. Site Planning for Urban Stream Protection. Center for Watershed Protection. Ellicot, MD; Masterson, J.P., and R.T. Bannerman. 1994. Impacts of Stormwater Runoff on Urban Streams in Milwaukee, Wisconsin. In National Symposium on Water Quality. 1994. American Water Resources Association. Middelburg, VA; and, Schueler, T. 1994. The Importance of Imperviousness. Watershed Protection Techniques 1:100-111.*

[16]*L. Wang, J. Lyons, and P. Kanehl, "Impacts of Urban Land Cover on Trout Streams in Wisconsin and Minnesota,* Transactions of the American Fisheries Society, *Vol. 132, 2003, pp. 825-839.*

The Mason Creek watershed overall had about 12 percent urban land use in 2010, which corresponds to about 2.5 percent directly connected imperviousness in the watershed (see Table I-3). That level of imperviousness is below the threshold level of 6 to 11 percent at which negative biological impacts can be expected to occur, which corresponds with the high quality cold water fishery observed within the mainstem of this system. In addition, the estimated levels of imperviousness by subwatershed for year 2010 and planned year 2035, as shown in Table I-3, are also not expected to exceed the 6 to11 percent range. This indicates that these relatively low levels of urban development are not expected to significantly contribute to the degradation of aquatic resources such as observed in other streams within southeastern Wisconsin.[17] Hence, although local stormwater management practices affecting runoff volume and quality such as promoting infiltration, green infrastructure projects, and preservation of riparian buffers will be key to mitigating the consequences of development within this watershed, agricultural land management practices should remain the priority focus to reduce pollutant loads to Mason Creek during stormwater events.

Description of the Farming Environment

Farming in the watershed is a significant economic factor with about 80 percent of the farm operations in row crop/cash grain production, and 20 percent feedlots and pasture. Loss of dairy herds over past decades has nearly eliminated hay production from the watershed. Demand for corn and soybean production, while not at an all-time high, is still good, and petroleum prices (fertilizer and fuel) are lower than in past years. Farmers continue to look for ways to increase yields by removing fence rows to increase land in production and in some cases putting land enrolled in Federal set aside programs back into production. Agricultural lands located along Mason Creek may be candidates for enrollment in Federal conservation programs.

There are approximately 170 rural properties/lots within the Mason Creek watershed. Roughly 110 of these parcels are in row crop operations and the rest are in pasture based upon the 2010 land use survey. Several of the landowners or their operators employ conservation practices such as reduced tillage and riparian buffers.

Field observations and review of data with the County conservationists identified less than five animal operations in the watershed (see Map B-1 in Appendix B - *STEPL Pollutant Loading Results for the Mason Creek Watershed*). Pastured beef and other livestock feeding operations, rotational grazing, and horse stables contribute to a diversity of manure management approaches within the watershed. There are no CAFO’s (Concentrated Animal Feeding Operations) in the watershed.

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[17]*SEWRPC Technical Report No. 39,* Water Quality Conditions and Sources of Pollution in the Greater Milwaukee Watersheds, *November 2007.*

Natural Resource Elements

Many important interlocking and interacting relationships occur between living organisms and their environment. The destruction or deterioration of any one element may lead to a chain reaction of deterioration and destruction among the others. The drainage of wetlands, for example, may have far-reaching effects. Such drainage may destroy fish spawning grounds, wildlife habitat, groundwater recharge areas, and natural filtration and floodwater storage areas. The resulting deterioration of surface water quality may, in turn, lead to a deterioration of the quality of the groundwater. Groundwater serves as a source of domestic, municipal, and industrial water supply and provides low flows in rivers and streams. The destruction of woodland and other upland cover types, which may have taken a century or more to develop, may result in soil erosion and stream siltation and in more rapid runoff and increased flooding, as well as destruction of wildlife habitat. Although the effects of any one of these environmental changes in isolation may not be overwhelming, the combined effects may lead eventually to the deterioration of the underlying and supporting natural resource base, and of the overall quality of the environment for life. The need to protect and preserve the environmental corridors and their associated complexes of wetland, upland, and critical species habitats within the watershed thus becomes apparent.

Primary Environmental Corridors

Primary environmental corridors (PEC) include a wide variety of important resource and resource-related elements. By definition, they are at least 400 acres in size, two miles in length, and 200 feet in width.[18] There are two separate PECs in the watershed under existing conditions, one in the northeast and one located along the entire length of Mason Creek, which together encompass about 1,280 acres, or about 24 percent, of the Mason Creek watershed. This PEC represents a composite of the best remaining elements of the natural resource base in the watershed, and contains almost all of the best remaining uplands, wetlands, and wildlife habitat areas (see "*Natural Areas and Critical Species Habitat Sites"* section below). It is also important to note that these high quality corridors are a part of one much large contiguous PEC that is shared with the neighboring North Lake, Little Oconomowoc River, and Oconomowoc River as shown on Map I-8. Hence, North Lake and Mason Creek and its associated shorelands are part of the highest quality natural resources within the watershed as well as the neighboring watersheds. This is why management of those areas is vital to protecting and maintaining the quality and integrity of this resource (see Appendix C-*Managing the Water's Edge-Riparian Buffer Guide*).

Secondary Environmental Corridors

Secondary environmental corridors (SEC) are at least 100 acres in size and one mile long. In 2010, as shown on Map I-8, there were no designated secondary environmental corridors within the Mason Creek watershed.

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[18]*SEWRPC Planning Report No. 42,* A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin, Amendment*, December 2010.*

Isolated Natural Resource Areas

Smaller concentrations of natural resource features that have been separated physically from environmental corridors by intensive agricultural or urban land uses have also been identified. These natural resource areas, which are at least five acres in size, are referred to as isolated natural resource areas and are shown on Map I-8. Widely scattered throughout the watershed, isolated natural resource areas covered about 137 acres, or nearly 3 percent, of the total study area in 2010. These INRAs still contains a variety of resource functions that include facilitating surface water drainage, maintaining pockets of natural resource features, and if connected with other INRAs or PEC could also enhance the movement of wildlife and dispersal of seeds for a variety of plant species.

Natural Areas and Critical Species Habitat Sites

Natural areas, as defined by the Wisconsin Natural Areas Preservation Council, are tracts of land or water so little modified by human activity, or sufficiently recovered from the effects of such activity, that they contain intact native plant and animal communities believed to be representative of the pre-European settlement landscape (see Map I-5). Natural areas are generally comprised of wetland or upland vegetation communities and/or complex combinations of both these fundamental ecosystem units. In fact, some of the highest quality natural areas within the Southeastern Wisconsin Region are wetland complexes that have maintained adequate or undisturbed linkages (i.e., landscape connectivity) between the upland-wetland habitats, which is consistent with research findings in other areas of the Midwest as well as in the Mason Creek watershed.[19] The extent and distribution of wetland and upland areas and their relationship to the designated natural areas and critical species habitats are shown on Map I-9.

Natural areas have been identified for the seven-county Southeastern Wisconsin Region in SEWRPC Planning Report No. 42, "*A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin*," published in September 1997, and amended in 2010. This plan was developed to assist Federal, State, and local units and agencies of government, and nongovernmental organizations, in making environmentally sound land use decisions including acquisition of priority properties, management of public lands, and location of development in appropriate localities that will protect and preserve the natural resource base of the Region. Washington and Waukesha Counties uses this document to guide land use decisions.

The identified natural areas were classified into the following three categories:

1. Natural area of statewide or greater significance (NA-1);

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[19]*O. Attum, Y.M. Lee, J.H. Roe, and B.A. Kingsbury, "Wetland complexes and upland-wetland linkages: landscape effects on the distribution of rare and common wetland reptiles,"* Journal of Zoology*, Vol. 275, 2008, pages 245-251.*

2. Natural area of countywide or regional significance (NA-2); or
3. Natural area of local significance (NA-3).

Classification of an area into one of these three categories was based upon consideration of several factors, including the diversity of plant and animal species and community types present; the structure and integrity of the native plant or animal community; the extent of disturbance by human activity, such as logging, grazing, water level changes, and pollution; the frequency of occurrence within the Region of the plant and animal communities present; the occurrence of unique natural features within the area; the size of the area; and the educational value.

The Mason Creek watershed contains one natural areas of local significance (NA-3) as shown on Map I-9.[20] Site 44 is the Mason Creek Swamp that comprises a large proportion of the headwaters of the Mason Creek watershed. This is a large (425 acres) wetland complex that includes a variety of deep marsh, shallow marsh, and sedge meadow plant communities. This is the highest quality plant community known to exist in the watershed, and it can serve as a potential seed sources for restoration in other areas (for more details see Appendix D-*Mason Creek Potentially Restorable Wetland Evaluation*).

Critical species are defined as those species of plants and animals that are designated by the State of Wisconsin to be endangered, threatened, or of special concern. There are five such plant and animal species known to occur in the watershed and they are listed in Table I-4. Photos of each of these critical species and links to life history information are included in Figure I-5.

Exotic/Invasive Species

Invasive species can have a negative impact on ecosystems. They can out compete native species that provide optimal habitats for a variety of wildlife, which causes an overall reduction in available wildlife habitat and species diversity. Invasive species such as Purple Loosestrife and Phragmites tend to populate disturbed areas such as roadside ditches and then expand into other areas. There are many exotic species located in the watershed. These species consist of reed canary grass, Purple Loosestrife, Cut Leaf Teasel, Phragmites, Garlic Mustard, Japanese Knotweed, buckthorn, and emerald ash borer to name a few. Invasive species are an important issue in this watershed and conservation practices that are implemented should be maintained to prevent establishment and spread of invasives, particularly when trying to restore native wetland habitat (see Appendix D-for more details).

[20]*Note: Site numbers correspond to those presented in the Regional Natural Areas Plan (SEWRPC Planning Report No. 42, Amendment December 2010).*

CLIMATE

Based on the 30-year average temperature and precipitation data from 1981-2010 for Wisconsin from the NOAA National Weather Service Forecast Office Milwaukee/Sullivan, the average annual temperature and precipitation range from about 45-48 degrees Fahrenheit and 34-36 inches, respectively, within the vicinity of the Mason Creek watershed.

However, it is also important to note that Wisconsin's climate and water resources are changing. Climate directly affects water resources and such resources can serve as indicators of climate change at various temporal and spatial scales. The Wisconsin Initiative on Climate Change Impacts (WICCI) has concluded that future climate projections may affect the quantity and quality of the State of Wisconsin's water resources. However, WICCI also found clear evidence from analysis of past trends and probable future climate projections that there will be different hydrologic responses to climate change in different geographic regions of the State (see Figure I-6). The differences reflect local variations in land use, soil type and surface deposits, groundwater characteristics, and runoff and seepage responses to precipitation, which illustrates the importance of considering the effects on hydrologic conditions of possible changes in those characteristics as part of a watershed protection plan strategy.

Climate change seems to be altering the availability of water (volume), the distribution of rainfall over time, and whether precipitation falls as rain or snow, each of which affects water's movement through a water cycle. As shown in Figure I-7, most of the water entering the landscape arrives as precipitation (rain and snowfall) that falls directly on waterbodies; or runs off the land surface and enters streams, rivers, wetlands, and lakes; or percolates through the soil, recharging groundwater that flows underground and re-emerges as springs discharging into lakes, wetlands, and streams. Even in the absence of climate change, when one part of the system is affected, all other parts are affected. For example, over drafting the shallow groundwater to irrigate crops or for providing a potable water supply, can lead to a reduction or complete loss in discharge of a local stream. More important, climate change exposes the vulnerabilities of water available within a given community, and this vulnerability is proportional to how much humans have altered how water moves through the water cycle (e.g., through reducing groundwater discharge potential during land development and/or through withdrawals from aquifers). This vulnerability becomes particularly evident during periods of prolonged drought conditions.

The WICCI Water Resources Working Group (WRWG) incorporated WICCI's 1980-2055 projections for temperature, precipitation (including occurrence of events), and changes in snowfall to guide their evaluation of potential impacts to hydrologic processes and resources.[21] This team of experts prioritized the highest potential climate change impacts on water resources and proposed adaptation strategies to address impacts across the State of Wisconsin as summarized below:

- **Minimize threats to public health and safety by anticipating and managing for extreme events through effective planning—floods and droughts.**

- **Increase resiliency of aquatic ecosystems to buffer the impacts of future climate changes by restoring or simulating natural processes, ensuring adequate habitat availability, and limiting human impacts on resources. Examples include limiting groundwater and surface water withdrawals, restoring or reconnecting floodplains and wetlands, and maintaining or providing migration corridors for fish and other aquatic organisms.**

- **Stabilize future variations in water quantity and availability by managing water as an integrated resource, keeping water "local" and supporting sustainable and efficient water use for humans and the environment.**

- **Maintain, improve, or restore water quality under a changing climate regime by promoting actions to reduce nutrient and sediment loading.**

Changing climatic conditions are drivers of water quality conditions within the Mason Creek system and these adaption strategies are important considerations for the protection of surface water and groundwater quality and quantity in this watershed.

TOPOGRAPHY AND GEOLOGY

The Mason Creek watershed lies in the Eastern Ridges and Lowlands geographical province of Wisconsin and was part of the glaciated portion of Wisconsin. Glaciers have greatly impacted the geology of the area. The Kankakee equivalent dolomite of the Silurian Group and the Maquoketa shale formation of the Ordovician Group are the major bedrock features within this watershed. The depth to bedrock generally ranges from 100 to 350 feet. The topography is generally smooth and gently sloping with some slopes steepened by post glacial stream erosion. The

[21] *The Water Resources Working Group (WRWG) included 25 members representing the Federal government, State government, the University of Wisconsin System, the Great Lakes Indian Fish and Wildlife Commission, and the Wisconsin Wetlands Association. For more details on climate change, impacts, adaptation, and resources visit* http://www.wicci.wisc.edu/water-resources-working-group.php.

main glacial landforms are ground moraine, outwash, and lake plain. The highest point in the watershed area is in the northeast area at 1,025 feet above National Geodetic Vertical Datum, 1929 adjustment (NGVD 29) and the lowest point in the watershed is 875 feet above NGVD 29 near the confluence with North Lake. The central portion of this watershed is relatively flat while the remaining northern and southern edges contain some ridges and rolling slopes.

GROUNDWATER RESOURCES

Groundwater not only sustains lake levels and wetlands and provides the perennial base flow of streams, but it is also a major source of water supply. In general, there is an adequate supply of groundwater within the Region to support the growing population, agriculture, commerce, and viable and diverse industry. However, overproduction and water shortages may occur in areas of concentrated development and intensive water demand.[22] The amount, recharge, movement, and discharge of groundwater is controlled by several factors, including: precipitation; topography; drainage; land use; soil; and the lithology and water-bearing properties of rock units. All of the communities within the Mason Creek watershed are dependent on groundwater for a potable water supply and for other commercial uses. Groundwater resources thus constitute an extremely valuable element of the natural resource base within the watershed. The continued growth of population and industry within the watershed necessitates the wise development and management of groundwater resources.[23]

Groundwater Recharge

Recharge to groundwater is derived almost entirely from precipitation. The amount of precipitation (and snowmelt) that infiltrates at any location depends mainly on the permeability of the overlying soils, bedrock or other surface materials, including human-made surfaces. As development occurs, stormwater management practices can be instituted that encourage infiltration of runoff. However, it is important to note that such practices have generally not been required to be installed prior to 1990 in the Mason Creek watershed. So, much of the urban development was not constructed to promote such infiltration in this watershed. Ideally, practices that promote infiltration need to be located on soils with permeable subsoils and adequate groundwater separation to allow infiltration, but minimize the potential for groundwater contamination. Most of the precipitation that does infiltrate (either naturally or through a stormwater management practice) will generally only migrate within the shallow aquifer system and may discharge in a nearby wetland or stream system. This process helps support base flows, wetland vegetation,

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[22]*SEWRPC Planning Report No. 52, A Regional Water Supply Plan For Southeastern Wisconsin, December 2010.*

[23]*Barlow, P.M., and Leake, S.A.,* Streamflow depletion by wells—Understanding and managing the effects of groundwater pumping on streamflow, *U.S. Geological Survey Circular 1376, 2012, see website at* http://pubs.usgs.gov/circ/1376/.

and wildlife habitat in these water resources. Therefore, as is the case for surface waters (lakes and streams), the quality of groundwater resources is clearly linked to the health and well-being of the biological communities (including humans) inhabiting those waters and their surrounding watersheds.[24]

Understanding recharge and its distribution is key to making informed land use decisions so that the groundwater needs of society and the environment can continue to be met. Fortunately, a groundwater recharge potential map derived from a soil-water balance recharge model was developed under the SEWRPC water supply planning program for the Southeastern Wisconsin Region. Groundwater recharge potential in the Mason Creek watershed is shown on Map I-10. That map can be used for identifying and protecting recharge areas that contribute most to baseflow of the ponds, streams, springs, and wetlands in the Mason Creek watershed.[25]

Groundwater recharge potential was divided into four main categories defined as: low, moderate, high, and very high. Any areas that were not defined were placed into a fifth category as undefined. These undefined areas are most often associated with groundwater discharge, which is why they tend to be located adjacent to streams as shown on Map I-10. Much of the Mason Creek watershed can be considered to have either moderate (1,903 acres, or 36 percent) or high (2,019 acres, or 38 percent) groundwater recharge potential, as shown on Map I-10. In about 18 percent of the watershed the groundwater recharge potential was undefined, with those areas largely associated with the Mason Creek Swamp and associated wetlands. Less than one percent of the watershed was comprised of low and very high recharge potential combined. Hence, protecting recharge areas, particularly those located on agricultural and other open lands that have not yet been developed, is important to the goals of sustainable groundwater use and a healthy natural environment in this watershed.

SOIL CHARACTERISTICS

Soil data for the watershed was obtained from the NRCS (SSURGO) database. Soil type and characteristics are important for planning management practices in a watershed. Factors such as erodibility, hydrologic soil group, slope, and hydric classification are important in estimating erosion and runoff in a watershed.

The five general soil associations found in the Mason Creek watershed include Hochheim-Theresa (53 percent), Casco-Fox-Rodman (17 percent), Houghton-Palms-Adrian (15 percent), Fox-Casco (14.7 percent), and Rodman-Casco (<1 percent). It is important to note that 71 percent the remaining agricultural and open lands within the

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[24]*David Hambright, "Golden Algae & the Health of Oklahoma Lakes," LAKELINE, Volume 32(3), Fall 2012.*

[25]*SEWRPC Technical Report No. 47,* Groundwater Recharge in Southeastern Wisconsin Estimated by a GIS-Based Water-Balance Model, *July 2008.*

watershed are classified as prime agricultural soils and an additional 20 percent are considered soils of statewide importance for agriculture, which demonstrates that this is highly productive farmland.

Hydrologic Soil Group

Soils are classified into hydrologic soil groups based on soil infiltration and transmission rate (permeability). Hydrologic soil group along with land use, management practices, and hydrologic condition determine a soil's runoff curve number as established by NRCS. Runoff curve numbers are used to estimate direct runoff from rainfall. There are four hydrologic soil groups: A, B, C, and D. Descriptions of Runoff Potential, Infiltration Rate, and Transmission Rate of each group are shown in Table I-5. Some soils fall into a dual hydrologic soil group (A/D, B/D, and C/D) based on their saturated hydraulic conductivity and water table depth when drained. The first letter applies to the drained condition and the second letter applies to the undrained condition. Table I-6 summarizes the percent of each group present in the watershed and Map I-11 shows the location of each hydrologic soil group. The dominant hydrologic soil groups in the watershed are Group B (52.3 percent) and Group B/D (14.1 percent). The majority of the soils in the Mason Creek watershed are Group B soils that have a moderately low runoff potential. However, up to 47 percent of the soils in the watershed may have moderately high to high runoff potential, which includes Group C soils as well as Group B/D and A/D soils in the undrained condition.

Soil Erodibility

The susceptibility of a soil to wind and water erosion depends on soil type and slope. Course textured soils such as sand are more susceptible to erosion than fine textured soils such as clay. Potentially highly erodible and highly erodible soils were mapped based on a combination of hydrologic soil groups, which accounts for soil type and other key features (see above), and slope. Soils with a 2 to 6 percent slope were considered potentially highly erodible soils and soils with a 6 percent or higher slope were considered highly erodible.[26] About 57 percent of the soils for which slopes and erosion potential have been classified in the Mason Creek watershed are considered potentially highly erodible to highly erodible (see Map I-12). There are 2,217 acres or 42 percent considered potentially highly erodible and 800 acres or about 15 percent are considered highly erodible.

[26]*Outagamie County Land Conservation Department*, Nonpoint Source Implementation Plan for the Plum and Kankapot Creek Watersheds, *141 pages, 2014.*

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MASON CREEK WATERSHED PROTECTION PLAN

Chapter I

WATERSHED SETTING AND CHARACTERISTICS

TABLES

PRELIMINARY DRAFT

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Table I-1

LAND USE REGULATIONS APPLICABLE WITHIN THE MASON CREEK WATERSHED BY CIVIL DIVISION: 2015

Community	Type of Ordinance				
	General Zoning	Floodplain Zoning	Shoreland Zoning	Subdivision Control	Erosion Control and Stormwater Management
Dodge County	Adopted[a]	Adopted[b]	Adopted[b]	Adopted[b]	Adopted[b]
Town of Ashippun	Regulated under County ordinance	Regulated under County ordinance	Regulated under County ordinance	Adopted[c]	Adopted[d]
Washington County	- -[e]	Adopted[e]	Adopted[e]	Adopted	Adopted
Town of Erin	Adopted	Regulated under County ordinance	Regulated under County ordinance	Adopted[f]	Regulated under County ordinance[g]
Waukesha County	- -[h]	Adopted[i]	Adopted[i]	Applies In shoreland areas only[j]	Adopted[i]
Town of Merton	Adopted	Regulated under County ordinance	Regulated under County ordinance	Adopted	Regulated under County ordinance

[a] *The Dodge County Land Use Code includes general zoning regulations that apply to nine of the 24 towns in the County.*

[b] *The Dodge County Land Use Code includes floodplain, shoreland, subdivision, erosion control, and stormwater management regulations that apply to all unincorporated (town) areas of the County.*

[c] *Both the Dodge County and Town of Ashippun subdivision ordinances apply within the Town. In the event of conflicting regulations in the Town and County ordinances, the more restrictive regulation applies.*

[d] *The Town of Ashippun subdivision ordinance includes erosion control and stormwater management regulations. The Town is also regulated under the Dodge County Land Use Code, which includes erosion control and stormwater management regulations. In the event of conflicting regulations in the Town and County ordinances, the more restrictive regulation applies.*

[e] *In 1986, Washington County rescinded its general zoning ordinance. All towns in the County have adopted a town zoning ordinance. County floodplain and shoreland regulations continue to apply in unincorporated (town) areas.*

[f] *Both the Washington County and Town subdivision ordinances apply within the Town of Erin. In the event of conflicting regulations, the more restrictive regulation applies.*

[g] *All towns in Washington County were given the option of being regulated under the County Erosion Control and Stormwater Management Ordinance, adopting a Town ordinance based on a model ordinance developed by the County and contracting with the County for enforcing the ordinance, or adopting a Town ordinance based on a model ordinance developed by the County with the Town taking responsibility for enforcing the ordinance. The Town of Erin chose to be regulated under the County ordinance.*

[h] *The Waukesha County Zoning Ordinance applies only in the Towns of Genesee, Oconomowoc, Ottawa, and Vernon. However, because the County has a general zoning ordinance, all zoning amendments (map and text amendments) to other town zoning ordinances within the County are subject to review and approval by the County Board.*

[i] *The Waukesha County Shoreland and Floodland Protection Ordinance and Storm Water Management and Erosion Control Ordinance apply only in unincorporated areas (towns) in the County.*

[j] *The Waukesha County subdivision ordinance applies only within shoreland areas in unincorporated (town) areas of the county. The County also reviews subdivision plats outside shoreland areas as an objecting agency under Chapter 236 of the Wisconsin Statutes.*

Source: SEWRPC.

Table I-2

LAND USE IN THE MASON CREEK WATERSHED: 2010-2035[a]

Category[b]	2010 Acres	2010 Percent of Total	2035 Acres	2035 Percent of Total	Change: 2010-2035 Acres	Change: 2010-2035 Percent
Urban						
Residential	607	11.5	676	12.8	70	11.5
Commercial	5	0.1	6	0.1	1	17.4
Industrial	0	0.0	0	0.0	0	0.0
Governmental and Institutional	0	0.0	0	0.0	0	0.0
Transportation, Communication and Utilities	220	4.2	220	4.2	0	0.0
Recreational	6	0.1	6	0.1	0	0.0
Subtotal	837	15.9	908	17.2	71	8.4
Rural						
Agricultural and Open Lands[d]	3,039	57.6	2,969	56.3	-71	-2.3
Wetlands[e]	1,097	20.8	1,097	20.8	0	0.0
Woodlands	284	5.4	284	5.4	0	0.0
Water	18	0.3	18	0.3	0	0.0
Subtotal	4,438	84.1	4,367	82.8	-71	-1.6
Total	5,275	100.0	5,275	100.0	0	- -

[a]*As approximated by whole U.S. Public Land Survey one-quarter sections.*

[b]*Off-street parking of more than 10 spaces is included with the associated land use.*

Source: SEWRPC.

Table I-3

OVERALL ESTIMATED PERCENT CONNECTED IMPERVIOUS SURFACE FOR THE MASON CREEK WATERSHED

Subwatershed	2010	2035
MC-1	1.2	1.2
MC-2	2.0	2.2
MC-3	2.3	2.4
MC-4	3.7	3.8
MC-2A-Internally Drained Area	1.7	1.7
MC-2B-Internally Drained Area	4.5	4.5
Total Watershed	2.5	2.6

Source: SEWRPC.

Table I-4

ENDANGERED AND THREATENED SPECIES AND SPECIES OF SPECIAL CONCERN IN THE MASON CREEK WATERSHED

Common Name	Scientific Name	Status under the U.S. Endangered Species Act	Wisconsin Status
Plants			
Pale Green Orchid[a]	*Plantanthera flava*	Not listed	Threatened
Animals			
Blanding's Turtle	*Emydoidea blandingii*	Under review	Special concern
Lake Chubsucker	*Erimyzon sucetta*	Not listed	Special concern
Slender Madtom	*Noturus exilis*	Not listed	Endangered
Veery	*Catharus fuscescens*	Not listed	Special concern

[a]*It is unlikely that suitable habitat for this species still exists where this occurrence was recorded.*

Source: Wisconsin Department of Natural Resources, Wisconsin State Herbarium, and SEWRPC.

Table I-5

DESCRIPTION OF HYDROLOGIC SOIL GROUPS (HSG)

HSG	Runoff Potential	Infiltration Rate	Transmission Rate
A	Low	High	High
B	Moderately Low	Moderate	Moderate
C	Moderately High	Low	Low
D	High	Very Low	Very Low

Source: Natural Resources Conservation Service and Outagamie County Land Conservation Department.

Table I-6

SOIL HYDROLOGIC GROUPS OF THE MASON CREEK WATERSHED

Soil Hydrologic Group	Percent of Watershed
B	52.3
B/D	14.1
C	20.1
C/D	<1.0
A	<1.0
A/D	13.2

Source: Natural Resources Conservation Service and SEWRPC.

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Chapter I

WATERSHED SETTING AND CHARACTERISTICS

FIGURES

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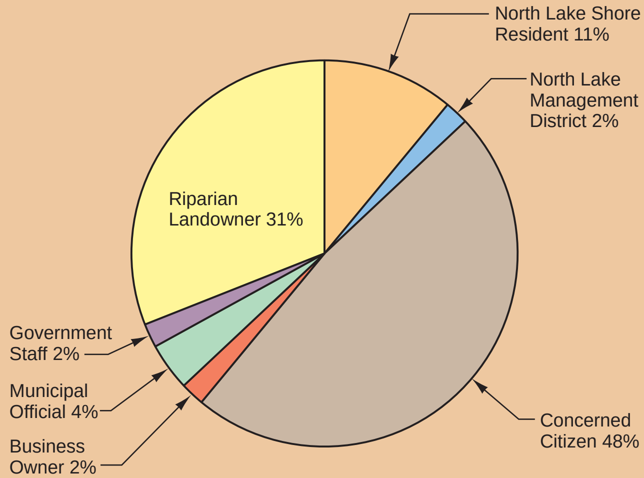
Figure I-1

BREAKDOWN OF WORK GROUP MEMBERS CONTRIBUTING TO THE FORMULATION OF THE MASON CREEK WATERSHED PROTECTION PLAN: 2013 THROUGH 2016

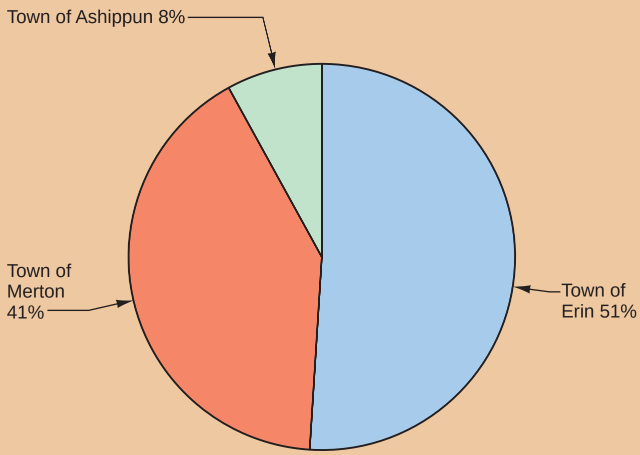


The composition of the work group demonstrates that the **greatest assets** to protect and improve Mason Creek **have been and continue to be the dedicated people** (individuals, organizations, and agency staff) **that live and/or work within the watershed**.

Source: SEWRPC.

Figure I-2

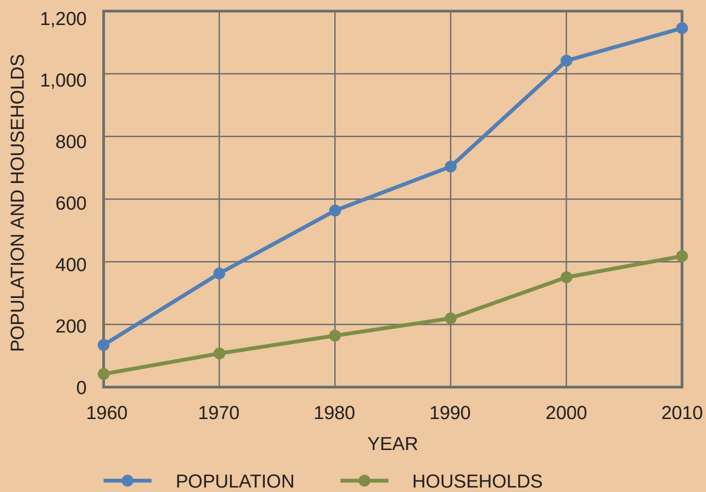
PROPORTION OF MUNICIPALITIES WITHIN THE MASON CREEK WATERSHED: 2014



Source: SEWRPC.

Figure I-3

POPULATION AND HOUSEHOLDS WITHIN THE MASON CREEK WATERSHED: 1960-2010



NOTE: Watershed area approximated by whole U.S. Public Land Survey quarter sections.

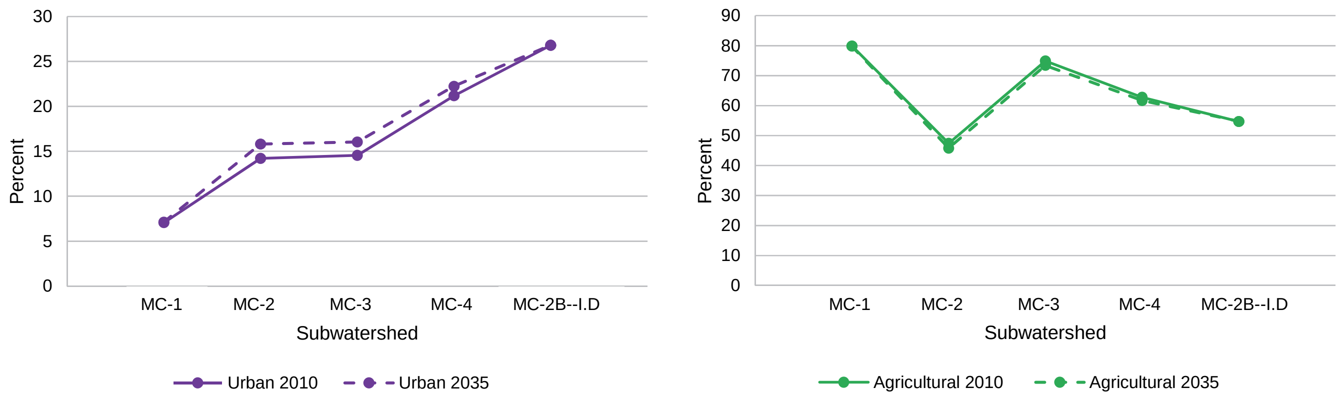
Source: U.S. Bureau of the Census and SEWRPC.

Figure I-4

EXISTING VERSUS PLANNED URBAN AND AGRICULTURAL LAND USE AMONG SUB-BASINS WITHIN THE MASON CREEK WATERSHED: 2010 VS 2035

URBAN LANDS

AGRICULTURAL AND OTHER OPEN LANDS



NOTE: Internally drained subwatershed MC-2A—I.D. is not shown in this figure due to its small size. In 2010, the internally drained subwatershed contained about six acres of woodlands and about 1.25 acres of single family residential land use. The land use is not projected to change in 2035.

Source: SEWRPC.

Figure I-5

STATE OF WISCONSIN ENDANGERED, THREATENED, AND SPECIAL CONCERN SPECIES IN THE MASON CREEK WATERSHED

Blanding's Turtle

Photo by G. Knudsen

Lake Chubsucker

Photo by John Lyons

Pale Green Orchid

Photo by WDNR.

Slender Madtom

Photo by John Lyons

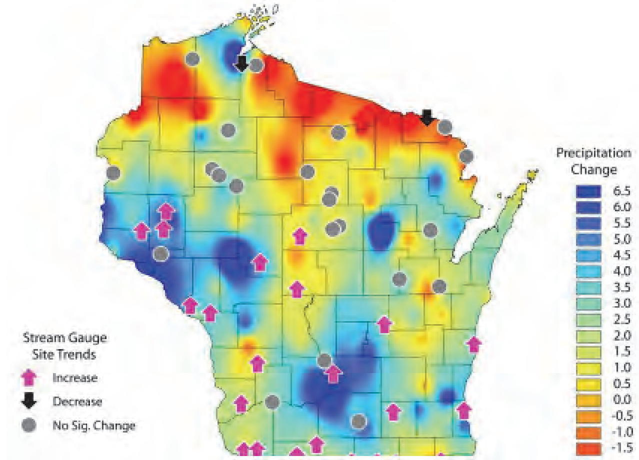
Veery

Photo by Laura Erickson

Source: Wisconsin Department of Natural Resources and SEWRPC.

Figure I-6

RIVER BASEFLOW TRENDS AND PRECIPITATION CHANGE IN WISCONSIN: 1950-2006

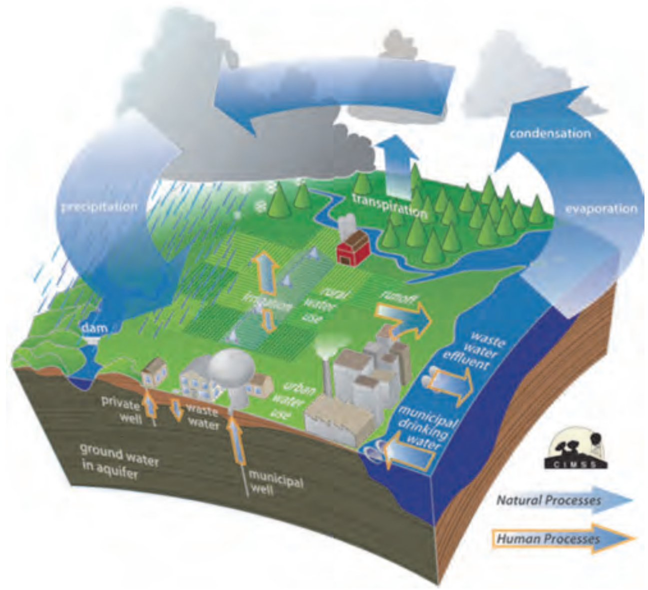


From 1950-2006, Wisconsin as a whole has become wetter, with an increase in annual precipitation of 3.1 inches. This observed increase in annual precipitation has primarily occurred in southern and western Wisconsin, while northern Wisconsin has experienced some drying. The southern and western regions of the State show increases in baseflow, corresponding to the areas with greatest precipitation increases.

Source: Wisconsin Initiative on Climate Change Impacts Water Resources Working Group and SEWRPC.

Figure I-7

HYDROLOGIC CYCLE OF WATER MOVEMENT



These schematic shows how human processes associated with land use development affect the natural processes of how water moves through its different states of the hydrologic cycle. Water returns to the atmosphere through evaporation (process by which water is changed from liquid to vapor), sublimation (direct evaporation by snow and ice), and transpiration (process by which plants give off water vapor through their leaves).

Source: Wisconsin Initiative on Climate Change Impacts Water Resources Working Group and SEWRPC.

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Chapter I

CHAPTER TITLE

MAPS

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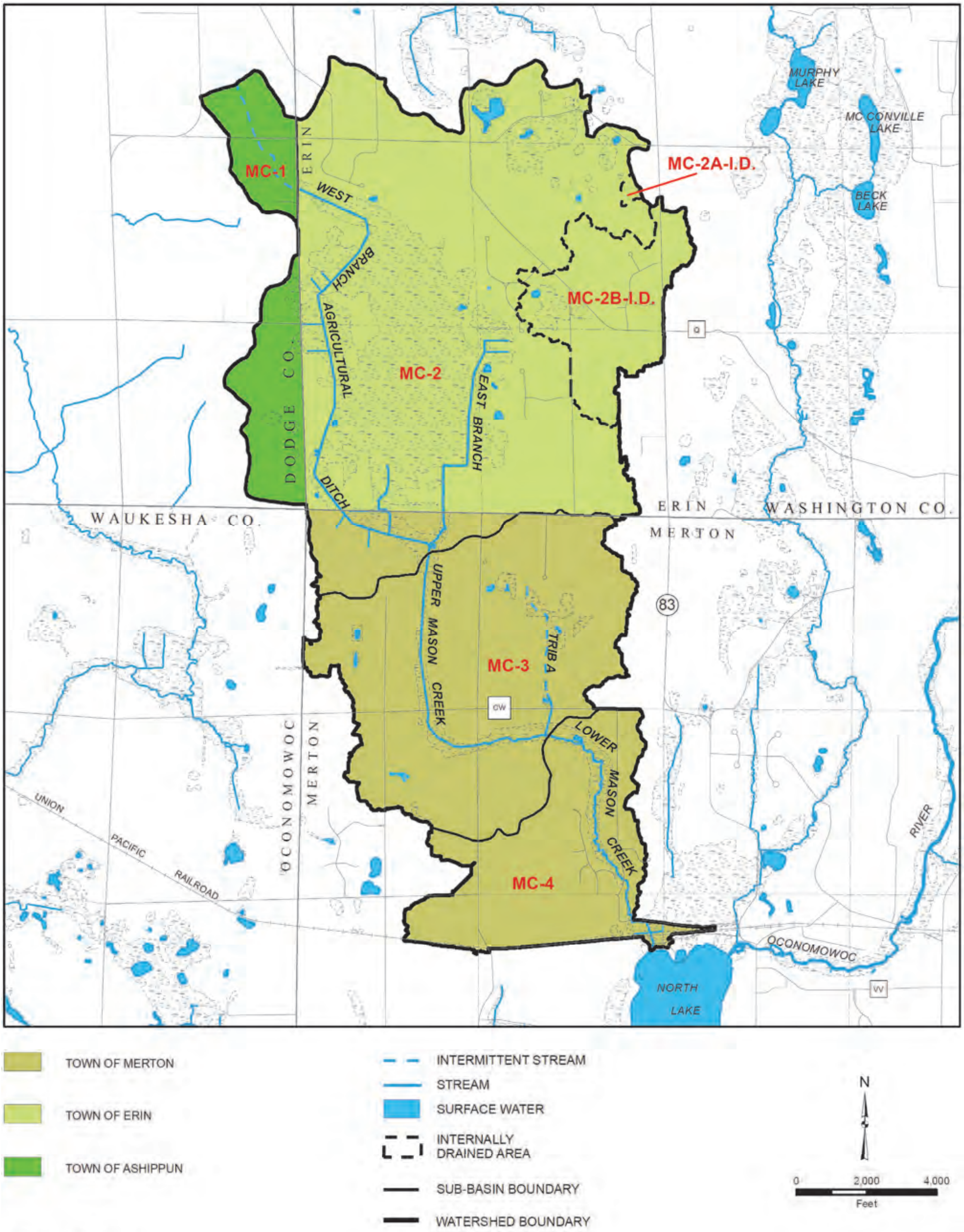
Map I-1

CIVIL DIVISIONS WITHIN THE MASON CREEK WATERSHED: 2015



Source: SEWRPC.

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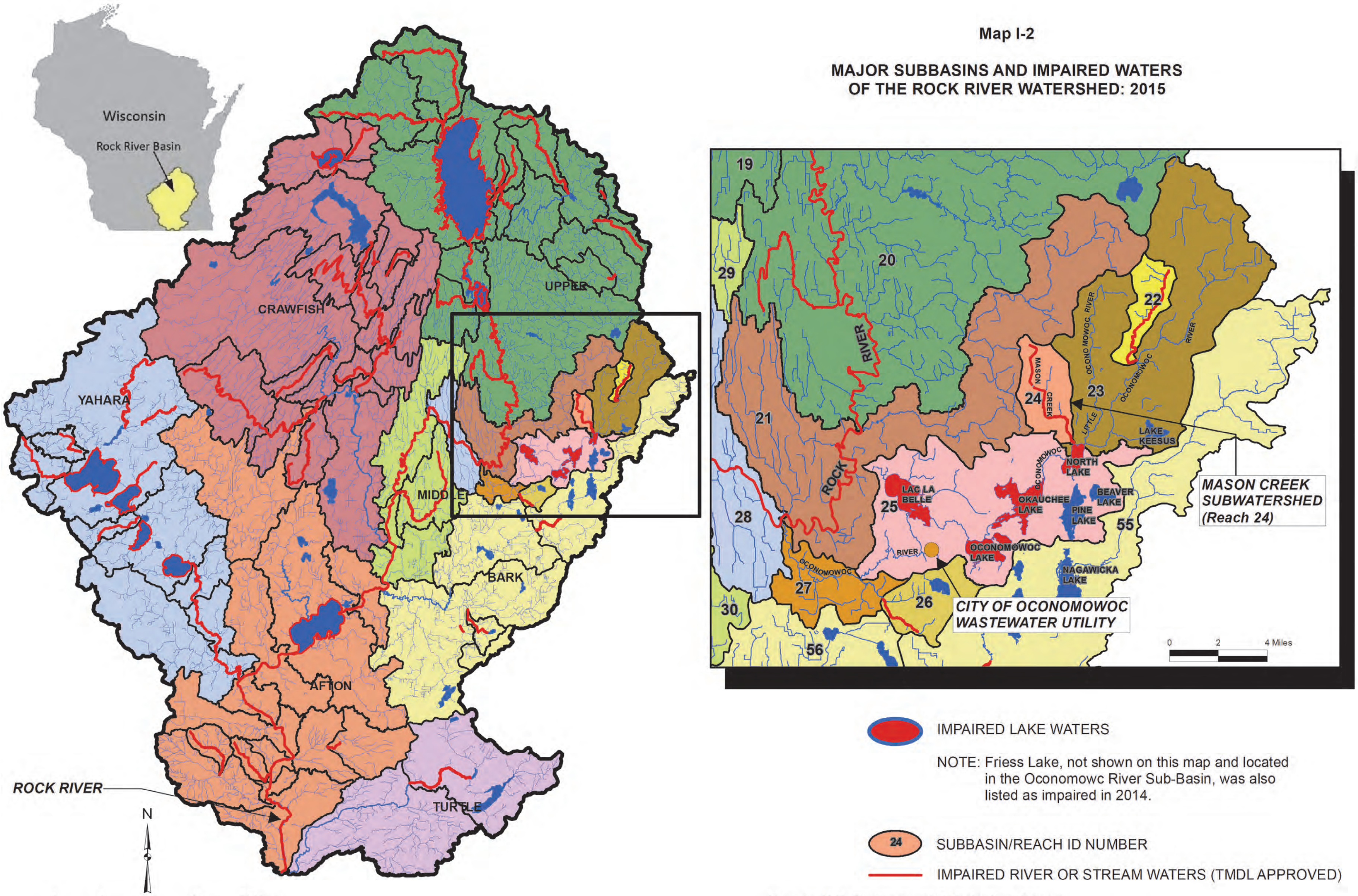
Map I-2

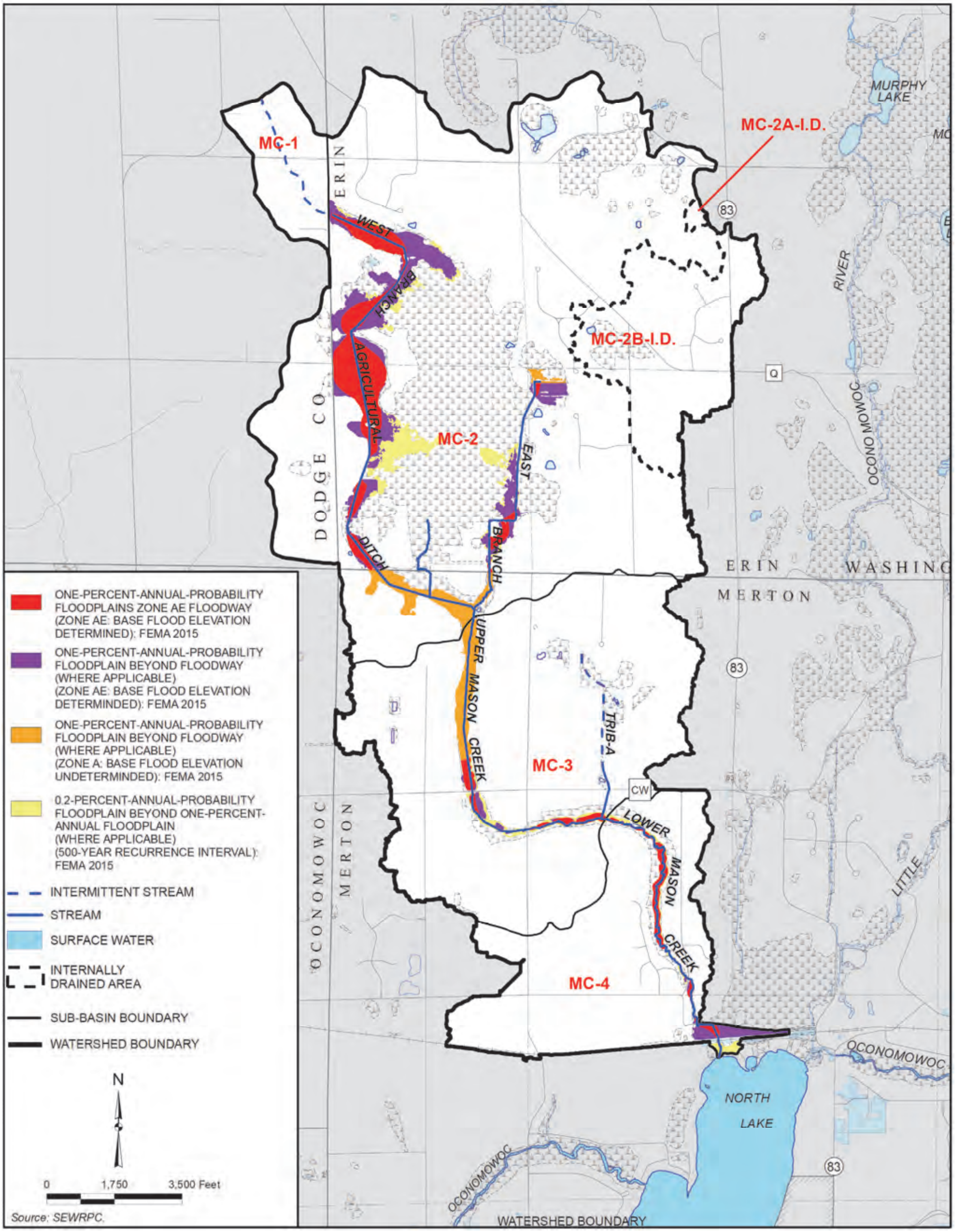
MAJOR SUBBASINS AND IMPAIRED WATERS OF THE ROCK RIVER WATERSHED: 2015



Source: U.S. Environmental Protection Agency, Wisconson Department of Natural Resources, and SEWRPC.

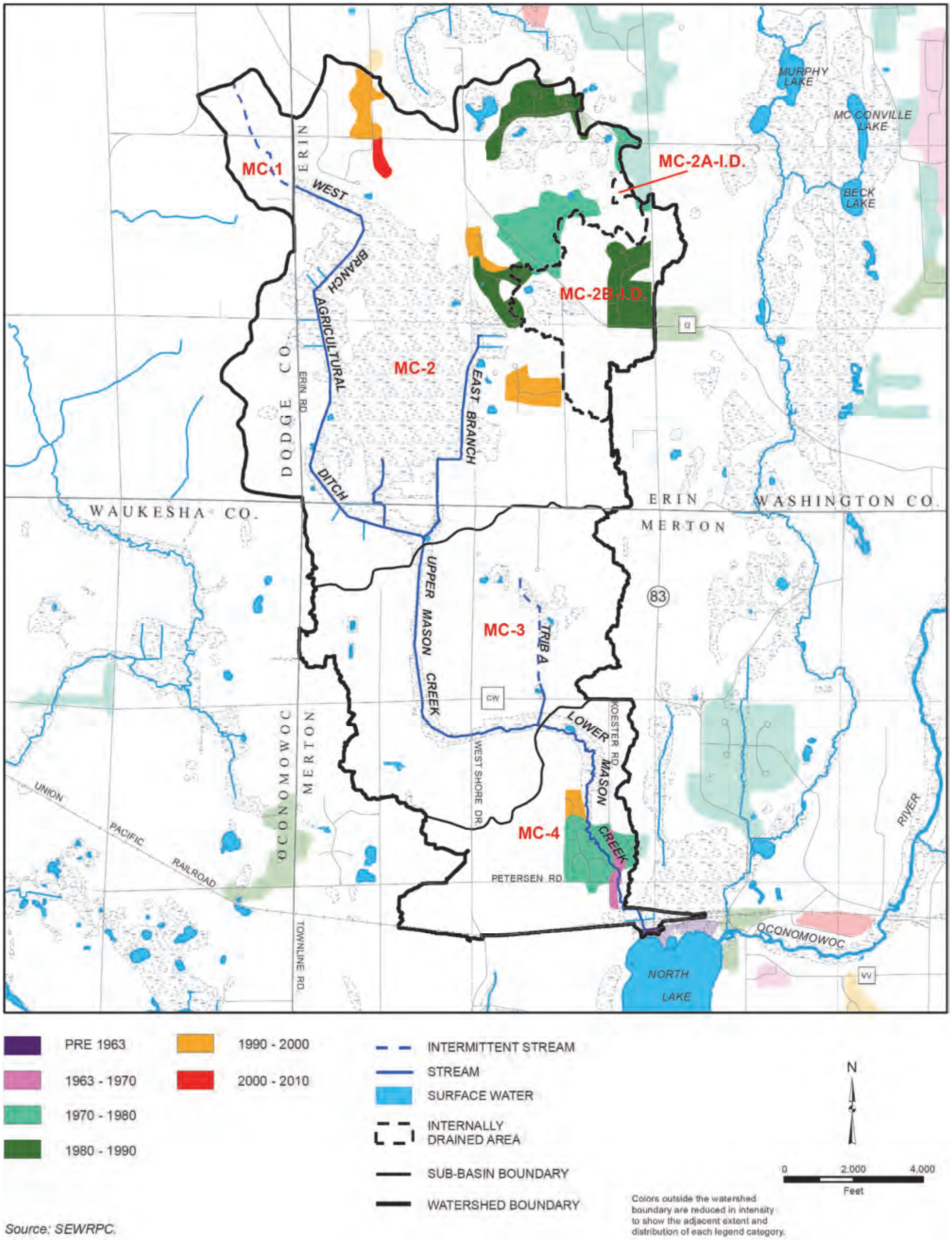
Map I-3

FLOODWAYS AND FLOODPLAINS WITHIN THE MASON CREEK WATERSHED: 2015



Map I-4

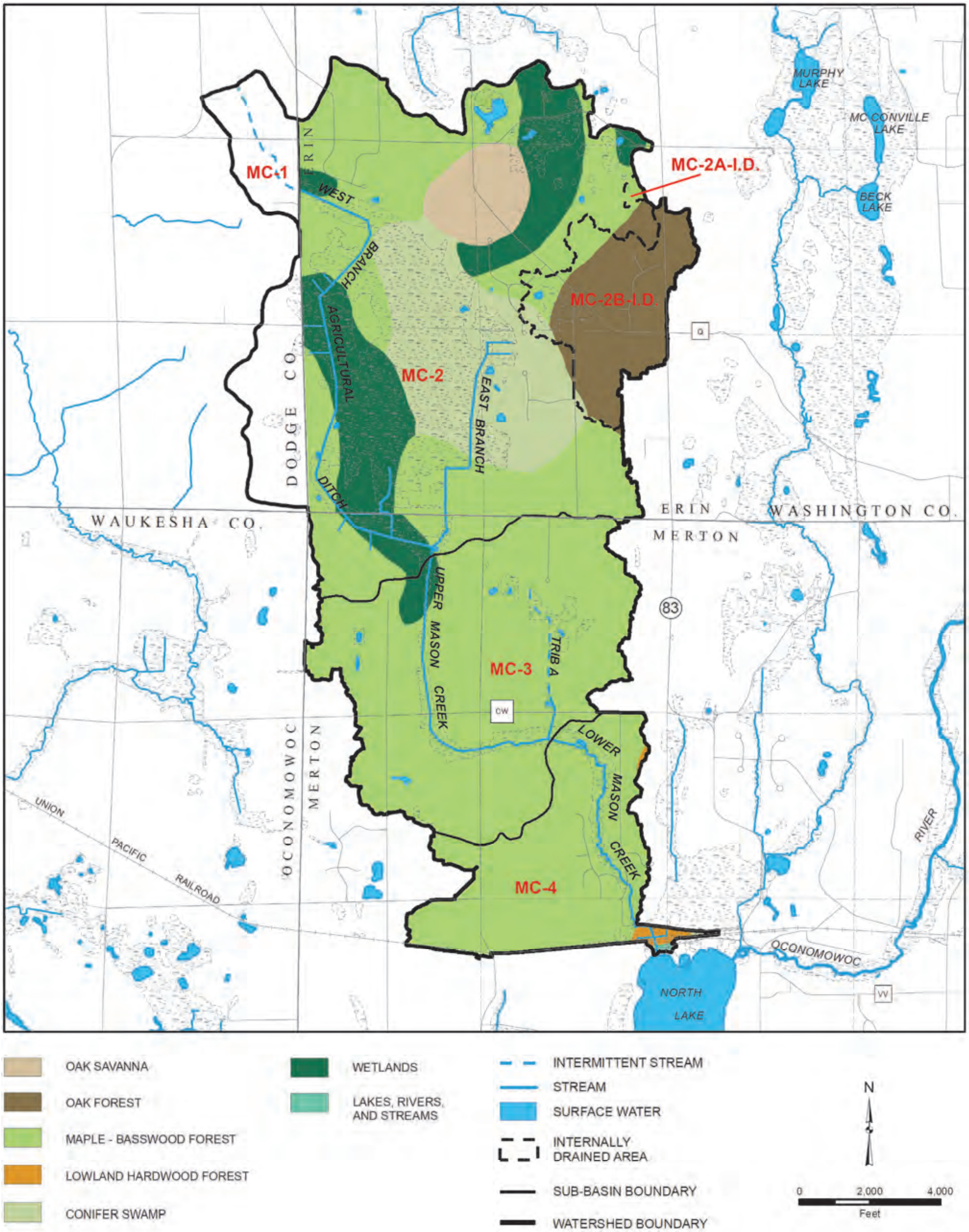
HISTORICAL URBAN GROWTH WITHIN THE MASON CREEK WATERSHED: 1850-2010



Source: SEWRPC.

Map I-5

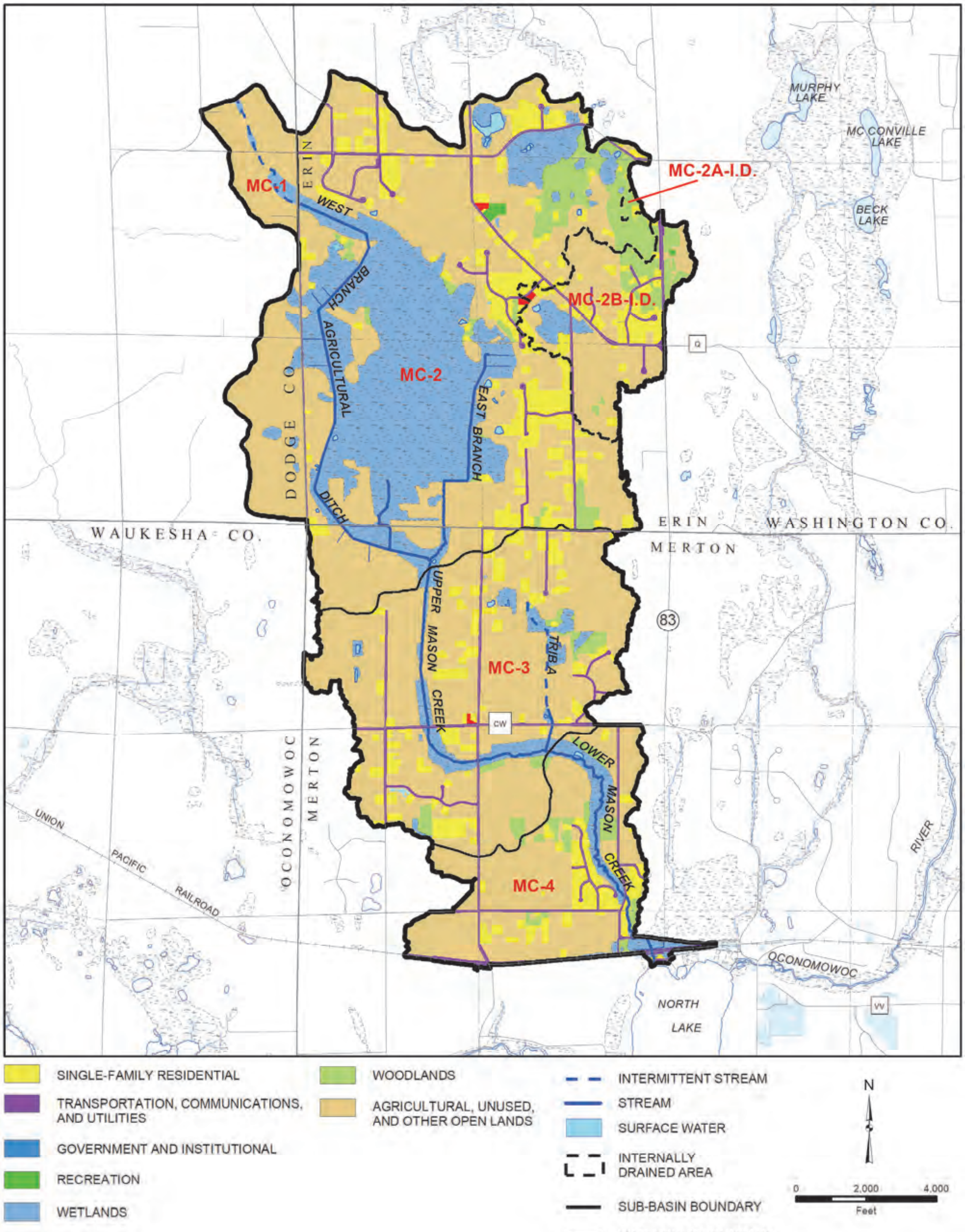
PRESETTLEMENT VEGETATION WITHIN THE MASON CREEK WATERSHED: 1836



Source: SEWRPC.

Map I-6

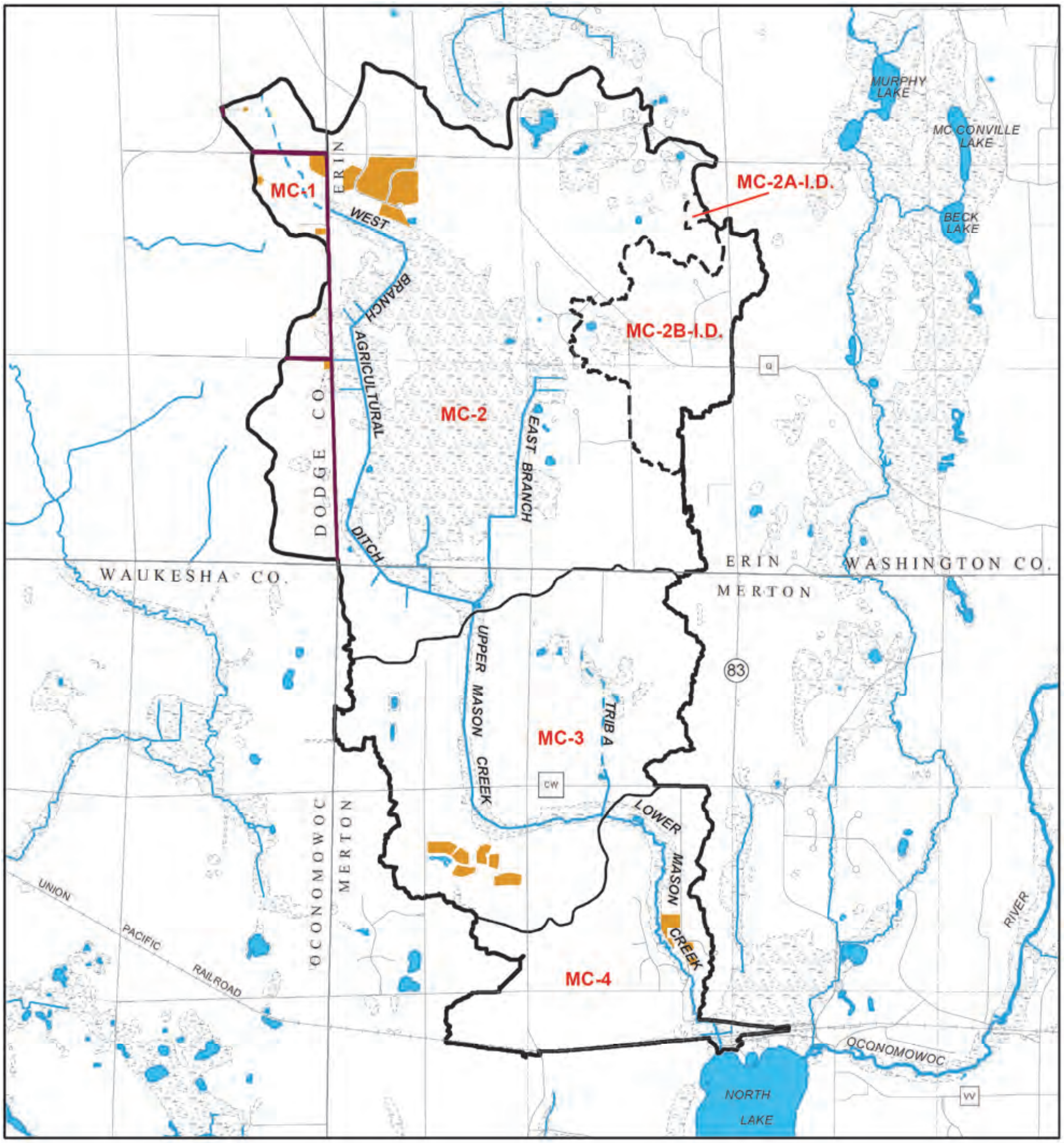
2010 LAND USE WITHIN THE MASON CREEK WATERSHED



Source: SEWRPC

Map I-7

2010 AGRICULTURAL, OPEN LANDS, AND WOODLANDS LOST TO 2035 URBAN PLANNED LAND USE WITHIN THE MASON CREEK WATERSHED



SINGLE-FAMILY RESIDENTIAL

TRANSPORTATION, COMMUNICATIONS, AND UTILITIES

INTERMITTENT STREAM

STREAM

SURFACE WATER

INTERNALLY DRAINED AREA

SUB-BASIN BOUNDARY

WATERSHED BOUNDARY

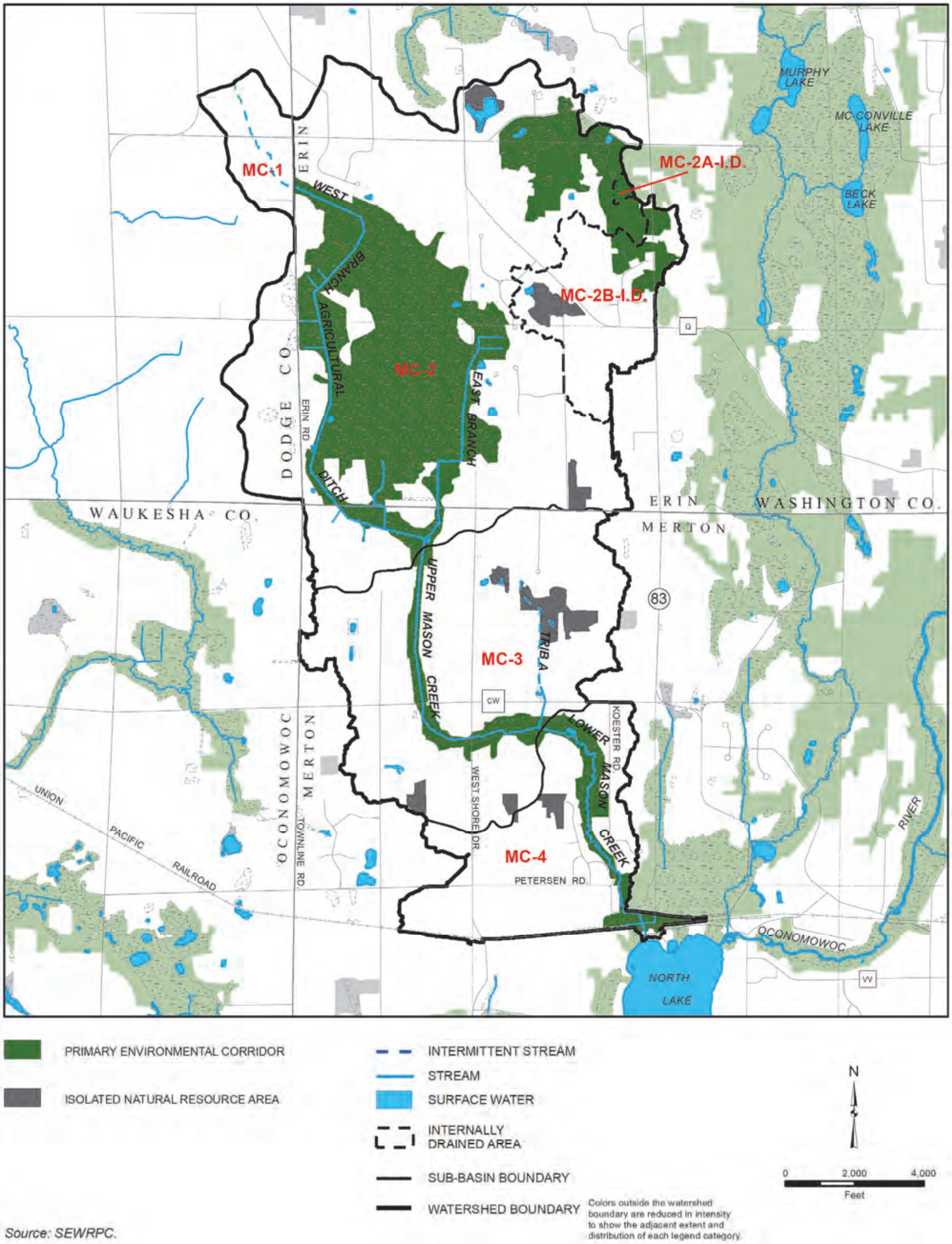
N

0 2,000 4,000
Feet

Source: SEWRPC.

Map I-8

ENVIRONMENTAL CORRIDORS WITHIN THE MASON CREEK WATERSHED: 2010



Source: SEWRPC.

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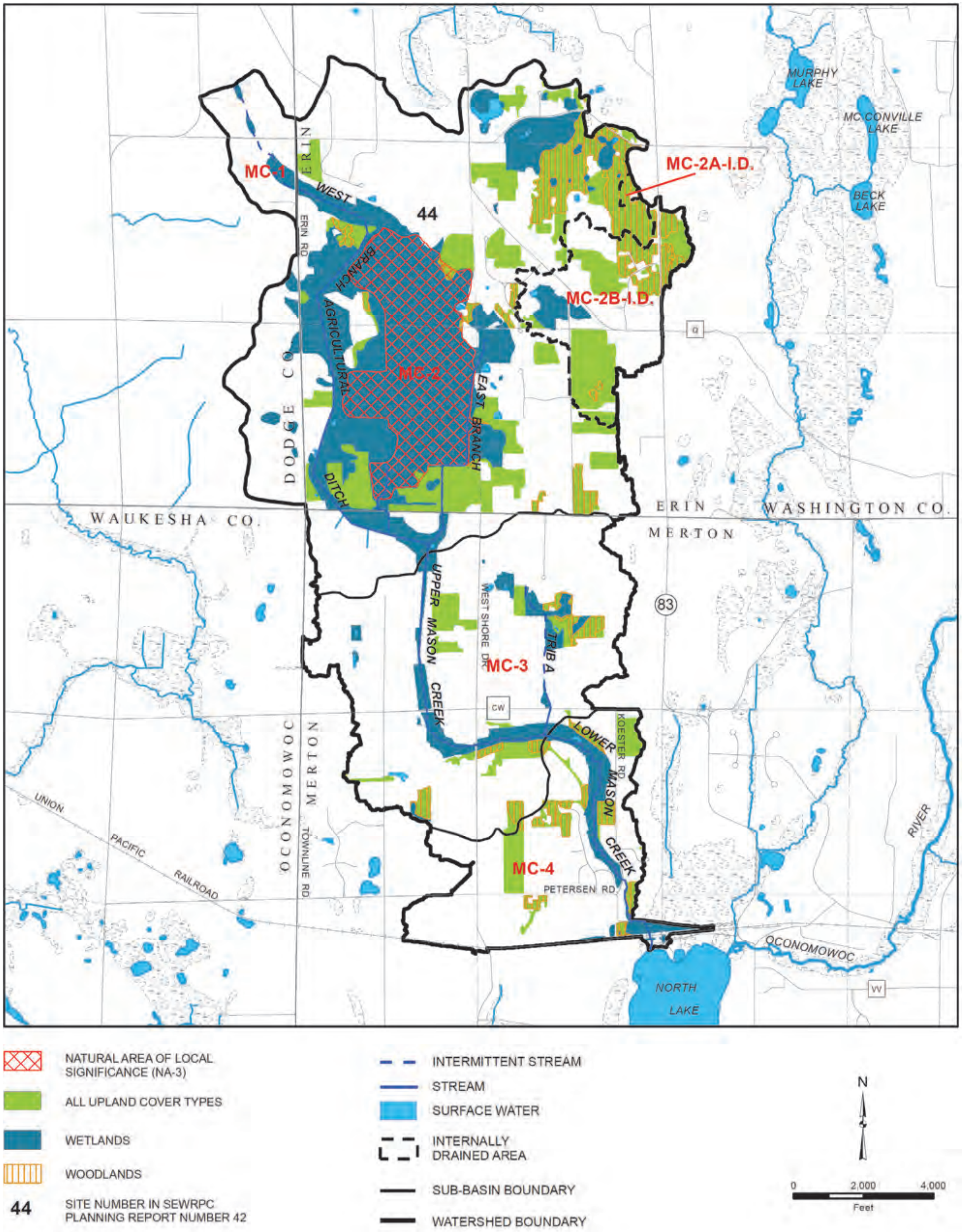
Map I-9

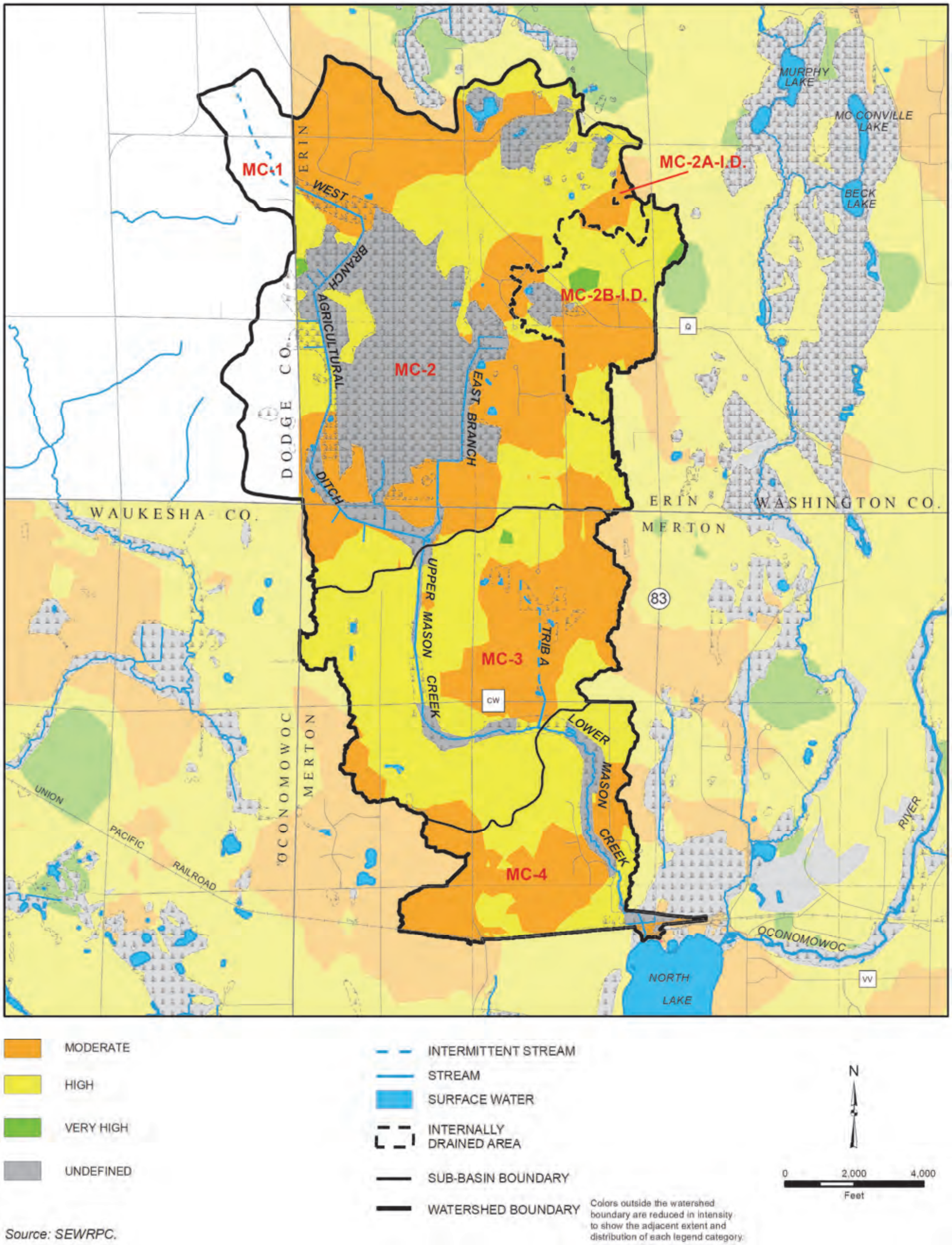
NATURAL AREAS, WETLANDS AND UPLAND COVER TYPES WITHIN THE MASON CREEK WATERSHED: 2010



Source: SEWRPC.

Map I-10

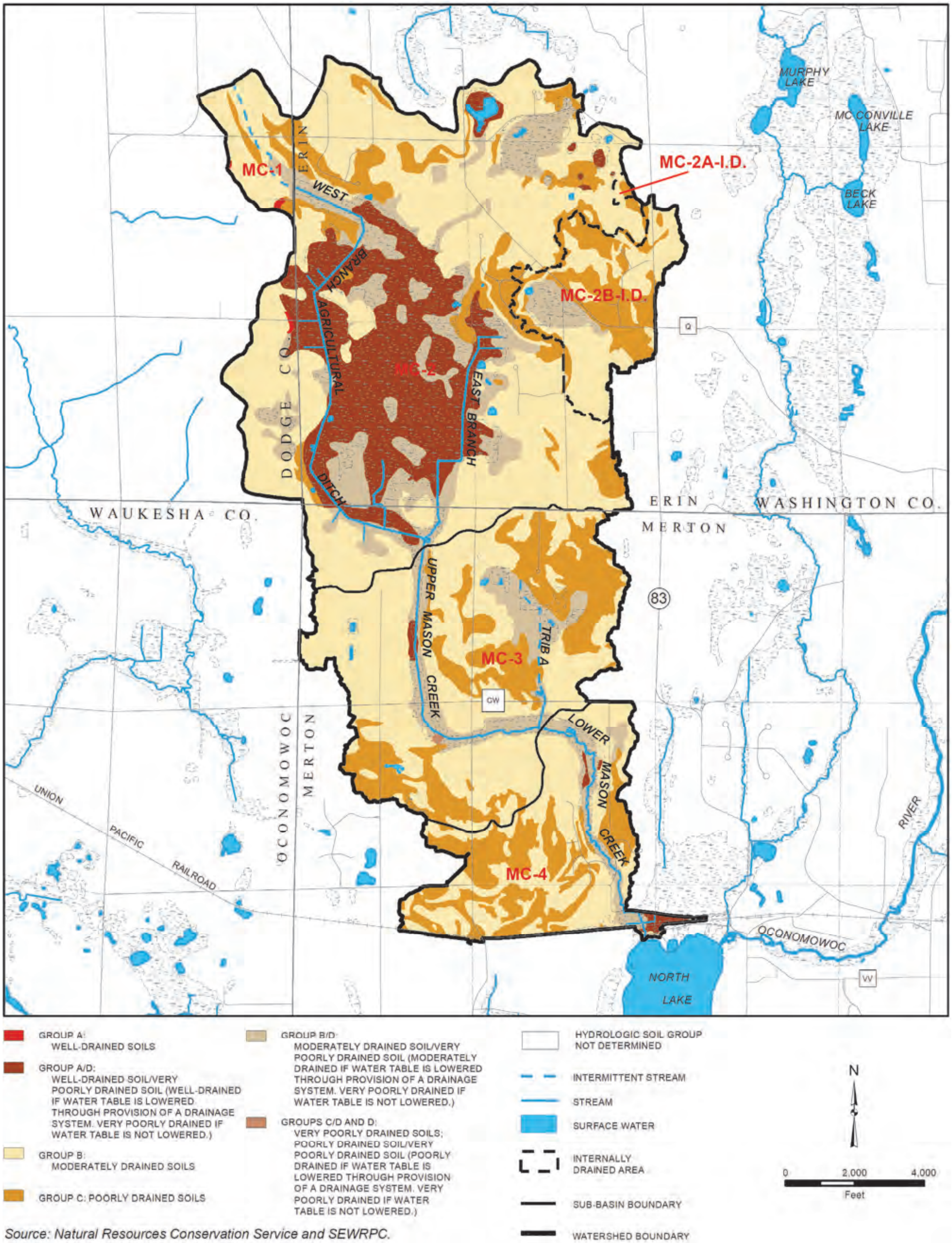
ESTIMATES OF GROUNDWATER RECHARGE WITHIN THE MASON CREEK WATERSHED: 2000



Source: SEWRPC.

Map I-11

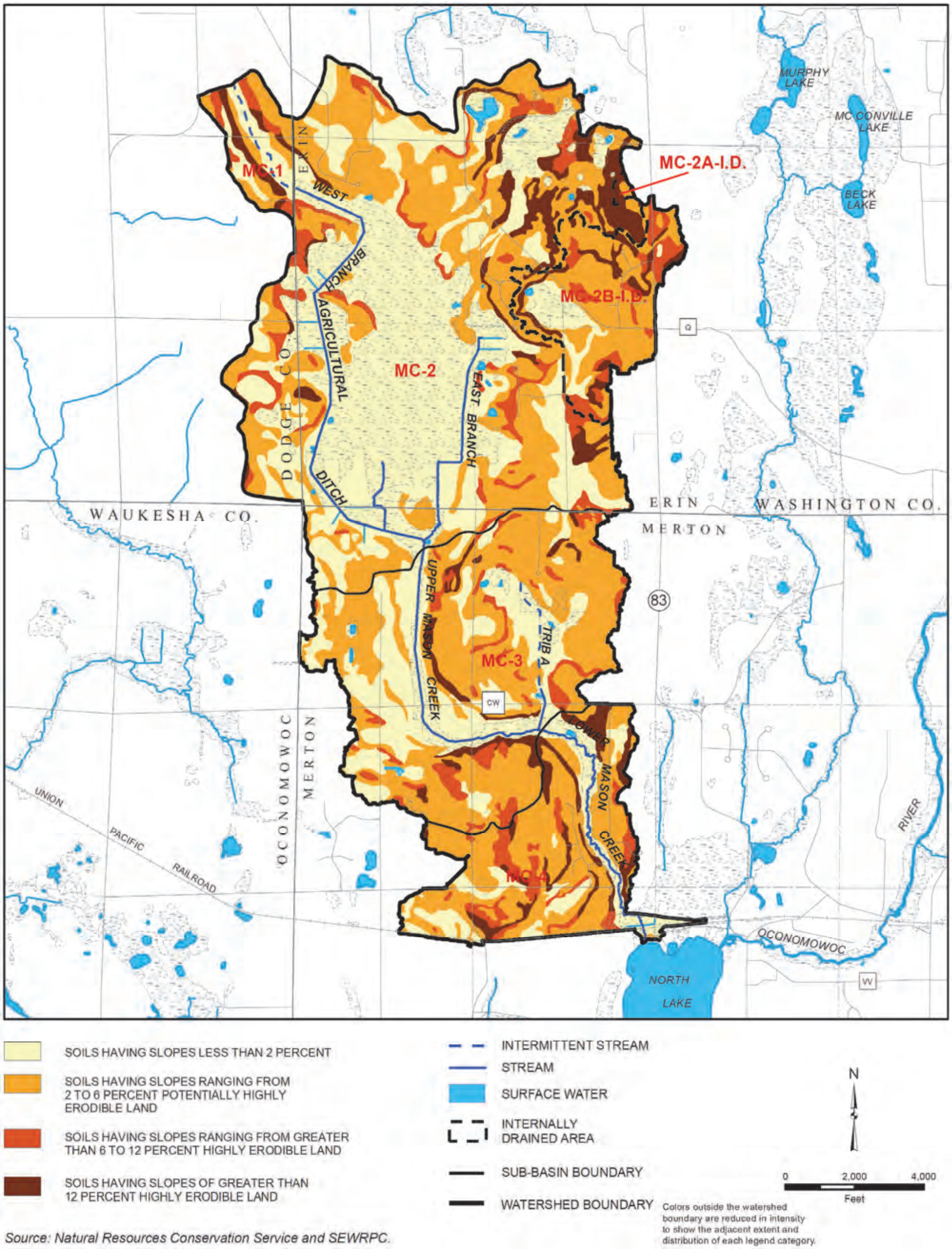
HYDROLOGIC SOIL GROUPS WITHIN THE MASON CREEK WATERSHED: 2010



Source: Natural Resources Conservation Service and SEWRPC.

Map I-12

SOIL SLOPES WITHIN THE MASON CREEK WATERSHED: 2010



Source: Natural Resources Conservation Service and SEWRPC.

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MASON CREEK WATERSHED PROTECTION PLAN

Chapter II

INVENTORY FINDINGS

INTRODUCTION

The health of a stream system is a direct reflection of its watershed. More specifically, changes in land use and water resources in a watershed affect the physical or chemical properties within streams, which in turn affect water quality, habitat, and resident biological communities. Hence, a stream's health is a result of the interaction of its physical, chemical, and biological components (see Figure II-1).

The condition of biological communities—which are collections of aquatic organisms—provides a direct measure of stream health. Reduced stream health is often associated with human-induced changes to the physical and chemical properties of streams that affect the condition of biological communities. Therefore, this chapter describes how land and water management activities within the Mason Creek watershed have influenced the physical, chemical, and biological properties of this stream system. Describing and inventorying those influences on the stream system enables development of effective management strategies aimed at restoring stream health that support the recommended management measures detailed in Chapter III of this report.

This chapter presents an inventory and analysis of the surface waters and related features of the Mason Creek watershed. Included is qualitative and quantitative information pertaining to 1) Physical Conditions—historical trends and current status of instream habitat quality within the Mason Creek system; 2) Chemical Conditions—historical trends and potential limitations to water quality and fishery resources; and 3) Biological Conditions—fishes and other aquatic organisms and wildlife characteristics of Mason Creek.

Environmental Factors Influenced by Agriculture and Urban Land Use

U.S. Geological Survey (USGS) scientists recently found that stream health was reduced at the vast majority of streams assessed in agricultural and urban areas across the nation.[1] The researchers found that the degree of ecological health within a stream system is directly related to the degree of human-induced changes in streamflow characteristics and water quality (nutrients and pesticides). Major findings and important implications of that study include:

- The presence of healthy streams in watersheds with substantial human influence indicates that it is possible to maintain and restore healthy stream ecosystems.
- Water quality is not independent of water quantity because flows are a fundamental part of stream health. Because flows are modified in so many streams and rivers, there are many opportunities to enhance stream health with targeted adjustments to flow management.
- Efforts to understand the causes of reduced stream health should consider the possible effects of nutrients and pesticides, in addition to modified flows, particularly in agricultural and urban settings.

More specifically, activities associated with agricultural and urban land uses have been demonstrated to influence the hydrologic, chemical, and physical factors of the streams, which are briefly described below and illustrated in Figure II-2.[2]

Hydrologic Impacts

The natural timing, variability, and magnitudes of streamflow influence many of the key physical, chemical, and biological characteristics and processes of a healthy stream system. For example, recurring high flows from seasonal rainfall or snowmelt shape the basic structure of a river and its physical habitats, which in turn influences the types of aquatic organisms that can thrive. For many aquatic organisms, low flows impose basic constraints on the availability and suitability of habitat, such as the amount of the stream bottom that is actually submerged. The life cycles of many aquatic organisms are highly synchronized with the variation and timing of natural streamflows. For example, the reproductive period of some species like northern pike is triggered by the onset of spring runoff.

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[1]*D.M. Carlisle and others*, The quality of our Nation's waters—Ecological health in the Nation's streams, *1993-2005: U.S. Geological Survey Circular 1391, 2013 (available online at:* http:// pubs.usgs.gov/circ/1391/*).*

[2]Ibid.

In general, human activities in agricultural settings alter the natural flow regime of streams and rivers through 1) subsurface drain tiles, which lower the water table and quickly route water to nearby streams; 2) ditching and straightening of headwater streams; and 3) irrigation, which supplements available water for crops. These changes can result in more rapid runoff, reduced streamflows during dry periods, and increased transport of sediments and pollutants. However, since there is a diversity of agricultural practices (see Figure II-2, Agricultural Stream Ecosystem), the impacts to stream ecosystems can be highly variable.

In an urban setting, human activities change the movement of water in a watershed through introduction of increased impervious surfaces, such as buildings and pavement for roadways and parking, which restrict the infiltration of precipitation into the groundwater system, combined with construction of artificial drainage systems (e.g., storm sewer systems) that quickly move runoff to streams (see Figure II-2, Urban Stream Ecosystem). These impervious surfaces can lead to increased stormwater runoff and higher and more variable peak streamflows (see Figure II-3), which scour the streambed or banks and degrade the stream channel. Reduced infiltration to groundwater can lead to diminished streamflows during dry periods, particularly in stream systems where groundwater is the main source of base flow. In addition, in urban areas with a groundwater supply serving residential, industrial, and commercial land uses, increases in the withdrawal of groundwater can also affect the natural flow regime of stream systems.

More specifically, recent research has shown that the hydrologic variables most consistently associated with changes in algal, invertebrate, and fish communities[3] are average flow magnitude; high flow magnitude, frequency and duration; and how rapidly the stream changes its width in response to changes in flow. As detailed in Chapter I of this report, the amount of urban development within portions of the Mason Creek watershed is at high enough levels to potentially have negative effects on water quality and water quantity, and the amount of urbanization is projected to increase.

To some degree, impervious surface impacts can be mitigated through implementation of traditional stormwater management practices and emerging green infrastructure technologies, such as pervious pavement, green roofs, rain gardens, bioretention, and infiltration facilities. Emerging technologies differ from traditional stormwater practices in that they seek to better mimic the disposition of precipitation on an undisturbed landscape by retaining and infiltrating stormwater onsite. A number of nontraditional, emerging low impact development technologies have been implemented throughout the Southeastern Wisconsin Region, including disconnecting downspouts; installing rain barrels, green roofs, and rain gardens; and constructing biofiltration swales in parking lots and along roadways. Experience has shown that these emerging technologies can be effective.

[3]*Personal Communication, Dr. Jeffrey J. Steuer, U.S. Geological Survey.*

Location of impervious surfaces also determines the degree of direct impact they will have upon a stream. There is a greater impact from impervious surfaces located closer to a stream, because there is less time and distance for the polluted runoff to be naturally treated before entering the stream. A study of 47 watersheds in southeastern Wisconsin found that one acre of impervious surface located near a stream could have the same negative effect on aquatic communities as 10 acres of impervious surface located further away from the stream.[4] Because urban lands located adjacent to streams have a greater impact on the biological community, an assumption might be made that riparian buffer strips located along the stream could absorb the negative runoff effects attributed to urbanization. Yet, riparian buffers may not be the complete answer since most urban stormwater is delivered directly to the stream via a storm sewer or engineered channel and, therefore, enters the stream without first being filtered by the buffer. Riparian buffers need to be combined with other management practices, such as detention basins, grass swales, and infiltration facilities, to adequately mitigate the effects of urban stormwater runoff. Combining practices into such a "treatment train" can provide a higher level of pollutant removal and reduction in the volume of runoff, than can single, stand-alone practices. Stormwater and erosion treatment practices vary in their function, which influences their level of effectiveness. Location of a practice on the landscape, as well as proper construction and continued maintenance, greatly influences the level of pollutant removal and runoff volume management.

Urbanization also creates other problems. Accumulations of trash and debris in urban waterways and associated riparian lands are unsightly and can cause physical and/or chemical (i.e., toxic) damage to aquatic and terrestrial wildlife. Sometimes debris can accumulate to such an extent that it may limit recreation and the passage of aquatic organisms and/or cause streambank erosion.

Chemical Impacts

The unique water chemistry requirements and tolerances of aquatic species help to define their natural abundance in a given stream, as well as their geographic distribution. Many naturally occurring chemical substances in streams and rivers are necessary for normal growth, development, and reproduction of biological communities. For example, sufficient dissolved oxygen in water is necessary for normal respiration. Dissolved oxygen concentrations in streams and rivers is determined by the water temperature and by physical aeration processes influenced by the slope and depth of the stream. Similarly, small amounts of nutrients (nitrogen, phosphorus, and silica) are necessary for normal growth of aquatic plants.

Human activities often contribute additional amounts of these naturally occurring substances, as well as other synthetic (manmade) chemicals, to streams from point and nonpoint sources. Runoff from agricultural lands (see Agricultural Stream Ecosystem in Figure II-2) may contain 1) sediment from soil erosion on tilled lands; 2) nutrients

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[4]*L. Wang, J. Lyons, P. Kanehl, and R. Bannerman, "Impacts of Urbanization on Stream Habitat and Fish Across Multiple Spatial Scales,"* Environmental Management, *Volume 28, 2001, pages 255-266.*

from the application of fertilizer and manure; and 3) pesticides used in the past and present to control insects, weeds, rodents, bacteria, or other unwanted organisms. Runoff from urban lands (see Urban Stream Ecosystem in Figure II-2) may contain 1) sediment from construction activities; 2) nutrients and pesticides applied to lawns and recreational areas; and 3) petroleum compounds, trace metals, and deicing salts from roads and parking lots. Point sources include municipal and industrial wastewater effluent that, depending on the sources of wastewater and level of treatment, may contain different amounts of nutrients and other contaminants.

Physical Impacts

Physical habitat includes factors such as streambed substrates, water temperature, and large debris from streamside vegetation. Streambed substrates include the rocks, sediments, and submerged woody material in a stream. Streambed sediments may range in size and composition from large rocks to sand and silt that reflect the local geology. These substrates are important because they provide living space for many stream organisms. Stable substrates, such as cobbles and boulders, protect organisms from being washed downstream during high flows and, thus, generally support greater biological diversity than do less stable substrates, such as sand and silt.

Water temperature is crucial to aquatic organisms because it directly influences their metabolism, respiration, feeding rate, growth, and reproduction. Most aquatic species have an optimal temperature range for growth and reproduction. Thus, their distributions are largely determined by regional differences in climate and elevation along with more local effects from riparian (stream corridor) shading and groundwater influence. Water temperature also influences many chemical processes, such as the availability of oxygen in water for fish and other aquatic life.

The riparian zone is the land adjacent to the stream inhabited by plant and animal communities that rely on periodic or continual nourishment from the stream. The size and character of riparian zones are important to biological communities because these have a major influence on the amount of shelter and food available to aquatic organisms and the amount of sunlight reaching the stream through the tree canopy, which influences water temperature and the amount of energy available for photosynthesis. Riparian zones also influence the amount and quality of runoff that reaches the stream.

Land uses that affect streamflow, sediment availability, or riparian vegetation alter physical habitats in streams. Some agricultural practices (see Agricultural Stream Ecosystem in Figure II-2), such as conventional tillage near streambanks and drainage modifications, lead to increased sediment erosion, channelization, or removal of riparian vegetation. Increased sediment from erosion can fill crevices between rocks and cobble in the streambed, which reduces living space for many stream organisms. As watersheds urbanize (see Urban Stream Ecosystem in Figure II-2), some segments of streams may be cleared, ditched, straightened, and enclosed to facilitate drainage and the movement of floodwaters. These modifications increase stream velocity during storms, which can transport large amounts of sediment, scour stream channels, and remove woody debris and other natural structures that provide habitats for stream organisms. In addition, culverts and ditches can be barriers to aquatic organisms that need to migrate throughout the stream network. Humans can alter natural stream temperature through changes in the amount and density of the canopy provided by riparian trees. In some extreme cases, streams in urban areas are routed through pipes and completely buried.

Mason Creek Drainage Network

Water from rainfall and snowmelt flows into streams by one of two pathways: 1) either directly flowing overland as surface water runoff or 2) infiltrating into the soil, recharging the groundwater, and eventually reaching streams as baseflow. Ephemeral, or intermittent, streams generally flow only during the wet season or during large rainfall events. Perennial streams that flow year-round are primarily sustained by groundwater during dry periods. The surface water stream network within the Mason Creek watershed is shown on Map II-1, where the intermittent reaches are shown as dashed lines and perennial streams are solid lines. Four sub-basin areas within this watershed are designated as MC-1 through MC-4, and are numbered from upstream to downstream in the watershed. In addition, Mason Creek was further divided into several discrete reaches, which were established based on a number of considerations including gradient, sinuosity, presence of culvert crossings, and instream physical characteristics. Mason Creek originates at the confluence of its East and West Branches, which are first order headwater streams and are approximately one mile and two miles long, respectively. The East Branch has a consistent baseflow of about 1.5 cubic feet per second (cfs) based on monitoring data from 2011 through 2012, and maintained a baseflow of one cfs during the severe drought in the summer of 2012. In contrast, the West Branch, which was constructed solely as an agricultural drainage ditch (hereinafter, West Branch Agricultural Ditch), contains very limited baseflows; one measurement of 0.2 cfs was taken on June 8, 2012, and no observations could be taken later that summer due to extreme low flows. The mainstem of Mason Creek basically begins at the confluence of the East and West Branch Agricultural Ditch forming a second order stream and is nearly 3.5 miles in total length. The mainstem can be divided into two main segments. As shown in Figure II-4 the Upper Mason Creek reach has a relatively shallow gradient (4.7 feet per mile) and baseflow discharge that ranges from about four to six cfs. In contrast, the Lower Mason Creek reach has a much steeper gradient (23.5 feet per mile) that flattens out near the railroad crossing just before it discharges into North Lake with a baseflow discharge that ranges from about eight to 16 cfs. Trib-A has a baseflow of about 0.5 cfs, and there is no discharge information for any of the other unnamed minor tributaries (see Map II-1). The summary statistics and recommendations in this report are organized according to these reaches and sub-basin areas.

WATER QUALITY

The Federal Clean Water Act (CWA) protects the nation’s waters and requires states to 1) adopt water quality criteria that the United States Environmental Protection Agency (USEPA) publishes under 304 (a) of the Clean Water Act, 2) modify 304 (a) criteria to reflect site-specific conditions, or 3) adopt criteria based on other scientifically defensible methods. Water quality standards require assigning a designated use to the waterbody.

Clean water is vital to individual human health, healthy communities, and the economy. Having clean water upstream is essential to having healthy communities downstream. The health of rivers and lakes depend on the tributaries and wetlands where they begin. Streams and wetlands provide many benefits to communities by conveying and storing floodwaters, assimilating and filtering pollution, and providing habitat for fish and wildlife.[5]

The Clean Water Rule: Definition of "Waters of the United States"

Protection for about 60 percent of the nation's streams and millions of acres of wetlands has been confusing and complex as the result of U. S. Supreme Court decisions in 2001 and 2006. The "Clean Water Rule: Definition of 'Waters of the United States'" was published by the USEPA and the U.S. Army Corps of Engineers on June 29, 2015, pursuant to the Federal Clean Water Act, to clarify which streams and wetlands comprise "water of the United States" that are regulated under the Act.[6] The Rule protects the types of waters that have historically been covered under the Clean Water Act. The Rule does not regulate most ditches and does not regulate groundwater, shallow subsurface flows, or tile drains. It does not make changes to current policies on irrigation or water transfers or apply to erosional features. The rule does not create any new requirements for farmers. Activities like planting, harvesting and moving livestock have long been exempt from Clean Water Act regulation, and the Clean Water Rule preserves those exemptions.[7]

Water Quality Standards

Water quality standards are the basis for protecting the quality of surface waters. The standards implement portions of the Federal Clean Water Act by specifying the designated uses of waterbodies and setting water quality criteria to protect those uses. The standards also contain policies to protect high-quality waters and to protect waters from being further degraded. Water quality standards are established to sustain public health and public enjoyment of waters and for the propagation and protection of fish, aquatic organisms, and other wildlife.

In Wisconsin, water quality standards are established and enforced by the Wisconsin Department of Natural Resources (WDNR) and are subject to approval by the USEPA. These standards consist of three elements: designated uses, water quality criteria, and an anti-degradation policy. These are set forth in Chapters NR 102, "Water Quality Standards for Wisconsin Surface Waters;" NR 103, "Water Quality Standards for Wetlands;" NR 104, "Uses and Designated Standards and Secondary Values;" NR 105, "Surface Water Quality Criteria for Toxic Substances;" and NR 207, "Water Quality Antidegradation," of the *Wisconsin Administrative Code*.

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[5]*See USEPA website for more information at http://www2.epa.gov/cleanwaterrule*

[6]*The Rule has been subject to several legal challenges. On October 9, 2015, the United States Court of Appeals for the Sixth Circuit issued an order temporarily blocking implementation of the Rule nationwide.*

[7]*http://www2.epa.gov/cleanwaterrule/what-clean-water-rule-does-not-do*

Designated Use and Impairments

The designated uses of a waterbody are a statement of the types of activities the waterbody should support—whether or not they are currently being attained. These uses establish water quality goals for the waterbody and determine the water quality criteria needed to protect the use. In Wisconsin, waterbodies are assigned four uses: fish and aquatic life, recreation, public health and welfare, and wildlife. The fish and aquatic life use is further divided into several categories:

- Coldwater community,
- Warmwater sportfish community,
- Warmwater forage fish community,
- Limited forage fish community, and
- Limited aquatic life community.

Coldwater communities include surface waters capable of supporting a community of coldwater fish and other aquatic organisms or serving as a spawning area for coldwater fish species. Warmwater sportfish waters include surface waters capable of supporting a community of warmwater sport fish or serving as a spawning area for warmwater sport fish. Warmwater forage fish waters include those surface waters capable of supporting an abundant diverse community of forage fish and other aquatic organisms. Because identical water quality criteria apply to them, the warmwater sportfish and warmwater forage fish categories are sometimes referred to as "warmwater fish and aquatic life (FAL)." Limited forage fish waters include surface waters of limited capacity and naturally poor water quality or habitat. These waters are capable of supporting only a limited community of forage fish and other aquatic organisms. Limited aquatic life waters include surface waters of severely limited capacity and naturally poor water quality or habitat. These waters are capable of supporting only a limited community of aquatic organisms. The latter two categories are considered variance categories. It is important to note that establishment of a stream water use objective other than coldwater or warmwater fish and aquatic life is not necessarily an indication of reduced water quality, since such streams may be limited by flow or size, but may still be performing well relative to other functions.

The WDNR also has classified some waters of the State as outstanding or exceptional resource waters. These waters, listed in Sections NR 102.10 and NR 102.11 of the *Wisconsin Administrative Code*, are not significantly impacted by human activities and are deemed to have significant value as fisheries, hydrologically or geographically unique features, outstanding recreational opportunities, and unique environmental settings. However, there are no streams with these designations in the Mason Creek watershed.

The water use objectives for fish and aquatic life for all reaches in the Mason Creek watershed are shown on Map II-2. Both the Lower and Upper reaches of Mason Creek are designated as a coldwater Class I (naturally reproducing, not stocked) brook trout community.[8] In addition, the coldwater community designation also extends partially upstream along the West Branch Agricultural Ditch of Mason Creek to the Washington-Waukesha county line, but the remainder of the West Branch Agricultural Ditch is classified as a warmwater fish and aquatic life community. The East Branch of Mason Creek and Trib-A reaches also were classified as warmwater fish and aquatic life communities. All of the remaining stream reaches in the watershed were not classified, so they are assigned the fish and aquatic life default standard. However, all of these waters within the Mason Creek watershed were classified as meeting the full recreational use waters designation. There are no designated outstanding or exceptional resource waters within the watershed.

The water use objectives shown on Map II-2 are regulatory designations. They serve to define the water quality criteria that apply to these waters and form the basis for determining whether the level of water quality in them meets the expectations set forth in the Federal Clean Water Act and Wisconsin law. However, it is important to note that these regulatory designations that were established in the 1980s and 1990s do not exactly match the current conditions of these reaches within this watershed.[9] For example, despite the West Branch Agricultural Ditch's regulatory warmwater and coldwater fish classifications described above, this reach is actually considered a Cool Water (Warm Transition Headwater) fishery based upon water temperature data collected as part of this planning study. In contrast, the East Branch of Mason Creek actually meets the coldwater trout stream standard, which exceeds the quality of its current designation as a warmwater fishery. These cool and cold water designations are a more accurate depiction of these reaches within this stream system and how they function, which are supported by both the biological and water quality observations. Although these revised classifications lack the regulatory significance of the designated uses shown on Map II-2, these revised classifications will be used to guide the assessment and management recommendations in this plan (see "*Biological Monitoring*" section below for more

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[8]*The WDNR uses three categories to classify the different types of trout streams throughout Wisconsin. Class 1 indicates the highest quality trout waters that have sufficient natural reproduction to sustain populations of wild trout, at or near carry capacity. Consequently, streams in this category require no stocking of hatchery trout. These streams or stream sections are often small and may contain small or slow-growing trout, especially in the headwaters. There are 5,289 miles of Class 1 trout streams in Wisconsin and they comprise 40% of Wisconsin's total trout stream mileage. See website at http://dnr.wi.gov/topic/fishing/trout/streamclassification.html*

[9]*WDNR,* A Nonpoint Source Control Plan for the Oconomowoc River Priority Watershed Project*, 1986; WDNR,* Upper Rock River Basin Water Quality Management Plan: A Five Year Plan to Protect and Enhance our Water Resources*, PUBL-WR-190-95REV, December 1995.*

details). In addition, WDNR staff identified that the lower 3.1 mile section of Mason Creek has not supported the potential coldwater community designation since 1995.[10]

Surface Water Quality Criteria

Water quality standards also specify certain criteria that must be met to ensure that the designated uses of waterbodies are supported. These water quality criteria are statements of the physical, chemical, and biological characteristics of the water that must be maintained if the water is to be suitable for the designated uses. Some criteria are limits or ranges of chemical concentrations that are not to be exceeded. Others are narrative standards which apply to all waters.

The applicable water quality criteria for all water uses designated in Southeastern Wisconsin are set forth in Tables II-1 and II-2. Table II-1 shows the applicable water quality criteria for all designated uses for five water quality parameters—dissolved oxygen concentration, pH, fecal coliform bacteria concentration, total phosphorus concentration, and chloride concentration. It also shows the water quality criterion for temperature that applies to limited aquatic life communities. Table II-2 shows the water quality criteria for temperature. All of the streams in the Mason Creek watershed have a seven-day consecutive low flow discharge of less than 200 cubic feet per second (cfs) with a 10-percent annual probability of occurrence, which is technically referred to as the 7Q10 low flow discharge. Thus, as indicated in Table II-2, those streams are assigned the standards for “small warmwater communities.”

In addition to the numerical criteria presented in the tables, there are narrative standards which apply to all waters. All surface waters must meet certain conditions at all times and under all flow conditions. Section NR 102.04(1) of the *Wisconsin Administrative Code* states that:

> “Practices attributable to municipal, commercial, domestic, agricultural, land development or other activities shall be controlled so that all waters including the mixing zone and the effluent channel meet the following conditions at all times and under all flow conditions:
>
> (a) Substances that will cause objectionable deposits on the shore or in the bed of a body of water shall not be present in such amounts as to interfere with public rights in the waters of the State.
>
> (b) Floating or submerged debris, oil, scum or other material shall not be present in such amounts as to interfere with public rights in the waters of the State.

[10]*WDNR,* Upper Rock River Basin Water Quality Management Plan: A Five-Year Plan to Protect and Enhance our Water Resources, *PUBL-WR-190-95REV, December 1995.*

> (c) Materials producing color, odor, taste, or unsightliness shall not be present in such amounts as to interfere with public rights in the waters of the State.
>
> (d) Substances in concentrations or combinations which are toxic or harmful shall not be present in amounts found to be of public health significance, nor shall such substances be present in such amounts as to interfere with public rights in the waters of the State."

Other Water Quality Guidelines

There are several water quality constituents for which the State of Wisconsin has not developed official water quality criteria. For many of these constituents, it would be useful to have some guidelines that could be used to evaluate what particular values of these constituents indicate regarding the quality of surface waters. Table II-3 sets forth guidelines for several water quality constituents. These guidelines are drawn from a variety of sources including the Rock River Total Maximum Daily Load (TMDL) study,[11] studies conducted in support of the development of water quality criteria for the State of Wisconsin,[12] and studies presenting recommendations to states and tribes for water quality criteria development.[13] These sources consist of work completed by the USEPA and WDNR or studies conducted by the USGS on behalf of the WDNR. Table II-3 combines information from all these sources to provide preferred guidelines for evaluating additional water quality constituents. These guidelines were developed specifically for Wisconsin and, in some cases, southeastern Wisconsin.

Three different types of guidelines are shown in Table II-3: TMDL target concentrations, recommended water quality criteria, and reference values. A TMDL target concentration represents a goal set by a TMDL study. It is a concentration or value of a constituent that defines acceptable water quality. A recommended water quality criterion is a scientific assessment of the effects of a water quality constituent on human health or aquatic life. Only when a recommended criterion is adopted by a state, tribe, or territory or promulgated by USEPA does it become the relevant standard for developing permit limits, assessing waters, and developing TMDLs. Finally, a reference value is a scientific assessment of the potential level of water quality that could be achieved in the absence of human

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[11]*U.S. Environmental Protection Agency and Wisconsin Department of Natural Resources,* Total Maximum Daily Loads for Total Phosphorus and Total Suspended Solids in the Rock River Basin: Columbia, Dane, Dodge, Fond du Lac, Green, Green Lake, Jefferson, Rock, Walworth, Washington, and Waukesha Counties, Wisconsin, *July 2011.*

[12]*D.M. Robinson, D.J. Graczyk, L. Wang, G. LaLiberte, and R. Bannerman,* Nutrient Concentrations and Their Relations to the Biotic Integrity of Wadeable Streams in Wisconsin, *U.S. Geological Survey Professional Paper No. 1722, 2006.*

[13]*U.S Environmental Protection Agency,* Ambient Water Quality Criteria Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria: Rivers and Streams in Nutrient Ecoregion VII, *EPA 822-B-00-018, December 2000; U.S Environmental Protection Agency,* Ambient Water Quality Criteria Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria: Lakes and Reservoirs in Nutrient Ecoregion VII, *EPA 822-B-00-009, December 2000.*

activities. Unless they are adopted by the State or promulgated by USEPA as water quality criteria, these guidelines have no regulatory impact. Instead they serve as indicators of where the division between good and poor water quality lies and can be used to serve as proxies in lieu of adopted water quality criteria to better understand water quality conditions within the Mason Creek watershed.

TMDL Requirements

Under the Federal Clean Water Act, states are required to develop Total Maximum Daily Loads (TMDLs) to address impaired waterbodies that are not meeting water quality standards. A TMDL includes both a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards and an allocation of that load among the various sources of that pollutant. The TMDL must also account for seasonal variations in water quality and include a margin of safety to account for uncertainty in predicting how well pollutant reductions will result in meeting water quality standards.

A TMDL allocates the allowable load between a wasteload allocation for point sources such as municipal wastewater treatment plants, industrial dischargers, concentrated animal feeding operations, and municipal separate storm sewer systems (MS4s); a load allocation for nonpoint sources such as agricultural sources, urban sources not covered under a discharge permit, and natural background loads; and a margin of safety. Wasteload allocations are implemented through limits established in discharge permits under the Wisconsin Pollutant Discharge Elimination System (WPDES). Load allocations are implemented through a wide variety of Federal, State, and local programs as well as voluntary action by citizens. These programs may include regulatory, non-regulatory, or incentive-based elements, depending on the program. Implementation of load allocations is typically an adaptive process, requiring the collaboration of diverse stakeholders and the prioritization and targeting of available programmatic, regulatory, financial, and technical resources.

As part of the Rock River Basin, the Mason Creek watershed is addressed in the Rock River TMDL that was approved in 2011.[14] This TMDL addresses impairments such as oxygen depletion, nuisance algae growth, reduced populations of submerged aquatic vegetation, water clarity problems, and degraded habitat resulting from high concentrations of total phosphorus (TP) and total suspended solids (TSS). It establishes annual baseline nonpoint source loads and target load allocations for TP and TSS in 84 sub-basins of the Rock River Basin, including Sub-Basin 24, which is the Mason Creek watershed.

As shown in Table II-4, **the water quality targets set forth in the Rock River TMDL report will require an estimated 92 percent reduction in TP (5,355 lbs) and 93 percent reduction in TSS (883 tons) from the median**

[14]Ibid.

annual nonpoint baseline loads for the Mason Creek watershed.[15] The Baseline column in Table II-4 represents the median of the ten year annual nonpoint source TP and TSS loads for the baseline period from 1989 to 1998 in the Mason Creek basin. The target column represents the annual nonpoint TP and TSS load allocation. The percent reduction column shows the TP and TSS reduction needed for the Mason Creek basin.

Under the Federal Clean Water Act, waterbodies that do not meet the applicable water quality standards are considered impaired. Section 303(d) of the Federal Clean Water Act requires that states periodically submit a list of impaired waters to the USEPA for approval. The Wisconsin Department of Natural Resources most recently submitted this list in 2016. Impaired waters in the Mason Creek watershed are shown on Map I-2 in Chapter I of this report. Mason Creek and the West Branch Agricultural Ditch of Mason Creek have been listed as impaired since 1998. The Upper and Lower sections of Mason Creek downstream of the Washington-Waukesha county line is considered impaired due to elevated water temperatures and degraded habitat resulting from high concentrations of sediment and TSS and due to low concentrations of dissolved oxygen resulting from high concentrations of total phosphorus. The West Branch Agricultural Ditch of Mason Creek upstream of the Washington-Waukesha county line is considered impaired due to elevated water temperatures and low dissolved oxygen concentrations resulting from high concentrations of sediment and TSS and due to low concentrations of dissolved oxygen resulting from high concentrations of total phosphorus. These impairments are addressed in the Rock River TMDL.[16]

It should also be noted that water from Mason Creek flows into North Lake, which was listed as impaired in the year 2014. Total phosphorus concentrations in North Lake exceed the applicable water quality criterion for total phosphorus; however, no specific biological impacts have been documented. Four additional lakes within the Oconomowoc River watershed were listed as impaired in 2014 that include: Friess Lake and Okauchee Lake for high phosphorus loads; Oconomowoc Lake for high mercury levels; and, Lac LaBelle for high polychlorinated biphenyls (PCBs) contamination (See Map I-2).

The developers of the Rock River TMDL used two models to calculate loads of TP and TSS from nonpoint sources for all the subwatersheds in the Rock River Basin. The Soil & Water Assessment Tool (SWAT Version 98.1) was used to calculate loads from agricultural and natural areas (i.e., forests and wetlands) and the Source Loading and Management Model (SLAMM version 9.4, PV & Associates, 2009) was used to calculate loads from urban areas. Modeled pollutant loadings indicated that over the course of an average year, agricultural lands are the source of the majority of TP and TSS in the Rock River Basin. Wastewater treatment facilities (WWTFs) contribute a significant amount of TP, but relatively little TSS. Loads of TSS and TP from natural background sources, urban

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[15]*See Appendix L and Appendix M of the 2011 Rock River TMDL report.*

[16]*Ibid.*

areas, and facilities covered under general permits represent a small fraction of the total load. More specifically, unit-area nonpoint source loading of 1.454 pounds per acre and 0.238 tons per acre, of TP and TSS, respectively, were calculated based on SWAT for Sub-Basin 24. The breakdown of daily TP and TSS loading capacity and allocations for Sub-Basin 24 are shown in Tables II-5 and II-6, respectively.

The TP loading capacity for Sub-Basin 24 was calculated as the load that will produce the monthly target concentration of 0.075 mg/l in approximately 7 out of 10 years. This target frequency was selected to ensure that loading capacity is not driven by high or low flows, but that water quality targets are met under most flow conditions. It should be noted that this monthly compliance rate will attain summer median targets in approximately 9 out of 10 years. Wasteload allocations are given for three classes of point sources: point sources covered under a Statewide WPDES general permit, MS4s, and WWTFs. The annual wasteload allocation for this sub-basin is 148.23 pounds of phosphorus. Relative to the Mason Creek watershed, two aspects of the wasteload allocation should be kept in mind. First, there are currently no permitted WWTFs within the watershed. Second, there are currently no facilities that discharge to waters of the watershed under a Statewide WPDES general permit. The consequence of this is that the annual wasteload allocations for WWTFs and general permit sources are both 0 pounds of phosphorus. The Rock River TMDL report identified that there were two MS4s that discharged into waters located in the Mason Creek watershed. However, as part of the watershed boundary assessment in this study, it was determined that the nine acres of the Town of Oconomowoc MS4 does not discharge into the Mason Creek basin. Therefore, the MS4 allocation component as shown in Tables II-5 and II-6 for phosphorus and total suspended sediment, respectively, only includes pollutant loads associated with the Town of Merton (i.e., the Town of Oconomowoc MS4 allocation was not included). The annual wasteload allocation for the Town of Merton's MS4 is 148.23 pounds of phosphorus. Load allocations for the Mason Creek watershed are given in Table II-5 for two classes of nonpoint sources: an allocation for natural background sources and a combined allocation for agricultural sources and urban sources that are not required to be covered under a WPDES discharge permit. The annual load allocation for this sub-basin is 318.10 pounds of phosphorus.

Table II-6 shows the daily TSS loading capacity and allocations. The TSS loading capacity for Sub-Basin 24 was calculated using monthly regression equations from the Rock River Basin SWAT model to determine the TSS load that is typically associated with the total phosphorus loading capacity. The annual wasteload allocation for this sub-basin is 17.30 tons of total suspended solids. Because there are currently no permitted WWTFs or dischargers permitted under a Statewide WPDES general permit located in this watershed, the annual wasteload allocations for WWTFs and general permit sources are both 0 tons of tons of suspended solids. Load allocations for Sub-Basin 24 are given in Table II-6 for two classes of nonpoint sources: an allocation for natural background sources and a combined allocation for agricultural sources and urban sources that are not required to be covered under a WPDES discharge permit. The annual load allocation for this sub-basin is 51.95 tons of total suspended solids.

The daily loading capacities and allocations shown in Tables II-4 and II-5 vary by month of the year. This reflects the fact that average total phosphorus and TSS loading varies substantially among months of the year. This variation is primarily driven by seasonal patterns in precipitation and vegetative cover that influence runoff and erosion rates. These same seasonal patterns also affect stream flow, which is the basis for pollutant assimilative capacity. To account for these patterns, calculations of loading capacity given in the tables are based on monthly patterns in stream flow, and the allocation of loads among sources is based on monthly variation in their relative contribution to current loads.

Meeting the water quality targets set in the Rock River TMDL report will require substantial reductions from the current MS4 and nonpoint source loading within the Mason Creek watershed. This will require an average monthly percent reduction from the annual baseline loads of total phosphorus of 11 percent and 39 percent for the Town of Merton MS4 and nonpoint sources, respectively.[17] It will also require an average monthly percent reduction from the annual baseline loads of total suspended solids of 12 percent and 43 percent for the Town of Merton MS4 and nonpoint sources, respectively.[18]

Point Sources

Point sources of pollution are discharges that come from a pipe or point of discharge that can be attributed to a specific source. In Wisconsin, the Wisconsin Pollutant Discharge Elimination System (WPDES) regulates and enforces water pollution control measures. The WDNR Bureau of Water Quality issues permits with oversight from the USEPA. There are four types of WPDES permits: Individual, General, Storm water, and Agricultural.

Individual permits are issued to municipal and industrial waste water treatment facilities that discharge to surface and/or groundwater. WPDES permits include limits that are consistent with the approved TMDL wasteload allocations. Facilities are required to report phosphorus and sediment loads to the WDNR in Discharge Monitoring Reports (DMR). However, there are no WPDES permit holders that discharge in the Mason Creek watershed. Less than four percent of the watershed is located in a planned sanitary sewer service area as shown on Map II-3. That area is directly adjacent to North Lake within the Town of Merton, but it is important to note that there is no known public sanitary service currently within this area. If sanitary sewers were to be installed in this area, it would be served by the City of Oconomowoc wastewater treatment plant (see http://www.oconomowoc-wi.gov/271/Sanitary-Sewer-Collection-System/). The City operates and maintains the system of collection sewers and lift stations, which serves the City of Oconomowoc and seven sanitary districts. The City owns, operates, and maintains the wastewater treatment facilities and discharges into the Oconomowoc River which, as shown on Map I-2, is well downstream of the Mason Creek watershed.

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[17]*See Appendix H of the 2011 Rock River TMDL report.*

[18]*See Appendix I of the 2011 Rock River TMDL report.*

To meet the requirements of the Federal Clean Water Act, the WDNR developed a permit program under Chapter NR 216, "Storm Water Discharge Permits," of the *Wisconsin Administrative Code*. An MS4 permit is required for a municipality that is either located within a Federally-designated urbanized area, has a population of 10,000 or more, or is designated for permit coverage by the WDNR. Municipal permits require stormwater management programs to reduce polluted stormwater runoff by implementing best management practices. Chapter NR 216 also requires certain types of industries in the State to obtain stormwater discharge permits from the WDNR, but there are no industrial stormwater permits issued in the Mason Creek watershed. The general permit requires an MS4 holder to develop, maintain, and implement stormwater management programs to prevent pollutants from the MS4 from entering State waters. Examples of stormwater best management practices used by municipalities to meet permit conditions include detention basins, street sweeping, filter strips, bioretention facilities, and rain gardens.

The Town of Merton is the only designated MS4 community in the watershed. The permit requires the Town to reduce polluted stormwater runoff by implementing stormwater management programs with best management practices. Waukesha County is currently designated as an MS4, but there are no County facilities covered under that permit that are located within the Mason Creek watershed. Nonetheless, the Town of Merton entered into an intergovernmental agreement with County for Stormwater Management Planning in March 2008. The Town and County work cooperatively to create urban storm water public education messages as well as to develop and enforce construction and post-construction site pollution control ordinances.

State and Federal laws also require that Concentrated Animal Feeding Operations (CAFOs) have Wisconsin Pollutant Discharge Elimination System (WPDES) permits. An animal feeding operation is considered a CAFO if it has 1,000 animal units or more. A smaller animal feeding operation may be designated a CAFO by the WDNR, if it discharges pollutants to a navigable water or groundwater. Permits for CAFOs require that the production area has zero discharge. There are currently no permitted CAFOs in the watershed.

Nonpoint Sources

SEWRPC Regional Water Quality Management Plan

The initial adopted regional water quality management plan, completed in 1979 by the Southeastern Wisconsin Regional Planning Commission, identified that diffuse or nonpoint agricultural pollution, and to a lesser extent urban sources of pollution, comprised the greatest proportion of the annual load in the Rock River Basin based upon conditions in 1975.[19] More specifically, agricultural nonpoint sources were estimated to contribute 88 percent of the total nitrogen, 55 percent of the total phosphorus, 81 percent of the biochemical oxygen demand (BOD), 96

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[19]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan For Southeastern Wisconsin: 2000, Volumes One through Three, *1978 and 1979.*

percent of the fecal coliform, and 58 percent of the total suspended sediment annual loads. The initial plan generally recommended nonpoint source pollution control practices for both rural and urban lands designed to reduce the pollutant loadings from nonpoint sources by about 25 percent, in addition to urban construction erosion control, streambank erosion control, and onsite sewage disposal system management. Finally, this plan also recommended that detailed local-level nonpoint source control plans be developed to identity appropriate pollution control practices.

WDNR Oconomowoc River Priority Watershed Program

The Oconomowoc River watershed, which includes Mason Creek, was selected in 1983 as a priority watershed under the Wisconsin Nonpoint Source Water Pollution Abatement Program. Priority watersheds were selected because of the severity of water quality problems in the watershed, the importance of controlling nonpoint sources in order to attain water quality standards, and the capability and willingness of local government agencies to carry out the planning and implementation of projects. An Oconomowoc River Priority Watershed Plan was completed in 1986 in cooperation with local units of government, Washington and Waukesha Counties, WDNR, and SEWRPC.[20] The upland erosion inventory conducted through the Oconomowoc River Priority Watershed project showed that more than 95 percent of the soil loss occurring in this watershed was from rural lands and the estimated upland erosion load being delivered from the Mason Creek subwatershed was 2,134 tons per year based on 1980 land use conditions. Of this total load, it was estimated that approximately 50 percent of the phosphorus load were contributed directly by agricultural runoff, which was the single largest pollutant source.[21] Hence, Mason Creek was determined to be one of the major sources of pollutant loads to North Lake and it was determined that a 65 percent reduction in the total phosphorus load was needed to effect any significant change in the trophic status in North Lake.[22]

The Oconomowoc River priority watershed plan identified specific actions necessary to reduce the water quality problems related to nonpoint sources in the watershed; tasks necessary to carry out the actions presented in the plan;

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[20]*Wisconsin Department of Natural Resources, Washington County Land Conservation Committee, Waukesha County Land Conservation Committee, Jefferson County Land Conservation Committee, in cooperation with University of Wisconsin-Extension, USDA Soil Conservation Service, USDA Agricultural Conservation and Stabilization Service, and the Southeastern Wisconsin Regional Planning Commission,* A Nonpoint Source Control Plan for the Oconomowoc River Priority Watershed Project*, Publication WR-194-86, Madison, Wisconsin, 1986.*

[21]Ibid.

[22]Ibid.

and the agencies responsible, and time frame, for completing those tasks.[23] The project implementation phase was carried out from 1984 through 1995 and included the following elements:[24]

- Provision of streambank erosion control practices for selected sites,
- Preparation of detailed conservation plans to develop management practices on cropland with high soil losses,
- Installation of facilities and management practices for problem barnyards,
- Installation of facilities and management practices for selected livestock operations to change manure spreading practices, and
- Implementation of construction site erosion controls, institution of public information and education programs on nonpoint source pollution abatement, and institution of sound urban best management practices.

Since the 1980s various projects to reduce nonpoint pollution loads within the Mason Creek watershed have been implemented, including reduced tillage, nutrient management plans, grass waterways, wetland restoration, riparian buffers (see "*Upland Inventory*" section below), d construction site erosion control, and stormwater management practices. This has led to a reduction in the overall pollution loads to Mason Creek and North Lake. However, as summarized above, the Rock River TMDL study verified that the majority of pollution in the Mason Creek watershed still comes from nonpoint sources. Agriculture is still the dominant land use in the Mason Creek watershed and modelling conducted for this watershed protection plan indicates that cropland accounts for 60 percent of total nitrogen, 73 percent of total phosphorus, 49 percent of BOD, and 66 percent of total suspended sediment nonpoint source loads as summarized in the STEPL load analysis documented in Appendix B. Other significant nonpoint pollutant sources in the watershed include pasture lands, feedlots, gullies, streambanks, and impervious surfaces associated with urban lands (see Appendix B for more details).

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[23]*Note that pollutant loads and load reduction goals were established and specific recommendations to implement nonpoint source pollution control in both rural and urban areas were identified in the Water Quality Management Plan for North Lake (SEWRPC Community Assistance Planning Report No. 54, A Water Quality Management Plan for North Lake, Waukesha County, Wisconsin, July 1982); however, the contribution of the Mason Creek watershed to pollutant loads to the Lake was not included in that plan.*

[24]*Wisconsin Department of Natural Resources,* Upper Rock River Basin Water Quality Management Plan, *Publication WR-190-88, Wisconsin, May 1989; Wisconsin Department of Natural Resources,* Upper Rock River Basin Water Quality Management Plan: A Five-Year Plan to Protect and Enhance our Water Resources, *Publication WR-190-95REV, December 1995.*

Nonpoint Source Regulations

In 2010, new State regulations went into effect in Wisconsin that restrict the use, sale, and display of turf fertilizer that is labeled as containing phosphorus or available phosphorus (Wis.Stats.94.643) The law states that turf fertilizer that is labeled as containing phosphorus or available phosphate cannot be applied to residential properties, golf courses, or publicly owned land that is planted in closely mowed or managed grass. The exceptions to the rule are as follows:

- Fertilizer that is labeled as containing phosphorus or available phosphate can be used for new lawns during the growing season in which the grass is established.

- Fertilizer that is labeled as containing phosphorus or available phosphate can be used if the soil is deficient in phosphorus, as shown by a soil test performed by a soil testing laboratory no more than 36 months before the fertilizer is applied. .

- Fertilizer that is labeled as containing phosphorus or available phosphate can be applied to pastures, land used to grow grass for sod, or any other land used for agricultural production.

In 2010, the State also placed restrictions on the sale of some phosphorus-containing cleaning agents.[25] Wisconsin also has State standards pertaining to agricultural runoff. Chapter NR 151, "Runoff Management," of the *Wisconsin Administrative Code* describes agricultural performance standards and prohibitions. Chapter NR 151 describes regulations relating to phosphorus index, manure storage and management, nutrient management, soil erosion, and tillage setback, as well as implementation and enforcement procedures for the regulations.

Water Quality Monitoring

Water quality information summarized in this section includes data collected at 13 sampling sites throughout the Mason Creek watershed by the WDNR, the University of Wisconsin-Milwaukee, the University of Wisconsin-Extension Water Action Volunteers Program (WAV), the City of Oconomowoc, and SEWRPC. Water quality monitoring sites in the Mason Creek watershed are shown on Map II-4 and described in Table II-7. The water quality monitoring efforts included several different parameters collected over the last seven years.

Several things should be kept in mind regarding the data available for evaluating water quality in the Mason Creek watershed. The data were collected by several agencies and organizations for a variety of purposes as part of a number of different studies. Each of these studies assessed a different group of water quality constituents. For some constituents,

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[25]*Section 100.28 of the* Wisconsin Statutes *bans the sale of cleaning agents for nonhousehold dishwashing machines and medical and surgical equipment that contain more than 8.7 percent phosphorus by weight. This statute also bans the sale of other cleaning agents containing more than 0.5 percent phosphorus by weight. Cleaning agents for industrial processes and dairy equipment are specifically exempted from these restrictions.*

this means that data are only available for some portions of the watershed. Each study also sampled for a different period. These periods range from a single sample collected at a site, through samples collected over a season, to long-term sampling programs that collected data for five years. Some sampling stations have been used by multiple agencies or in multiple studies (see Table II-7). While the use of multiple data sources has extended the period of record at these stations, it should be kept in mind that differences among studies in the constituents sampled may allow for fewer time-based comparisons than would be expected based purely on the length of the period of record.

Water Quality Conditions

In the analyses that follow, distributions of water quality data are shown using box plots to illustrate changes among stations from upstream to downstream over three time periods between 2009 and 2014. Figure II-5 shows an example of the symbols used in box plots. In this type of graph, the horizontal center line within the box marks the location of the median—the value above which and below which half the data lie. Along with the median, the two ends of the box mark the locations of the quartile divisions. These ends indicate the values of the 25th and 75th percentile of the data. These three divisions divide the distribution into four quartiles which each contain one quarter of the instances. The length of the box shows the range of the central 50 percent of the instances. This is known as the interquartile range. The "whiskers" extending from the box show the range of instances that are within 1.5 box-lengths from the 25th or 75th percentile lines of the box (*i.e.,* within lengths 1.5 times the interquartile range from the upper and lower boundaries of the box). Stars indicate outliers that are more than 1.5 box-lengths but less than three box-lengths from the box. Open circles indicate extreme values that that lie more than three box-lengths from the box.[26]

It is important to recognize that water quality monitoring has not been conducted within the Mason Creek watershed for a long enough period of time to assess long-term trends and changes in conditions. Most of the stations where water chemistry has been sampled have periods of record shorter than 16 months. The 14-month period of record for continuous monitoring of water temperature is also short. It is also important to note that collection of data for some constituents was restricted to only one or a few sampling stations. For example, the concentration of total suspended solids was assessed only at those sites monitored by the University of Wisconsin-Milwaukee (see Table II-7). Due to these limitations, the water quality data presented in this report constitute "a snapshot in time" to define existing conditions within surface waters of the Mason Creek watershed. Due to the lack of historical data, the available water chemistry data are not sufficient to assess whether these existing conditions are similar to or different from historical conditions.

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[26]*Different statistical analysis software packages and statistical graphics software packages follow different conventions in the construction of box plots. In all conventions, the ends of the box represent the values of the 25th and 75th percentile and the box itself indicates the interquartile range. The conventions differ in what is represented by the ends of the whiskers. The box plots presented in this report follow the conventions used in the SYSTAT, version 13, software package.*

For this study, dissolved oxygen, pH, total phosphorus, total nitrogen, total suspended solids, suspended sediment concentration, specific conductance, chlorophyll-*a*, turbidity, and water temperature parameters were used to assess water quality conditions in Mason Creek and its tributary streams. These water quality constituents are defined and discussed in the subsections that follow.

Additional information regarding the levels of compliance with water quality criteria and water use objectives in the Mason Creek watershed is provided later in this section in the "Summary" subsection.

Dissolved Oxygen

The concentration of dissolved oxygen in water is a major determinant of the suitability of a waterbody as habitat for fish and other aquatic organisms because most aquatic organisms require oxygen to survive. Though tolerances vary by species, most aquatic organisms have minimum oxygen requirements. For example, common carp (*Cyprinus carpio*) are very tolerant of concentrations of dissolved oxygen below 2.0 mg/l and can survive at concentrations below 1.0 mg/l.[27] Bluegill, on the other hand, depend on water with dissolved oxygen concentrations above 5.0 mg/l.[28]

Sources of dissolved oxygen in water include diffusion of oxygen from the atmosphere and photosynthesis by aquatic plants and suspended and benthic algae. Processes that remove dissolved oxygen from water include diffusion of oxygen to the atmosphere, respiration by aquatic organisms, and bacterial decomposition of organic material in the water column and sediment. Several factors can influence these processes, including the availability of light, the clarity of the water, the presence of aquatic plants, the presence of organic material in water or sediment, and the amount of water turbulence. Water temperature has a particularly strong effect for two reasons. First, the solubility of most gasses in water decreases with increasing temperature. Thus as water temperature increases, the water is able to hold less oxygen. Second, the metabolic demands of organisms and the rates of oxygen-demanding processes, such as bacterial decomposition of organic substances, increase with increasing temperature. As a result, the demands for oxygen in waterbodies tend to increase as water temperature increases.

Concentrations of dissolved oxygen in surface waters typically show a strong seasonal pattern that is driven by seasonal changes in water temperature. Highest concentrations usually occur during the winter. Concentrations decrease through the spring to reach a minimum during summer. Concentrations rise through the fall to reach maximum values in winter. Because the warmest water temperatures occur in the summer, this is the most important time of the year for determining physiological limitations for aquatic organisms based on dissolved oxygen concentrations. Dissolved oxygen concentrations in some waterbodies may also show daily fluctuations in which high concentrations occur during

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[27]*U.S. Fish and Wildlife Service,* Habitat Suitability Index Models: Common Carp, *1982.*

[28]*U.S. Fish and Wildlife Service,* Habitat Suitability Index Models: Bluegill, *1982.*

daylight due to photosynthesis and lower concentrations occur during periods of darkness when photosynthesis ceases and respiration increases.

As previously discussed, the minimum dissolved oxygen criterion for coldwater streams such as Mason Creek downstream from the Washington-Waukesha county line is 6.0 milligrams per liter (mg/l) during most of the year and 7.0 mg/l during the spawning season. For warmwater FAL streams such as Mason Creek upstream from the Washington-Waukesha county line and Mason Creek's tributaries, the minimum dissolved oxygen criterion is 5.0 mg/l (see Table II-1).

Between 2009 and 2014, dissolved oxygen concentrations in Mason Creek ranged between 1.10 and 15.50 mg/l, with a mean value of 9.57 mg/l. Figure II-6 shows dissolved oxygen concentrations at several sampling stations along the Creek. Dissolved oxygen concentrations were above the State water quality criterion for coldwater streams of 6.0 mg/l in almost all of samples collected. Dissolved oxygen concentrations in a few samples were below the spawning season water quality criterion of 7.0 mg/l. None of the samples in which dissolved oxygen concentrations were below 7.0 mg/l were collected during the spawning season.

Concentrations of dissolved oxygen in Mason Creek appear to be higher and more variable at downstream stations than at upstream stations (Figure II-6). This may be an artifact related to differences in the numbers of samples collected at each station. At each of the upstream stations located at the concrete bridge site, CTH CW, W. Shore Drive, and Koester Road, dissolved oxygen concentrations were assessed in only five to six samples. By contrast, over 30 samples were collected and assessed for dissolved oxygen concentrations at each of the downstream stations at Petersen Road and Northwoods Drive. This is partially related to the periods of record at these stations. Sampling was conducted at the four upstream stations over periods ranging between 11 and 15 months. The periods of record at the downstream stations were longer: 37 months at Northwoods Drive and 63 months at Petersen Road. The longer periods of record and larger numbers of samples at the downstream stations probably give a better characterization of the variability of dissolved oxygen concentrations in the stream.

Figure II-7 shows dissolved oxygen concentrations in three streams tributary to Mason Creek: Trib-A, which crosses CTH CW just prior to discharging into Mason Creek; the East Branch; and the West Branch Agricultural Ditch of Mason Creek. Concentrations of dissolved oxygen in Trib-A ranged between 6.30 mg/l and 9.46 mg/l with a mean value of 7.63 mg/l. Concentrations of dissolved oxygen in the East Branch ranged between 7.40 mg/l and 10.10 mg/l with an mean value of 8.12 mg/l. Dissolved oxygen concentrations in all of the samples collected from these streams were above the State's water quality criterion for warmwater streams (5.0 mg/l) and coldwater streams (6.0 mg/l), except for the West Branch Agricultural Ditch. The West Branch Agricultural Ditch only had one sample collected in June 2012, but that sample only achieved 4.5 mg/l and saturation of 52 percent. This site was not sampled again in August 2012 because there was not enough discharge to collect a proper sample.[29] This site was sampled previously in 1983. Although concentrations did not fall below 5.0 mg/l, they were never as high as the 6.0 mg/l concentration recommended for trout, and dissolved oxygen saturations were low (54-67 percent). Hence, although the number of observations are limited, dissolved oxygen concentrations in the West Branch Agricultural Ditch were at or below the applicable State water quality criterion of 5.0 mg/l for warmwater streams and never achieved the coldwater streams criterion of 6.0 mg/l. These low concentrations limit the availability of these portions of the stream for use by trout or other fish and other aquatic organisms. The low dissolved oxygen concentrations may be related to decomposition of organic matter in the sediment through chemical and biological processes, which removes oxygen from the overlying water.

pH

The acidity of water is measured using the pH scale. This is defined as the negative logarithm of the hydrogen ion (H+) concentration, which is referred to as the standard pH unit or standard units (stu). It is important to note that each unit of the scale represents a change of a factor of 10. Thus the hydrogen ion concentration associated with a pH of 6.0 stu is 10 times the hydrogen ion concentrations associated with a pH of 7.0 stu. A pH of 7.0 stu represents neutral water. Water with pH values lower than 7.0 stu has higher hydrogen ion concentrations and is more acidic, while water with pH values higher than 7.0 stu has lower hydrogen ion concentrations and is less acidic.

Many chemical and biological processes are affected by pH. The solubility and availability of many substances are influenced by pH. For example, many metals are more soluble in water with low pH than they are in water with high pH. In addition, the toxicity of many substances to fish and other aquatic organisms can be affected by pH. Different organisms are capable of tolerating different ranges of pH, with most preferring ranges between about 6.5 and 8.0 stu. For example, carp, suckers, and catfish generally prefer a pH range between 6.0 and 9.0 stu, although carp have been reported to tolerate water with pH values as low as 5.4 stu.[30] Sunfish, such as bass and crappies, prefer a narrower pH range between about 6.5 and 8.5 stu. Snails, clams, and mussels which incorporate calcium carbonate into their shells require higher pH values. Typically, they tolerate a range between about 7.5 and 9.0 stu. Some aquatic invertebrates prefer relatively narrow pH ranges. For example, many mayfly, stonefly, and caddisfly nymphs prefer water with pH values between 6.5 and 7.5 stu. Other aquatic invertebrates are able to tolerate much wider pH ranges. For example, mosquito larvae have been reported as living in natural waters with pH as low as 2.4 stu.[31]

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[29]*Personal Communication, Dr. Jerry Kaster, UW-Milwaukee faculty, June 2015.*

[30]*J.E. McKee and H.W. Wolf,* Water Quality Criteria (second edition), *California State Water Quality Control Board, Publication No. 3-A, 1963.*

[31]*J.B. Lackey, "The Flora and Fauna of Surface Waters Polluted by Acid Mine Drainage,"* Public Heath Reports, Washington, *Volume 53, pages 1499-1507, 1938.*

Several factors influence the pH of surface waters. Because of diffusion of carbon dioxide into water and associated chemical reactions, rainfall in areas that are not impacted by air pollution has a pH of about 5.6 stu. The pH of rainfall in areas where air quality is affected by oxides of nitrogen or sulfur tends to be lower. The mineral content of the soil and bedrock underlying a waterbody has a strong influence on the waterbody's pH. Because much of the Mason Creek watershed is underlain by carbonate bedrock such as dolomite, pH in the waterbodies of the watershed tends to be between about 7.0 and 9.0 stu. Pollutants contained in discharges from point sources and in stormwater runoff can affect a waterbody's pH. Photosynthesis by aquatic plants, phytoplankton, and algae can cause pH variations both on a daily and seasonal basis.

Figure II-8 shows pH at several sampling stations along Mason Creek. Over the period of record, the pH in the Creek ranged between 6.6 and 8.3 stu, with a mean value of 7.5 stu. Values of pH in all samples were within the range of 6.0 stu to 9.0 stu specified in Wisconsin's water quality criteria (see Table II-1). At all of the sampling stations, most values of pH varied by less than ± 1.0 stu from the station's mean value.

Water in the Trib-A and East Branch tributaries was slightly more acidic than the samples in Mason Creek. The values of pH in Trib-A ranged between 6.5 and 7.2 stu with a mean value of 6.9 stu. The values of pH in the East Branch ranged between 6.5 and 7.9 stu with a mean value of 7.2 stu. Values of pH in all samples collected from these reaches were within the range of 6.0 stu to 9.0 stu specified in Wisconsin's water quality criteria (see Table II-1). At all of the sampling stations, most values of pH varied by less than ± 1.0 stu from the station's mean value.

Chloride

Chlorides of commonly occurring elements are highly soluble in water and are present in some concentration in all surface waters. Chloride is not decomposed, chemically altered, or removed from the water as a result of natural processes. Natural chloride concentrations in surface water reflect the composition of the underlying bedrock and soils, and deposition from precipitation events. Waterbodies in southeastern Wisconsin typically have very low natural chloride concentrations due to the dolomite bedrock found in the Region. These rocks are rich in carbonates and contain little chloride. Because of this, the sources of chloride to surface waters in the Mason Creek watershed are largely anthropogenic, including sources such as salts used on streets, highways, and parking lots for winter snow and ice control; salts discharged from water softeners; and salts from treated wastewater and animal wastes. Because of the high solubility of chloride in water, if chloride is present, stormwater discharges are likely to transport it to receiving waters. High concentrations of chloride can affect aquatic plant growth and pose a threat to aquatic organisms. Impacts from chloride contamination begin to manifest at a concentration of about 250 milligrams per liter and become severe at concentrations in excess of 1,000 milligrams per liter.[32] The State of Wisconsin has promulgated two water quality

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[32]*Frits van der Leeden, Fred L. Troise, and David Keith Todd,* The Water Encyclopedia, Second Edition, *Lewis Publishers, Inc., 1990.*

criteria for chloride, and acute toxicity criterion and a chronic toxicity criterion (Table II-1). Under the acute toxicity criterion, the maximum daily concentration of chloride is not to exceed 757 mg/l more than once every three years. Under the chronic toxicity criterion, the maximum four-day concentration of chloride is not to exceed 395 mg/l more than once every three years.

Chloride monitoring was conducted at one station in Lower Mason Creek at River Mile 0.30 at Petersen Road as part of a special study in partnership with WAV and the U.S. Geological Survey (USGS) over the period from 2012 through 2015. Five chloride measurements were taken ranging from a minimum of 16.8 mg/l to a maximum of 46.5 mg/l, with a mean of 30 mg/l. However, as part of this WAV and USGS study, 44 specific conductance measurements were taken to be used as a surrogate to infer trends in chloride concentrations in Mason Creek. The specific conductance measurements ranged from a minimum of 360 microSiemens per centimeter (μS/cm) to a maximum of 980 µS/cm and a calculated mean of 766 µS/cm. Based upon the specific conductance measurements it was estimated that there is an approximate mean chloride concentration of 150 mg/l in Mason Creek, which is below the acute and chronic state standards.

The measured and estimated concentrations of chloride reported for Mason Creek are below the applicable water quality criteria. However, the available chloride data set is not adequate for assessing trends in chloride concentrations over time in surface waters in the Mason Creek watershed. Despite this it may be possible to infer likely trends in chloride concentrations from those occurring in other surface waters of the Southeastern Wisconsin Region and the Rock River Basin. Long-term trends toward increasing chloride concentrations have been documented in surface waters of the Region. These increases have been detected in several stream and river systems[33] and several lakes.[34] Long-term trends toward increasing chloride concentrations have also been documented in the Yahara Lakes, which are located in the Rock River Basin.[35] Finally, there is some evidence that chloride concentrations may be increasing in shallow groundwater, which is the source of baseflow for streams and lakes.[36] This widespread trend toward increasing chloride concentrations in surface waters suggests that it is likely that chloride concentrations are increasing in surface waters

[33]*For example, see SEWRPC Technical Report No. 39,* Water Quality Conditions and Sources of Pollution in the Greater Milwaukee Watersheds, *November 2007; SEWRPC Community Assistance Planning Report No. 316,* A Restoration Plan for the Root River Watershed, *July 2014.*

[34]*For example see SEWRPC Community Assistance Planning Report No. 315,* A Water Resources Management Plan for the Village of Chenequa, Waukesha County, Wisconsin, *June 2014.*

[35]*Richard C. Lathrop, "Chloride and Sodium Trends in the Yahara Lakes,"* Research Management Findings, *No. 12, Wisconsin Department of Natural Resources, June 1988; Rick Wenta and Kristi Sorsa,* Road Salt – 2013, *Public Health Madison and Dane County, January 3, 2014.*

[36]*SEWRPC Community Assistance Planning Report No. 316,* op. cit.

throughout the Mason Creek watershed. As previously noted, important sources of chlorides to lakes and streams in southeastern Wisconsin are anthropogenic in origin, and include salts used on streets and highways for winter snow and ice control, salts discharged from water softeners, and salts from treated wastewater and animal wastes.

Because winter deicing activities are a major contributor of chlorides to the environment, it would be expected that chloride concentrations in streams such as Mason Creek would vary seasonally, with highest concentrations occurring during and after winter storm events and during periods of snowmelt in the winter and spring. This pattern has been observed in other streams. In two highly urbanized streams in the Menomonee River watershed, chloride concentrations as inferred from measurements of specific conductance reached levels known to be highly toxic to aquatic organism during the winter deicing season on several occasions.[37] It should be noted that, because of its high solubility, chloride can enter, and accumulate in, groundwater. This can result in contributions of chlorides to streams through inputs of groundwater-derived baseflow. These contributions can occur throughout the year. During low streamflow periods in particular, they may cause instream chloride concentrations to be elevated.

Therefore, given these concerns and the high probability that chloride concentrations will continue to increase in both surface water and shallow groundwater within the Mason Creek watershed, the concentration of chloride in Mason Creek is an important issue of concern.

Specific Conductance

Conductance measures the ability of water to conduct an electric current. Because this ability is affected by water temperature, conductance values are corrected to a standard temperature of 25ºC (77º Fahrenheit). This corrected value is referred to as specific conductance. Pure water is a poor conductor of electrical currents and exhibits low values of specific conductance. For example, distilled water produced in a laboratory has a specific conductance in the range of 0.5 to 3.0 microSiemens per centimeter, a very low value. The ability of water to carry a current depends upon the presence of ions in the water, and on their chemical identities, total concentration, mobility, and electrical charge. Solutions of many inorganic compounds, such as salts, are relatively good conductors. As a result, specific conductance gives a measure of the concentration of dissolved solids in water, with higher values of specific conductance indicating higher concentrations of dissolved solids.

Under certain circumstances, measurements of specific conductance may act as a useful surrogate for measurements of the concentrations of particular dissolved materials. For example, as noted in the "Chloride" subsection above,

[37] *Corsi, S.R., D.J. Graczyk, S.W. Geis, N.L. Booth, and K. D. Richards, "A Fresh Look at Road Salt: Aquatic Toxicity and Water-Quality Impacts on Local, Regional, and National Scales," Environmental Science & Technology, Volume 44, 2010.*

measurements of specific conductance were used to give indications of chloride concentrations within Mason Creek as part of a special WAV and USGS study. Due to the presence of a linear relationship between specific conductance and chloride concentrations,[38] ambient chloride concentrations can be estimated using specific conductance. The advantage to this is that specific conductance can be measured inexpensively in the field using a hand-held meter. Measurements of chloride concentrations require chemical analysis. However, it should be noted that estimates from this sort of regression model should be interpreted with caution. A comparison of the chloride concentrations predicted by the USGS regression model to actual chloride concentrations in samples collected from the Root River found that the regression model usually predicted higher concentrations based upon specific conductance than were observed in the River.[39] Hence, periodic collection of chloride data along with specific conductance measurements could be helpful in refining the regression relationship.

Over the period of record from 2009 through 2014, specific conductance among sampling stations in Mason Creek ranged between 365 microSiemens per centimeter (μS/cm) and 778 μS/cm, with a median value of 628 μS/cm as shown in Figure II-9. The values of specific conductance show a trend toward increasing from upstream to downstream between the concrete bridge (RM 3.30) and Koester Road (RM 0.50) sampling stations, with median values increasing from 588 μS/cm at the concrete bridge station to 658 μS/cm at the Koester Road station. Given that samples were generally collected at these four stations on the same dates, it is likely that this is not an artifact of sampling. This increase may reflect inputs of dissolved material from runoff or the sources along the length of the stream. Monitoring results for Trib-A, the East Branch, and the West Branch Agricultural Ditch generally showed that specific conductance was similar to the range of values observed within the mainstem of Mason Creek.

Nutrients

Nutrients are elements and compounds needed for plant and algal growth. They are often found in a variety of chemical forms, both inorganic and organic, which may vary in their availability to plants and algae. Typically, plant and algal growth and biomass in a waterbody are limited by the availability of the nutrient present in the lowest amount relative to the organisms' needs. This nutrient is referred to as the limiting nutrient. Additions of the limiting nutrient to the waterbody typically result in additional plant or algal growth. Phosphorus is usually, though not always, the limiting nutrient in freshwater systems. Under some circumstances nitrogen can act as the limiting nutrient.

Sources of nutrients to waterbodies include both sources within the waterbody and sources in the contributing watershed. Within a waterbody, mineralization of nutrients from sediment, resuspension of sediment in the streambed,

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[38]*Steven R. Corsi, David J. Graczyk, Steven W. Geis, Nathaniel L. Booth, and Kevin D. Richards, "A Fresh Look at Road Salt: Aquatic Toxicity and Water Quality Impacts on Local, Regional, and National Scales,"* Environmental Science & Technology, Volume 44. 2010.

[39]*SEWRPC Community Assistance Planning Report No. 316, op. cit.*

erosion of the streambed and banks, and decomposition of organic material can contribute nutrients. Nutrients can also be contributed by point and nonpoint sources within the watershed.

Phosphorus

As noted above, phosphorus is usually, though not always, the limiting nutrient in freshwater systems. One form has been sampled in surface waters of the Mason Creek watershed: total phosphorus, which consists of all of the phosphorus contained in material dissolved or suspended in water. Total phosphorus consists of a variety of chemical forms of phosphorus that may vary in their availability to plants and algae. Because the degree of eutrophication in freshwater systems generally correlates more strongly with total phosphorus concentration than with the concentrations of other fractions such as dissolved phosphorus or orthophosphate, the State's water quality criteria are expressed in terms of total phosphorus and water quality sampling tends to focus most strongly on assessing total phosphorus concentrations.

Phosphorus can be contributed to waterbodies from a variety of point and nonpoint sources. In rural settings, phosphorus from agricultural fertilizers or animal manure spread on fields may be contributed through discharges from drain tiles or direct runoff from fields into waterbodies. Phosphorus also may be contributed by poorly maintained or failing private onsite wastewater treatment systems. In urban settings, phosphorus from eroded soil, pet waste, leaves placed in the street in fall, and other sources may be discharged through storm sewer systems and through direct runoff into streams. Cross-connections between sanitary and storm sewer systems, illicit connections to storm sewer systems, and decaying sanitary and storm sewer infrastructure may contribute sanitary wastewater to waterbodies through discharges from storm sewer systems.

The Rock River TMDL sets a target concentration of 0.075 mg/l total phosphorus for streams in the Mason Creek watershed.[40] This reflects the fact that the applicable water quality criterion for streams of the Mason Creek watershed is that concentrations of total phosphorus are not to exceed 0.075 mg/l (see Table II-1).

Concentrations of total phosphorus in Mason Creek ranged from 0.030 mg/l to 1.450 mg/l with median value of 0.495 mg/l. Figure II-10 shows total phosphorus concentrations at several sampling stations along Mason Creek. Several things are evident in this figure. Concentrations of total phosphorus were high at all sampling stations. In fact, concentrations of total phosphorus in the vast majority of samples exceeded the State's water quality criterion for total phosphorus. Concentrations at the Northwoods Drive sampling station were lower than those detected at upstream stations. The median concentration at Northwoods Drive was 0.085 mg/l, while the median concentrations

[40]*USEPA and WDNR*, Total Maximum Daily Loads for Total Phosphorus and Total Suspended Solids in the Rock River Basin: Columbia, Dane, Dodge, Fond du Lac, Green, Green Lake, Jefferson, Rock, Walworth, Washington, and Waukesha Counties, Wisconsin, *prepared by the CADMUS Group, July 2011*.

at the stations farther upstream ranged between 0.325 mg/l and 0.728 mg/l. This difference may reflect the difference in period of record at these stations. Alternatively, it may reflect mixing between water at the Northwoods Drive station with water from North Lake.

Figure II-11 shows concentrations of total phosphorus in the streams tributary to Mason Creek: Trib-A, the East Branch, and the West Branch Agricultural Ditch. Concentrations of total phosphorus in Trib-A ranged from 0.150 mg/l to 1.400 mg/l with a median value of 1.070 mg/l. Concentrations of total phosphorus in the East Branch ranged from 0.040 mg/l to 1.400 mg/l with a median value of 0.960 mg/l. Although there was only one sample collected in the West Branch Agricultural Ditch, it contained the highest concentration of total phosphorus of 1.52 mg/l that was recorded in the entire Mason Creek watershed. Among these stations, concentrations in almost all samples were higher than the State’s water quality criterion for total phosphorus.

The high concentrations of total phosphorus throughout the Mason Creek stream network indicate that phosphorus is a problem and an important water quality issue throughout this watershed.

NITROGEN

A variety of nitrogen compounds that act as nutrients for plants and algae are present in surface waters. Typically, only a small number of forms of nitrogen are examined and reported in water quality sampling. Total nitrogen includes all of the nitrogen compounds and ions in dissolved or particulate form in the water. It does not include nitrogen gas, which is not usable as a nutrient by most organisms. Total nitrogen is a composite of several different compounds which vary in their availability to algae and aquatic plants and in their toxicity to aquatic organisms. Common inorganic constituents of total nitrogen include ammonia, nitrate, and nitrite. These are the forms that most commonly support algal and plant growth. Total nitrogen also includes a large number of nitrogen-containing organic compounds, such as amino acids, nucleic acids, and proteins that commonly occur in natural and polluted waters. These compounds are reported as organic nitrogen.

Nitrogen compounds can be contributed to waterbodies from a variety of point and nonpoint sources. In urban settings, nitrogen compounds from lawn fertilizers and other sources may be discharged through storm sewer systems and through direct runoff into streams. Cross-connections between sanitary and storm sewer systems, illicit connections to storm sewer systems, and decaying sanitary and storm sewer infrastructure may contribute sanitary wastewater to waterbodies through discharges from storm sewer systems. In rural settings, nitrogen compounds from chemical fertilizers and animal manure that are applied to fields may be contributed through discharges from drain tiles or direct runoff from fields into waterbodies. Nitrogen compounds may also be contributed by poorly maintained or failing private onsite wastewater treatment systems.

Occasionally, nitrogen acts as the limiting nutrient for algal and plant growth in freshwater systems. This usually occurs when concentrations of phosphorus are very high.

With the exception of ammonia, the State of Wisconsin has not promulgated water quality criteria for any nitrogen compounds. In the absence of specific State water quality criteria, guidelines for concentrations of total nitrogen, nitrate plus nitrite, and total Kjeldahl nitrogen that can be used to evaluate water quality conditions are shown in Table II-3. For nitrogen compounds, these guidelines are reference values which are scientific assessments of the potential level of water quality that could be achieved in the absence of human activities. Total Kjeldahl nitrogen consists of the concentration of nitrogen in the forms of ammonia and organic nitrogen. It should be noted that Wisconsin has issued acute and chronic toxicity criteria for ammonia. The values of these criteria in any waterbody at any time depend upon the water use objective for the waterbody, the ambient temperature, and the ambient pH.

Concentrations of total nitrogen in Mason Creek ranged from 1.03 mg/l to 2.58 mg/l, with a median value of 1.71 mg/l. Figure II-12 shows total nitrogen concentrations at sampling stations along Mason Creek. It is evident from the data that concentrations of total nitrogen in all samples collected from Mason Creek were greater than the guideline values given in Table II-3.

Figure II-13 shows concentrations of total nitrogen in three streams tributary to Mason Creek: Trib-A and the East and West Branch Agricultural Ditch of Mason Creek. Concentrations of total nitrogen in Trib-A ranged from 2.58 mg/l to 5.32 mg/l with a median value of 3.82 mg/l. Concentrations of total nitrogen in the East Branch ranged from 1.30 mg/l to 5.32 mg/l with a median value of 1.67 mg/l. At these stations, concentrations in all samples were higher than the guideline values given in Table II-3. It should also be noted that concentrations of total nitrogen in Trib-A were generally higher than those found at sampling stations along the mainstem of Mason Creek (Figure II-12).

As previously noted, total nitrogen consists of several different classes of inorganic and organic nitrogen compounds. All of these would need to be simultaneously sampled to completely characterize the existing state of nitrogen chemistry in a waterbody. This was not done for total nitrogen samples collected in the Mason Creek watershed. Because of this, nothing can be said about the relative proportions of the different chemical forms of nitrogen in samples collected from the watershed.

Concentrations of total nitrogen are higher in streams of the Mason Creek watershed than reference levels that indicate the potential level of water quality that could be achieved in the absence of human activities. These high concentrations indicate that nitrogen is a problem and an important water quality issue in this watershed.

Suspended Materials

Suspended material in surface waters consists of particles of sand, silt, and clay; planktonic organisms; and fine organic and inorganic debris. The composition of suspended material varies with characteristics of the watershed and pollution sources.

Energy in water motions keeps particulate material suspended in water. Because the density of these particles is greater than the density of water, they will settle out of the water in the absence of water motions such as flow or mixing. The rate at which a particle settles is a function of its size, density, and shape. In general, larger and denser particles will settle more quickly than smaller and less dense particles. Flow and mixing will keep particles suspended, with stronger flow or mixing being required to keep larger or denser particles suspended. This has implications for suspended material in waterbodies. In streams, for example, higher concentrations and larger and denser particles are associated with higher water velocities—both in fast-moving sections of streams and during high flow periods. If water velocities are great enough, they may cause resuspension of sediment from the bed or erosion from the bed and banks of the stream. By contrast, deposition of suspended material may occur in slow-moving streams or during periods of low flow, with progressively smaller and lighter particles being deposited with decreasing water motions. The result of this is that concentrations of suspended material and the nature of the suspended particles in a waterbody vary, both spatially and over time.

Sources that contribute suspended material to waterbodies include sources within the waterbody and sources in the contributing watershed. Within a waterbody, resuspension of sediment in the beds of waterbodies and erosion of beds and banks can contribute suspended materials. Suspended materials can also be contributed by point and nonpoint pollution sources within the watershed. Concentrations of suspended materials in most discharges from point sources are subject to effluent limitations through the WPDES permit program that limit the concentrations and amounts of total suspended solids that can be discharged. A variety of nonpoint sources can also contribute suspended materials to waterbodies. Many BMPs for urban and rural nonpoint source pollution are geared toward reducing discharges of suspended materials.

Several different measures can be used to examine the amount of suspended materials in water. These methods differ both in the approach taken and in the characteristics actually being measured. Two measures are commonly used to assess the bulk concentration of suspended materials in water: total suspended solids (TSS) and suspended sediment concentration (SSC). Both of these are based upon weighing the amount of material retained when a sample is passed through a filter. They differ in the details of sample handling and subsampling. It is important to note that these two measures are not comparable to one another.[41] Turbidity is another measure of the amount of suspended materials in water. Turbidity measures the degree to which light is scattered as it passes through water. Higher concentrations of suspended materials in water are generally associated with greater scattering of light and have higher turbidity. A final measure is the concentration of chlorophyll-*a*, which estimates the biomass of phytoplankton suspended in the water.

TOTAL SUSPENDED SOLIDS

As previously described, suspended solids consist of particles of sand, silt, and clay; planktonic organisms; and fine organic and inorganic debris suspended in the water column. High concentrations of suspended solids can cause several impacts in waterbodies. High turbidity is a result of high concentrations of suspended solids. High concentrations of suspended solids reduce the penetration of light into the water, reducing the amount of photosynthesis. In addition, suspended particles absorb more heat than water does. As a result, this can lead to an increase in water temperature in streams. Both of these effects can lead to lower concentrations of dissolved oxygen. High concentrations of suspended solids can clog the gills of fish and other aquatic organisms, stressing them physiologically—in some cases fatally. Deposition of sediments may alter the substrate, making it unsuitable as habitat for aquatic organisms, or changing channel characteristics. In addition, as a result of physical and chemical interactions, other materials may adsorb to particles suspended in water. Examples include poorly soluble organic molecules, such as polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and pesticides; nutrients, such as phosphate and nitrate ions; metals, such as copper and zinc ions; and microorganisms, such as bacteria and viruses. As a result, some pollutants may be carried into, or transported within, waterbodies in association with suspended material. In areas where sediment is deposited, reservoirs of these pollutants may accumulate in the sediment. While the State of Wisconsin has not promulgated water quality criteria for suspended solids, the Rock River TMDL report sets a target concentration of 26 mg/l TSS for streams in the Mason Creek watershed.[42]

Figure II-14 shows TSS concentrations at sampling stations along Mason Creek. Concentrations of TSS in Mason Creek ranged between 4 mg/l and 509 mg/l over the period of record with a median concentration of 50 mg/l and a mean concentration of 147 mg/l. The fact that the mean concentration is higher than the median concentration indicates that the distribution of concentrations of TSS is highly skewed, with higher concentrations being relatively rare and lower concentrations being more common. When high concentrations of TSS occur, they are usually associated with high stream discharge.

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[41] *J.R. Gray, G.D. Glysson, L.M Turcios, and G.E. Schwartz,* Comparability of Suspended-Sediment Concentration and Total Suspended Solids Data, *U.S. Geological Survey Water-Resources Investigations Report No. 00-4191, 2000.*

[42] *The Cadmus Group, 2011,* op. cit.

Concentrations in most samples were greater than the target concentrations of 26 mg/l set by the Rock River TMDL. At most sampling stations, the Figure II-14 shows evidence of the skewed distribution of concentrations that was discussed in the previous paragraph. The highest average and most variable concentrations of TSS were observed at the concrete bridge station (RM 3.30), which is the station farthest upstream. Lower concentrations were observed at the two stations downstream at CTH CW (RM 2.50) and W. Shore Drive (RM 2.10) from the most upstream station. These decreases in TSS are likely associated with these particles settling out of the water column in this section of the Creek. This is consistent with the sediment depth distributions observed in this reach and also consistent with the low slopes that help promote sediment deposition (see "*Stream Conditions*" section below for more details). TSS concentrations within the Lower Mason Creek reach were observed to increase downstream of the W. Shore Drive station as shown in Figure II-14, which is consistent with an increase in channel slope and decreased sediment deposition in the stream channel.

Concentrations of TSS in nearly all samples collected from sites on Trib-A and the East and West Branch Agricultural Ditch of Mason Creek were greater than the target concentrations of 26 mg/l set under the Rock River TMDL study (see Figure II-15). Concentrations of TSS in Trib-A ranged from 12 mg/l to 475 mg/l with a mean value of 113 mg/l and a median value of 37 mg/l. Concentrations of TSS in the East Branch ranged from 12 mg/l to 300 mg/l with a mean value of 157 mg/l and a median value of 168 mg/l. Only one sample was collected on the West Branch Agricultural Ditch of Mason Creek, but the TSS concentration was observed to be 509 mg/l. Therefore, the maximum recorded TSS concentrations observed in the Trib-A and West Branch Agricultural Ditch tributaries were the highest recorded readings in the stream network of Mason Creek.

These results help to establish that TSS is a widespread and chronic problem throughout the entire Mason Creek network, from headwaters to downstream reaches, that occurs during high discharge events as well as at baseflow conditions. These TSS observations also are consistent with the ongoing increased sediment building up at the inlet to North Lake from Mason Creek as shown in Figure II-16.

TURBIDITY

Turbidity is a measure of the clarity of water and is similar to TSS measurements in that high turbidity is a result of high concentrations of suspended solids. It results from light being scattered and absorbed by particles and molecules rather than being transmitted through the water. Turbid water appears cloudy. Turbidity is caused by fine material that is suspended in the water, such as particles of silt, clay, finely divided organic and inorganic material, and planktonic organisms. Colored substances that are dissolved in the water can also contribute to turbidity. There are several ways of measuring turbidity. It is often measured using a nephelometer, which is a specialized optical device that measures the amount of light scattered when a beam of light is passed through a sample. The unit of measurement for this method is called a nephelometric turbidity unit (ntu), with low values indicating high water clarity and high values indicating low water clarity. Other methods involve measuring the depth of water through which a black and white disk remains visible. For lakes and ponds, this is often done at the site using a Secchi disk. For streams this is done using a transparency tube. High turbidity can significantly reduce the aesthetic quality of lakes and streams, having a harmful impact on recreation. It reduces the penetration of light into the water, reducing the amount of photosynthesis. In addition, suspended particles absorb more heat than water does. As a result, high turbidity can lead to an increase in the water temperature in streams. Both of these effects can lead to lower concentrations of dissolved oxygen.

Turbidity can be strongly influenced by streamflow. During periods of low flow, turbidities are low, usually less than 10 ntu. During periods of high flow, water velocities are faster and water volumes are higher. This can stir up and suspend material from the streambed, causing higher turbidities. If high flows are the result of precipitation or snowmelt, particles from the surrounding land are washed into the stream. This can make the water a muddy brown color, indicating water that has higher turbidity values.

Turbidity can harm fish and other aquatic life by reducing food supplies, degrading spawning beds, and affecting gill function. It can also reduce the growth of aquatic plants. The State of Wisconsin has not promulgated water quality criteria for turbidity. For streams, the USEPA recommends that turbidity not exceed of 1.70 nephelopmetric turbidity units (ntu) (see Table II-3).

Turbidity values at sampling stations along Mason Creek ranged from below the limit of detection to 241 ntu, with a mean value of 33.8 and a median value of 12.8 ntu. The fact that the mean concentration is higher than the median concentration indicates that the distribution turbidity is highly skewed, with higher turbidity being relatively rare and lower turbidity being more common. When high turbidity occurs, it is often associated with high stream discharge. The results from the turbidity sampling stations along Mason Creek were very similar to the TSS results as summarized above.

CHLOROPHYLL-*A*

Chlorophyll-*a* is a pigment found in all photosynthetic organisms, including plants, algae, and photosynthetic bacteria. Measurements of chlorophyll-*a* are used to estimate the biomass of phytoplankton suspended in the water column. It is important to keep in mind that this is an estimate of the entire phytoplankton community. Chlorophyll-*a* concentration can vary depending on several factors other than the total biomass of phytoplankton present, including which species are present, the amount of light available, the ambient temperature, and nutrient availability. High concentrations of chlorophyll-*a* are indicative of poor water quality and are often associated with high turbidity, poor light penetration, and nutrient enrichment. The State of Wisconsin has not promulgated water quality criteria for chlorophyll-*a*. For streams, the USEPA recommends that chlorophyll-*a* concentrations not exceed of 1.50 micrograms per liter (μg/l) (see Table II-3).

Chlorophyll-*a* concentrations in Mason Creek generally ranged between 3.2 μg/l and 154.6 μg/l, with a mean value of 18.4 μg/l. Figure II-17 shows chlorophyll-*a* concentrations at sampling stations along Mason Creek. Concentrations in all samples were greater than the guideline value given in Table II-3. Similar concentrations and ranges of concentrations were observed at most sampling stations along the Creek. The exception to this generalization was at the Northwoods Drive station, which achieved a maximum chlorophyll-*a* concentration of 154.6 μg/l. Chlorophyll-*a* concentrations at this site were more variable and much greater than all the other sites. It is important to note that site is affected by backwater from North Lake, which likely explains the higher concentrations of chlorophyll-*a* in this portion of Mason Creek.

Similar to results above, chlorophyll-*a* concentrations in most samples collected from the tributaries to Mason Creek were greater than the guideline value given in Table II-3. Concentrations of chlorophyll-*a* in Trib-A ranged from 3.2 μg/l to 77.4 μg/l with a mean value of 22.0 μg/l. Concentrations of chlorophyll-*a* in the East Branch of Mason Creek ranged from 1.4 μg/l to 10.9 μg/l with a mean value of 5.3 μg/l. Finally, one sample from the West Branch Agricultural Ditch was observed to have a chlorophyll-*a* concentration of 4.7 μg/l.

These high concentrations of chlorophyll-*a* are consistent with the high nutrient concentrations as summarized above and indicate a high level of eutrophication throughout the entire Mason Creek system.

Water Temperature

The temperature of a waterbody is a measure of the heat energy it contains. Water temperature drives numerous physical, chemical, and biological processes in aquatic systems. Processes affected by temperature include the solubility of substances in water, the rates at which chemical reactions progress, metabolic rates of organisms, the settling rates of small particles, and the toxicity of some substances. For example, the solubility of many gases in water decreases as water temperature increases. The solubility of oxygen in water is an example of this—colder water can hold more dissolved oxygen. By contrast, the solubility of many solids in water increases as water temperature increases. Temperature is a major determinant of the suitability of waterbodies as habitat for fish and other aquatic organisms, particularly temperatures in the summer (June through August) that are the most limiting physiologically, largely due to having the highest temperatures and lowest dissolved oxygen levels than any other time period of the year. Each species has a range of temperatures that it can tolerate and a smaller range of temperatures that are optimal for growth and reproduction. These ranges are different for different species. As a result, very different biological communities may be found in similar waterbodies experiencing different temperature regimes. In Wisconsin for example, high-quality warmwater systems are characterized by many native species, including cyprinids, darters, suckers, sunfish, and percids that typically dominate the fish assemblage. In contrast to warmwater streams, coldwater systems are characterized by few native species, with salmonids (trout) and cottids (sculpin) dominating, and they lack many of the taxonomic groups that are important in high-quality warmwater streams.

Air temperatures affect water temperatures, especially in smaller waterbodies. Solar heating strongly influences water temperature and factors that affect the incidence of light on waterbodies or light penetration through waterbodies can affect temperature. The presence of suspended material or colored dissolved material in the water column can increase the absorbtion of light by the waterbody, leading to heating. Water temperature can also be affected by discharges of groundwater, stormwater runoff, and discharges from point sources.

SEWRPC staff deployed continuous monitoring devices at seven locations to measure water temperatures and one additional site to monitor air temperatures from 2013 through 2014. These devices were programmed to record temperature in hourly increments. Table II-7 and Map II-4 describe the locations, river miles, and collection dates for those continuous monitoring devices.

The series of plots within Figure II-18 shows water temperatures from seven sites within, and four sites adjacent to, the Mason Creek watershed, and air temperatures from one site in the center of the Mason Creek watershed over a 438-day period running from spring 2013 to mid-summer 2014. Between May 31, 2013, and August 11, 2014, water temperatures in streams from among all sampling sites in the Mason Creek watershed ranged from about 0.0^{o}C to 25.2^{o}C, with a mean value of 9.5^{o}C and a median value of 11.3^{o}C. The data show that air temperatures are major determinants of water temperatures, which can be observed in the daily fluctuations that show the increase in temperature during the day and cooling at night. Figure II-18 also shows that water temperatures at a particular site are dependent upon both the current and preceding daily air temperature conditions. So, as daily temperatures increase over time water temperatures within the streams tend to cumulatively get warmer or the opposite can occur as temperatures decrease, which is illustrated among the transitions from one season to the next.

Figure II-18 also shows that the daily fluctuations and maximum temperatures overall are reduced in sections of stream with increased groundwater discharge, such as in the East Branch (average daily water temperature fluctuations of about 1.7^{o}C) compared to the West Branch Agricultural Ditch (average daily water temperature fluctuations of about 3.5^{o}C). Sites with greater proportions of groundwater discharge are also evident during the colder time periods, which are characterized by decreased daily fluctuations and water temperatures that consistently remain greater than zero (i.e., preventing water from freezing). Hence, groundwater discharge leads to decreased water temperatures in summer and increased water temperatures in the winter. This warmwater buffering in the winter is critical for the protection, development, and successful hatching of brook trout eggs that incubate within streambed substrates around October and emerge as fry in March. For example, the Unrein pond site is a good illustration of a site dominated by high groundwater discharge. As shown in Figure II-18 this site contained some of the lowest daily fluctuations and lowest recorded summer water temperatures of all the sites within the Mason Creek watershed as well as warm temperatures in the winter (never decreased below 4.0^{o}C). This pond site was observed to consistently discharge into the East Branch of Mason Creek, but it does not have any surface water inlet, so this pond’s discharge is comprised solely of groundwater inputs as substantiated by the recorded temperature data. It is important note that the East Branch of Mason Creek demonstrated that it had the warmest winter temperatures of any sampling site within Mason Creek, often exceeding 5.0ºC and sometimes 6.0ºC. Hence, similar to the Unrein pond site, this indicates that the East Brach contains a high amount of groundwater discharge. In addition, these winter temperatures indicate that this reach has the greatest potential for successful brook trout spawning compared to all the other sites in Mason Creek. This was supported by direct observation of brook trout actively spawning within the East Branch of Mason Creek in the fall of 2014 (see Figure II-19), which has not been observed in any other location in the watershed.

In general, summer conditions demonstrate that there is an overall decrease in water temperatures from upstream to downstream within Mason Creek as shown in Figure II-18. The West Branch Agricultural Ditch contained the warmest temperatures of all sampled reaches or sites within the Mason Creek watershed with maximum summer daily means that ranged from 18.7ºC to 21.7ºC. This reach also achieved the highest maximum daily recorded temperatures within the entire river network of 23.3ºC and 25.2ºC in July 2013 and 2014, respectively. Although there is limited historical information on the West Branch Agricultural Ditch, it was reported that this reach achieved a maximum temperature of 23.9ºC in the summer of 1983.[43] In addition, recent research has found that mean daily water temperatures above 21.0ºC is considered and ecological threshold that induces an endocrine and cellular stress response by elevating plasma concentrations or cortisol, glucose, and heat shock protein.[44] Hence, above-optimum water temperatures (i.e. greater than 21.0ºC) in the West Branch Agricultural Ditch likely limits the presence of brook trout in this reach, due to the negative effects of the neuroendocrine stress response on growth, reproduction, and survival.

These characteristics determine that this reach can be classified as a cool "warm transition" headwater stream, which is consistent with previous observations that this reach does not support a coldwater brook trout fishery.[45]

In contrast, the East Branch was significantly cooler than the West Branch Agricultural Ditch by an average of 4.8ºC to 5.0ºC in the summers of 2013 and 2014, respectively. The beneficial impact of the colder water from the East Branch mixing with the warmer waters of the West Branch Agricultural Ditch is evident in the Mason Creek

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[43]*Wisconsin Department of Natural Resources,* A Nonpoint Source Control Plan for the Oconomowoc River Priority Watershed Project, *Publication WR-194-86, 1986.*

[44]*Chadwick, J.G., K.H. Nislow, and S.D. McCormick, "Thermal Onset of Cellular and Endocrine Stress Responses Corresponding to Ecological Limits in Brook Trout, and Iconic Cold-Water Fish,"Conservation Physiology, 3:cov017, 2015.*

[45]*John Lyons and others, 2009, "Defining and Characterizing Coolwater Streams and Their Fish Assemblages in Michigan and Wisconsin, USA," North American Journal of Fisheries Management, Vol. 29, pages 1130–1151.*

station at RM 3.42 just downstream of the confluence of these two tributaries that form the beginning of the Upper Mason Creek reach. Summer temperatures at RM 3.42 are on average 3.1^{o}C colder than the West Branch Agricultural Ditch site upstream. Summer water temperatures continue to decrease by about 0.5^{o}C between RM 3.42 to CTH CW at RM 2.50. This decrease in temperature seems to reflect additional inputs of groundwater into this section of stream, which is consistent with an increase in about 2 to 4 cubic feet per second (cfs) in baseflow discharge between these stations. The East Branch and the Upper Mason Creek sites never exceeded an average maximum daily summer temperature of 15.7^{o}C and 17.3^{o}C, respectively, which confirms that these are high quality cold headwater trout stream reaches.[46] This is supported by the presence of adult brook trout since at least the 1970s.

In the transition from the Upper to the Lower Mason Creek stations water temperatures tend to become slightly warmer. Between RM 2.53 and Koester Road (RM 0.50) within Lower Mason Creek, summer water temperatures begin to increase on average by about 0.5^{o}C. Then, water temperatures tend to increase by an additional 1.3^{o}C between RM 0.5 and Northwoods Drive (RM 0.04), just upstream from the confluence with North Lake. However, it is important to note that despite this slight warming trend, neither of these two stations within the Lower Mason Creek reach ever exceeded an average maximum daily summer temperature of 17.0^{o}C at RM 0.5 and 18.4^{o}C at RM 0.04, which confirms that these reaches can support coldwater brook trout.[47] This is supported by the periodic presence of adult brook trout since at least the 1970s. However, as shown in Figure II-18 maximum daily temperatures at RM 0.04 has been shown to periodically exceed 21.0^{o}C in the summer periods in both 2013 and 2014. Hence, these above-optimum water temperatures (i.e. greater than 21.0^{o}C) in the reach may also explain that temperatures are periodically limiting the presence of brook trout in the lower portion of this reach, due to the negative effects of the neuroendocrine stress response on growth, reproduction, and survival.[48]

The ambient temperature as well as the acute and sublethal water quality criteria for temperature in warmwater streams and lakes are set forth and further described in Table II-2. Between late spring 2013 and mid-summer 2014, daily maximum water temperatures in the East Branch, Unrein Pond, Upper and Lower Mason Creek, and Trib-A reaches

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[46]*K.E. Wehrly, L. Wang, and M. Mitro, "Field-Based Estimates of Thermal Tolerance Limits for Trout: Incorporating Exposure Time and Temperature Fluctuation,"* Transactions of the American Fisheries Society, *Volume 139, 2007, pages 365-374.*

[47]*K.E. Wehrly, L. Wang, and M. Mitro, "Field-Based Estimates of Thermal Tolerance Limits for Trout: Incorporating Exposure Time and Temperature Fluctuation,"* Transactions of the American Fisheries Society, *Volume 139, 2007, pages 365-374.*

[48]*Chadwick, J.G., K.H. Nislow, and S.D. McCormick, "Thermal Onset of Cellular and Endocrine Stress Responses Corresponding to Ecological Limits in Brook Trout, and Iconic Cold-Water Fish,"Conservation Physiology, 3:cov017, 2015.*

never exceeded the applicable acute criterion for temperature as shown in Table II-2. The West Branch Agricultural Ditch rarely exceeded the acute criterion, but it did exceed the sublethal criterion for temperature (i.e., calendar week average of daily maximum temperatures) about 25 percent of the time annually and about 46 percent of the time during the growing season. Most exceedances of the acute temperature criteria occurred in the West Branch Agricultural Ditch of Mason Creek during the months June and July. The Unrein Pond never exceeded the sublethal criteria for temperature and the East Branch rarely exceeded them. The Upper and Lower Mason Creek reaches met the applicable sublethal criteria about 92 percent and 88 percent of the time annually, respectively and slightly less than that during the growing season.

Water temperature data collected indicated that the Mason Creek and associated tributaries would be likely to support a coldwater fishery. However, in the West Branch Agricultural Ditch of Mason Creek as well as the Upper and Lower reaches of Mason Creek water temperatures sometimes exceed the applicable acute criterion during summer months and the applicable sublethal criterion during non-winter months. This indicates that temperatures are likely impacting the quality of the fishery in this stream system. This suggests that temperatures may occasionally be restricting the availability of some habitat to coldwater fish species, particularly brook trout spawning or juvenile rearing, in this stream system as well as the overall quality of the fishery.

Finally, to better understand the temperature characteristics of Mason Creek and its implications to North Lake, temperature loggers were deployed at the downstream limits of the Little Oconomowoc and Oconomowoc Rivers, and one site downstream of North Lake as shown in Figure II-18. These results indicate that Mason Creek contains the coldest temperatures followed by the Little Oconomowoc River and the Oconomowoc River, which is the warmest system of the three. Note that, likely primarily due to discharge of heated surface waters from North Lake, the site downstream of North Lake is consistently much warmer than the other sites upstream of North Lake and often exceeds 30.0^{O}c. The one exception to this trend is in the spring (i.e. May through June), because it takes time for the larger volumes of water and in some years ice within North Lake to warm up that cause water temperatures downstream of the Lake to be slightly colder than upstream. Although Mason Creek is only estimated to provide about seven percent of the inflow to North Lake, it can readily be seen that this discharge of very cold and well-oxygenated water is a significant benefit for the sustained protection of the diverse fishery and recreational quality within the Lake. Coldwater Class I brook trout stream systems are extremely rare in southeastern Wisconsin.

Summary

Mason Creek has a very high amount of nutrients and suspended solids in the water. A visual assessment of Mason Creek during a peak storm or runoff event clearly shows high amounts of sediment being carried as seen in both upstream areas (Figure II-20) and downstream areas (Figure II-16). Periodic algae blooms are also common during the summer months, particularly in the lowest reach just upstream of North Lake. Although the data are somewhat limited by the number of samples, it is apparent that the highest concentrations in suspended solids, total phosphorus, and nitrogen are associated with the greater discharges in Mason Creek, so the highest amounts of pollutant loading occurs during higher flow events. This indicates that a significant amount of the pollutants can be attributed to runoff.

Table II-8 presents a comparison of water quality constituents among reaches of the Mason Creek watershed to applicable water quality criteria for the period beginning in 2009 and continuing through mid-2014. This comparison looks at water quality conditions throughout the year and through the examination of ambient levels of five water quality constituents: water temperature and concentrations of dissolved oxygen, chloride, and total phosphorus (no data are available for fecal indicator bacteria). In the case of water temperature and chloride concentration, ambient levels were compared to two applicable criteria—one which applies to acute effects to aquatic organisms and another which applies to chronic conditions. It should be noted that these levels of compliance as shown in Table II-8 throughout the year were compared to compliance rates specifically during the growing season between May through October among years 2009 through 2014, as recommended in the Rock River TMDL report. Comparison of the values among each of the reaches within Mason Creek shows that the levels of compliance with the applicable water quality criteria achieved during the growing season were similar to those achieved during the rest of the year for all parameters. In addition, the recommended water quality guidelines for total suspended solids, nitrogen, chlorophyll-a, transparency tube, and turbidity as summarized in Table II-3 were also used to assess water quality conditions within Mason Creek. Review of the data is summarized below:

- Dissolved oxygen concentrations were above the State water quality criterion for coldwater streams of 6.0 mg/l in all of samples collected among the East Branch, Upper and Lower Mason Creek, and Trib-A reaches, except for one date at the Petersen Road station in Lower Mason Creek. Dissolved oxygen concentrations in a few samples were below the spawning season water quality criterion of 7.0 mg/l, but that did not occur during the spawning season. Although the data are limited, the West Branch Agricultural Ditch did not meet the warmwater fish and aquatic life criterion of 5.0 mg/l, which is consistent with observations that this site has not been conducive to support brook trout since at least 1983.

- Water temperature data collected indicated that the Mason Creek and associated tributaries would be likely to support a coldwater fishery. However, in the West Branch Agricultural Ditch of Mason Creek as well as the Upper and Lower reaches of Mason Creek water temperatures sometimes exceed the applicable acute criteria during summer months and the applicable sublethal criteria during non-winter months. This indicates that temperatures are likely impacting the quality of the fishery in this stream system. This suggests that temperatures may occasionally be restricting the availability of some habitat to coldwater fish species, particularly brook trout spawning or juvenile rearing, in this stream system as well as affecting the overall quality of the fishery. More specifically, chronic and periodic above-optimum water temperatures (i.e. greater than 21.0^{o}C) in the West Branch Agricultural Ditch and Lower Mason Creek reaches, respectively, demonstrates that water temperatures are likely limiting the presence of brook trout in these reaches, due to the negative effects of the neuroendocrine stress response on growth, reproduction, and survival. [49]

- Based upon these water quality conditions, several of the reaches within Mason Creek need their designated water use objectives revised. Both the East Branch of Mason Creek and Trib-A reaches meet the coldwater fish and aquatic life community criteria for both temperature and dissolved oxygen requirements, so these should be upgraded from their current warmwater fish and aquatic life designation to a coldwater designation. In particular, the East Branch of Mason Creek is the only location where brook trout spawning has been observed in this river system, which demonstrates its critical importance to sustaining the Class I (naturally reproducing) brook trout fishery within Mason Creek. In contrast, the lower 0.66 miles of the West Branch Agricultural Ditch (i.e., from the Washington-Waukesha County Line to the confluence with the East Branch) does not have enough groundwater discharge to meet the temperature and dissolved oxygen requirements for a coldwater designation, and these findings are consistent with observations that brook trout have never been observed or collected in this reach. Therefore, this portion of the West Branch Agricultural Ditch should be downgraded from a coldwater fish and aquatic life community to a warmwater designation, which is consistent with the existing designation of the upper portion of the West Branch Agricultural Ditch.

- The measured and estimated (from specific conductance) concentrations of chloride reported for Mason Creek are below the applicable water quality criteria. However, there is a known widespread regional trend toward increasing chloride concentrations in surface waters, which suggests that it is highly likely that chloride concentrations are increasing in surface waters throughout the Mason Creek watershed. Of particular concern, because of its high solubility, chloride can enter and accumulate in groundwater. This can result in contributions of chlorides to streams and North Lake through inputs of groundwater-derived baseflow. Therefore, given these surface water and shallow groundwater quality potential concerns in the concentrations of chloride in Mason Creek, continued monitoring will be important.

- High concentrations of nutrients are present in surface waters of the Mason Creek watershed. Concentrations of total phosphorus in the vast majority of samples collected from Mason Creek and in almost all of the samples collected from the tributary streams were above the State's water quality

[49]*Chadwick, J.G., K.H. Nislow, and S.D. McCormick, "Thermal Onset of Cellular and Endocrine Stress Responses Corresponding to Ecological Limits in Brook Trout, and Iconic Cold-Water Fish,"Conservation Physiology, 3:cov017, 2015.*

criterion of 0.075 mg/l. Depending on the reach sampled, compliance with State standards for phosphorus concentrations generally ranged from zero to less than 38 percent of the samples collected from the Creek. High concentrations of total nitrogen were also detected. While the State has not promulgated water quality criteria for nitrogen, concentrations of total nitrogen in all samples collected from Mason Creek and two tributary streams were higher than guideline values representing the potential level of water quality that could be achieved in the absence of human activities. These high levels of nutrients are also associated with high concentrations of chlorophyll-*a*, which indicates a high level of eutrophication throughout the Mason Creek system.

- Concentrations of total suspended solids (TSS), which measures the amount of material suspended in the water column, are high. TSS concentrations in most samples collected were higher that the target concentrations of 26 mg/l set under the Rock River TMDL study, which indicates that this is a chronic problem during both baseflow and higher discharge events. Similar results were observed for turbidity. These observations also are consistent with the ongoing increased sedimentation at the inlet to North Lake from Mason Creek.

Based upon the results of the water quality sampling data from 2009 through 2014 (Table II-8), the surface waters of the Mason Creek watershed appear to be only partially achieving the recommended water use objective of coldwater community in the Upper and Lower Mason Creek, East Branch, and Trib-A reaches. The West Branch Agricultural Ditch appears to be only partially meeting its designated use objective of warmwater fish and aquatic life and cannot achieve the necessary physiological requirements to support the survival, growth, or reproduction of coldwater brook trout designated use objectives. Given that no recent sampling has been conducted for fecal coliform bacteria or *Escherichia coli*, it is not possible to assess whether surface waters of the Mason Creek watershed are achieving their designated water use objective or recreational use.

As noted previously, the Federal Clean Water Act considers waterbodies that do not meet the applicable water quality standards to be impaired and requires that states periodically submit a list of impaired waters to the USEPA for approval. It also requires the states to develop TMDLs to address impaired waters and Wisconsin most recently submitted this list in 2016. Impaired waters in the Mason Creek watershed are shown on Map I-2 in Chapter I of this report. The mainstem of Mason Creek has been listed as impaired since 1998. The Upper and Lower reaches of Mason Creek and the lower portion of the West Branch Agricultural Ditch downstream of the Washington-Waukesha county line are considered impaired due to elevated water temperatures and degraded habitat resulting from high concentrations of sediment and TSS and due to low concentrations of dissolved oxygen resulting from high concentrations of total phosphorus. The West Branch Agricultural Ditch of Mason Creek upstream of the Washington-Waukesha county line is considered impaired due to elevated water temperatures and low dissolved oxygen concentrations resulting from high concentrations of sediment and TSS and due to low concentrations of dissolved oxygen resulting from high concentrations of total phosphorus. These impairments section are addressed under the Rock River TMDL study.[50] It should also be noted that water from Mason Creek flows into North Lake, which is listed as impaired on the proposed 2014 list. Total phosphorus concentrations in North Lake exceed the applicable water quality criterion for total phosphorus; however, no specific biological impacts have been documented.

As summarized in the "TMDL Requirements" subsection above, as part of the Rock River Basin, the Mason Creek watershed is addressed under the Rock River TMDL study.[51] This TMDL sets water quality targets and establishes wasteload allocations and load allocations for total phosphorus and totals suspended solids in 84 sub-basins of the Rock River watershed, including a sub-basin consisting of the Mason Creek watershed. Meeting the water quality targets set under the Rock River TMDL will require substantial reductions in nonpoint source loads. As shown in Table II-4, **the water quality targets set forth in the Rock River TMDL report will require an estimated 92 percent reduction in TP (5,355 lbs) and 93 percent reduction in TSS (883 tons) from the median annual nonpoint baseline loads for the Mason Creek watershed.**[52]

Biological Conditions

The quality of streams and rivers is often assessed based on measures of the chemical or physical properties of water. However, a more comprehensive perspective includes resident biological communities. Guidelines to protect human health and aquatic life have been established for specific physical and chemical properties of water and have become useful yardsticks for assessing water quality. Biological communities provide additional crucial information because they live within streams for weeks to years and, therefore, integrate through time the effects of changes to their chemical or physical environment.[53]

In addition, biological communities are a direct measure of stream health—an indicator of the ability of a stream to support aquatic life. Thus, the condition of biological communities, integrated with key physical and chemical properties, provides a comprehensive assessment of stream health. The presence and abundance of species in a biological community are a function of the inherent requirements of each species for specific ranges of physical and chemical conditions. Therefore, when changes in land use and water management in a watershed cause physical or

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[50] *USEPA and WDNR, 2011,* op. cit.

[51] *USEPA and WDNR, 2011,* op. cit.

[52] *See Appendix L and Appendix M of the 2011 Rock River TMDL report.*

[53] *D.M. Carlisle and others,* The Quality of Our Nation's Waters—Ecological Health in the Nation's Streams, *1993–2005: U.S. Geological Survey Circular 1391, 2013 (available online at:* http:// pubs.usgs.gov/circ/1391/*).*

chemical properties of streams to exceed their natural ranges, vulnerable aquatic species are eliminated, and this ultimately impairs the biological condition and stream health.[54]

Aquatic and terrestrial wildlife communities have educational and aesthetic values, perform important functions in the ecological system, and are the basis for certain recreational activities. The location, extent, and quality of fishery and wildlife areas and the type of fish and wildlife characteristic of these areas are important determinants of the overall quality of the environment in the Mason Creek watershed.

Fisheries Classification

Based on a combination of detailed temperature data (see "*Water Quality*" section above),[55] fish species occurrence and abundance observations, and WDNR's natural community classification rating model, reaches within Mason Creek were classified into their appropriate biotic community and ecological conditions (i.e., streamflow and water temperature).[56] These results indicate that the East Branch and the Upper and Lower Mason Creek reaches meet the cold headwater fisheries classification as shown on Map II-5. The definition of a cold headwater stream condition is:

> Small, perennial stream with cold summer temperatures. Collectively, coldwater fishes are usually abundant (catch rate of greater than 100 fish per 100 meters of stream length sampled) to common (10 to 100 fish per 100 meters), transitional fishes are common to absent, and warmwater fishes are absent. Because of the small size of the stream, trout populations often consist almost exclusively of small fish (less than 5 inches) with larger fish absent except perhaps during spawning periods.

Results also showed that the West Branch Agricultural Ditch of Mason Creek is a cool (warm transition) headwater stream as shown on Map II-5.[57] The definition of a cool (warm transition) headwater stream condition is:

> Small, sometimes intermittent stream with cool to warm summer temperatures. Coldwater fishes are uncommon to absent, transitional fishes are abundant to common, and warmwater fishes are

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[54]Ibid.

[55]*K.E. Wehrly, L. Wang, and M. Mitro, "Field-Based Estimates of Thermal Tolerance Limits for Trout: Incorporating Exposure Time and Temperature Fluctuation,"* Transactions of the American Fisheries Society, *Volume 139, 2007, pages 365-374.*

[56]*John Lyons, "Patterns in the species composition of fish assemblages among Wisconsin streams,"* Environmental Biology of Fishes *Volume 45, 1996, pages 329-341; John Lyons, "Proposed temperature and flow criteria for natural communities for flowing waters," February 2008, updated October 2012; and, John Lyons, "Wisconsin Department of Natural Resources, An Overview of the Wisconsin Stream Model," January 2007.*

[57]*John Lyons and others, 2009, "Defining and Characterizing Coolwater Streams and Their Fish Assemblages in Michigan and Wisconsin, USA," North American Journal of Fisheries Management, Vol. 29, pages 1130–1151.*

common to uncommon. Headwater species are abundant to common, mainstem species are common to absent, and river species are absent.

According to WDNR researchers, coolwater streams, which are intermediate in character between coldwater ‘‘trout’’ streams and more diverse warmwater streams, occur widely in temperate regions, including the State of Wisconsin.[58] Fish assemblages in coolwater streams tend to be variable but are generally intermediate in species richness and overlapped in composition with coldwater and warmwater streams.

Through calculation of the Index of Biotic Integrity (IBI), data on the fish community can provide insight into the overall health of the stream ecosystem. Fish catches can also reveal trends in the populations of rare and sport fish species. The overall goal of monitoring is to better document the current status of Mason Creek and its tributaries and to provide an early warning of declines in environmental quality and fisheries associated with human development in the watershed. Due to the fundamental differences among warmwater, coolwater, and coldwater streams, a separate Index of Biotic Integrity was developed to assess the health of each of these types of streams.[59] Therefore, the coldwater and coolwater indices are most appropriate for the fisheries assessment of Mason Creek.

Based upon the fisheries assessments conducted between 1975 through 2014 by WDNR among several sites within the mainstem of this system, the Upper Mason Creek seems to generally have remained as a good to excellent coldwater fishery and the Lower Mason Creek has generally ranged from a very-poor to fair coldwater fishery. Considering that this system experienced a severe drought in the summer of 2012, the continued good to excellent coldwater classification in the Upper Mason Creek from 2012 to 2014 demonstrates the resiliency of this portion of the system. In addition, although data were unpublished, 52 brook trout were recorded by WDNR in the Upper mainstem of Mason Creek (RM 3.32) just downstream the confluence of the East Branch and West Branches Agricultural Ditch,[60] which demonstrates a sustained population for more than 30 years and average catch rates of more than 50 brook trout per survey. In contrast, no brook trout have ever been recorded to be present within the West Branch Agricultural Ditch. Since 2012 there has only been one survey conducted in 2014 at Petersen Road within Lower Mason Creek that only achieved a poor coldwater rating. This poor rating was partly the result that no brook trout were observed in that particular survey. In fact, brook trout were only observed in five of the total nine times that the Lower Mason Creek reach was sampled as shown in Table II-9. When brook trout were present,

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[58]*Lyons et al 2009*

[59]*John Lyons, "Development and Validation of an Index of Biotic Integrity for Coldwater Streams in Wisconsin,"* North American Journal of Fisheries Management, *Volume 16, May 1996.*

[60]*Wisconsin Department of Natural Resources,* A Nonpoint Source Control Plan for the Oconomowoc River Priority Watershed Project, *Publication WR-194-86, 1986.*

catch rates were consistently lower than the upper reach and averaged less than seven brook trout per survey. These results are likely related to a combination of degraded water quality, habitat conditions, and fish passage limitations (see below and "*Stream Conditions*" section for more details). These poor to fair coldwater ratings are also partly the result of the presence of warmwater and more tolerant fish species migrating into the lower portions of Mason Creek, which is not unexpected given its proximity to North Lake. Although this poor to fair coldwater rating is somewhat troubling, it is important to note that the Lower Mason Creek reach has been consistently functioning as an excellent coolwater fishery since 1981 as shown in Table II-9. These results further support the evidence that the Mason Creek system is sustained by shallow groundwater inputs and that the West Branch Agricultural Ditch and Lower reach of Mason Creek are impaired, or limiting, to the brook trout fishery. This demonstrates the importance of continuing to protect groundwater recharge in this watershed.

Although the fish IBI is useful for assessing environmental quality and biotic integrity in streams, it is most effective when used in combination with additional data on physical habitat, water quality, macroinvertebrates, and other biota when evaluating a site.[61] This supplemental data is summarized below.

Fish Species Diversity
A review of the fish data collected in Mason Creek between 1975 and 2014 indicates that 35 different fish species were observed to occur within this system (see Table II-9). Only five species of fishes were present in the Upper reach of Mason Creek, while the remaining 30 fish species were found in the Lower reach of Mason Creek. Catch rates mirrored total fish species richness, which indicated the Upper reach ranged between one and five species per survey and the Lower reach ranged between five and 18 species of fishes per survey. These differences are consistent with the high quality cold headwater fishery observed in Upper Mason Creek versus the high quality cool headwater fishery in Lower Mason Creek. However, these differences are so consistent and dramatic it seems that there may be one or more fish passage barriers at and just downstream of Koester Road that restrict fish species from migrating upstream of this road crossing (see "*Stream Conditions*" section below).

Coldwater systems are characterized by few native species, with salmonids (trout) and cottids (sculpin) dominating, and they lack many of the taxonomic groups that are important in high-quality warmwater streams.[62] An increase in fish species richness in coldwater fish assemblages often indicates environmental degradation. When degradation occurs, the small number of coldwater species is replaced by a larger number of more physiologically tolerant cool and warmwater species, which is the opposite of what tends to occur in warmwater fish assemblages. The Upper

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[61] *John Lyons,* General Technical Report NC-149, op. cit.

[62] *John Lyons, "Development and Validation of an Index of Biotic Integrity for Coldwater Streams in Wisconsin,"* North American Journal of Fisheries Management*, Volume 16, May 1996.*

Mason Creek is consistently comprised of brook trout, central mudminnow, creek chub, brook stickleback, and pearl dace (Table II-9), which is a typical cold headwater fish assemblage. One notable exception or missing species from this coldwater assemblage is mottled sculpin, which is a high quality coldwater indicator species for trout.[63]

The consistent presence of brook trout is an excellent sign of a healthy fishery, however, the exact origin or source of brook trout within Mason Creek is unclear. There is no record or mention of them within Mason Creek by WDNR in the 1963 Washington County or Waukesha County surface water resource reports.[64] These reports only note that forage fish are limited in the headwaters and common in downstream reaches. The first record of brook trout in both Mason Creek and North Lake was not until the spring of 1975. There are no records of brook trout stocking by WDNR staff in either Mason Creek or North Lake. It is possible that this is a relict population left over since the glaciers retreated or this could be a naturalized population that was stocked sometime near or before late 1960s to early 1970s. The lack of mottled sculpin, which is a high quality coldwater indicator species for trout, suggests that the brook trout in Mason Creek most likely became naturalized from a stocked population somewhere in the watershed, possibly from a stocked pond. For example, the only other brook trout population within the Oconomowoc River watershed is located many miles downstream in Rosenow Creek, which is a cold headwater tributary to Lac LaBelle. Historic fisheries records from WDNR files indicate that both brook trout and brown trout have been stocked within Rosenow Creek since the early 1900s.[65] Natural reproduction of both brook and brown trout were observed in the headwater areas in 1959,[66] and this coldwater fish assemblage also lacks mottled sculpin. Despite its unknown origins, this self-sustaining population of brook trout is rare in Southeastern Wisconsin and is evidence of the high quality groundwater discharges within Mason Creek that supports this fishery.

Brook trout have very unique habitat requirements throughout their life history to survive, grow, and reproduce.[67] As shown in Table II-10 brook trout spawning occurs from mid-September through mid-November and is initiated

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[63]*George C. Becker, Fishes of Wisconsin, University of Wisconsin Press, Madison, Wisconsin, 1983.*

[64]*Ronald J. Poff and C. W. Threinen,* Surface Water Resources of Washington County*, Lake and Stream Classification Project, Wisconsin Conservation Department, Madison, Wisconsin, 1963; and, Ronald J. Poff and C. W. Threinen,* Surface Water Resources of Waukesha *County, Lake and Stream Classification Project, Wisconsin Conservation Department, Madison, Wisconsin, 1963.*

[65]*SEWRPC Staff Memorandum,* Data Analysis and Recommendations Relating to the Proposed Relocation of the North Branch of Rosenow Creek for the STH 67 Oconomowoc Bypass Project—Stream Relocation Project in the Town Of Oconomowoc, Waukesha County*, July 19, 2007.*

[66]*Wisconsin Conservation Department (Wisconsin Department of Natural Resources), Intra Department Memorandum, Stocking Trout in Rosenow Creek, Waukesha County, January 26, 1959.*

[67]*Raleigh, R.F.,* Habitat suitability index models: Brook trout, United States Fish and Wildlife Service Biological Report 82 (10.24)*, Fort Collins, CO, 1982. [online] http://www.nwrc.usgs.gov/wdb/pub/hsi/hsi-024.pdf; Thomas*

by decreasing day length, increased late fall flows, and drops in water temperature to less than 9°C. Brook trout usually mature at age two, but males can reach maturity as early as age one. During spawning, mature females dig nests known as redds, where eggs are deposited, fertilized, and covered with gravel. Redds tend to be located in riffle habitats where velocity, depth, and bottom configuration induce water flow though stream substrates (i.e., upwelling). These redds are easy to recognize and remain visible for several weeks in the streambed after they are constructed, so these can be easy to monitor and track from year to year, which is a good way to gauge spawning activities on a river system. Incubation periods for brook trout can range from 30 days at mean water temperatures of 11.2°C to 165 days at mean water temperatures of 1.9°C, which shows that development is temperature dependent. Brook trout larvae remain in redds for several weeks after hatching as they continue to develop. Once fry emerge from the gravels, these juvenile or Young-of-Year (YOY) individuals migrate to lower velocity margins of the channel near the streambanks for protection and to feed. As both body size increases and swimming ability improves they tend to inhabit faster and deeper water habitat areas.

Despite the continued persistence of brook trout within the Mason Creek, as noted above they have never been observed within the West Branch Agricultural Ditch and are not as abundant or consistently found within the Lower Mason Creek reach, which is likely a result of the elevated temperatures and total suspended solid concentrations negatively affecting the distribution and abundance of brook trout in this system. Recent research has found that mean daily water temperatures above 21.0^{O}C is considered and ecological threshold that induces an endrocrine and cellular stress response by elevating plasma concentrations or cortisol, glucose, and heat shock protein (see "*Water Temperature*" section above).[68] Hence, above-optimum water temperatures (i.e. greater than 21.0^{O}C) in the West Branch Agricultural Ditch and Lower Mason Creek reaches likely limits the presence of brook trout, due to the negative effects of the neuroendocrine stress response on growth, reproduction, and survival. In addition, trout are sight feeders and nearly all of their diet comes from aquatic and terrestrial invertebrate drift within the water column, and also includes fish for the larger adults. So, the elevated total suspended solids measured at baseflow and higher flow events within Mason Creek may be limiting feeding and growth rates of brook trout. In addition, deposition of fine sediments within spawning redds can greatly reduce hatching success of the eggs. There are some potential riffle spawning habitats within the Lower Mason Creek reach, but it is unknown if spawning and successful egg hatching is actually occurring in these areas. If spawning and egg hatching is occurring in the lower portions of Mason Creek, it is likely that spawning success is being negatively impacted by the chronic sediment loads and

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Slawski, An Analysis of Biotic and Abiotic Factors Influencing Fish Species Assemblages in a Cold-Water Stream, *PhD Dissertation, The University of Wisconsin-Milwaukee, May 1997.*

[68]*Chadwick, J.G., K.H. Nislow, and S.D. McCormick, "Thermal Onset of Cellular and Endocrine Stress Responses Corresponding to Ecological Limits in Brook Trout, and Iconic Cold-Water Fish,"Conservation Physiology, 3:cov017, 2015.*

deposition. Therefore, maintaining optimal water temperatures and achievement of the pollutant load reduction goals are a high priority concern to protect and improve the brook trout population within Mason Creek.

Optimal brook trout riverine habitat is characterized by clear, cold spring-fed water; a silt-free rocky substrate in riffle (shallow water, fast flowing)-run (deeper water, moderate flows) areas; an approximate 1:1 pool (deepest water, slow flow)-riffle ratio; well vegetated stream banks; abundant instream cover; and relatively stable water flow, and temperature regimes.[69] Cover is an important feature for the survival of brook trout. Large woody debris (stumps, logs, roots), boulders, and undercut banks are key sheltering habitats for trout, but cover also can be provided by overhanging vegetation, submerged vegetation, rocky substrate, suitable water depths (greater than 0.5 feet), low current velocity (less than 0.5 feet/second), and water surface turbulence. The lack of optimal pool depth (greater than, or equal to, 3.0 feet) is a limiting factor for trout survival, particularly during low-flow conditions in late summer and throughout the winter. Therefore, adequate pool depth is critical for maintaining trout populations. Based upon the cross section survey conducted on this system it appears that pool depths—particularly within the channelized portions of both Upper and Lower Mason Creek reaches—are not adequate to support trout, since water depths rarely exceed 2.0 to 2.5 feet.

Despite monitoring since 1975, no distinction has been made between the presences of juvenile versus adult species among the recorded fish survey data, so it is unclear where juvenile or Young-of-Year (YOY) individuals are occurring in this system. As previously mentioned, undercut banks are necessary components for survival, particularly with YOY, which require habitat with cover and lower water velocities along stream margins than adult trout[70] (Raleigh 1982). Juvenile mortality in the first year of life is high and overwinter survival is greatly enhanced by warmer temperatures during the winter. Therefore, based on the temperature data among all the reaches summarized above, the East Branch contained the warmest winter temperatures and would be the most likely reach to support juvenile overwinter survival. Knowing where these areas exist is vital, so they can be protected and potentially enhanced to improve survival and abundance of brook trout in Mason Creek. Location of juveniles can also provide insights as to where successful spawning is occurring, so these areas can also be identified and protected.

The only observation of active brook trout spawning within Mason Creek was observed in the lower portion of the East Branch during the 2014 fall survey as shown in Figure II-19. This reach contained shallow riffles with substrate

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[69] *Raleigh, R.F., Habitat suitability index models: Brook trout, United States Fish and Wildlife Service Biological Report 82 (10.24), Fort Collins, CO, 1982. [online] http://www.nwrc.usgs.gov/wdb/pub/hsi/hsi-024.pdf*

[70]Ibid.

sizes less than 2.0 inches in diameter, which are within the optimal range for brook trout spawning.[71] Although it was not possible to inventory very much of this reach, due to limits in property access, recent visual observations indicated that there were more riffles with appropriate substrates upstream of where the survey ended.[72] It is possible that this is the only reach where brook trout are successfully reproducing, and this is sustaining the entire population of trout within Mason Creek. Extensive ditching or channelization has removed the naturally meandering channel and associated riffle and pool habitats within Mason Creek. These ditched areas are mostly comprised of silts over clay substrates, which are not conducive to brook trout spawning or egg development. Successful spawning, egg development, and hatching is crucial to the continued existing and potential improvement of brook trout within Mason Creek. Thus, the loss of the historical pool-riffle habitat structure, due to channelization or ditching to promote agricultural production, on this system demonstrates a serious loss to the available spawning, juvenile rearing, and adult habitats within this system. Restoring the historical meandering channel patterns (see "*Stream Condition*" section below)—particularly in both the Upper and Lower Mason Creek reaches and their associated riffle, pool, and run habitats—exemplifies the greatest potential to improve the brook trout fishery along with reductions of nonpoint source loads as summarized above. Therefore, the continued protection and future improvement of the brook trout population and associated cold water fishery represents a major criteria assessment goal in order to demonstrate achievement of the water quality objectives in Mason Creek.[73]

In addition to brook trout, since at least the mid-1990s another excellent sign of a healthy fishery is the distribution and abundance of rainbow darter, rock bass, and smallmouth bass within the Lower Mason Creek reach (see Map II-5 and Figure II-21), which are all sensitive warmwater fish species. Just as described above, the Lower Mason Creek fishery contains a high quality coolwater fish assemblage that tends to be variable, but is generally intermediate in species richness and contains a variety of coldwater, coolwater, and warmwater fish species. In addition to the sensitive warmwater species mentioned above, this reach also contains bluegill, common shiner, hornyhead chub, logperch, largemouth bass, bluntnose minnow, common carp, green sunfish, and bullhead warmwater species. The coolwater species include Johnny darter, pearl dace, brook stickleback, central mudminnow, creek chub, and white sucker. Finally, the coldwater species include both brook trout and brown trout, but these species are not dominant. Brown trout are not native to Wisconsin and their recent presence in 2008 and 2014 within the Lower Mason Creek reach suggests that these are an artifact of recent brown trout stocking on the

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[71]*Reiser, D. W., and T. A. Wesche,* Determination of physical and hydraulic preferences of brown and brook trout in the selection of spawning locations*, Water Resources Res. Inst., Univ. Wyo., Laramie. Water Res. Series 64. 100 pp., 1977.*

[72]*Thomas Slawski, PhD., Chief Biologist, SEWRPC staff, June 3, 2016.*

[73]*Wisconsin Department of Natural Resources,* A Nonpoint Source Control Plan for the Oconomowoc River Priority Watershed Project*, Publication WR-194-86, 1986.*

Oconomowoc River. The consistent presence of these sensitive warmwater and coldwater fishes is an indication of sustained good water quality in Mason Creek, because they have a low tolerance to pollution and silt.

Despite the continued presence of sensitive warmwater and coldwater fish species within the Lower Reach of Mason Creek, there seems to have been a loss of at least 12 fish species since 1975 or 1981 that include: northern pike, a sensitive coolwater species; slender madtom, an intolerant warmwater, a State-designated endangered fish species; lake chubsucker, a State-designated species of special concern; central and largescale stonerollers; brook silverside; fantail darter; stonecat; spotfin shiner; fathead minnow; pumpkinseed; and yellow perch. This indicates a potential loss of more than 30 percent of the fish species diversity in this reach and is indicative of degradation of this system. This may be related to the high nutrient concentrations, higher water temperatures, and/or suspended sediments within this reach and demonstrates the importance of continued monitoring on this system.

There are more species of fish observed in Mason Creek than in North Lake. However, approximately 62 percent, or 22 of the fish species found within Mason Creek, also reside within North Lake. Hence, just as there is an important linkage in water quality between Mason Creek and North Lake, there is also a vital connection between the Lake and its tributaries regarding the abundance and diversity of the fishery. The ability to migrate between a tributary and lake environment for thermal refuge, overwintering, spawning, feeding, or other essential life history requirement is what helps to sustain a healthy fishery. For example, the first ever record of logperch in the Lower Mason Creek reach was in 2014, which indicates that this species likely emigrated from either the Little Oconomowoc or Oconomowoc Rivers where it has been firmly established since at least 1975. This species requires gravel and washed sands for spawning sites, and the ability to migrate amongst each of these rivers and the Lake helps to promote establishment of new populations to expand species ranges and exchange between existing populations throughout this connected system to help ensure their overall survival. The presence of logperch in Mason Creek is indicative of the interdependence of the Little Oconomowoc River, Oconomowoc River, Mason Creek, and North Lake.

North Lake seems to have lost a two-story fishery, due to eutrophication over the last 100 years. A “two story” fishery occurs when a lake is capable of supporting warmwater species like bass, northern pike, and muskellunge in its warm, “top story,” while at the same time also supporting cold water species like cisco or whitefish in its deeper, colder, well-oxygenated “lower story.”[74] For example, Lac Courte Oreilles, a 5,139-acre lake located in Sawyer County, Wisconsin, with a maximum depth of 90 feet, is a rare two-story fishery lake. This lake has smallmouth and largemouth bass, walleye, northern pike, muskies and other warm water species in the top story,

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[74]*Frank Pratt, WDNR, Lac Courte Oreilles – a Rare and Fragile “Two Story Fishery” see website link at http://cola-wi.org/fish-wildlife*

while at the same time supports both cisco and lake whitefish in its narrow, colder layer of water in its lower story. Cisco or lake herring were first reported to occur in North Lake on August 25, 1911. In fact, from 1911 through 1927, cisco were found in high abundance in all of the deepest Oconomowoc River watershed lakes including North, Pine, Okauchee, Oconomowoc, Silver, Fowler, and LaBelle.[75] Cisco were reported to be present and afforded winter angling opportunities as recently as 1963 in North Lake and summer kills of ciscoes were reported in Pine Lake up till the early 1980s. Recent sampling in 2013 verified that cisco populations generally still persist in most of the lakes within the Oconomowoc River watershed, but their abundances are significantly reduced and they are likely extirpated from Lac LaBelle and Silver Lake. Surprisingly, small or low abundances of cisco are still found in Fowler, North, and Pine Lakes; high abundances in Oconomowoc Lake; and very high abundances in Okauchee Lake. These results generally indicate an overall loss in the extent and distribution of cold water habitat throughout the Oconomowoc River system, but some populations still thrive and this fishery has a good potential to be restored.

The greatest threat and management challenge of cisco populations in inland lakes is the enrichment of the waters, which during the summer results in the depletion of dissolved oxygen levels in the lower stratum (i.e., deep waters). This depletion forces the cisco into the upper strata or surface waters where temperatures are unfavorable for survival. Such conditions in lakes leads to significant cisco mortalities. Summer kills of ciscoes were reported in several of the chain of lakes within the Oconomowoc River system as early as 1927. It has been well established that North Lake has experienced summer total dissolved oxygen depletion in the bottom or deep waters since the early 1900s and that condition has not improved.[76] Hence, the accelerated eutrophication in North Lake has likely led to the loss of cisco and of the structure of this two story fishery, which also has been associated with a decrease in lake condition and degraded fishery quality. For example, cisco in the existing two-story fishery of Lac Courte Oreilles, as summarized above, is one reason that lake consistently produces big gamefish, including world-class muskellunge. By comparison, North Lake contains many of the same gamefish, including smallmouth and largemouth bass, walleye, and northern pike, and cisco likely made up a larger proportion of the diet of those fishes when cisco were more abundant. So, the loss of the majority of the cisco population indicates a significant loss of 1) the amount and quality of cold water habitats in North Lake and 2) access to a high quality food source for gamefish species with those two factors likely contributing to an imbalance of the fishery in this lake. **Therefore, the improvement of the cisco population in North Lake and restoration of the "two story" fishery could be a useful assessment criteria to determine whether implementation of pollutant load reductions within Mason Creek are being successful.** Using the estimated oxythermal niche boundary, which is a combination of limiting dissolved oxygen (DO) concentrations and temperatures combined, would provide a benchmark for quantifying

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[75]*Alvin Robert Cahn, "An Ecological Study of Southern Wisconsin Fishes: the Brook Silversides (Labidesthes sicculus) and the Cisco (Leucichthys artedi) in Their Relations to the Region," Illinois Biological Monographs, Volume XI, January 1927.*

[76]*WDNR, Oconomowoc River Priority Watershed, 1986, op. cit.*

potential refuge habitat in North Lake, potential risks of extinction, and for measuring the effectiveness of efforts in Mason Creek to protect North Lake. So, the effects of hypolimnetic oxygen changes on cisco thermal habitat could be quantified by comparing relative positions of oxythermal conditions measured with summer profiles on North Lake, without having to conduct fishery surveys. Mapped profiles of temperature and dissolved oxygen concentrations through the entire water column would probably approach the oxythermal niche boundary (e.g. lethal temperature was 23.0^{o}C at 5.0 mg/L DO concentration, 22.0^{o}C at 3.0 mg/L DO concentration, and 19.5^{o}C at 1.0 mg/L DO concentration) as thermal habitat deteriorates, particlulary in late summer.[77] In other words, because cisco require cold well-oxygenated waters, they are sentinels of the health of the lakes they inhabit, so increased abundance of the existing self-sustaining naturally reproducing population of cisco within North Lake would be a key indicator that the overall quality of the Lake ecosystem is improving.[78]

Mussels

Freshwater mussels are large bivalve (two-shelled) mollusks that live in the sediments of rivers, streams, and some lakes. Mussels are considered one of the most endangered families of animals in North America. These soft-bodied animals are enclosed by two shells made mostly of calcium and connected by a hinge. Mussels can typically be found anchored in the substrate, with only their siphons occasionally exposed. They typically favor sand, gravel, and cobble substrates. They play an important role in aquatic ecosystems by helping stabilize river bottoms; serving as natural water filters; providing excellent spawning habitat for fish; and serving as food for fish, birds, and some mammals. Live mussels and relic shells provide a relatively stable substrate in dynamic riverine environments for a variety of other macroinvertebrates, such as caddis flies and mayflies, and for algae.

Mussels are viewed as important, sensitive indicators of changing environmental conditions. Water and sediment quality are important habitat criteria for mussels. Most species of freshwater mussels prefer clean running water with high oxygen content, and all species are susceptible to pollution, including pesticides, heavy metals, ammonia, and algal toxins. Mussels can be used to document changes in water quality over long periods of time since they are long-lived. Shells accumulate metals from both water and sediment, so testing heavy metal concentrations in shells can tell researchers when water in a given area was first contaminated. The presence or absence of a particular mussel species provides information about long-term water health. Because juvenile forms of mussels are more susceptible to pollution than the adult forms, finding juveniles with few adults nearby may indicate a newly colonized area. In general, having healthy diverse populations of mussels means the water quality is good.

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[77] *Peter C. Jacobson and others, "Field Estimation of a Lethal Oxythermal Niche Boundary for Adult Ciscoes in Minnesota Lakes," Transactions of the American Fisheries Society, Volume 137, pages 1464-1474, 2008.*

[78] *John Lyons, Jeff Kampa, Tim Parks, and Greg Sass,* The Whitefishes of Wisconsin's Inland Lakes: the 2011-2014 Wisconsin Department of Natural Resources Cisco and Lake Whitefish Survey, *Fisheries and Aquatic Research Section, WDNR, February 2015.*

Mussels have never been sampled for in the Mason Creek watershed, so their abundance and diversity within this system is unknown.

Benthic Macroinvertebrates

Benthic macroinvertebrates are organisms without backbones that inhabit the substrates such as sediments, debris, logs, and plant vegetation in the bottom of a stream or creek for at least part of their life cycle. Macroinvertebrates are visible to the naked eye, are abundant in freshwater systems, and include insect larvae such as leeches, worms, crayfish, shrimp, clams, mussels, and snails. Since benthic macroinvertebrates develop and grow within the water, they are affected by local changes in water quality. Just like fishes some are more tolerant to pollution and some are more sensitive, which makes them good indicators of water quality.

The majority of macroinvertebrates tend to be found within the shallow, fast flowing riffle habitats of streams compared to deeper and slower flowing pool or run habitats. Riffles can range from uneven bedrock or large boulders to sand substrates. However, the optimum riffle substrates for macroinvertebrates are characterized by particle diameters ranging from gravels (one inch) to cobbles (ten inches). Water flowing through these areas provides plentiful oxygen and food particles. Riffle-dwelling communities are made up of macroinvertebrates that generally require high dissolved oxygen levels and clean water, and most are intolerant of pollution. For example, mayflies (Ephemeroptera), stonefly larvae (Plecoptera), and caddisfly larvae (Trichoptera) tend to be found in cold, clear flowing water with a gravel or stone bottom with high dissolved oxygen concentrations. Caddisfly larvae, in particular are sensitive to pollution and oxygen depletion.[79]

Macroinvertebrate analyses were conducted by the WDNR from 1979 to 2013 at five locations on Mason Creek and in some cases on the same dates as the fisheries samples (see Map II-5). As noted above, the number and type of macroinvertebrates present in a stream can provide an indicator of water quality. Hence, multiple indices that include the Hilsenhoff Biotic Index (HBI), Family- Level Biotic Index (FBI),[80] Index of Biotic Integrity (IBI), HBI Max 10, species richness, genera richness, and percent EPT (percent of individuals or Genera comprised of Ephemeroptera, Plecoptera, and Trichoptera) were used to classify macroinvertebrate and environmental quality in Mason Creek as shown in Table II-11. The five sites that were surveyed on Mason Creek ranged from fair to very good quality, but the majority of the rankings indicated a good to very good quality condition (see Table II-11).

[79]*Osmond, D.L., and others. 1995. WATERSHEDSS: Water, Soil and Hydro-Environmental Decision Support System, http://h2osparc.wq.ncsu.edu, North Carolina State University Water Quality Group, 1995, see website at http://www.water.ncsu.edu/watershedss/info/macroinv.html*

[80]*William L. Hilsenhoff*, Rapid Field Assessment of Organic Pollution with Family-Level Biotic Index, *University of Wisconsin- Madison, 1988.*

This ranking was supported by a moderate to high species richness, genera richness, and percent EPT values for individuals and genera.

Comparison of the historical sample ratings to the more recent samples site collected in 2003 and 2012 indicates that the Lower Mason Creek site has retained a good to very good quality and the Upper Mason Creek maintained a good quality score (see Table II-11).[81] In addition, the WDNR conducted a special summer assessment on Mason Creek in 1983 and identified good biotic quality ratings for sites in the Upper and Lower Mason Creek reaches,[82] which is consistent with current conditions. However, it is important to note that the Koester Road site within the Lower Mason Creek reach, which contained some gravel substrates, significant siltation was observed. The sampling in 1983 also found that the East Branch had the highest quality score (very good), and the West Branch Agricultural Ditch had the worst score (very poor), compared to other sites in the watershed. These results are consistent with the historical and current water quality conditions within Mason Creek and confirm that the West Branch Agricultural Ditch of Mason Creek has historically contained very poor water quality and biotic community conditions. These very poor conditions have likely negatively impacted the coldwater brook trout fishery within Mason Creek since the West Branch Agricultural Ditch was channelized sometime between 1909 and 1937 (see "*Stream Conditions*" section below). As previously mentioned, no brook trout have ever been observed to be present within the West Branch Agricultural Ditch. In contrast, the East Branch has very good water quality, and it has been, and continues to be, a critical reach that supports the high quality brook trout fishery in Mason Creek.[83] This reach has existed since the original plat map of 1837, which confirms that this is part of the originally designated Mason Creek, and has likely been sustained by significant groundwater discharge.

Although overall benthic macroinvertebrate quality is good to very good within Mason Creek, as previously mentioned, channelization has removed the naturally meandering channel and associated riffle habitats within the Upper and Lower Mason Creek reaches. Brook trout are voracious and opportunistic feeders and will consume whatever is most readily available, but Ephemeroptera, Trichoptera, and Diptera often make up a large component of their diet.[84] Riffle habitats produce the highest abundance and diversity of macroinvertebrate food for brook trout compared to other instream habitats. Therefore, the loss of these riffle habitats significantly reduced the abundance

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[81]*M.T. Barbour, J. Gerritsen, B.D. Snyder, and J.B. Stribling,* Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, *Second Edition, EPA 841-B-99-002, U.S. Environmental Protection Agency, Office of Water, Washington, D.C., 1999.*

[82]*Hilsenhoff, W.L.,* Using a Biotic Index to Evaluate Water Quality in Streams*, WDNR Technical Bulletin No. 132, Madison, Wisconsin, 1982.*

[83]*WDNR, Oconomowoc River Priority Watershed, 1986, op. cit.*

[84]*Pauline Adams, Christopher James, and Clay Speas,* Brook trout (Salvelinus fontinalis) Species and Conservation Assessment, *Prepared for the Grand Mesa, Uncompahgre, and Gunnison National Forests, March 2008.*

and availability of food for brook trout in Mason Creek, which has likely limited the overall growth and/or population size throughout the watershed. Thus, restoring the historic meandering channel patterns and associated riffle and pool habitats—particularly in both the Upper and Lower Mason Creek reaches—presents the greatest potential to improve macroinvertebrate quality and the associated brook trout fishery along with reductions of nonpoint source pollution loads.

Wisconsin researchers have generally found that as the amount of human land disturbance increases, such as in the Mason Creek watershed, the subsequent macroinvertebrate community diversity and abundance decreases. Although this system has been able to maintain fair to very good macroinvertebrate community quality, there is still potential for improvement. Thus, continued monitoring of the macroinvertebrate community will be an important and effective tool, or biological indicator, to assess changes in water quality in the future, particularly as the recommendations in this plan to improve water quality are implemented.

POLLUTANT LOADING MODEL

As previously noted (see "*TMDL Requirements*" subsection), the most current pollution load and wasteload allocations and load and wasteload reduction goals for the impaired portion of Mason Creek (Sub-Basin 24) (see Tables II-5 and II-6) were developed under the Rock River TMDL. The SWAT model developed under the TMDL study indicated that agriculture is the main contributing source of sediment and phosphorus in the Mason Creek watershed, and all of the tributary subwatersheds draining into that waterbody. Therefore, **to be consistent with the Rock River TMDL nonpoint source load reduction requirements, load reductions for the Mason Creek watershed need to meet or exceed 92 percent for total phosphorus (5,355 lbs) and 93 percent for total suspended sediment (883 tons) from the median annual nonpoint baseline load as shown in Table II-4.** [85]

To better refine pollutant loading and sources within the Mason Creek watershed, a separate USEPA Spreadsheet Tool for Estimating Pollutant Load (STEPL) model was applied under this study.[86] STEPL employs simple algorithms to calculate nutrient and sediment loads from different land uses and the load reductions that would result from the implementation of various best management practices (BMPs). STEPL provides a user-friendly Visual Basic (VB) interface to create a customized spreadsheet-based model in Microsoft (MS) Excel. It computes watershed surface runoff; nutrient loads, including total nitrogen, phosphorus, and 5-day biochemical oxygen demand (BOD); and sediment delivery based on various land uses and management practices. For each of the four sub-basins (MC-1 through MC-4) and two additional internally drained areas (MC-2A and MC-2B) within the

[85]*See Appendix L and Appendix M of the 2011 Rock River TMDL report.*

[86]*Information on the STEPL model can be found on the website* http://it.tetratech-ffx.com/steplweb/.

watershed, the annual nutrient loading was calculated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as the land use distribution and management practices. The annual sediment load (sheet and rill erosion only) is calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. The sediment and pollutant load reductions that result from the implementation of BMPs are computed using generalized BMP efficiencies. STEPL model results for pollutant loading and load reductions are shown in Appendix B.

It is important to note that although it is likely that the pollutant loads estimated using the STEPL model overestimate the actual loads entering Mason Creek, based on comparison to measured instream loads summarized above and other modeling techniques such as SWAT,[87] STEPL is an effective tool to assess existing load allocations and potential reductions for planning purposes.

The pollutant modeling results from the STEPL analysis in this study and the modeling results from the aforementioned Rock River TMDL study both demonstrated that agricultural land is the main contributing source of pollutants in the Mason Creek watershed. Figure II-22 shows that the highest loads of nitrogen, phosphorus, BOD, and sediment would be expected to come from cropland within the Mason Creek watershed. Cropland accounted for about 60 percent of total nitrogen, 73 percent of total phosphorus, 49 percent of BOD, and 66 percent of total suspended sediment annual nonpoint source loads. Thus, the majority of the targeted management measures in this plan are focused on cropland BMPs as summarized in Chapter III of this report. Pasture, feedlots, septic systems, gullies, and streambanks were also determined to contribute to pollutant loads, but these are much less significant than cropland sources.

Urban nonpoint source pollutant loads only accounted for a small proportion of the existing total load within the Mason Creek watershed, or about nine percent of the TP and five percent of TSS loads (Figure II-22). Based upon the planned year 2035 levels of urban development these loads are expected to increase (see Map I-7). Therefore, reduction of nonpoint source pollution loads from areas of existing and planned development is an important issue that needs to be addressed in this plan and a necessary component of the overall load reduction goals for this watershed.[88]

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[87]*Outagamie County Land Conservation Department,* Nonpoint Source Implementation Plan for the Plum and Kankapot Creek Watersheds*, 2014.*

[88]*Performance standards for control of urban nonpoint source pollution from existing and new development are set forth in Chapter NR 151, "Runoff Management," of the* Wisconsin Administrative Code. *The Town of Merton, which has been designated as an MS4 community subject to Wisconsin Pollutant Discharge Elimination System permit requirements under Chapter NR 216, "Storm Water Discharge Permits," of the* Wisconsin Administrative Code*, is required to meet those standards.*

WATERSHED INVENTORY RESULTS

The staffs of the U.S. Department of Agriculture (USDA) National Resources Conservation Service (NRCS), WDNR, Washington County Planning and Parks Department, and Waukesha County Department of Parks and Land Use Land Resources Division assisted the SEWRPC staff in gathering information on livestock operations, gullies, potentially restorable wetlands, riparian buffers, and farming practices throughout the watershed.

SEWRPC staff also conducted a survey of streambank erosion conditions and instream habitat conditions for the mainstem of Mason Creek and selected tributaries from 2012 through 2015.

Current Management Practices/Projects Summary

Conservation practices installed within the Mason Creek watershed over the last 30 years, since publication of the Oconomowoc River Priority Watershed plan,[89] include:

- Conservation tillage practices on approximately five percent of the cropland in the watershed,
- No till practices on approximately 50 percent of the cropland in the watershed,
- Nutrient management plans for 50 percent of the cropland in the watershed, and
- Protection and/or establishment of 1,418 acres of riparian buffers.

As shown in Figure II-23, based on application of the USEPA STEPL model, these projects are providing significant annual pollutant load reductions to Mason Creek, and are helping the watershed to meet approximately 35 percent and 36 percent of annual pollutant load reduction goals for Total Phosphorus (TP) and Total Suspended Sediment (TSS), respectively (see Appendix B). Hence, maintenance of these practices is an important element of this plan to ensure that they are still functioning as designed. However, it is important to note that these existing practices are not enough to achieve the load reduction goals needed to meet the TMDLs for the Mason Creek watershed (Sub-Basin 24) as summarized above. A description of current practices and proposed projects are discussed in more detail below.

Feedlot Inventory Results

Locations of current livestock operations were compiled in consultation with local NRCS staff and Washington and Waukesha County staff, and from USDA 2012 agriculture census data and 2010 and 2015 digital, color orthophotographs obtained by Washington and Waukesha Counties under a program administered by SEWRPC. It was estimated that there are approximately three active livestock operations or feedlots with an estimated 119 beef and dairy cattle, 19 swine, 10 sheep, 39 horses, 39 chickens, one turkey, and two ducks in the Mason Creek watershed. Onsite barnyard inventories were not conducted on any of these sites, so the exact number of animal

[89] *WDNR, Oconomowoc River Priority Watershed, 1986, op. cit.*

units are unknown. However, none of these farms is a large enough operation to be classified as a permitted Concentrated Animal Feeding Operation or CAFO. Locations of the feedlots or livestock operations in the watershed are shown in Map B-1 of Appendix B.

Feedlot area estimates were made for the largest sites that could be identified in the watershed using geographic information system (GIS) data and tools and the 2010 and 2015 digital, color orthophotographs. Those areas were used in the STEPL model to estimate pollution loads (Appendix B). Based upon this data, as shown in Figure II-22, it was estimated that runoff from feedlots constitutes approximately 12.4 percent of the nitrogen, 6.2 percent of the phosphorus, 7.0 percent of the BOD, and none of the sediment load from agriculture each year. Thus, feedlot runoff from livestock operations is generally not a significant source of nutrient loads in this watershed. In addition, there was no evidence of trampled streambanks or cattle observed in Mason Creek and neither Washington County nor Waukesha County staff were aware of any significant problems associated with livestock operations within the watershed.[90] It is likely that these fairly small operations can reduce any annual loads with low cost, clear water diversions and roof gutters, although more specific information would be needed to make specific recommendations. Although barnyard runoff is only contributing a small percentage of the total nutrient and sediment loading in this watershed, it is always an important issue as long as any animal units are kept within the watershed.

Upland Inventory

Agricultural uplands were inventoried using GIS data and tools, County and NRCS information, and digital, color orthophotography.

Tillage Practices and Residue Management

Crop residue levels do not remain static and often a producer's crop rotation plan will dictate changes to the tillage practice at the end of a growing season. For this reason, an annual inventory of tillage conditions is not as useful as understanding the current and recent year practices on a particular farm field. Nonetheless, estimates provided by County staff and qualitative observations indicate that a range of low to high residue practices (see Figure II-24) are being practiced within the watershed. In addition, visible signs of erosion are prominent throughout the watershed. Rill erosion and some gullies were visible on or adjacent to several fields. A rill is a shallow channel (no more than a few inches deep) cut into soil by the erosive action of flowing water. Similar but smaller incised channels are known as microrills and larger incised channels are known as gullies. As noted above, some form of conservation tillage is practiced on approximately five percent of the cropland in the watershed, and no till cultivation is practiced on an additional 50 percent. No till is far more effective than conventional tillage in reducing nutrient and sediment runoff, and the overall goal for this watershed is for farmers to change from conventional and

[90]*Personal Communication, Paul Sebo, Washington County, and Perry Lindquist, Waukesha County.*

less effective forms of conservation tillage, increasing no till practices from being applied on 50 percent of the cropland to being applied on 75 percent. Application of STEPL indicates that implementation of 75 percent no till practices within the Mason Creek watershed could produce additional pollutant load reductions of 4,306 lbs of nitrogen, 1,319 lbs of phosphorus, 2,282 lbs of BOD, and 356 tons of sediment from croplands on an annual basis (see Figure II-23).

Cover Crops

The benefits of establishing cover crops include reducing soil erosion, reducing the need for synthetic fertilizers, building organic matter in the soil, and improving local waterways. Contrary to early concerns by farmers and other conservationists, use of cover crops actually leads to increased yields not a decrease.[91] Cover crops, or plants such as winter wheat (see Figure II-25) are planted and grown before the cash crop season. According to a recent survey funded by the USDA Sustainable Agriculture Research and Education program and the American Seed Trade Association, during the 2014-15 growing season, more than 1,200 farmers found that corn yields rose on average 3.7 bushels per acre (2.1 percent) and soybean yields increased 2.2 bushels per acre (4.2 percent) when planted in fields with cover crops. This was the third year in a row where the farmers who were surveyed observed an increase in yield when cover crops were incorporated.

Cover crops are not currently being implemented within the Mason Creek watershed. Under this plan, a goal was adopted to establish cover crops on 50 percent of the cropland or about 987 acres within the watershed. The anticipated load reductions attributable to such a level of cover crop establishment are 4,243 lbs of nitrogen, 1,031 lbs of phosphorus, 2,048 lbs of BOD, and 320 tons of sediment from croplands on an annual basis (See Figure II-23). In addition, such practices are expected to greatly improve overall soil health in the watershed.

Nutrient Management

Nutrient management plans are conservation plans designed to address concerns related to soil erosion, manure management, and nutrient applications. Nutrient management plans must meet the standards of the Wisconsin NRCS 590 Standard.

Based upon Washington County and Waukesha County records, there are currently 987 acres, or about 50 percent of the cropland in the watershed, under a nutrient management plan. All agricultural operators in the watershed should have nutrient management plans, so developing plans for the remaining 50 percent, or 987, acres is the ultimate goal for this watershed. Implementation of nutrient management plans for all cropland within the Mason Creek watershed is expected to provide additional pollutant load reductions of 1,590 lbs. of nitrogen, 664 lbs. of

[91]*2015 Cover Crop Survey Analysis, see website: http://www.sare.org/Learning-Center/From-the-Field/North-Central-SARE-From-the-Field/2015-Cover-Crop-Survey-Analysis*

phosphorus, 1,463 lbs. of BOD, and 229 tons of sediment on an annual basis (see Figure II-23). It is important that each County monitors to insure full and effective implementation of nutrient management plans.

Soil Health/Quality Indicators

The Phosphorus Index (PI) and soil phosphorus concentrations are monitored as part of nutrient management planning on farms. The PI is calculated by estimating average annual runoff phosphorus delivery from each field to the nearest surface water based on the field's soil conditions, crops, tillage, manure and fertilizer applications, and long term weather patterns. The higher the Index number, the greater the amount that the field is contributing phosphorus to local waterbodies. Tracking of soil test phosphorus concentrations and phosphorus index (PI) in the watershed can be useful in prioritizing fields for improved management practices; however, there are many additional physical, chemical, and biological soil quality indicators available for farmers, conservationists, and soil scientists to assess and manage soil health (see Appendix E). The soil quality indicators as summarized in Appendix E directly relate soil quality with soil function, so these are more straightforward and effective parameters to assess and manage soil health than the PI. Therefore, as more landowners in the watershed in both Washington County and Waukesha County sign up for nutrient management plans, more soil quality indicators will be monitored and data will become available to assess and improve soil function for this watershed.

Erosion Vulnerability

Priority fields for conservation practices were evaluated using slope, soils, and floodplain information (see Maps I-3, I-11, andI-12). Cropland underlain with soil that has the potential to produce more runoff (i.e., lower infiltration rates and steep slopes) are more likely to have runoff and erosion problems. Any cropland with a mean slope of two percent or greater was considered a priority field for conservation practices (see "*Soil Erodibility*" section in Chapter I of this report). More specifically, fields with slopes of 2 to 6 percent were designated as high priority, and fields with 6 percent or higher slope were considered critical. In addition, as a general rule, effectiveness of agricultural Best Management Practices (BMPs) in improving water quality decreases with distance from a waterbody. Based upon these conditions a general parcel level agricultural priority map for BMP implementation (Map II-6) was developed for three categories:

> ***High priority***-Agricultural lands that are intersected by waterways. This includes parcels containing waterbodies such as drainage ditches and tributaries draining directly to Mason Creek or floodways and/or floodplains of Mason Creek as designated by the Federal Emergency Management Agency (FEMA) (see Map I-3).
>
> ***Moderate priority***-Agricultural lands that are not directly connected to Mason Creek, but still contain some portion of fields with 6 percent or higher slope, soils with higher runoff potential, and/or isolated wetlands or ponds.

Low priority-Agricultural lands that are not directly connected to Mason Creek. These parcels generally contain fields with less than 6 percent slope and soils with lower runoff potential.

This prioritization scheme is designed to first address the highest priority or critical parcel sites for which pollutant loads can be most cost-effectively reduced. Within the Mason Creek watershed the greatest proportions of high and moderate priority fields occur within sub-basins MC-3, MC-2, MC-4, and MC-1 (in descending order). The use of BMPs such as cover crops, no tillage, nutrient management plans, gully stabilization, and establishment of riparian buffers/wetland restoration practices on all priority fields will be necessary to achieve pollution load reductions.

Potential Restorable Wetlands

Wetlands provide a number of benefits such as water quality improvement, wildlife habitat, and flood mitigation. According to the USEPA a typical one-acre wetland can store about one million gallons of water.[92] Restoring wetlands in the watershed area will provide water storage and reduce sediment and phosphorus loading. Establishing restored wetlands, particularly as riparian buffers (see "*Riparian Corridor Conditions*" subsection below), can help reduce pollution loads from tile drains, barnyards, and upland runoff, and can be implemented in areas where frequent crop damage occurs due to flooding.

Hydric soils characteristic of wetland conditions form under settings where the ground was saturated with water for long enough periods of time to cause changes in the soil properties. These unique soils and growing conditions fostered a suite of plant species that thrive in wet, oxygen-deprived soil. The very few wetlands remaining in the Mason Creek watershed, outside of the large wetland complex associated with the Mason Creek Swamp natural area (see Map I-9), are found along the main stem of the Creek. Pella silt loam, Pistakee silt loam, and Brookston silt loam are the predominant hydric soil types, and are very productive when the water table is lowered. Tile systems discharging to the mainstem and tributaries of the Creek are common throughout the watershed.

Under the Rock River TMDL study, each subwatershed was analyzed to identify locations of potentially restorable wetlands (PRW) using the Wisconsin Wetlands Inventory, hydric soils, and land cover data.[93] A candidate area for wetland restoration was defined as any wetland that was historically a wetland but has since been drained due to tiling and ditching or has been filled in. A wetland was considered potentially restorable if it met hydric soil criteria

[92] *U.S. Environmental Protection Agency (USEPA),* Wetlands: Protecting Life and Property from Flooding*, May 2006, USEPA843-F-06-001, Website:http://water.epa.gov/type/wetlands/outreach/upload/Flooding.pdf.*

[93] *USEPA and WDNR, 2011, op. cit.*

and was not in an urban area. The TMDL analysis estimated that there are about 329 acres of potentially restorable wetlands in the Mason Creek watershed. The modeled load reductions also showed that if 80 percent of the potentially restorable wetlands are restored it is estimated that sediment loads would be reduced 55 percent and phosphorus loads would be reduced 44 percent in the Mason Creek watershed. Hence, according to the analysis, restoring wetlands could result in a significant reduction in pollutant loading, and would be a key component to address nonpoint source soil erosion.

Using the WDNR potentially restorable wetlands GIS layer, potential wetland restoration sites in the Mason Creek watershed were evaluated for their feasibility for restoration based on location and size. Any wetland less than five acres was considered economically infeasible and removed from consideration. Any site that was located in an area of existing or ongoing development was eliminated. After these adjustments were made, there were approximately 205 acres of potentially restorable wetland identified within the Mason Creek watershed as shown on Map II-7 was determined to be potentially feasible. Sub-basin MC-2 contains 124 acres of PRW, which is more than twice the amount of PRW in any other sub-basin. Sub-basins MC-3 and MC-1 each contain the next highest areas of PRW with 56 acres and 14 acres, respectively. Collectively, sub-basins MC-4, and MC-2B comprise the remaining 11 acres of PRW. Sub-basin MC-2A does not contain any PRW.

Implementing restoration of wetlands will be difficult since it involves taking agriculture land out of production. However, these important riparian areas were considered a high priority to protect and restore physiochemical function to reduce pollution loads and improve biodiversity and landscape connectivity within this watershed.

The load reductions associated with these potential wetland restorations are shown in Figure II-26, which also includes load reductions for high priority 75 foot riparian buffer width areas and steep slope areas (see "*STEPL Load Reduction Results for Existing Riparian Buffers, 75-Foot Riparian Buffer Expansion Areas, Conversion of Farmed Potential Restorable Wetlands, and Conversion of Farmed Steep Slopes*" sections and Maps B-1 and B-2 in Appendix B of this report). Potentially restorable wetland areas are also good candidate sites for constructed floodplain benches associated with remeandering the Upper and Lower Mason Creek reaches and/or opportunities to modify tile drainage to reduce pollution loads. Therefore, any PRW areas that are located within the existing floodplain boundary would be a high priority for conversion to wetland, because their location would facilitate a higher level of protection to reduce pollutants from entering into Mason Creek. Potential wetland restoration sites will have to be further evaluated onsite prior to any design and implementation.

Agricultural Tile Drainage

Tile outlets draining directly to Mason Creek or its tributaries were identified as part of the stream inventory conducted between 2012 and 2014. Locations of the tiles are shown on Maps F-1 through F-5 in Appendix F. This information, coupled with the soils information, indicates it is likely that the great majority, or all, of the fields within this watershed contain a tile drainage system. Tile drains in fields can act as a conduit for nutrient transport to streams if not managed properly. Treating tile drainage at the outlet and better management of nutrient/manure applications on fields can reduce the amount of phosphorus reaching Mason Creek. Some options for treating tile drainage at the outlet include constructing a floodplain bench associated with remeandering the mainstem of Mason Creek and/or installation of drainage water control structures to retain water in the soil column beneath fields under certain conditions.

Riparian Corridor Conditions

Healthy riparian corridors help to protect water quality, groundwater, fisheries and wildlife, and ecological resilience to invasive species, and can reduce potential flooding of structures and harmful effects of climate change.[94] The health of riparian corridors is largely dependent upon width and continuity. Therefore, efforts to protect and expand the remaining riparian corridor width and continuity are the foundation for protecting and improving the fishery, wildlife, and potential recreation within the Mason Creek watershed.

The provision of buffer strips along waterways represents an important intervention that addresses anthropogenic sources of contaminants. Even relatively small buffer strips provide a degree of environmental benefit, as suggested in Table II-12 and Figure II-27 and further discussed in Appendix C.[95] The Wisconsin Buffer Initiative (WBI) further developed two key concepts that are relevant to this plan: 1) riparian buffers are very effective in protecting water resources and 2) riparian buffers need to be a part of a larger conservation system to be most effective.[96] However, it is important to note that the WBI limited its assessment and recommendations to the protection of water quality, and did not consider the additional values and benefits of riparian buffers. Research clearly shows that riparian buffers can have many potential benefits, such as flood mitigation, prevention of channel erosion, provision of fish and wildlife habitat, enhancement of environmental corridors, and water temperature moderation (see Appendix C). However, the nature of the benefits and the extent to which the benefits are achieved is site-specific. Consequently, the ranges in buffer width for each of the buffer functions shown in Figure II-27 are large. Buffer widths should be based on desired functions, as well as site conditions. For example, based upon a number of studies of sediment removal, buffer widths ranging from about 25 to nearly 200 feet achieved removal efficiencies of

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[94]*N.E. Seavy, et al., "Why Climate Change Make Riparian Restoration More Important than Ever: Recommendations for Practice and Research,"* Ecological Restoration, *Volume 27, Number 3, September, 2009, pages 330-338; "Association of State Floodplain Managers, Natural and Beneficial Floodplain Functions: Floodplain Management—More Than Flood Loss Reduction, 2008,"* www.floods.org/NewUrgent/Other.asp.

[95]*Data were drawn from A. Desbonnet, P. Pogue, V. Lee, and N. Wolff, "Vegetated Buffers in the Coastal Zone – A Summary Review and Bibliography," CRC Technical Report No. 2064. Coastal Resources Center, University of Rhode Island, 1994.*

[96]*University of Wisconsin-Madison, College of Agricultural and Life Sciences,* The Wisconsin Buffer Initiative, *December 2005.*

between 33 and 92 percent, depending upon local site conditions such as soil type, slope, vegetation, contributing area, and influent concentrations, to name a few. More specifically, recent research has identified several key characteristics associated with successful buffer effectiveness to reduce pollutant loads in agricultural settings as summarized below:[97]

- Field slopes should generally range between one and nine percent. Sites with high slopes are not effective, because runoff velocities are too high, which reduces trapping efficiency. Site with slopes that are too low are not as effective, because the hydraulic gradient is insufficient.

- Field soil loss rates must be less than 10 tons per acre, otherwise rate of soil deposition will exceed the buffer trapping efficiency. If soil loss rates are excessive, other agricultural BMPs should be implemented to reduce erosion rates prior to buffer installation.

- The ratio of field area to buffer area should preferably not be greater than 50:1, unless soil erosion rates are very low. Buffers need to intercept the dominant flow path that transports pollutants on the field to be effective, and it is important to promote sheet flow of field runoff through the buffer to effectively remove pollutants. So, field rill and gully erosion must be addressed with conservation tillage or plugs or some other technique prior to discharging into the buffer, so that overland flow is dispersed and not in the form of concentrated flow.

- For site conditions where precipitation intensity exceeds infiltration capacity of the field tributary to the buffer (i.e., dominant flow path is overland surface runoff), the buffer strip must allow for sediment deposition, nutrient uptake, denitrification, and/or degradation of pesticides through reduction of overland velocity, increased infiltration capacity, and increased surface roughness.

- For site conditions where precipitation intensity is less than the infiltration capacity (i.e. dominant flow path is subsurface lateral flow and/or saturation excess, tile drainage), constructed wetland buffers can provide suitable increases in nutrient uptake, infiltration capacity, retention and denitrification, and degradation of pollutants. Buffers are only effective in removing pollutants from subsurface flow when the soil root zone is deep enough to intercept shallow groundwater subsurface flows.

Figure II-27 also shows that for any particular buffer width, for example 75 feet, the buffer can provide multiple benefits, ranging from water temperature moderation to enhancement of wildlife species diversity. A benefit not

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[97]*Rebecca A. Rittenburg, and others, "Agricultural BMP Effectiveness and Dominant Hydrological Flow Paths: Concepts and a Review," Journal of the American Water Resources Association, 51(2): pages 305-329, 2015.*

shown in the figure includes bank stabilization, which is an important concept in utilizing buffers for habitat protection (see Appendix C).

While it is clear from the literature that wider buffers can provide a greater range of values for aquatic systems, the need to balance human access and use with the environmental benefits to be achieved suggests that a 75-foot-wide riparian buffer provides a minimum width necessary to contribute to good water quality and a healthy aquatic ecosystem. In general, most pollutants are removed within a 75-foot buffer width. However, from an ecological point of view, 75-foot-wide buffers are inadequate for the protection and preservation of groundwater recharge or wildlife species. Riparian buffer strips greater than 75 feet in width provide significant additional physical protection of streamcourses, owing to their function in intercepting sediment and other contaminants mobilized from the land surface as a result of natural and anthropogenic activities. These wider buffers also serve to sustain groundwater recharge and discharge relationships, and to provide biological benefit from the habitat established within the shoreland and littoral areas associated with streams and lakes.[98]

For example, the highest quality environmental corridors, natural areas, and vegetation communities are located within and adjacent to the riparian buffer network throughout the Mason Creek watershed as shown on Maps I-9 and II-8. In other words, riparian buffers are a vital conservation tool that provides the connectivity among landscapes to improve the viability of wildlife populations within the habitats comprising the primary environmental corridor and isolated natural resource areas.[99]

As previously mentioned, healthy and sustained aquatic and terrestrial wildlife diversity is dependent upon adequate riparian buffer width and habitat diversity. Specifically, recent research has found that the protection of wildlife species is determined by the preservation or protection of core habitat within riparian buffers with widths ranging from a minimum of 400 feet to an optimal 900 feet or greater as summarized in Appendix C. These buffer areas are essential for supporting healthy populations of multiple groups of organisms, including birds, amphibians, mammals, reptiles, and insects and their various life stages. For example, some species of birds, amphibians, turtles, snakes, and frogs have been found to need buffer widths as great as 2,300 feet, 1,500 feet, 3,700 feet, 2,300 feet, and 1,900 feet, respectively, for at least part of their life histories. Hence, preservation of riparian buffers to widths

[98]*See, for example, Brian M. Weigel, Edward E. Emmons, Jana S. Stewart, and Roger Bannerman, " Buffer Width and Continuity for Preserving Stream Health in Agricultural Landscapes,"* Wisconsin Department of Natural Resources Research and Management Findings*, Issue 56, December 2005.*

[99]*Paul Beier and Reed F. Noss, "Do Habitat Corridors Provide Connectivity?,"* Conservation Biology*, Volume 12, Number 6, December 1998.*

of up to 1,000 feet or greater represents the optimal condition for the protection of wildlife in the Mason Creek watershed.[100]

Map II-8 shows the major natural cover types both within and outside of the existing riparian buffers distributed throughout the Mason Creek watershed. This inventory shows that the riparian buffers are comprised of a variety of wetland (emergent/wet meadow, flats, forested, and scrub/shrub) and upland (brush, grassland, upland conifer, and deciduous) vegetation communities. Each of these habitats is necessary to support the life history requirements of multiple wildlife species. For example, amphibians and reptiles have been reported to utilize numerous habitat types that include seasonal (ephemeral) wetlands, permanent wetlands (lakes, ponds, and marshes), wet meadows, bogs, fens, small and large streams, springs and seeps, hardwood forest, coniferous forest, woodlands, savannahs, grasslands, and prairies.[101] Hence, it is this mosaic of habitats and the ability of organisms to travel between them at the correct times in their lives to survive, grow, and reproduce, which is essential to support an abundant and diverse wildlife community throughout this watershed.

The development patterns and infrastructure that humans create on the landscape lead to a number of obstructions that can limit both the availability of wildlife habitat and the ability for organisms to travel between habitats. These obstructions are primarily a result of roadways, railways, and buildings that fragment the natural landscape. Therefore, an effective management strategy to protect wildlife abundance and diversity in the Mason Creek watershed would be to maximize critical linkages between habitat areas on the landscape, ensuring the ability of species to access these areas. Examples of critical linkages include the following:

- Water’s edge (lake, pond, river, wetland) to terrestrial landscapes (i.e., riparian buffer width);
- Water’s edge to water’s edge (e.g., river to ephemeral pond, lake to ephemeral pond, permanent pond to ephemeral pond); and
- Habitat complexes or embedded habitats-Wetland to upland (e.g., seep to prairie) and upland to upland (e.g., grassland to woodland).

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[100]*The shoreland zone is defined as extending 1,000 feet from the ordinary high water mark of lakes, ponds, and flowages and 300 feet from the ordinary high water mark of navigable streams, or to the outer limit of the floodplain, whichever is greater. To be consistent with this concept and to avoid confusion, the optimum buffer width for wildlife protection is defined as extending 1,000 feet from the ordinary high water mark on both sides of the lakes, ponds, and navigable streams in the watershed.*

[101]*Kingsbury, B.A. and J. Gibson (editors),* Habitat Management Guidelines for Amphibians and Reptiles of the Midwestern United States, *Partners in Amphibian and Reptile Conservation Technical Publication HMG-1. 2nd Edition, 2012, 155 pages.*

In addition, connecting the multiple isolated natural resource areas (INRAs) throughout the Mason Creek watershed to the larger primary environmental corridor (PEC) area and building and expanding upon the existing protected lands, represent a sound approach to enhance the corridor system and wildlife areas within the watershed.

Existing and Potential Riparian Buffers

Map B-2 in Appendix B shows the current status of existing and potential riparian buffers at the 75-foot, 400-foot, and 1,000-foot widths and priority potential restorable wetland areas along Mason Creek and its major tributary streams. Buffers on Map II-9 were primarily developed from 2010 digital orthophotographs and the 2010 WDNR Wisconsin Wetland Inventory, and from inventories of PEC, SEC, and INRA. Polygons were created using GIS techniques to delineate contiguous natural lands (i.e., nonurban and nonagricultural lands) comprised of wetland, woodland, and other open lands adjacent to waterbodies. Those lands comprise a total of about 1,427 acres, or about 27 percent, of the total land area within the Mason Creek watershed. As shown on Map II-9 and in Figure II-28, the most extensive existing buffers outside of internally drained sub-basins were found within sub-basin MC-2. Those buffers comprise about 40 percent (1,104 acres) of the total land area in that sub-basin. In contrast, sub-basins MC-1, MC-4, and MC-3 contain about 17, 15, and 11 percent buffers, respectively. Comparison between the existing buffers versus the potential buffers at the 75-foot, 400-foot, and 1,000-foot widths throughout the Mason Creek watershed indicates that the existing buffers contain some areas whose widths exceed 1,000 feet from the edge of the stream, which indicates they are providing significant water quality and wildlife protection (see Map II-9). These extensive buffers are mostly associated with the Mason Creek Swamp natural area.

A large proportion of the agricultural areas throughout the watershed show encroachments into the 75-foot and 400-foot riparian zones as shown on Map II-9. In particular, the most significant encroachments into the riparian zone within the 75-foot width are located within sub-basins and reaches: MC-3, Upper Mason Creek and Trib-A reaches; MC-4, Lower Mason Creek; and MC-1 and MC-2, adjacent to the West Branch Agricultural Ditch. In descending order, these sub-basins contain the following potential areas available to restore riparian buffers within the 75-foot width: MC-3 (7.7 acres), MC-2 (5.4 acres), MC-1 (3.8 acres), and MC-4 (2.7 acres). Therefore, although the majority of the Mason Creek stream network is fairly well buffered, these encroachments within the 75-foot width represent significant gaps in the protection of water quality for a total area of nearly 20 acres or 0.4 percent of the watershed. The analysis also shows that there is the potential to establish and expand buffers in each of the sub-basins at the 400-foot and 1,000-foot widths (see Figure II-28 and Map II-9).

Riparian Buffer Protection and Prioritization Strategies

All riparian buffers provide some level of protection that is greater than if there were no buffer at all. However, wider buffers provide a greater number of functions (infiltration, temperature moderation, and species diversity) than narrower buffers. Therefore, it is important that existing buffers be protected and expanded where possible.

The riparian buffer network out to the 75-foot, 400-foot, and 1,000-foot widths as summarized above provides the framework upon which to protect and improve water quality and wildlife within the Mason Creek watershed. This framework can be achieved through a combination of strategies that include land acquisition, regulation, and best management practices.

Land Acquisition

The prioritization for acquisition of these lands (including PEC and INRA, and the natural areas (NA)) should be based upon the following order of importance (from highest to lowest priority):

1. Existing riparian buffer (protect what exists on the landscape),

2. Potential riparian buffer lands up to 75 feet wide (minimum level of protection for effective pollutant removal),

3. Potential restorable wetlands and steep slope areas (see Map B-2 in Appendix B) (priority for pollutant removal and wildlife habitat protection),

4. Potential riparian buffer lands up to 400 feet wide (minimum wildlife protection), and

5. Potential riparian buffer lands up to 1,000 feet wide (optimum wildlife protection).

In addition, special consideration should be given to 1) the acquisition of riparian buffers in locations designated as having high to very high groundwater recharge potential as shown on Map I-10 in Chapter I of this report and 2) connecting and expanding critical linkages among habitat complexes to protect wildlife abundance and diversity. Furthermore, connecting the multiple INRAs throughout the Mason Creek watershed to the larger PEC areas, as well as building and expanding upon the existing protected lands, represents a sound approach to enhance the corridor system and wildlife areas within the watershed.

Regulatory and Other Opportunities

Chapter NR 115, "Wisconsin's Shoreland Protection Program," of the *Wisconsin Administrative Code* establishes a minimum 35-foot development setback running parallel to the ordinary high water mark of navigable lakes, streams, and rivers. There also is a required minimum tillage setback standard of five feet from the top of the channel of surface waters in agricultural lands called for under Section NR 151.03 of the *Wisconsin Administrative Code*. Instream field observations in the watershed and orthophotograph interpretation indicate that Mason Creek and its tributaries flowing through agricultural lands meet the five-foot tillage setback. As summarized above, not having an adequate buffer between a field and a waterway can contribute to significant sediment and phosphorus loading to the waterway and can significantly limit wildlife habitat. In addition, based upon the water quality and wildlife goals for this watershed, neither the 5-foot tillage setback nor the 35-foot buffer requirement are adequate to achieve the pollutant load reduction goals and resource protection concerns.

It is important to note that crop yield losses have been found to be greatest along the edges of drainage ditches that tend to get flooded. Therefore, adding a buffer to these areas would not be taking prime production areas out of a field. Fields with high slopes (Map I-12) and high erosion potential (Map I-11), fields where the minimum riparian buffer width of 75 feet is not being met (Map II-9) and/or crop land is located within the one-percent-annual-probability (100-year recurrence interval) floodplain (Map I-3), and fields containing potentially restorable wetlands within 1,000 feet of a waterway are considered priority fields for installation of riparian buffers. In addition, in expanded riparian buffers on cropland, the 75 feet adjacent to the waterway are envisioned to be harvestable buffers, so that farmers can periodically harvest the grasses to feed livestock. Expansion of riparian buffers to the 400- and 1,000-foot widths, or greater to the extent practicable, are not likely to be achievable until such time that the agricultural land is converted to urban uses. At that time, it may be possible to design portions of the development to accommodate such buffer widths. Hence, this will likely be the last chance to establish such critical protective boundaries around waterways before urban structures and roadway networks are constructed.

Primary environmental corridors (PEC) have a greater level of land use protections compared to secondary corridors, isolated natural resource areas, or designated natural areas outside of PEC. Therefore, the regulatory strategy to expand protections for vulnerable existing and potential riparian buffers would be to increase the extent of primary environmental corridor designated lands within the Mason Creek watershed. In particular, there is only one PEC in the Mason Creek watershed called the Mason Creek Swamp, which comprises a significant amount of the headwater area of Mason Creek and extends along the Upper and Lower Mason Creek reaches all the way downstream to North Lake (see Map II-10). Therefore, this PEC presents the greatest opportunity to expand primary environmental corridors. Since this area already meets the minimum size requirements for designation as a PEC, any lands with sufficient natural resource features adjacent or connecting to this existing PEC could potentially be incorporated into this designation. Therefore, if buffers could be established adjacent to existing PEC, then these have the potential to be upgraded to PEC. For example, as shown in Figure II-29 nine acres of cropland adjacent to the West Branch Agricultural Ditch were converted to buffer and restored to wetland vegetation in 2015. This expansion of buffer protection combined with addressing erosion from the concentrated flow areas/Gully 1 and 2 (see "*Concentrated Flow/Gully Stabilization*" section and Figure II-30) has reduced annual pollutant loads by 116 lbs. of phosphorus and 164 tons of TSS, and has increased the PEC by an additional nine acres. This is a great example of collaboration and how shared funding among project partners (i.e., Natural Resources Conservation Service (NRCS), City of Oconomowoc, and the North Lake Management District) can be effectively used to protect water quality in Mason Creek, protect the floodplain, and expand environmental corridors for fish and other wildlife.

Wetlands located within PEC lands have been designated as Advanced Delineation and Identification (ADID) wetlands under Section 404(b)(1) of the Federal Clean Water Act and are deemed generally unsuitable for the discharge of dredge and fill material. In addition, the nonagricultural performance standards set forth in Section NR

151.125 of the Wisconsin Statutes, require establishment of a 75-foot impervious surface protective area adjacent to these higher-quality wetlands. This designated protective area boundary is measured horizontally from the delineated wetland boundary to the closest impervious surface.[102] Hence, these wetlands would have additional protections from being filled and from being encroached upon by future development, thus, they will retain their riparian buffer functions.

Best Management Practices and Programs for Riparian Buffers

A large portion of the existing and potential riparian buffers within agricultural as well as urban areas of the watershed are privately owned. It is the private landowner's choice to establish a buffer. In addition, although riparian buffers can be effective in mitigating the negative water quality effects attributed to agricultural management practices and urbanization, they alone cannot address all of the pollution problems associated with these land uses. Therefore, in agricultural settings riparian buffers need to be combined with other management practices, such as barnyard runoff controls, manure storage, filter strips, nutrient management planning, constructing grassed waterways, and reduced tillage, to mitigate the effects of agricultural runoff. In addition, riparian buffers in urban areas need to be combined with other management practices, such as infiltration facilities, wet detention basins, porous pavements, green roofs, and rain gardens to mitigate the effects of urban stormwater runoff. Therefore, the best management practices to improve and protect water quality in both agricultural and urban areas are essential elements for the protection of water quality and quantity and wildlife within the Mason Creek watershed (see Chapter III for more details).

Recent research has indicated that converting up to eight percent of cropland at the field edge from production to create wildlife buffer habitat leads to increased yields in the cropped areas of the fields and that this positive effect becomes more pronounced with time.[103] As a consequence, despite the initial loss of cropland for habitat creation, overall yields for the entire field were maintained and even increased for some crops compared to the control areas. Although it took about four years for the beneficial effects on crop yield to manifest themselves in this research project, this increase in yields was largely attributed to an increased abundance and diversity of crop pollinators within the wildlife habitat areas. Such results suggest that at the end of a five-year crop rotation, there would be no adverse impact on overall yield in terms of monetary value or nutritional energy, and that in subsequent years, pre-buffer yields would be maintained or increased. Hence, establishment of buffers or the sacrifice of marginal cropland edges to create wildlife buffer habitat within these riparian buffer areas within the Mason Creek watershed may actually lead to increased crop yields, so this practice may be economically feasible over the long-term for

[102]*Runoff from impervious surfaces located within the protective area must be adequately treated with stormwater best management practices.*

[103]*Richard Pywell et. al. 2015.*

farmers. More importantly, these results also demonstrate that lower yielding field edges within Mason Creek may be better used as non-crop habitats to provide services supporting enhanced crop production, benefits for farmland biodiversity, and protection of water and soil health.[104]

In Wisconsin, the USDA offers technical assistance and funding to support installation of riparian buffers and wetlands on agricultural lands. A 14- to 15-year contract must be entered into by the landowner or operator and the land is only eligible under certain conditions. Normally the land must have recently been in agricultural production or use. Because the program requires a lengthy contract it is often difficult to get farmers and/or landowners to commit to installing and maintaining riparian buffer strips. To overcome this, a custom program that offers a shorter time commitment, potentially five years, with a yearly payment incentive greater than what the USDA program offers, has found favor in other counties in the State, and should be developed for the Mason Creek watershed.

Concentrated Flow/Gully Stabilization

GIS data along with digital, color orthophotographs and information from the onsite field surveys conducted as part of this study were used to estimate the location and extent of concentrated flow/gullies in fields, along field edges, and roadway ditches in the Mason Creek watershed. A total of about 4,392 linear feet, or 0.83 mile, of potential gullies/concentrated flow areas were identified as shown in Map B-3 in Appendix B. Those gullies were estimated to produce about 2.6 percent of the annual nitrogen load, 4.5 percent of the annual phosphorus load, 2.5 percent of the annual BOD load, and 21 percent of the annual sediment load from the Mason Creek watershed as shown in Figure II-22 (see Map B-3 in Appendix B for more details). Sub-basin MC-2 contains all of the concentrated flow/gullies that were observed in the watershed.

Grassed waterways are proposed to be installed in each of the seven mapped high priority sites as shown in Map B-3 in Appendix B. The potential load reductions associated with the proposed grassed waterway projects in sub-basin MC-2 are shown in Figure II-30. It may be possible to stabilize concentrated flow areas while still promoting productive agricultural practices, if the concentrated flow areas are seeded with permanent cover crops and no-till practices are followed. However, since several of these concentrated flow areas are roadway ditches or connected to roadway ditches, the use of ditch checks or some other grade control structure to temporarily impound and/or slow stormwater runoff and facilitate water quality improvement through infiltration, filtration, and sediment deposition would be effective (see Appendix G). In addition, this technique may also be used to establish/restore wetland vegetation, where appropriate (see Appendix H and "*Stream Conditions*" section below for more details). It is important to note that the pollution reduction effects of such grade control structures were not modeled, but use of such techniques in combination with grassed waterway implementation would reduce sediment and nutrient loads beyond what was modeled for grassed waterways alone.

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[104]*Richard Pywell et. al. 2015.*

Stream Conditions

SEWRPC staff conducted field inventories from August through November 2014 to quantitatively and qualitatively characterize the physical characteristics of streams within the Mason Creek watershed. Both quantitative and qualitative measures were largely based upon the WDNR Baseline Monitoring protocols for instream fisheries habitat assessment.[105] A total of 149 cross sections surveys were obtained throughout the watershed and the number of transects ranged from 15 to 25 per mile, depending on the reach sampled (see Maps F-1 through F-5 in Appendix F). An additional 38 and 35 maximum water depths were recorded in pool and riffle habitats, respectively, to assess habitat number and quality in order to supplement information between cross sections where the full complement of data was collected. Physical characteristics measured and/or noted included water and sediment depth, low flow and bankfull channel width and depth, substrate composition, undercut bank, bank slopes, bank erosion, and floodplain connectivity, where appropriate. The remaining cover, or cover-related, parameters that include overhanging vegetation, woody debris, macrophytes, algae, and shading were each qualitatively estimated to assess overall habitat cover quality.[106] Locations of trash and other debris in or adjacent to the stream channel were also mapped. Finally, a fish passage assessment was conducted for the mainstem of Mason Creek.

Streambank Erosion

The WDNR 24K Hydrography data set, supplemented with two-foot contour interval land surface elevation data, was used to determine the location of streams in the watershed area. Streambank erosion was inventoried by walking the streams with a handheld GPS device. Information on soil type, height, length, and bank slope were collected and photos were taken. Lateral recession rate was determined using criteria in Table II-13 and soil density was determined by soil type using NRCS Technical Guidance.[107] The lowest density value for the soil types and the lowest value for lateral recession were used for all calculations as summarized in Appendix B. Approximately six miles of the of Mason Creek drainage network were inventoried. Most of the streambanks within the areas surveyed, or 93.2 percent, were in fair to good or stable condition. However, about 0.4 miles, or 2,169 linear feet, of stream were actively eroding as shown on Map B-3 in Appendix B. More specifically, about 21 percent of the erosion sites or 458 linear feet were considered to have slight lateral recession rates, and 74 percent (1,598 linear feet) moderate

[105]*WDNR*, Guidelines for Evaluating Habitat of Wadable Streams, *Bureau of Fisheries Management and Habitat Protection, Monitoring and Data Assessment Section, Revised June 2000; Timothy Simonson, John Lyons, and Paul Kanehl, "Guidelines for Evaluating Fish Habitat in Wisconsin Streams,"* General Technical Report NC-164, *1995; and Lihzu Wang, John Lyons, and Paul Kanehl, "Development and Evaluation of a Habitat Rating System for Low-Gradient Wisconsin Streams,"* North American Journal of Fisheries Management, *Volume 18, pages 775-785, 1998.*

[106]*Edward T. Rankin,* The Quality Habitat Evaluation Index [QHEI]: Rationale, Methods, and Application, *State of Ohio Environmental Protection Agency, November 1989.*

[107]*Natural Resources Conservation Services (NRCS),* Streambank Erosion. Field Office Technical Guide, *November 2003, Retrieved from: efotg.nrcs.usda.gov/references/public/WI/StreambankErosion.doc*

lateral recession, and five percent (113 linear feet) severe lateral recession. This is a real improvement within the watershed, because it was determined in the mid-1980s that there were approximately 7,000 linear feet (1.3 miles) of eroding streambank, primarily due to cattle and machinery crossings.[108]

Sediment loss calculations for inventoried sites were determined using STEPL and are shown in Appendix B. Soil eroded from streambanks was estimated to account for about 0.1 percent of the annual nitrogen load, 0.1 percent of the annual phosphorus load, 0.1 percent of the annual BOD load, and 0.8 percent of the annual sediment load in the Mason Creek watershed as shown in Figure II-22. Hence, although there was active erosion occurring among sites within Mason Creek, none of these sites were considered excessive except Site 3, which was estimated to be contributing more than 7.5 tons of sediment per year as shown in Appendix B. Therefore, this site is considered to be a high priority for mitigation of streambank erosion. This erosion site is already planned to be addressed in summer 2016, with funding provided by the North Lake Management District and the Oconomowoc Watershed Protection Program (OWPP) (see Figure II-31 for more details). The other erosion sites should only be addressed if they become more severe.

It is important to note that, although streambank erosion is not a significant source of sediment to Mason Creek, the streambed within the channelized portions of Mason Creek contains a significant source of sediment that is negatively impacting water quality and wildlife within this system as well as in North Lake (see "*Habitat Quality*" section below for more details). The locations of the deepest sediments within the Mason Creek streambed, as shown on Map II-11, correspond with the channelized reaches that have low floodplain connectivity (i.e., disconnected or partially connected areas) (see Figure II-32). In other words, the sediment deposition is an artifact of the channelization under which the channel was likely excavated deeper and wider than necessary. Such over-excavation promotes deposition of sediment that is easily eroded when discharges increase. Such erosion will continue without intervention. Intervention in this case can range from installation of ditch plugs within the West Branch Agricultural Ditch (see Appendix H) to remeandering the stream to its historic condition within the Upper Reach of Mason Creek (see "*Stream Restoration*" section below and Chapter III for more details). Restoring Mason Creek to its original, or near original, highly meandering stream channel sinuosity and pool-riffle structure along with re-connecting the floodplain will restore the ability of the stream to dissipate erosive water velocities during high flow conditions as well as store and process pollutant loads (see below for more details).

Livestock can cause significant degradation to streams if not managed properly, which was an important issue in the 1980s. There were limited signs of degradation due to livestock access among stream reaches within the areas

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[108]*WDNR, Oconomowoc River Priority Watershed, 1986, op. cit.*

surveyed. It is important to continue to limit livestock access to waterways to protect Mason Creek from excessive erosion and nutrient loading.

Slope and Sinuosity

Stream characteristics, such as slope, length, and sinuosity are determined by a combination of geological history (i.e., glaciation) and human intervention (i.e., lake impoundments and channelization). Based upon this information, it was determined that there were two distinct stream reaches comprising the mainstem of Mason Creek (see Map II-1 and Table II-14). In addition, three tributaries to Mason Creek, including the West Branch Agricultural Ditch, East Branch, and Trib-A were also assessed under this project (see Map II-1). The extent of the physical data collected within Mason Creek and other reaches within this watershed as part of this study is shown in Appendix F, and any gaps in data collection along the waterways were the result of respecting private property owners' requests to not access the stream through their properties.

The longitudinal slope of a channel is the ratio of elevation change between two points on the channel bed to the length of the channel between the same two points. Slope is an indicator of stream energy or power. The lower the slope, the lower the energy, and the slower the water flows. Stream slopes within mountainous stream systems are typically greater than 10 percent. However, slopes within the Mason Creek and tributary reaches are more indicative of lowland streams found in Southeastern Wisconsin and generally do not exceed 0.5 percent, as shown in Table II-14. As previously mentioned in the "Mason Creek Drainage Network" section above, Figure II-4 and Table II-14 show that the Upper Mason Creek reach has a relatively shallow gradient of 0.08 percent (about 4.7 feet per mile). This is actually the lowest slope of all reaches in the watershed, but also very similar to the West Branch Agricultural Ditch and East Branch reach tributaries. These reaches tend to accumulate fine sediments because of their low stream slopes. In contrast, the Lower Mason Creek reach and Trib-A have steeper gradients of 0.45 percent and 0.56 percent, respectively, which is why these reaches are dominated by larger substrates such as sands, gravels, or cobbles. However, the slope of the Lower Mason Creek reach flattens out just downstream of the railroad crossing of this reach near North Lake. Hence, the backwater effect of North Lake extends almost all the way up to the railroad crossing, which means that this lowest portion of the stream has the same surface water elevation as the Lake. Therefore, water velocities are much reduced in this section compared to upstream reaches and sediments tend to accumulate in this area.

Healthy streams naturally meander or migrate across a landscape over time. Sinuosity is a measure of how much a stream meanders. It is defined as the ratio of channel length between two points on a channel to the straight-line distance between the same two points. Sinuosity or channel pattern can range from straight to a winding, or meandering, pattern. Channelized sections of streams that have been straightened typically have low sinuosity closer to one. Stream reaches within the Mason Creek that include both channelized and nonchannelized segments have sinuosities that ranged from 1.03 to 1.27 in 2010, as shown in Table II-14.

Comparison of the original 1837 plat of survey, 1909 USGS quad map, 1937 aerial photo, and the 2010 and 2015 orthophotos demonstrate several important features of this watershed:

1. The East Branch of Mason Creek is the true headwaters of Mason Creek. As shown on Map II-12 and extracted from notes of the 1837 survey, the East Branch was drawn in the original survey and contained a surface water width of two feet. However, by 1937 this reach was channelized/relocated and ditched to improve drainage from lands upstream of this area and the water width was about four feet and the depth was 0.5 foot at that same location. In addition, a flow-through spring pond was constructed in the lower portion of the East Branch near the confluence with the West Branch Agricultural Ditch sometime from 1941 through 1950, and then this pond was disconnected from the East Branch by 1963.

2. The West Branch Agricultural Ditch and its associated drainage ditches did not exist in 1837 nor in 1909. The West Branch Agricultural Ditch was constructed through the western edge of the Mason Creek Swamp sometime between 1909 and 1937, to improve agricultural drainage. Because this ditch was constructed mostly through highly organic and unconsolidated Houghton mucky peat soils, it has contributed significantly to degraded water quality conditions in Mason Creek. This ditch currently has an average wetted width of about four feet and a depth of 0.3 foot.

3. The upper portion (upstream of CTH CW) of the Upper Mason Creek reach was channelized sometime before 1937 and the lower portion was channelized sometime between 1937 and 1941. As a result of channelization, this historically naturally meandering stream, which could still be easily identified on both the 1937 and 1941 aerial maps, was shortened by about 0.5 mile from its original length. This ditching profoundly degraded the instream habitat quality and diversity, natural geomorphology, floodplain connectivity, and sediment transport capabilities within Mason Creek. As shown on Map II-12 and extracted from notes of the 1837 survey, this reach had surface water widths of 13.2 feet and 10 feet where it crossed survey section lines. This reach now has an average water width of about 10 feet and depth of one foot at both of these sites.

4. The Lower Mason Creek reach was the most undisturbed reach in the entire watershed, except for the lowest portion of this reach. As shown in the 1837 survey (Map II-12), Mason Creek used to discharge directly into the Oconomowoc River downstream of North Lake. Mason Creek was shortened by about 1.2 miles and re-routed to drain directly into North Lake sometime before the year 1909 (see Map II-12) and has continued to discharge into the Lake for at least 107 years. As shown on Map II-12 and extracted from notes of the 1837 survey, this reach had a surface water width of 20 feet. This reach now has an average water width of about 16 feet and a depth of 0.5 foot at that site.

Comparison of the historic Pre-1941 versus 2010 stream alignments as shown on Map II-13 shows that this system was much more sinuous under Pre-1941 conditions (see Table II-14). As identified above, the actual distance of stream channel lost on the Upper Mason Creek reach is well established (see Map II-13 and Table II-14). Actual distance of stream channel lost from the pre-settlement period is likely significantly greater for the Trib-A and East Branch tributaries, but, because of a lack of aerial photography prior to 1937, it is unknown where the original stream channels were located. Examination of the 1937 and 1941 aerial photographs indicates that more than 95 percent of the stream network within the watershed had already been straightened by that time period to facilitate the intense agricultural use of the land. Most of the remaining impacts to Mason Creek that occurred after 1941 were to accommodate the construction of roads.

Straightening meandering stream channels or "channelization" was once a widely used and accepted technique in agricultural management. The U.S. Department of Agriculture NRCS (formerly Soil Conservation Service) cost shared such activities up to the early 1970s within southeastern Wisconsin.[109] The objectives of channelization were to reduce floods on lands adjacent to the channelized reaches by conveying stormwater runoff more rapidly, to facilitate drainage of low-lying agricultural land, and to allow more efficient farming in rectangular fields. In many cases channelization was likely accompanied by the installation of drain tiles within the farm fields to better facilitate water movement off the field and to lower groundwater levels. Only a few tile outlets were observed discharging to Mason Creek. Their locations are shown on Maps F-1 through F-5 in Appendix F.

Through channelization and installation of drain tiles, farmers attempted to protect their crops by lowering the groundwater table and increasing the capacity to convey water downstream. Channelization can lead to instream hydraulic changes that can decrease or interfere with the connection between the channel and overbank areas during floods. This may result in reduced filtering of nonpoint source pollutants by riparian area vegetation and soils and increased erosion of the banks. Channelization can also lead to increased water temperature, which was demonstrated in the West Branch Agricultural Ditch, due to the loss of riparian vegetation, and it can alter instream sedimentation rates and paths of sediment erosion, transport, and deposition. For example, the most heavily channelized sections of stream assessed under this study, particularly the West Branch Agricultural Ditch and the Upper Mason Creek reaches contained some of the greatest amounts of streambed deposition. In addition to the loss of stream length, channel straightening causes a major decrease in the number of pool and riffle structures within the stream system. Pool-riffle sequences are often found in meandering streams, where pools occur at meander bends and riffles at crossover stretches.[110] Therefore, channelization activities, as traditionally accomplished

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[109]*Personal Communication, Gene Nimmer, NRCS engineer.*

[110]*N.D. Gordon, et al.,* Stream Hydrology, *John Wiley and Sons, April 1993, page 318.*

without mitigating features, generally lead to a diminished suitability of instream and riparian habitat for fish and wildlife, which was observed in channelized reaches of Mason Creek and its tributaries where there is a lack of riffle habitat (see Map II-14).

Streams are transport systems for water and sediment and are continually eroding and depositing sediments, which causes the stream to migrate. When the amount of sediment load entering a stream is equal to what is being transported downstream—and stream widths, depths, and length remain consistent over time—it is common to refer to that stream as being in a state of "dynamic equilibrium." In other words, the stream retains its physical dimensions (equilibrium), but those physical features are shifted, or migrate, over time (dynamic). For example, it is not uncommon for a low-gradient stream in Southeastern Wisconsin to migrate more than one foot within a single year. Reaches in the Mason Creek watershed that were not channelized, particularly the Upper Portion of Lower Mason Creek, still exhibit healthy meanders that have migrated only slightly over the nearly 70 years between 1941 and 2010 as shown on Map II-13. This reach also contains some of the highest quality habitat in the entire watershed (see "*Habitat Quality*" subsection below).

Evaluation of the channelized reaches of Mason Creek, considering channelization and floodplain connectivity along with onsite survey data and known sediment loads, generally indicates that the channelized reaches have an unstable streambed, and are not in a state of dynamic equilibrium. This instability is largely related to the channelization and floodplain connectivity. The Mason Creek system is partially-connected or disconnected from its floodplain in several areas of the watershed, particularly within the Upper Mason Creek reach, which is partially or fully disconnected over its entire length (see Map II-11). In contrast, the Lower Mason Creek reach and the East Branch Tributary are both well-connected to the floodplain. Floodplain connectivity can be defined in several ways such as the bank height ratio, entrenchment ratio, or stage/discharge relationships. A good connection between Mason Creek and its floodplain is critical in helping to protect the streambed and streambanks by allowing flood flows to dissipate into the floodplain and reducing water velocities that would cause erosion, while at the same time allowing sediments and other pollutants to be deposited into the floodplain. In addition, in reaches with an extensive floodplain and/or riparian buffer the River system naturally makes adjustments to changes in discharge and sediment loads. It is also important to note that the extent of meandering increases with the area tributary to the stream reach, so as tributary area increases, so does the width of the meander belt (see Appendix C).

Stream Reach Dynamics

There is a general increase in stream wetted widths as well as mean and maximum water depths in Mason Creek from upstream to downstream as shown in Figure II-33 and Map II-15. These measurements were obtained for approximate low flow conditions for this system in late summer 2014 among pool, riffle, and run habitats (see "*Habitat Quality*" section below for more details). A low flow is a seasonal phenomenon that usually occurs in summer and is an important component of the flow regime regarding the ability of a river or stream to support adequate water quality and health of the aquatic community. Figure II- shows increases in the highest measured width that is not an outlier for any of the pool, riffle, or run habitat types ranging from about two feet to nine feet in the East Branch, six feet to 14 feet in the Upper Reach, and six feet to nearly 30 feet in the most downstream Lower Mason Creek reach where there is a backwater effect from North Lake. Figure II-33 also shows that depths generally range from about 0.2 to nearly three feet from upstream to downstream. Note that the West Branch Agricultural Ditch contains no pool or riffle habitats, and has the shallowest and narrowest low flow channel conditions compared to all other reaches.

Despite this expected normal increase in water widths and depths from upstream to downstream, there is a non-uniform distribution of organic muck and silt sediments among the Mason Creek reaches as shown as in Figure II-34 and on Map II-11. The organic muck and silt sediments are comprised of a matrix of organic and mineral soils. Based on the level of decomposition, the organic soils are classified either as peat (slightly decomposed organic material) or muck (highly decomposed organic material). Within this watershed, the majority of muck soils forming sediments within Mason Creek are likely derived from the Houghton mucky peat, Palms mucky peat, and Ogden muck soil groups. Organic soils have lower bulk densities, in other words lower weight per unit of volume, and greater pore space than mineral soils. Consequently, organic soils are easily transported in flowing water. The mineral soils in the watershed are largely comprised of silts that are a granular material of a size somewhere between sand and clay, so these small diameter particles are also easily transported in water. Within this watershed, the majority of silts forming sediments within Mason Creek are likely derived from Pella silt loam, Theresa silt loam, Fox silt loam, Brookston silt loam, Dodge silt loam, Lamartine silt loam, Casco loam, St. Charles silt loam, and Wallkill silt soil groups. Silt may occur as a soil or as sediment mixed in suspension with water (also known as a suspended load) in a body of water such as a Mason Creek. Depending on the diameter of silt, Figure II-35 shows that the minimum erosion velocity ranges from about 0.5 to 1.6 feet per second (15 to 50 cm/s) and the minimum transport velocity ranges from about 0.0033 to 0.02 feet per second (0.1 to 0.5 cm/s). Since these sediments within Mason Creek are a combination of organic muck and silts, the greater proportion of organic matter content amongst the silt sediments results in higher pore space, thereby decreasing bulk density. Consequently, the organic muck and silt sediments within Mason Creek are highly erodible and easily transported, which accounts for the high and very high suspended loads observed in both low flow and high flow conditions, respectively, contributing to impairment of water quality (see "*Suspended Materials*" section above).

Based on the comprehensive cross section survey results, both mean and maximum organic muck and silt sediment depths among reaches ordered from deepest to shallowest are (1) West Branch Agricultural Ditch, (2) Upper Mason Creek, (3) combined drainage ditches that drain directly to the West Branch Agricultural Ditch (see Map II-11), (4) East Branch, and (5) Lower Mason Creek (see Figure II-34). This uneven distribution of these organic muck and silt sediments is an artifact of several key features that include, but are not limited to:

- Nonpoint source upland erosion from agricultural lands (see "*Pollutant Loading Model*" section above),
- Geologic soil types within the landscape (see "*Soil Characteristics*" section in Chapter I of this report)
- Ditching or channelization, and
- Overall reach slope and discharge.

The reaches with the greatest slopes, which include both Lower Mason Creek and the East Branch, contained the least amounts of organic muck and silt sediments. Mucks and silts are still present, but do not dominate as in the other reaches, because the steeper slopes provide overall greater water velocities and capability to transport these sediments downstream. In contrast, muck and silt sediments have accumulated to excessive amounts within the West Branch Agricultural Ditch and Upper Mason Creek reaches, which have the lowest slopes. In addition, these two reaches were entirely channelized to improve agricultural drainage, and they have no significant ability to sort sediments compared to a naturally meandering stream. These channelized ditches were likely over-excavated in width and depth, which created slow water velocity conditions suitable for deposition of these muck and silt soils that eroded from upland areas.

The distribution of the mean water and sediment depths among transects within the West Branch Agricultural Ditch and Upper Mason Creek reaches are illustrated in Figure II-36. Within the West Branch Agricultural Ditch water depths are very small and the sediment depths are greater on average than the Upper Mason Creek reach to which it discharges. In some transects, the organic muck and silt sediments were deposited on top of clay pan,[111] but in most cases survey crews could not determine the actual bottom of the channel. Cutting this drainage ditch through Houghton peaty muck established a concentrated flow path that provides a continuous supply of both organic peat and muck sediments to be transported downstream into Mason Creek. In contrast, within the Upper Mason Creek reach, all the deposited organic muck and silt sediments are sitting on top of a mixture of very firm substrates primarily composed of sand, gravel, and/or cobble.

However, it is important to note that it was not possible to know how long it may have taken to fill the West Branch Agricultural Ditch or Upper Mason Creek ditches with sediment, nor is it known how fast this sediment is being supplied into each reach or how fast this sediment is being transported downstream out of each reach and, ultimately, to North Lake. Therefore, it was not possible to establish rates of deposition within the Mason Creek reaches as part of this study. Although the tools were not available to model the pollutant loads associated with these streambed sediments, it was possible to estimate the volumes of organic muck and silt sediments among reaches as shown in

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[111]*A claypan is a dense, compact, slowly permeable layer in the subsoil having a much higher clay content than the overlying material. Claypans are usually hard when dry, and plastic and sticky when wet and limit or slow the downward movement of water through the soil.*

Table II-15. The greater volumes and depths of the sediment can be associated with greater impairments to water quality and fish and aquatic life because more sediments contain more pollutants, can smother or bury organisms and habitats, and have greater capacity to reduce hyporheic (the zone below the water-streambed interface) connectivity.[112]

Table II-15 shows that that there are more than 3,700 cubic yards and 3,000 cubic yards of organic muck and silt sediments in the West Branch Agricultural Ditch and Upper Mason Creek reaches, respectfully. This illustrates that these reaches contain excessive amounts of sediments readily available for transport to downstream reaches and North Lake. In contrast, the Lower Mason Creek reach contained about 900 cubic yards of organic silt and muck sediments. Although this is about one-fourth of the sediment volume in the West Branch Agricultural Ditch and one-third the Upper Mason Creek reach sediment volume, it also demonstrates that this sediment is being transported into habitats downstream and some of it is being deposited, likely contributing to the impairment of water quality and fisheries habitat. Basically, sediments were observed to be accumulating in the deeper and slower velocity pool and run habitats, which is consistent with the high suspended sediment load concentrations observed during low flow conditions. So, the large amounts of readily transportable sediment bedload within the upstream reaches (West Branch Agricultural Ditch and Upper Mason Creek) are being chronically eroded and deposited in habitats downstream as well as in North Lake, even during baseflow or low flow conditions. Because of the large sediment volumes in these reaches, during rainfall events the amounts of transported sediments are essentially limited by the depth of flow and the reach slopes, which is why all of these reaches are observed to transform to a deep chocolate brown (i.e., high sediment loads), even after the smallest rainfall events.

Given these large volumes of sediment in streams throughout the Mason Creek watershed, it is not possible that this accumulated sediment could have originated from streambank erosion, because there was not enough erosion to account for the large volumes of sediment deposited. This demonstrates that this sediment is likely coming from upland areas throughout the watershed, which is supported by the pollutant load modeling described above. However, this also demonstrates the significance of the existing sediment already deposited on the streambed of the Creek and its contribution to the impairments of water quality and fisheries habitat. **Therefore, it is important that reduction of the existing sediment bedload within the West Branch Agricultural Ditch and Upper Mason Creek reaches be addressed under this plan.** Since upstream reaches are loading sediment into downstream reaches, sediment bedload prevention/mitigation should be completed in the most upstream West Branch Agricultural Ditch and associated drainage ditches before the Upper Mason Creek reach can be addressed. This approach would also address the worst reach first.

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[112]*Minnesota Department of Natural Resources,* Watershed Health Assessment Framework, Geomorphology - Soil Erosion Susceptibility*, http://www.dnr.state.mn.us/whaf/about/scores/geomorphology/soil_erodibilty.html*

There is an important difference between low flow versus bankfull channel conditions. Low flow, commonly referred to as low-water discharge, and sustained, or fair weather, runoff are not determinants of overall streambed and streambank channel shape and form. In contrast, the bankfull discharge is considered to be the channel-forming or effective discharge.[113] It is also defined by the discharge that occurs when water just begins to leave the channel and spread onto the floodplain. The quantity and movement of both water and sediment is what determines channel dimension and shape, and effective discharge is the amount of water (volume per unit time) that transports the most sediment over the long term for any given stream system (see Appendix I for more details). Therefore, bankfull channel dimensions are important characteristics of stream power or channel forming discharge, which corresponds to the highest water velocities and ability to transport sediments. The effective discharge typically occurs only a few times annually and is generally defined as the 1.5-year recurrence interval flow event.[114] As shown in Figure II-37, the channel forming discharge or bankfull channel dimensions increase among reaches from upstream (East Branch) to downstream (Lower Mason Creek) as the drainage area increases. Mean bankfull channel width conditions show an increase from about nine to 20 feet, but there is no apparent increase in depth from upstream to downstream, which ranges from about 2.0 to 2.25 feet.

Based upon the channel slope and bankfull depths of flow, the East Branch was estimated to be able to transport sediment sizes up to medium gravel (8.0 to 16.0 millimeters in diameter). Hence, this reach can easily transport all substrate particles equal to medium gravels and smaller, which includes fine gravels, course to very fine sands, course to very fine silts, and coarse to very fine clays. This is consistent with observations that this reach was dominated by sands, gravels, and cobbles amongst riffle habitats and organic silts and muck mixed with sands within the slower pool and run habitats.

Both the West Branch Agricultural Ditch and Upper Mason Creek reaches were estimated to be able to transport sediment sizes up to very fine gravels (2.0 to 4.0 millimeters in diameter) based upon the channel slope and bankfull depths of flow. Thus, during these high flow conditions these reaches are capable of eroding and transporting significant volumes of the accumulated organic muck and silt stored within the streambed sediments as noted above and on Map II-11 and in Figure II-36 and Table II-15.

In comparison, the Lower Mason Creek reach was estimated to be able to transport the largest sediment sizes up to course gravels (16.0 to 32.0 millimeters in diameter) based upon the channel slope and bankfull depths of flow. The riffle habitat located within this reach, as shown in Figure II-38, demonstrates that the particle diameter sizes on the

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[113]*Leopold, L. B. (1994). A view of the river. Cambridge: Harvard University Press.*

[114]*V.T. Chow,* Open-Channel Hydraulics, *McGraw Hill, New York, 1988.*

channel bed are significantly larger than the medium sized gravels, because these substrates are more stable and less easily transported than the smaller medium sized gravels being carried downstream. However, due to the more natural sinuosities of this reach, it also contains the greatest diversity and mixture of clay, silt, sand, cobble, and boulder substrates and instream habitats (see "*Habitat Quality*" subsection below). Organic silt and muck sediments accumulate in the lower velocity pool and run habitats during low flow periods. Deposition of these organic sediments also dominates in the lower downstream portions of this reach where the backwater conditions created by North Lake slow water velocities and facilitate deposition of these finer substrates within the channel and inlet area of the Lake.

The bankfull channel dimensions and associated discharge is critically important when considering potential projects to restore streambed and/or streambanks and to improve fisheries habitat within Mason Creek. If a newly reconstructed stream channel is improperly sized it could lead to excessive erosion of the channel bed or banks (i.e., too narrow or shallow) or aggradation (i.e., too deep or wide). Therefore, it is very important that any stream restoration within Mason Creek incorporate appropriate bankfull channel dimensions as one of the design parameters along with the associated geomorphological parameters such as slope; sinuosity; belt width; radius of curvature of the bends; substrate sizes; and low flow pool, riffle, and run habitat dimensions. The bankfull width and depth dimensions discussed above and shown in Figure II-37 should be used as part of the stream restoration design parameters and goals within Upper Mason Creek. In addition, the historic stream channel alignment for Pre-1941 conditions (see Map II-13) should be used to approximate the appropriate design parameters and goals for slope; sinuosity; belt width; radius of curvature of the bends; and distribution and length of low flow pool, riffle, and run habitat dimensions. However, it is important to note the channel forming discharge of bankfull channel dimension can change, particularly as a watershed becomes more urbanized. Greater urbanization is associated with greater amounts of impervious surfaces, which increases runoff that can lead to increases in discharge and stream power causing the stream to increase in size (erode its streambed or streambanks) in response. Thus, monitoring bankfull channel conditions over time is also a good way to track the health of the stream in terms of its ability to maintain its dimensions and/or whether or not it is in equilibrium with the adjacent land uses and management practices within the watershed.

Habitat Quality

Mason Creek and its main tributaries are a low-gradient stream system, which is characterized by a gradient of about 0.005 feet/feet or lower. High quality, low gradient streams tend to lack riffles and have relatively slow currents, small substrate particle sizes, and well developed meandering (i.e., high sinuosity) channel morphology. Such systems often flow through wetlands and may have very soft, unconsolidated (i.e., organic) substrates and poorly defined channels in some cases. Such characteristics have made low-gradient streams candidates for channelization for agricultural development along with installation of tiles to improve drainage, which is what has occurred to a large extent in the Mason Creek system.

Despite the extensive channelization that has occurred in this watershed, the amount, quality, and diversity of available instream fisheries habitat ranges from poor to excellent based upon results of the low gradient stream habitat index (Table II-16) in all areas except for the West Branch Agricultural Ditch. As shown in Table II-16 this index incorporates several habitat variables that are well established as strongly influencing fish communities and biotic integrity.[115] Those habitat variables include channelization percent and age, instream cover, bank erosion, sinuosity, standard deviation of thalweg depth, and buffer vegetation. Instream cover can include several features such undercut banks, overhanging vegetation, woody debris, boulders, and emergent and/or submergent aquatic plants (i.e. macrophytes). The standard deviation in thalweg depth is a measurement of the variability of water depths, which is a good measure of the variability of stream channel morphology. So greater variability in water depth is reflected in greater diversity of pool, riffle, and run habitat units within a reach or stream and their associated differences in water depth, velocity, and substrate diversity. For example, channelized or straightened streams tend to have uniform conditions, whereas meandering streams tend to have a greater variety of habitats. Diverse habitat generally supports more species, a greater variety of life-stages, and higher abundance of fish.

The West Branch Agricultural Ditch contains the poorest habitat quality rating compared to the other reaches in the watershed. The best scores for this reach are for time since channelization, relatively limited erosion, and fairly good protection by riparian buffers. However, as discussed above, this reach has very poor base flows during dry periods and flashy flows during rainfall events, limited to no instream cover, no substrate diversity, no pool or riffle habitats to support trout, limited variation in water depths, and extensive streambed sediments and associated pollutants. This reach has likely not supported brook trout in the past nor does it currently support trout.

In contrast, the East Branch is the original/historic headwaters of Mason Creek as shown on the original 1837 plat survey (Map II-12). It continues to provide consistent high quality groundwater discharge that is the keystone to sustaining brook trout within Mason Creek. Despite significant channelization, this reach has reestablished fair to good habitat quality, at least within its lower portion.[116] This segment contained good overall quality of instream thalweg depth diversity, stable banks, extent of protective riparian buffers, and instream cover such as woody structure and substrate diversity. Figure II-38 shows good examples of typical instream cover variables observed within the Mason Creek watershed that includes submergent and emergent macrophytes (i.e., vegetation), overhanging vegetation, cobble and boulder substrates, and woody debris. This reach has a good pool-riffle structure. The riffle habitats contain substrate sizes conducive to brook trout spawning and egg development. The

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[115]*Lihzu Wang, John Lyons, and Paul Kanehl, "Development and Evaluation of a Habitat Rating System for Low-Gradient Wisconsin Streams,"* North American Journal of Fisheries Management, *Volume 18, pages 775-785, 1998.*

[116]*SEWRPC staff were unable to gain access to the remainder of this tributary, due to inability to obtain permissions to pass through private property.*

slower velocity pool and run habitats and associated depths that range from about 0.5 to 1.25 feet are also ideal for juvenile trout rearing habitat after the brook trout fry emerge from eggs, which occurs from about April to August. This is the only location where brook trout spawning was observed to occur in the entire watershed (see Figure II-19), which demonstrates its continued capacity to support a critical life stage of this sensitive cold water species. Since it was only possible to survey the lower portion of this tributary, it is possible that there are more spawning sites upstream of the ones observed. **It is a high priority to protect the surface water and groundwater quality and discharge of this tributary, which contains vital spawning and juvenile rearing habitats that help to sustain the naturally reproducing brook trout population within Mason Creek.**

In addition, as mentioned in the "Slope and Sinuosity" section above, a flow through spring pond was constructed in the lower portion of the East Branch near the confluence with the West Branch Agricultural Ditch between the years 1941 through 1950, and then this pond was disconnected from the East Branch by 1963. This coldwater spring pond could provide important cold, deepwater habitat in the hottest summer periods and warm, deepwater habitat in the overwintering periods for brook trout and other fishes, amphibians, and reptiles, if a direct connection with Mason Creek could be restored between these habitats**.**

The Lower Mason Creek reach contains the highest quality habitat rating (good to excellent) compared to all the other reaches in the watershed for each of the habitat variables. Not surprisingly, this is also associated with the highest quality fishery observations and diversity in the watershed. This is also consistent with the highest quality in thalweg depth, instream cover, and diversity of substrates, which is characteristic of a well-balanced distribution of pool, riffle, and run habitats (see Maps II-14 and II-15). This reach contains the deepest and highest quality pool habitats within Mason Creek. About 50 percent of the pools had depths between 1.5 to 2.0 feet and 25 percent of the deepest pool habitats had depths ranging from about 2.0 to nearly 3.0 feet (see Figure II-33). However, none of these achieved a maximum depth of three feet, which is considered the minimum optimal pool depth for brook trout. As a general rule of thumb, depths of three to six feet are considered necessary for quality brook trout pool habitat.[117] The lack of optimal pool depth is likely a limiting factor for trout survival within Mason Creek, particularly during low flow conditions in late summer and throughout the winter. Although this reach does not have the potential to achieve desired pool depths, due to the availability of water, hydrological soils, and geomorphological conditions within this area, this reach is connected to North Lake, which can serve as an important deep water overwintering habitat.[118] Unfortunately, fish passage seems to be limited within this reach at

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[117]*(USFS 1994, Raleigh et al.1986).*

[118]*David P. Boucher, Maine Department of Inland Fisheries and Wildlife,* Seasonal Movements and Habitat Use of Brook Trout in the Magalloway River, Fishery Final Report Series No. 08-01, *January 2008, see website at https://www1.maine.gov/ifw/fishing/reports/fishery_division/2005/seasonalmovementandhabitatuseofbrooktrout.htm*

Koester Road and a private drive just downstream of this crossing (see "*Stream Crossings*" section below). Brook trout can pass downstream through these crossings, but neither brook trout nor any other fish species can pass back upstream through Koester Road. Any brook trout that pass downstream of these two road crossings would have good access to North Lake as an overwintering refuge, but would be permanently confined within the 0.5-mile-long lower section of Mason Creek. Therefore, brook trout would be unable to migrate upstream to spawn in the headwaters in spring or to feed in riffle habitats or seek cooler refuge upstream in late summer. These fish passage barriers are likely to be negatively impacting brook trout populations within Mason Creek.

Past channelization combined with limited riparian buffer protection have occurred to a much greater degree in Upper Mason Creek than in Lower Mason Creek, and the overall quality is reduced, particularly in regards to thalweg depth diversity and instream cover. This degradation is associated with the loss of the pool-riffle habitat structure, and is a reflection of the extensive channelization that occurred within this reach prior to 1941. Riffle habitats were completely removed, which likely limited the availability of production areas for aquatic bugs/food in Mason Creek. In addition, the number and extent of pool habitats was greatly reduced, and the remaining pool habitats rarely exceed two feet in depth. Streams can recover from past channelization, which is why the criterion of channelization age is included in the habitat quality rating (i.e., more years post channelization is associated with a higher quality score). However, research has shown that there are limits to the ability of streams to recover from past channelization, particularly in low gradient streams. For example, despite channelization that has occurred 78 or more years ago in this reach, it still contains much poorer habitat diversity in terms of instream cover, substrates, habitat types, and increased sediment deposition compared to the downstream reach that was not as channelized (see "*Streambank Erosion*" subsection for more details). However, despite this degradation, this reach continues to be associated with a consistent abundance of adult brook trout observations, at least just upstream of the CTH CW roadway, which is likely an artifact of the exceptional ground water quality and quantity discharge in this portion of the reach. As noted above, adequate pool depth and riffle habitats are critical for maintaining trout populations, so lack of these habitats is likely limiting the existing brook trout population within this reach. However, if this section of the stream was designed and constructed to its original, or near original, pre-1941 meandering channel conditions, it may have the potential to achieve desired pool depths of up to three feet in some areas. In addition, this section of stream has a great potential to increase the number and extent of riffle habitats to improve food production and to provide potential spawning habitats.

Similar to the East Branch tributary reach, the Trib-A reach also has been significantly modified due to channelization and contains areas were riparian buffer protection needs improvement. Given the higher slope of this reach combined with channelization, it is anticipated that streambank erosion may be an issue in this reach. However, SEWRPC staff could not gain access to this tributary through private properties to assess streambank stability or instream habitats further. This tributary has been identified to be consistently discharging into Mason Creek since at least 1837. The 1837 plat of survey notes indicated Trib-A to be over six times wider (13.2 feet) than the East Branch tributary (2.0 feet) and approximately the same width as the Upper Mason Creek reach as shown on Map II-12. This indicates that Trib-A has likely been sustained by fairly significant groundwater discharge that helps to support the coldwater brook trout fishery in Mason Creek. Hence, this tributary also may be supporting critical brook trout spawning or juvenile rearing habitats.

It is important to note that the lowest habitat scores in all cases were associated with the modified sections of streams that were highly channelized. Although the Upper Mason reach continues to recover from past channelization, it is clear that this channelized segment is limiting habitat quality for brook trout within Mason Creek and will not likely recover on its own without more intensive intervention. Hence, this channelized reach provides the greatest potential for instream habitat recovery within the Mason Creek watershed for brook trout. In addition, Mason Creek has a high potential for recovery for two key reasons. First, this riverine system contains good quality source populations of macroinvertebrate and brook trout fishery assemblages, primarily due to its high quality and quantity of groundwater discharge. Therefore, creation or rehabilitation of habitats is likely to lead to increased abundance and distribution of these key ecological indicators. Second, there are several opportunities to restore some of the most degraded reaches in this system to their original, or near original, channel configuration to restore sediment transport and floodplain connectivity, and to improve water quality and fisheries habitat (see Figure II-39). In addition, remeandering can also help restore hyporheic (i.e., under) flow, which occurs in the subsurface area beneath and alongside a streambed where there is mixing of shallow groundwater and surface water, particularly within riffle habitats. The flow dynamics and behavior in this zone are recognized to be important for surface water/groundwater interactions to improve water quality (reduce instream water temperatures and improve dissolved oxygen), potentially attenuate contaminants,[119] and promote fish spawning and egg development habitats. Therefore, returning this stream to its original or near original channel configuration and appropriately sized pool-riffle structure would restore instream habitat and floodplain connectivity and reduce streambed deposition, and it would also reinstate the connection of the surface water in this channel to the relict alluvium to restore hyporheic flows. However, it is important to note that the remeandering/reconstruction of the Upper reach of Mason Creek should not be conducted until the majority of the cropland erosion and streambed sediment loads within and adjacent to the West Branch Agricultural Ditch are addressed.

Trash and Debris

Although the accumulation of trash and debris is not part of the habitat scores as summarized above, these materials degrade the aesthetics of the stream system and can cause physical and/or chemical (i.e., toxic) damage to aquatic and terrestrial wildlife. Therefore, Commission staff recorded and mapped the significant trash and debris that was

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[119] *Justin E. Lawrence et. al., "Hyporheic Zone in Urban Streams: A Review and Opportunities for Enhancing Water Quality and Improving Aquatic Habitat by Active Management,"* Environmental Engineering Science, *Volume 30(8): 480-501, August 2013.*

encountered during the comprehensive survey (specific details in Appendix F, Maps F-1 through F-5). There was a very limited amount of trash or debris observed within Mason Creek and its tributaries.

Stream Crossings and Dams

Culverts tend to have a destabilizing influence on stream morphology and can create selective barriers to fish migration because swimming abilities vary substantially among species and size-classes of fish, affecting their ability to traverse the altered hydrologic regime within the culverts (see Figure II-43).[120] Fish of all ages require freedom of movement to fulfill needs for feeding, growth, and spawning. Such needs generally cannot be found in only one particular area of a stream system. These movements may be upstream or downstream and occur over an extended period of time, especially in regard to feeding. In addition, before winter freeze-up, fish tend to move downstream to deeper pools for overwintering. Fry and juvenile fish also require access up and down the stream system while seeking rearing habitat for feeding and protection from predators. The recognition that fish populations are often adversely affected by culverts has resulted in numerous designs and guidelines that have been developed to allow for better fish passage and to help ensure a healthy sustainable fisheries community.[121]

Brook trout, a highly sought gamefish species, has limited leaping and swimming abilities and is not expected to be able to traverse these structures, which is likely contributing to the impairment of this species throughout Mason Creek.[122] Given these limitations, brook trout are a good template species for structure design or modification for fish passage at critical low flow conditions. Higher flow conditions are also important to consider as part of road crossing design to accommodate for sediment transport and floodplain connectivity to the extent practicable (see Figure II-41).

Bridges and culverts can affect stream widths, water and sediment depths, velocities, and substrates. These structures also have the potential to pose physical and/or hydrologic barriers to fish and other aquatic organisms. Therefore, SEWRPC staff conducted an inventory of 18 structures on the mainstem of Mason Creek and two crossings on the East Branch of Mason Creek (see Map J-1 in Appendix J), describing structure condition and assigning a fish passage rating as summarized in Table J-1 and the photos in Figure J-1 in Appendix J. The majority

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[120]*Stream Enhancement Research Committee, "Stream Enhancement Guide," Province of British of Columbia and the British Columbia Ministry of Environment, Vancouver, 1980.; and, Thomas M. Slawski and Timothy J. Ehlinger, "Fish Habitat Improvement in Box Culverts: Management in the Dark?"* North American Journal of Fisheries Management, *Volume 18, 1998, pages 676-685.*

[121]*B.G. Dane,* A Review and Resolution of Fish Passage Problems at Culvert Sites in British Columbia, *Canada Fisheries and Marine Sciences Technical Report 810, 1978. Chris Katopodis, "Introduction to Fishway Design," Freshwater Institute Central and Arctic Region Department of Fisheries and Oceans, January, 1992.*

[122]*Luther Aadland, Minnesota DNR,* Reconnecting Rivers: Natural Channel Design in Dam Removal and Fish Passage, *January 2010.*

of the structures were identified to be passable, but two structures were considered complete barriers and four were considered partial barriers to passage.

Structure No. 7 at River Mile (RM) 0.41 at a private drive in Lower Mason Creek was rated as a complete barrier to fish passage (Figure II-40). This structure is considered a complete barrier during low flow conditions, because the outlet is perched 0.6 feet above the downstream water surface. Even if fish could jump into the pipe, which is highly unlikely, water depths within the pipe are too low for passage. This elliptical pipe also is considered a barrier to fish passage at higher flows, because water velocities are likely too fast for fishes to through this narrow pipe opening. This is evidenced by a scoured pool depth of 2.7 feet just downstream of the outlet. This pipe has a width of less than five feet, which is much too narrow, because bankfull widths in this area range from about 12 to 15 feet. This structure seems to show signs of instability, because culvert sections are pulling apart underneath the driveway. Based upon review of historical aerial photographs, this structure was built sometime between 1970 and 1980, which means that it is between 35 and 45 years old and may be reaching its life expectancy. Therefore, this structure is a high priority to improve fish passage for brook trout.

Structure No. 9 at RM 0.50 at Koester Road in Lower Mason Creek was also rated as a complete barrier to fish passage (Figure II-40). This structure is considered a complete barrier during low flow conditions, because there are excessive amounts of cobble and boulder substrates blocking flows at the inlet (acting like a dam and impounding water upstream) and flows are split among three separate pipes. Consequently, water depths are too low to provide adequate fish passage. At high flows, water depths are likely to be too low and water velocities too excessive to enable fish passage. The condition of these three corrugated metal pipes is poor, with multiple locations where holes have rusted through. Based upon review of historical aerial photographs, this structure was built sometime between 1970 and 1980, which means that it is between 35 and 45 years old and has apparently exceeded its life expectancy. Therefore, this structure is a high priority to improve fish passage for brook trout.

Structure No. 19 at RM 0.05 on the East Branch of Mason Creek at a private drive was rated as a partial barrier to fish passage (see Appendix J and Figure II-40). This structure is a ford that is located approximately 264 feet upstream from the confluence with Upper Mason Creek (see Map J-1 in Appendix J). A ford is a shallow place with good footing where the Creek may be crossed by wading, or inside a vehicle or tractor getting its wheels wet. This structure is considered a partial barrier during low flow conditions, because water depth and width is limited, which is likely limiting brook trout passage. A wood plank combined with additional stone was placed to provide a trail crossing on the downstream edge of the ford, creating the narrow water width and shallow depth and causing water to back up into the ford. In addition, one seven-inch diameter pipe has been installed underneath the plank crossing as shown in Figure II-40 and two additional seven-inch diameter pipes have been installed underneath the entire length of the roadway to reduce water depths over the ford. These pipes, combined with the stone in the downstream portion of the ford which impounds water and with a poorly-graded roadway, have created excessive water widths at the ford as shown in Figure II-40. These impounded conditions create slack water exposing this portion of the stream to increased warming, which can degrade water quality.

There are three additional structures that are considered to be potential barriers limiting fish passage under low-flow conditions. These include Structure No. 12 at RM 1.26 in Lower Mason Creek and Structures No. 15 at RM 2.51 and No. 16 at RM 3.28 in Upper Mason Creek (see Appendix J):

- Structure No. 12 is a private road crossing that consists of one four-foot-diameter round concrete culvert that is undersized for fish passage and that is creating water velocities that prohibit the ability of many species of fish to pass through at baseflow conditions.

- Structure No. 15 at CTH CW consists of a 15-foot-wide and 3.5-foot-high corrugated metal pipe arch culvert. Roadside fencing has fallen into the stream on the downstream side of the culvert and is accumulating debris and likely impeding fish passage.

- Structure No. 16 consists of two abandoned private culverts, one a 4.2-foot-wide by 3.0-foot-high metal elliptical culvert and one 1.5-foot-diameter circular metal culvert, both of which are collecting debris and likely impeding fish passage.

Although there are only six structures considered to be either complete or partial barriers to fish passage, their combined impact on the fish communities could potentially be significant. Each of these structures, particularly the complete barriers (Structures No. 7 and 9) within Lower Mason Creek, significantly limit the ability of fish and other organisms to move between North Lake and Mason Creek and separate the deeper water habitats in the downstream reaches from shallower habitats in the upstream reaches of Mason Creek.[123]

Beaver Dams
There was no beaver activity in terms of beaver chew, felled trees, dams, or huts in the Mason Creek watershed observed during the time of this inventory. Beaver dams have the potential to limit fish passage, particularly by brook trout trying to migrate into upstream tributaries to lay their eggs. On the other hand, it is also known that beaver dams, and the wetlands that they create, add to the diversity of both instream habitat and the riparian corridor buffers for multiple wildlife species. Therefore, it is important to continue to monitor for beaver activity and take action where appropriate, but also to recognize that that there are important tradeoffs to be considered between fish

[123]*M. W. Diebel, M. Fedora, S. Cogswell, and J. R. O'Hanley, "Effects of Road Crossings on Habitat Connectivity for Stream-Resident Fish, River Research and Applications", Published online in Wiley Online Library (wileyonlinelibrary.com) DOI: 10.1002/rra.2822, Copyright © John Wiley & Sons, Ltd., 2014.*

passage and natural wetland creation. It is important to keep in mind that beavers are an important part of the overall native wildlife within this stream system and their associated dams are a low cost way to establish vital wetland habitat.

Habitat Quality Summary

In summary, the Lower Mason Creek reach contains the highest quality habitat (good to excellent) and the West Branch Agricultural Ditch contains the poorest habitat quality rating compared to the other reaches in the watershed. Both the East Branch and Upper Mason Creek reaches contain habitat quality that is intermediate compared to the other reaches in the watershed. The habitat impairments on this stream system are mostly due to the combination of channelization, limited riparian buffers, and fish passage barriers. This degradation is associated with the loss of the pool-riffle habitat structure and is a reflection of the extensive channelization that has occurred within this reach prior to 1941. This system has great potential for recovery and there are opportunities to improve habitat quantity and quality for brook trout (particularly in Upper Mason Creek) and the ability of fish to travel within Mason Creek and between Mason Creek and North Lake by addressing fish passage impediments (particularly in the Lower Mason Creek). However, habitat and associated water quality improvements within Mason Creek for brook trout and the associated coldwater fishery cannot be accomplished without addressing the nonpoint source pollutant loads and streambed sediment loads from the West Branch Agricultural Ditch.

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SEWRPC Community Assistance Planning Report No. 321

MASON CREEK WATERSHED PROTECTION PLAN

Chapter II

INVENTORY FINDINGS

TABLES

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Table II-1

APPLICABLE WATER QUALITY CRITERIA FOR STREAMS AND LAKES IN SOUTHEASTERN WISCONSIN

Water Quality Parameter	Designated Use Category[a]						Source
	Coldwater Community	Warmwater Fish and Aquatic Life	Limited Forage Fish Community (variance category)	Special Variance Category A[b]	Special Variance Category B[c]	Limited Aquatic Life Community (variance category)	
Temperature (°F)	See Table II-2					86.0 °F	NR 102 Subchapter II
Dissolved Oxygen (mg/L)	6.0 minimum 7.0 minimum during spawning	5.0 minimum	3.0 minimum	2.0 minimum	2.0 minimum	1.0 minimum	NR 102.04(4) NR 104.04(3) NR 102.06(2)
pH Range (standard units)	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	NR 102.04(4)[d]
Fecal Coliform Bacteria (MFFCC)							NR 102.04(5) NR104.06(2)
Geometric Mean	200	200	200	1,000	1,000	200	
Single Sample Maximum	400	400	400	2,000	- -	400	
Total Phosphorus (mg/l)							NR 102.06(3) NR 102.06(4) NR 102.06(5) NR 102.06(6)
Designated Streams[e]	0.100	0.100	0.100	0.100	0.100	0.100	
Other Streams	0.075	0.075	0.075	0.075	0.075	- -	
Stratified Reservoirs	0.030	0.030	0.030	0.030	0.030	- -	
Unstratified Reservoirs	0.040	0.040	0.040	0.040	0.040	- -	
Stratified Two-story Fishery Lakes	0.015	0.015	0.015	0.015	0.015	- -	
Stratified Drainage Lakes	0.030	0.030	0.030	0.030	0.030	- -	
Unstratified Drainage Lakes	0.040	0.040	0.040	0.040	0.040	- -	
Stratified Seepage Lakes	0.020	0.020	0.020	0.020	0.020	- -	
Unstratified Seepage Lakes	0.040	0.040	0.040	0.040	0.040	- -	
Chloride (mg/l)							NR 105.05(2) NR 105.06(5)
Acute Toxicity[f]	757	757	757	757	757	757	
Chronic Toxicity[g]	395	395	395	395	395	395	

[a] *NR 102.04(1) All surface waters shall meet the following conditions at all times and under all flow conditions: substances that will cause objectionable deposits on the shore or in the bed of a body of water, floating or submerged debris, oil, scum, or other material, and materials producing color, odor, taste or unsightliness shall not be present in such amounts as to interfere with public rights in waters of the State. Substances in concentrations which are toxic or harmful to humans shall not be present in amount found to be of public health significance, nor shall substances be present in amounts which are acutely harmful to animal, plant, or aquatic life.*

[b] *As set forth in Chapter NR 104.06(2)(a) of the* Wisconsin Administrative Code.

[c] *As set forth in Chapter NR 104.06(2)(b) of the* Wisconsin Administrative Code.

[d] *The pH shall be within the stated range with no change greater than 0.5 unit outside the estimated natural seasonal maximum and minimum.*

[e] *Designated in Chapter NR 102.06(3)(a) of the* Wisconsin Administrative Code. *There are no designated streams in the Jackson Creek watershed.*

[f] *The acute toxicity criterion is the maximum daily concentration of a substance which ensures adequate protection of sensitive species of aquatic life from the acute toxicity of that substance and will adequately protect the designated fish and aquatic life use of the surface water if not exceeded more than once every three years.*

[g] *The chronic toxicity criterion is the maximum four-day concentration of a substance which ensures adequate protection of sensitive species of aquatic life from the chronic toxicity of that substance and will adequately protect the designated fish and aquatic life use of the surface water if not exceeded more than once every three years.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table II-2

AMBIENT TEMPERATURES AND WATER QUALITY CRITERIA FOR TEMPERATURE FOR NONSPECIFIC STREAMS AND LAKES IN SOUTHERN WISCONSIN[a]

Month	Cold Water Communities			Large Warmwater Communities[b]			Small Warmwater Communities[c]			Limited Forage Fish Communities[d]			Inland Lakes and Impoundments[e]		
	Ta	**SL**	**A**	**Ta**	**SL**	**A**	**Ta**	**SL**	**A**	**Ta**	**SL**	**A**	**Ta**	**SL**	**A**
January	35	47	68	33	49	76	33	49	76	37	54	78	35	49	77
February	36	47	68	33	50	76	34	50	76	39	54	79	39	52	78
March	39	51	69	36	52	76	38	52	77	43	57	80	41	55	78
April	47	57	70	46	55	79	48	55	79	50	63	81	49	60	80
May	56	63	72	60	65	82	58	65	82	59	70	84	58	68	82
June	62	67	72	71	75	85	66	76	84	64	77	85	70	75	86
July	64	67	73	75	80	86	69	81	85	69	81	86	77	80	87
August	63	65	73	74	79	86	67	81	84	68	79	86	76	80	87
September	57	60	72	65	72	84	60	73	82	63	73	85	67	73	85
October	49	53	70	52	61	80	50	61	80	55	63	83	54	61	81
November	41	48	69	39	50	77	40	49	77	46	54	80	42	50	78
December	37	47	69	33	49	76	35	49	76	40	54	79	35	49	77

NOTE: Acronyms for temperature criteria categories include; **Ta**-ambient temperature, **SL**-sublethal temperature, and **A**-acute temperature. The ambient temperature, sublethal water quality criterion, and acute water quality criterion specified for any calendar month shall be applied simultaneously to establish the protection needed for each identified fish and other aquatic life use. The sublethal criteria are to be applied as the mean daily maximum temperature over a calendar week. The acute criteria are to be applied as the daily maximum temperature. The ambient temperature is used to calculate the corresponding acute and sublethal criterial and for determining effluent limitations in discharge permits under the Wisconsin Pollutant Discharge Elimination System.

[a]*As set forth in Section NR 102.25 of the* Wisconsin Administrative Code.

[b]*Waters with a fish and aquatic life use designation of "warmwater sportfish community" or "warmwater forage fish community" and unidirectional 7Q10 flows greater than or equal to 200 cubic feet per second. The 7Q10 flow is the seven-day consecutive low flow with a 10 percent annual probability of occurrence (10-year recurrence interval).*

[c]*Waters with a fish and aquatic life use designation of "warmwater sportfish community" or "warmwater forage fish community" and unidirectional 7Q10 flows less than 200 cubic feet per second. The 7Q10 flow is the seven-day consecutive low flow with a 10 percent annual probability of occurrence (10-year recurrence interval).*

[d]*Waters with a fish and aquatic life use designation of "limited forage fish community."*

[e]*Values are applicable for those lakes and impoundments south of STH 10.*

Source: Wisconsin Department of Natural Resources.

Table II-3

GUIDELINES FOR WATER QUALITY CONSTITUENTS IN SOUTHEASTERN WISCONSIN FOR WHICH WATER QUALITY CRITERIA HAVE NOT BEEN PROMULGATED

Water Quality Parameter	Stream Guideline	Lake and Reservoir Guideline	Category	Source
Total Suspended Solids (mg/l)	26	- -	TMDL target concentration	Rock River TMDL[a]
Nitrogen				
Total Nitrogen (mg/l)	0.65[b]	0.66	Streams: reference value Lakes: recommended criterion	USGS/WDNR[c] USEPA[d]
Nitrate plus Nitrite (mg/l)	0.94	0.04	Reference value	USEPA[d,e]
Total Kjeldahl Nitrogen (mg/l)	0.65	0.54	Reference value	USEPA[d,e]
Chlorophyll-*a* (μg/l)	1.50[f]	2.63	Recommended criteria	USEPA[d,e]
Transparency tube (cm)[g]	> 115	- -	Reference value	USGS/WDNR[c]
Secchi Depth (m)	- -	3.33[h]	Recommended criterion	USEPA[d]
Turbidity (ntu)	1.70[i]	- -	Recommended criterion	USEPA[e]

[a]*U.S. Environmental Protection Agency and Wisconsin Department of Natural Resources,* Total Maximum Daily Loads for Total Phosphorus and Total Suspended Solids in the Rock River Basin: Columbia, Dane, Dodge, Fond du Lac, Green, Green Lake, Jefferson, Rock, Walworth, Washington, and Waukesha Counties, Wisconsin, *July 2011.*

[b]*This is a reference value developed by USGS and WDNR for streams for this portion of Wisconsin. It should be noted that USEPA has developed a similar reference value for the southern Wisconsin till plains area of 1.30 mg/l and a recommended criterion for Nutrient Ecoregion VII (mostly glaciated dairy region) of 0.54 mg/l.*

[c]*D.M. Robertson, D J. Graczyk, L. Wang, G. LaLiberte, and R. Bannerman,* Nutrient Concentrations and Their Relations to the Biotic Integrity of Wadeable Streams in Wisconsin, *U.S. Geological Survey Professional Paper No. 1722, 2006.*

[d]*U.S. Environmental Protection Agency,* Ambient Water Quality Criteria Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria: Lakes and Reservoirs in Nutrient Ecoregion VII, *EPA 822-B-00-009, December 2000.*

[e]*U.S. Environmental Protection Agency,* Ambient Water Quality Criteria Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria: Rivers and Streams in Nutrient Ecoregion VII, *EPA 822-B-00-018, December 2000.*

[f]*This is consistent with the finding by USGS and WDNR of reference values for chlorophyll-*a *in wadeable streams in Wisconsin between 1.20 and 1.70* µ*g/l. It should be noted that the guideline and reference values are based upon fluorometric analysis of chlorophyll-*a *concentrations. Other values may apply for chlorophyll-*a *concentrations that were determined using other techniques.*

[g]*This is based on the use of a minimum transparency tube length of 120 cm.*

[h]*For the southern Wisconsin till plains area, the USEPA found a reference value for secchi depth of 3.19 m.*

[i]*It should be noted that the guideline and recommended criterion are based upon nephelometric analysis of turbidity. Other values may apply for turbidity determined using other techniques.*

Source: U.S. Environmental Protection Agency, U.S. Geological Survey, Wisconsin Department of Natural Resources, and SEWRPC.

Table II-4

TMDL REACH 24 (MASON CREEK WATERSHED) BASELINE MEDIAN ANNUAL TOTAL PHOSPHORUS (TP) AND TOTAL SUSPENDED SOLIDS (TSS) LOADS, ANNUAL LOAD ALLOCATIONS, AND TARGET LOAD REDUCTIONS FROM THE ROCK RIVER TMDL REPORT: 2011

Pollutant	Baseline Median Annual Nonpoint Load[a]	Annual Load Allocation[b]	Target Annual Nonpoint Load Reduction	Percent Reduction
Total Phosphorus	5,821 (lbs)	466 (lbs)	5,355 (lbs)	92
Total Suspended Solids	952 (tons)	69 (tons)	883 (tons)	93

[a]These median values were calculated using the annual modeled nonpoint source loads for TP and TSS from 1989 to 1998 that were included in Appendix L and Appendix M of the 2011 Rock River TMDL report.

[b]Due to an updated watershed boundary delineation by SEWRPC staff, it was determined that the nine acre portion of the watershed within the Town of Oconomowoc does not discharge into the Mason Creek watershed. Hence, the annual load allocations do not include the 9.9 lbs/year of TP and 1.16 tons/year of TSS from the Town of Oconomowoc MS4 portion of the watershed.

Source: USEPA, WDNR, and SEWRPC.

Table II-5

DAILY TOTAL PHOSPHORUS ALLOCATIONS FOR ROCK RIVER WATERSHED SUB-BASIN 24 FROM THE ROCK RIVER WATERSHED TMDL

Allocation Component	Daily Total Phosphorus Load (pounds per day)												Annual Load Allocation (pounds per year)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Wasteload Allocation													
General Permit Sources	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Municipal Separate Storm Sewer Systems (MS4)	0.49	0.56	0.41	0.31	0.32	0.47	0.49	0.46	0.37	0.32	0.33	0.36	148.23
Waste Water Treatment Facility (WWTF)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subtotal	0.49	0.56	0.41	0.31	0.32	0.47	0.49	0.46	0.37	0.32	0.33	0.36	148.23
Load Allocation													
Background	0.00	0.01	0.02	0.03	0.03	0.04	0.03	0.05	0.03	0.04	0.01	0.01	9.16
Ag/Non-Permitted Urban	0.33	0.79	1.13	1.63	1.67	1.47	0.90	0.61	0.52	0.51	0.34	0.27	308.94
Subtotal	0.33	0.80	1.15	1.66	1.70	1.51	0.93	0.66	0.55	0.55	0.35	0.28	318.10
Total Loading Capacity	0.82	1.36	1.56	1.97	2.02	1.98	1.42	1.12	0.92	0.87	0.68	0.64	466.33

Note: The MS4 allocation component only includes pollutant loads associated with the Town of Merton, because it was established that the nine acres of the Town of Oconomowoc MS4 does not discharge into Mason Creek. The Rock River TMDL study included the nine acres in the Town of Oconomowoc in the Mason Creek watershed.

Source: U.S Environmental Protection Agency and Wisconsin Department of Natural Resources.

Table II-6

DAILY TOTAL SUSPENDED SOLIDS ALLOCATIONS FOR ROCK RIVER WATERSHED SUB-BASIN 24 FROM THE ROCK RIVER WATERSHED TMDL

Allocation Component	Daily Total Suspended Solids Load (tons per day)												Annual Load Allocation (tons per year)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Wasteload Allocation													
General Permit Sources	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Municipal Separate Storm Sewer Systems (MS4)	0.09	0.09	0.04	0.03	0.03	0.05	0.04	0.04	0.04	0.03	0.03	0.07	17.30
Waste Water Treatment Facility (WWTF)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subtotal	0.09	0.09	0.04	0.03	0.03	0.05	0.04	0.04	0.04	0.03	0.03	0.07	17.30
Load Allocation													
Background	0.01	0.02	0.01	0.03	0.03	0.02	0.01	0.01	0.01	0.02	0.01	0.01	5.76
Ag/Non-Permitted Urban	0.14	0.26	0.18	0.19	0.19	0.16	0.08	0.06	0.06	0.06	0.05	0.10	46.19
Subtotal	0.15	0.28	0.19	0.22	0.22	0.18	0.09	0.07	0.07	0.08	0.06	0.11	51.95
Total Loading Capacity	0.24	0.37	0.23	0.25	0.25	0.23	0.13	0.11	0.11	0.11	0.09	0.18	69.25

Note: The MS4 allocation component only includes pollutant loads associated with the Town of Merton, because it was established that the nine acres of the Town of Oconomowoc MS4 does not discharge into Mason Creek. The Rock River TMDL study included the nine acres in the Town of Oconomowoc in the Mason Creek watershed.

Source: U.S. Environmental Protection Agency and Wisconsin Department of Natural Resources.

Table II-7

WATER QUALITY SAMPLING STATIONS WITHIN THE MASON CREEK WATERSHED: 2009-2014

Stream	Sub-Basin	River Mile (see Map II-4)[a]	Location	Source of Data	Site Identification	Period of Record
East Branch headwaters	MC-2	0.05	W. Shore Drive at farm field road	UW-Milwaukee	UWM-6	9/15/2011 – 8/17/2012
		0.01	22 feet upstream from Upper Mason Creek	SEWRPC	SEWRPC-G	5/31/2013 – 8/11/2014
West Branch drainage ditch	MC-2	0.20	Private land (Morris Farm)	UW-Milwaukee	UWM-7	6/8/2012
		0.01	22 feet upstream from Upper Mason Creek	SEWRPC	SEWRPC-E	5/31/2013 – 8/11/2014
Upper Mason Creek	MC-3	3.42	Mason Creek downstream of East Branch	SEWRPC	SEWRPC-D	5/31/2013 – 8/11/2014
		3.30	Concrete Bridge at W. Shore Drive	UW-Milwaukee	UWM-5	9/15/2011 – 8/17/2012
		2.50	CTH CW	City of Oconomowoc	Ocon-2	4/30/2014 – 8/12/2014
				SEWRPC	SEWRPC-C	5/31/2013 – 8/11/2014
				UW-Milwaukee	UWM-4	9/15/2011 – 8/17/2012
				WDNR	10016883	4/7/2014
		2.10	W. Shore Drive (south of CTH CW)	UW-Milwaukee	UWM-3	9/15/2011 – 8/17/2012
Lower Mason Creek	MC-4	0.50	Koester Road	SEWRPC	SEWRPC-B	5/31/2013 – 8/11/2014
				UW-Milwaukee	UWM-2	9/15/2011 – 8/17/2012
		0.30	Petersen Road	Water Action Volunteers	WAV-2	4/17/2009 – 7/11/2014
				WDNR	10038441	5/7/2012 – 9/9/2012
		0.04	Northwoods Drive	City of Oconomowoc	Ocon-1	4/30/2014 – 8/12/2014
				SEWRPC	SEWRPC-A	5/31/2013 – 8/11/2014
				UW-Milwaukee	UWM-1	9/15/2011 – 8/17/2012
				Water Action Volunteers	WAV-1	7/28/2011 – 8/13/2014
Trib-A	MC-3	0.10	CTH CW at Farm	UW-Milwaukee	UWM-8	9/15/2011 – 8/17/2012
Private Pond	MC-2	- -	Pond	SEWRPC	SEWRPC-F	5/31/2013 – 8/11/2014

[a]For sites on Mason Creek, the river mile is the distance upstream from the confluence with North Lake. For tributaries to Mason Creek, the river mile is the distance upstream from the confluence with Mason Creek.

Source: SEWRPC.

Table II-8

WATER QUALITY CHARACTERISTICS OF STREAMS IN THE MASON CREEK WATERSHED DURING THE YEARS 2009-2014

			Percent of Samples Meeting Water Quality Criteria					
				Temperature		Chloride		
Stream Reach (see Map II-4)	Stream Length (miles)	Codified Water Use Objective[a]	Dissolved Oxygen[b]	Sublethal[b]	Acute[b]	Chronic[b]	Acute[b]	Total Phosphorus[b]
West Branch Agricultural Ditch[c]	2.26	FAL	0.0 (1)	75.5 (53)	97.5 (438)	- -	- -	0.0 (1)
East Branch headwaters	1.35	FAL	100 (6)	98.4 (62)	100 (438)	- -	- -	16.7 (6)
Upper Mason Creek (from confluence of the East and West Branches to confluence with Trib-A)	1.73	COLD	100 (19)	91.9 (124)	100 (876)	- -	- -	21.7 (23)
Lower Mason Creek (from the confluence with Trib-A to North Lake)	1.72	COLD	98.6 (73)	87.9 (124)	100 (876)	100 (5)	100 (5)	37.5 (16)
Private Pond(Unrein Property)	- -	FAL	- -	100.0 (62)	100.0 (438)	- -	- -	- -
Trib-A	0.87	FAL	100 (6)	- -	- -	- -	- -	0.0 (6)

Note: Since there were no Fecal Coliform Bacteria or Escherichia coli data to asses water quality for these constituents, they were not reported in this table.

[a]*COLD indicates coldwater fish and aquatic life community, FAL indicates warmwater fish and aquatic life.*

[b]*Number of samples is indicated in parentheses.*

[c]*As shown on Map II-2 the lower 0.66 miles of the West Branch drainage ditch from the Washington-Waukesha County Line to the confluence with the East Branch of Mason Creek is designated as COLD, but this agricultural ditch has never met the coldwater designation and was combined with the FAL classification for this reach.*

Source: SEWRPC.

Table II-9

FISH SPECIES COMPOSITION BY PHYSIOLOGICAL TOLERANCE AND REACH IN THE MASON CREEK WATERSHED: 1952-2014

Species According to Their Relative Tolerance to Temperature	Stream Reach (see Map II-5)																	
		Lower Mason Creek										Upper Mason Creek						
	North Lake	Northwoods Drive (RM 0.04)	Peterson Road (RM 0.25)					Koester Road (RM 0.50)			Westshore Drive (RM 2.12)	CTH CW (RM 2.51)						Private Farm (RM 3.32)
	1952-2012	1975	1981	1994	1995	2006[a]	2014	1975	2003	2008	2014	2008	2010	2011	2012	2013	2014	2014
Coldwater																		
Intolerant																		
Brook Trout	X	X	- -	X	X	X	- -	- -	- -	X	- -	X	X	X	X	X	X	X
Intermediate																		
Brown Trout	- -	- -	- -	- -	- -	- -	- -	- -	- -	X	X	- -	- -	- -	- -	- -	- -	- -
Transitional																		
Sensitive																		
Northern Pike	X	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Intermediate																		
Johnny Darter	X	- -	X	- -	- -	X	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Pearl Dace	- -	- -	- -	- -	- -	- -	- -	- -	X	- -	- -	- -	- -	- -	X	- -	- -	X
Walleye	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Yellow Perch	X	X	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Tolerant																		
Brook Stickleback	- -	- -	- -	- -	- -	- -	- -	- -	- -	X	X	X	- -	- -	- -	- -	X	X
Central Mudminnow	- -	- -	- -	- -	X	X	X	X	X	X	X	X	X	- -	X	- -	X	X
Creek Chub	X	X	X	X	X	X	X	X	X	X	X	- -	- -	X	- -	- -	- -	X
White Sucker	X	X	X	X	X	X	X	X	X	X	- -	- -	- -	- -	- -	- -	- -	- -
Warmwater																		
Intolerant																		
Slender Madtom[b]	- -	- -	- -	- -	- -	- -	- -	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Sensitive																		
Rainbow Darter	X	- -	X	X	- -	X	X	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Rock Bass	X	X	X	- -	- -	X	X	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Smallmouth Bass	X	- -	X	- -	- -	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Intermediate																		
Black Crappie	X	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Bluegill	X	X	- -	- -	- -	X	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Bowfin	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Brook Silverside	X	- -	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Brown Bullhead	X	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Central Stoneroller	- -	- -	X	- -	- -	- -	- -	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Common Shiner	X	X	X	X	X	- -	- -	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Emerald Shiner	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Grass Pickerel	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Largescale Stoneroller	- -	- -	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Logperch	- -	- -	- -	- -	- -	- -	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Fantail Darter	- -	- -	- -	- -	- -	- -	- -	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Hornyhead Chub	- -	- -	X	X	X	- -	X	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -

Species According to Their Relative Tolerance to Temperature	Stream Reach (see Map II-5)																	
	Lower Mason Creek										Upper Mason Creek							
	North Lake	Northwoods Drive (RM 0.04)	Peterson Road (RM 0.25)					Koester Road (RM 0.50)			Westshore Drive (RM 2.12)	CTH CW (RM 2.51)						Private Farm (RM 3.32)
	1952-2012	1975	1981	1994	1995	2006[a]	2014	1975	2003	2008	2014	2008	2010	2011	2012	2013	2014	2014
Lake Chubsucker[c]	X	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Largemouth Bass......	X	X	X	- -	- -	X	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Warmwater (continued)																		
Intermediate (continued)																		
Mimic Shiner	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Pumpkinseed	X	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Spotfin Shiner	- -	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Stonecat....................	- -	- -	- -	- -	- -	- -	- -	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
White Bass................	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Tolerant																		
Black Bullhead	X	X	- -	- -	- -	- -	X	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Bluntnose Minnow.....	X	- -	X	- -	- -	X	- -	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Common Carp...........	X	X	X	- -	- -	- -	- -	- -	- -	- -	X	- -	- -	- -	- -	- -	- -	- -
Fathead Minnow	- -	- -	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Green Sunfish	X	X	X	- -	- -	- -	X	- -	X	- -	- -	- -	- -	- -	- -	- -	- -	- -
Yellow Bullhead	X	X	- -	- -	- -	- -	- -	X	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Total Number of Species	28	18	17	6	6	11	12	14	5	6	5	3	2	2	3	1	3	5
Cool-Cold Transition IBI Qualitative Score	- -	- -	Excellent	- -	- -	Excellent	Excellent	Excellent	Fair	Excellent	Good	Good	Good	Good	Good	Good	Good	Good
Coldwater IBI Qualitative Score	- -	- -	Poor	- -	- -	Fair	Poor	Fair	Very Poor	Fair	Fair	Excellent	Good	Excellent	Excellent	Excellent	Good	Good

[a] *Sampling site includes 0.25 miles of Mason Creek from Peterson Road to Koester Road.*

[b] *Designated endangered species.*

[c] *Designated species of special concern.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table II-10

APPROXIMATE TIMING OF THE FOUR MAJOR LIFE HISTORY STAGES FOR BROOK TROUT

Life Stage	Fall			Winter			Spring			Summer		
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Spawning Period												
Egg Incubation Period												
Summer Rearing												
Winter Rearing												

Note: Variation and overlap in timing among stages is due to variations in habitats occupied by this species.

Source: Adapted from Pauline Adams, Christopher James, and Clay Speas, Brook trout (Salvelinus fontinalis) Species and Conservation Assessment, Prepared for the Grand Mesa, Uncompahgre, and Gunnison National Forests, March 2008.

Table II-11

WATER QUALITY RATINGS USING MACROINVERTEBRATE INDICES AMONG SITES WITHIN MASON CREEK: 1979-2014

Parameters	Stream Sites (see Map II-5)								
	Lower Mason Creek			Upper Mason Creek					
	Peterson Road (RM 0.25)	Koester Road (RM 0.50)		Westshore Drive (RM 2.12)	CTH CW (RM 2.51)				Private Farm (RM 3.32)
	2014	1995	2003	2014	5/12/1979	1979	1995	2014	2014
HBI (Hilsenhoff Biotic Index)	Very Good (4.37)	Good (4.99)	Good (5.38)	Very Good (4.16)	Good (4.82)	Good (4.21)	Good (4.53)	Good (5.23)	Good (4.69)
FBI (Family-Level Biotic Index)	Good (4.53)	Very Good (4.25)	Fair (5.26)	Very Good (4.17)	Good (4.66)	Very Good (3.85)	Good (4.39)	Fair (5.35)	Good (4.55)
IBI (Index of Biotic Integrity)	Fair (4.16)	Fair (4.07)	Fair (3.73)	Fair (3.99)	Fair (4.22)	Fair (4.82)	Fair (5.04)	Fair (4.85)	Fair (4.01)
HBI Max 10	Very Good (4.33)	Good (5.03)	Good (4.73)	Good (4.73)	Good (4.79)	Very Good (4.28)	Good (4.84)	Good (5.04)	Good (5.10)
Percent EPT (Ephemeroptera, Plecoptera, and Trichoptera)-Individuals	34	66	27	5	36	65	33	20	52
Percent EPT-Generas	30	37	22	23	38	39	27	29	33
Species Richness	22	20	18	16	16	19	23	27	22
Genera Richness	21	19	18	16	16	18	22	27	20

Note: Unless otherwise noted all samples were collected in the fall season.

Source: University of Wisconsin-Stevens Point, Wisconsin Department of Natural Resources, and SEWRPC.

Table II-12

EFFECT OF BUFFER WIDTH ON CONTAMINANT REMOVAL

Buffer Width Categories (feet)	Contaminant Removal (percent)[a]				
	Sediment	Total Suspended Sediment	Nitrogen	Phosphorus	Nitrate-Nitrogen
1.5 to 25					
Mean	75	66	55	48	27
Range	37-91	31-87	0-95	2-99	0-68
Number of Studies	7	4	7	10	5
25 to 50					
Mean	78	65	48	49	23
Range	- -	27-95	7-96	6-99	4-46
Number of Studies	1	6	10	10	4
50 to 75					
Mean	51	- -	79	49	60
Range	45-90	- -	62-97	0-99	- -
Number of Studies	5	- -	2	2	1
Greater than 75					
Mean	89	73	80	75	62
Range	55-99	23-97	31-99	29-99	- -
Number of Studies	6	9	8	7	1

[a]*The percent contaminant reductions in this table are limited to surface runoff concentrations.*

Source: University of Rhode Island Sea Grant Program.

Table II-13

STREAM EROSION LATERAL RECESSION RATE DESCRIPTIONS

Lateral Recession Rate (feet per year)	Category	Description
0.01-0.05	Slight	Some bare bank but active erosion not readily apparent. Some rills but no vegetative overhang. No exposed tree roots
0.06-0.2	Moderate	Bank is predominantly bare with some rills and vegetative overhang. Some exposed tree roots but no slumps or slips
0.3-0.5	Severe	Bank is bare with rills and severe vegetative overhang. Many exposed tree roots and some fallen trees and slumps or slips. Some changes in cultural features such as fence corners missing and realignment of roads or trails. Channel cross section becomes U-shaped as opposed to V-shaped
0.5+	Very Severe	Bank is bare with gullies and severe vegetative overhang. Many fallen trees, drains and culverts eroding out and changes in cultural features as above. Massive slips or washouts common. Channel cross section is U-shaped and stream course may be meandering

Source: Natural Resources Conservation Service.

Table II-14

PHYSICAL CHARACTERISTICS OF STREAM REACHES WITHIN THE MASON CREEK WATERSHED: PRE-1941 VERSUS 2010

Reaches (see Map II-1)	Reach Length (miles)		Sinuosity		2010		
	PRE-1941	2010	PRE-1941	2010	Minimum Elevation (feet above NGVD29)	Maximum Elevation (feet above NGVD29)	Slope (percent)
Upper Mason Creek	2.22	1.73	1.39	1.03	936	944	0.08
Lower Mason Creek	1.87	1.72	1.43	1.27	898	936	0.45
Tributaries							
East Branch headwaters	0.77[a]	1.35	1.30[a]	1.06	946	956	0.19
West Branch Agricultural Ditch	2.22	2.26	1.01	1.03	944	960	0.13
Trib-A	--	0.87	--	1.04	936	962	0.56

NOTE: The differences in reach lengths between years were due to limitations in the ability to discern a stream channel on the historical aerial maps and/or channel modification.

[a]Since there were no other sources of data, these were estimated from the 1837 platted survey and recorded notes.

Source: SEWRPC.

Table II-15

ESTIMATED SURFACE WATER VOLUME VERSUS ORGANIC MUCK AND SILT STREAMBED SEDIMENT VOLUME AMONG THE WEST BRANCH AGRICULTURAL DITCH, UPPER MASON CREEK, AND LOWER MASON CREEK REACHES: 2014

Reach	Reach Conditions				Water Volume (length x width x water depth)		Sediment Volume (length x width x sediment depth)	
	Length (feet)	Mean Water Width (feet)	Mean Water Depth (feet)	Mean Sediment Depth (feet)	Cubic Feet	Cubic Yards	Cubic Feet	Cubic Yards
West Branch Agricultural Ditch	10, 560	3.7	0.3	1.2	11,722	434	100,109	3,708
Upper Mason Creek	9,134	8.9	0.9	1.0	73,163	2,710	81,293	3,011
Lower Mason Creek	9,082	13.4	0.8	0.2	97,359	3,606	24,340	902

NOTE: A mean bankfull width of 7.9 feet was used to calculate the average volume of sediment within the West Branch Agricultural Ditch (as opposed to water width as used in the other reaches), because that width better reflects flat banks just above water level that contain saturated organic muck and silt sediments available for transport to downstream reaches.

Source: SEWRPC.

Table II-16

LOW GRADIENT STREAM HABITAT QUALITY CRITERIA SCORES AMONG REACHES WITHIN THE MASON CREEK WATERSHED: 2014

Habitat Criteria	Mainstem Reaches		Tributary Reaches		
	Upper Mason	Lower Mason	East Branch headwaters	West Branch Agricultural Ditch	Trib-A[a]
Channelization (percent)	61-100	1-9	61-100	61-100	61-100
Channelization (age in years)	>20	>20	>20	>20	>20
Instream Cover (percent)	5-10	11-14	5-10	<5	Not Assessed
Bank Erosion (percent)	<7	7-50	<7	7-50	Not Assessed
Sinuosity (ratio)	<1.05	1.21-1.40	1.05-1.20	<1.05	<1.05
	0.05-0.25	>0.40	0.26-0.40	<0.05	Not Assessed
Buffer Vegetation (percent)	51-90	51-90	>90	51-90	20-50

Note: the red, yellow, green, and blue fill colors are associated with poor, fair, good, and excellent habitat criteria scores, respectively.

[a]*This tributary was not assessed, because staff could not gain access to it through private properties.*

Source: Adapted from Wang et. al., Development and Evaluation of a Habitat Rating System for Low-Gradient Wisconsin Streams, North American Journal of Fisheries Management , 18:775-785, 1998, and SEWRPC.

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SEWRPC Community Assistance Planning Report No. 321

MASON CREEK WATERSHED PROTECTION PLAN

Chapter II

INVENTORY FINDINGS

FIGURES

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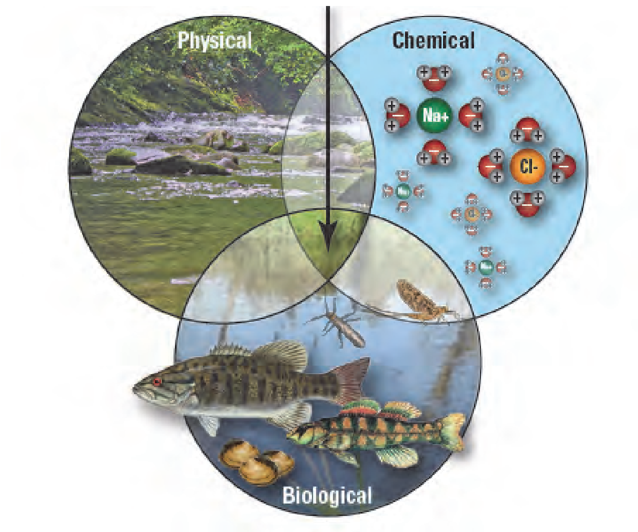
Figure II-1

ECOLOGICAL STREAM HEALTH



This simple diagram shows that a stream's ecological health (or "stream health") is the result of the interaction of its biological, physical, and chemical components. Stream health is intact if (1) its biological communities (such as algae, macroinvertebrates, and fish) are similar to what is expected in streams under minimal human influence and (2) the stream's physical attributes (such as streamflow) and chemical attributes (such as salinity or dissolved oxygen) are within the bounds of natural variation.

Source: Modified from D.M. Carlisle and others, The quality of our Nation's waters—Ecological health in the Nation's streams, 1993–2005: U.S. Geological Survey Circular 1391*, 120 p.,* http://pubs.usgs.gov/circ/1391/*, 2013, and SEWRPC.*

Figure II-2

ILLUSTRATIONS OF THE DYNAMIC COMPONENTS OF NATURAL, AGRICULTURAL, AND URBAN STREAM ECOSYSTEMS

NATURAL STREAM ECOSYSTEM

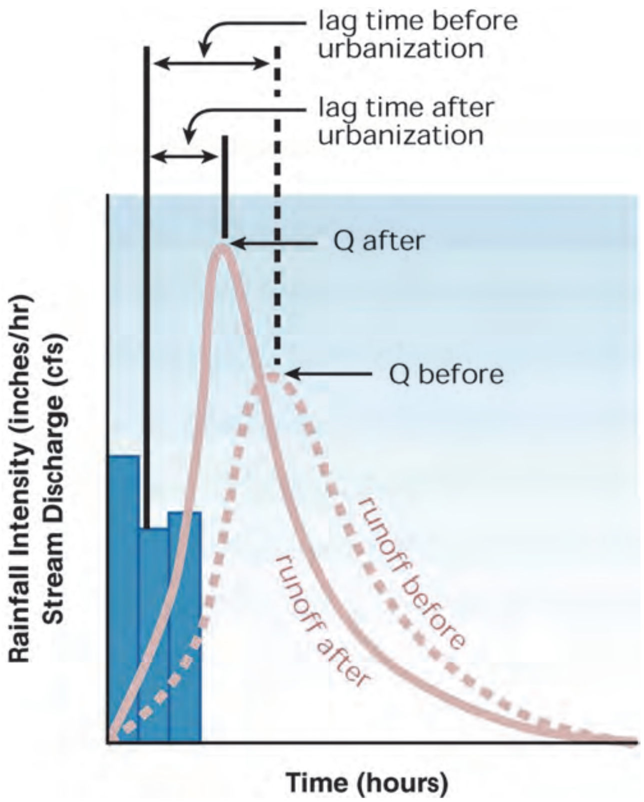
AGRICULTURAL STREAM ECOSYSTEM

URBAN STREAM ECOSYSTEM

Source: Illustrations by Frank Ippolito/www.productionpost.com. Modified from D.M. Carlisle and others, The quality of our Nation's waters—Ecological health in the Nation's streams, 1993–2005: U.S. Geological Survey Circular 1391*, 120 p.,* http://pubs.usgs.gov/circ/1391/*, 2013, and SEWRPC.*

Figure II-3

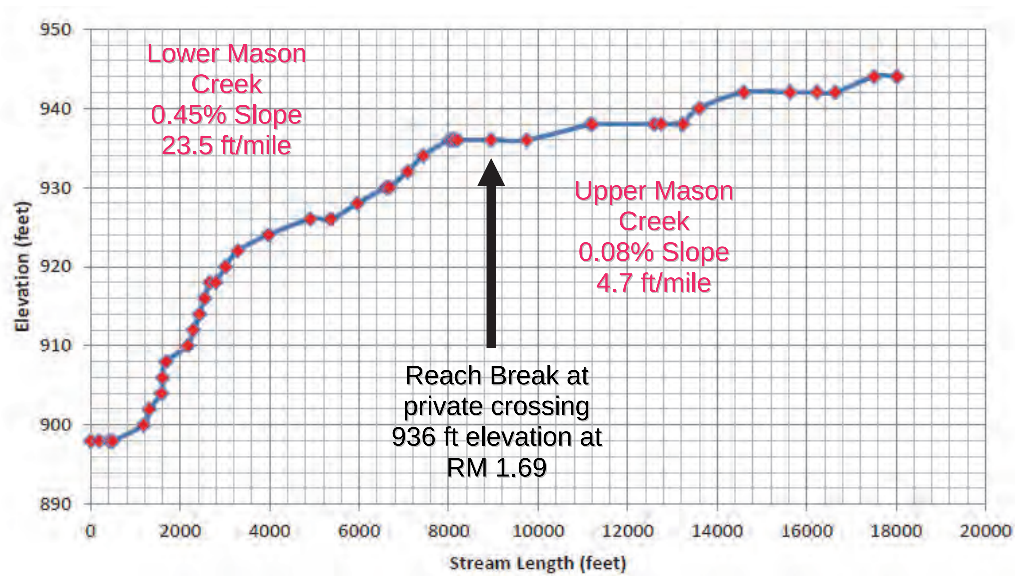
A COMPARISON OF HYDROGRAPHS BEFORE AND AFTER URBANIZATION



Source: Federal Interagency Stream Restoration Working Group (FISRWG), Stream Corridor Restoration: Principles, Processes, and Practices, *October 1998.*

Figure II-4

STREAM GRADIENT BASED ON SURFACE WATER ELEVATIONS WITHIN THE UPPER AND LOWER REACHES OF MASON CREEK: 2010

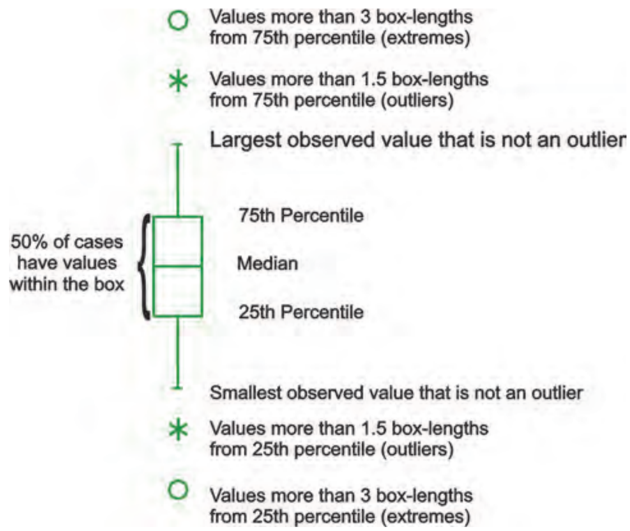


Note: Elevation is based on National Geodetic Vertical Datum (NGVD) 1929.

Source: SEWRPC.

Figure II-5

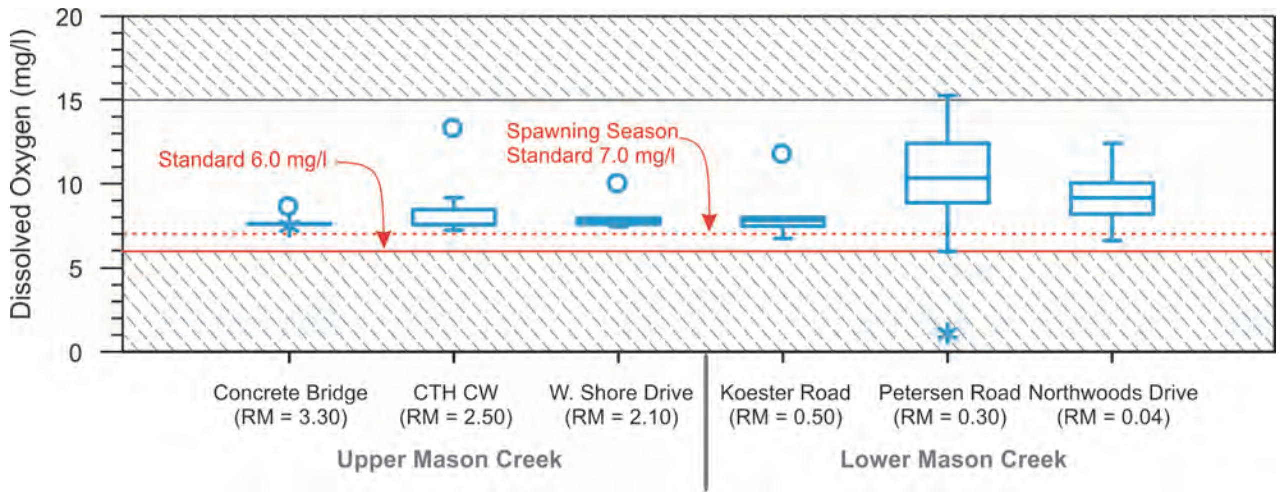
EXPLANATION OF SYMBOLS USED IN BOX-PLOT GRAPHS



Source: SEWRPC.

Figure II-6

DISSOLVED OXYGEN CONCENTRATIONS AT WATER QUALITY SAMPLING STATIONS ALONG MASON CREEK: 2009-2014



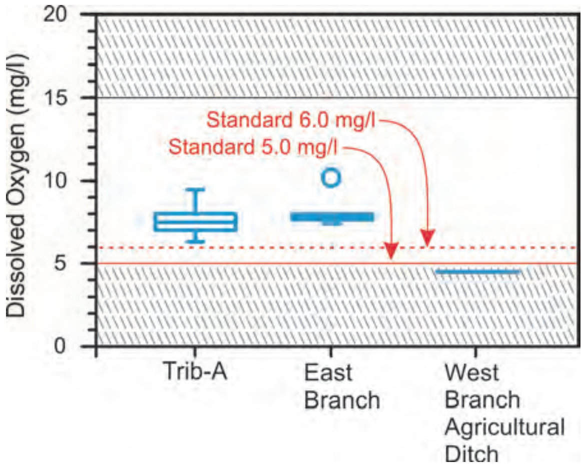
NOTE: See Figure II-5 for description of symbols. See Table II-7 and Map II-4 for locations of sample sites.

Saturation levels of dissolved oxygen of 140 percent and higher can cause fish kills. A 15 Mg/l dissolved oxygen concentration translates to a saturation of approximately 150 percent at an average water temperature of 14 degrees Celsius.

Source: Wisconsin Department of Natural Resources, University of Wisconsin-Milwaukee, University of Wisconsin-Extension, and SEWRPC.

Figure II-7

DISSOLVED OXYGEN CONCENTRATIONS IN TRIBUTARIES WITHIN THE MASON CREEK WATERSHED: 2011-2014



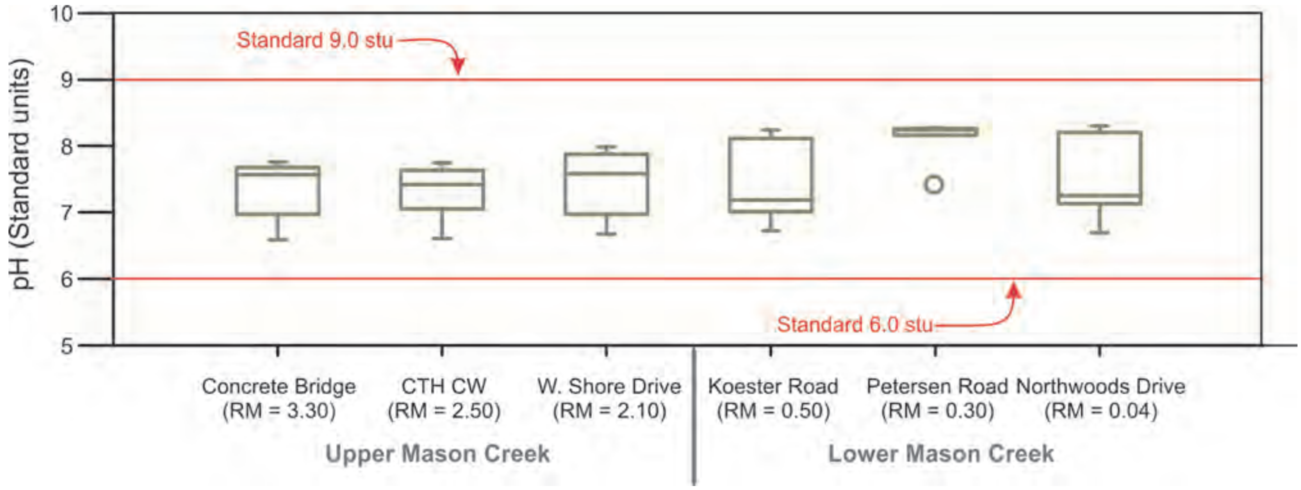
NOTE: See Figure II-5 for description of symbols. See Table II-7 and Map II-4 for locations of sample sites.

Saturation levels of dissolved oxygen of 140 percent and higher can cause fish kills. A 15 mg/l dissolved oxygen concentration translates to a saturation of approximately 150 percent at an average water temperature of 14 degrees Celsius.

Source: University of Wisconsin-Milwaukee and SEWRPC.

Figure II-8

pH AT WATER QUALITY SAMPLING STATIONS ALONG MASON CREEK: 2009-2014

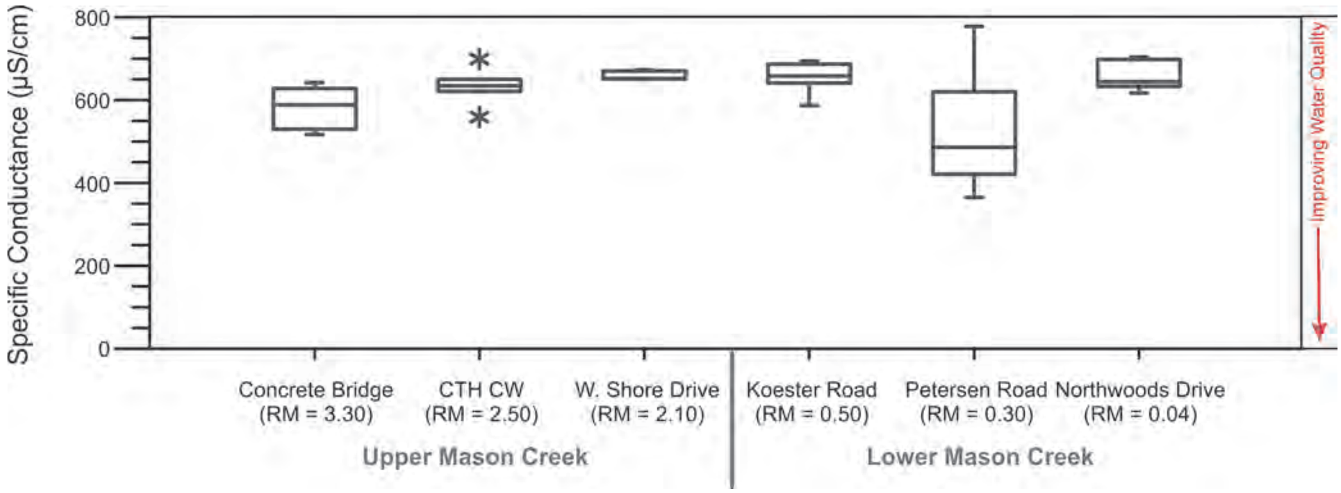


NOTE: See Figure II-5 for description of symbols. See Table II-7 and Map II-4 for locations of sample sites.

Source: Wisconsin Department of Natural Resources, University of Wisconsin-Milwaukee, and SEWRPC.

Figure II-9

SPECIFIC CONDUCTANCE AT WATER SAMPLING STATIONS ALONG MASON CREEK: 2009-2014

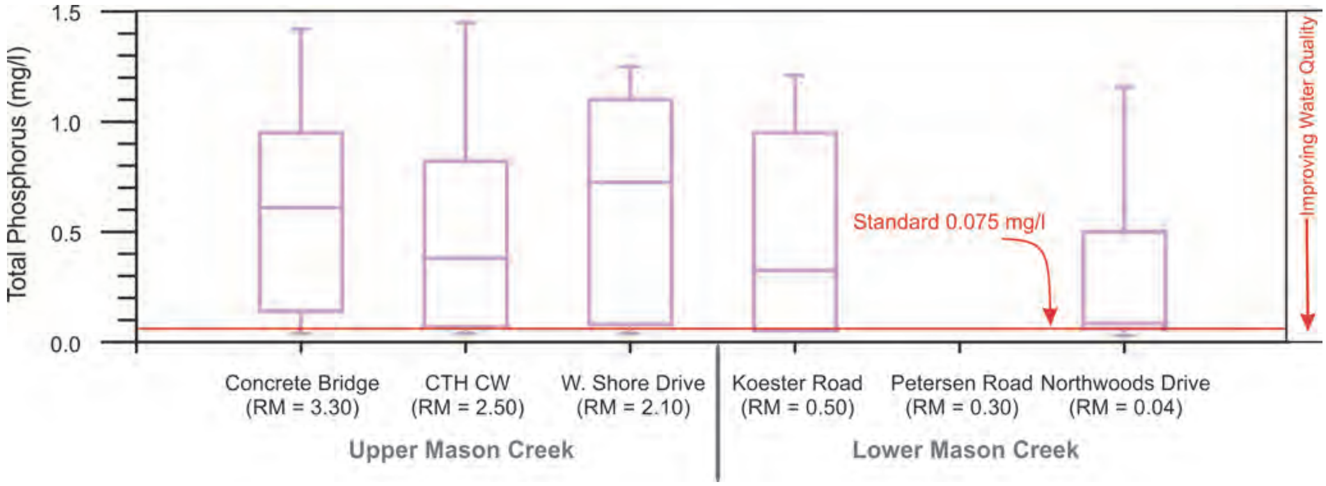


NOTE: See Figure II-5 for description of symbols. See Table II-7 and Map II-4 for locations of sample sites.

Source: University of Wisconsin-Milwaukee, University of Wisconsin-Extension, and SEWRPC.

Figure II-10

TOTAL PHOSPHORUS CONCENTRATIONS AT WATER QUALITY SAMPLING STATIONS ALONG MASON CREEK: 2009-2014

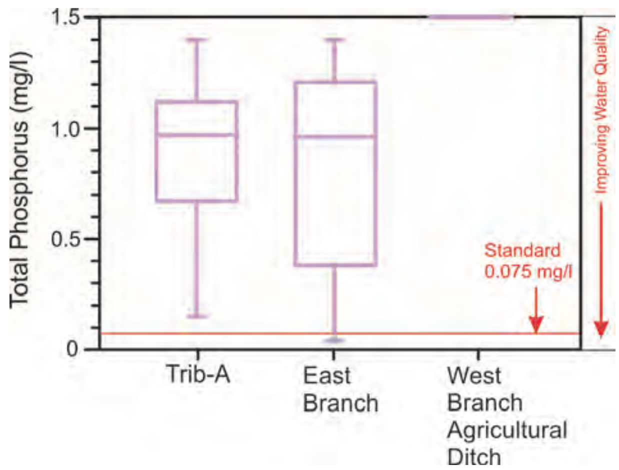


NOTE: See Figure II-5 for description of symbols. See Table II-7 and Map II-4 for locations of sample sites.

Source: University of Wisconsin-Milwaukee, City of Oconomowoc, and SEWRPC.

Figure II-11

TOTAL PHOSPHORUS CONCENTRATIONS IN TRIBUTARIES WITHIN THE MASON CREEK WATERSHED: 2011-2012

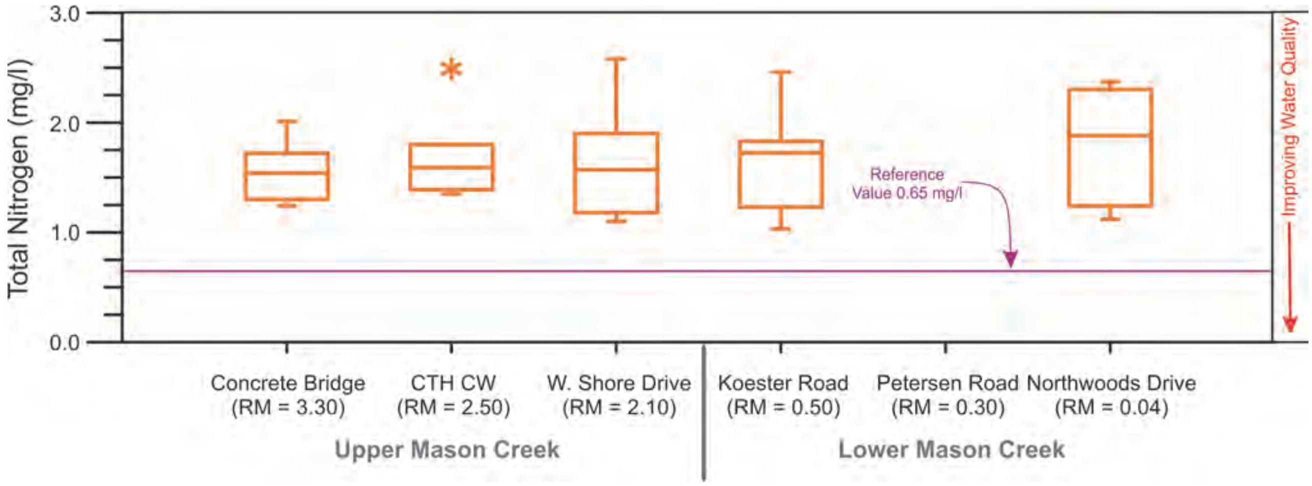


NOTE: See Figure II-5 for description of symbols. See Table II-7 and Map II-4 for locations of sample sites.

Source: University of Wisconsin-Milwaukee and SEWRPC.

Figure II-12

TOTAL NITROGEN CONCENTRATIONS AT WATER QUALITY SAMPLING STATIONS ALONG MASON CREEK: 2009-2014

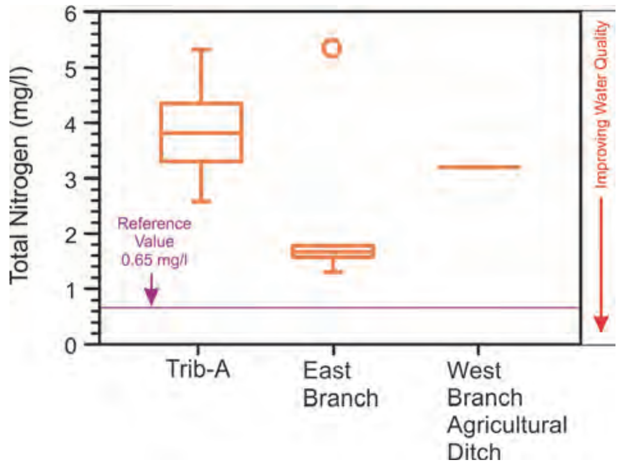


NOTE: See Figure II-5 for description of symbols. See Table II-7 and Map II-4 for locations of sample sites.

Source: University of Wisconsin-Milwaukee and SEWRPC.

Figure II-13

TOTAL NITROGEN CONCENTRATIONS IN TRIBUTARIES WITHIN THE MASON CREEK WATERSHED: 2011-2012

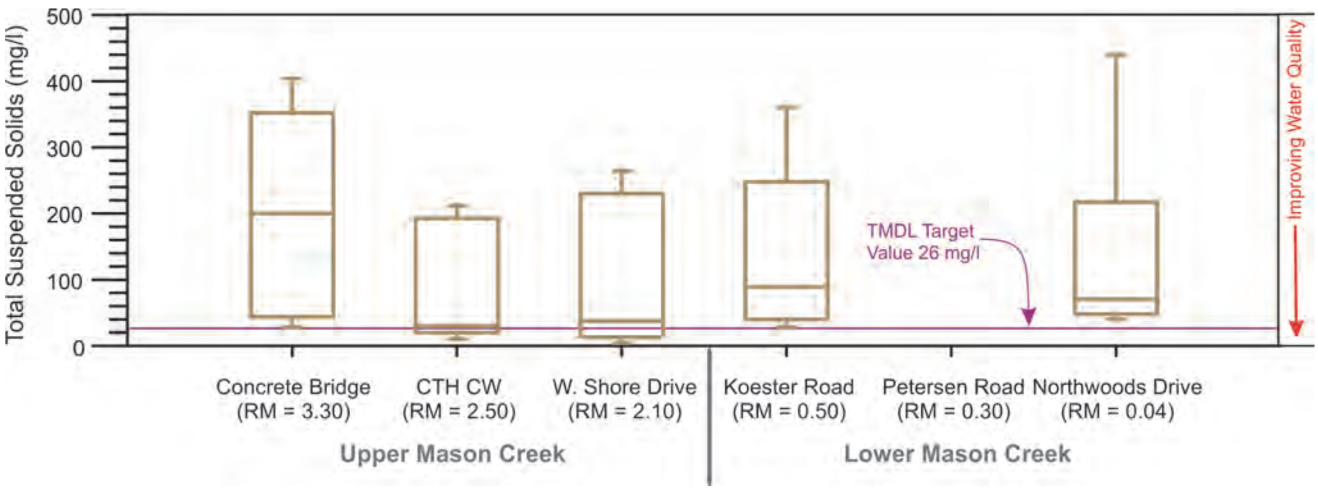


NOTE: See Figure II-5 for description of symbols. See Table II-7 and Map II-4 for locations of sample sites.

Source: University of Wisconsin-Milwaukee and SEWRPC.

Figure II-14

TOTAL SUSPENDED SOLIDS CONCENTRATIONS AT WATER QUALITY SAMPLING STATIONS ALONG MASON CREEK AND TRIBUTARIES: 2009-2014

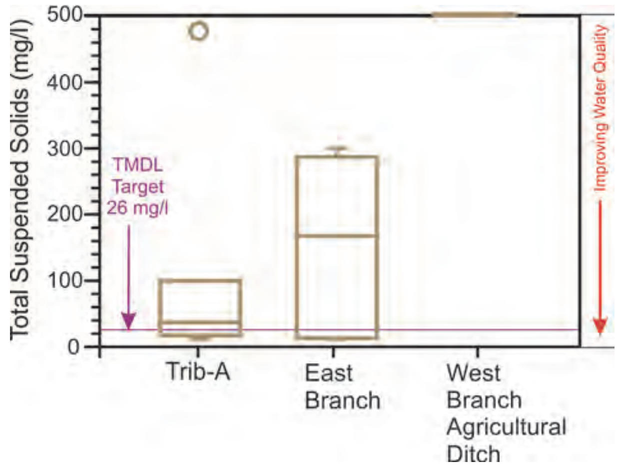


NOTE: See Figure II-5 for description of symbols. See Table II-7 and Map II-4 for locations of sample sites.

Source: University of Wisconsin-Milwaukee and SEWRPC.

Figure II-15

TOTAL SUSPENDED SOLIDS CONCENTRATIONS IN TRIBUTARIES WITHIN THE MASON CREEK WATERSHED: 2011-2012



NOTE: See Figure II-5 for description of symbols. See Table II-7 and Map II-4 for locations of sample sites.

Source: University of Wisconsin-Milwaukee and SEWRPC.

Figure II-16

MASON CREEK AT LOWFLOW AND HIGH FLOW CONDITIONS AT INLET TO NORTH LAKE: 2012 AND 2014

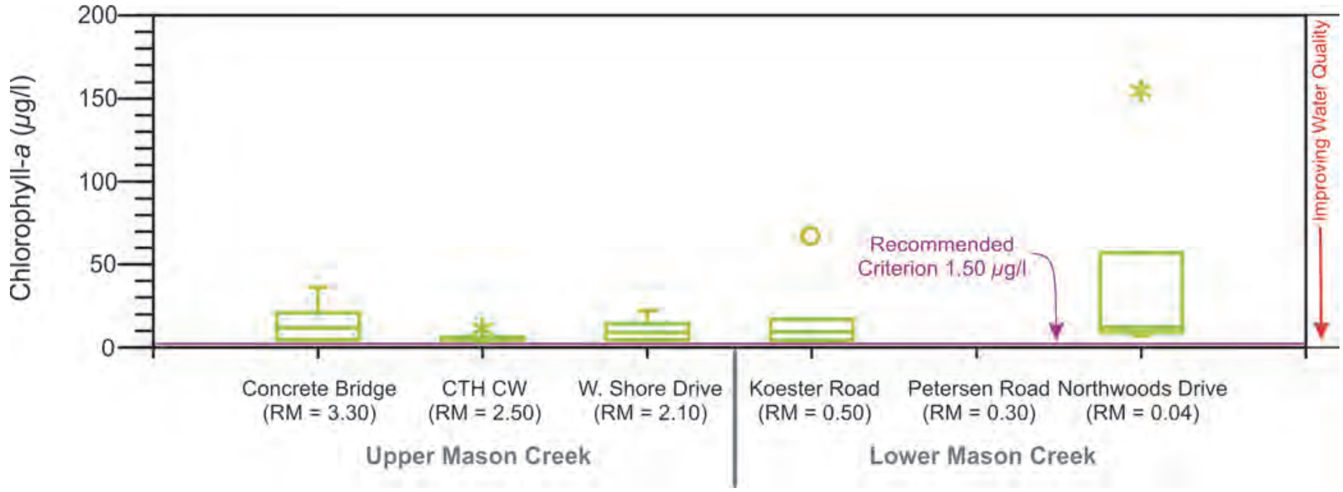
LOW FLOW CONDITIONS- LOW SUSPENDED SEDIMENTS IN WATER ON SEPTEMBER 25, 2012

HIGH FLOW CONDITIONS-HIGH SUSPENDED SEDIMENTS DISCHARGING AFTER RAINFALL EVENT ON JULY 22, 2014

Source: North Lake Management District and SEWRPC.

Figure II-17

CHLOROPHYLL-*a* CONCENTRATIONS AT WATER QUALITY SAMPLING STATIONS ALONG MASON CREEK: 2009-2014



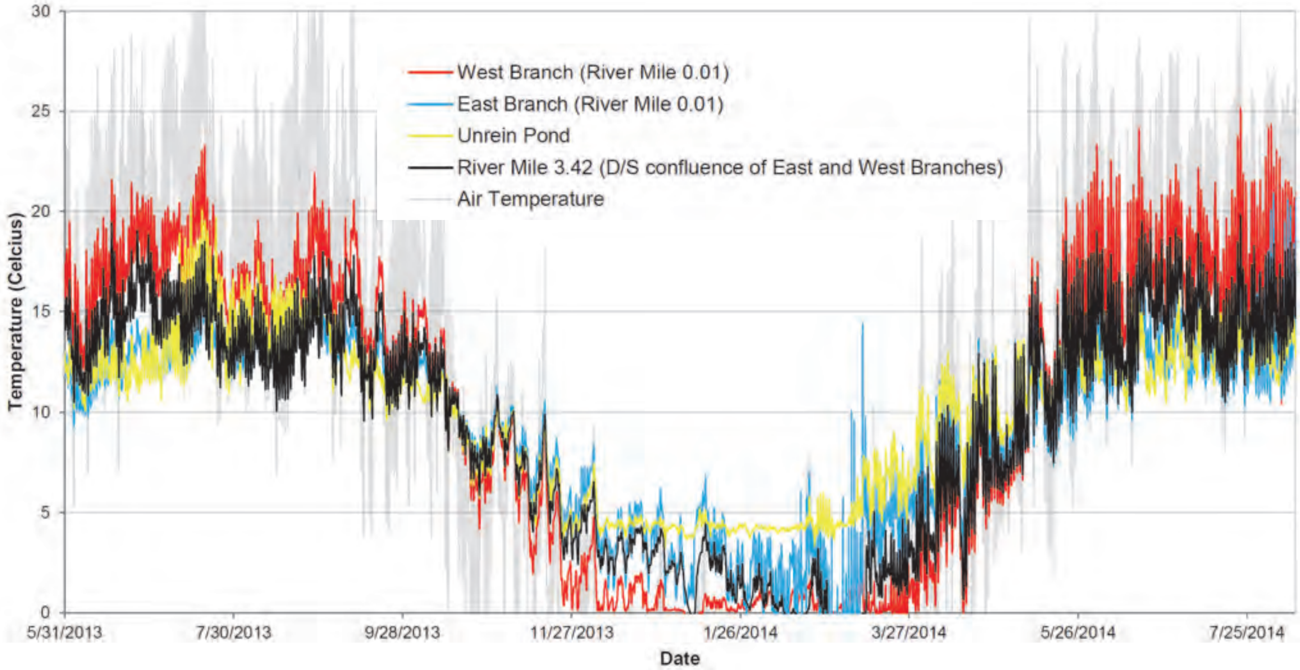
NOTE: See Figure II-5 for description of symbols. See Table II-7 and Map II-4 for locations of sample sites.

Source: University of Wisconsin-Milwaukee and SEWRPC.

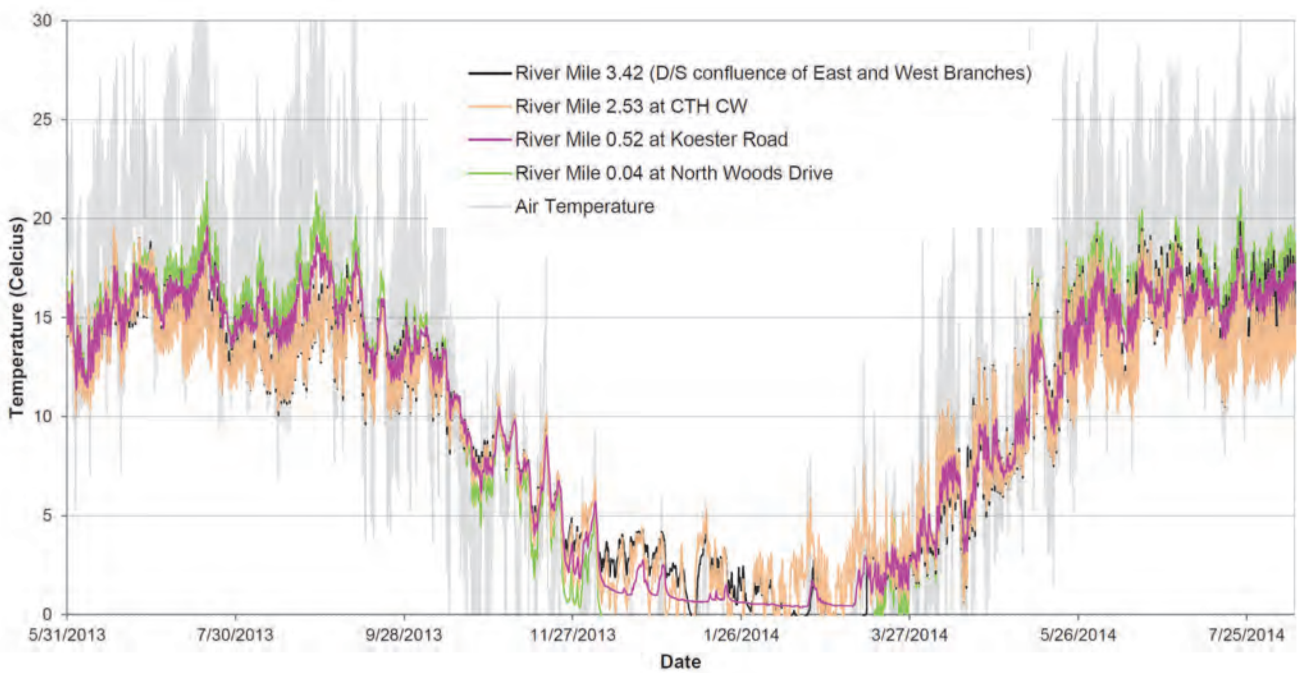
Figure II-18

HOURLY WATER AND AIR TEMPERATURES AMONG SITES AND REACHES WITHIN AND ADJACENT TO THE MASON CREEK WATERSHED: MAY 31, 2013 THROUGH AUGUST 11, 2014

EAST BRANCH VERSUS WEST BRANCH OF MASON CREEK



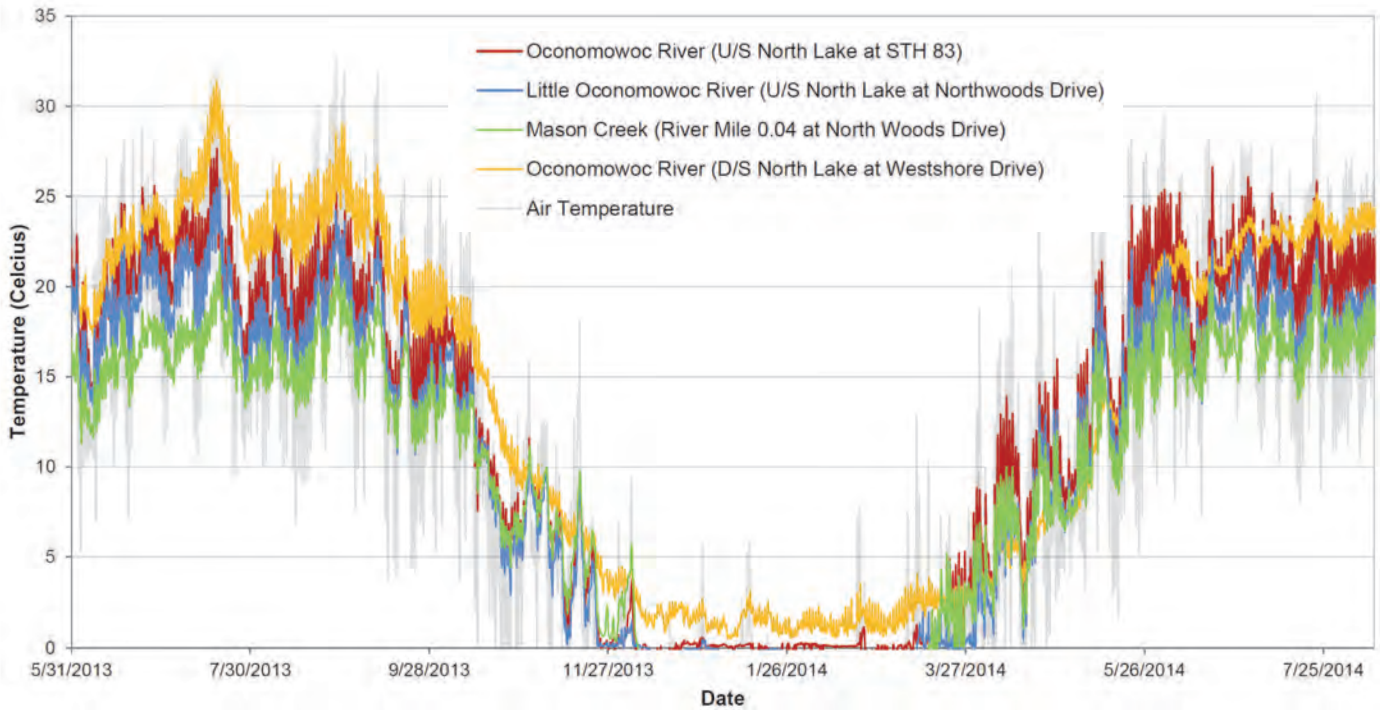
UPPER AND LOWER REACHES OF MASON CREEK



Source: SEWRPC.

Figure II-18 (Continued)

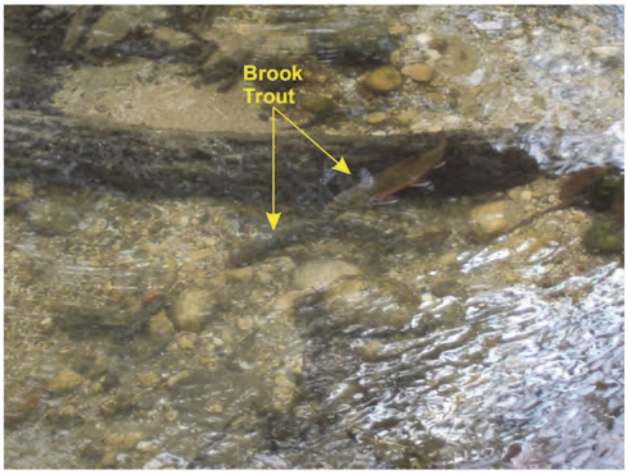
MAJOR STREAMS THAT DISCHARGE TO NORTH LAKE VERSUS THE OUTLET OF NORTH LAKE



Source: SEWRPC.

Figure II-19

BROOK TROUT SPAWNING IN TRIBUTARY B TO MASON CREEK—OCTOBER 21, 2014



Source: SEWRPC.

Figure II-20

HIGH SUSPENDED SEDIMENT LOADS IN GULLY NUMBER 7 AND CONCENTRATED FLOW COMING OFF AN AGRICULTURAL FIELD – DECEMBER 19, 2014

Gully #7 Along Erin Road

Concentrated Flow area coming off agricultural field

Concentrated Flow Entering Culvert Leading to Gully #7

Source: SEWRPC.

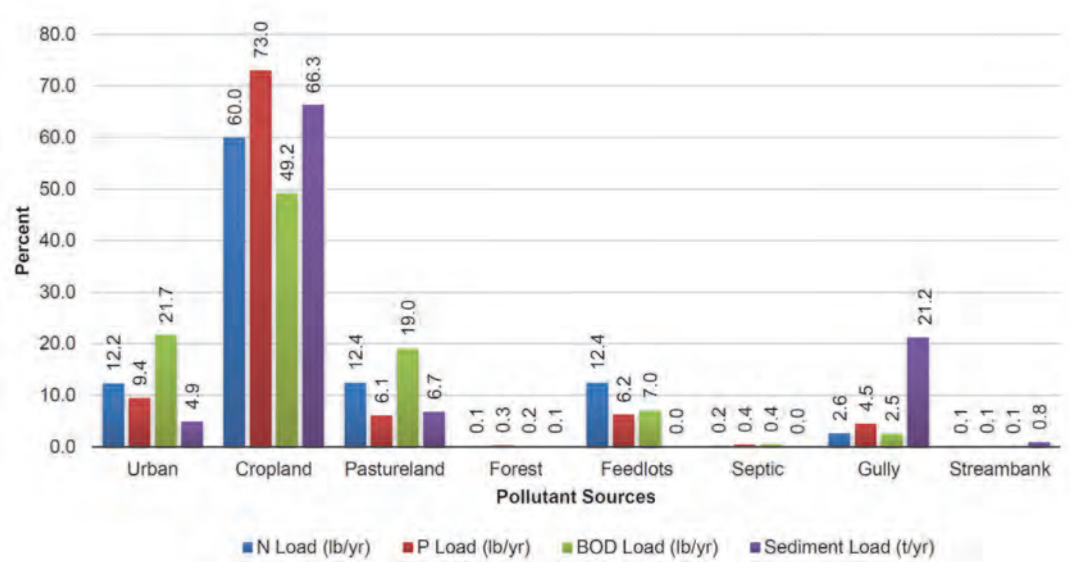
Figure II-21

WDNR STAFF ELECTROFISHING SURVEY TECHNIQUE AND SENSITIVE WARMWATER, COOLWATER, AND COLDWATER FISH SPECIES FOUND IN MASON CREEK: 2014

Source: Maggie Zoellner, Kettle Moraine Land Trust, Inc., and SEWRPC.

Figure II-22

PROPORTION OF NITROGEN (N), PHOSPHORUS (P), BIOLOGICAL OXYGEN DEMAND (BOD), AND SEDIMENT LOADS AMONG POLLUTANT SOURCES WITHOUT BEST MANAGEMENT PRACTICES (BMPs) WITHIN THE MASON CREEK WATERSHED: 2010



Note: this modeled data was based upon year 2010 land use and any additional known installed practices or conditions up to year 2014, where applicable.

Source: U. S. Environmental Protection Agency, Washington County, Waukesha County, Wisconsin Department of Natural Resources, and SEWRPC.

Figure II-23

EXISTING AND PROPOSED ANNUAL LOAD REDUCTIONS AMONG AGRICULTURAL BMPs APPLIED TO CROPLAND FOR TOTAL PHOSPHOURS (LBS/YEAR) AND SUSPENDED SEDIMENT (TONS/YEAR) WITHIN THE MASON CREEK WATERSHED: 2015

Note: Proposed load reductions shown in these graphs include both load reductions from existing practices and load reductions from additional proposed Agricultural BMPs. The load reductions for nitrogen and BOD are not included in this figure, but were proportionally similar to the phosphorus and sediment load reductions shown.

Source: SEWRPC.

Figure II-24

EXAMPLES OF TYPICAL FARMING PRACTICES WITHIN THE MASON CREEK WATERSHED

LOW RESIDUE WITH EROSION AND CONCENTRATED FLOW

HIGH RESIDUE/NO TILL FARMING PRACTICE

NOTE: These photos were not from the Mason Creek watershed.

Source: Maggie Zellner, Kettle Moraine Land Trust, Inc., and SEWRPC.

Figure II-25

ONE EXAMPLE OF COVER CROP FARMING BEST MANAGEMENT PRACTICE

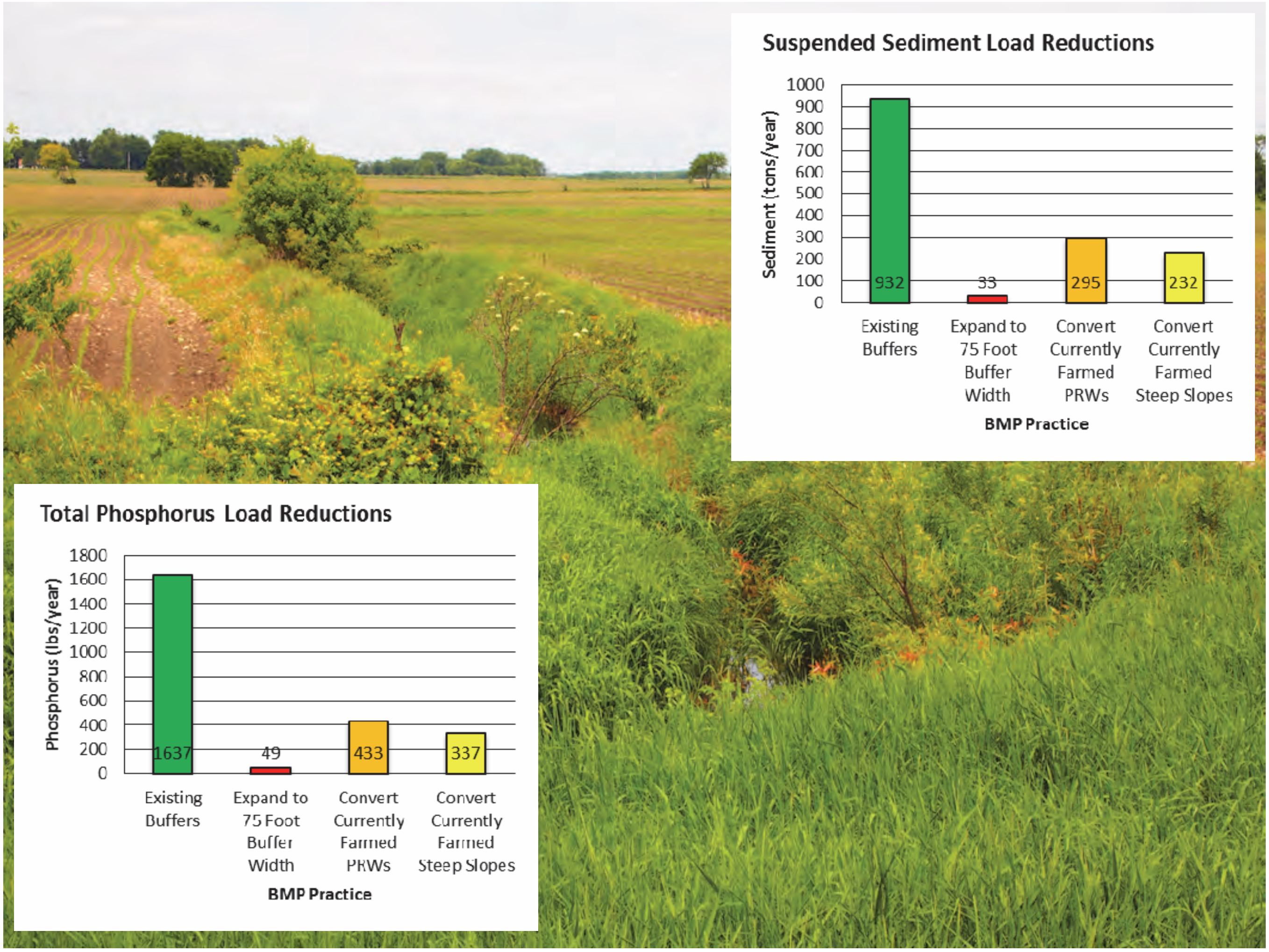
COVER CROP WINTER WHEAT NO-TILL PLANTED INTO SHREDDED CORN STALKS

NOTE: This photo was not taken in the Mason Creek watershed.

Source: NRCS and SEWRPC.

Figure II-26

ANNUAL POLLUTANT LOAD REDUCTIONS FOR EXISTING RIPARIAN BUFFERS, PROPOSED 75-FOOT RIPARIAN BUFFER EXPANSION, PROPOSED CONVERSION OF CURRENTLY FARMED POTENTIALLY RESTORABLE WETLAND, AND PROPOSED CONVERSION OF CURRENTLY FARMED STEEP SLOPES WITHIN THE MASON CREEK WATERSHED: 2015 (AREAS CORRESPOND WITH MAPS B-1 AND B-2 IN APPENDIX B)



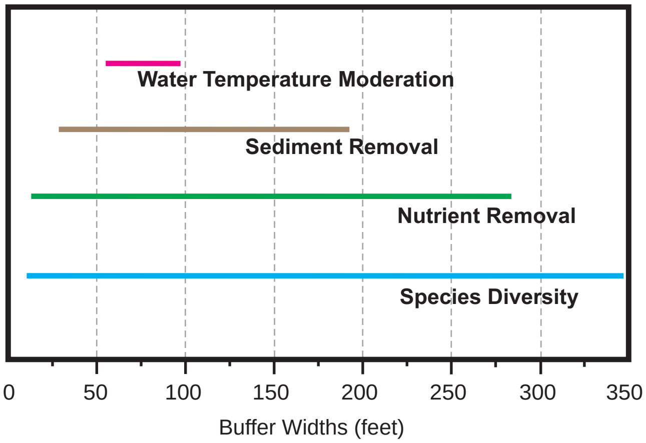
Notes: The load reductions for nitrogen and BOD are not included in this graph, but were proportionally similar to the phosphorus and sediment load reductions shown.

PRWs = Potentially Restorable Wetlands

Source: SEWRPC.

Figure II-27

RANGE OF BUFFER WIDTHS FOR PROVIDING SPECIFIC BUFFER FUNCTIONS

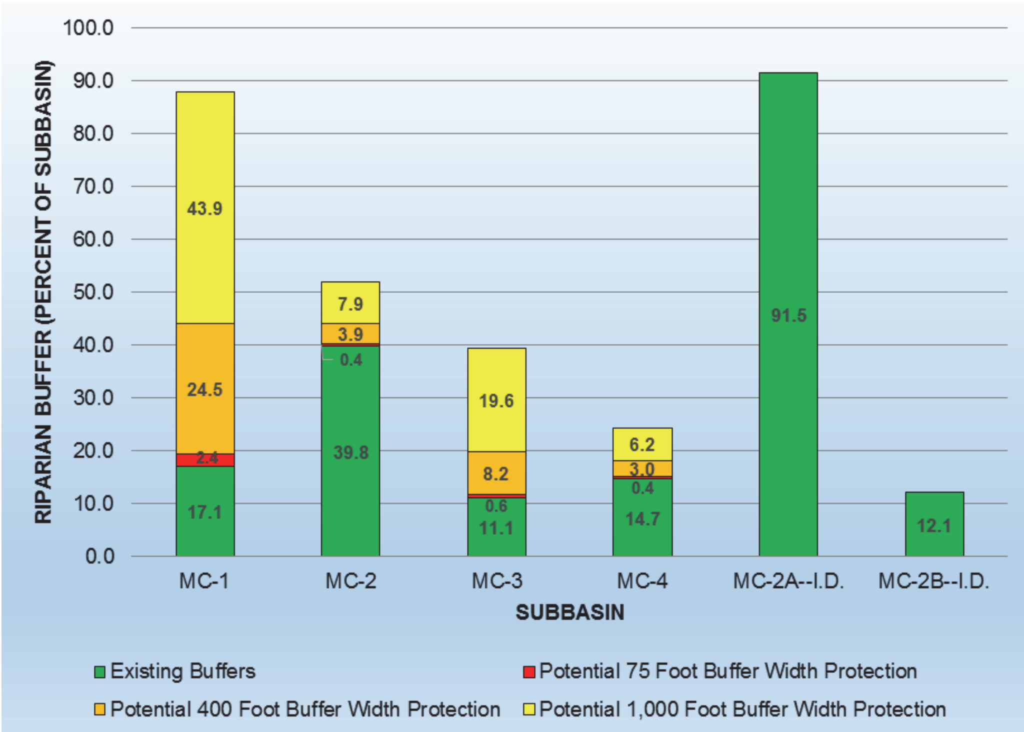


NOTE: Site-specific evaluations are required to determine the need for buffers and specific buffer characteristics.

Source: Adapted from A. J. Castelle and others, "Wetland and Stream Buffer Size Requirements-A Review," Journal of Environmental Quality*, Vol. 23.*

Figure II-28

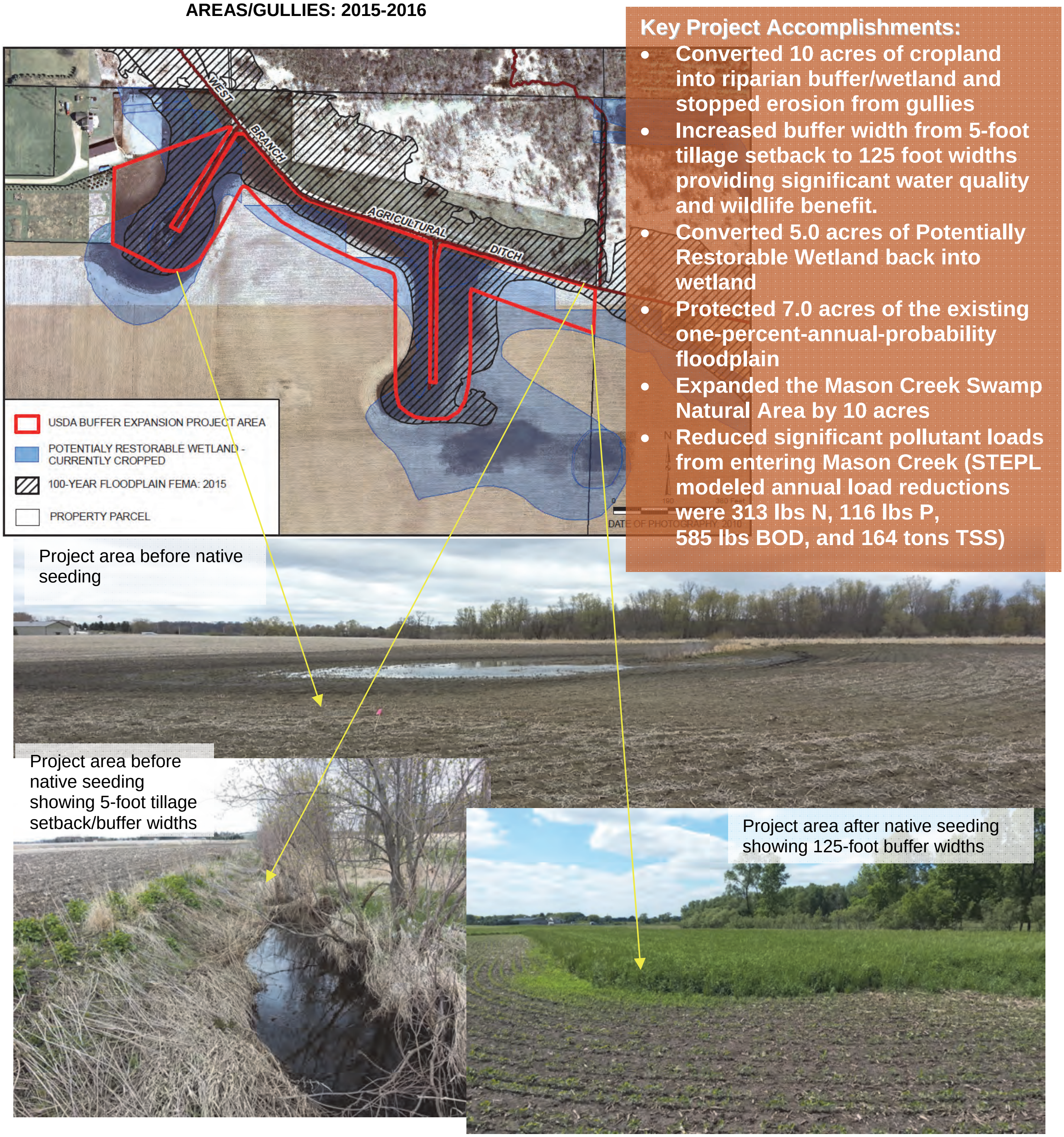
PERCENT EXISTING AND POTENTIAL RIPARIAN BUFFERS WITHIN EACH SUBBASIN IN THE MASON CREEK WATERSHED: 2010



Source: SEWRPC.

Figure II-29

EXAMPLE OF RIPARIAN BUFFER EXPANSION PROJECT ESTABLISHED ADJACENT TO THE WEST BRANCH AGRICULTURAL DITCH AND CONCENTRATED FLOW AREAS/GULLIES: 2015-2016

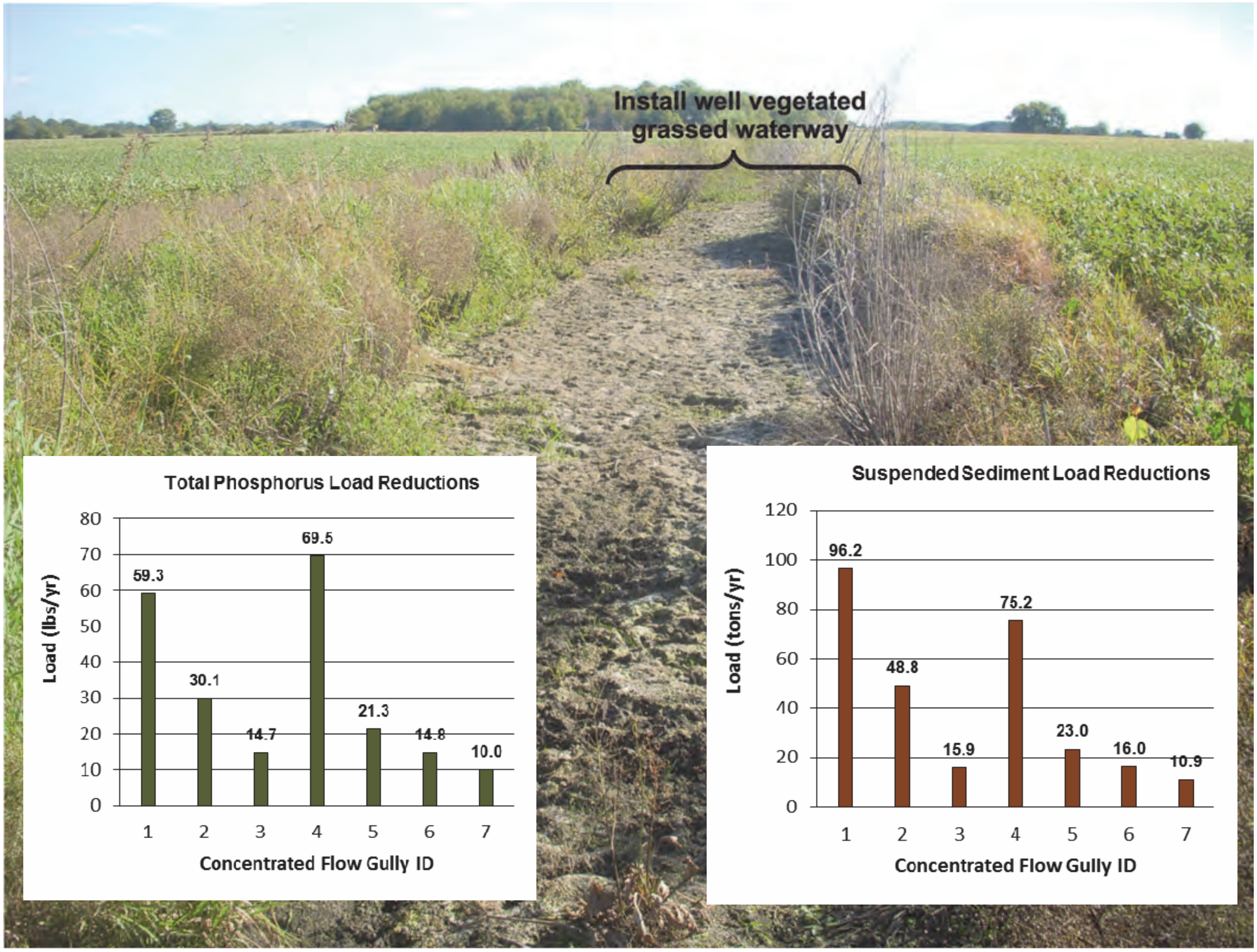


NOTE: This project was funded in partnership with the Natural Resources Conservation Service (NRCS), City of Oconomowoc, and the North Lake Management District.

Source: NRCS, City of Oconomowoc, North Lake Management District, and SEWRPC.

Figure II-30

ANNUAL POLLUTNAT LOAD REDUCTIONS FOR PROPOSED GRASSED WATERWAYS AMONG SUBBASINS FOR TOTAL PHOSPHOURS (LBS/YEAR) AND SUSPENDED SEDIMENT (TONS/YEAR) WITHIN THE MASON CREEK WATERSHED: 2015



Notes: The load reductions for nitrogen are not included in this graph, but were proportionally similar to the phosphorus and sediment load reductions shown.

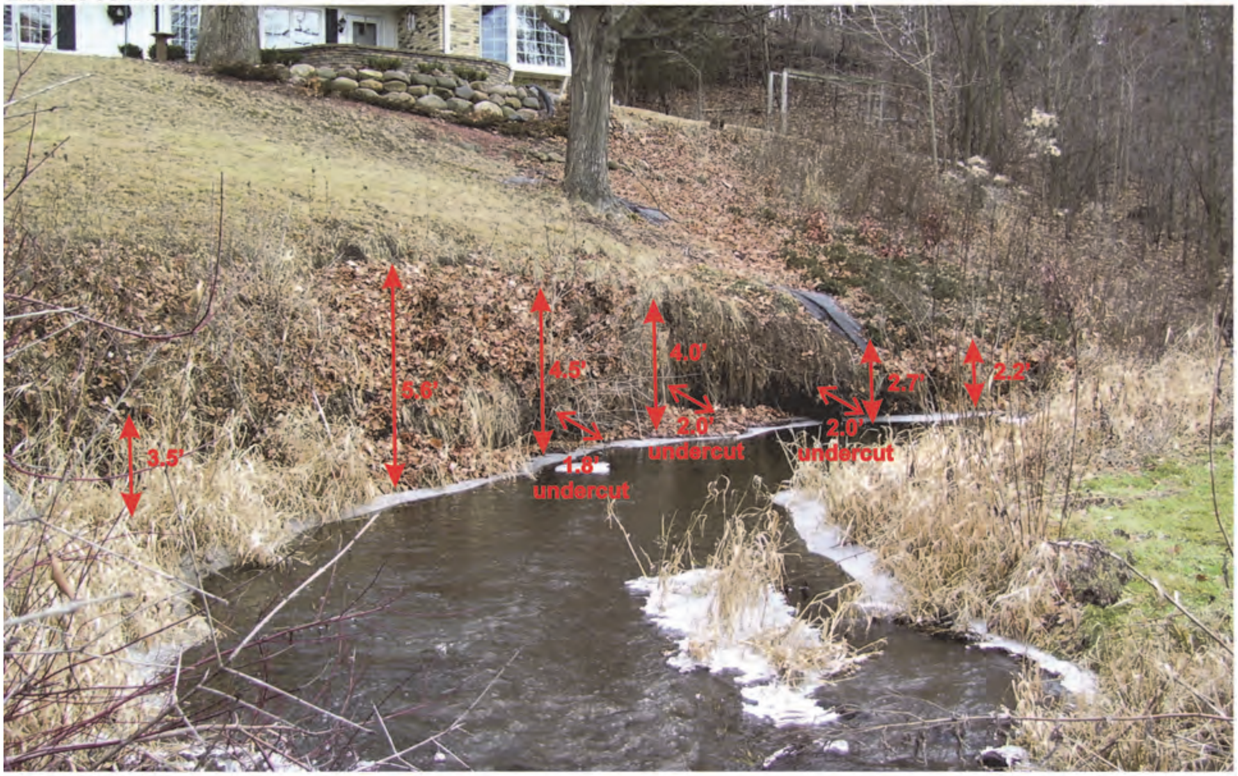
The photograph above shows Gully 1.

Source: SEWRPC.

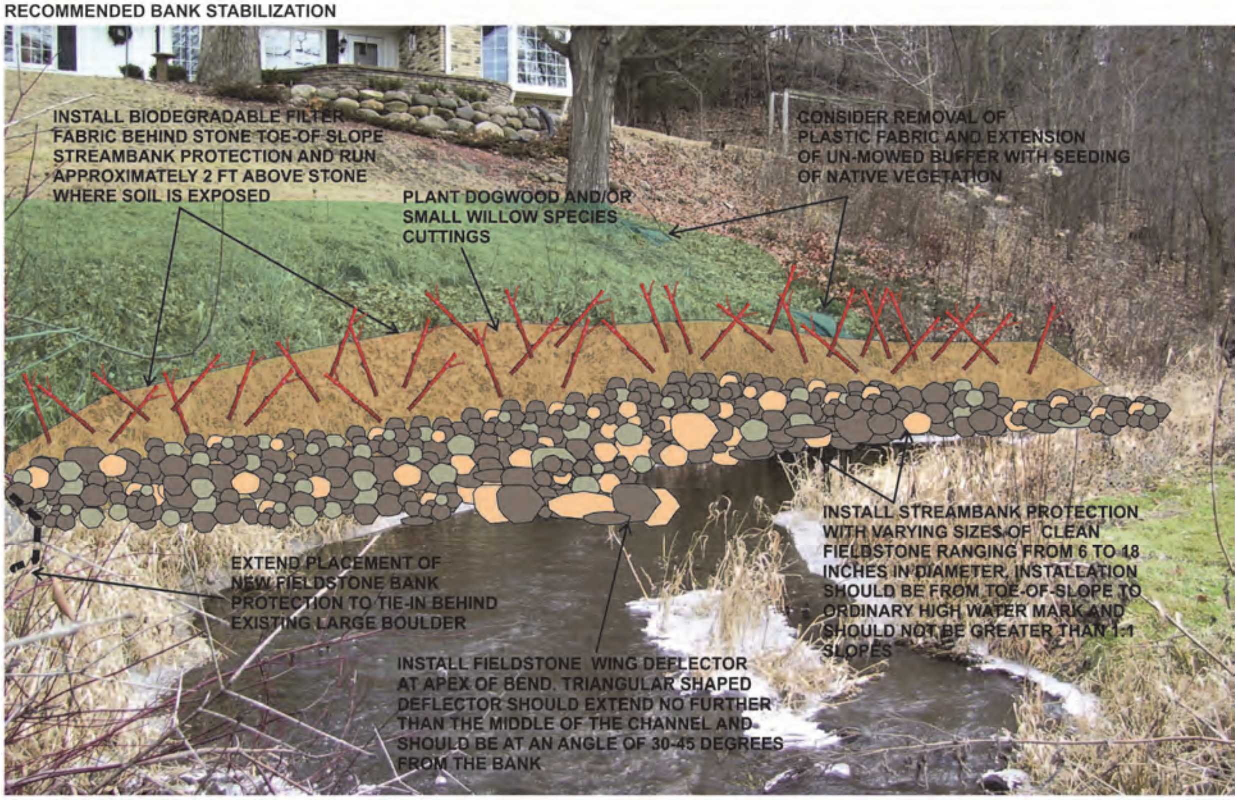
Figure II-31

EXISTING CONDITIONS AND RECOMMENDED BANK STABILIZATION ACTIONS FOR EROSION SITE No. 3 JUST DOWNSTREAM OF KOESTER ROAD ON MASON CREEK: 2015

EXISTING CONDITIONS



RECOMMENDED BANK STABILIZATION



Source: SEWRPC.

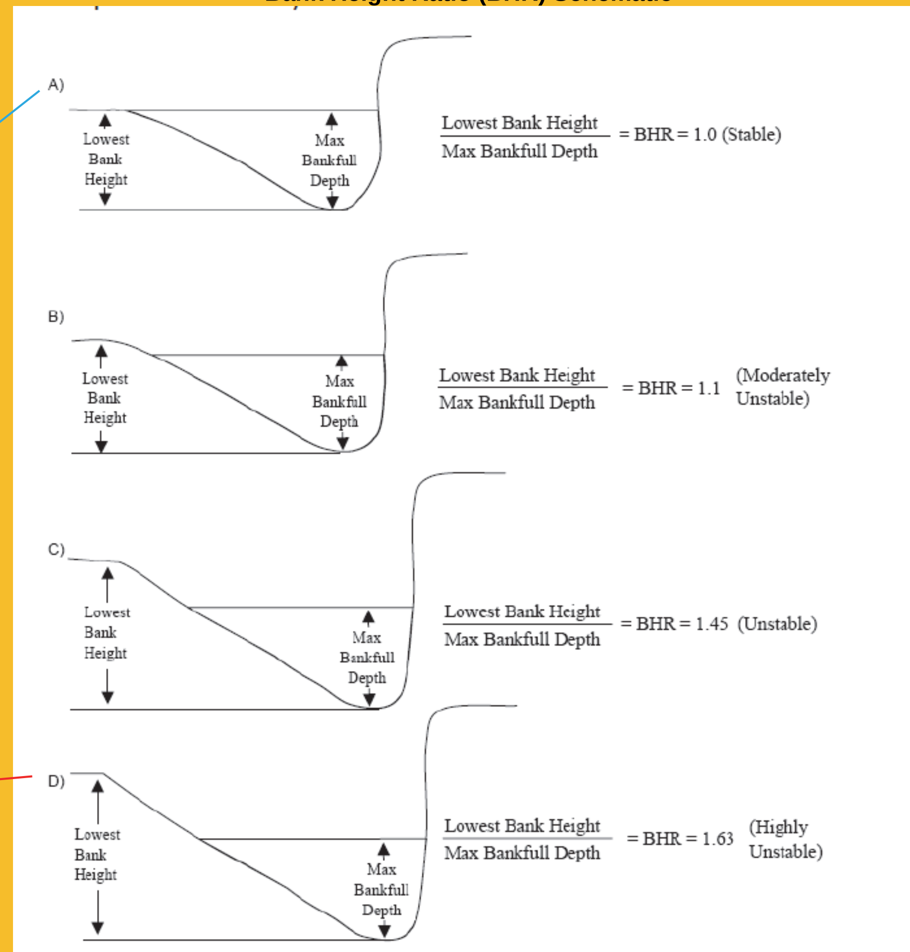
Figure II-32

FLOODPLAIN CONNECTIVITY COMPARISON AMONG REACHES AND SCHEMATIC OF BANK HEIGHT RATIO (BHR) WITHIN THE MAINSTEM OF MASON CREEK: 2014

East Branch-Connected Floodplain & Stable Streambanks

Upper Mason Creek-Disconnected Floodplain & Sediment Accumulation within the Streambed (see Map II-11)

Bank Height Ratio (BHR) Schematic



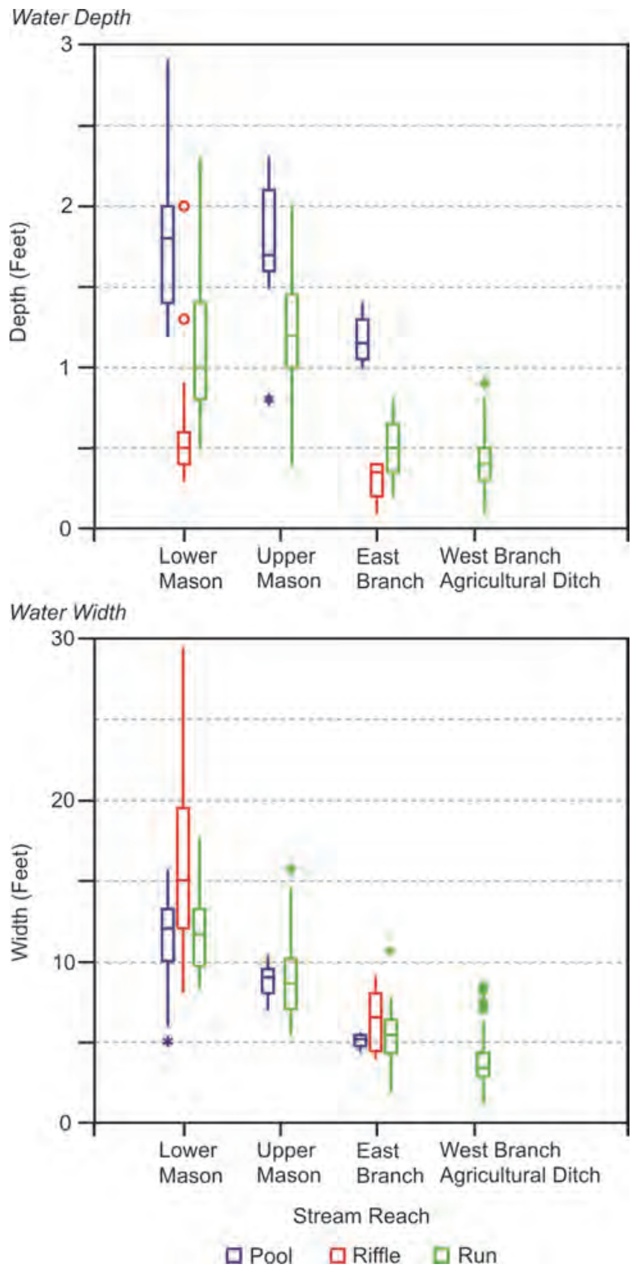
Note: BHR is the height of the top of the bank divided by the bankfull discharge height. Typically measured from the toe. The BHR is a relative measure of the floodplain connectivity to the bankfull channel.

Source: W. Barry Southerland, Fluvial Geomorphologist, NRCS, http://www.ars.usda.gov/SP2UserFiles/Place/30501000/esd/talks07/geomorph_terms.pdf, and SEWRPC.

PRELIMINARY DRAFT

Figure II-33

MAXIMUM WATER DEPTH AND MEAN STREAM WIDTH AMONG HABITAT TYPE AND REACHES IN THE MASON CREEK WATERSHED: 2014

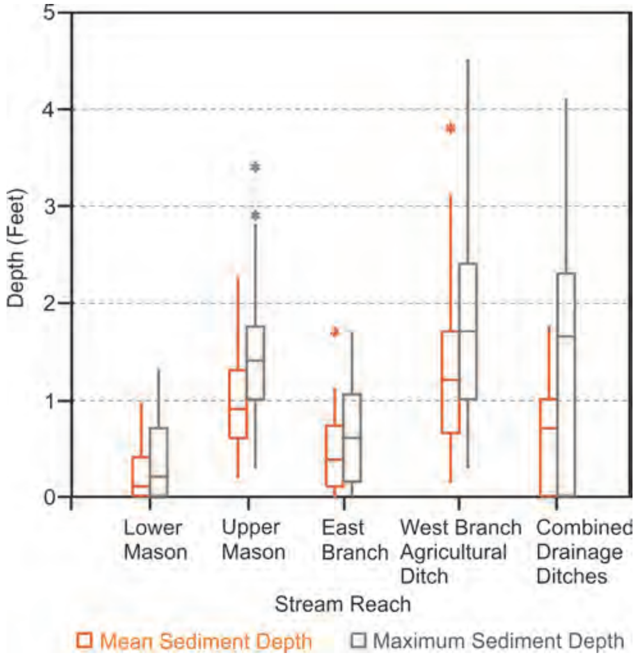


NOTE: See Figure II-5 for description of symbols.

Source: SEWRPC.

Figure II-34

MEAN AND MAXIMUM UNCONSOLIDATED ORGANIC MUCK AND SILT DEPTH AMONG REACHES IN THE MASON CREEK WATERSHED: 2014

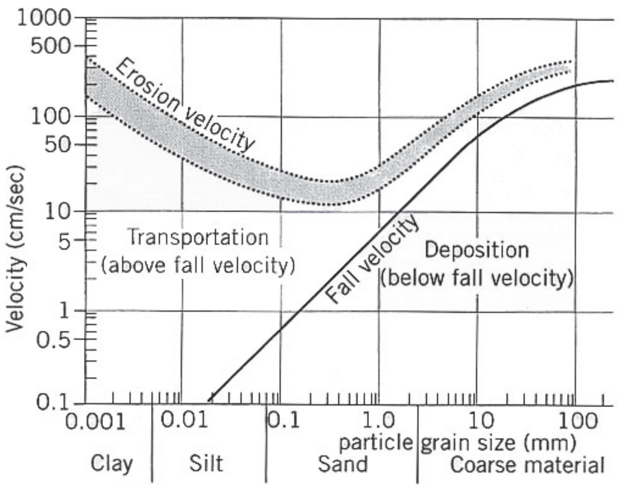


NOTE: See Figure II-5 for description of symbols.

Source: SEWRPC.

Figure II-35

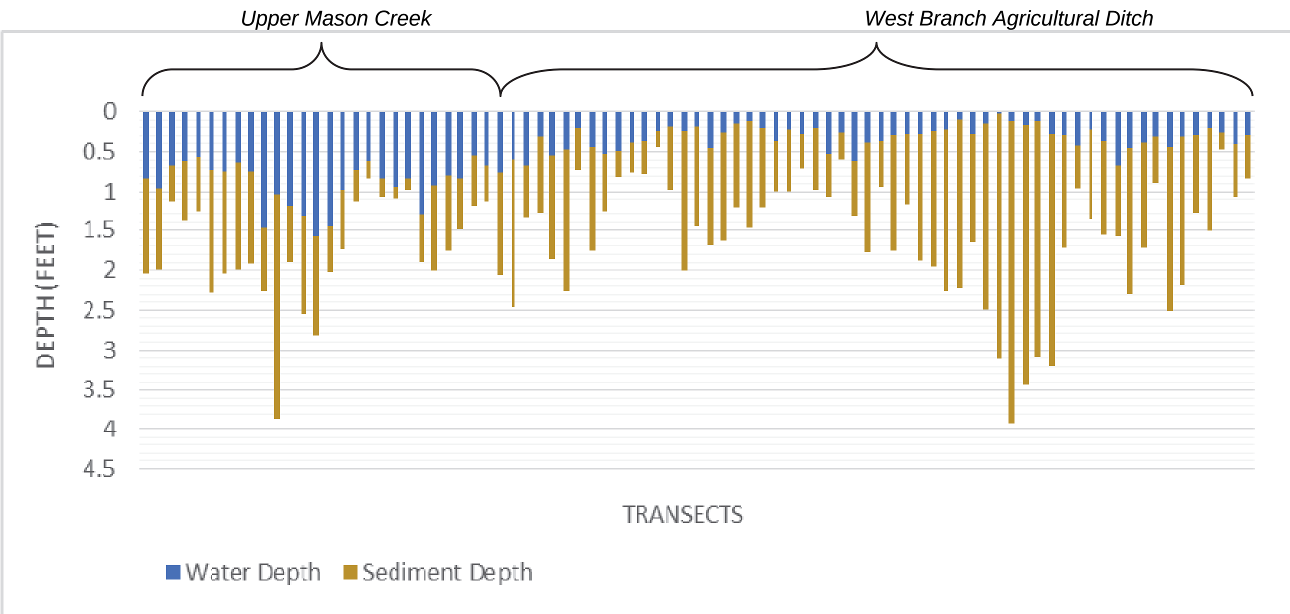
RELATIONSHIP OF TRANSPORTED PARTICLE SIZE TO WATER VELOCITY (HJULSTROM CURVE)



Source: Dr Laurie's Geog Blog website at https://dlgb.files.wordpress.com/2008/09/hjulstrom_curve_task.jpg and SEWRPC.

Figure II-36

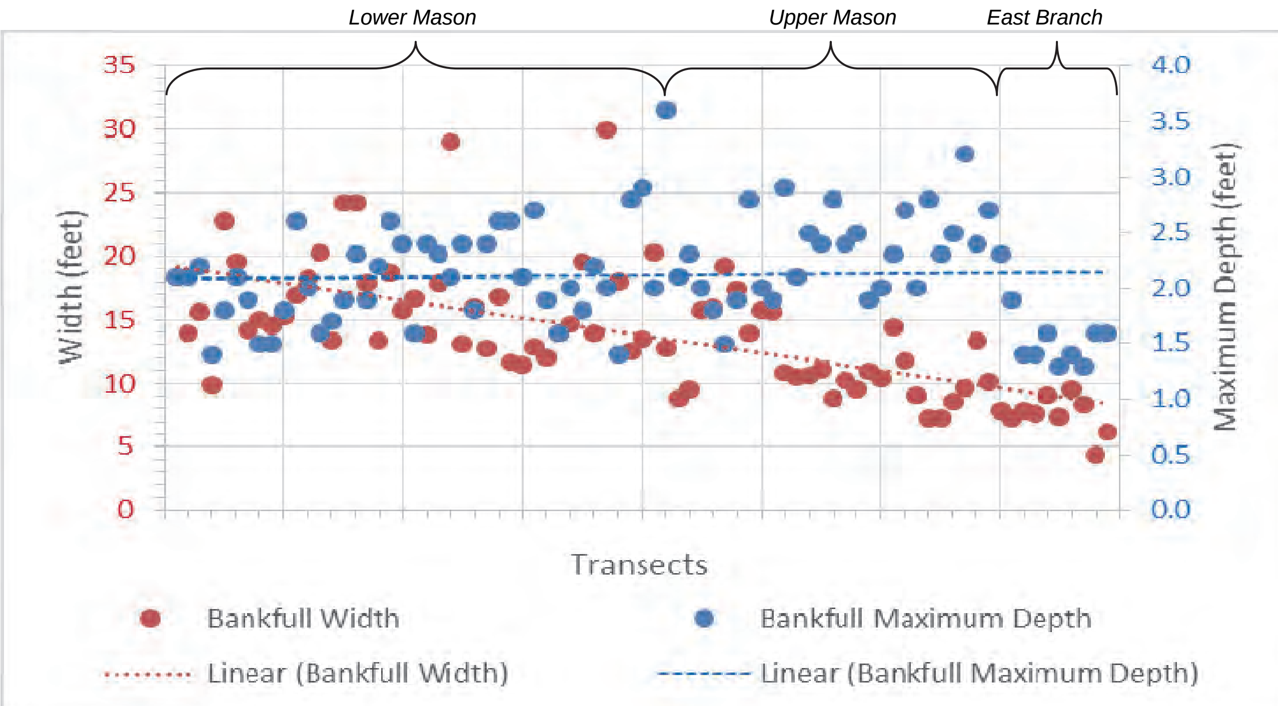
MEAN WATER DEPTH AND UNCONSOLIDATED ORGANIC MUCK AND SILT DEPTH CONDITIONS WITHIN THE UPPER MASON CREEK AND WEST BRANCH AGRICULTURAL DITCH REACHES: 2014



Source: SEWRPC.

Figure II-37

BANKFULL WIDTH AND MAXIMUM DEPTH CONDITIONS AMONG THE UPPER AND LOWER MAINSTEM REACHES AND EAST BRANCH TRIBUTARY REACH WITHIN THE MASON CREEK WATERSHED: 2014



Source: SEWRPC.

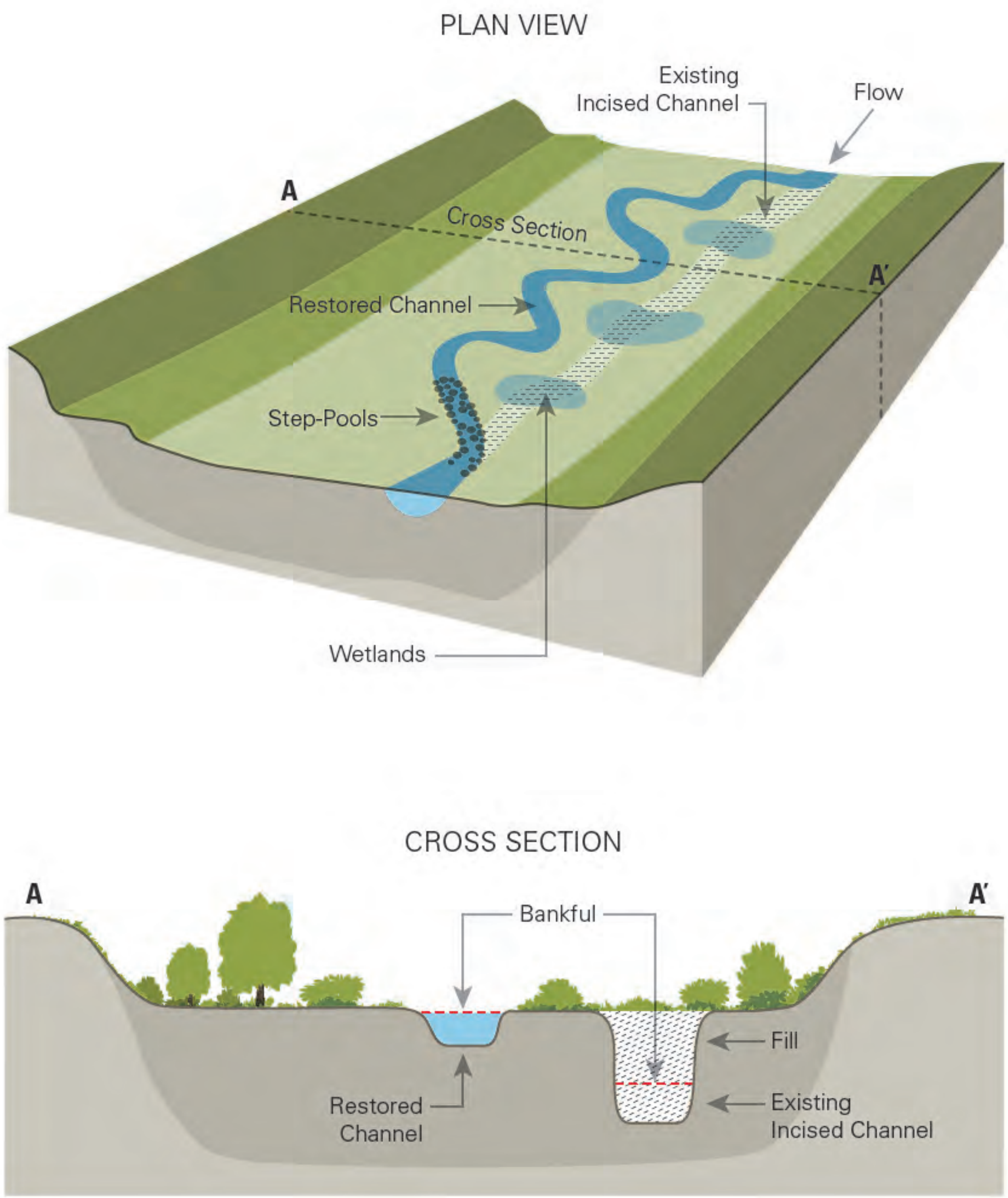
Figure II-38

EXAMPLES OF INSTREAM COVER WITHIN THE MASON CREEK WATERSHED: 2014

Source: SEWRPC.

Figure II-39

POTENTIAL STREAM RESTORATION DESIGN EXAMPLE FOR MASON CREEK TO IMPROVE STREAM FUNCTION THROUGH DIVERTING OR RECONSTRUCTING A MORE NATURAL MEANDERING CHANNEL FROM A CHANNELIZED/INCISED CONDITION



Source: Rosgen Priority Level 1 restoration approach adapted from Harman, W., et al. 2012. A Function-Based Framework for Stream Assessment and Restoration Projects. US Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Washington, DC EPA 843-K-12-006.

Figure II-40

FISH PASSAGE BARRIERS ALONG THE MAINSTEM OF MASON CREEK: 2014

Structure No. 7 at River Mile 0.41-Complete Barrier

- *Private driveway culvert is perched 0.6 feet above water surface limiting fish passage for native fish species for all flows except extreme flooding events, due to limited jumping abilities and/or behavior*

Structure No. 9 at River Mile 0.5—Koester Road,-Complete Barrier

- *Excessive amounts of cobble and boulders piled on the upstream side of culverts causing limited fish passage for native fish species for all flows except for high water events due to limited jumping ability and/or behavior*

Source: SEWRPC

Figure II-40 Continued

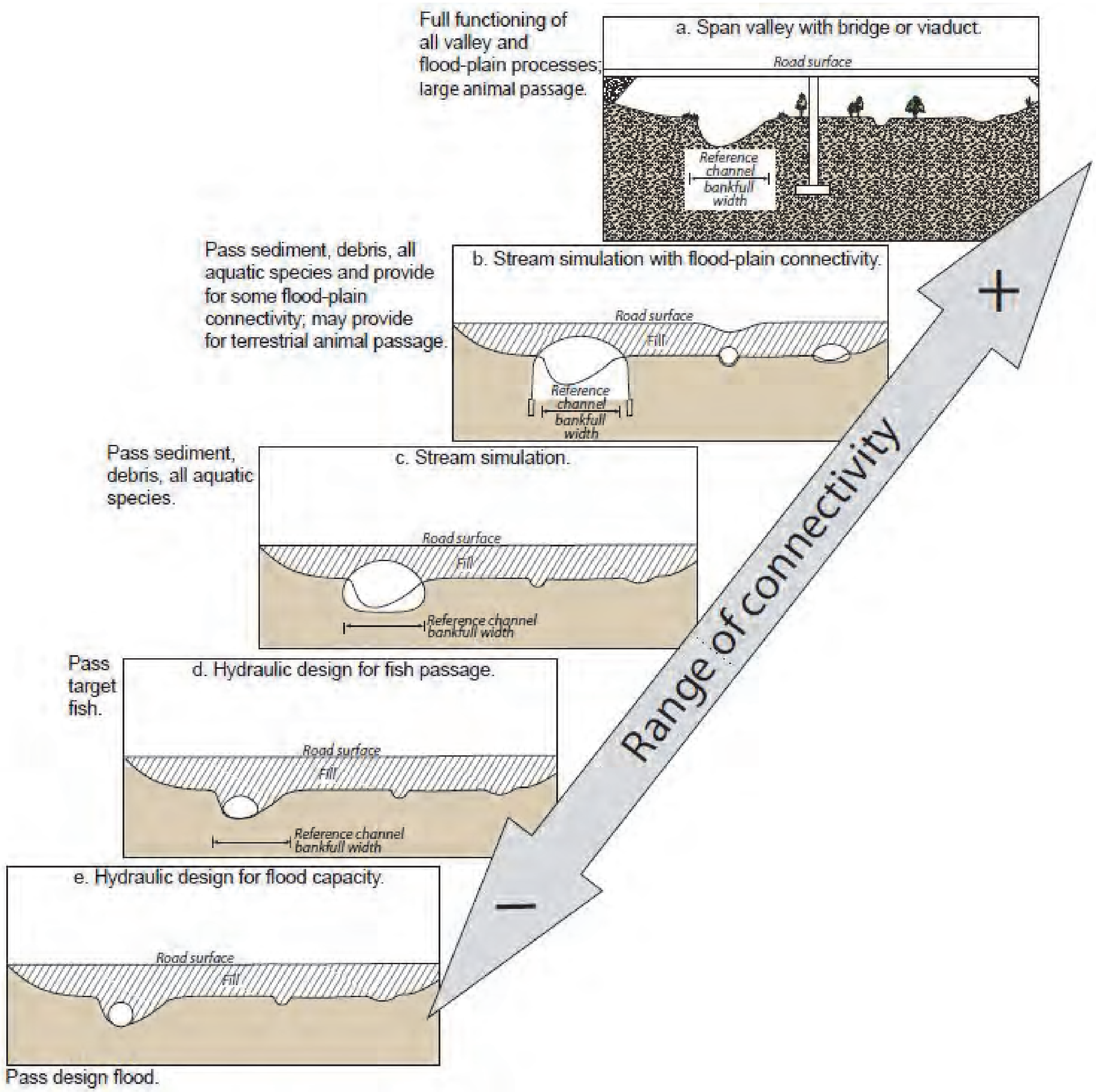
No. 19 at River Mile 0.05 on the East Branch of Mason Creek-Partial Barrier

- *Ford at Private driveway contains shallow water depths with obstructions combined with embedded pipes diverting flow are partially limiting fish passage for native brook trout, particularly at low flows, due to limited jumping abilities and/or swimming behavior*

Source: SEWRPC.

Figure II-41

RANGE OF CROSSING ECOLOGICAL OBJECTIVES AND EXAMPLES OF CORRESPONDING DESIGN APPROACHES



Source: U.S. Department of Agriculture (USDA) Forest Service, Stream Simulation: An Ecological Approach To Providing Passage for Aquatic Organisms at Road Stream Crossings*, Forest Service Stream-Simulation Working Group, National Technology and Development Program, 7700—Transportation Mgmt, 0877 1801—SDTDC, August 2008.*

Figure II-42

TYPICAL EXAMPLES OF ROCK VANE RESTORATION PRACTICES DESIGNED TO IMPOUND WATER AND PROTECT STREAMBANK EROSION, WHILE PROMOTING FISH PASSAGE

J-Hook Vane

A J-hook vane is an upstream pointing line of rocks that originates at one bank and terminates somewhere in the middle of the stream. The most upstream portion of the structure bends back on itself, like a "J," curving into the middle of the channel. This bent portion serves to concentrate flow and scour out a pool while the length closer to the shore deflects flow away from the bank.

Source: Minnesota River Basin Data Center, see website at http://mrbdc.mnsu.edu/

Cross Vanes

Beaver Run Stream Restoration Project Cross-vane Structure--A cross-vane (2-7% slope) has a vane on each side which covers 1/3 of the bankfull width and the invert portion covers the middle 1/3. They are commonly used for grade-control and to reduce nearbank stress by redirecting flow through the center of the channel. It can also considered a habitat improvement structure.

Source: USFWS.

Cross Vane Stream Deflectors within Log Frame

Wallacks Branch Habitat Project (http://fortbedfordtu.org/projects/wallacksbranchhabitat.htm, bedfordcountyconservation.com)

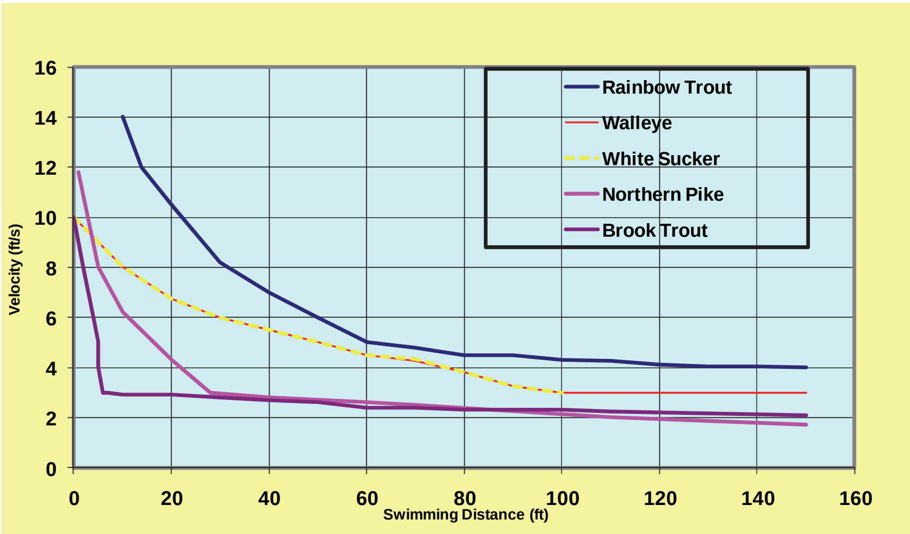
Source: Trout unlimited and Bedford County Conservation District.

Series of Cross Vanes with Large Habitat Boulders

Source: NRCS, see website http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/?cid=stelprdb1043249

Figure II-43

RELATIONSHIP AMONG SPECIES BETWEEN WATER VELOCITY AND FISH SWIMMING ABILITY (DISTANCE BETWEEN RESTING AREAS)



Source: Ontario Ministry of Natural Resources, Environmental Guidelines for Access Roads and Water Crossings*, Toronto, Ontario 64 p. (order from OMNR Information Centre, Toronto 1-800-667-1940), 1988, and SEWRPC.*

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7/13/16, 8/1/2016, 10/31/2016

SEWRPC Community Assistance Planning Report No. 321

MASON CREEK WATERSHED PROTECTION PLAN

Chapter II

MAPS

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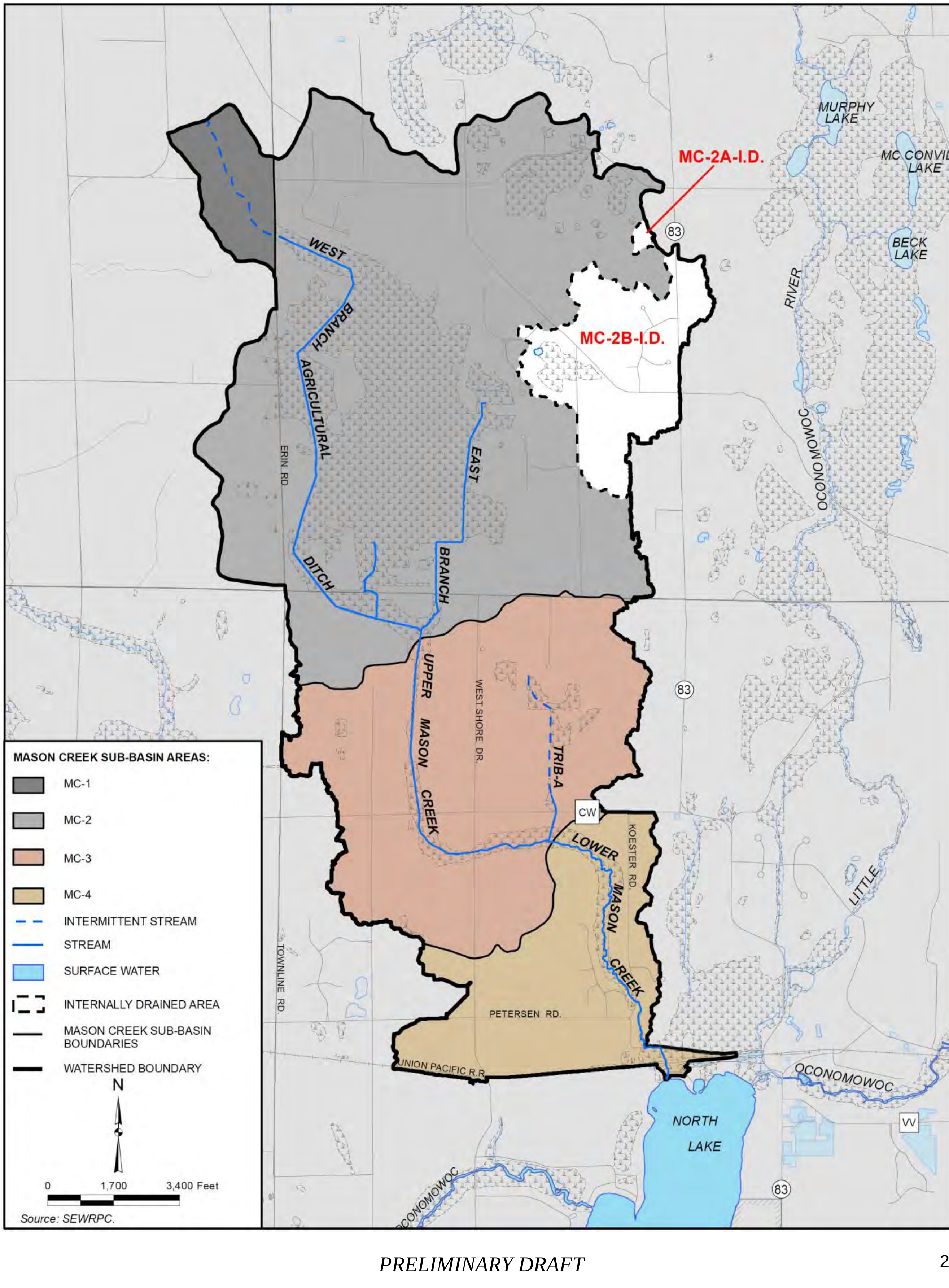
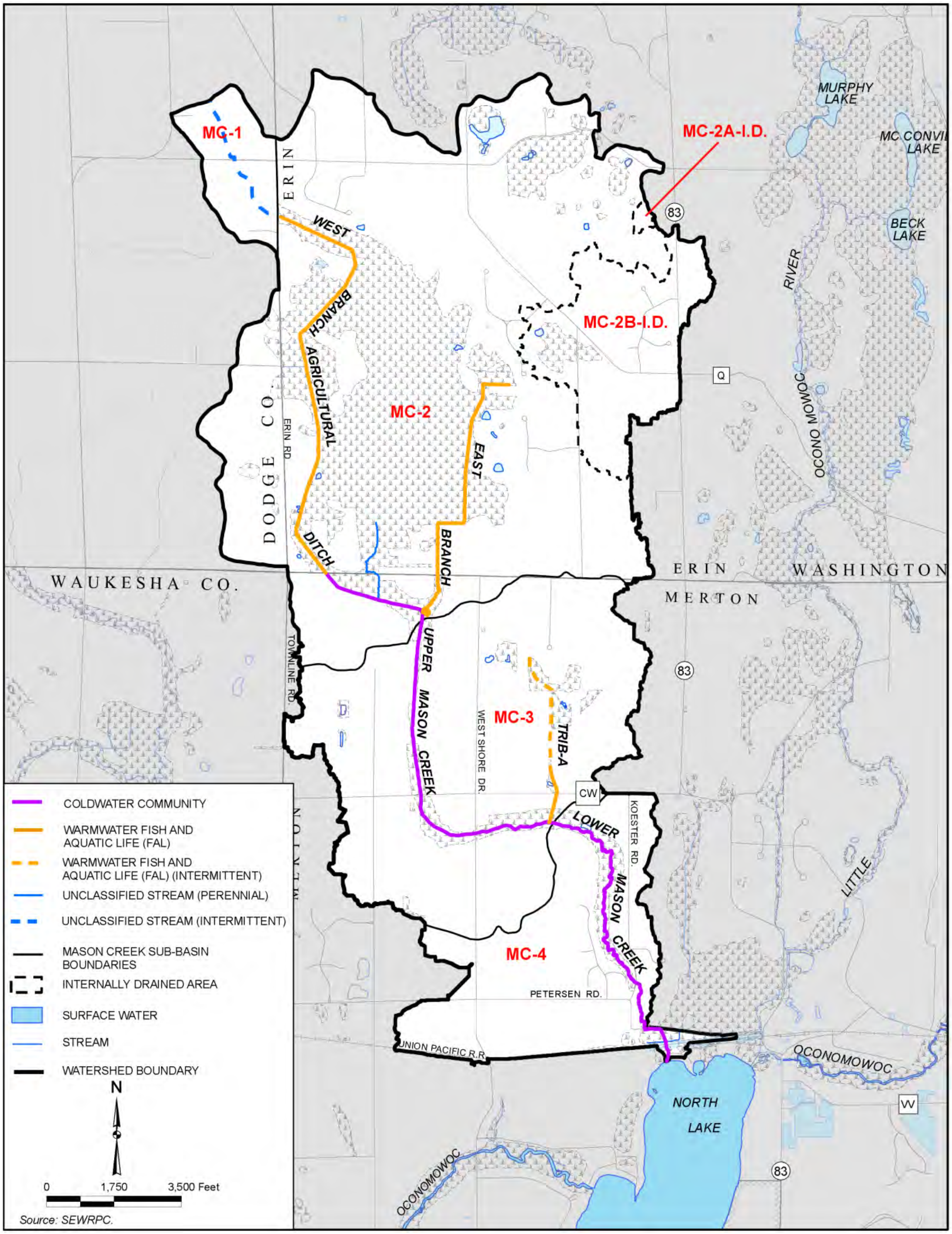
Map II-1

STREAM REACHES AND SUB-BASINS WITHIN THE MASON CREEK WATERSHED: 2015



Map II-2

CURRENT REGULATORY WATER USE OBJECTIVES FOR SURFACE WATERS WITHIN THE MASON CREEK WATERSHED: 2015



Source: SEWRPC.