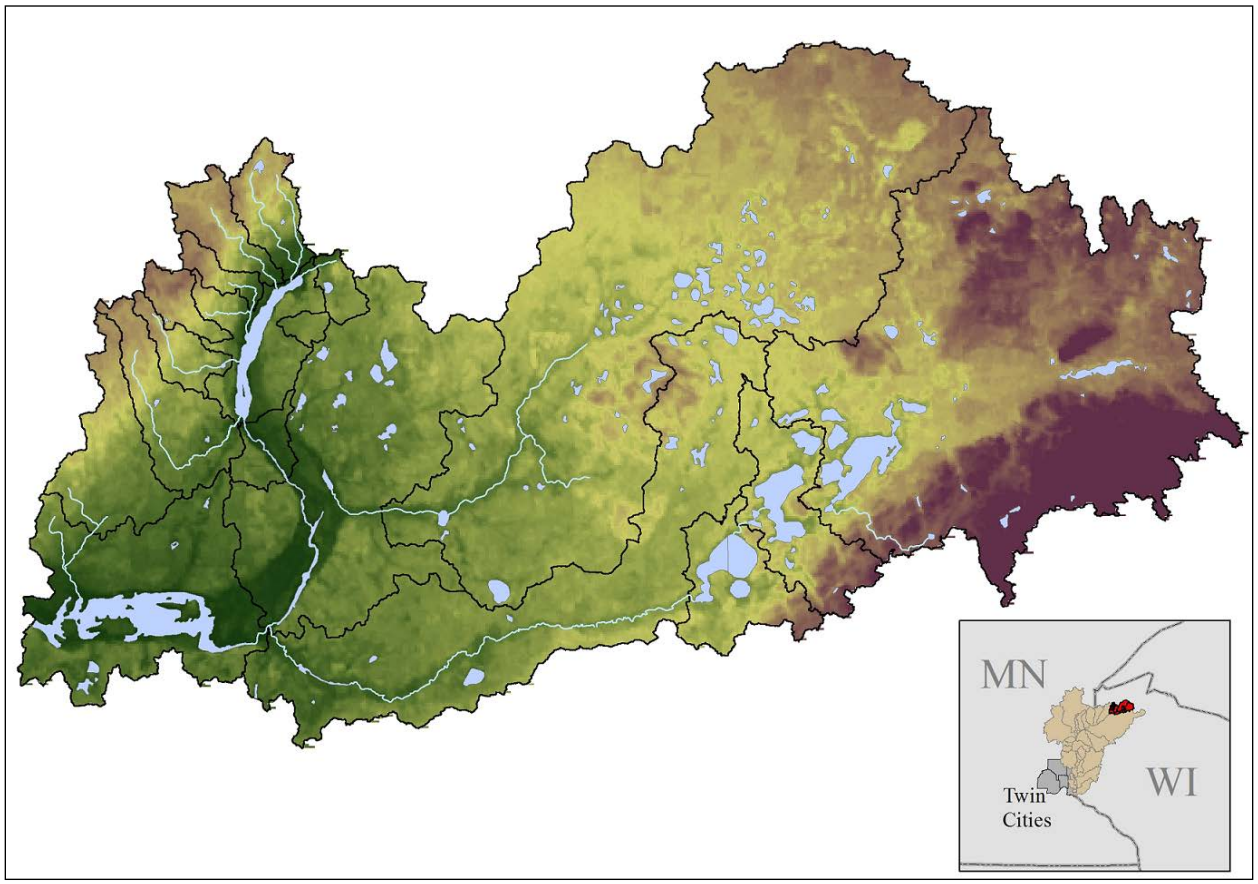
Watershed Study Report

For The

Headwaters of the St. Croix River Basin, WI



November 2013

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TABLE OF CONTENTS

EXECUTIVE SUMMARY 1

1 INTRODUCTION 3
1.1 Project Authority 3
1.2 Report Purpose and Scope 3
1.3 Project Location 4
1.4 Discussion of Prior Studies, Reports, and Existing Water Projects 5

2. PROJECT OBJECTIVES 8
2.1 Problems and Opportunities 8
2.2 Planning Objectives 9
2.3 Watershed Study Approach 10
2.4 Resource Significance 10
2.5 Constraints 11
2.6 Federal Interest Determination 12

3. WATERSHED OVERVIEW 13
3.1 Basic Environmental Characteristics 13
3.2 Social Resources 22

4. EXISTING CONDITIONS FOR PRIORITY WATER RESOURCE ISSUES 26
4.1. Hydrology, Groundwater and Water Quality 26
4.2 Wetland Resources and Functions 38
4.3 Fish Passage and Biotic Connectivity 47
4.4 Aquatic and Riparian Habitat 57
4.5 Invasives Species Management 66
4.6 Water Level Management for St. Croix Flowage 69
4.7 Recreational and Social Resources 69

5. EVALUATION OF POTENTIAL FUTURE DEVELOPMENT **72**
5.1 Overview **72**
5.2 Methods for Forecasting Future Development **74**
5.3 Results **75**
5.4 Influence of Future Build Out on Priority Water Resource Issues **77**
6. RECOMMENDATIONS **82**
6.1 Long Term Goals **82**
6.2 Recommendations **84**
6.3 Resource-Specific Recommendations **91**
6.4 Resource Monitoring Needs **93**
7. COORDINATION AND VIEWS **94**
7.1 Study Coordination and Public Review **94**
7.2 State and Federal Agencies **94**
7.3 Nongovernmental Organizations **94**
7.4 Tribal Interests **94**
8. References **95**

Figure 1 - St. Croix Headwaters Watershed in northwestern Wisconsin. 4
Figure 2 - St. Croix Headwaters Watershed, including elevations (upper map) 5
Figure 3 - Lake St. Croix Sub-watershed Phosphorus Export [load per unit area] 9
Figure 4 - Gordon Dam on the St. Croix Flowage. 13
Figure 5 - Soil types within the St. Croix Headwaters Watershed. Source: USDA-NRCS 15
Figure 6 - Areas of the Headwaters Watershed that are most directly connected to 16
Figure 7 - Drought conditions as identified August 18, 2009. Data source: U.S. Drought 17
Figure 8 - Pigeon Lake in the SCHW during more "typical" water elevations in 2005 17
Figure 9 - Landcover/landuse areas of the SCHW. Source: NLCD 2001 (USGS, 2007). 18
Figure 10 - Relative amount of impervious surface, by sub-basin, for the St. Croix 20
Figure 11 - Relative amount of impervious surface for sub-basins adjacent to 21
Figure 12 - Sampling points for water quality and surface water discharge during 2008 27
Figure 13 - Rainfall events and observed river discharge for the St. Croix River 28
Figure 14 - Comparison between historic and recent total phosphorus concentrations 31
Figure 15 - Annual total phosphorous loading from different watersheds across the 32
Figure 16 - Annual total phosphorous yield from different watersheds across the 32
Figure 17 - Relationship between Secchi depth and total phosphorous concentrations 37
Figure 18 - Water-Table map of SCHW and Surrounding Area. Water table contours in 38
Figure 19 - Wetland areas identified for SCHW for the WWI. 40
Figure 20 - Wetland areas within the SCHW identified as having a moderate or high 43
Figure 21 - Wetland areas within the SCHW identified as having a moderate or 44
Figure 22 - Wetland areas within the SCHW identified as having a moderate or high 45

Figure 23 - Area of the SCHW assessesed for historical wetland mapping. 46
Figure 24 - Dam locations for conceptual fish passage plans. 48
Figure 2 5- Conceptual plan for fish passage at Gordon Dam via bypass channel. 49
Figure 26 - Conceptual plan for fish passage at the Eau Claire Hydropower dam 51
Figure 27 - Ward Dam on the Eau Claire River observed during spring 2009. 52
Figure 28 - Mooney Dam (Lower Eau Claire Lake dam) observed during August 2009 53
Figure 29 -Conceptual plan for fish passage at Mooney Dam via a bypass channel. 54
Figure 3 0- Middle Eau Claire Lake Dam observed during August 2009. Observations 55
Figure 31 - Conceptual plan for fish passage at Middle Eau Claire Lake Dam via a rock rapids .. 55
Figure 32 - Upper Eau Claire Lake dam observed during August 2009 56
Figure 33 - Surface waters with Critical Habitat Mapping performed in the SCHW 58
Figure 34 - Example Critical Habitat Map for Upper Eau Claire Lake. All critical 59
Figure 35 - Average aquatic plant biomass (grams dry weight) from randomly distributed 64
Figure 36 - St. Croix Flowage, formed by Gordon Dam, at the downstream extent of 67
Figure 37 - Brule-St Croix Legacy Forest areas, shown in orange shading, within the SCHW 71
Figure 38 - Early and current parcel patterns in the Town of Barnes in Bayfield County 73
Figure 39 - Existing buildings and parcel patterns (2009) for the SCHW. 75
Figure 40 - Existing (2009) and projected maximum building counts for the SCHW 76
Figure 41 - Existing (2009) and maximum projected building development patterns for 76
Figure 42 - Example: a direct drainage overlay has special provisions in addition to the 86
Figure 43 - An example of a conservation subdivision design from Walworth County, WI. 87
Figure 44 - Landowner A, a farmer, would like to get additional economic return from 87
Figure 45 - Large woody debris placed in the riparian zone on Bony Lake, Bayfield 89

TABLE OF TABLES

Table 1 - Population 22
Table 2 - Percent of Population by Age Group (2010) 22
Table 3 - Housing Units and Status (2010) 23
Table 4 - Per Capita Income 23
Table 5 - Poverty Rate (2006-2010 Estimate) 23
Table 6 - Location description for sampling locations of water quality and surface discharge ... 27
Table 7 - Growing season baseflow conditions at monitoring sites in the SCHW during 2009. . 29
Table 8 - Lakes within the SCHW with total hardness (mg CaCO3) of less than 25mg/l. 35
Table 9 - Total phosphorous criteria (ug/l) for lakes in the SCHW. 35
Table 10 -SCHW lakes with mean summer total phosphorous concentrations exceeding 36
Table 11 - Wisconsin Wetland Inventory (WWI – 2009) 39
Table 12 - Wetland Functional Summary - 2009 41
Table 13 - Critical habitat sites and acreages for select water resources in the SCHW 59
Table 14 - Upper Eau Claire Lake Critical Habitat Site Justifications. Justification definitions 60
Table 15 - Critical Habitat Justification Descriptions 60
Table 16 - Estimated percent impervious surface within 300ft of identified waterbodies 62
Table 17 - Douglas County Waterbodies within the SCHW with identified AIS 62

Table 18 - Bayfield County Waterbodies within the SCHW with identified AIS 63
Table 19 - Estimated percent impervious surface, existing primary structures and projected ... 79

APPENDIXES

A Evaluations of Hydrology, Groundwater and Water Quality
A1. Limnological and Loading Response Analysis of St. Croix Flowage, Upper St. Croix River Watershed, Wisconsin
B Wetlands Resources
C Critical Habitat Assessments for Select Water Resources
D Invasive Species
E Watershed Build-Out Analysis
F Additional Project Data

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Executive Summary

A watershed study was performed for the St. Croix Headwaters Watershed (SCHW), including areas upstream of Gordon Dam near Gordon, WI. The study focused on priority water resource issues identified through collaboration with the local sponsor and stakeholders. This included evaluating existing conditions for water quality; wetlands presence and function; aquatic habitat; fish passage; aquatic invasive species and St. Croix Flowage Management. Potential for future development was also assessed, including potential impacts of development on priority water resources. Finally, recommendations were made to direct future watershed management. Findings generally include the following:

Existing water quality conditions are generally good for area lakes and rivers. Total phosphorus and suspended sediment concentrations are low when compared to similar watersheds in Wisconsin. Individual waterbodies such as Upper St. Croix and Pickerel lakes had phosphorus concentrations above criteria values and would be targets for future action. External efforts such as the Lake St. Croix TMDL do have slightly lower future phosphorus loading targets for the Headwaters area, and future management could target BMPs to help meet these targets.

Detailed wetlands mapping using the Wisconsin Wetland Inventory classification system identified 30,809 acres of wetlands in the watershed. This compares to 20,693 acres with existing available wetland maps. The reason for the increase includes improved mapping methods and high-resolution imagery, allowing for improved mapping resolution. A functional assessment was performed through collaboration of stakeholders, and local and regional wetlands experts familiar with the study area. These experts collaboratively identified wetland functions of greatest interest for the SCHW, including surface water detention, nutrient transformation and shoreline stabilization. These wetland functional areas were mapped, allowing resource managers to understand which wetlands performed given functions at key points in the watershed.

The watershed study evaluated potential opportunities for fish passage at several barriers on the St. Croix and Eau Claire rivers. Conceptual plans for fish passage were identified for these locations. No projects were identified for federal construction, but may be pursued by local interests.

In addition to fish passage opportunities, important aquatic habitat areas (hereafter referred to as "critical habitat") were mapped on 14 different waterbodies, including Upper St. Croix Lake, the St. Croix Flowage, and several lakes within and near the Eau Claire lakes chain. This mapping identifies specific habitat areas that are especially worthy of future protection. An assessment of riparian impervious surfaces was also performed for most lakes in the watershed and helps identify riparian areas that may be most disturbed from existing development. Waters with the some of the highest levels of imperviousness include Island (Bayfield Co.), Upper St. Croix, Ellison, Pickerel and the Eau Claire chain. Lakes with high level of disturbance could be targets for riparian habitat protection and restoration.

For Aquatic Invasive Species, existing data was supplemented with field surveys to better understand the status of various AIS within the watershed. Potential management measures are discussed, as well as what actions could be taken when new infestations are identified.

Water level management in the St. Croix Flowage is largely dictated by State regulatory requirements. There are significant limitations on how water level elevations could be manipulated within the confines

of state law. Although water levels might be manipulated to control aquatic vegetation or for recreational interests, such measures would come at the risk of disrupting an ecosystem that provides great fish and wildlife habitat, and functions as a periodic sink for phosphorus. Any changes to existing management would require very careful scrutiny and thorough collaboration among stakeholders, including tribal interests.

To understand potential risks from future development, a build-out analysis was conducted to demonstrate where maximum development would occur based on existing regulations and zoning ordinances. It is unknown if or when maximum development would occur in the future. However, between 7,000 and 8,000 new structures could be built within the existing regulatory limits. Existing zoning and regulations would focus much of this development on riparian areas, or areas that have directly connected drainage to the St. Croix and Eau Claire river systems.

Maximum future development would likely increase the risk of lower water quality. Changes would probably be modest for the broader watershed, but could be greater for individual waterbodies. Though systemic increases may be modest, future development could still hinder the ability to meet phosphorus reduction goals for this watershed, as identified in the Lake St. Croix TMDL. Increased development could also result in more disturbance to riparian areas and potentially impact critical habitat. Lakes that could have the greatest increases in riparian zone development include Upper St. Croix and the Eau Claire chain of lakes. While smaller lakes may not have as many individual new properties under development pressure, the relative contribution of future development could still be problematic.

In addition to suggestions noted above, the study includes many basic recommendations for protection of both systemic and site-specific resources. Priority areas of concern include both systemic and site-specific water quality; habitat and riparian zone protection; invasive species management; fish passage improvement and management of St. Croix Flowage. Recommendations include actions that can be undertaken by stakeholders such as improved land use and property management, smart development, stormwater management and other similar activities.

While this study characterizes existing and potential future conditions, and makes recommendations to potentially meet future objectives, the reality is that environmental conditions and stakeholder priorities change over time. Any of the recommendations provided herein should be revisited and considered collaboratively by basin stakeholders moving forward. Stakeholders should work together to refine watershed priorities and management actions to meet these priorities. Their efforts should also include monitoring to evaluate the effectiveness of various actions. Ultimately, successful watershed management can only be done collaboratively and adaptively over time to meet changing conditions. This study provides the baseline for beginning this process, but basin stakeholders must take the initiative to work together on challenging issues moving forward.

1 INTRODUCTION

1.1 Project Authority

The St. Croix Headwaters Watershed Study is authorized by a Resolution of the Committee on Transportation and Infrastructure of the U.S. House of Representatives, September 25, 2002:

> *Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, that the Secretary of the Army is requested to review the report of the Chief of Engineers on the St Croix River, Wisconsin and Minnesota, published as House Document 462, 71st Congress, 2nd Session, and other pertinent reports to determine whether modifications to the recommendations contained therein are advisable at the present time in the interest of flood damage reduction, environmental restoration and protection, water quality and related purposes to include developing a comprehensive coordinated watershed management plan for the development, conservation, and utilization of water and related land resources in the St Croix River Basin and its tributaries.*

The St. Croix Headwaters Watershed Study was included in the ST. CROIX RIVER BASIN RECONNAISSANCE STUDY 905(b) Analysis Report (USACE 2007), which was approved on March 8, 2007. That report included a series of recommendations including integrated watershed analysis and detailed planning for several St. Croix Basin Subwatersheds, including the Upper St. Croix River. Federal (Corps of Engineers) interest in the St. Croix Headwaters is based on the potential local and systemic benefits of a watershed study.

During the spring of 2007, the Wisconsin Department of Natural Resources (WiDNR) expressed an interest in partnering on a detailed feasibility study for the Upper St. Croix River. Based on the recommendations contained in the 905(b) report, as well as interest expressed by WiDNR, the federal government entered into a Feasibility Cost Share Agreement on October 26, 2007. The study was cost shared 50/50 between the non-federal sponsors and the federal government.

1.2 Report Purpose and Scope

The primary purpose of this study is to provide an overview of existing conditions for key water resources in the upper St. Croix River Basin Headwaters, and guide watershed management activities, including efforts to maintain or restore water quality, aquatic and wetland habitats, and address other water resource issues. Concerns will be addressed within a watershed context, linking conditions on the landscape with key water resource issues. Connections also will be drawn to link environmental values with social and economic values.

Although the St. Croix River Headwaters Watershed (SCHW) is generally considered to be of good quality, there is concern that habitat has and will continue to degrade. Since significant watershed protection has been proposed for the broader St. Croix River Basin, it's appropriate that a watershed study should be performed for the headwaters to protect water quality and aquatic habitat in this area. This will help ensure water flowing in the St. Croix River is of appropriate quality to meet aquatic habitat objectives at locations further downstream.

Aquatic resource issues evaluated during this study were primarily environmental in nature. The study also investigated opportunities for Federal (Corps) construction projects in support of primary watershed objectives. No such opportunities for future U.S. Army, Corps of Engineers (USACE) engineering and construction projects were identified. However, recommendations have been made for other entities, primarily local government, to act to preserve water quality and environmental conditions.

1.3 Project Location

The study area includes the entire SCHW upstream of Gordon Dam near Gordon, WI (Figures 1 and 2). This includes nearly 335 square miles, split between Douglas and Bayfield counties in Wisconsin. Major tributaries include the St. Croix and Eau Claire Rivers. The watershed includes many miles of stream, river and lake habitat, as well as wetland and uplands.

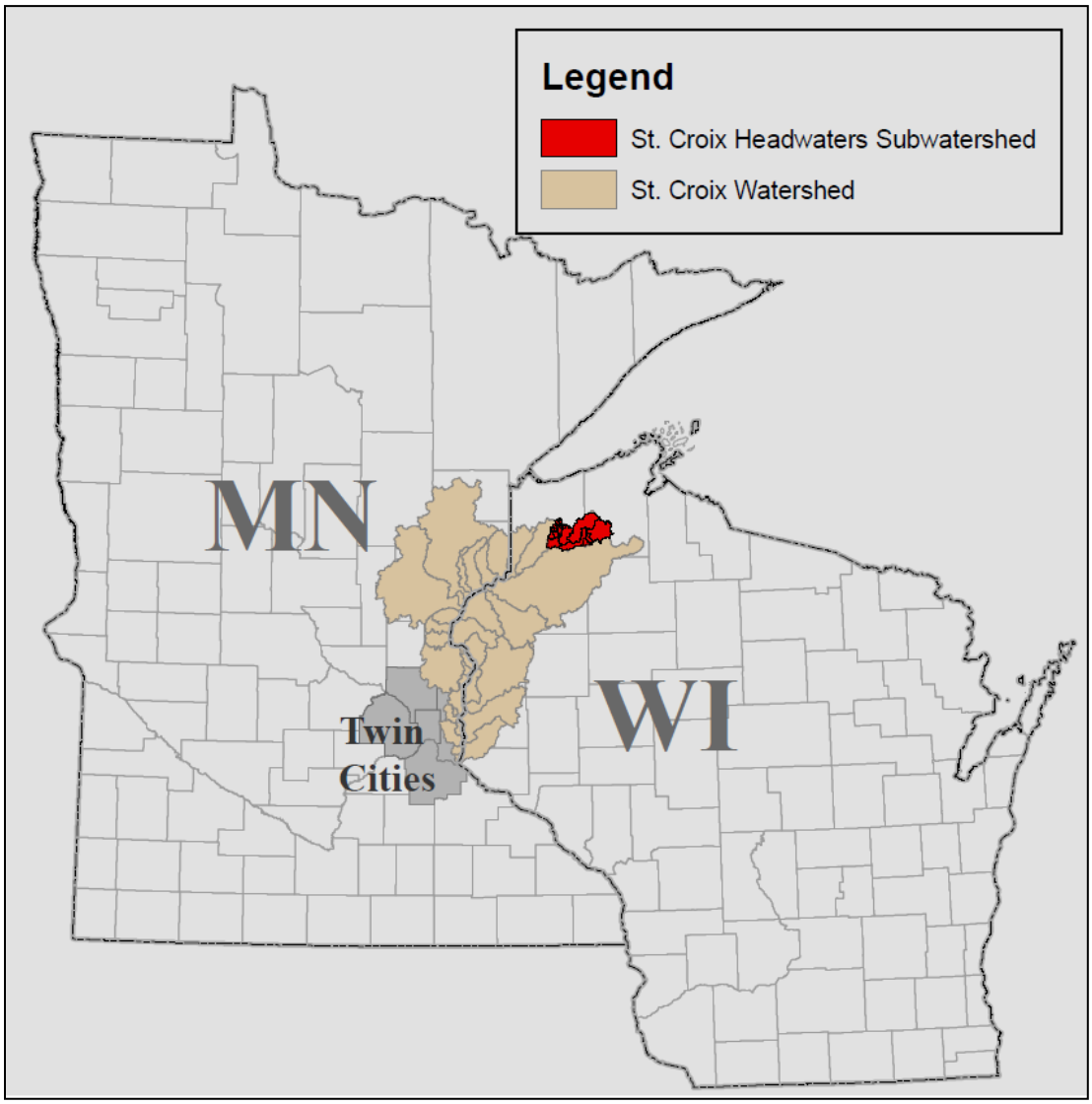

Figure 1 - St. Croix Headwaters Watershed in northwestern Wisconsin.

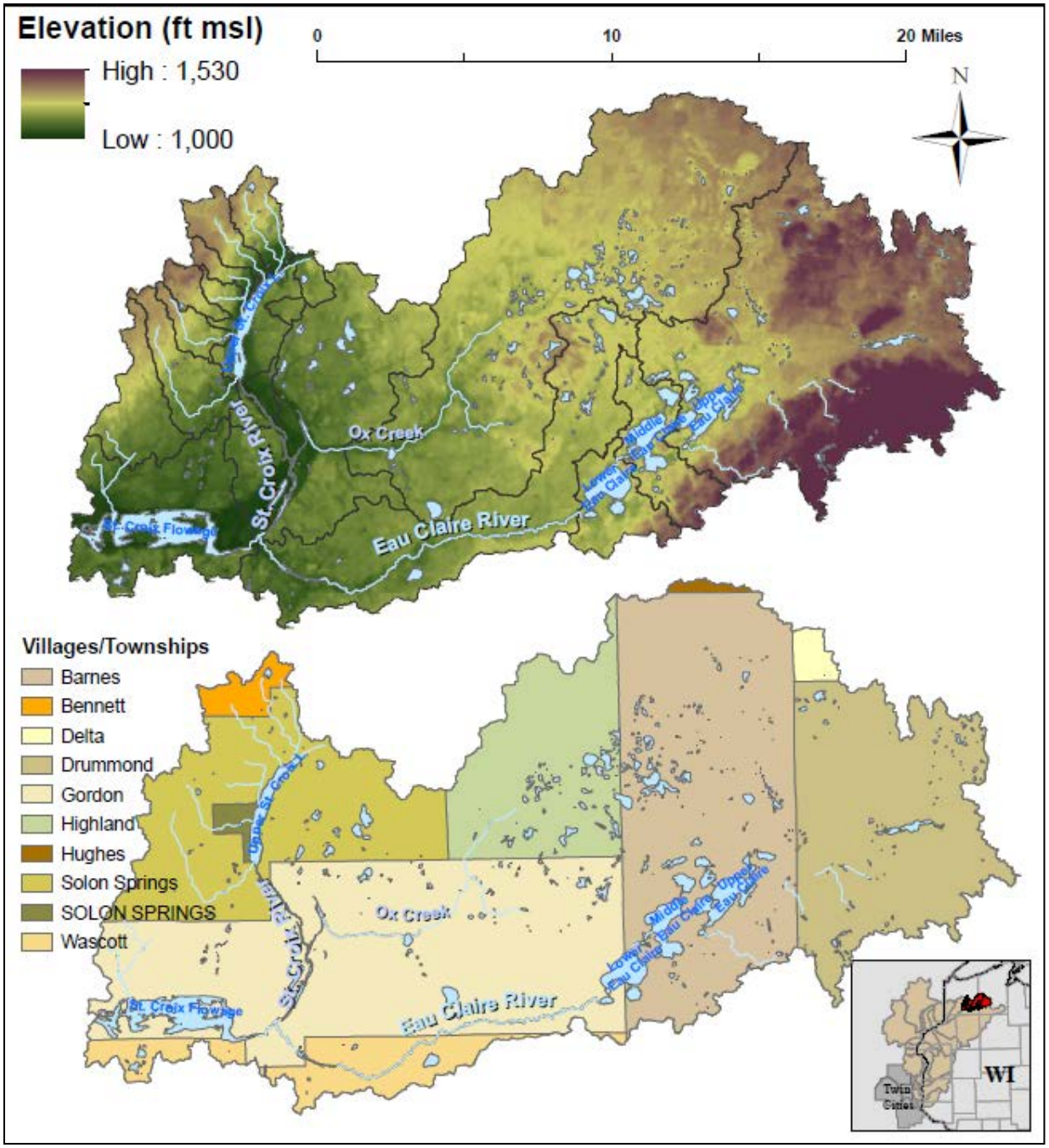

Figure 2 - St. Croix Headwaters Watershed, including elevations (upper map) and villages and townships (lower map).

1.4 Discussion of Prior Studies, Reports, and Existing Water Projects

<u>Applicable studies, reports, and projects include the following:</u>

- Lake St. Croix Total Maximum Daily Load. Prepared in Partnership by Minnesota Pollution Control Agency and Wisconsin Department of Natural Resources; with St. Croix Basin Water

Resources Planning Team, Science Museum of Minnesota, St. Croix Watershed Research Station and Barr Engineering Company. Final May 2012.

- USACE, USDA and the Village of Solon Springs partnered for construction improvements to the Solon Springs wastewater treatment facility. The facility, originally constructed in the 1970s, was undersized, no longer met water quality standards and had leaky force mains. The project, constructed under the Section 154 Northern Wisconsin Environmental Infrastructure Program, has been completed, with dedication on 20 April 2012.

- Tomahawk and Sandbar Lake Aquatic Plant Management Plans: Eurasian Watermilfoil Management & Control in Northern Clear-Water Systems. Report produced by Wisconsin DNR and Town of Barnes. 2010.

- Bony Lakewide Restoration and Conservation Project. Bayfield County Land and Water Conservation Department. 2007 thru 2013.

- Eau Claire Lakes Lake Management Plan. Town of Barnes. Also available via Wisconsin DNR. December 2006.

- ST. CROIX RIVER BASIN RECONNAISSANCE STUDY Section 905(b) Analysis (Water Resources Development Act of 1986) Minnesota and Wisconsin; USACE, St. Paul District; January 2007.

- St. Croix basin phosphorus-based water-quality goals. St. Croix Basin Water Re-sources Planning Team, August 2004. Davis, P. 2004.

- Pilot Study of Fluctuating Lake Levels on the Upper St. Croix Lake, Southwestern Douglas County, Wisconsin. University of Wisconsin – Superior. 2001.

- Upper St. Croix and Eau Claire Rivers Priority Watershed Surface Water Resources Appraisal Report. Wisconsin DNR, 1997.

- Upper St Croix Flowage Land Acquisition-Bell Trust/Wilcox Island. Douglas County acquired 128 acres of land on the St. Croix Flowage to protect the headwaters of the St. Croix Scenic Riverway. Purchased in 1996.

- St. Croix River Final Feasibility Report (July 1986): The St. Paul District, Corps of Engineers, report was prepared as a follow-up to the 1984 reconnaissance report. Detailed analysis was performed for flood damage reduction at Stillwater and New Richmond. No structural or nonstructural plans were feasible for Stillwater. At New Richmond, tentative plans for flood damage reduction were formulated. However, the community decided not to participate.

- St. Croix River Reconnaissance Report (January 1984): The St. Paul District, Corps of Engineers, prepared this report to update the evaluation of flood problems and needs in the St. Croix River basin and describe the proposed conduct of this feasibility study.

- FINDINGS OF FACT, CONCLUSIONS OF LAW AND ORDER In the Matter of the Investigation on Motion of the Department of Natural Resources of Complaints of High Water Levels and

Resulting Property Damage In Upper St. Croix Lake, Douglas County, Wisconsin. 3-NH-79-801. WiDNR response following a State hearing. Wisconsin DNR. 1980. (Contained at Appendix F).

- Water Resources Subregion Plan for the Saint Croix River Basin (June 1979). Prepared by the Upper Mississippi River Basin Commission to describe existing conditions in the basin and recommend a comprehensive water resources plan for the region.

- Upper Mississippi River Comprehensive Basin Study (1972): This report, completed by the Upper Mississippi River Basin Coordinating Committee, suggested a potential flood control project on the St. Croix River consisting of a reservoir near St. Croix Falls

- The St. Croix National Scenic Riverway, which includes both the Namekagon and St. Croix Rivers, was established in 1968 under the National Wild and Scenic Rivers Act. This riverway begins immediately downstream of Gordon Dam.

- Phase I Report on Study of Flood Control and Related Purposes for St. Croix River Basin, Minnesota and Wisconsin (January 12, 1968): The report examined various problems and needs in the basin including flood control, navigation, water power, irrigation, watershed protection, land drainage, fish and wildlife needs, and recreation. The report concluded that reservoirs would best meet the objectives of an overall plan, and recommended further study of a multiple-purpose reservoir near St. Croix Falls. The study also found that a local flood protection project was feasible for Stillwater, but this measure was not included in the recommended plan. Further study was not begun because of the pending St. Croix Wild and Scenic River designation.

- Plan of Survey for Flood Control and Related Purposes, St. Croix River, Minnesota and Wisconsin (May 10, 1966): This report was prepared by the St. Paul District, Corps of Engineers, and recommended a study to determine the most suitable plan for a multiple-purpose development to meet the water resource needs of the St. Croix River basin, estimate the cost of improvements selected, and determine the economic feasibility of the improvements.

- Review of Reports on St. Croix River, Minnesota and Wisconsin, at Hudson, Wisconsin (January31, 1940): Prepared by the U.S. Engineer Office, St. Paul. The report found that the need for a small-boat harbor at Hudson was local and that Federal participation in such a development was not justified. A review of reports on the St. Croix River at Stillwater, dated April 24, 1940, recommended no further work.

- Several efforts have been performed through the watershed for AIS monitoring, inspection, eradication/control, and education/public outreach related to AIS. Lakes of interest include Upper St. Croix Lake, St. Croix Flowage, Upper, Middle and Lower Eau Claire lakes; Robinson, Island, George, Tomahawk and Sandbar lakes. Efforts typically lead by local entities through funding support from Wisconsin DNR.

- Multiple efforts targeted for improved management of Upper St. Croix Lake.

- Public outreach on improved lake management and watershed conditions performed frequently by Wisconsin DNR and local Non-Governmental Organizations.

2. PROJECT OBJECTIVES

2.1 Problems and Opportunities

Problems and Opportunities for the St. Croix Watershed

A description of problems and opportunities for the broader St. Croix Watershed is provided in the 905(b) Reconnaissance Report (USACE 2007). Key issues will be summarized here.

Recent problems and opportunities have most frequently focused on environmental concerns including: elevated sediment and nutrient loading to the St. Croix River; loss of aquatic and riparian habitat; aquatic invasive species; and endangered aquatic species. Watershed planning was favorably sought as a way to holistically address environmental concerns in the basin. Some concerns with flooding have previously been identified, though recent concerns were relatively smaller in scale and involved few people. No focused flood damage reductions needs were identified through the 905b.

WiDNR (2002) identified a list of its priority water resource issues for the St. Croix River basin. From this list, the top three were identified as a top priority:

1. Shoreland (lakes and rivers) habitat protection and restoration.
2. Nonpoint source runoff contamination of surface water.
3. Cooperation with grassland/prairie and wetland restoration initiatives to protect water quality and enhance wildlife habitat.

Detailed planning for St. Croix Basin phosphorous management has been underway for several years. It culminated in a Final Total Maximum Daily Load (TMDL) study for Nutrients, produced in partnership between the Minnesota Pollution Control Agency and the Wisconsin Department of Natural Resources (TMDL 2012; Figure 3). Through this lengthy process, the TMDL has proposed a standard of 40 µg/L total phosphorus (June through September mean concentration) be implemented for protection of Lake St. Croix (lower St. Croix River). Extensive study indicates that this level best represents the unimpaired state of the lake in the 1940s prior to extensive land use changes in the basin and the modernization of agricultural practices (TMDL 2012). The TMDL also sets goals of 12 µg/L Chlorophyll-a, and 1.5 m, Secchi depth.

The Upper St. Croix Watershed (which includes an area slightly larger, about 475 mi^2, than the SCHW discussed here) has one of the lowest total phosphorous yields in the entire St. Croix Basin with phosphorous exports of about 0.10 kg/ha-yr. Almost all of this loading is from natural sources. The TMDL targets a goal of phosphorous export reduction of 5% (about 600kg/yr) to meet phosphorous targets in Lake St. Croix (TMDL 2012).

Problems and Opportunities for the St. Croix Headwaters Watershed

Existing and potential future development may impact the high quality environmental resources of the watershed. Study interests were almost entirely environmental. In general, environmental conditions within the watershed are very good. However, there are signs of degradation, particularly within areas of heavier development. Degradation will continue in the future with additional development, particularly if development progresses without careful management.

A focused effort was made to identify key water resource issues for consideration within this watershed

study. Problems or concerns identified by the sponsor and local constituents included the following:

- Elevated nutrient levels and loading to lakes, tributaries and St. Croix River.
- Lack of understanding of groundwater quality and movement
- Limited knowledge of existing wetland conditions.
- Loss of wetland habitat and wetland function.
- Reduced habitat quality, particularly for riparian habitat and sensitive aquatic habitat.
- Continued spread and resulting impacts of invasive species.
- Potential impact of dams on the diversity of fish and related aquatic resources.
- Water level management on St. Croix Flowage (reservoir above Gordon Dam) as it relates to conditions both within and upstream of the flowage. This includes:
    - Abundant aquatic vegetation in the flowage
    - Influence on water elevations above the flowage, including Upper St. Croix Lake.

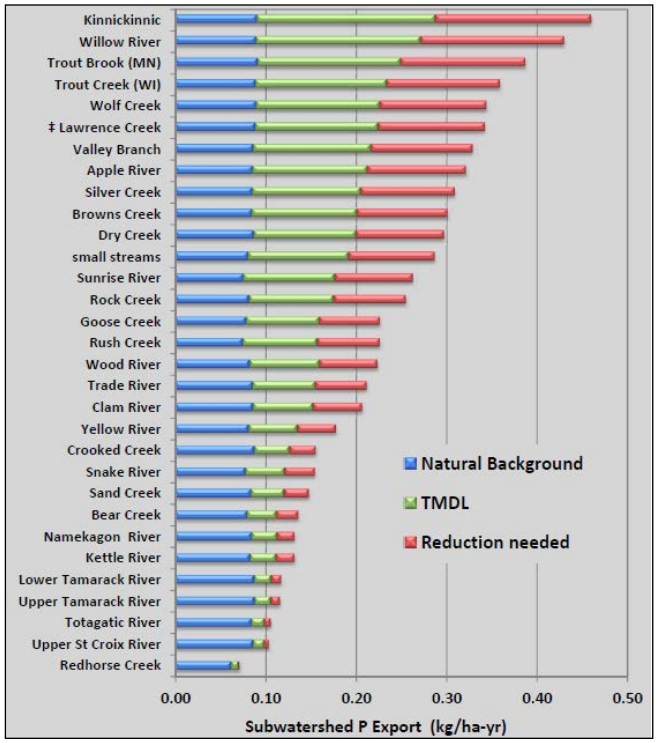

Figure 3 - Lake St. Croix Sub-watershed Phosphorus Export [load per unit area] for all major subwatersheds. Upper St. Croix Watershed is slightly larger than St. Croix Headwaters Watershed. (Source TMDL 2012)

The problems identified above present opportunities to better evaluate these issues, and provide recommendations for how they can be addressed. This could include anything from simple Best Management Practices (BMPs) for land use, to construction projects for habitat restoration or similar measures. Future smart development also could be employed to ensure the protection of the watershed's high quality resources. This report will identify potential actions, including what entities may be able to act on these recommendations. Local stakeholders strongly desire specific actions they can work at to address specific concerns outlined above.

2.2 Planning Objectives

The overarching goals for this study include characterizing existing conditions, potential future conditions, and identifying opportunities to protect and improve environmental resources and ecosystem functions. The water and related land resource problems and opportunities identified represent planning objectives to provide focus for the recommendation of future activities for environmental protection.

2.3 Watershed Study Approach

Building upon these identified watershed problems, opportunities and objectives, collaboration with the sponsor and local stakeholders identified a series of specific priority issues for analysis within this watershed study.

Priority Water Resource Issues Evaluated:

1. Water quality, including nutrient and sediment transfer
2. Wetland evaluation and functional assessment
3. Aquatic and Riparian Habitat Conditions and Restoration
4. Invasive Species Management
5. Water level management of St. Croix Flowage
6. Comprehensive fish passage improvement
7. Recreational and social resource planning.

The study characterizes existing conditions for each of these priority water resource issues. Given the primary concern is protection of resources from the effects of future development, a build-out analysis was performed. A build-out analysis projects where maximum future development can occur based on current zoning practices, environmental conditions (e.g., wetland areas), and other considerations. Information from the build-out analysis was then used to assess how maximum future development might affect future resource conditions for these primary issues. Based on these results, recommendations are provided to minimize the effects of future development on water resources.

2.4 Resource Significance

St. Croix Basin

Resources of the St. Croix River basin are ecologically, economically, and culturally significant. At least four federally listed endangered mussel species occur in the basin: the Higgins' eye pearly mussel (*Lampsilis higginsii*), winged mapleleaf (*Quadrula fragosa*), snuffbox (*Epioblasma triquetra*) and spectaclecase (*Cumberlandia monodonta*). The winged mapleleaf is especially representative in that it was historically found in 34 rivers in 12 States. Habitat degradation has reduced winged mapleleaf to only a couple remaining populations in the world, one of which is a confirmed reproducing population limited to a single stretch of the St. Croix River. Given their life history, mussels are excellent indicators of habitat quality. The high-quality habitat provided by this midsize river is extremely rare.

In addition to its ecological importance, the St. Croix River basin is heavily used for recreation. The St. Croix National Scenic Riverway, which extends 252 miles, includes the majority of both the St. Croix and Namekagon Rivers. The upstream extent of the Wild and Scenic River designation begin at Gordon Dam of the St. Croix Flowage.

Given its proximity to Minneapolis/St. Paul, as well as several communities in western Wisconsin, the basin is within easy access of more than 3 million people. This proximity subjects the watershed not only to heavy recreational use, but also to development and growth. This increases the potential for stressors to impact water resources within the basin.

In addition to the ecological, recreational and aesthetic resources identified above, the basin also provides important economic values. The southern part of the basin includes extensive agricultural use that provides important economic income for the area. Recreational use of the basin brings in tourism dollars. Urban growth and development in the area has been and will continue to be important for the local economy, especially in the southern part of the basin.

St. Croix Headwaters Watershed

Significance will be described in terms of technical, public and institutional significance, as required by USACE policy (ER 1105-2-100).

The SCHW is the source of water for the valuable St. Croix Basin described above. As such, the SCHW is critical in determining water quality, sediment transport and other functions that drive habitat quality in the downstream St. Croix River. The SCHW is itself generally considered of exceptional quality for a range of valuable water resources. This includes great water quality, aquatic habitat and wetland resources. The watershed has 160 miles of streams and rivers, 197 lakes and almost 38,000 acres of wetlands. For these reasons, the SCHW is technically significant.

Recreational use of the basin is high and brings in dollars through tourism and recreation. Land in the area, particularly water front property, is highly desirable and important revenue via property taxes. Various public users have voiced concern over protection of environmental quality of the SCHW. For these reasons, the SCHW is publically significant.

As outlined above, the downstream extent of the SCHW marks the beginning of the National Wild and Scenic River designation for the St. Croix River. The State of Wisconsin thinks so favorably of this area that in May 2012 it announced its intention to make the largest recreational and forest land acquisition in state history, an easement on 67,346.8 forest acres in the St. Croix headwaters area of Douglas, Bayfield, Burnett and Washburn counties. The purchase – known as the Brule-St. Croix Legacy Forest - includes large areas within this watershed. Phase I, completed in 2012, included approximately 40 square miles within the SCHW. Phase II, which is still in planning, would include additional watershed area. If both Phase I and II are completed, this transaction will cost the State of Wisconsin over $17 million. Wisconsin DNR has identified that the purchase would provide public access to areas that will otherwise be maintained solely for forest production. The Forest Legacy Program, which is a strong partnership with the US Forest Service, supports efforts to protect private forest land from being converted to non-forest use. Sustainable timber harvest would still be allowed, meaning the area would still provide local and regional economic benefits. However, through careful management, the area also will provide valuable habitat and hopefully have minimal adverse effects to water resources. For these reasons, the SCHW is institutionally significant.

2.5 Constraints

Constraints are factors that restricted the planning process or implementation of features. Constraints include legal, policy, resource and environmental factors. The study authorization provides the initial study boundaries. In this case, the authorization is quite broad, with the study limited to evaluation of water resource issues within the SCHW. Priority issues were identified through collaboration with the project sponsor and received the majority of project focus. Project funding also was a constraint for both USACE and WiDNR and limited the scope and depth of analyses performed.

2.6 Federal Interest Determination

Opportunities were sought during this study for potential USACE construction projects. Primary focus was for environmental restoration, and considered opportunities in the watershed for fish passage, dam removal, wetlands restoration, riparian corridor restoration, and other opportunities. However, no projects were identified that would be good candidates for USACE involvement.

This study discusses several potential fish passage projects in Section 4. However, all of these projects would be best handled by local government or other interested parties. They likely would not involve detailed engineering solutions, and/or could likely be implemented with relatively low cost measures. These types of projects are not strongly suited to USACE participation, and are more effectively pursued at local levels. This study does include conceptual ideas for fish passage projects at specific sites based on similar projects that have been built regionally. In the case of dam removal, interest was expressed with removal of a local hydropower dam that had not operated for several years. Local stakeholders were interested in the benefits of removal and were concerned if the dam was in disrepair it might be at risk for failure. However, discussions with the dam owner revealed plans to renovate the dam and resume hydropower operations.

The study determined that wetland restoration opportunities are limited in the basin, and the best potential site would have included project costs largely focused on real estate transactions with minimal design or construction work needed. Riparian habitat restoration is a strong need in the basin, particularly on area lakes. These however would be very basic projects better accomplished through local initiatives.

In the absence of any realistic potential projects, this study did not perform detailed alternatives formulation, design or cost estimation, and no formal cost-benefits analyses were performed. The study did not identify any implementable USACE projects, or other needs for more detailed study or USACE participation. However, it should be reiterated that these analyses and recommendations provide important guidance to local water resource managers, and will positively benefit the SCHW and its many residents and users.

3. WATERSHED OVERVIEW

The following section provides a brief overview of existing conditions for water resources, along with a brief summary of economic and social resources. Detailed discussion of priority water resources issues identified for evaluation through this study is presented in Section 4.

3.1 Basic Environmental Characteristics

Watershed Delineation

A surface watershed is the land area where runoff from precipitation drains to a waterbody or wetland. A watershed is determined by topography and drainage patterns. The process for delineation of this watershed is outlined in Appendix A. Watershed boundaries were first generated in GIS using specialized software and digital elevation models. The watershed boundaries depicted in this report were created using the most up to date 10-meter resolution digital elevation model available at the time from the U.S. Geological Survey (high-resolution LIDAR Data is not currently available for the area). During the 2008 field season, ground truthing of the surface watershed was performed to identify discrepancies between actual watershed boundaries and those generated from GIS. This resulted in the watershed boundary identified in Figure 2, including boundaries for each of the indicated major sub-watersheds.

The watershed area includes the entire SCHW upstream of the Gordon Dam (Figure 4). This includes nearly 335 square miles.

Figure 4 - Gordon Dam on the St. Croix Flowage. This barrier is the downstream extent of the St. Croix Headwaters Watershed, and also marks the beginning the St. Croix Wild and Scenic River designation.

General Surface Water Features

The watershed is drained by approximately 160 mi of rivers and streams which make up two major river systems, the St. Croix and Eau Claire Rivers. There are 197 lakes within the watershed, of which 70% are seepage lakes (lakes with no surface inflow or outflow), 17% are spring/groundwater drainage lakes (lakes with surface outflow), 9% are drainage lakes (lakes with surface flow in and out of the lake), and 4% are reservoir/impoundments. The watershed includes 30,809 acres of wetlands (14.3% of watershed area; Appendix B).

Geology, Soils, and Topography

Geology, soils, and topography provide the foundational drivers of hydrology and water quality within a watershed. Each plays a role in how much water runs off the landscape or infiltrates to groundwater, as well as the basic chemistry of surface water. Soil type is used to help predict the fraction of precipitation that infiltrates or becomes runoff and the potential movement of pollutants within a watershed. Sandy soils have a greater potential to infiltrate and transport water and contaminants than organic and clay-rich soils.

Soils include post-glacial sediments that overlie bedrock, the result from a multitude of glacial advances and retreats, the most recent being the Lake View Advance, which retreated c.a. 9,500 years before present. The glacial sediments in the SCHW are an almost continuous layer over bedrock, and can be up to approximately 200 feet thick.

The majority of the SCHW is covered in sand-textured soils, with organic-rich soils in low-lying wetland areas (Figure 5). The permeability of sandy soils is very high, with infiltration rates averaging between 5 to 10 inches per hour. Organic-rich soils in wetland and low-lying river floodplain areas of the watershed have much lower infiltration rates, ranging from 0.8 to 2.5 inches per hour (Young and Hindall 1973; as cited in UW Superior 2001).

Topography plays an important role in water quality by influencing runoff generation, erosion rates, and groundwater recharge. Surface elevations range from 1,000 to 1,530 ft. above mean sea level with areas of high relief along stream valleys and lake shores (Figure 2). The hummocky (irregularly rolling) topography of the SCHW, a product of the multiple glaciations, has many gradual slopes which allows for the slowing and infiltration of runoff. Closed depressions and irregular surface features interrupt surface drainage patterns forming large, internally drained areas. Areas of internal drainage provide groundwater recharge by capturing runoff in a basin which allows for infiltration.

Surface Water Contributing Areas

It is helpful to understand both where water is originating from and how the water is moving within the watershed. The contributing area of the SCHW is comprised of both the surface watershed and groundwater watershed. Contributions of water from within a watershed are not uniform, with areas closer to a waterbody having greater and swifter impacts to lakes and streams than other areas within the watershed. In some parts of the watershed, runoff may drain to a depression in the landscape where the water collects and infiltrates to groundwater. From the standpoint of surface runoff, this type of area is considered disconnected from the lakes and streams. Between these two extremes are areas within the watershed that are less connected to the waterbodies, only becoming connected following snowmelt or very large rain storms. Identifying these different areas within a watershed can help in

planning development and land use across the watershed. In areas with a more direct connection to the surface water, more stringent practices pertaining to runoff could be applied. Conversely, in areas disconnected from surface drainage, more stringent practices pertaining to maintaining groundwater quality could be applied.

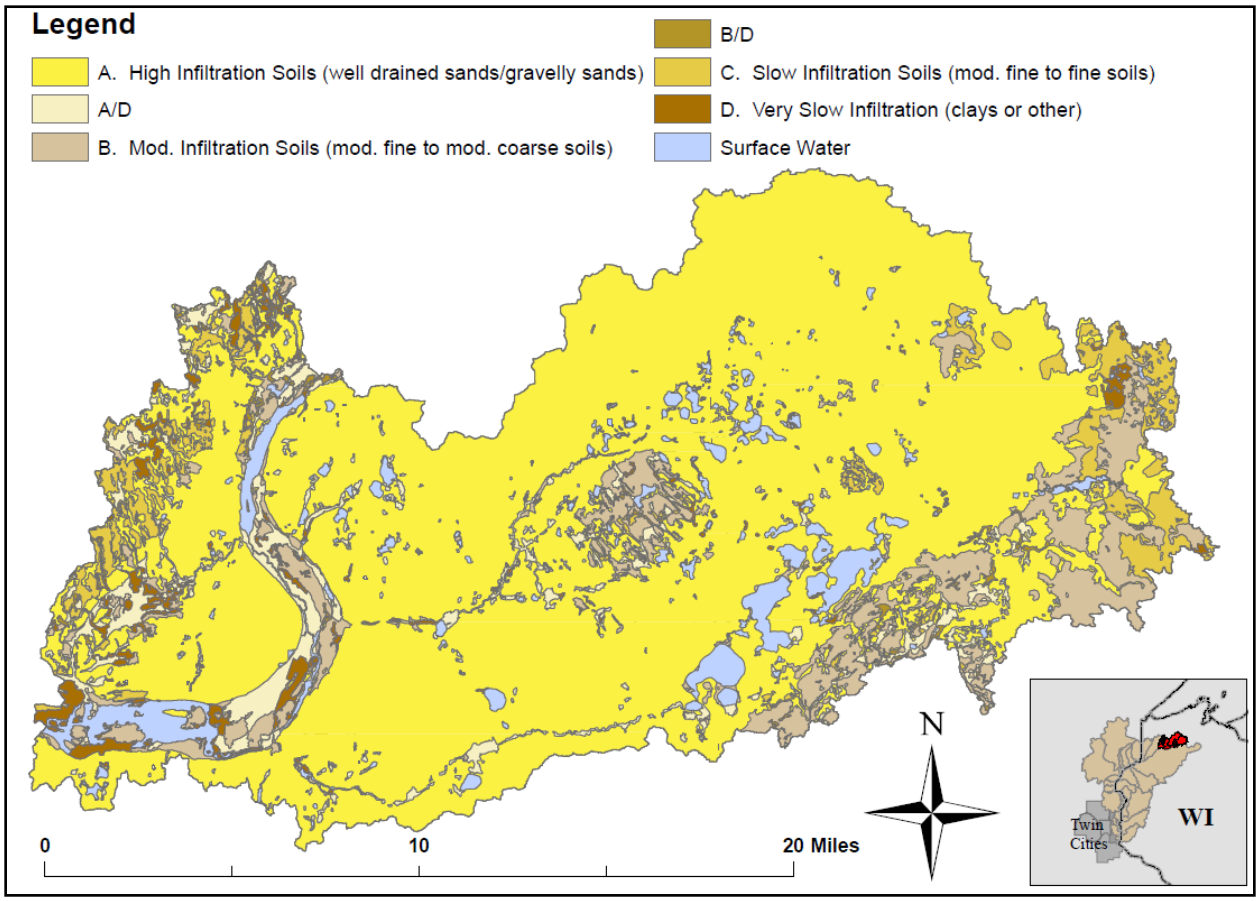

Figure 5 - Soil types within the St. Croix Headwaters Watershed. Source: USDA-NRCS SSURGGO soil coverage. If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils in their natural condition are in group D and assigned to dual classes.

Watersheds with an abundance of both steeply sloped land and impervious surfaces can deliver large volumes of surface runoff by avoiding infiltration and swiftly funneling runoff directly to a water body. The amount of the landscape connected to surface water and the slope of the landscape affect both the stream response to rain events and the amount and timing of sediment and pollutant delivery to a stream. Small streams receiving high volumes of runoff tend to be flashier, that is, have a more pronounced change in stream stage in a shorter amount of time, than larger streams.

Areas of the SCHW that were most directly connected to surface waters flowing to the St. Croix River were mapped based on the distribution of slopes, soil type, and direct or internal drainage (Figure 6, Appendix A). Areas identified as Tier 1 have the greatest potential to impact St. Croix River water quality because the land within those areas has an uninterrupted slope to the drainage network, making it a potential source of storm runoff. Tier 2 represents areas that may be connected to the potential

contributing areas (i.e. Tier 1) by changes to the landscape. Tier 2 areas are especially sensitive to road construction and the associated cut and fill and installation of culverts; these practices could artificially connect portions of the watershed to the stream drainage network, shifting them from a Tier 2 area to a Tier 1 area.

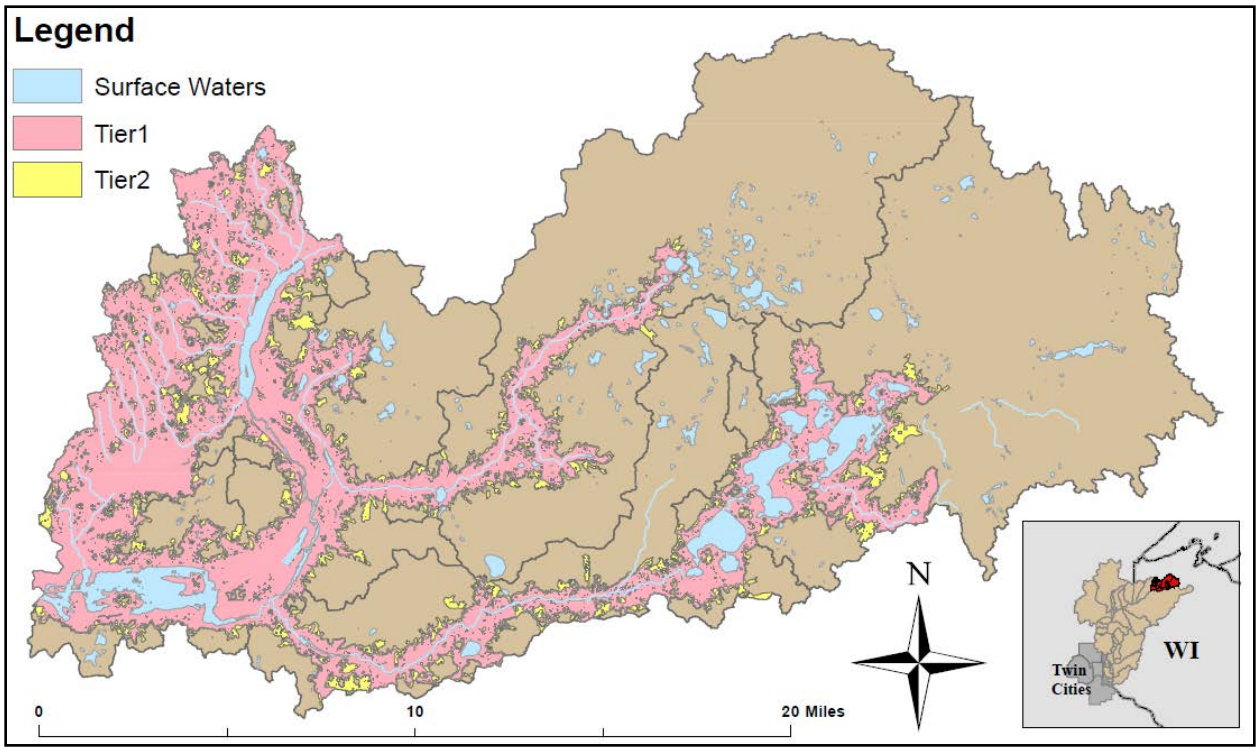

Figure 6 - Areas of the Headwaters Watershed that are most directly connected to surface waters flowing directly to the St. Croix River. Tier 1 areas are most directly connected; Tier 2 areas could be connected (i.e. becoming Tier 1) by changes to the landscape.

Out of a watershed area of approximately 335 mi^2, Tier 1 covers approximately 90 mi^2, or about 27% of the watershed. Tier 2 covers an additional 19 mi^2, or approximately 5%-6% of additional watershed area.

Climate

The St. Croix River is within the humid continental climate, characterized by variable weather patterns and large seasonal temperature changes. Most of the precipitation historically occurs from May through August (Sather and Johannes, 1973). The average annual precipitation for this area is approximately 31 inches, 18 of which return to the atmosphere via evaporation and transpiration (Cahow and Roesler, 1997). The remaining 13 inches recharges groundwater or contributes to surface runoff.

During early years of this watershed study, precipitation was below normal values particularly during the summer months (Figure 7, Appendix A). Precipitation events of a large enough intensity to produce runoff during the growing season (May – September) were uncommon, notably from 2005 through 2008 (Turyk et al., 2008). A total of 17.2 in. and 11.8 in. of precipitation fell during the 2008 and 2009 growing seasons, respectively; the normal precipitation for the growing season is 20.1 in. These were the years for the majority of field observations relating to stream flows and water quality. This resulted in lower stream discharge levels, lower lake elevations and potentially differences in water quality and aquatic habitat than might be observed during wetter periods (Figure 8). Thus, the results detailed later in this study are representative of a dry period and not of normal or wet conditions in the SCHW. Conversely, precipitation returned to wetter conditions during 2010 and early 2011, after much of the field work for this study was completed.

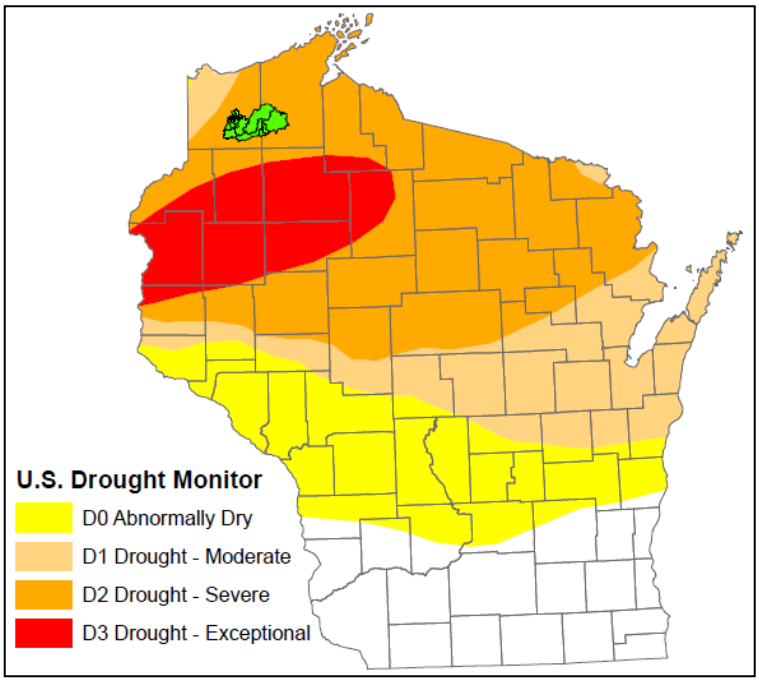

Figure 7-Drought conditions as identified August 18, 2009. Data source: U.S. Drought Monitor, NDMC, USDA and NOAA.

Figure 8 - Pigeon Lake in the SCHW during more "typical" water elevations in 2005, and lower elevations in 2009 resulting from drought.

Land Cover and Land Use

The Upper Saint Croix Headwaters Watershed is located within two ecological landscapes in northwestern Wisconsin. The Northwest Sands Ecological Landscape covers approximately the western two-thirds of the watershed. It consists of flat plains or terraces along glacial melt water channels and pitted outwash plains containing kettle lakes. The North Central Forest Ecological Landscape occupies about one-third of the eastern portion of the watershed. This area is generally characterized by ground moraines, pitted outwash plains, and bedrock outcrops.

Both land cover and land use practices have a strong influence on water quality. Development often leads to modifications of natural drainage patterns and changes in vegetative cover. The removal of native plants, which provide shade, filter and decelerate runoff, can lead to warmer water, higher sediment and nutrient loads in a waterbody. Possible long-term effects on a stream from these changes include a decrease in stream baseflow, a flashier stream response to rain events, and an increase in stream temperatures. For both lakes and streams, the removal of riparian vegetation causes an increase in the amount of nutrient rich soil particles transported to the water body during precipitation events.

The land use, classified under NLCD 2001 (USGS, 2007), is primarily forests and grasslands, which make up 66% and 17% of the 335 mi^2 watershed, respectively (Figure 9; Appendix A). Agricultural and developed lands combined make up approximately 5% of the land use.

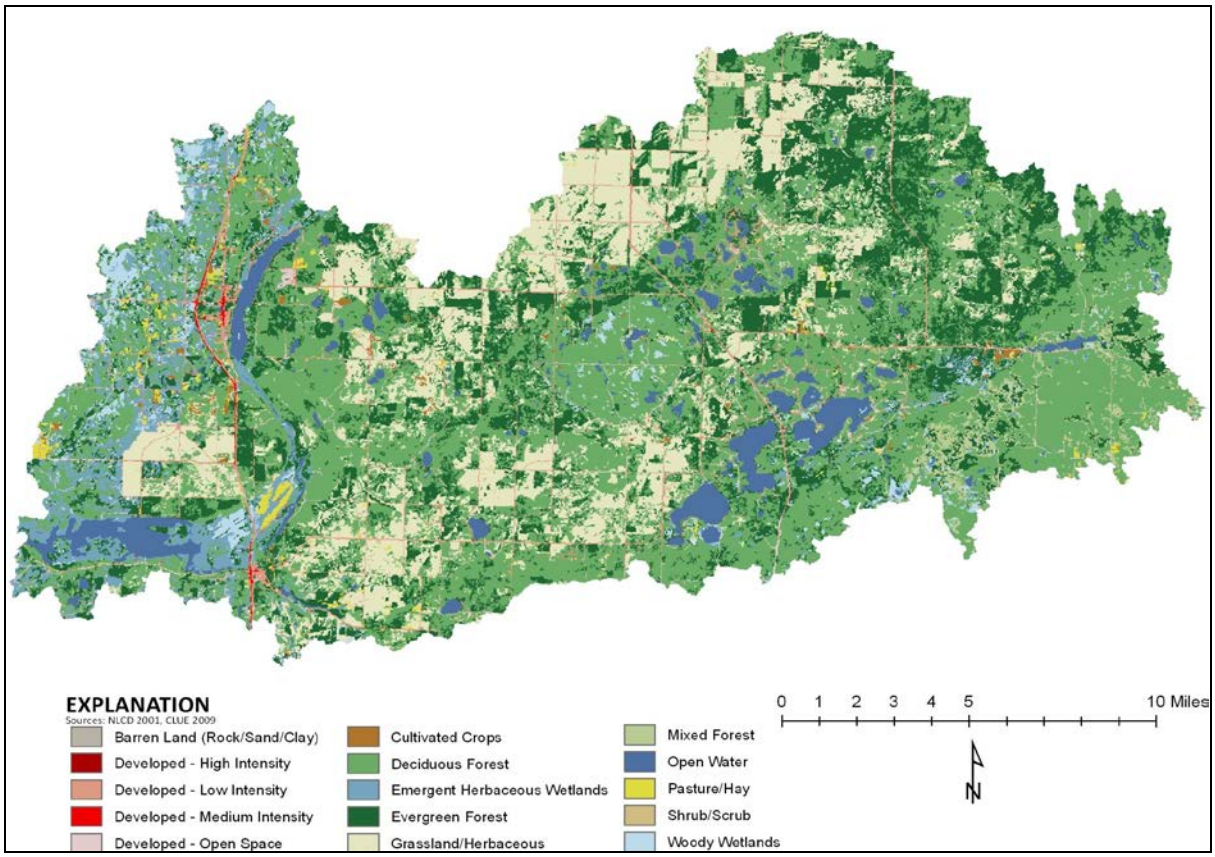

Figure 9 - Landcover/landuse areas of the SCHW. Source: NLCD 2001 (USGS, 2007).

Impervious Surface

Another important consideration in watershed management is the presence and influence of impervious surfaces. Impervious surfaces, such as roads, rooftops and compacted soils, can reduce or prevent the infiltration of runoff. Impervious surfaces can also increase the amount of stormwater flowing directly to lakes and streams. This can negatively impact water quality and aquatic habitat.

The Center for Watershed Protection (CWP; Zielinski, 2002) correlated watershed imperviousness with stream quality, identifying levels of degradation with impervious thresholds of 10% and 25%. Watersheds with less than 10% imperviousness have a "sensitive" watershed classification and are characterized by high quality streams, stable channels, and excellent habitat. Watersheds with imperviousness greater than 10 % show signs of deterioration whereby sensitive stream elements are lost from the system. Watersheds with greater than 25% imperviousness have an "impacted" classification. These are characterized by poor water quality, stream instability, and having poor biodiversity. Similarly, Wang et al. (1997) observed that the amount of urban land had a strong negative relationship with stream biotic integrity, and there appeared to be a threshold between 10%-20% urban land use where IBI scores declined dramatically. When considering coldwater streams in Minnesota and Wisconsin, Wang et al. (2003) observed that imperviousness of less than about 6% appeared to support quality coldwater fish communities. Imperviousness above 11% resulted in poor quality communities. Between 6% and 11%, minor changes in urbanization could result in major changes in stream fishes. This suggests that coldwater streams are much more sensitive to imperviousness and similar disturbance.

As a part of this study, impervious surface was estimated to better assess overall development and disturbance within the basin. This was a desktop exercise within GIS where existing data and recent aerial imagery was reviewed to identify existing structures such as houses, cabins, buildings and similar features. First, an impervious surface layer containing existing structures for Douglas County was obtained from UW-Superior (UW-Superior, unpublished data collected under contract to Community GIS). This was then clipped for the Douglas County portion of the watershed. Then, high-resolution, 2009 spring leaf-off aerial photography was reviewed to manually digitize remaining structures within the watershed portion of Bayfield County. Additional aerial photos also were reviewed to help verify questionable features and complete the digitization of structures.

Impervious road features within the study area were then collected using TANA street data from 2009 and clipped to the study area. To calculate total impervious area for roads, road widths were estimated based on their classification within the TANA database. Streets were given an approximate width of 20 feet, county roads a width of 30 feet, and highways a width of 55 feet. Visual observation within GIS suggested this typically approximated the surface of roadways. Multiplying the length of a road by these assumed widths resulted in total impervious area. The areas from the three road classifications were then added together to form a total area count for each county within the study area. The total impervious area of roads and structures were added together to estimate total impervious area across the watershed.

It is estimated that the SCHW includes approximately 1.2% of its total area as impervious surface. Relative levels of imperviousness are low across the SCHW, with levels generally ranging from 1% to 2% in various subwatersheds (Figure 10). The sub-basin with the greatest amount of impervious surface is the area around Upper St. Croix Lake (USCL).

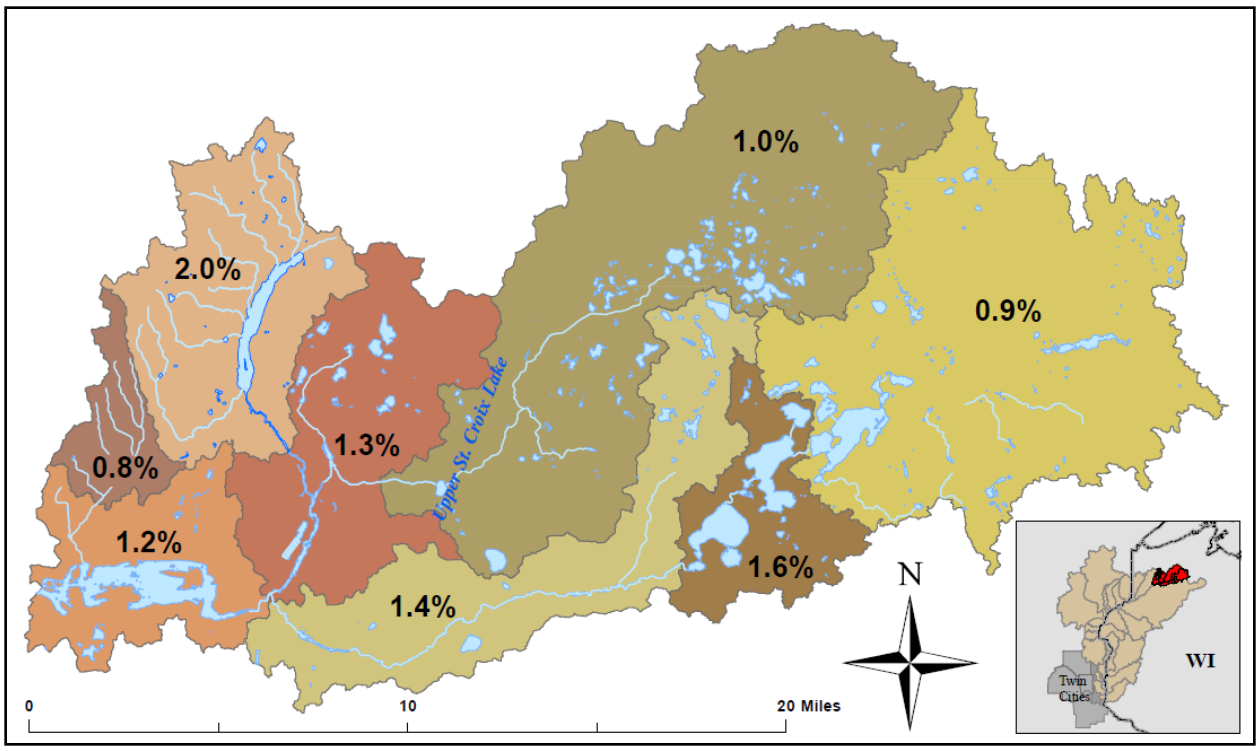

Figure 10 - Relative amount of impervious surface, by sub-basin, for the St. Croix Headwaters Watershed.

A more detailed look at the USCL area shows that imperviousness within sub-watersheds around USCL range from less than 1% to just over 3%. The highest levels are associated with Solon Springs and the development adjacent to USCL. These levels are also low compared to more urbanized watersheds, and probably explain why streams in this area continue to maintain relatively high quality. However, additional development that increases impervious levels much above existing conditions could result in reduced habitat quality. Park Creek and Spring Creek (Figure 11) could be most vulnerable given they are small coldwater streams with currently high resource quality. Impervious levels approaching 5% to 6% could threaten these valuable resources. A detailed assessment of riparian development for specific surface waters is also provided later in Section 4.

Hydrology, Groundwater and Water Quality

Detailed discussion on hydrology, groundwater and water quality is provided in Section 4 as a priority resource issue. In general, the SCHW has good surface water quality; however, a few specific waterbodies do show evidence of degrading water quality.

Wetland Resources

Detailed discussion on wetland resources is provided in Section 4 as a priority resource issues. In short the watershed includes 30,809 acres of wetlands (14.3% of total watershed) that provide a wide range of valuable functions.

Fisheries Resources

Detailed discussion on fish passage, aquatic habitat and aquatic invasive species are further provided in Section 5. The following is a general characterization of fisheries resources based on existing information.

Fisheries resources in the watershed include a diverse mix of lake and riverine habitat. Riverine habitat includes coldwater streams, the majority of which are found in the headwaters of the St. Croix River and flow into USCL. The St. Croix River between USCL and St. Croix Flowage is a slow-moving, warmwater river that includes a mix of species typical of both lakes and warmwater rivers. The Eau Claire River is a small, warmwater river originating from the Eau Claire chain of lakes.

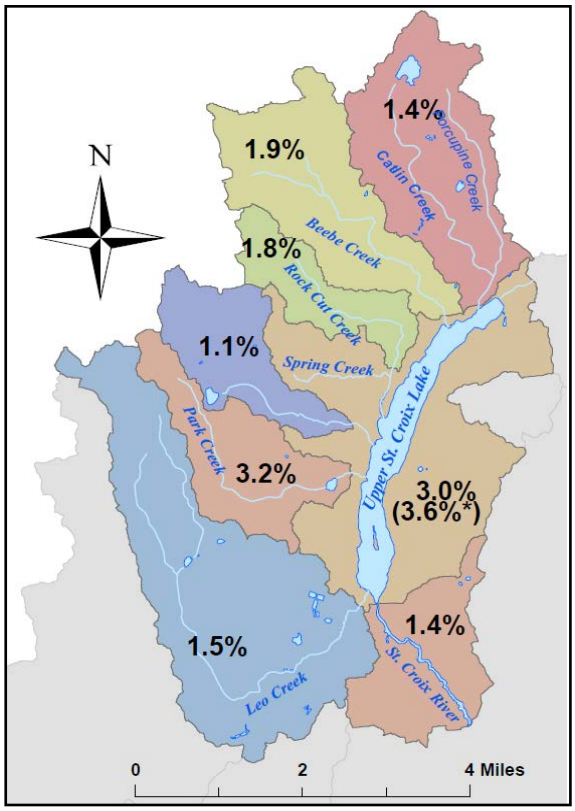

Figure 11- Relative amount of impervious surface for sub-basins adjacent to and including Upper St. Croix Lake (USCL). The percent impervious area for the USCL subwatershed is 3.6% when not including the 828 surface acres of USCL.

Wisconsin DNR has previously performed assessments of stream health within the SCHW using observations of fish diversity. This approach, using an "Index of Biotic Integrity" (IBI), characterizes stream health based on its fish community characteristics. Spring Creek and Park Creek, two tributaries to Upper St. Croix Lake, had IBI scores indicating quality coldwater habitat. Park Creek had a single station that was characterized as "good" habitat during 2006, while Spring Creek had six different locations monitored over multiple years (2001 and 2004), with IBI scores ranging from "fair" to "excellent." These observations and recent literature discussion on the relationship of impervious surface and habitat quality generally agree with the relative percentage of impervious surface located in the subwatersheds of these tributaries.

By comparison, fish observations from Upper Ox Creek in the central area of the watershed had an IBI ranking of Fair (single station sampled in 2003). Observations from the Eau Claire River had IBI rankings ranging from Poor to Excellent. The Poor ranking occurred immediately below the Eau Claire River hydropower dam, while the sites with Fair to Excellent observations occurred upstream between the impoundment and Lower Eau Claire Lake (five stations sampled during 2007).

In addition to observations on fish abundance and diversity, similar observations on mussel communities were made at several locations in the watershed during 2008 and 2009 (Matt Berg, unpublished data). This included mussel sampling on the St. Croix River above the St. Croix Flowage, as well as sampling from several sites on the Eau Claire River and Upper and Lower Ox Creek. Observations generally suggest there are healthy mussel populations within the watershed with a range of abundance and diversity. Reproduction also was evident with multiple size classes evident at several sampling sites.

The area immediately below Gordon Dam also had a high density and diversity of mussels (Matt Berg, unpublished data). The makeup of the mussel community was different than that above Gordon Dam; however, the differences don't necessarily suggest unhealthy conditions above or below the dam. The differences are more likely due to hydraulic and substrate conditions at the individual sites, and the fish that frequent those areas. The high numbers and diversity of mussels isn't unusual immediately downstream of fish barriers. However, the high numbers and diversity also are indicative of the quality habitat and water quality immediately downstream of the watershed.

3.2 Social Resources

Population and Economics

The SCHW straddles the border between Douglas and Bayfield Counties in northwestern Wisconsin, with slightly over half of its area located in Douglas County. Some of the following data is presented by census tract. These are subareas of counties for which data can be presented at a finer resolution than a county basis. In Douglas County, Census Tract 303 contains most of the watershed area located within that county. The watershed area in Bayfield County is located in Census Tracts 9604 and 9606.

Population – Bayfield and Douglas Counties have experienced very little population growth since 2000 compared to the state (Table 1). The area's population, especially Bayfield County, is significantly older than that of the state (Table 2). Washburn (2010 population of 2,117) is the county seat of Bayfield County and Superior (2010 population of 27,244) is the county seat of Douglas County. These are both located along Lake Superior outside of the Headwaters Watershed area. The largest town within the watershed is Solon Springs (2010 population of 600) in Douglas County.

Table 1 - Population

	2000	2010	% Change
Bayfield County	15,013	15,014	0.01%
Douglas County	43,287	44,159	2.01%
Wisconsin	5,363,675	5,686,986	6.03%

Table 2 - Percent of Population by Age Group (2010)

Age Group	Bayfield County	Douglas County	Wisconsin
18 years and over	81.0%	78.6%	76.4%
45 years and over	57.0%	43.6%	41.3%
65 years and over	20.7%	14.4%	13.7%
Median age (years)	49.4	39.8	38.5

Housing - In the study area, like much of northern Wisconsin, outdoor recreation is a significant part of the region's lifestyle. This is reflected in the status of housing units. Housing units are classified by the census as either occupied or vacant. Occupied units are inhabited year round either by the owner or a renter. A large portion of the vacant units are occupied on a seasonal or recreational basis and often serve as a secondary residence for owners. Table 3 illustrates the vacant seasonal variety as a significant percentage of the housing units, especially in the census tracts in which the study area is located.

With regard to housing, water front property in the region is valued higher than land-locked property. Through discussions with a local county assessor in 2012, a quality, one-acre lot on a desirable lake could potentially be worth over $100,000, while a similar rural lot not on the water may be valued at less than $10,000. These are approximate values that vary based on many factors, but demonstrate how much more "valuable" waterfront property can be. Because waterfront property is valued higher, the resulting property tax revenue also will be higher. This is valuable revenue for local government and provides important financial benefits. While much of this report focuses on environmental protection, it should also be recognized that waterfront property is a tremendous financial benefit to the local units of government that oversee the SCHW.

Income - Per capita income for Bayfield and Douglas Counties lags behind the state and the nation. However, as Table 4 shows, the gap has closed since 2000 as per capita income for the counties has increased at a considerably higher rate. With the lower per capita income, it would be expected that the poverty rate may be higher, which is true for the counties as a whole. However, for the census tracts in which the Headwaters Watershed is located the poverty rate is somewhat lower (Table 5).

Table 3 - Housing Units and Status (2010)

	Bayfield County			Douglas County	
Status	Total	CT 9606	CT 9604	Total	CT 303
Total Housing Units	12,999	3,294	3,824	22,825	4,832
Occupied	6,686	1,028	2,141	18,555	2,193
% of Total	51.4%	31.2%	56.0%	81.3%	45.4%
Vacant	6,313	2,266	1,683	4,270	2,639
% of Total	48.6%	68.8%	44.0%	18.7%	54.6%
Vacant - Seasonal	5,582	2,120	1,497	3,192	2,437
% of Total	42.9%	64.4%	39.1%	14.0%	50.4%

Note: CT = Census Tract

Table 4 - Per Capita Income

	2000	2010	% Increase
Bayfield County	16,407	24,028	46.40%
Douglas County	17,638	24,552	39.20%
Wisconsin	21,271	26,624	25.20%
United States	21,587	27,334	26.60%

Table 5 - Poverty Rate (2006-2010 Estimate)

	Percentage
	All People
United States	13.8%
Wisconsin	11.6%
Bayfield County	12.3%
CT 9606	8.8%
CT 9604	8.8%
Douglas County	12.8%
CT 303	8.2%

Recreational Use

Recreational use is extremely important in the watershed, providing social and related economic values. Social uses surveys have been performed for certain focused lake areas in the watershed and help characterize values associated with surface waters in the basin (Flowage Survey 2008; Lakes Survey 2006). Recreational activities most frequently identified include boating, swimming, fishing, scenery or wildlife observations and canoeing/kayaking. Surveys also suggest strong environmental interest with a desire to have quality lake environments. The survey of recreational interests for the St. Croix Flowage

demonstrates local concern with high abundance of aquatic vegetation. This is not surprising since control of submerged vegetation is often an issue of discussion on mid-western lakes. St. Croix Flowage has particularly abundant vegetation given its shallow depths and clear water.

Flooding and Flood Damage Reduction

Flooding concerns in the SCHW are generally limited. The one potential flooding issue that has periodically been discussed includes high water levels on USCL. Fluctuating lake levels in USCL have been an issue of debate for about seventy years. Gordon Dam was constructed in 1931, which is located about 14 miles downstream of USCL. Many residents of Solon Springs have long argued that Gordon Dam is responsible for periodic flooding on USCL by creating backwater conditions (UW Superior 2001).

High water appears to affect low-level structures around USCL. Recent events, such as August 2010, have potentially affected over 100 structures and 90 property owners (Wisconsin DNR personal communication). A survey in the 1990s indicated that 45 landowner lots around USCL are floodplain properties susceptible to high water flood events. An additional 71 residences may experience partial flooding of low-lying acreage during high water (Hlina 1997, as reported in UW Superior 2001).

Multiple efforts have been pursued to evaluate whether Gordon Dam operations or other factors may be influencing periodic high water conditions. This has included investigations by Wisconsin DNR (WiDNR 1980, provided at Appendix F) and UW Superior (2001). Other factors that could be influencing USCL water elevations include abundant vegetation between St. Croix Flowage and ULSC, gravel bars just upstream of St. Croix Flowage, bridges between USCL and St. Croix Flowage, and/or other factors (WiDNR 1980; UW Superior 2001).

Wisconsin DNR (1980) performed several analyses and concluded the following:

> "The major downstream obstruction causing high water problems on Upper St. Croix Lake is the Old Highway 53 bridge which was constructed in 1929. Backwater effects from the bridge range from approximately 0.5 feet during the mean annual flood to approximately 1.2 feet for floods in excess of the ten year flood."
>
> "The Gordon Dam does not have a backwater effect on Upper St .Croix Lake unless it is raised to an elevation of 1015.0 feet, U. S.G.S . datum. The maximum elevation of the Gordon Dam was authorized by order 2-WP-1459, dated June 5, 1964 to be 1014 .0 feet."

Douglas County owns and operates Gordon Dam. The county's management strategy for flowage water levels is to maintain a consistent water elevation near but below 1,014 ft. This is below the threshold of 1015ft identified above.

UW Superior (2001) performed some additional analyses on this issue. They noted that historical flooding appears to occur during abnormal rainfall events that occur during otherwise wet periods when soil moisture contents are high. This results in lower infiltration rates and greater surface run off. The effects for USCL are also enhanced by the efficiency of eight high gradient tributaries streams that feed into the low gradient USCL and downstream river system. This results in precipitation runoff that can be rapid to USCL, which then slows as flows exit USCL and travel downstream to Gordon Dam.

UW Superior (2001) evaluated precipitation events that occurred during the period 1999 thru 2000. This was an extremely wet period with several successive rain events, particularly during 1999. They made volumetric calculations of precipitation events and compared them to available storage within USCL. UW Superior stated "Volumetric calculations indicate that the five major precipitation events that occurred between June 1 and July 31 delivered water volumes to the basin that exceeded lake storage capacity by 280 to 1000 times." These successive rain events saturated soils, culminating in a storm on July 26, which dropped between five and six inches of rain on the watershed over a period of less than six to eight hours. This rain event primarily flowed overland, overwhelming the storage capacity of USCL, which in turn resulted in flooding around USCL.

In terms of the flooding causes, UW Superior (2001) also noted that "the likely contribution of various historical "culprits" (i.e., the dam, the weeds etc.), have little or no effect on the overall "flood" hydrology of the system."

Though flooding concerns have been around for many years, the issues were not critical enough to be identified as one of the priority resource issues during the early phases of this watershed study. This may have been influenced by the fact that the first three years of the study occurred during a drought, at which time flooding issues were not of immediate concern. Flooding issues resurfaced following high water which occurred in August 2010, as well as the spring 2011. However, it was collectively decided that existing information should be used to consider potential flooding, and another detailed evaluation of this situation was not practical, given the limited financial resources available. Coordination with the sponsor and Douglas County suggested that additional study may not provide substantial additional value in understanding this issue. As such, no further analysis on the causes of flooding adjacent to USCL was performed. However, if local entities wish to pursue this in the future, Appendix F includes guidance on how a hydraulics evaluation could be conducted to better evaluate issues with water elevation.

Based on existing information, it appears highly unlikely that flood damages warrant some type of USACE involvement in Flood Damage Reduction. No detailed evaluations of flood damage reduction (FDR) measures were performed for this analysis. It appears unlikely that any FDR project could be identified that would be in the federal interest of a traditional USACE flood project.

UW Superior (2001) identified measures that can be considered by local interests for dealing with flooding issues adjacent to USCL. Stakeholders also may consider removal or modification of the Old Highway 53 bridge to reduce flood risk. Wisconsin DNR (1980) estimated the bridged caused a 1.2 foot backwater effect at a 10% annual chance flood event. The need for this bridge has been minimized with the adjacent, existing U.S. Highway 53 bridge. Bridge removal would be better handled by local interests than as a USACE project.

4. EXISTING CONDITIONS FOR PRIORITY WATER RESOURCE ISSUES

Collaboration with the sponsor during early stages of the study identified a series of specific priority issues for analysis.

Priority Water Resource Issues Evaluated:

1. Hydrology, groundwater and water quality, including nutrient and sediment transfer
2. Wetland evaluation and functional assessment
3. Comprehensive fish passage improvement
4. Aquatic and Riparian Habitat Conditions and Restoration
5. Invasive Species Management
6. Water level management of St. Croix Flowage
7. Recreational and social resource planning.

4.1. Hydrology, Groundwater and Water Quality

Water quality has become a major environmental focus in the St. Croix Basin, particularly in terms of Total Phosphorous loading. Given its position in the watershed, the SCHW is very important in terms of its influence on water quality within the broader basin. While water quality in the SCHW is generally considered to be quite good, the importance of this variable to local stakeholders, and its influence on downstream water quality and habitat, warranted a detailed evaluation of water quality conditions.

Within this study component, detailed evaluations were done to better understand hydrology and water quality of surface and groundwater. This included various evaluations of both lotic (river/stream) and lentic (lake) environments. Studies also were performed to understand general contributions, flow and quality of groundwater. Sediment and nutrient loading were a priority issue for stakeholders and has been included in this assessment. An assessment of how future development could impact water quality was also performed through use of the Soil and Water Assessment Tool (SWAT). This specific evaluation will be discussed in Section 5.

The specific reports outlining water quality evaluation are included in Appendix A and A1, and are summarized here. Water quality variables considered within this analysis included phosphorous, nitrogen, suspended solids, chloride (an indicator of human disturbance), along with other variables. Secchi disk also is discussed as a measure of water clarity. This evaluation included a review of historical water quality data as well as an extensive effort to collect new data from key points in the watershed. Because the bottom of the watershed is the St. Croix Flowage, and because reservoirs can have a dramatic effect on water quality variables, an additional analysis was done to specifically evaluate loading into and out of St. Croix Flowage. Loading out of the flowage thus represents what is being released to the St. Croix River at the beginning of its Wild and Scenic River Designation.

<u>Watershed Hydrology and Stream Water Quality</u>

The following discussion focuses on hydrology and water quality conditions for rivers and streams contributing to the St. Croix River, culminating in the St. Croix River as it flows over Gordon Dam.

Historical data is available that describes watershed hydrology. Additional data was also collected to better understand hydrology and estimate constituent loading during water quality assessments. As a part of hydrology and water quality assessments, stream gages were established at select points

throughout the watershed allowing continuous collection of stream stage. Figure 12 demonstrates the locations where hydrology and water quality variables were measured. The sampling site ID numbers are also referenced in Table 6. Recorded stream stages were then correlated to stream-discharge relationships. This allows the estimate of continuous stream discharge over time (Appendix A). Flow monitoring occurred from May 29 thru November 5, 2008 and March 27 thru October 17, 2009.

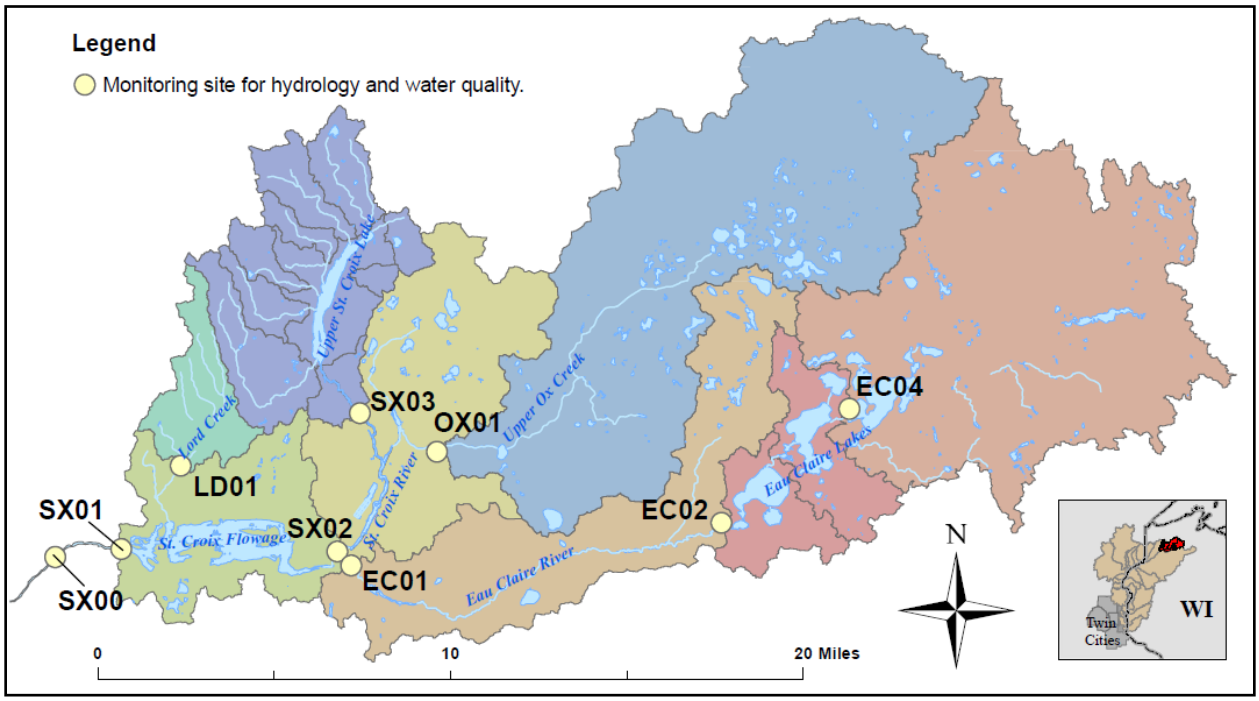

Figure 12 - Sampling points for water quality and surface water discharge during 2008 and 2009 within the SCHW.

Table 6- Location description for sampling locations of water quality and surface discharge. Table corresponds with Figure 12.

Site ID	River
SX00	St. Croix River downstream of Gordon Dam
SX01	St. Croix River at Gordon Dam
SX02	St. Croix River at Highway 53
SX03	St. Croix River at Cut-away Dam, just downstream of Upper St. Croix Lake
LD01	Lord Creek at County Highway M
OX01	Ox Creek near confluence with St. Croix River.
EC01	Eau Claire River near confluence with St. Croix River
EC02	Eau Claire River just downstream of Lower Eau Claire Lake
EC04	Eau Claire River just downstream of Upper Eau Claire Lake.

During 2008 and 2009, continuous flow observations into St. Croix Flowage (SX02) generally ranged between 100 and 200 cfs (Figure 13). Average baseflow conditions for the SCHW are provided in Table 7. Baseflow represents the stream flow when runoff is negligible and groundwater is the dominant contributor to the stream. In addition, a baseflow index, which is the ratio of baseflow to total stream flow, was calculated to identify the dominant flow source in the basin. During 2008 and 2009

streamflows in the SCHW was baseflow dominated. The groundwater contribution to streamflow for 2008 and 2009 was likely influenced by the dry conditions of those years. During wetter years, there would likely be a slight decrease of the baseflow index. Streamflows in general would be higher during wetter years compared to those observed in 2008 and 2009.

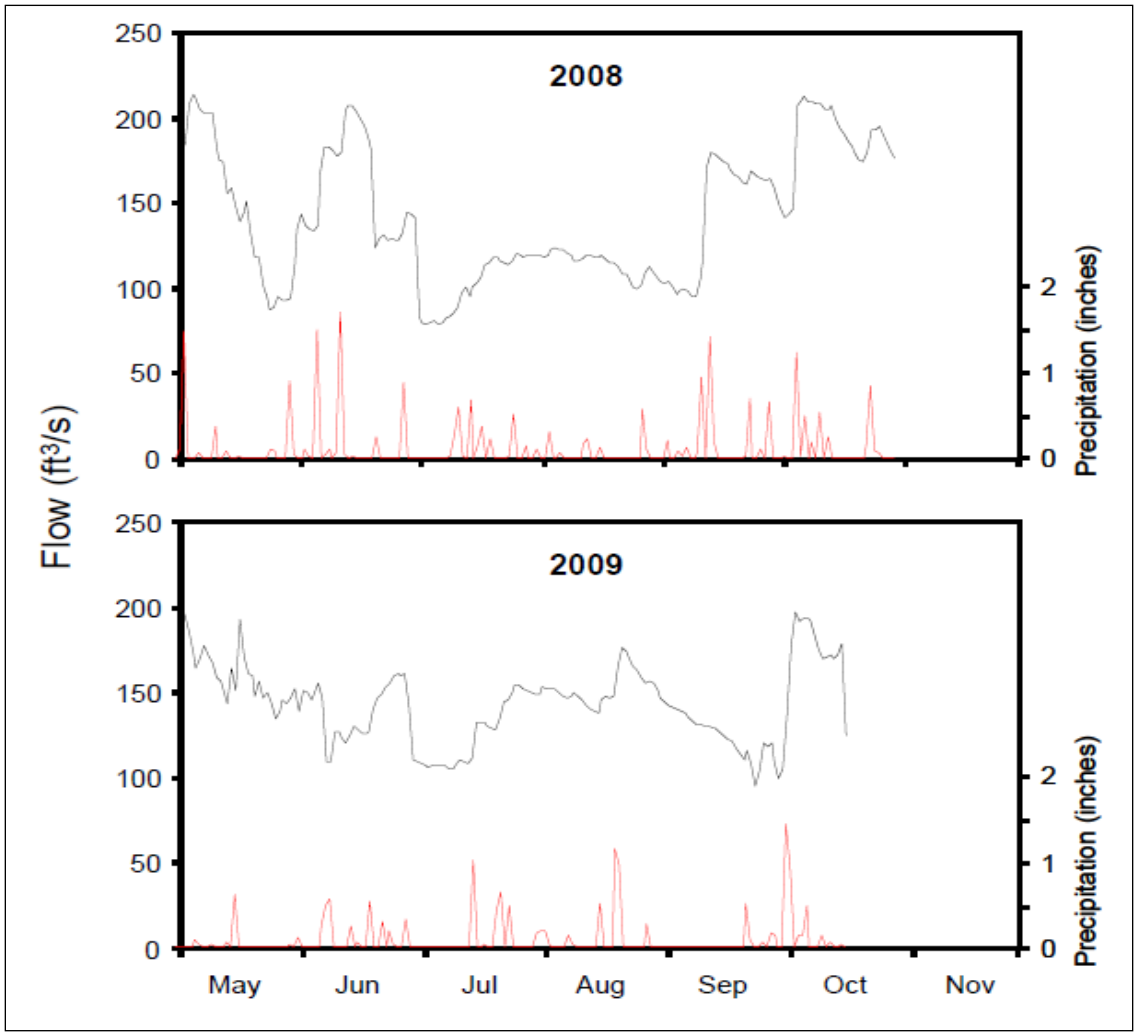

Figure 13 - Rainfall events and observed river discharge for the St. Croix River above St. Croix Flowage during 2008 and 2009.

The long term hydrologic budget of the SCHW (Cahow and Roesler, 1997) found that 42% of the precipitation falling on the watershed either becomes runoff or infiltrates to the groundwater where it may eventually provide stream baseflow or potentially follow deep groundwater flow paths out of the watershed. The remaining 58% of the precipitation returns to the atmosphere via evaporation and transpiration. During the periods of monitored flow in 2008 and 2009 at SX00, streamflow accounted for an average of 24% of the precipitation that fell, suggesting that approximately half of the precipitation that does not return to the atmosphere infiltrates to groundwater. Water in groundwater storage provides baseflow during drought conditions and sustained flow during winter months.

Table 7 - Growing season baseflow conditions at monitoring sites in the SCHW during 2008 and 2009.

		Avg Baseflow (cfs)		Baseflow Index	
Location	**Site**	**2008**	**2009**	**2008**	**2009**
Eau Claire R. above St. Croix Confluence	EC01	77.9	59.8	0.95	0.95
Eau Claire R. just below Lower Eau Claire L.	EC02	51.9	41.3	0.94	0.90
Eau Claire R. just below Upper Eau Claire L.	EC04	21.7	19.4	0.94	0.87
Lord Creek	LD01	1.8	1.1	0.55	0.66
Ox Creek	OX01	18.8	11.0	0.90	0.94
St. Croix R downstream of Gordon Dam	SX00	165.1	152.0	0.84	0.91
St. Croix R at Highway 53 Bridge	SX02	117.1	131.1	0.88	0.93
St. Croix River downstream of USCL	SX03	30.7	19.0	0.89	0.92

Basic River/Stream Water Chemistry

Field chemistry varied throughout the watershed. Descriptive statistics for pH, dissolved oxygen (DO) and other variables can be found in Appendix A. During this study, all monitoring sites except Lord Creek (LD01) and the St. Croix River below USCL (SX03) had pH values which were consistently slightly alkaline. Slightly acidic pH values were measured at these two sites. At Lord Creek, the values are likely due to the large amount of wetlands in that watershed and the associated organic acids produced by decaying vegetation. Acidic conditions just below USCL occurred during August 2009 during the height of backwater flow conditions; the low flow (approximately 10 cfs) and large amount of vegetation in the channel mimicked wetland conditions. High pH values (greater than 9) were measured at Gordon Dam (SX01), St. Croix River at Highway 53 (inflow to St. Croix Flowage; SX02), and just below USCL (SX03), though only once at each site in the early growing seasons in 2008 and 2009. High pH is associated with productive waters, where high rates of photosynthesis lower the dissolved carbon dioxide concentration which causes an increase in the pH. Low pH levels (less than 5) are detrimental to immature fish and aquatic insects and were not observed during this study.

For DO, the Eau Claire River sites (EC01, EC02 and EC04), Ox Creek (OX01) and the St. Croix River downstream of Gordon Dam (SX00) had similar median DO concentrations with values of approximately 9 mg·L-1 (Appendix A). Site SX02 had a slightly lower median concentration (approximately 8.5 mg·L-1) and SX03 had the lowest median DO (7.4 mg·L-1). Though DO concentrations vary throughout the day, very low concentrations (as low as 2.6 mg·L-1) were measured during the day at site SX03 in August and September 2008 and August 2009 during the height of the back-water conditions. The low concentrations may be due to a combination of warming water temperatures, minimal discharge (resulting in slow moving water) , and heavy aquatic vegetation. Wisconsin has a DO water quality standard of 5 mg·L-1, which is considered the minimum concentration necessary to support aquatic life. The low concentrations observed at SX03 may have occurred naturally.

Phosphorous

Phosphorus is an important nutrient in aquatic ecosystems. In most of Wisconsin's surface water, phosphorus is the limiting nutrient (compared to nitrogen). An increase in the level of phosphorus generally leads to an increase the productivity of algae and aquatic plants. Excessive phosphorous can lead to excessive plant growth or algal blooms. This can alter physical habitat, influencing factors such as dissolved oxygen, transparency and light penetration, which can have a cascading effect in the ecosystem. Excessive oxygen consumption from an increase of decomposing plant material, or from

plant respiration during night or low-light conditions, can lead to fish kills. Excessive phosphorus can also cause taste and odor problems in waters used for human consumption. Potential phosphorous sources in the watershed are included in Appendix A, but include natural sources, surface runoff from developed areas, septic systems, a local cranberry operation, and other sources.

Based on EPA (2001) suggested stream ambient total phosphorous concentrations, the streams at sites SX02 and LD01 can be classified as moderately fertile and the remainder as low in plant nutrients. In 2010, Wisconsin established numeric criteria for total phosphorus in ch. NR 102.06, Wis. Adm. Code. Criteria were established to guide managers and decision makers on the status of water quality and river or lake health. These criteria are used as the threshold for determining whether a waterbody is impaired. In most cases, the total phosphorous criteria for rivers and streams in Wisconsin is established at 75 µg·L-1, which all of the SCHW stream monitoring sites fall below (Figure 14; Appendix A). Concentrations greater than the WiDNR total phosphorous criteria for streams were only measured during rainfall runoff flows (Figure 14). The effect of this concentration on lakes and impoundments will vary among waterbodies. The measured low dissolved mineral concentrations observed in the St. Croix River Headwaters would likely result in an increase in algae and aquatic plant growth with minimal additions of phosphorus.

When comparing a number of streams or stream reaches and their contributions to a system, it is often preferable to look at loads and yields of constituents. These values are obtained by multiplying concentrations by the stream flow. A load represents mass per time. An example is pounds of phosphorus per year. Yields represent an area weighted average of the nutrient load and are often reported as the estimated annual average pounds of nutrient per acre (e.g., lbs·ac-1·yr-1). Loads are estimated using continuous flow records and a number of water quality samples representing a variety of flow regimes. The water quality model FLUX (Walker, 1999) was used to explore these nutrient loads. This model simulates the total load, in pounds per year (lbs/year), through flow-concentration relationships developed using average daily flows and sample concentrations.

Loads and yields were computed for each monitoring site for the 2008 and 2009 sample periods. The highest phosphorous loads were found in the St. Croix River at Old Hwy 53 (SX02) and at the St. Croix River at Scott's Bridge (SX00) (Figure 14). SX02 also had the highest total phosphorous concentrations which occurred during rain events. The high phosphorous exports at these sites and the increase in phosphorous loading between SX03 and SX02 may be a reflection of the large percentage of wetlands bordering the Upper St. Croix River in this location. It's also possible the cranberry bog between SX03 and SX02 could be contributing to phosphorous loading. Detailed evaluation of where phosphorous is originating from was not performed, thus it can't be determined specifically what is triggering the phosphorous increases between SX03 and SX02.

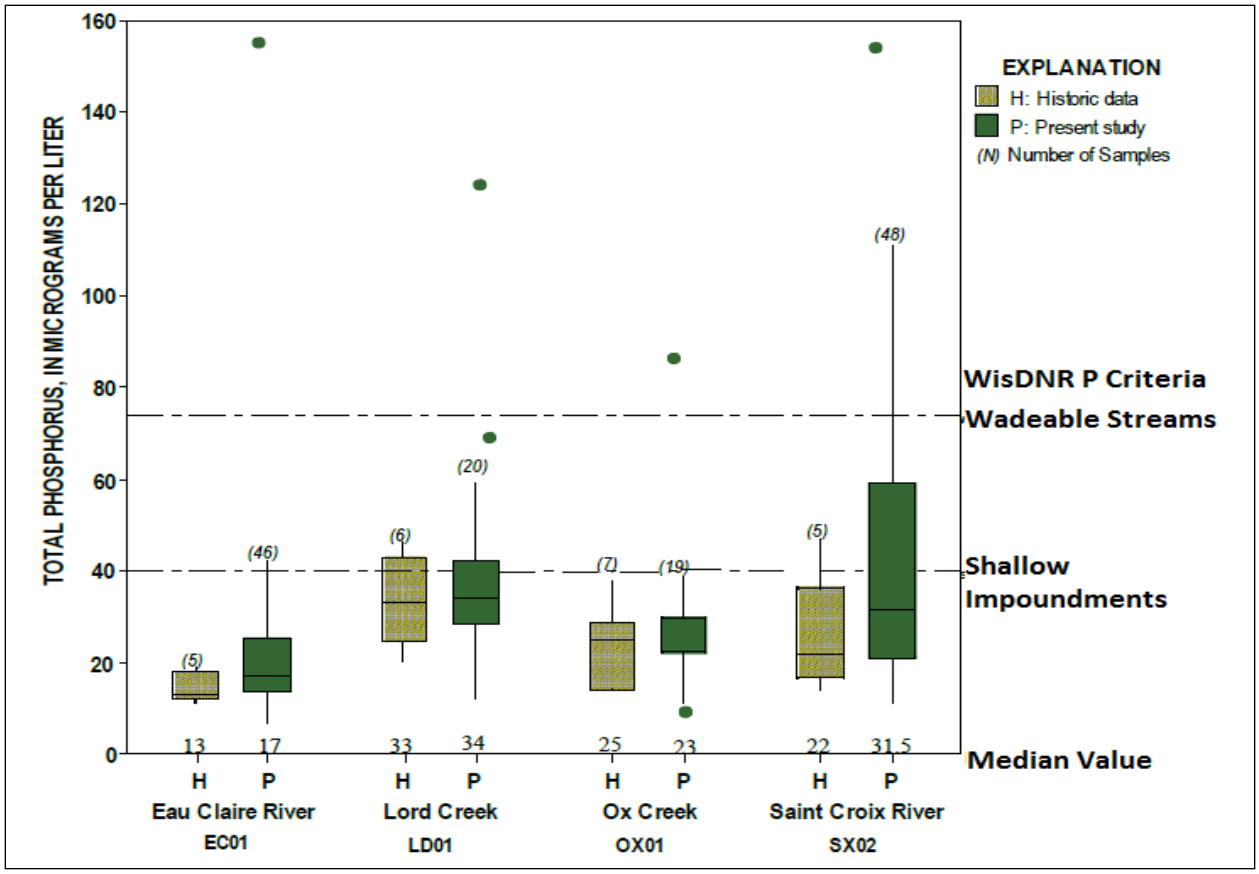

Figure 14 - Comparison between historic and recent total phosphorus concentrations measured in the Upper St. Croix – Eau Claire River Watershed. Historic data were collected between 1995 and 2005; present data were collected from 2006 through 2009. Upper outliers (dots) are measures from event runoff samples; three runoff measures from the St. Croix River (243, 348, and 401 µg·L-1) and one measure from the Eau Claire River (422 µg·L-1) fell outside of the graph scale (Appendix A).

Lord Creek at CTH M (LD01), the Eau Claire River at Outlet Bay Road (EC04), the Moose River (MS01, a watershed adjacent to the SCHW), and Ox Creek (OX01), with relatively undeveloped watersheds, were found to have the lowest total phosphorous loads. In both 2008 and 2009, phosphorous yields from EC04 and OX01 were the lowest (Figure 15). The Eau Claire River was found to increase in both total phosphorous load and yield in the downstream direction (Figure 15 and 16).

The average annual (2008 and 2009) total phosphorous yield in the SCHW (SX00) was found to be 0.04 lbs·ac-1·yr-1. This is lower than other watersheds of similar size in the St. Croix River basin. For example, the Willow River below Little Falls Lake in St. Croix County, with a watershed of 278 mi², was found to have a total phosphorous export of 0.13 lbs·ac-1·yr-1 (K. Schreiber, unpublished data). Other northern Wisconsin streams with similar sized watersheds with greater total phosphorous yields include the Yellow River in north central Wisconsin with a drainage area of 369 mi² and a yield of 0.44 lbs·ac-1·yr-1, and the South Fork of the Hay River in northern Dunn County, with a 418 mi² watershed and an estimated yield of 0.79 lbs·ac-1·yr-1 (K. Schreiber, unpublished data). It is likely that the low precipitation during this study resulted in lower than typical loads and yields of total phosphorous in the tributaries and rivers. The low loads and yields suggest that the SCHW is in a state where thoughtful

planning for future development and implementation of appropriate land management practices could prevent damage to the waters and associated environmental and economic costs.

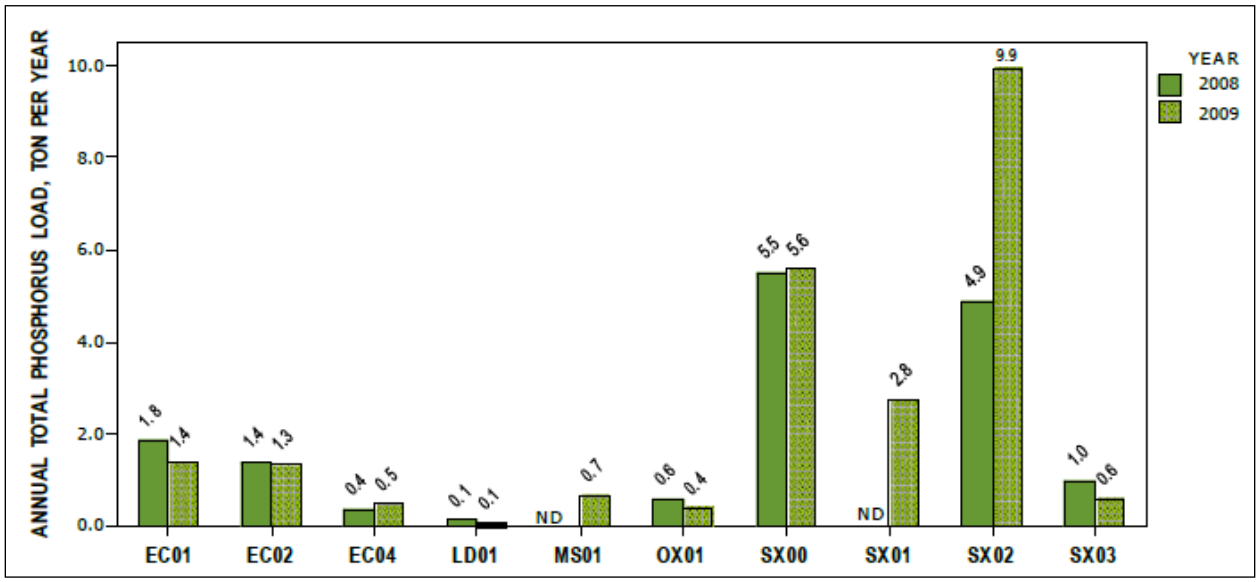

Figure 15 - Annual total phosphorous loading from different watersheds across the SCHW, and the adjacent Moose River watershed (MS01).

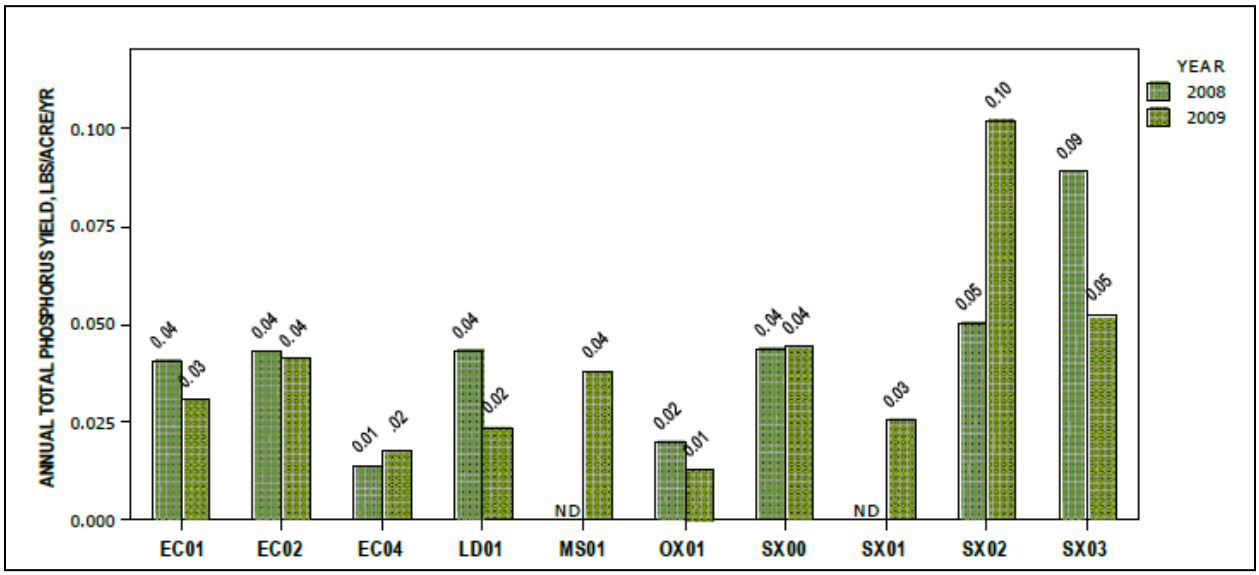

Figure 16 - Annual total phosphorous yield from different watersheds across the SCHW, and the adjacent Moose River watershed (MS01).

Flow-weighted total phosphorus concentrations of loads entering St. Croix Flowage were modest compared to other watersheds in Western Wisconsin and ranged between 0.031 and 0.037 mg/L (Appendix A1). The soluble phosphorus concentration of St. Croix River loads was low at less than ~

0.020 mg/L. However, this fraction represented approximately half of the total phosphorus load and was available for algal uptake. Average concentrations for total phosphorous were similar between the St. Croix River and Lord Creek, the two primary features that load to St. Croix Flowage. (Appendix A1). External loading appeared to be the primary phosphorus source to the Flowage as internal sediment phosphorus release appears negligible (Appendix A1). Mean summer total phosphorous concentrations for St. Croix Flowage outflow during 2008 and 2009 were 0.026mg/l (Appendix A1). Calculated phosphorous loads above St. Croix Flowage were similar to those below the flowage in 2008; and higher than those below the flowage in 2009 (Figure 15). It appears the St. Croix Flowage may, at times, be working to trap phosphorous.

Nitrogen

Nitrogen is another primary nutrient in aquatic ecosystems and is important for plant and animal survival and growth. Elevated nitrogen concentrations can lead to abundant plant growth which in turn may have devastating effects on stream and lake ecosystems, affecting aquatic plants, invertebrates, fish, and humans. However, concentrations of nitrogen species (different forms) were low throughout the watershed (Appendix A) and can remain so with the implementation of best management practices. All sites in the St. Croix River Headwaters were found to decrease in mean nitrate+nitrite-N concentration from baseflow to runoff conditions, except EC01 which remained similar. This indicates that runoff is diluting baseflow concentrations and suggests groundwater discharge is the primary source of nitrates in the watershed.

Suspended Solids

Total Suspended Solids (TSS) is a measurement of the organic and mineral particles that are in a water column. TSS can be an indicator of runoff from exposed soil sources such as disturbed forested areas, gardens, construction sites, and unpaved driveways and roads. TSS can also move to a river through conduit discharges, such as storm sewers and municipal effluent pipes, and over impervious surfaces such as roads and driveways. High concentrations of TSS can transport other constituents, such as pesticides, nutrients, and bacteria. These materials adhere to soil colloids and are carried into lakes and streams by surface runoff (USEPA, 2006). Excess TSS can also turn waters murky, limiting the penetration of sunlight into the water column. The decrease in sunlight inhibits plant growth and decreases visibility for various aquatic animals, including fish. The murky water also absorbs more heat energy from the sun which increases water temperatures and decreased dissolved oxygen concentrations.

The average TSS load of the SCHW to the St. Croix River Basin, as measured at SX00 in 2008 and 2009, was approximately 460 ton·yr-1. This load is an order of magnitude smaller than the loads of similarly sized watersheds in northern Wisconsin (Appendix A). While this is a strong indicator of low TSS, the relatively small estimated TSS loading of the SCHW is likely a reflection of the dry years in which this study was performed. With fewer large rain events generating runoff in 2008 and 2009, the TSS loads and yields are likely less than normal. The highest TSS load within the sub-watersheds was measured at the St. Croix River at Old Hwy 53 (SX02), which during this study supplied an average of approximately 290.6 ton·yr-1.

Total suspended solids loading to St. Croix Flowage was relatively low during 2008 and 2009. Higher TSS contributions were observed coming from Lord Creek, with relatively low TSS concentrations from the St. Croix River. However, total loading (kg/day) was much higher from the St. Croix River given the

substantially higher discharge, relative to Lord Creek. Loading from St. Croix Flowage downstream was also low, with average summer concentrations of 1.5mg/l TSS. Similar to phosphorous, the flowage also appears to be trapping sediment.

Chloride

Chloride is a common ion used as an indicator of other contaminants within a watershed. Human activity is often attributed to the presence of chloride as it is not commonly found in the geology or soils of Wisconsin (Shaw et al., 2002). A combination of road salt, fertilizer use, septic system effluent, and municipal wastewater discharge are likely sources of these elevated concentrations. Studies have shown that if chloride is entering surface waters primarily via groundwater discharge, chloride concentrations will be higher during baseflow than during event flow because of runoff driven dilution (Barker, 1986).

Chloride concentrations measured in the streams of the SCHW are generally representative of the background groundwater concentrations which have been identified as less than 2 mg·L-1. The highest chloride yield was found to be from the Upper St. Croix Lake sub-watershed (SX03; Appendix A). This reflects the greater development in that watershed. Chloride yields were found to decrease traveling downstream in the St. Croix River, likely due to the inputs of streams and groundwater with more dilute concentrations. The lowest chloride load and yield were found in the Ox Creek and upper Eau Claire River (EC04) sub-watersheds. This can be attributed to the relatively undeveloped nature of the sub-watersheds, and the minimal human presence. The measured chloride concentrations in the SCHW are not problematic to aquatic organisms.

Lake Water Quality

The following focuses on water quality conditions for lakes within the SCHW. The SCHW includes 197 lakes that range in size from less than one acre up to the 2,200+ acre Gordon Flowage. Some of these are directly connected and contribute to water quality of the St. Croix River. These occur within the directly connected areas identified in Figure 6. Many, however, are isolated and not connected through surface water. This includes about 70% of these lakes which are considered seepage lakes. Review of historic lake data, as well as evaluation of lakes during this study, help better understand lake water quality within the SCHW.

Lakes within the SCHW have low levels of carbonates. All of the 42 lakes observed during this study had total hardness concentrations less than 90 mg/l (Appendix A). Lakes with concentrations less than 90 mg/l have a greater response by algae to phosphorus additions, and may benefit from phosphorus management (Shaw et al., 2009). Total hardness concentrations less than 25 $mg \cdot l^{-1}$ $CaCO_3$ also present an increased risk from their susceptibility to acid rain and a limited capacity to neutralize toxins. These lakes may benefit from efforts to prevent surface runoff containing phosphorus from reaching the lake (Shaw et. al, 2009). Of the 42 lakes analyzed for total hardness, 16 had an average concentration less than 25 $mg \cdot l^{-1}$ $CaCO_3$, with 15 of the 16 being seepage lakes (Table 8). The Eau Claire River area had higher concentrations of total hardness and alkalinity. Not surprising, the Eau Claire chain of lakes had similarly high total hardness compared to other lakes in the watershed.

Table 8 - Lakes within the SCHW with total hardness (mg CaCO3) of less than 25mg/l.	
Lake	mg $CaCO_3$
Beauregard Lake	8
Breakfast Lake	24
East Eight Mile Lake	24
Island Lake (Bayfield County)	24
Island Lake (Douglas County)	8
Kelly Lake	20
Lake of the Woods	16
Lund Lake	9
North Ducetts Lake	16
Rock Lake	8
Sauntrys Pocket Lake	15
South Ducetts Lake	14
Spider Lake	19
Webb Lake	15
West Twin Lake	7
Wilderness Lake	9

Based on observations for both nitrogen and phosphorous, it appears that lakes in the SCHW are phosphorous-limited. This is not unusual as phosphorus limits plant and algae growth in 80% of Wisconsin's lakes (Shaw et. al, 2002). While most lakes had recent phosphorous concentrations within ranges that are generally considered "healthy," there were some lakes that had concentrations warranting concern.

Lake phosphorous levels were evaluated through examination of recent historical data. Data analysis followed the protocol identified in the Wisconsin 2012 Consolidated Assessment and Listing Methodology (WisCALM; WiDNR 2012). The results observed here were compared to standards identified by WiDNR (2012). These standards have been established based on lake type to guide managers and decision makers on the status of water quality and lake health. Thresholds exist to assess impairment to recreation, as well as fish and wildlife (Table 9). The phosphorus threshold for recreation impairment is lower than that for fish and wildlife, and was selected to identify impaired lakes.

Table 9 - Total phosphorous criteria (ug/l) for lakes in the SCHW.

	Total Phosphorus (ug/l) Impairment	
Lake Type	**Recreational**	**Fish and Aquatic Life**
Shallow Headwater Drainage	≥40	≥100
Shallow Lowland Drainage	≥40	≥100
Shallow Seepage	≥40	≥100
Deep Headwater Drainage	≥30	≥60
Deep Lowland Drainage	≥30	≥60
Deep Seepage	≥20	≥60
Deep Two-Story Fishery	≥15	≥15

Of the 14 lakes with adequate recent data, two lakes had average summer phosphorous concentrations that exceeded the recreational threshold based on their lake type: Lower Eau Claire and Middle Eau Claire lakes (Table 10). Three additional lakes had average phosphorous concentrations approaching the threshold: Pickerel Lake, George Lake and Upper Eau Claire Lake.

Table 10 - SCHW lakes with mean summer total phosphorous concentrations exceeding either criteria or flag values (based on lake type).

Waterbody Name	Lake Type	Summer TP (ug/l)	Recreational Impairment Threshold	Relation to Threshold
Middle Eau Claire L. - Deep Hole	Deep Two-Story	16	15	Clearly Exceeds
Lower Eau Claire L. - Deep Hole	Deep Two-Story	20	15	Clearly Exceeds
Pickerel Lake - Deep Hole	Deep Seepage	18	20	May Exceed
George Lake - Near Deep Hole	Deep Two-Story	14	15	May Exceed
Upper Eau Claire L. - Deep Hole	Deep Two-Story	14.5	15	May Exceed

One of the lakes that remained below its respective threshold is Upper St. Croix Lake. This lake had previously been identified for high phosphorus levels and reduced water quality, and was an area of concern with local stakeholders. However, based on recent observations (average summer TP of about 31 ug/L) and its respective lake type (impairment threshold of 40 ug/L for shallow lowland drainage lakes), this water body would not be identified as impaired for phosphorus.

Water clarity is often a good indicator of water quality. The amount of suspended solids (turbidity) within the water column, the color of the water, and algae largely affect water clarity measures. A Secchi disc is the most common tool for measuring water clarity. The disc is used to measure the depth that light penetrates into the water and roughly represents the depth that aquatic plants can grow.

An evaluation of 72 lakes displayed a broad range of water clarity measurements across the SCHW (Appendix A). Water clarity was typically quite good during July and August, with most lake observations in excess of 5 ft. Many lakes had observations in excess of 10 ft, with the greatest clarity typically observed in Upper and Middle Eau Claire lakes, and Bony Lake (secchi disk readings periodically in excess of 20 ft). Conversely, Upper St. Croix Lake has frequently observed Secchi disk readings of less than 5ft.

Same date concentrations of Total Phosphorous were plotted against measures of Secchi depth to evaluate the relationship of these measures in the study lakes. Unfortunately, the relationship between total phosphorous and Secchi depth was weak ($R^2 = 0.16$; Figure 17; Appendix A). This is likely due to the fact that many waterbodies in the SCHW have stained dark brown water due to natural tannins. This reduces water clarity measures. We were not able to substantiate this supposition because there was insufficient color data from the lakes in this dataset.

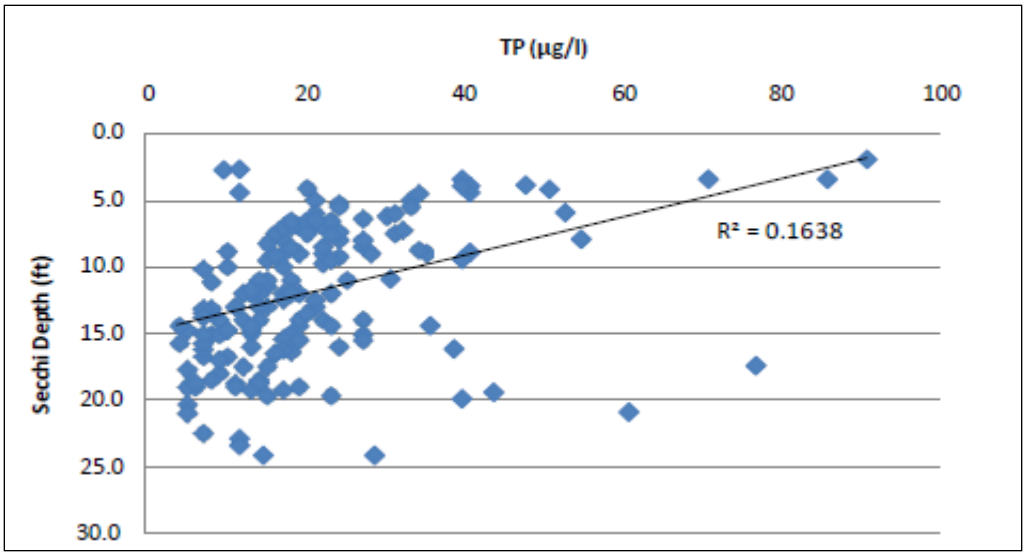

Figure 17 - Relationship between Secchi depth and total phosphorous concentrations for same date lake water quality samples in the SCHW.

Groundwater

A groundwater watershed is the land area where groundwater flows to wetlands, streams, and lakes. A contour map of water-table elevations (10 ft interval), covering the SCHW and the immediate surroundings, was created using surface elevations of waterbodies found on USGS 7.5-minute topographic maps and using water-table elevations from the WiDNR water well data files (Appendix A). Lake surface and stream elevations during baseflow are considered a reflection of water-table elevations. The water-table map was used to delineate the SCHW groundwater watershed. When viewing a water-table map, groundwater flow paths are assumed to be perpendicular to water-table elevation lines, with groundwater flowing from areas of higher water-table elevation to areas of lower water-table elevation.

A map of the groundwater watershed is provided in Figure 18. The water-table map indicates the primary flow direction of groundwater is east to west in the St. Croix River Headwaters and was used to delineate the groundwater watershed for the study area. The groundwater watershed of the SCHW is different than the surface watershed, most notably in the northeast. Groundwater in this area contributes to surface waters outside the SCHW, mostly the Brule River basin to the north.

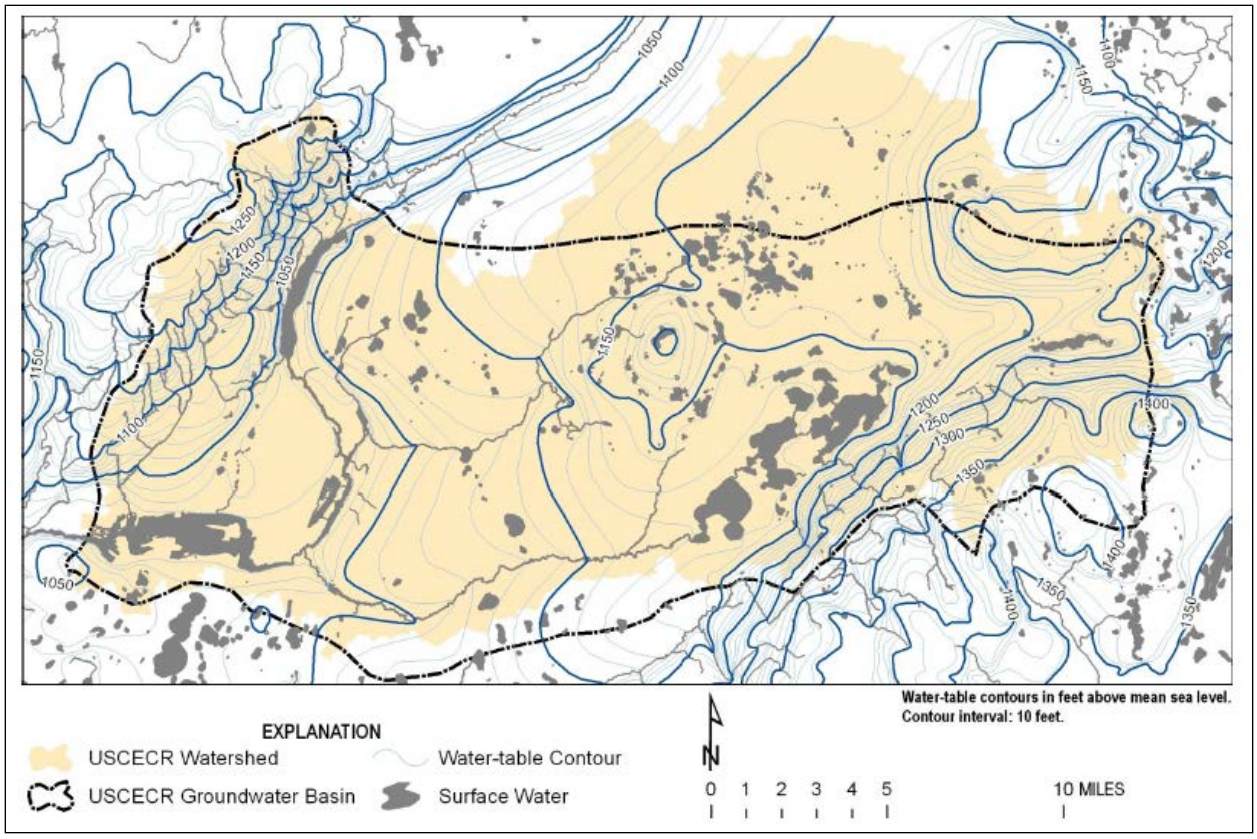

Figure 18 - Water-Table map of SCHW and Surrounding Area. Water table contours in feet above mean sea level. Contours at 10-foot intervals.

A water-table map is a useful tool for the management of groundwater resources. It can be used to identify upland recharge and lowland discharge areas, which can then be afforded the proper consideration or protection. Groundwater flow directions determined from the map allow for the delineation of groundwater watersheds on a smaller scale and can also assist in land management decisions. For example, if groundwater is entering a lake from the east, a possible management action would be to implement rules to minimize the impacts from septic systems servicing a large number of people on the east side of the lake. Another use of water-table maps is defining wellhead protection areas for high capacity/municipal wells.

4.2 Wetland Resources and Functions

<u>Wetlands Summary</u>

Historical data, recent aerial imagery and field investigation were reviewed to better understand and map existing wetland resources of the SCHW. This evaluation is detailed in Appendix B and summarized here. This effort was done collaboratively and involved wetlands experts from USACE, WiDNR, USFWS and regional university consultants.

Wetlands were mapped and classified using computer digitizing methods in GIS with subsequent field verification of several locations and wetland types. Wetlands were concurrently mapped using the

Wisconsin Wetland Inventory (WWI), U.S. Fish and Wildlife Service National Wetland Inventory (NWI) Cowardin system, and Landscape, Landform, Water Flow Path, and Waterbody (LLWW) classification systems. Note that the WWI is accepted by resource agencies for identifying general wetland presence, but does not replace regulatory needs for formal delineation. For the western portion of the watershed, wetlands were also mapped for 1948 and 1992. This historical data was compared to 2009 data to provide insight into wetland change over time.

A summary of wetland area and types, according to the WWI classification system, is presented in Table 11 and Figure 19. Under the WWI, total wetlands in the watershed include 30,809 acres (Table 11). This compares to 20,693 wetland acres for the SCHW using the existing available WWI wetland maps. Thus, this effort identified almost 50% additional wetland areas for the SCHW than the existing wetlands database used for Wisconsin. The reason for the increase includes improved mapping methods and high-resolution imagery, allowing for improved mapping resolution. Not surprisingly, most of the wetland in the watershed is classified under the WWI as forested or scrub-shrub, at 54.4% and 18% respectively (Figure 19). These two classes account for almost 75% of the wetlands in the watershed. Emergent wetlands make up most of the remaining area at 14.4% of total wetland.

The amount of wetland varies between the WWI and NWI system (Appendix B). The most significant difference is that the NWI includes deep water as wetland habitat, which is not included under the WWI. By comparison, the NWI classification system includes 37,790 acres of wetlands (Appendix B). This includes 6,650 acres of deepwater lake habitat not included as wetland under the WWI.

Table 11 - Wisconsin Wetland Inventory (WWI – 2009)

Summary Parameter		Acreage	% Watershed Acreage	% Total Wetland Acreage
General				
Total Watershed Area		215,508.3	--	
Wetland		30,808.9	14.3%	--
Non-Wetland (all other areas)		184,699.1	85.7%	--
WWI Class				
A	Aquatic Bed	688.0	0.3%	2.2%
E	Emergent/Wet Meadow	4,434.4	2.1%	14.4%
S	Scrub/Shrub	5,540.4	2.6%	18.0%
T	Forested	16,760.4	7.8%	54.4%
F	Flats/unvegetated wet soil	60.3	0.0%	0.2%
W	Open Water	3,325.3	1.5%	10.8%
DW*	Deep Water	6,650.0	3.1%	--

*Deepwater areas are technically not a wetland under the WWI, but are included here for comparison.

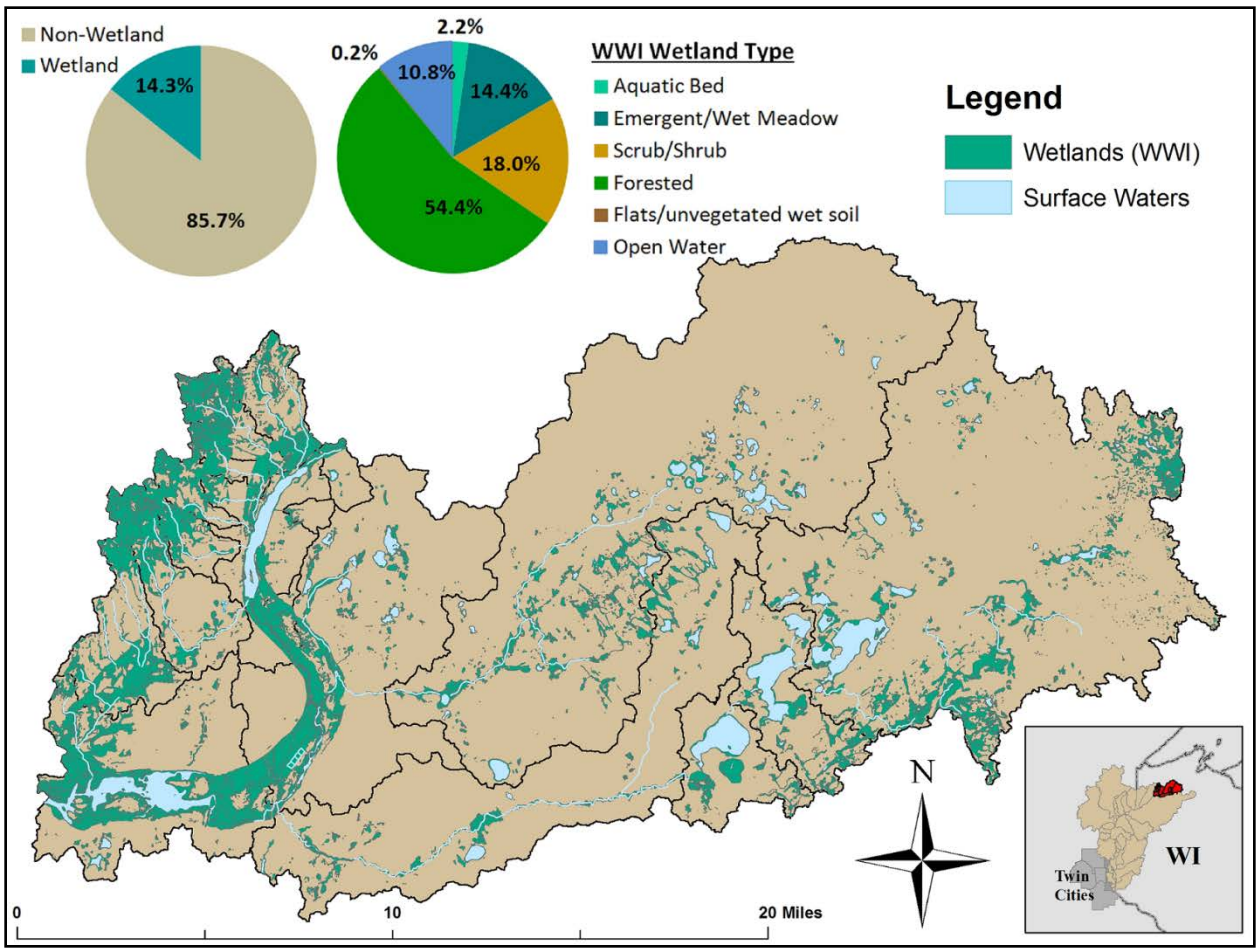

Figure 19 - Wetland areas identified for SCHW for the WWI.

<u>Wetland Functional Assessment</u>

An additional wetland classification system is the LLWW, sometimes referred to as NWI Plus. This expands on the NWI to include descriptions of landscape position (relation of a wetland to a waterbody), landform (physical shape of the wetland), water flow path (e.g., inflow, outflow, throughflow, isolated), and waterbody type. A detailed breakdown of the LLWW and these wetland characteristics is provided in Appendix B.

Most importantly, the use of LLWW descriptors allowed a wetland functional assessment to be performed. Wetland functions are the specific goods and services provided by wetlands based on the conditions and processes that are present. Since wetlands can perform more than one function and some are better able to provide one function than others, wetlands can be classified as highly or moderately performing in a given function.

A functional assessment was performed through collaboration of stakeholders, and local and regional wetlands experts familiar with the study area. These experts collaboratively identified wetland functions of greatest interest for the SCHW:

1. Surface Water Detention (SWD) – storage of runoff from rain events and spring melt waters which attenuates peak flood levels downstream.
2. Surface Water Maintenance (SWM) – this is often referenced as stream flow maintenance. During drought conditions and periods of low discharge, wetlands provide a source of water to keep streams from drying up.
3. Nutrient Transformation (NT) – wetlands through natural chemical processes break down nutrients from both natural sources as well as fertilizers and other pollutants essentially treating the runoff.
4. Sediment Retention (SR) – wetlands act as filters to physically trap sediment particles before they are carried further downstream.
5. Carbon Sequestration (CAR) – wetlands serve as carbon sinks that help trap atmospheric carbon.
6. Shoreline Stabilization (SS) – wetland plants help hold the soil to prevent erosion.
7. Fish Habitat (FIS) – wetlands serve as habitat for a variety fish. Within this function is a special category containing those factors such as stream shading that keeps water temperatures low enough for cold water species such as trout.
8. Waterfowl Habitat (WFH) – wetlands serve as habitat for waterfowl, and other water birds such as coots and loons.
9. Shorebird Habitat (SBH) – wetlands serve as habitat for shorebirds, such as herons, egrets, and sandpipers.
10. Amphibian Habitat (APH) – wetlands serve as habitat for amphibians such as frogs, toads and salamanders.
11. General Wildlife Habitat (GWH) – wetlands serve as habitat for a variety of other animals from songbirds to turtles to larger mammals such as deer and raccoons.

Wetlands classification discussed above using criteria for NWI and LLWW were then analyzed in GIS to assess which wetlands performed which of the functions identified above. Wetlands were classified as high or moderate for performing the wetland functions being evaluated. The results were summarized and displayed on maps in order to provide a better understanding of the processes occurring at various locations in the watershed. Results are discussed briefly here, with focus on select functions of interest. The complete results, including associated maps, are provided in Appendix B.

For wetland functionality, carbon sequestration, surface water detention, and surface water maintenance were performed by the most wetlands. The least common function performed was shorebird habitat with less than 3.8% of the wetland (Table 12).

Table 12 - Wetland Functional Summary – 2009 (Based on NWI and LLWW; Appendix B)

Summary Parameter		Acreage	% Watershed Area	% total wetland area
General				
	Total Watershed Area	215,508.3	--	
	Upland	177,718.5	82.5%	--
	Wetland (NWI)	37,789.8	17.5%	--
Surface Water Detention (SWD)				
	High	18,284.3	8.5%	48.4%
	Moderate	14,315.7	6.6%	37.99%
Functional Total		32,600.0	15.1%	86.3%
Surface Water Maintenance (SWM)				

	High	26,765.2	12.4%	70.8%
	Moderate	4,918.2	2.3%	13.0%
Functional Total		31,683.4	14.7%	83.8%
Nutrient Transformation (NT)				
	High	16,745.4	7.8%	44.3%
	Moderate	7,201.1	3.3%	19.1%
Functional Total		23,946.5	11.1%	63.4%
Sediment Retention (SR)				
	High	14,222.4	6.6%	37.6%
	Moderate	4,659.5	2.2%	12.3%
Functional Total		18,881.9	8.8%	50.0%
Carbon Sequestration (CAR)				
	High	4,839.3	2.2%	12.8%
	Moderate	32,950.5	15.3%	87.2%
Functional Total		37,789.8	17.5%	100.0%
Shoreline Stabilization (SS)				
	High	7,852.4	3.6%	20.8%
	Moderate	3,552.2	1.6%	9.4%
Functional Total		11,404.6	5.3%	30.2%
Fish Habitat (FIS)				
High		10,829.4	5.0%	28.7%
Moderate		3,322.8	1.5%	8.8%
Functional Total (High + Moderate)		14,152.2	6.6%	37.4%
Trout (stream shading)		2,730.8	1.3%	7.2%
Waterfowl/Waterbird Habitat (WFH)				
High		5,815.3	2.7%	15.4%
Moderate		10,250.1	4.8%	27.1%
Function Total		16,065.3	7.5%	42.5%
Shorebird Habitat (SBH)				
High		60.3	0.0%	.02%
Moderate		1,380.2	0.6%	3.7%
Functional Total		1,440.5	0.7%	3.8%
Amphibian Habitat (APH)				
High		5,067.2	2.4%	13.4%
Moderate		3,017.8	1.4%	8.0%
Functional Total		8,085.1	3.8%	21.4%

General Wildlife Habitat (GWH)			
High	24,829.7	11.5%	65.7%
Moderate	2,681.9	1.2%	7.1%
Functional Total	27,511.6	12.8%	72.8%

Surface Water Detention

Wetlands trap and store surface water which can come in the form of precipitation or snow melt. The wetlands then release the water slowly over time through surface or groundwater. From a human perspective, this process equates to lower peak flood levels. Appendix B describes wetlands that perform this function at a "High" or "Moderate" level. Wetlands that perform surface water detention in the SCHW are identified in Figure 20. Of particular note are the wetlands that perform this function near USCL. Given low-land flooding concerns around the lake, wetlands in this area are especially valuable for this particular function. Development activities that reduce or eliminate this functional value in this particular area could exacerbate flooding potential in Solon Springs and around USCL.

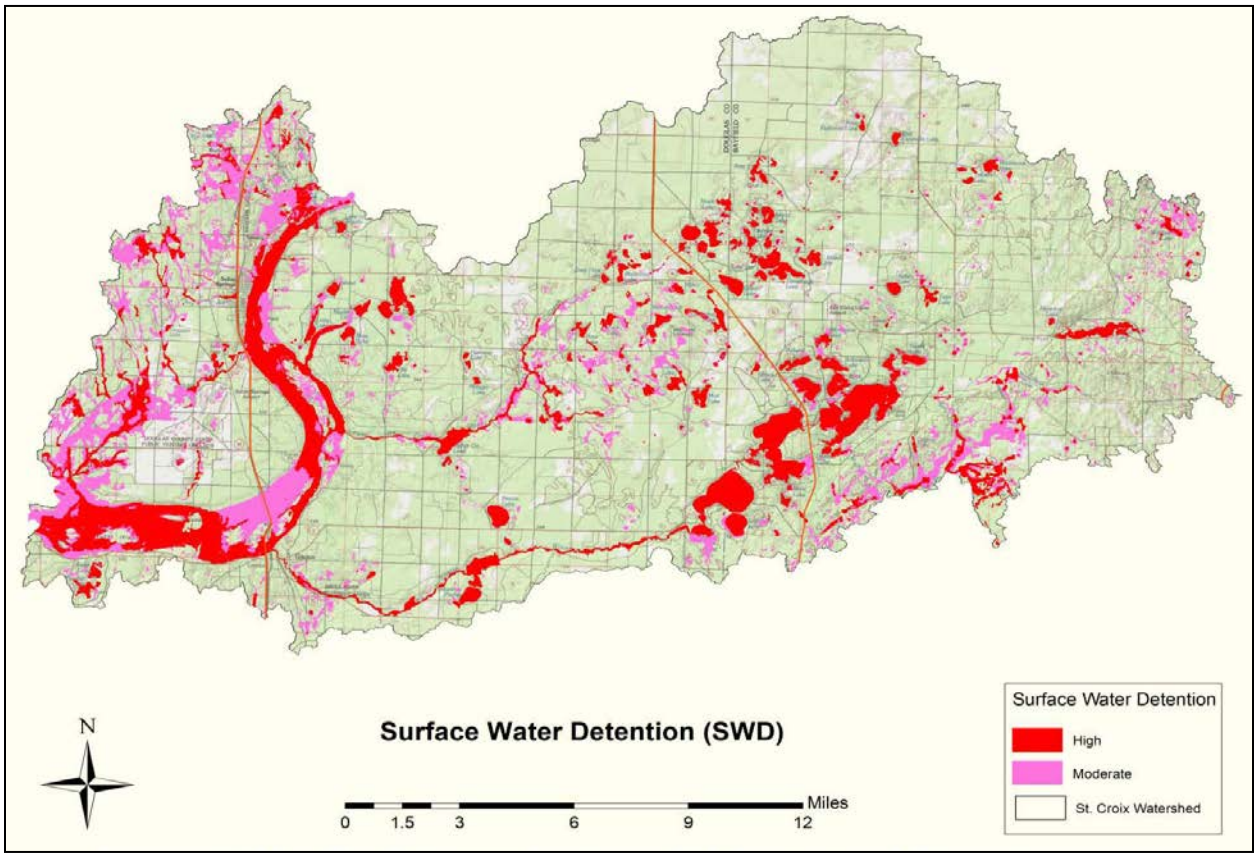

Figure 20 - Wetland areas within the SCHW identified as having a moderate or high functional value for surface water retention.

Nutrient Transformation

Nutrient transformation refers to how wetlands break down nutrients from natural sources as well as fertilizers and other pollutants. Wetlands performing this function are sinks for excess nutrients. The nutrients are prevented from moving further through the watershed through either storage or by wetland vegetation using the nutrients for their own life cycle. Appendix B describes wetlands that perform this function at a "High" or "Moderate" level. Wetlands that perform nutrient transformation in the SCHW are identified in Figure 21. Given the broad concern for nutrient loading and water quality, these wetlands are important for individual waterbodies, as well as overall nutrient transport throughout the basin. Wetlands adjacent to lakes suffering from increased eutrophication (e.g., the Eau Claire lakes) may be especially valuable for maintenance and protection. Wetlands performing this function that also occur within the surface water connected areas (Figure 6) are important for nutrient transport downstream through the watershed. Protection of these wetland areas would be similarly important.

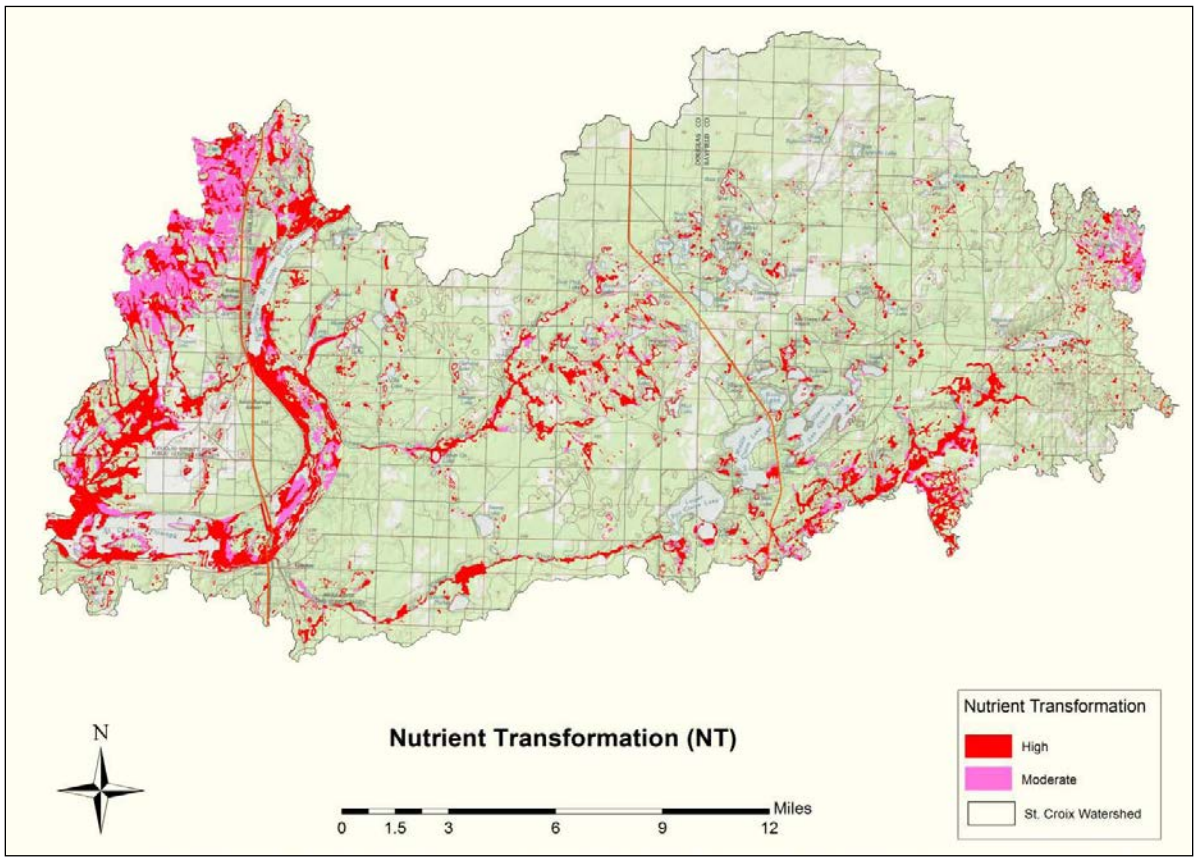

Figure 21 - Wetland areas within the SCHW identified as having a moderate or high functional value for nutrient transformation.

Shoreline Stabilization

Natural shoreline stabilization structures and vegetation prevent erosion or remediate erosion that has already occurred by binding soils. Vegetation and mixed vegetation along lake, river, stream, and pond shorelines prevent soil from being washed or blown away. Vegetation is the main factor that

contributes to wetlands functioning for shoreline stabilization. Appendix B describes wetlands that perform this function at a "High" or "Moderate" level.

Wetlands that perform shoreline stabilization in the SCHW are identified in Figure 22. Given the concern with aquatic and riparian habitat protection (both lake and stream), protection of wetlands in these areas is important. Of note is wetlands often perform multiple functions as can be seen by comparing Figures 20, 21 and 22. Wetlands that perform multiple functions, especially at a high level, can be valuable and worthy of protection.

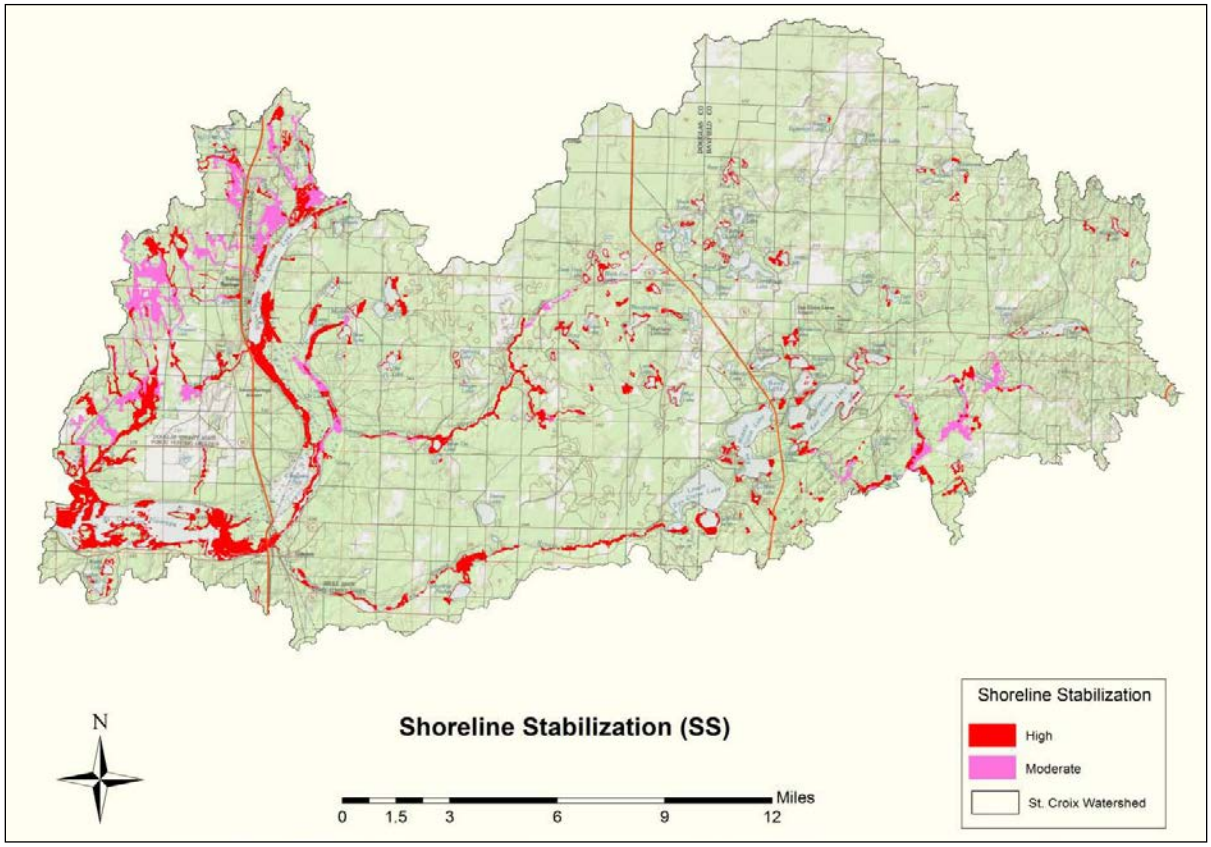

Figure 22 - Wetland areas within the SCHW identified as having a moderate or high functional value for shoreline stabilization.

<u>Historical Wetlands Analysis</u>

Wetland loss has been a major problem for vast areas of the mid-west. In Wisconsin, it is estimated that about half of the state's wetlands have been lost— a reduction from 10 million to 5 million acres (Wisconsin DNR 2008). To evaluate potential wetlands loss in the SCHW, historical wetlands were mapped based on 1948 and 1992 era imagery. These were then compared with the current, 2009 data for the study area. The first quality aerial photography was available was 1948; it was chosen because it provides a good baseline for analysis. The other year chosen was 1992, because it is just prior to the implementation of significant wetland regulation in Wisconsin.

Due to limited image availability and funding, the entire watershed was not mapped for historical wetlands loss. Only the western watershed area, outlined in Figure 23, was evaluated. However, this area will provide great insight into potential wetland losses. It is an area with both the greatest concentration of wetlands, and the greatest potential for loss due to development in Solon Springs and along the U.S. Highway 53 corridor.

The analysis for historical loss is detailed in Appendix B. It is difficult to determine any definite trends from just three time "snapshots", but a few statements can be made about the data. The overall numbers indicate the amount of wetland present in the watershed has remained relatively unchanged over the time period examined. The ratio of wetland to upland within the study area is a very consistent 37% wetland to 63% upland for all three time eras examined. This does not mean that there haven't been changes in wetland type or function, but it does mean losses in one area have been offset by gains in other areas.

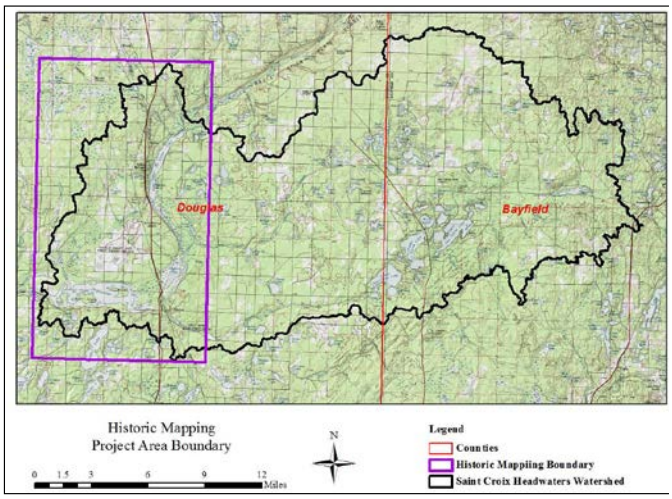

Figure 23 - Area of the SCHW assessesed for historical wetland mapping.

A summary of the historical wetland functions was also produced with some functions showing gains and others losses when the 2009 data was compared to the historical data. For select wetland functions, the total acreage for surface water detention has increased over time, but it appears the gains are in the moderately functioning category while the highly functioning acreage is decreasing. Nutrient transformation acreage decreased between 1948 and 1992 and then bounced back to some degree between 1992 and 2009. Shoreline stabilization remained basically flat across the three time frames.

The NWI classes were also summarized to demonstrate changes amongst classes. Most of the changes in wetland class occurred between three NWI classes: emergent, forested, and scrub-shrub. A possible cause for this is the timber harvest cycle. Because timber harvest is a significant industry in the Saint Croix Headwaters, tracts of land could be in various stages of regeneration, with the emergent tracts having been the most recently logged, and forested tracts reaching the stage where they might be logged in the near future, and scrub-shrub tracts in the interim stages.

In terms of wetland fill activities, approximately 58.6 acres had been filled in the area of historical analysis between 1992 and 2009. The main uses for which wetlands are being filled in the Saint Croix Headwaters are roads followed by residential. In fact roughly 90% of the filled wetlands were converted to these two land uses.

4.3 Fish Passage and Biotic Connectivity

Overview

Connectivity is an important attribute of aquatic habitat for river fishes. Fish have evolved migratory strategies to take advantage of complex river habitats. Fish undergo migrations for many reasons, including: food availability, spawning, overwintering, refugia during extreme hydrologic events (floods, droughts) or other reasons. Dams and similar structures reduce the connectivity of aquatic habitat by restricting movement of river fish. This can limit the extent and quality of habitats they can occupy.

Fish passage could benefit a wide range of fish species, as well as mussels. The lake sturgeon is of special interest to WiDNR in terms of potential fish passage benefits. In many instances dams have played a role in diminished populations of lake sturgeon (Aadland et al 2005; Daugherty 2006). WiDNR has been stocking lake sturgeon in the upper St. Croix River since 2002 in anticipation that eventually fish passage could be restored to the extent that would provide a mix of habitat types that would enable a self-sustaining population to be restored. Lake sturgeon also has been observed below Gordon Dam periodically over the past 10 years.

This effort comprehensively looked at barriers to fish migration and potential fish passage projects at several dams in the watershed. This included Gordon Dam, the Eau Claire River Hydroelectric Dam, Ward Dam, Mooney Dam, Middle Eau Claire Lake Dam, and Upper Eau Claire Lake Dam (Figure 24). Basic fish passage options were considered for each location, including discussion of potential benefits.

Considerations were given as to whether any federal action might be warranted through an ecosystem restoration project under this authority, or the USACE Continuing Authorities Program Section 206. However, it quickly became apparent that none of the sites would have been good candidates given project scale, potential cost and limited benefits. However, it is possible that the recommendations contained herein could be used by the project sponsor, or local interests, to implement fish passage in the future. It should be noted the thoughts and plans expressed here are highly conceptual and would require detailed review and design. Detailed drawings or cost estimates were not prepared. Real Estate interests, including discussions with dam owners, also would need to occur. It is possible that property owner interest may preclude the conceptual alternatives provided here.

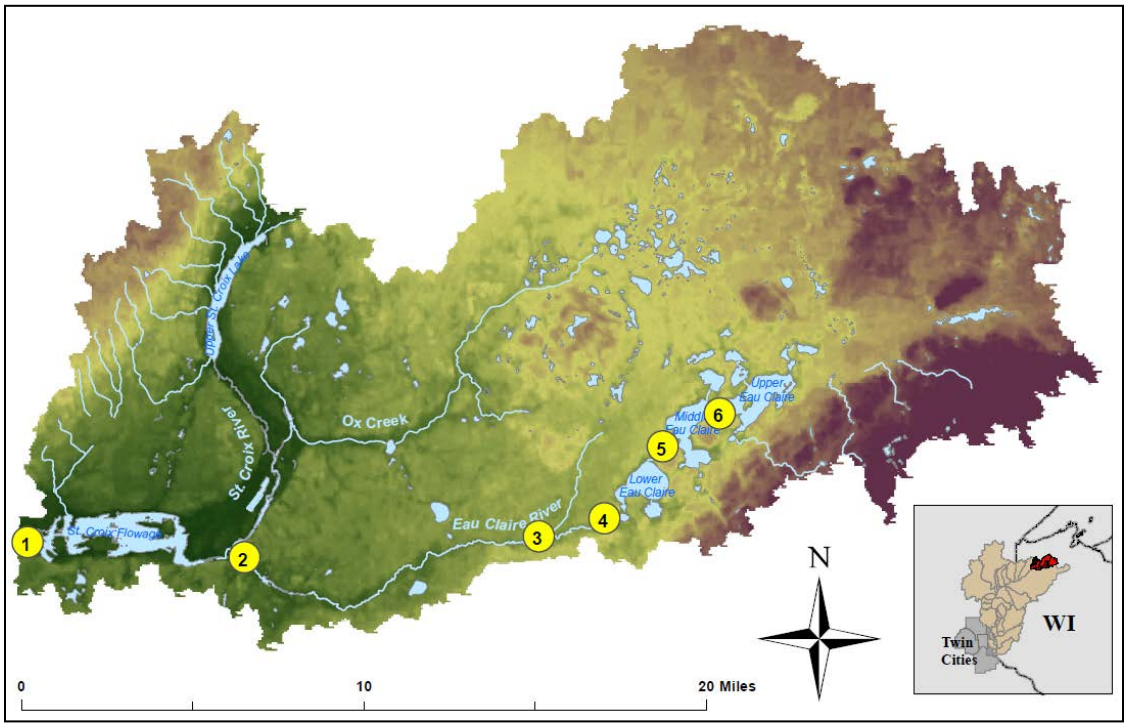

Figure 24 - Dam locations for conceptual fish passage plans.

1. Gordon Dam

Gordon dam separates the SCHW from the remainder of the St. Croix Basin. Completed in 1937 and renovated in 1988, this dam creates the St. Croix Flowage. The dam is owned and operated by Douglas County, WI. Gordon Dam is a stop log structure with a hydraulic height of approximately 8 ft (WiDNR dams database). Dam operation and history is discussed elsewhere in this report. During the summer, the dam is operated to minimize waterlevel fluctuations within the flowage.

Dam removal is not possible given the ecological, social and economic values of the flowage. Rock rapids fishways have been an increasingly popular option for improving fish passage over small dams. However, implementation of a rock rapids fishway would not prove practical since this would render the dam a fixed-crest spillway. This would eliminate the ability to operate the dam to control flow and water elevations within the flowage.

Given the need to manage flowage water levels, the most favorable option would be a fish bypass channel around Gordon Dam. This could provide fish passage and maintain the ability to control water levels. This fish passage option was initially considered during the development of the original St. Croix Basin Recon Study (USACE 2007). These initial, conceptual plans will be provided here.

Under this option, fish passage would begin with a box culvert installed to pass flow through the existing dam embankment (Figure 25). The box culvert could be manipulated to influence flow conveyance. Successful fish bypass channels often target to pass at least 10% to 20% of available flow to attract fish to the bypass channel entrance and effectively pass them upstream. Based on hydrologic observations this suggests the bypass channel may need to pass at least 20 to 40 cfs. However, the exact flow

volumes for conveyance would need to be further verified. Fish passage for large body fish, such as adult lake sturgeon, could require deeper riffles and pools than could adequately be provided with 20 cfs. A bypass channel that maximizes flow may be most desirable. The size of channel needed, as well as the size of the box culvert to control flow, would be fine tuned during more detailed design phase.

Figure 25 - Conceptual plan for fish passage at Gordon Dam via bypass channel.

Flow from the box culvert would pass through an approximately 750 ft long channel with the confluence immediately adjacent to the existing dam (Figure 25). The channel would include a series of riffle weirs to facilitate grade control along the channel. Given the long distance, slopes of less than 2% should be achievable. Drops at individual weirs could be accomplished at 0.5 ft/weir, which would help weaker swimming fish.

From these very initial plans, a preliminary rough cost estimate, for construction only, was about $300,000 (USACE 2007). This estimate did not include costs for real estate or additional study phases. It is also possible that additional erosion protection would be needed along the embankment to ensure that flow along its base does not jeopardize embankment integrity. Extensive erosion protection was not factored into this basic cost estimate. Additional funds would be needed for regular operation and maintenance of such a structure. Any fish passage project also would need full coordination and cooperation with Douglas County who owns and operates Gordon Dam.

It should be noted that downstream fish passage could be an issue with this design approach. Adult fish that migrate upstream, as well as young-of-year or juvenile fish, may have a difficult time migrating back through the flowage and finding the fish bypass channel to move back downstream. It's uncertain if fish would swim over top of the existing dam, especially benthic fish such as sturgeon. If they did, they could be subject to injury or mortality. This issue might be slightly reduced by moving the upstream entrance of the fish bypass channel closer to the dam. This could require an alternative alignment, differences in channel slope and potentially cost. To some extent this risk may be unavoidable with any alternative based on a fish bypass channel, rather than a rock rapids fishway or similar design that conveys all river flow downstream.

Although this barrier separates the St. Croix River from a large watershed area, the benefits from fish passage at this site would likely be modest at best. Review of biological data suggests some differences in fish and mussel communities above and below the dam. However, the differences are not dramatic, and may be due more to habitat differences than lack of biotic connection. The amount of available habitat upstream also is limited and not extraordinarily unique. Habitat availability would increase if fish passage was provided at the hydroelectric dam on the Eau Claire River, with approximately 11 miles of upstream river habitat made available. Fish passage at this site might be considered for local implementation if fish passage were implemented at the Eau Claire Hydroelectric Dam.

2. Eau Claire Hydroelectric Dam

This dam is just upstream of the confluence of the Eau Claire River, separating the Eau Claire River from the remainder of the SCHW. The dam is relatively tall with a height of 33 ft (hydraulic height of 24 ft; Figure 26) and is a part of a small hydropower facility. The dam has not been used for power generation for several years. The project sponsor and local entities wondered whether an opportunity might exist for dam removal under this study. This would improve fish passage, and alleviate local concern of potential dam failure. With this interest, the dam owner was identified and contacted to discuss the dam's future.

As of 2012 the Eau Claire Hydroelectric Dam is owned by Dahlberg Light and Power. According to ownership, the dam was built in 1933 and produced power until 1996. The plant has two generators with a combined capacity of 257KW. The plant was taken off-line in 1996 for repairs, and at that time was not cost-effective to operate. The facility has recently been under lease to different companies. The dam is currently leased to Flambeau Hydro LLC a wholly owned subsidiary of Renewable World Energies LLC. Although power has not been generated since 1996, discussion with the dam owners in 2009 and again in 2012 indicated the intent to resume power generation. It is assumed the dam will be maintained for this purpose.

Dam removal is not currently an option. The most favorable option at this site would be a fish bypass channel around the dam. One conceptual bypass channel is provided at Figure 26. Similar to Gordon Dam, fish passage would begin with a box culvert installed to pass flow through the dam embankment. A fish bypass channel would then work around the impoundment back to the Eau Claire River immediately below the dam. Entrance to the fish bypass channel could be located at the confluence where flows from the powerhouse meet flows from the overflow spillway. Channel sinuosity and gradient could be optimized, to the extent practical, to something similar to the adjacent Eau Claire River. This option could provide fish passage and maintain the ability to generate hydropower. Benefits from fish passage at this site could be modest, with fish movement restored through several miles of river and potentially the Eau Claire Lakes with additional fish passage projects.

Construction cost for this bypass channel would likely be greater than those identified for a similar project at Gordon Dam. However, costs include not only project construction and maintenance, but also lost hydropower production. As discussed by the dam owner, an important consideration is how any bypass channel might limit power generation. The Eau Claire River has relatively low discharge (e.g., 100 cfs or less), and an effective fish bypass channel, especially for lake sturgeon, may necessitate diversion of substantially more than 20% of flows. This likely would have economic ramifications to a facility that may have limited economic potential to begin with. Impacts to power generation might be reduced if the fish bypass channel is operated only during specific migration periods. For example, fish passage could be performed during important periods for sturgeon migration, resulting in operation of only four to six weeks. This would require careful consideration of timing and duration of important migrational periods both upstream and downstream. Ultimately, any future discussions for fish passage at this site would need to include full collaboration and additional analyses with the dam owner and leasers.

Similar to Gordon Dam, downstream fish passage could be an issue. Adult fish that migrate upstream, as well as young-of-year or juvenile fish, may have a difficult time migrating through the impoundment and finding the fish bypass channel to move back downstream. This location is complicated by the fact that small fish that move down to the dam could be subject to entrainment through power turbines, resulting in injury or mortality. This issue might be slightly reduced by moving the upstream entrance of the fish bypass channel closer to the dam. This could require an alternative alignment, differences in channel slope and potentially cost. To some extent this risk may be unavoidable.

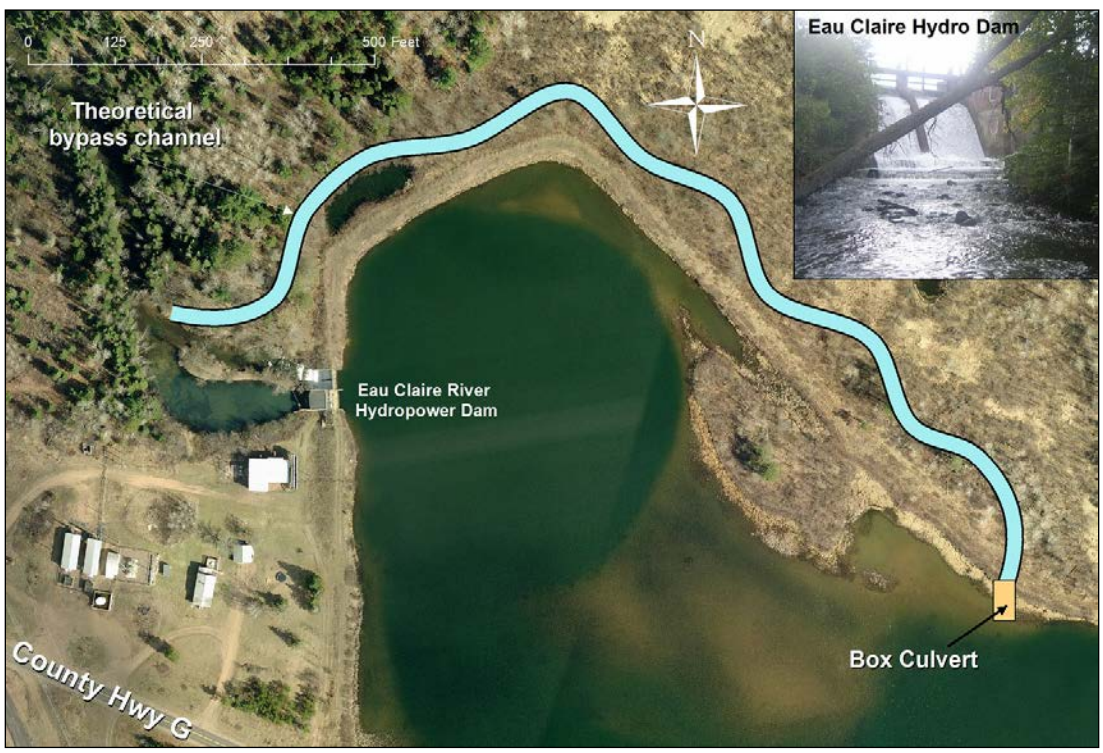

Figure 26 - Conceptual plan for fish passage at the Eau Claire Hydropower dam via a bypass channel.

3. Ward Dam

Ward Dam is on the Eau Claire River approximately 3.5 downstream from Mooney Dam on Lower Eau Claire Lake (Figure 27). According to the WiDNR on-line dams database, Ward Dam is owned by Minnesota Land, Log and Manufacturing. It's a fixed crest weir with an estimated hydraulic height of approximately 6 ft (WiDNR pers. comm). It's not known if the dam provides any meaningful economic or social benefits.

No coordination of a possible project has occurred with the local dam owner. The ideas expressed here are only conceptual. Any future project would need full coordination and consent of the local owner. Fish passage at this location would probably be best solved by either dam removal, or implementation of a rock rapids fishway. Dam removal may be the least expensive option. Access would be needed from adjacent property for temporary construction.

Fish passage at this site would provide access to an additional 3.5 miles of river habitat up to Mooney Dam. Benefits would be limited to providing fish access to the upper river, and potentially lake habitat should fish passage be implemented at Mooney Dam. Fish passage at this location would only be a priority if fish passage is first established at the hydro dam, and possibly at Mooney Dam upstream. The habitat above Ward Dam doesn't appear to be especially unique to provide increased value for the limited area.

Figure 27 - Ward Dam on the Eau Claire River observed during spring 2009.

4. Mooney Dam

Mooney Dam is owned and operated by Douglas County (Figure 28). It has a hydraulic height of approximately 4 ft (WiDNR dams database). It is a stoplog structure with four gate bays that can be manipulated to regulate upstream water elevations within Lower Eau Claire Lake. Removal of the dam would have strong local opposition and is not considered an option.

Implementation of a rock rapids fishway also would not prove practical since this would render the dam a fixed-crest spillway. This would eliminate the ability to manipulate lake outflow via stop logs. In order to maintain the ability to control upstream water elevations while providing fish passage, a bypass channel would likely present the best option for fish passage at this location.

One conceptual bypass channel is provided at Figure 29. Although cost estimates were not calculated they might be generally similar to those for fish passage around Gordon Dam. Such an alternative could provide fish passage and maintain the ability to control discharge at the dam. The exact channel dimensions and corresponding flow diversion would need to be identified. Given the lower discharges at this location (e.g., observed baseflows of 40 to 50 cfs), and given there is no need to balance flows with hydropower interests, fish passage should consider options that would maximize flow volume.

If discharge manipulation is no longer needed at the dam, another alternative option would be a rock rapids fish passageway similar to that outlined below for Middle Eau Claire Dam. A rock rapids fishway could potentially be less expensive to construct compared to a fish bypass channel, though a more detailed design may be needed to confirm this. In addition, a rock rapids fishway (i.e., fixed crest weir) also could have social impacts that would need careful coordination.

Mooney dam separates the Eau Claire River from Lower Eau Claire Lake. Benefits would be limited to providing fish access from the Eau Claire River to deep, natural lake habitat in Lower Eau Claire Lake. Given the species present it is uncertain if these benefits are meaningful.

Figure 28 - Mooney Dam (Lower Eau Claire Lake dam) observed during August 2009. Photo during a period of substantial drought, and provides insight into low-flow conditions.

Figure 29 - Conceptual plan for fish passage at Mooney Dam via a bypass channel.

5. Middle Eau Claire Lake Dam

This dam is owned and operated by Bayfield County, WI. It's a fixed-crest concrete dam with no ability to control upstream water elevations (Figure 30). On-site observations suggest the hydraulic height is probably five to six feet. The dam increases lake elevations and augments valuable aquatic lake habitat in Middle Eau Claire Lake. The dam is unique in that it includes a small adjacent lock that allows movement of recreational watercraft between Lower and Middle Eau Claire lakes. Benefits include providing fish access between these two lakes. Habitat types are similar between the two areas. Fish also would have access to adjacent Bony Lake, although it's unknown how much fish move between Bony and Middle Eau Claire Lake.

Given potential impacts to habitat, recreation and lakeshore property ownership, dam removal isn't a viable option. A by-pass channel, similar to those proposed above, likely would not work at this location. The dam is located directly beneath a highway bridge that constricts the project site. It may be possible for a fish bypass channel to be constructed through the recreational lock, extending downstream to optimize desired grade and water velocities. This option could be considered down the road if or when a detailed study is deemed appropriate.

Another option is a rock rapids structure downstream of the existing dam crest. A series of rock weirs could be built across the channel, each dropping water elevations 0.7 to 1.0 ft per weir. The head difference observed during September 2009 was between 4.5 and 5 ft. Since this was during late summer under substantial drought conditions, it probably represents fairly extreme conditions for the head differential needed for consideration during design.

Figure 30 - Middle Eau Claire Lake Dam observed during August 2009. Observations were made during a period of substantial drought, and provide insight into low-flow conditions. Bridge above is for South Shore Road.

Rock rapids fish passage projects have been commonly constructed in the Midwest. One example of a project similar to this site is provided at Figure 31. This project at the outflow of Potato Lake (Park Rapids, MN) was constructed for less than $30,000 in 2004 (Minnesota DNR 2010). That doesn't mean that a project could be constructed here for this cost. But it does provide some context of potential expense. In fact, Minnesota DNR has constructed many projects of similar scale for less than $100,000 (Minnesota DNR 2010).

Figure 31 - Conceptual plan for fish passage at Middle Eau Claire Lake Dam via a rock rapids. This example project is located at Potato Lake near Park Rapids, MN (Source MnDNR 2010). A similar project could potentially be implemented at Middle Eau Claire Lake.

Any rock rapids project would require further analysis to ensure the structural integrity of the dam would not be jeopardized. Consideration would also be given to the integrity and use of the adjacent lock. One trade-off may include closure of the lock. It's uncertain whether the lock could remain operational, at least without requiring substantial additional design and cost. It may be less costly to

build a project that result in closing off the lock. In fact, the easiest and best long-term option could include dam removal and constructing a rock rapids fishway to function as a new dam. Ultimately, any rock rapids fishway would require additional planning as to account for long-term dam stability, including whether or not a recreational lock is desired at this site in the future. Analysis and coordination also would need to be done to ensure the stability and maintenance of the bridge and would not be compromised.

Though benefits of a project may not be substantial, they might be achieved at a fairly modest cost. If local entities are interested in a potential project, further coordination and design would be needed to refine goals for the sites, potential alternatives, and project costs.

6. Upper Eau Claire Lake Dam

The Upper Eau Claire Lake outlet includes a fixed crest weir with boulders on the downstream face (Figure 32). The dam is privately owned and has a listed hydraulic height of three feet. This structure is likely passable to certain species under some conditions. Fish passage could be improved with minimal effort. Additional rock placement and grading could achieve a more gradual gradient with pools between rock riffle weirs, similar to that discussed in Figure 31. Cost for this activity would appear small. Access would be needed from adjacent property for temporary construction. No coordination of this alternative has occurred with the local dam owner. The ideas expressed here are only conceptual. Any future project would need full coordination and consent of the local owner.

This dam separates Middle and Upper Eau Claire Lakes. Benefits would be limited to providing fish access between these two waterbodies. Habitat types are similar between the two areas. Fish also would have access to Birch, Robinson, Shunenberg and Sweet lakes, although it is unknown how much fish move among these waterbodies.

This location might represent a great opportunity to implement a demonstration project at fairly low cost with monitoring fish movement and population or community response between the two lakes. Basic tagging of fish within the two lakes, followed by subsequent sampling, could help better understand fish movement and potential benefits.

Figure 32 - Upper Eau Claire Lake dam observed during August 2009. This observation was made during a period of substantial drought, and provides insight into low-flow conditions.

Other Barriers

Additional dams exist in the SCHW, though these are mostly private and impact small streams. Fish passage at these locations may have minimal value for likely project costs. In addition, Appendix A also identified road culverts around the USCL , describing vertical drop to the stream bed below. This provides insight into whether or not these culverts are passable to fish. The greater drops may be potentially less passable to fish. The ability for fish to migrate through culverts can also be influenced by the culverts themselves. Those that constrict flow (resulting in increased velocities), and/or have no substrate complexity may also hinder fish movement.

Several resources are available for local entities to improve connectivity through culverts and road crossings. These include those listed below. Future road projects in the SCHW should at least consider the potential for improved stream connectivity, as appropriate.

FishXing. Software and learning systems for fish passage through culverts. U.S. Forest Service http://www.stream.fs.fed.us/fishxing/

Fish Friendly Culverts - Proper design, installation, and maintenance can protect both roadways and fish. UW Extension. http://clean-water.uwex.edu/pubs/pdf/fishfriendlyculverts.pdf

Planning, Design and Construction of Fish Friendly Stream Crossings. USFWS on-line information. http://www.fws.gov/midwest/Fisheries/StreamCrossings/

Design of Road Culverts for Fish Passage. Washington Department of Fish and Wildlife. First published in 1999, with updates through at least 2003. http://wdfw.wa.gov/publications/00049/wdfw00049.pdf

4.4 Aquatic and Riparian Habitat

Critical Habitat Summary

Increases in shoreline development are changing lake ecosystems. The conversion of natural lakeshore to residential development has greatly accelerated over the past 30 years. While many positive measures have been initiated within Wisconsin over the past few decades, habitat and water quality continue to be impacted.

Critical Habitat Designation is a program that includes formal designations of areas considered important to fish and wildlife. Critical Habitat is classified into three categories: sensitive areas, public rights features, and resource protection areas (uplands within the shoreline zone). These three elements combine to provide regulatory and management advice to the State of Wisconsin, counties, local units of governments, and others who are interested in protecting and preserving these unique habitats for future generations. Designation of Critical Habitat aims to serve four primary purposes:

1) Resource protection through science based regulatory review.
2) Community-based resource protection through community education, planning and zoning.
3) A guide to land-trusts and others acquiring land and conservation easements.
4) A mechanism to track long-term changes in these habitats.

Critical habitat evaluations were performed on 14 different waterbodies in the SCHW (Figure 33). Limitations in funding and staff time prevented a broader evaluation of more areas. As such, this review focused on lakes and rivers of particular interest, including those of greatest size, public use, known habitat concerns, and other reasons.

Identification of critical habitat areas was conducted by a team consisting of the WiDNR county fisheries biologist, water resources specialist, wildlife biologist, and critical habitat coordinator. Initially, WiDNR staff compiled and reviewed existing natural resource data that help identify areas of focus related to fish, wildlife, endangered resources, and their habitats before going into the field. In the field, staff used existing natural resource data, delineation guidance, and professional judgment to establish the boundaries of the sites containing critical habitat. Critical Habitat Designation boundaries were recorded in the field using map grade GPS units. For each site, staff inventoried current shoreline management practices occurring along littoral, bank, riparian, and setback zones following standardized methods. Depending on the features of each area being delineated, standardized sampling of emergent and submergent aquatic vegetation, substrate, and woody habitat was also conducted.

A brief overview summary of critical habitat by waterbody is included in Table 13. The complete assessment of critical habitat areas, including a report for each waterbody evaluated, is included at Appendix C. These reports include detailed maps indicating all critical habitat areas and types. Each report also includes management recommendations for habitat protection. This includes General Lakewide Recommendations for protection of the entire lake, as well as Specific Site Recommendations for the protection of each Critical Habitat Area. An example critical habitat map is provided for Upper Eau Claire Lake (Figure 34). An explanation and acreages of critical habitat on Upper Eau Claire is provided at Tables 14 and 15.

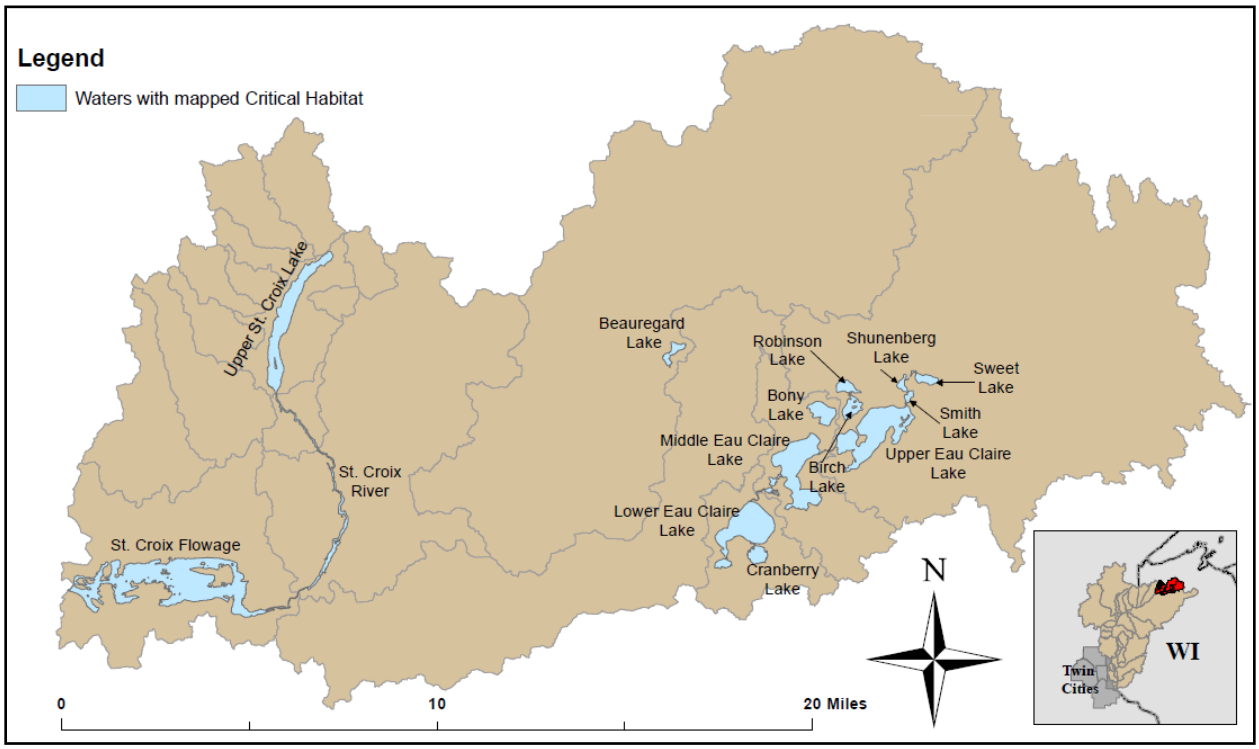

Figure 33 - Surface waters with Critical Habitat Mapping performed in the SCHW. All critical habitat reports are included at Appendix C.

Table 13 - Critical habitat sites and acreages for select water resources in the SCHW.

Waterbody	Total Critical Habitat Areas	Total Critical Habitat Acreage (Ac)
Beauregard Lake	11	32.2
Birch	8	36
Bony	13	26.4
Cranberry	8	112.5
Lower Eau Claire	9	112.5
Middle Eau Claire	16	235.5
Robinson	5	71.6
Shunenberg	1	44.3
Smith	2	33.7
St. Croix Flowage	1	3596
St. Croix River	2	1,161.1
Sweet	9	39.3
Upper Eau Claire	22	145.8
Upper St. Croix Lake	22	145.8

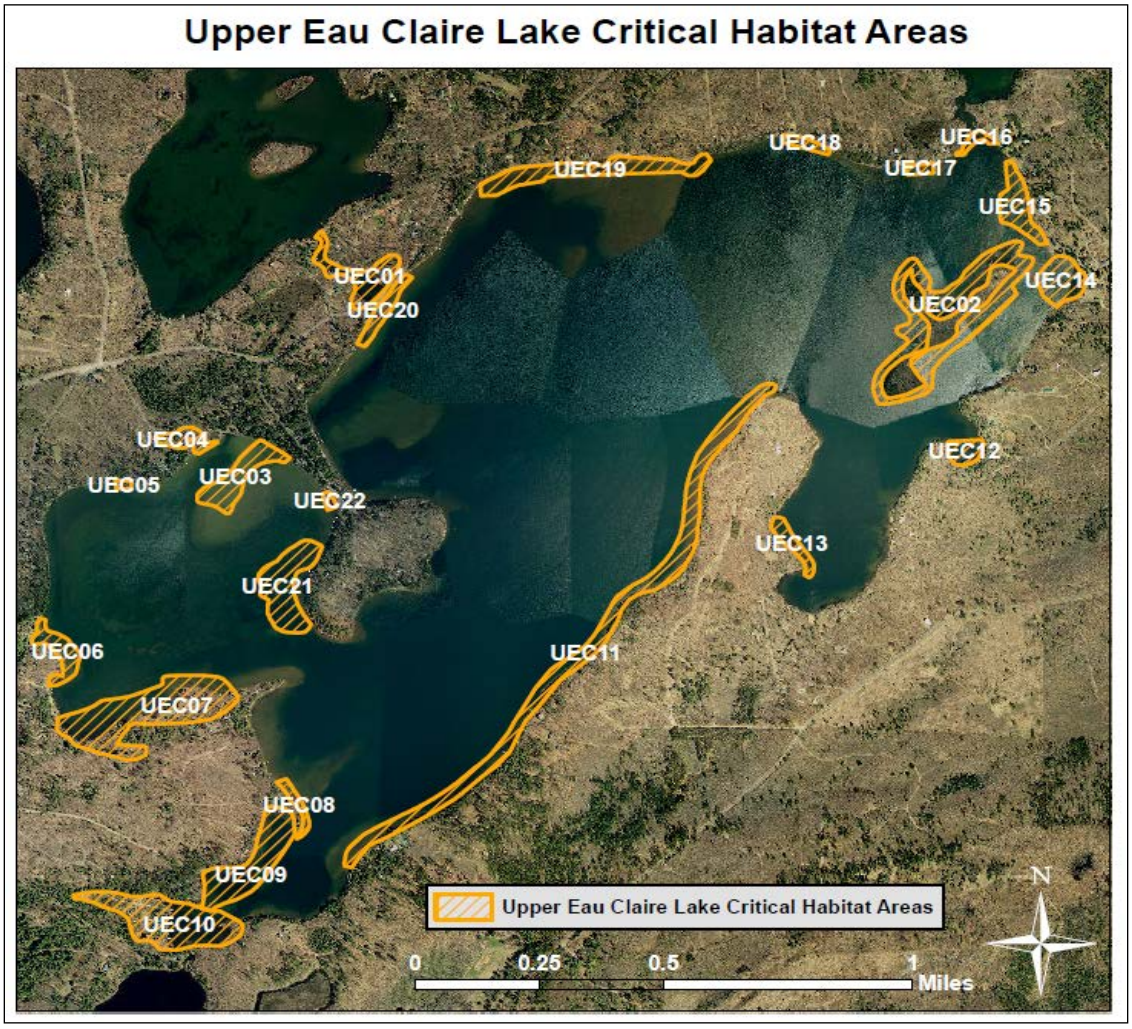

Figure 34 - Example Critical Habitat Map for Upper Eau Claire Lake. All critical habitat maps, including a description of habitat type and recommendations for management, are included at Appendix C.

Table 14 - Upper Eau Claire Lake Critical Habitat Site Justifications. Justification definitions listed at Table 15.

Critical Habitat ID	Acres	Justification					DNR Classification
UEC01	5.6	3	6	11	-	-	Sensitive Area
UEC02	21.2	8	4	2	11	10	Sensitive Area
UEC03	5.8	4	-	-	-	-	Sensitive Area
UEC04	2.2	6	-	-	-	-	Sensitive Area
UEC05	0.4	4	-	-	-	-	Sensitive Area
UEC06	3.5	4	7	-	-	-	Sensitive Area
UEC07	20.4	6	3	-	-	-	Sensitive Area
UEC08	1.1	7	8	-	-	-	Public Rights Feature
UEC09	10.4	2	-	-	-	-	Sensitive Area
UEC10	14.5	3	6	-	-	-	Sensitive Area
UEC11	24.7	8	-	-	-	-	Public Rights Feature
UEC12	2	2	-	-	-	-	Sensitive Area
UEC13	1.8	7	8	-	-	-	Public Rights Feature
UEC14	4.4	2	3	-	-	-	Sensitive Area
UEC15	4.7	4	-	-	-	-	Sensitive Area
UEC16	0.9	4	-	-	-	-	Sensitive Area
UEC17	0.7	4	-	-	-	-	Sensitive Area
UEC18	1.1	4	-	-	-	-	Sensitive Area
UEC19	9.2	4	-	-	-	-	Sensitive Area
UEC20	2.4	8	-	-	-	-	Public Rights Feature
UEC21	8.4	2	-	-	-	-	Sensitive Area
UEC22	0.4	4	-	-	-	-	Sensitive Area

Table 15 - Critical Habitat Justification Descriptions

Justifications	Justification Feature	Classification
1	Bio-diverse Submerged Aquatic Vegetation (SAV)	Sensitive Area
2	SAV Important to Fish and Wildlife Habitat	Sensitive Area
3	Emergent and Floating Leaf Vegetation	Sensitive Area
4	Rush Beds (Scirpus spp.)	Sensitive Area
5	Wild Rice Bed	Sensitive Area
6	Extensive Riparian Wetland	Sensitive Area
7	Woody Habitat	Public Rights Feature
8	Spawning Substrate	Public Rights Feature
9	Water Quality (springs, etc)	Public Rights Feature
10	Natural Scenic Beauty	Public Rights Feature
11	Navigational Thoroughfare	Public Rights Feature

Detailed Impervious Surface Summary

A general discussion of watershed impervious surface is provided above. A more detailed assessment of impervious area also was performed to better assess overall development around several waterbodies in the SCHW. This was a desktop exercise performed in GIS where all impervious features were mapped for areas within 300 feet of select water resources. The distance of 300 feet was selected as it represents the distance from which impervious surface standards are calculated, as required by State of Wisconsin Administrative Code, NR 115 - Wisconsin's Shoreland Protection Program.

This analysis used the same GIS data discussed above for the entire watershed. However, to better approximate impervious features in riparian areas, driveways also were digitized within the 300 foot lake buffers to provide a more precise estimate for those areas. This digitization was done by hand, using the same 2009 leaf-off imagery that was used for the structure digitization. Driveways were only digitized within the 300 foot buffers, not for the entire watershed study area, as a comprehensive dataset was not feasible given time and cost constraints. As such, the impervious estimates for riparian areas would tend to error toward greater impervious contributions compared to the analysis done for the entire watershed.

A summary by waterbody, and relative percentage of impervious surface, is provided in Table 16. The analysis provides a general indication of lakeshore disturbance. The relative amount of impervious surface ranged from as high as 10%, to less than 1%. While the ramifications of different impervious levels have been studied for watersheds, it is less clear what levels should be targeted or maintained for riparian property. However, Table 16 provides an understanding of which lakes have the greatest development and may be areas of focus for lakeshore restoration or management. Lakes with higher impervious surface, perhaps 5% or more impervious within 300 ft of the lakeshore, may be worthy for focused action. Lakes with elevated impervious levels and other identified resource issues (e.g., degraded water quality) are particularly good candidates for future management actions.

It should be noted that this was a desktop exercise and didn't include field verification. Existing property management could be such to minimize disturbance. For example, property owners could maintain adequate property riparian buffers, avoid removal of near-shore aquatic vegetation and woody debris, and minimize impervious surface and other actions. In some cases, landowners have actively worked to restore woody debris. This has occurred extensively on Bony Lake which was identified as having about 7% impervious. Initial efforts also have been performed on USCL, which had an impervious cover of about 5%. These and similar activities are not reflected in this analysis and would certainly help to reduce riparian disturbance. However, the results expressed in Table 16 can help identify and prioritize waterbodies where future management actions could be pursued.

4.5 Invasive Species Management

Aquatic Invasive Species (AIS) have become a significant concern for area water resources. When introduced to new areas, AIS can spread quickly and colonize in larger numbers, displacing native species and altering the ecosystem. When introduced to a new area, AIS typically lack natural competitors or predators to keep their numbers in check. Ecosystems often see lower total numbers of native species, and lower diversity of species, where competition occurs with AIS.

Invasives can also impact recreational activities. AIS can alter ecosystems which can influence recreation activities. For example, rusty crayfish can reduce native vegetation, impacting fish habitat and angling. Eurasian water milfoil can grow thick making swimming difficult and undesirable, while zebra mussels present sharp shells that can result in cuts and other injuries. Even the aesthetics of waterbodies can be impacted as dense stands of a single species can overwhelm the landscape.

Table 16 - Estimated percent impervious surface within 300ft of identified waterbodies within the SCHW. Waters are lakes unless otherwise noted.

Lake	% imperv	Lake	% imperv	Lake	% imperv
Island (Bayfield Co)	10.3	Little Simms	2.9	Saint Croix R.	1.3
Lower Eau Claire	9.2	Island (Douglas Co)	2.9	Nancy	1.2
Upper Saint Croix	9.1	Loon	2.9	High Life	1.1
Lake of the Woods	8.3	Murray	2.8	Hay	1
Ellison	8.1	Metzger	2.7	Mountain	0.9
Pickerel	7.8	Twin	2.4	St. Croix Flwg.	0.8
George	7.2	Idlewild	2.4	Lake Catherine	0.7
Bony	7.1	Cranberry	2.4	Twin	0.7
Kelly	6.2	Muck	2.4	Priest	0.7
Middle Eau Claire	6.0	Flamang	2.2	Henderson	0.7
Robinson	5.7	Rock	2.2	Devils	0.7
Turtle	5.4	Ole	2.1	Upper Ox	0.7
Upper Eau Claire	5.2	Hopkins	2	Scott	0.6
Sand	4.9	Little Island	2	Blue	0.6
Breakfast	4.9	Spider	2	Mountain	0.6
Long	4.8	Mimi	1.9	Mud	0.5
Tars	4.5	Tomahawk	1.7	Lund	0.5
Sauntrys Pocket	4.4	Bass	1.7	Muskrat	0.3
Shunenberg	4.4	Webb	1.7	Lower Ox Cr.	0.3
Sand Bar	4.2	Swenson	1.7	Connor	0.2
Birch	4.2	Smith	1.6	Black Fox	0.2
Pigeon	3.8	Eau Claire R.	1.5	One Mile	0.1
Beauregard	3.6	Catherine	1.4	Boot	0.1
Swett	3.3	Deer Print	1.4	George	0.1
Simms	3.3	Flat	1.3	Mirror	0
East Eightmile	3.1				

Known AIS populations

Waterbodies within the SCHW known to be infested with AIS are identified in Table 17 and 18. It should be noted that AIS continue to spread and additional waterbodies could be infested beyond those identified. AIS can spread easily downstream, so those species found higher in the watershed can be expected to spread down through the St. Croix Flowage and downstream St. Croix River.

Table 17 - Douglas County Waterbodies within the SCHW with identified AIS

Eau Claire River	River	Rusty Crayfish
Lower Eau Claire Lake	Drainage Lake	Rusty Crayfish, Purple Loosestrife
Saint Croix River	River	Japanese Mystery Snail, Rusty Crayfish, Phragmites
St Croix Flowage	River impoundment	Chinese Mystery Snail, Curly-Leaf Pondweed, Eurasian Watermilfoil, Phragmites
Upper Saint Croix Lake	Drainage Lake	Banded Mystery Snail, Rusty Crayfish, Purple Loosestrife, Yellow iris.

Table 18 - Bayfield County Waterbodies within the SCHW with identified AIS

Eau Claire River	River	Rusty Crayfish
George Lake	Seepage Lake	Freshwater Jellyfish, Eurasian Watermilfoil
Lower Eau Claire Lake	Drainage Lake	Rusty Crayfish, Purple Loosestrife
Middle Eau Claire Lake	Drainage Lake	Banded Mystery Snail, Curly-Leaf Pondweed, Rusty Crayfish
Pigeon Lake	Seepage Lake	Freshwater Jellyfish
Robinson Lake	Seepage Lake	Banded Mystery Snail
Sand Bar Lake	Seepage Lake	Eurasian Watermilfoil
Tomahawk Lake	Seepage Lake	Eurasian Watermilfoil
Upper Eau Claire Lake	Drainage Lake	Chinese Mystery Snail, Curly-Leaf Pondweed, Rusty Crayfish

AIS Control Measures

Multiple management plans have been developed to address AIS issues in specific waterbodies. This includes plans for Tomahawk and Sandbar Lakes, and the St. Croix Flowage. Management Plans for the St. Croix flowage are the most comprehensive and include detailed control measures for AIS and additional wetland invasive species, as well as monitoring activities. All available AIS management plans are included at Appendix D.

These management plans consider a variety of control measures based on the target AIS and waterbody characteristics. Aquatic vegetation can be controlled by various forms of direct physical removal, as well as chemical control. Some chemicals, such as 2,4-D herbicide, appears to be selective for specific species (e.g., Eurasian water-milfoil) when applied at the right time and dose. However, if not applied at precise times and doses, 2,4-d can also kill native plants, including native watermilfoils, lily pads, and watersheild. This was demonstrated through experimentation in Tomahawk Lake (test lake with 2,4-D herbicide applied) and Sandbar Lake (control lake with no chemicals applied). Tomahawk Lake observed significant reductions in all aquatic plants following application of 2,4-D (Figure 35). While it did kill off Eurasian water-milfoil, it also caused substantial reductions in other plants. There were also subsequent changes to water quality to Tomahawk Lake, potentially a result of the vegetation die-off from herbicide treatment. While herbicides can be effective tools, these results help demonstrate that their use must be done carefully, and with an understanding of the potential ramifications to broader lake ecology and water quality. It should also be recognized that such treatments can be costly. Wisconsin DNR has estimated that lakewide treatment of Sand Bar Lake (124 acres in size) with liquid 2,4-D would potentially cost $10,000 - $20,000. SEH (2011) suggested that chemical control of curly-leaf pondweed on the St. Croix Flowage could cost $400 to $800 per acre. Chemical control also does not guarantee that AIS will not re-establish in future years.

Physical removal of invasive plants is another management option and can include several forms. Each method has both positive and negative ramifications (Appendix D). For example, hand removal by diving can be highly specific for species and locations, but is labor intensive. Use of a mechanical harvester can be more efficient, removing large amounts of vegetation in a relatively short time period. However, there are many challenges with harvesters. They are not species specific and remove all vegetation in their path. While relatively maneuverable in open water, their size still limits the area they can operate. They are most effective in larger lakes with ample littoral zone depth and where the target species is almost mono-typical. They also are limited to the depth they can harvest, potentially from the

surface to a depth of five feet (SEH 2011). Harvesting also creates a substantial number of plant fragments that escape from the pick-up conveyor to be spread around the Flowage by natural and man-made means.

Both chemical and mechanical treatments most likely will not completely remove AIS from an infested lake. Given this, and the fact that AIS are found in several waterbodies within and near the SCHW, both chemical and mechanical control measures should be viewed as short-term or temporary measures to manage AIS. Long-term AIS control is most likely a long-term commitment for infested waters.

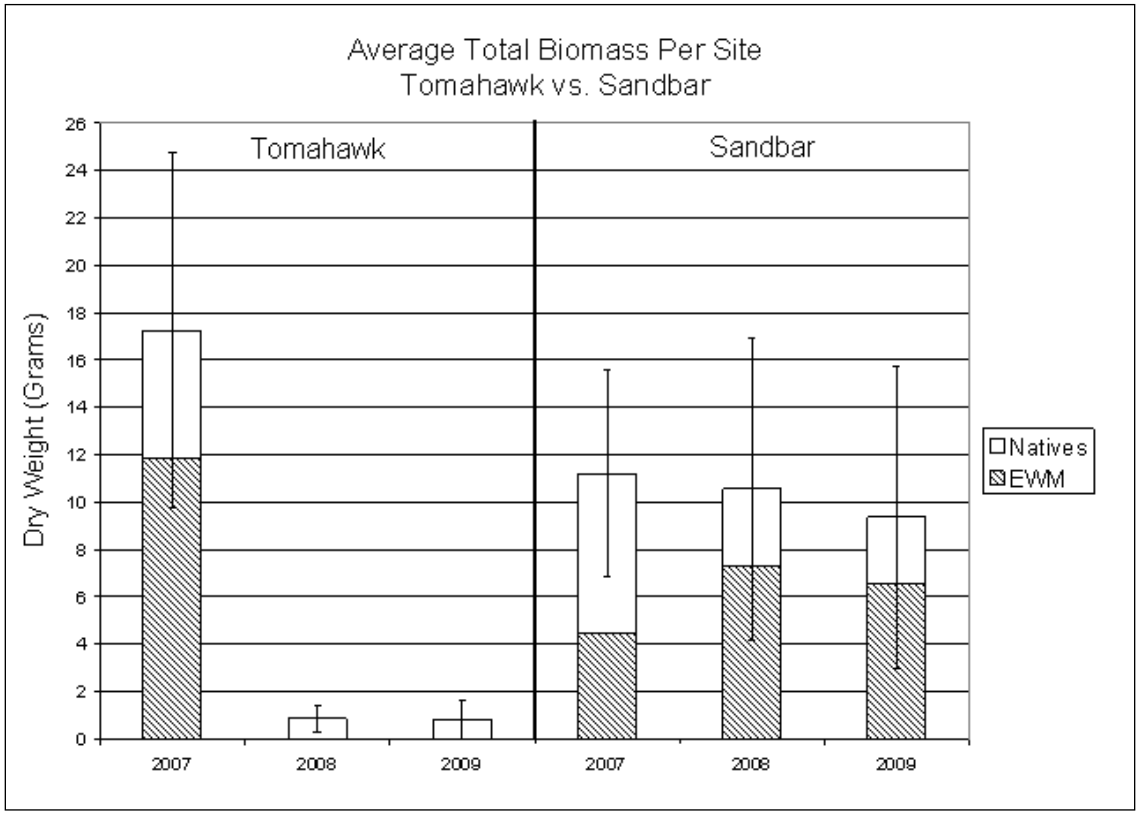

Figure 35 - Average aquatic plant biomass (grams dry weight) from randomly distributed sites prior to and following herbicide treatment on Tomahawk (2,4-D treatment) and Sandbar (reference) Lakes.

<u>Potential Future AIS Populations</u>

Additional AIS are near the SCHW and could potentially infest waters in the near future. AIS are especially abundant in Lake Superior which is less than 30 miles from the SCHW. AIS spread by human activities could be especially likely given this close proximity (e.g., spread through boat trailoring, bait bucket transfers, and other means). It should also be noted that AIS are spread through other natural causes, although human actions is typically the most common form of spread.

A species that could be most imminent for infestation is the zebra mussel which is in near-by lakes in both Douglas and Bayfield County. Zebra mussels are often spread via boat movement between lakes which has led to rapid spread of this species between waterbodies that are otherwise unconnected.

A risk assessment has recently been completed that assessed potential risk of zebra mussel spread in lakes of the St. Croix Basin (USACE 2007a; Wu et al 2010). While none of the lakes from the SCHW were included in that assessment, key variables can be reviewed to characterize risk for infestation in area lakes. These key variables include Total Calcium (Ca) and Total Hardness (CaCO3). Lakes with low concentrations of Ca (<12 mg/l) and CaCO3 (< 25mg/l) would generally be less favorable to zebra mussel infestations. Conversely, lakes with higher concentrations (e.g., CaCO3 >90 mg/l) would be very favorable for zebra mussel establishment (USACE 2007; Wu et al 2010).

Many of the lakes in the St. Croix Headwaters are "soft water " lakes, meaning they have lower measurements of total hardness. They also are lower in Ca concentrations. This suggests that many lakes would be at lower risk for zebra mussel infestation. It does not preclude zebra mussels from these areas; rather it only suggests that zebra mussels may not do as favorably.

Conversely, there are some waterbodies with higher total hardness and Ca concentrations that would be at greater risk. While no waterbodies had total hardness above 90 mg/l, several waterbodies had Ca and CaCO3 concentrations in a range that could still be favorable for zebra mussels. Lakes that typically had favorable observations of Ca and CaCO3 include the three Eau Claire lakes, Bony Lake, Pigeon Lake, Sweet Lake, Robinson Lake and Upper Ox Lake. The Eau Claire lakes may be especially at risk to zebra mussels given the high volume of boat traffic they observe.

Other waterbodies of interest include USCL and St. Croix Flowage. USCL is on the fringe of adequate Ca and CaCO3 concentrations typical of supporting zebra mussels. The lake may be more resistant to zebra mussel infestation, but care should still be exercised to minimize potential expansion to this lake. St. Croix Flowage is also on the fringe of acceptable water quality, but more favorable than USCL for supporting zebra mussels. Given its position in the watershed and the life history characteristics of zebra mussel, St. Croix Flowage is probably more susceptible to infestation from this species.

Additional analyses were recently completed to assess the potential for AIS to actively move on their own across the continental divide that separates the Mississippi River Basin from the Great Lakes Basin via the wetlands area between the Upper St. Croix and Brule rivers (USACE 2012). This pathway could potentially allow active swimming AIS (e.g., fish or parasites) to move from Lake Superior up the Brule River and cross into the St. Croix Basin during flooding periods. The analysis also assessed the potential for AIS to move up the Mississippi River and into the SCHW.

In short, the potential for AIS to actively swim to the SCHW from the downstream Mississippi River is non-existent due to the presence of several dams, including the large hydroelectric dam at St. Croix Falls. This dam precludes AIS from reaching the SCHW on their own. Gordon Dam also would provide a barrier under all but the most extreme flood events. Human transport is the greatest threat for AIS transport to the area.

Similarly, the probability of AIS reaching the divide location from the Great Lake side is also low given the presence of a dam, coldwater habitat conditions and stream gradient. In addition the likelihood of AIS crossing this divide location is low for many species. The area between the Brule and St. Croix headwaters is wetland but does include a slightly elevated ridge between the two. There is no clearly defined flow path between these two basins under most conditions. As such, the site would appear unlikely to support active movement of AIS from downstream Lake Superior.

Other Invasive Species Concerns

In addition to AIS, invasive species also can inhabit wetlands and terrestrial areas. Reed canary grass is a common invasive species that WiDNR identifies as dominating almost half a million acres of Wisconsin's wetlands. Two invasives that have recently been identified in the SCHW include the wetland species Phragmites and Purple Loosestrife. Additional information on wetland AIS of concern is available on-line from WiDNR.

Watershed Rapid Response Plan to new AIS Discoveries

For future planning, a proposed rapid response plan has been developed for the SCHW to address future AIS discoveries (Appendix D). This plan will be coordinated through appropriate agencies for support. This plan will remain flexible over time to adjust for new AIS threats that may emerge. The key focus is to emphasize the importance of AIS identification, and develop a framework for communication on the discovery and potential control options to minimize the threat to the specific waterbody, and potential spread to other areas in the SCHW.

4.6 Water Level Management for St. Croix Flowage

Gordon Dam History and Operation

Gordon Dam was constructed in 1937 as part of a Works Progress Administration (WPA) project during the Great Depression (UW Superior 2001). This project created the St. Croix Flowage, a reservoir with a surface area of 2,247 acres (Figure 36). Gordon Dam is presently owned and operated by Douglas County. The dam was renovated in 1988 and currently is a stop log structure operated to maintain a relatively constant reservoir elevation. Stop logs are added or removed in response to base flow and hydrologic events to maintain a discharge that facilitates consistent reservoir levels. Even after rain events, reservoir levels typically fluctuate by only a few tenths of a foot or less. Summer time water elevations are held near but below 1,014ft msl. Water elevation requirements are identified in the WiDNR opinion order 3-NW-79-801 (Appendix F), dated April 16, 1980, where maximum water levels are to be 1,014.0 feet U.S.G.S. datum, with the maximum level measured at the dam.

As outlined above, Gordon Dam and the St. Croix Flowage have been an area of controversy for many years in terms of perceived influence on flooding adjacent to USCL. Flowage water levels also have been an item of contention for lake front property owners and recreational interests. Frustration has often been expressed that Gordon Dam should be operated to increase water depths for the benefit of boating. Dam operation is sometimes blamed when boats run aground or strike underwater objects (e.g., the water is too shallow). Others have suggested flowage water levels should be manipulated to manage submersed aquatic vegetation, usually with the intent of reducing vegetation for "improved" boating or swimming activities. These conflicts on water elevations have been an area of extreme frustration for the dam owners. Maintaining constant water elevations is challenging with the current dam design, but has generally been achieved. Still, dam operation is a frequent complaint that is voiced to the dam owner.

Figure 36 - St. Croix Flowage, formed by Gordon Dam, at the downstream extent of the SCHW. Aerial photo from 2009.

St. Croix Flowage Biotic Conditions

Detailed assessments have been performed on the flowage, including surveys for depth, substrate aquatic vegetation (Swenson et al 2008; Johnson 2011) and defining critical habitat (Appendix C). St. Croix Flowage is 2,247 acres with a maximum depth of 28 feet, but a median depth of 7 feet (WiDNR web data). Slightly less than half of the reservoir is less than three feet deep, with the majority of this area is in the eastern portion of the flowage. This is also where the majority of lake front property residences are found. About 96% of the flowage sediment is muck substrate. St. Croix Flowage has very limited shoreline development. Much of the riparian area remains undisturbed, contributing woody debris, stable shorelines and a mix of vegetation within the riparian zone. Less than 1% of the riparian corridor is impervious surface (Table 16).

The St. Croix Flowage has a large and highly diverse aquatic plant community (Swenson et al 2008; Johnson 2011; Appendix C). Aquatic plant growth has been observed down to a depth of about 17 ft, with submergent and/or emergent aquative vegetation growing throughout almost all of the flowage. Comprehensive surveys in 2007 identified plants at 93% of the sites sampled, including 58 aquatic plant species. The St. Croix Flowage has the most diverse aquatic plant communities compared to several other flowages in northern Wisconsin. Plants present typically indicate a healthy aquatic ecosystem. The management of the flowage includes stable water levels and minimal fluctuations. This has allowed for stable conditions for aquatic plants, and in some cases, may increase the possibility for the presence of rare species that may be less tolerant of disturbance. Wild rice is abundant in areas upstream of the flowage, and stable water elevations helps this species to thrive.

Two aquatic invasive plants were found: Eurasian water milfoil and curly-leaf pondweed. Curly-leaf pondweed is thought to be primarily limited to the western lake basin. A survey in 2011 in the western basin of the flowage found a sparse distribution and low abundance of curlyleaf pondweed turions. This suggests the St. Croix Flowage did not support widespread dense curlyleaf growth in 2011 (Johnson 2011).

Similarly Eurasian water milfoil has primarily been located in the western basin with small but growing beds of this species. Surveys in 2012 found Eurasian water milfoil remained limited to the western basin but with populations that continue to expand. In response to this, chemical treatment is planned for spring of 2013. Managers feel this is the best approach to control this species before it becomes more widespread throughout the flowage.

St. Croix Flowage also has a quality warmwater fishery. This fishery is largely due in part to the undisturbed shorelines, rich aquatic plant community and stable reservoir elevations. Dominant species include typical assemblages for shallow, clear water lakes in northwest Wisconsin, including largemouth bass, bluegill and northern pike.

St. Croix Flowage Recreation and Social Views

Recreational use of the flowage is very important for area residencies and tourists. There is a county park at Gordon Dam, and two public boat launches on the flowage. There is also a campground on the south side of the flowage near Gordon Dam.

A sociological survey was completed in 2008 to help describe existing use and views on the flowage (St. Croix Flowage Association unpublished data). The following discussion is from the summary of this survey. Responses were received from 40 property owners (over 60% of the total Flowage property owners) and 70 non-property owners (usually people recreating on the lake).

The top recreational activities identified in the survey included fishing, "appreciating the peace and tranquility", "observing wildlife/bird watching", and "enjoying the scenery." Summer is the time of greatest public use, with winter the least.

Survey responses suggest an interest in maintaining a quality lake environment. Water quality appeared to be a lower priority, while shoreline vegetation and buffer zones were a greater concern. However, the greatest concerns identified included: *invasive plant growth, native plant growth,* and *water levels too low.* Over 85% of respondents said there were "far too many" or "too many" aquatic plants. The large majority of respondents felt the St. Croix Flowage Association should encourage removal of aquatic plants in the Flowage. However, there was also a strong interest in "restoring wild rice" to its former range in the Flowage.

Management Opportunities

Gordon Dam does provide an opportunity to manage water elevations to balance recreational, social and other interests on the flowage. The WiDNR opinion order does provide limits on maximum elevations; however, water levels could be manipulated below that. Water levels could not be increased for water depth given that the lake is currently managed near but below 1014, which is the maximum elevation identified in the WiDNR opinion order.

Water level management is frequently used on reservoirs to meet a wide range of needs. This has included meeting recreational needs, controlling or encouraging aquatic plant growth, and other priorities. However, any manipulation on water elevations at St. Croix Flowage, beyond existing practices must be considered very carefully.

St. Croix Flowage provides high quality fish and wildlife habitat due to its undisturbed nature and high abundance and diversity of aquatic plants. The aquatic plant community is due, at least in part, to the stable nature of water elevations. Stable water elevations are especially important for wild rice. Thus, any interest in promoting wild rice growth would need to consider how water manipulation could affect that goal. Other methods for vegetation control, whether by mechanical means such as harvest, or by chemical control, should also be carefully considered.

Admittedly, this desire for aquatic vegetation for habitat is in conflict with the desire of property owners and recreators who would prefer lower plant densities. However, there are risks to reducing aquatic vegetation. Aquatic vegetation helps to anchor lake substrate. This can be especially important in large, shallow impoundments where aquatic vegetation can minimize sediment resuspension during wind events (James and Barko, 1994). Potential risk for sediment resuspension might be especially high on the flowage where fine substrates dominate, and most of the eastern half of the flowage is extremely shallow (e.g., less than three feet deep). Given the large size, wind would have a mile in some areas to build wave heights which could generate waves capable of stirring up bottom sediments. Given the general westerly wind direction, and the fact that the shallowest water is generally on the eastern end of the flowage, this could result in increased turbidity, particularly on the eastern end of the flowage where most lake front property owners reside. If water clarity is reduced, it could further hamper aquatic vegetation. This could also begin to favor species such as common carp. Carp are present in low numbers in the flowage, but could become more abundant if habitat conditions deteriorate. In higher numbers they could certainly have an increased impact on water quality and plant abundance. Lastly, loss of aquatic vegetation could affect nutrient cycling within the flowage. Currently, the flowage is periodically a sink for downstream phosphorous transport. This could be interrupted with a large reduction in aquatic plants.

It must be noted that the levels to which any of these changes would happen are speculative. However, it is critical to realize that once managers go down the path of altered management, there are changes to the flowage that could potentially be difficult to predict, wide-ranging, and difficult to reverse after the fact.

One factor that may compound vegetation management is the presence of invasive species such as Curly-Leaf Pondweed and Eurasian Water-Milfoil. Management for these and other invasive species could become a larger issue, especially if their numbers dominate the flowage and crowd out native species. In these instances, management actions could be warranted to control these species. This could include a number of actions, whether mechanical harvest, chemical control, water level manipulation or other actions.

4.7 Recreational and Social Resources

Recreational use is extremely important in the SCHW, especially with its water resources. Outdoor activities take place on the great variety of water types, including lakes, warmwater rivers and coldwater trout streams. Outdoor recreation such as hiking, biking, hunting and nature viewing are prevalent. WiDNR estimated tourism expenditures in the four-county area (Douglas, Bayfield, Burnett and Washburn counties) totaled over $346,500,000 and supported 8,791 jobs in 2010. This supports recreation from land and water resources are a tremendous economic benefit to the area.

Public Use Areas

Many public areas exist in the SCHW that facilitate recreation. Waters in Wisconsin are a public resource and can be accessed from public right-of-ways. Many of the lakes also have boat ramps that provide public access. Several other areas also provide public access to land and water resources, including the Brule River State Forest, Douglas County State Hunting Grounds, and the Chequamegon National Forest.

As discussed in Section 2, WiDNR has recently embarked on the largest recreational and forest land acquisition in state history, with an easement of about 67,300 forest acres in Douglas, Bayfield, Burnett and Washburn counties. A large portion of this area is in the SCHW (Figure 37). The transaction, to be known as the Brule-St. Croix Legacy Forest, will occur in two phases. Phase I, approved in May 2012, is for a working forest easement on 44,679 acres at a price of $11,260,000. Phase I included approximately 40 square miles within the SCHW (Figure 37). Phase II, which is still in planning, would include additional acquisitions in the watershed area. Phase II covers about 22,668 acres (some of which is in the SCHW) at a cost of $6,007,000. Phase II is proposed as a 2014 transaction. Taken together, the project will protect 67,346.8 acres as sustainable, working forest land permanently open to the public for outdoor recreation. The easement keeps this significant forest area in productive forest use under private ownership. The long term forestry use will help support the timber industry and related jobs and also provides a very large area for permanent public access for hunting, fishing, trapping, cross country skiing, bird-watching and hiking. The land will remain in undeveloped condition and will be managed by the private landowner to insure productive pine forests while benefiting globally significant Pine Barrens habitat found in the area.

Social Views on Recreation and Water Resources

Recreational use surveys have been performed for St. Croix Flowage and the Eau Claire lakes area. Discussion for St. Croix Flowage was provided above. The survey performed for the Eau Claire Lakes area in 2006 focused on social views of lake front property owners and provides their perspective (Town of Barnes/Eau Claire Lakes association unpublished data). The survey included over 400 respondents from property owners on 10 different lakes around the Eau Claire Lakes area (Town of Barnes). While this may not be a comprehensive survey of the entire SCHW, it provides good perspective on the views of this important user group. A large percentage (78%) of respondents were at or over 51 years old (e.g., near or at retirement age). Respondents included a mix of year-round property owners (24%), seasonal property owners (33%), and non-resident property owners (40%).

The survey generally indicates that owners are passionate about their lake and its quality. Almost all respondents (91%) view the lakes as an important resource to the community. Popular activities include swimming, boating, fishing, canoeing/kayaking, and wildlife observing. Most respondents felt that area lakes "were used at the right level." There was some interest in greater control over use of personal water craft (e.g., jet skies), with mixed views on power limits of motor boats.

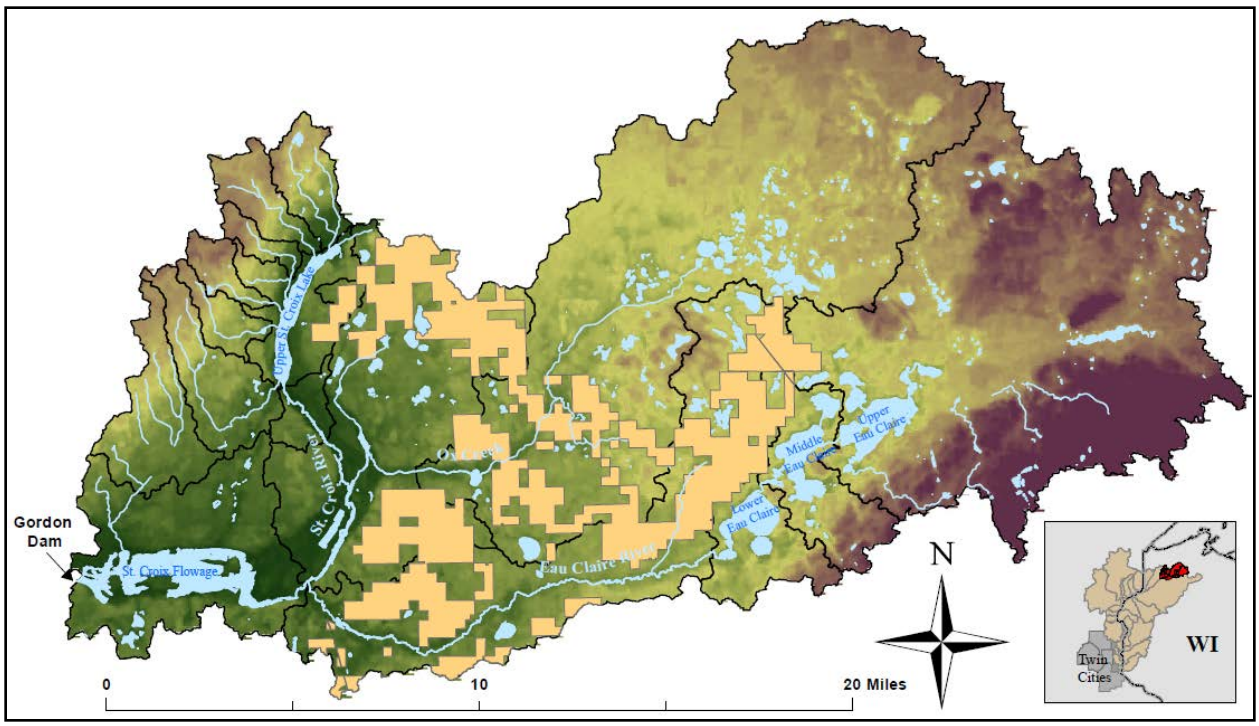

Figure 37 - Brule-St Croix Legacy Forest areas, shown in orange shading, within the SCHW. Property shown is from the Phase I easement. Additional area will be pursued during Phase II.

Most respondents indicated water quality had either some, or a great effect on whether to use the lake for recreation. When asked about contributing factors to surface water problems, property owners frequently cited fertilizers and pesticides, lawn maintenance, high density development and septic systems, as well as other factors.

The vast majority of respondents (85%), said they would support ordinances that would restrict the use of phosphorus-based fertilizers on lake front properties. Other actions that many lakeshore owners would support to benefit area lakes include enforcing zoning ordinances, keeping people informed, monitoring lake quality, and watching for/reporting exotic plants. Interestingly, when asked “How would you feel about "stricter" enforcement of the current lakeshore ordinance requiring lake shore property owners to have a vegetative buffer along the shoreline” only about 53% supported the idea, while about 40% were neutral or opposed the idea.

5. EVALUATION OF POTENTIAL FUTURE DEVELOPMENT

5.1 Overview

As rural areas continue to outpace urban areas in terms of population growth, the demands on the attractive natural amenities (i.e., riparian areas) for development has been growing. Adding new homes to the landscape increases the amount of impervious surface in the form of rooftops, driveways, asphalt, and compacted earth, preventing the infiltration of water into the ground. As a result, stormwater runoff over the land surface greatly increases, even during small rainstorm events. This alteration of the water cycle can have significant impacts to waters and habitat of the SCHW.

To cope with this demand and to better understand the development potential around some of the region's waterbodies, a residential build-out analysis was performed for the entire SCHW. Over the years, parts of the watershed have experienced waves of growth and development. Figure 38 illustrates the results of more than 50 years of land division in the Town of Barnes in Bayfield County, with lots created at or near the minimum lot size. One can see that in 1954 the area was mostly undeveloped, with few landowners. Over the years, hundreds of small lots have been created, and although many remain undeveloped, the stage has been set for high residential density. Conducting a build-out analysis provides visual evidence of what certain land use regulations can potentially look like in terms of density and location. An understanding of the potential of future growth can have wide ranging effects on local government decisions. Policies from housing to economic development to transportation are all influenced by the quantity and quality of future growth, so the ability to "see into the future" can help local decision makers make more informed decisions.

The SCHW is located in both Bayfield and Douglas Counties. The residents of the area have or are currently going through the comprehensive planning process which contains specific goals and objectives for a desired future landscape. The primary tools for achieving many of these goals are the county's zoning ordinances.

The build-out analysis is a tool used to project all possible future growth potential in a community given present environmental and physical constraints and current land use regulations using GIS. Build-out analysis can be used to visualize current land use in an area, such as a town or watershed, and to simulate where future development can occur under the current zoning. The analysis can reflect the density of development and the consequences of zoning ordinances (and alternative scenarios) and the effects of those changes on future resources, like water quality, infrastructure costs, and population, to name a few.

A build-out analysis can help residents understand what their municipality, or a section of it, will look like if built to the capacity allowed in current zoning and answers the question "how many buildings can be built in this area according to current land use regulations?" A build-out can also help identify changes needed in local master plans, zoning ordinances, and development regulations. While build-out studies are useful, they generally cannot predict when full development will occur. This depends on many pressures, such as the local or regional economy and other socioeconomic variables.

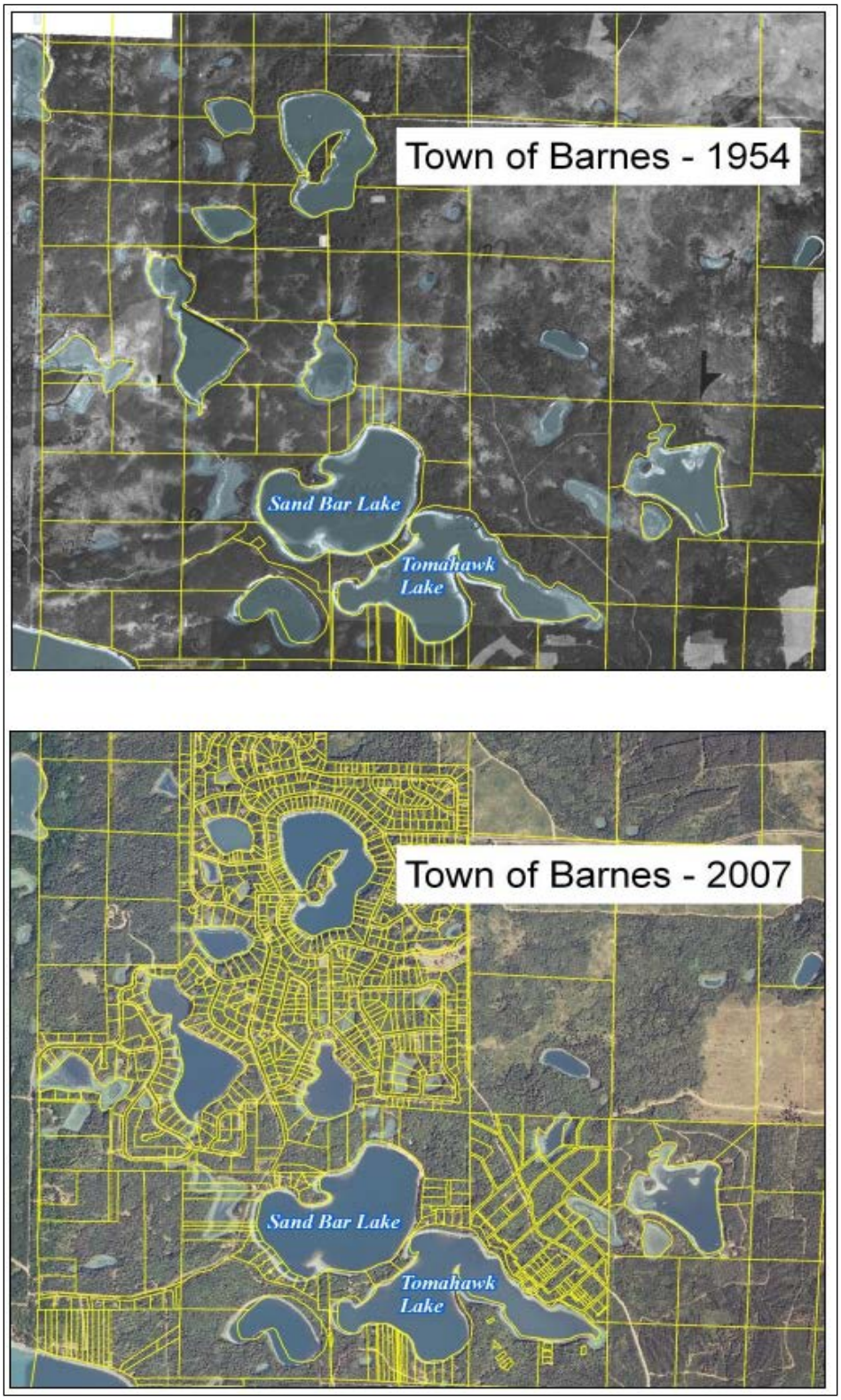

Figure 38 - Early and current parcel patterns in the Town of Barnes in Bayfield County. Some areas have experienced complete build-out in terms of lot creation.

The goal of this watershed build-out study is to provide insight to local decision-makers and interest groups on the scope and magnitude of future development patterns based on current land regulations. For this effort, the number, location, and disturbance area of potential dwelling units were used to quantify the amount of development and land use change possible at complete build-out. These are indicators of impervious surfaces for non-point source pollution. By understanding the potential changes of these indicators, decision-makers and citizens can better identify actions needed to protect the resources of the SCHW.

Note that this build-out analysis projects what could happen under the current regulatory framework. This analysis makes no prediction about when, or even whether, complete build-out will occur. The build-out assessment is only concerned with what the maximum permitted development is under a certain set of regulations.

5.2 Methods for Forecasting Future Development

A complete description of the build-out analysis, including the methods used, is contained in Appendix E. The basic approach will be summarized here.

The analysis begins with collecting available land information GIS layers. Available information on slopes, existing development, land use, wetlands, surface waters, roads, and public and industrial lands was combined in GIS to create a comprehensive view of the watershed's environmental and physical resources. Current land use data was established from updating the USGS 2001 National Land Cover Dataset (NLDC) with current building locations. The updating included digitized buildings for the watershed portion of Douglas County, while a building point shapefile was available for Bayfield County.

The digital tax parcel layers were obtained from each county's Land Information Office, and was crucial to the build-out analysis. Also critical to a build-out analysis is the feasibility of modeling zoning requirements. Zoning information was obtained for the two counties and the Village of Solon Springs. Provisions were included to account for zoning associated with shorelands, roads and road setbacks.

Community Viz™ Build-Out Wizard, an ArcGIS extension, was used to generate future development scenarios of the entire watershed. The Build-Out Wizard includes tools for performing a spatial analysis in which it attempts to place as many buildings within the buildable parts of each parcel. The buildable sections are the areas that are outside the development constraint determined based on the data inputs outlined above (e.g., existing buildings, zoning ordinances, setbacks, etc).

The wizard was used to create three scenarios of future development at complete build-out in the watershed based on alternative wetland layers.

Build-Out Scenarios Based on assumed wetland areas

1. Wisconsin Wetland Inventory (WWI) used as the only wetland constraint.
2. WWI and NRCS hydric/partially hydric soils as wetland constraints.
3. WWI, NRCS hydric/partially hydric soils, and WiDNR wetland points as wetland constraints.

The WiDNR wetland points are potential wetlands under five acres in size. They were collected as a point layer from the WiDNR's Surface Water Data Viewer and buffered to create polygons of 2.5 acres to represent their approximate size and location.

Revised wetlands data collected during this project (Section 4.2) was not included in this analysis. The reason is the data sources identified above remain the typical standard for initially assessing potential wetland presence. However, the new wetlands data was compared to projected development to assess potential development risk in wetland areas not captured by the traditional wetlands databases.

The amount of impervious surface associated with different development patterns was estimated from locally derived data. Local impervious surface data was combined with the digital parcel layer to calculate an average percent imperviousness for different residential lot sizes. We applied the different levels of imperviousness to each build-out scenario to calculate the approximate amount of impervious surface per new residential building. Finally, we combined the build-out results to the current land use coverage to calculate potential change for the entire watershed and within direct drainage areas.

5.3 Results

Figure 39 shows current building locations and the 2009 parcel pattern. There was estimated to be 3,817 buildings in the watershed (excluding secondary buildings).

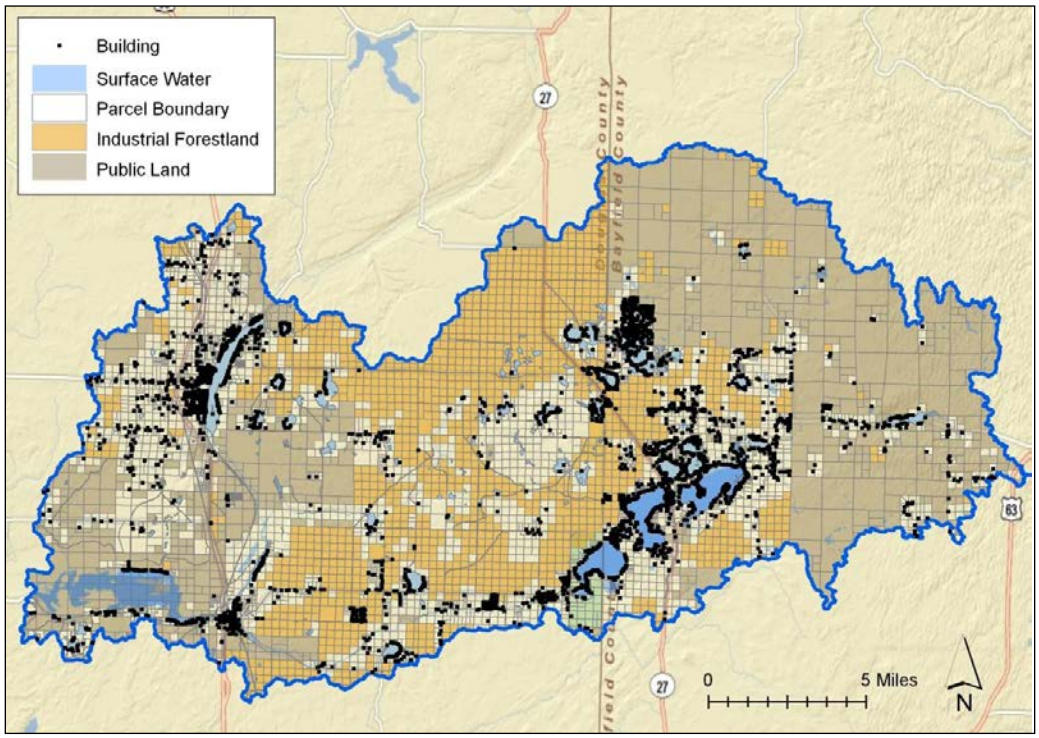

Figure 39 - Existing buildings and parcel patterns (2009) for the SCHW.

Under the watershed's current zoning density, the model projects a theoretical maximum of 11,660 buildings, including 7,843 new buildings and the 3,817 existing buildings under Scenario 1 (Figure 40). The distribution of these new units is indicated in Figure 41. Each red dot represents a potential new residential development that could be built. Much of the watershed likely is not developable because of the abundance of both public lands and industrial forests. However, a significant amount of development exists throughout the watershed, especially along roads and in close proximity to riparian areas.

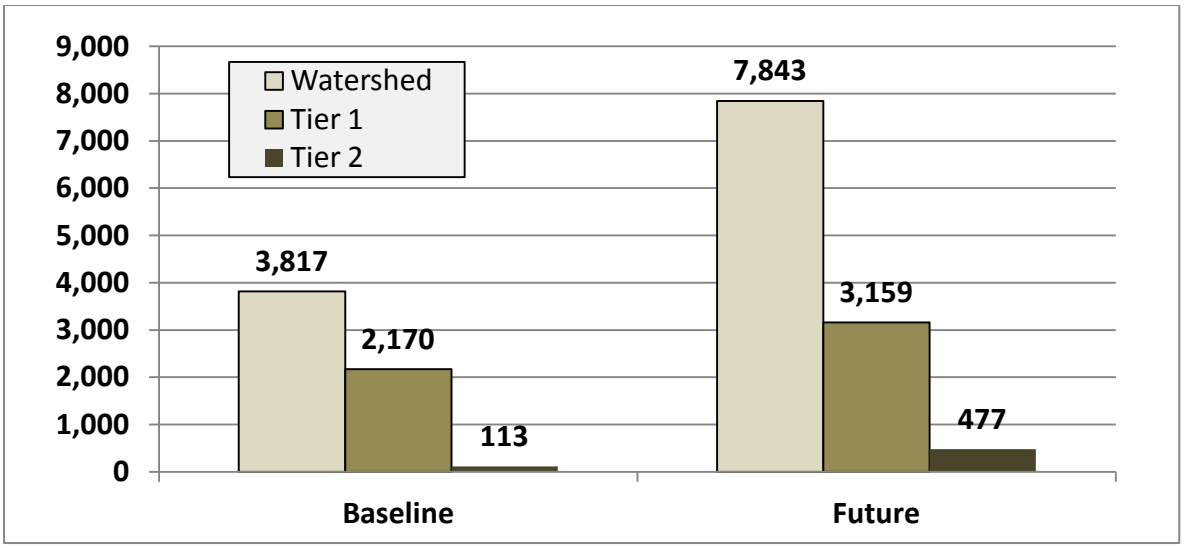

Figure 40 - Existing (2009) and projected maximum building counts for the SCHW, based on current zoning practices. Future numbers represent additional structures in addition to those in the baseline. Tier 1 areas are most directly connected to surface water drainage; Tier 2 areas could be connected (i.e. becoming Tier 1) by changes to the landscape.

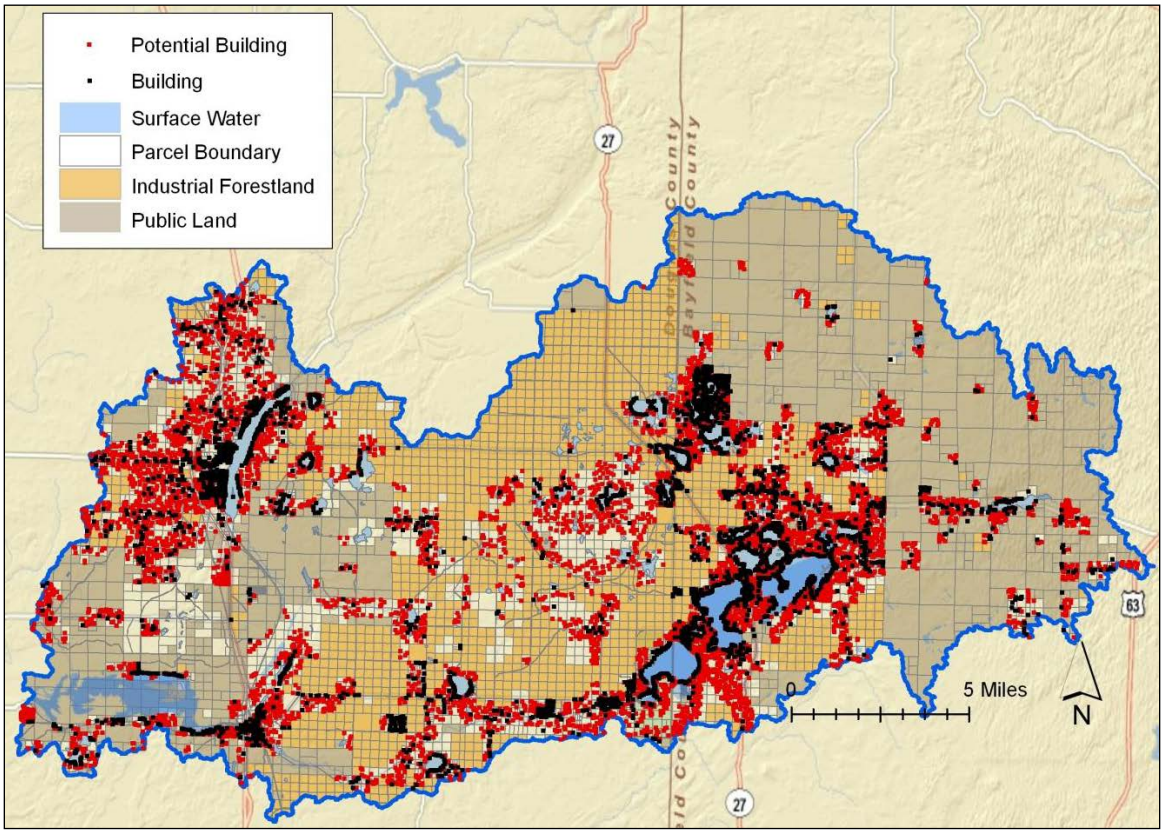

Figure 41 - Existing (2009) and maximum projected building development patterns for the SCHW.

Also presented in Figure 40 are the results of the number of residential buildings in the direct drainage areas. Nearly 40% of potential new, future residential dwelling units are located in Tier 1 (areas most directly draining to the St. Croix River), which covers about 27% of the watershed. Even though the total land area of the tiers accounts for about 32% of the entire watershed, almost half of potential new residential development takes place within these connected areas.

The results for Scenarios 2 and 3 are provided in Appendix E, but are generally similar to those for Scenario 1. For example Scenario 2 projects new dwelling counts of 7,167, and Scenario 3 includes 7,107 new dwellings. General distribution patterns are the same.

The results of this build-out analysis show there is a significant amount of development potential in SCHW. If every available lot subdivided and developed to the maximum extent allowable, the current zoning could result in a total of 7,843 new homes or buildings, more than doubling the current number. The findings in this report show that the current zoning in the watershed aims to concentrate development in meaningful patterns in an effort to reflect appropriate land use policies. However, a great portion of the development potential occurs in resource-sensitive areas. More importantly, the build-out analysis shows much of land in the watershed is off limits to development because of environmental and physical constraints. However, a large portion of the remaining developable lands are in close proximity to surface water features. If the most connected drainage lands completely develop at the maximum density allowed under the current zoning, roughly 3,159 new homes could be built in the most connected lands to surface water features.

Note that development in other portions of the watershed is also possible. This analysis assumed forestry-zoned areas would experience little to no development. However, industrial forest companies, like Plum Creek or Wausau Paper currently own nearly 58,000 acres in the watershed. Most of their forestland is zoned F-1, which allows for residential development on 4.5 acres in Douglas County. If these companies decide to divest and develop some of their more amenity-rich tracts of land, it could open the door to additional developable lots. Development could be expanded further if these forested areas are subsequently rezoned from forestry to residential areas. While this could open the door for new development, it might also provide flexibility with where this development occurs. It's possible that development could be steered away from environmentally sensitive areas.

5.4 Influence of Future Build Out on Priority Water Resource Issues

Water Quality

A SWAT model was developed for the watershed and used to estimate annual flow and phosphorous loading for baseline conditions with additional impervious surfaces. The hydrologic modeling generated through SWAT was used to estimate nutrient loading by assuming phosphorus concentrations for the baseflow and surface runoff. Appendix A provides a full description of this SWAT modeling effort.

The results of the SWAT modeling suggest an increase in total phosphorus loading with increasing watershed development. If maximum development were to occur, the model estimates an increase of approximately 2,000 to 3,000kg/year in total phosphorous from directly connected areas of the watershed. This would represent a relative increase of 25% to 50% on phosphorous loading, depending on the assumed baseline total phosphorous concentrations. Not surprisingly, the increase in phosphorous loading is considerably smaller if impervious is not directly connected to the stream system. Under maximum build out, areas not directly connected to the river system result in minor

contributions of total phosphorous loading from the watershed (e.g., 200 to 300 Kg P annual loading from indirectly connected areas).

Bathtub modeling of St. Croix Flowage suggests the flowage may be capable of trapping some of this additional phosphorous prior to downstream transport. A simulated 50% increase in phosphorus loading to St. Croix Flowage over 2008 conditions resulted in a predicted 35% increase in total phosphorus concentrations (Appendix A1). This may help reduce potential increases in downstream phosphorous transport, but would not eliminate them. In addition, effects to the aquatic community of the flowage itself would be affected.

In addition to general watershed increases in total phosphorous loading, water quality impacts could certainly occur to individual waterbodies. Lakes with significant adjacent development could see reductions in water quality. Thus, lakes with existing impairments could be especially susceptible to additional development. USCL, with its existing concerns over water quality and potential for future development, could be at increased risk for water quality impacts. Other lakes in the SCHW could also be at risk.

The small coldwater creeks that enter USCL also could be at increased risk for adverse effects. These small tributaries are of high quality, but could see reductions in water quality (and subsequent reductions as fish habitat) as impervious surface increases in the subwatersheds west of USCL (Figure 11). Impervious levels in the Park Creek subwatershed are already over 3%. Impervious levels that approach 5% to 6% could threaten these valuable resources. Park Creek could be at the greatest risk for reductions in water quality and corresponding fish habitat as a result of development.

Wetlands

The build-out analysis projects future development based on identified constraints. One such constraint is knowledge of available wetlands. The build-out analysis was based on existing wetlands data available within the WWI. This is the data most often initially sought to verify potential wetlands in areas of development. However, as outlined above, the existing WWI identifies substantially fewer wetland areas than the revised wetlands analysis performed here. As such, the build-out analysis suggests levels of development that could occur on or near wetlands not currently mapped. An absence of wetlands in the WWI does not clear permit requirements for potential construction. However, when such data is lacking, it increases the chances of potential development within wetland areas.

The build-out analysis projected over 700 future structures that fell within wetland areas identified during the wetland mapping analysis performed under this study. Over nine percent of the maximum projected future structures (730 of 7,843 structures) fell within newly mapped wetland areas. This strongly suggests the revised wetlands data layers developed through this study should be used for future reference to minimize risk of potential fill and development activities in wetland areas. Note that while WWI is accepted by resource agencies for identifying general wetland presence, it does not replace the need for formal wetland delineation often required for permitted actions. Rigorously following the regulatory process will help ensure wetland fill activities occur with proper review and permitting.

Critical and Riparian Habitat

The build-out analysis provides insight into what riparian areas could experience with future development. Projections for development (excluding secondary buildings) are provided for select lakes within the SCHW. The greatest development was projected for Middle and Upper Eau Claire lakes (Table 19). These are two of the larger lakes in the SCHW, but they also have 5% to 6% impervious surface within their 300-ft riparian corridor under existing conditions. Lakes such as Island, Lower Eau Claire, Upper St. Croix and Ellison have existing impervious surfaces over 8%, and could see a 10% to 28% future increase in additional structures adjacent to the lake. The amount of impervious surface associated with this development could increase similarly, though total impervious surface also factors in adjacent roads, highways and other features. However, these four lakes could be further stressed given the amount of development already present.

It should be reiterated that extensive development is possible adjacent to many SCHW waterbodies. Table 19 only reflects how GIS projected development within a 300 ft buffer of the given water resource. However, much more development is projected in areas near these waters, but just outside of the riparian buffer. This development can also affect adjacent waterbodies as run off can influence water quality, hydrology, habitat and other features. Care must also be given to planning development in these adjacent areas, especially where surface flow is directly connected to adjacent surface waters.

Table 19 - Estimated percent impervious surface, existing primary structures and projected future structure development within 300ft of identified lakes within the SCHW.

Lake	Lake area (ac)	% existing imperv	Exist. struct	Future struct.	Lake	Lake area (ac)	% existing imperv	Exist. struct	Future struct.
Island (Bayfield)	63	10.3	48	7	Sauntrys	103	4.4	29	4
Lower Eau Claire	784	9.2	131	37	Shunenberg	43	4.4	14	2
Upper Saint Croix	828	9.1	263	28	Sand Bar	127	4.2	34	12
Lake of the Woods	34	8.3	36	1	Birch	129	4.2	43	12
Ellison	118	8.1	42	9	Pigeon	200	3.8	37	4
Pickerel	89	7.8	54	2	Beauregard	87	3.6	44	8
George	50	7.2	30	9	Sweet	85	3.3	23	6
Bony	190	7.1	51	8	Simms	151	3.3	30	4
Kelly	56	6.2	16	1	East Eightmile	32	3.1	8	1
Middle Eau Claire	887*	6.0	203	115	Island (Doug.)	45	2.9	17	6
Robinson	89	5.7	36	7	Loon	101	2.9	17	2
Turtle	25	5.4	15	4	Cranberry	122	2.4	14	6
Upper Eau Claire	1,02	5.2	177	82	Rock	52	2.2	7	5
Sand	99	4.9	19	5	Ole	14	2.1	11	7
Breakfast	11	4.9	12	2	Smith	32	1.6	10	7
Long	46	4.8	16	7	Catherine	70	1.4	24	16

*includes aquatic area between Middle and Lower Eau Claire lakes.

Aquatic Invasive Species

Development in and of itself may not contribute to additional AIS in the basin. However, AIS are more likely to establish within ecosystems that are disturbed or unhealthy. The disturbance created from

development and the potential for more degraded habitat that accompanies development could foster conditions AIS may be able to capitalize on if introduced. Healthy, robust ecosystems are often best suited to avoid adverse effects of invasive species.

In addition, as more people live or recreate in the SCHW in the future, the risk for transport and establishment of AIS certainly increases. Waterbodies at risk will be those that see the greatest increases in public use, as well as those that are hydrologically connected where biota can be transported downstream by flow, or actively swim/move upstream. Waterbodies that could thus be at greatest risk include USCL, the Eau Claire Lakes and connected waterbodies and St. Croix Flowage.

Water Level Management on St. Croix Flowage

Development in and of itself probably would not directly necessitate changes to management in the future. However, an increase in impervious surface could result in streams that are more "flashy" in terms of their hydrograph following storm events. This could make operation of Gordon Dam more difficult when trying to maintain constant reservoir elevations. As conditions change in the future, whether independent of or indirectly related to development, any conclusion for reservoir management could be revisited.

Comprehensive Fish Passage

Development alone would not directly influence whether or not comprehensible fish passage is desirable in the SCHW. However, as conditions change in the future, the need for fish passage could be revisited. This could include changes to the ecosystem where benefits from fish passage become more important, or unique opportunities arise where implementing fish passage becomes more cost effective, or can be done without major social conflict.

Recreational and Social Resources

Development provides important economic benefits to the region, but could potentially impact water quality and aquatic habitat. Changes to water quality and habitat could influence people's choices to recreate and use water resources. Water quality is not only an ecological or recreational variable. A positive relationship exists between the water quality of surface water and the value of adjacent property. Select studies have been conducted that were able to document this. Some studies have even quantified the effect that water quality can have on property values similar to the effects of structural or locational qualities. Work done by the North Temperate Lakes – Long Term Ecological Research (NTL-LTER) program has demonstrated important economic and ecological links among property valuation, shoreline zoning regulations and water quality (Provencher 2005). While zoning regulations may adversely affect the value of a parcel of land due to use restrictions, the improvements to water quality and general aesthetics that lake-wide regulation provides may enhance property values. Improvements in water clarity of Vilas County lakes, for example, have shown to raise the value of undeveloped lakeshore property by about 3.6% (Provencher 2005). Another study in Maine concluded that water clarity significantly affects property values around lakes (Holly et al 1996). A 1-meter improvement in water clarity resulted in increased average property values ranging from $11 to $200 per foot of lake frontage.

This study did not in any way attempt to quantify how either improved or degraded water quality would directly impact home values specifically in the SCHW. It is uncertain whether the costs of any single or

collective actions to improve water quality might be recouped through improved property values. However, it is clear actions to improve water quality not only provide ecological or aesthetic benefits but also can provide economic value as well.

Other Resource Issues

Future development could influence other resource categories outside of the priority issues addressed above. One is the potential issue of flooding adjacent to USCL. The threat for potential flooding could increase with additional development as a result of an increase in impervious surface. As displayed in Figure 41, a significant amount of development could occur within the area around USCL, particularly to the west of the lake. This is an area of high relief where an increase in impervious surface would increase potential overland flow to USCL. There also are wetlands that provide the function of Surface Water Detention, some of which are not mapped with the existing WWI. Future losses of these wetlands could result in reduced capability to store water from storm events and/or snow melt, leading to increased flood peaks. The amount of buildout portrayed in Figure 41 is a maximum level based on current zoning, and it's uncertain when or if this buildout will ever occur. However, given current infrastructure, its location on a US highway and proximity to Duluth, MN and Superior, WI, it is not unreasonable to think that this area of the watershed could be at the greatest risk for future development.

6. RECOMMENDATIONS

6.1 Long Term Goals

Long term management goals can be established for any of the priority resources discussed. These can remain flexible over time and be adjusted based on priorities, shifting conditions, etc. The following are basic management goals and objectives for priority water resource issues. However, these can and should be tailored by basin stakeholders based on the results obtained from this and future studies and the collective goals for watershed quality shared by these stakeholders.

Water Quality Goals

The Lake St. Croix TMDL (2012) targets a phosphorous export reduction goal of 5% (about 600kg/yr) from the Upper St. Croix Watershed, an area over 40% larger than the SCHW. Phosphorous reductions in the SCHW would be more difficult to achieve with future development, but not impossible. Improvement in existing land use combined with managed future growth could work towards that goal. Land and water management in the SCHW could target to maintain existing sediment and nutrient loading conditions at Gordon Dam. During dry conditions (like those observed in 2008 and 2009) this would mean a mean summer total phosphorous concentration of about 0.025 mg/l and a total suspended solid concentration of about 1-3 mg/l. This is roughly three to six tons of annual phosphorous loading, and 150 to 300 tons of annual sediment loading (TSS).

If acceptable to watershed stakeholders, the long term goal for the SCHW could be to reduce annual phosphorous loading from the watershed by 5%, thus contributing toward the broader Lake St. Croix TMDL. Reductions this small would be difficult to measure, and would represent a decrease of 0.001-0.002mg/l of mean summer total phosphorous concentrations observed in 2008 and 2009 at the St. Croix Flowage. This would equate to a reduction of roughly 500lbs total phosphorous of annual phosphorous reduction (based on 2008 and 2009 observations). Although these reductions are relatively small, resource managers could strive for reductions in phosphorous loading to participate in contributing to the broader basin goals.

Future goals for watershed nutrient loading can also be tailored to address the long-term needs identified for the Wisconsin Nutrient Reduction Strategy (Wisconsin DNR 2013). This report was still under development at the time this study was completed. The State reduction strategy is being developed in response to the Gulf Hypoxia Action Plan (GHAP 2008). This plan called for each state in the Mississippi River Basin to develop a strategy by 2013 to reduce the amount of phosphorus and nitrogen carried in rivers from the state to address the biological "dead zone" in the Gulf of Mexico. Future SCHW nutrient loading goals can also be tailored to meet those identified in the final version of this broader State plan.

In addition to basin phosphorous loading, loading to individual waterbodies is also important for water quality. Site specific water quality goals can be established for any individual waterbody. High priority waterbodies could include the lakes identified in Table 10 that had mean total phosphorous concentrations approaching or exceeding identified phosphorus thresholds. Long term goals could target, at a minimum, reducing mean total phosphorous concentrations below respective thresholds.

Wetlands

Typical philosophy for management and permit regulations on wetland activities is for no net wetland loss from fill or similar action. This goal could be maintained in the future at both the watershed and subwatershed level, and even within individual drainages (e.g., contributing area of a seepage lake). Protection against wetland loss could apply not only to wetland type, but also wetland function. This would help ensure that important wetland functions such as Nutrient Transformation, Surface Water Detention and others are maintained. Site-specific wetland goals and objectives could be established for specific waterbodies or drainage areas. Wetlands data collected thru this study can be evaluated in the future to verify whether or not the quantity and function of wetlands has changed over time. Metrics would include acreage of wetland types and functions.

In addition to preventing further loss, future goals could include replacing lost wetland areas and improving wetland functions. This could be especially important in the western watershed, where fill activities and land use may have had the greatest effects on wetland quantity and function. Functions of greatest interest likely include Surface Water Detention and Nutrient Transformation. Wetlands that impact USCL could be priority areas for future work.

Aquatic and Riparian Habitat

Long-term goals could include protection of existing aquatic and riparian habitat resources. More specific objectives could include protecting/maintaining the specific critical habitat areas mapped in Appendix C. Metrics to evaluate effectiveness include verifying the quantity (acres) and type of critical habitat are maintained over time for the waterbodies assessed. Changes in footprint location also could be compared.

Goals could also include maintaining existing levels of impervious surface for riparian areas. Site-specific objectives could be considered for sensitive areas, including waterbodies with existing high levels of disturbance or known impairments (e.g., water quality impairments). Riparian areas with greater than 10% disturbance appear especially vulnerable.

Aquatic Invasive Species

AIS spread by many vectors and complete control of spread is difficult, if not impossible. However, the realistic long term goal is to "minimize potential spread of AIS to new waterbodies." An additional goal could be to manage or contain new AIS infestations to the extent practical, recognizing that each new case will have to be considered independently as to the appropriate control actions. More specific goals would need to be considered on a case by case basis.

St. Croix Flowage Water Level Management

Establishment of long term goals is discussed below under the recommendations for St. Croix Flowage water level management.

Comprehensive Fish Passage

No specific projects to improve fish passage are being pursued under this project. Future development should strive to not further impact biological connectivity in the SCHW. In addition, local entities can

also consider ways to improve fish passage past existing barriers (e.g., dams, culverts, etc) as opportunities arise that would make projects more affordable and/or implementable.

Recreation and Social Use

Long-term goals include maintaining strong public use of existing water resources. Managers should work hard to engage the public to keep them aware of resource issues that threaten the quality of the environment they are enjoying. This should include not only lakeshore and Tier 1 property owners, but also others who use land and waters.

6.2 Recommendations

The following recommendations are based on work performed to date, and additional outside studies, including the Lake St. Croix TMDL (2012). They will help to maintain water quality, habitat quality and other resource goals established above. In addition to benefiting water quality and habitat, these recommendations will help to benefit recreational use and aesthetic values. These provide direct economic benefits to the area, including benefits at the county and local levels. Thus, these recommendations are made for benefit for all those that live in and visit the SCHW.

Collaboration and Adaptive Management

With a finite amount of time and resources, local and state resource managers will need to prioritize management and restoration activities. The project sponsor has expressed an interest in forming a watershed alliance for future water resource management. The desire is to manage resources at the watershed level and not based on political boundaries. This may be best accomplished through an adaptive process where managers meet regularly (e.g., quarterly) to review projects across the watershed, including study or project implementation status, prioritization, monitoring/study results, funding status, etc. This type of effort has already been applied across the larger St. Croix Basin via the St. Croix Basin Water Resources Planning Team. A similar "Watershed Coordination Team" could be developed to collaborate and guide water resource planning within the St. Croix Headwaters. The addition of a specific Watershed Coordinator would be especially helpful in organizing a coordination team. Funding opportunities might be available through Wisconsin DNR to help partially cover a job appointment for a watershed coordinator hired at the local level.

The formation of a Watershed Coordination Team could include any of several regulatory agencies and interested parties, including Wisconsin DNR, Douglas and Bayfield Counties, the Village of Solon Springs, the Township of Barnes, other towns, NGOs, lake owner association reps, and other entities. Formation of this group with periodic meetings would, at a minimum, improve coordination of watershed issues, and could go a long way toward establishing goals specific to individual waterbodies, or the broader watershed, that local stakeholders could all take ownership in. This clearly would not result in agreement on all issues, but would be a way to bring sensitive issues up for open discussion. It is also a way to adapt goals and monitoring needs to resources over time. This supports a more adaptable approach which is more responsive as watershed threats change or evolve in the future.

A Watershed Coordination Team also could work to identify and prioritize potential management actions, restoration projects, and monitoring needs. This could also include working collaboratively to identify methods for implementation, and funding sources. Plans could be further fleshed out with the

development of "Action Plan" to build off this watershed plan and guide participating entities through implementation of activities to meet specific goals and objectives. Plans should remain flexible and be revised as priorities and resource needs change over time.

Future management and restoration actions may also be best implemented in an adaptive fashion. Implementing actions or projects over time is most realistic, and could include periodic monitoring to evaluate measure effectiveness, and whether or not goals are progressing. Data collected thru this study provides an excellent baseline for comparison of future water quality and habitat conditions. Watershed managers should be sure that future monitoring is based on clearly defined monitoring goals and objectives, with an understanding of how data will be used. Monitoring should be prioritized and focus on appropriate areas. Monitoring needs are discussed below, but should be initially established by the watershed agency team, and modified thru time as necessary to meet future needs.

Actions for Future Smart Growth and Development

Implementation of land use policies, regulations and non-regulatory strategies are critical components for protecting valuable resources including aquatic habitat, wetlands and water quality. In addition to benefits for aquatic resources, planning, zoning, and other conservation tools are used for ensuring the management of wildlife habitat, providing for sustainable development, protecting property values, and maintaining community character. The following are land use and voluntary land protection recommendations.

- Pursue Direct Drainage Overlay Zone – prevent potentially polluting sources from locating in susceptibility areas. Overlay zoning is an effective approach that does not require major revisions to the existing ordinances. The overlay district can share common boundaries with the base zone or cut across base zone boundaries. For example, the direct drainage areas (Tier 1) can be placed over the existing base zoning districts as an overlay zone with special provisions, like setting impervious surface limits, in addition to those from the underlying base zone (Figure 42).

- Consider conservation easements to protect sensitive areas in the direct drainage areas (Tier 1) and throughout the watershed. A conservation easement is an incentive-based, legally binding, land use restriction placed on property to restrict the development, management, or use of the land in order to protect a resource. The incentive may manifest itself in a variety of ways including tax incentives, comprehensive land use plans that involve the establishment of conservancy areas or the purchase of conservation easements by public or private conservation organizations such as land trusts. Conservation easements can be an effective avenue for protecting a watershed's natural resources. In this case, the build-out results can be used to help identify some of the areas of the watershed most vulnerable to development.

- Conservation subdivision designs should be promoted throughout the watershed and especially within direct drainage tiers and districts already zoned for residential development. A conservation design (cluster development) is a type of "Planned Unit Development" in which the underlying zoning and subdivision ordinances are modified to allow buildings (usually residences) to be grouped together on part of the site while permanently protecting the remainder of the site from development (Figure 43). This type of development provides great flexibility of design to fit site-specific resource protection needs while allowing for the same number of residences under current zoning and subdivision regulations. The conservation subdivision concept could potentially preserve

the rural character of the watershed and limit the potential for runoff associated with higher density development near the shoreline regions and within Tier 1 areas.

- A transfer of development rights program should be considered to help limit the amount of development within direct drainage areas. Transfer of Development Rights (TDR) is a voluntary, incentive-based program that allows landowners to sell development rights from their land to a developer or other interested party who then can use these rights to increase the density of development at another designated location (Figure 44). In this case, the preservation zone would be the delineated direct drainage areas so that the immediate riparian areas would be protected from future development and impervious surfaces.

- Work with the towns in the watershed to develop their own subdivision ordinances to be more restrictive than the county's. Each town could, for example, adopt a subdivision ordinance that classifies all new lots under a certain size as a major land division, thus requiring minimum standards to be met related to impervious surfaces, building placement, and sanitation. Together with zoning, this approach could help to shape the layout, design, and density of future development in the watershed.

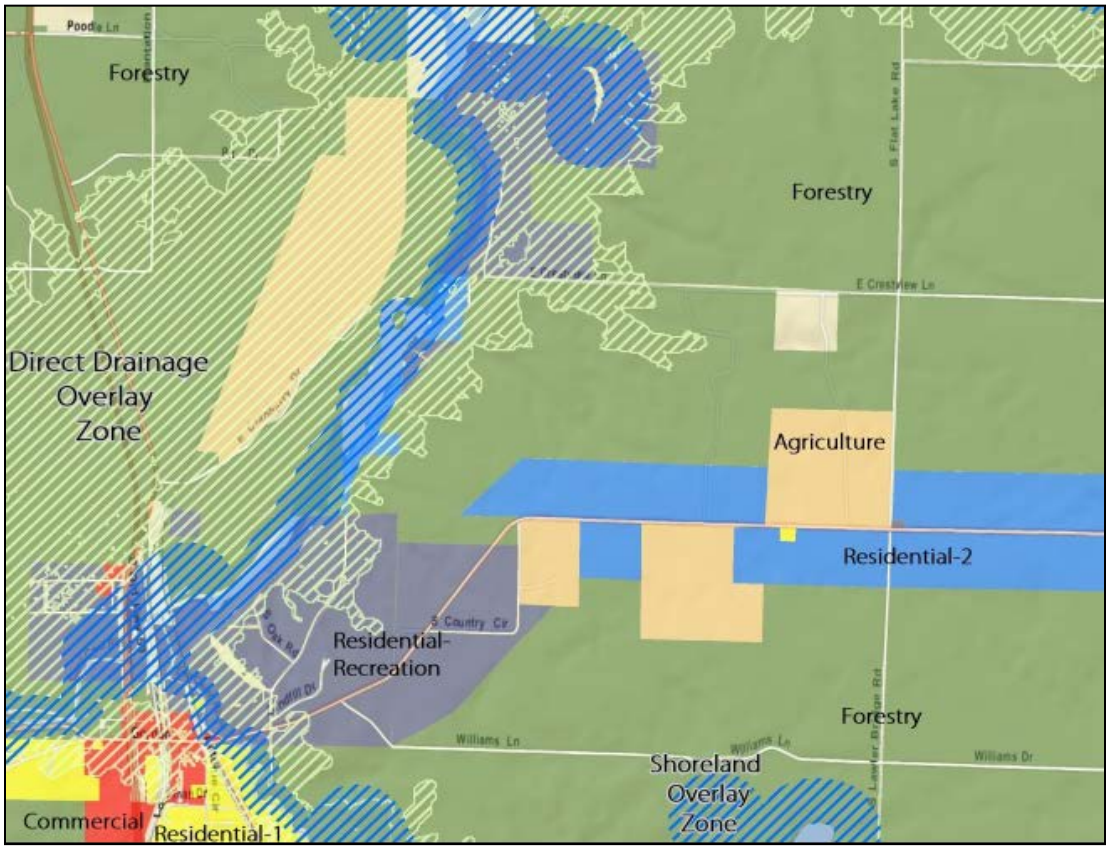

Figure 42 - Example: a direct drainage overlay has special provisions in addition to the requirements of the base county zones in order to protect water quality and riparian habitat.

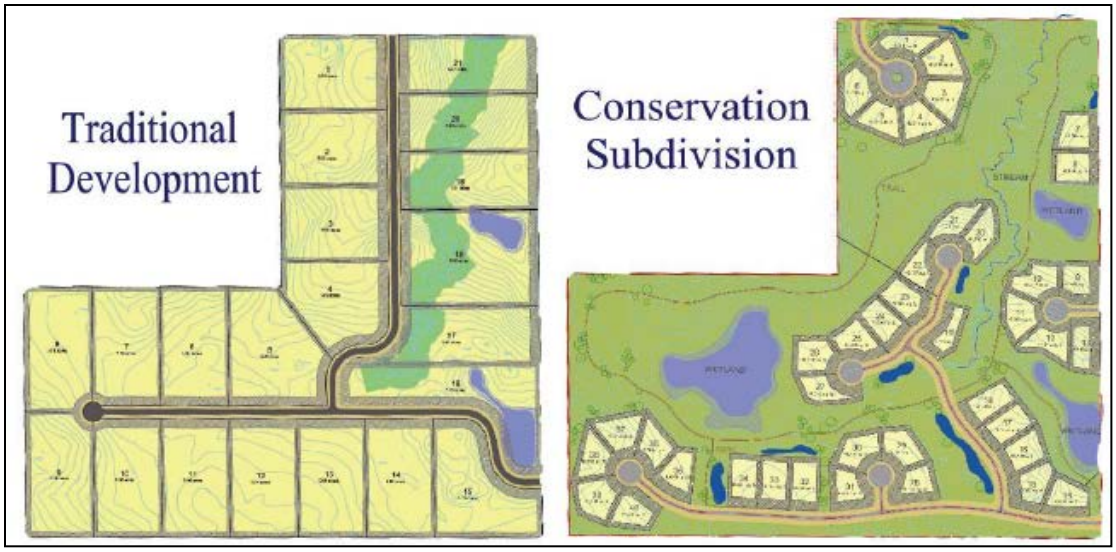

Figure 43 - An example of a conservation subdivision design from Walworth County, WI. Minimum lot sizes were reduced, but design allowed for 70 acres of common open space, the protection of a stream corridor, and natural stormwater management.

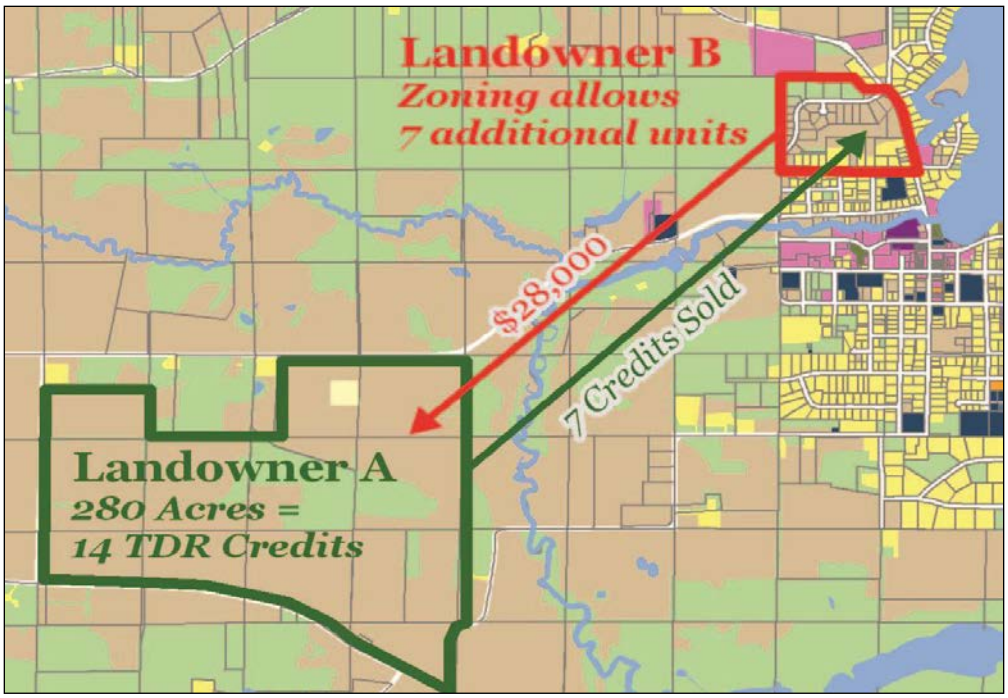

Figure 44 - Landowner A, a farmer, would like to get additional economic return from his property. In exchange for restrictions on his land, landowner A sells the development rights that, that under the program, are associated with his property. This permanent prevention of development helps the community reach its farmland preservation goals. Landowner B would like to develop her property in the receiving area which already has public services. Landowner B finds that she would earn a larger profit by purchasing TDR credits from Landowner A, thereby allowing her to build more housing units.

Homeowners Actions

Every citizen and visitor to the basin can make simple adjustments that will make a difference in the amount of phosphorus reaching our surface waters. Household wastes discharged through our home plumbing either reach an individual septic system or a community wastewater facility for further treatment and some level of phosphorus removal. Yard wastes and land use also affect sediment and nutrients in runoff carried to ditches, dry runs, small tributaries, wetlands, lakes, and rivers throughout the watershed. Here are some recommendations for everyone in the basin:

- Use phosphorus-free dish detergent and fabric softener.
- Compost food wastes and lawn clippings.
- Keep leaves and grass clippings out of the storm sewer drains.
- Dispose of pet waste properly.
- Use phosphorus-free lawn fertilizers.
- Let driveway and roof top runoff soak into the ground (use rain gardens, vegetative swales, etc.).
- Minimize hard surfaces like rooftops and driveways on your property.
- Properly maintain septic systems. Ensure septic systems are in compliance with local laws.
- Plant trees and shrubs in place of turf to help capture rainwater and minimize runoff.

Shorefront Property Actions

Shorefront property owners are another vital group for protecting aquatic habitat and water quality. Here are some recommendations for better managing riparian lots and shorelines:

- Properly maintain septic systems. Ensure septic systems are in compliance with local laws. Site new systems as far from surface waters as reasonably possible.
- Restore native vegetation and shorefront buffers to control runoff, minimize shoreline erosion and decrease grassed areas (in compliance with local zoning ordinances).
- Leave aquatic vegetation, fallen trees and woody habitat in place in the shallow water zone to provide valuable habitat and protect the shoreline from wave erosion. Where absent, consider opportunities to restore woody debris and aquatic vegetation in shallow riparian areas (Figure 45).
- Ensure riparian property management and development are in compliance with local and State ordinances and laws.
- Identify sources of runoff and find ways to intercept and infiltrate rainwater (rain barrels, rain gardens, infiltration pads, etc.).
- Use good erosion control practices around any ground-disturbing activities to prevent runoff and siltation.

Actions for Businesses, Churches, Schools, etc.

In addition to the recommendations above for homeowners, below are some general recommendations for these sectors:

- Use low or no-phosphorus products in manufacturing, cleaning and lawn care.
- Reduce runoff from roofs and parking areas through infiltrative practices.
- Implement water conservation measures.

Although agriculture is limited in the SCHW, watershed managers also could collaborate with agricultural interests to employ BMPs in their operations. This could help minimize potential for phosphorous loading, and other pollutants.

Figure 45 - Large woody debris placed in the riparian zone on Bony Lake, Bayfield County, WI. This is a valuable measure to help protect from shoreline erosion and provide valuable fish habitat.

Stormwater Management

Stormwater management is an important way for developed areas to help keep our waters healthy. The following activities can be undertaken to reduce contaminated runoff to local waterbodies:

- Develop a stormwater plan for future improvements to deal with the runoff using infiltration wherever possible (rather than piping it directly to surface water).
- Develop and enforce a stormwater ordinance to protect surface waters.
- Monitor for success and provide adequate funding for local efforts.
- Continue regular street sweeping and stencil storm drains.
- Educate community members about the sources of runoff and what they can do to help.

Silviculture

Forestry is a predominant land use across the SCHW. As such, it has potential for greatly influencing surface water resources, including input of nutrients and sediment via soil erosion. In general, it appears sound forestry practices are generally in place within the SCHW. Stakeholders can work with the timber industry to ensure this remains the case into the future. This can include implementing silviculture operations, forest stewardship planning and BMPs that are appropriate for given sites and activities. Guidelines can be found in Wisconsin's Forestry Best Management Practices for Water Quality (Wisconsin DNR 2010) or similar state-approved forestry BMP guidebook.

Wetlands

In congruence with the recommendations above, resource managers should continue maintaining compliance with the Clean Water Act, Section 404, and similar State requirements for wetland fill actions. Avoidance and minimization of unnecessary impacts to wetlands should be incorporated into predevelopment planning, zoning and land use regulation so as to maximize flexibility and minimize conflict during the permitting and development processes. Protection against wetland loss could apply not only to wetland type, but also wetland function. This would help ensure that important wetland functions such as Nutrient Transformation, Surface Water Detention and others are maintained. If wetland fill actions are sought, mitigation actions could strive to replace wetland quantity and function in these same areas.

Wetland protection also could be emphasized in sensitive areas. For example, in areas draining to the Eau Claire lakes, protection of wetlands that contribute to Nutrient Transformation functions would be important for limiting nutrient loading. Protecting wetlands that contribute to Surface Water Detention could help address concerns that water level fluctuations around Upper St. Croix Lake will not be exacerbated. Wetlands that perform multiple functions, as identified in Appendix B, could be especially worthy of protection.

Opportunities should be pursued, when available, to restore lost wetlands or improve wetland functions. The western watershed, and in particular the drainage area for Upper St. Croix Lake are strong areas for focus. These actions would provide both site-specific and downstream benefits, and help off-set changes that have occurred within this area due to development.

Fish Passage and Biotic Connectivity

Stakeholders can consider opportunities in the future to implement fish passage projects. Such opportunities could arise as infrastructure is maintained or repaired. For example, fish passage could be discussed as a feature at any dam that requires repair, maintenance or replacement. Some projects, such as fish passage at Upper Eau Claire Lake, could be very inexpensive and serve as a pilot project to assess fish movement between lakes in the watershed.

Road and bridge construction and maintenance also should strive to minimize future impacts to connectivity. Where practical, plan roads and driveways to minimize the number of stream crossings. Construct bridges as stream crossings whenever possible and replace culverts with bridges when possible. Future bridges and culverts should be designed to be “fish friendly” and maintain biotic connectivity.

Aquatic and Riparian Habitat Protection

Resource managers can observe and enforce existing rules and regulations associated with critical habitat designations identified in Appendix C. This applies not only to future development, but existing development as well. Implement projects that restore riparian habitat, near-shore woody debris and near-shore submergent and emergent vegetation. Implement measures to stabilize areas of gully and rill erosion.

Resource managers can ensure that existing laws and ordinances for shoreline properties are enforced. In addition, managers can ensure that impervious surface requirements outlined in NR-115 are adhered

to for future development. However, it should be noted that NR-115 provides great flexibility on impervious surface requirements. NR-115 states "A county may allow up to 15% impervious surface on the portion of a lot or parcel that is within 300 feet of the ordinary high−water mark." Possibly more could be allowed with a permit and approved mitigation plan. Unfortunately, impervious levels of 15% or more could have strong impacts on water quality and riparian habitat. Managers may want to carefully consider how development is allowed where resulting impervious levels rise above 10% on any waterbody. This may be best addressed by establishing allowable levels of imperviousness on a waterbody-by-waterbody basis and could vary depending on how development is implemented.

Reducing Risk of Aquatic Invasive Species Transfer

Tools to minimize risk of AIS spread include observing and enforcing existing laws on AIS. Continued education and public outreach also is extremely valuable to inform the public and help minimize the threat of human transport. Use of rapid response plans also will help to respond to new infestations and potentially control future problems.

Caution may be advisable when creating new AIS regulations that might limit public access to surface waters. This can certainly be done, and may help further minimize risk of AIS transfer. However, while reducing public access may reduce risk, it comes at the expense of limiting public access and the strong social and economic value that comes with public use. It should be recognized AIS can move by many vectors, and even the best efforts will not eliminate the spread of AIS. Thus, limiting public access should be carefully considered, including understanding whether AIS transfer risk is substantially reduced through reduced public access.

6.3 Resource-Specific Recommendations

Water resources of specific interest include the following. These areas could strongly consider the recommendations above for smart growth/development, actions for property owners, or other site-specific actions.

Eau Claire Lakes; Pickerel and George Lakes

The area around Eau Claire Lakes could be a high priority location for future focus. Existing development is relatively high with potential for considerable future development. The three lakes in the Eau Claire chain, as well as Pickerel and George Lake, are already suffering from reduced water quality and heavy shoreline development. Collectively, water and habitat quality could be further reduced with development both on the lake shore, and within close proximity to the water. Given the desirable nature of lake-front property, and how fast available lakefront lots are purchased, these areas could be at a fairly high risk for future development.

Efforts could be considered to limit extensive development on these lakes. If development is allowed, it could be carefully managed to minimize for potential disturbance. Continued emphasis should be placed on ensuring septic system compliance for all residencies, particularly those in Tier 1 direct drainage areas. Homeowners should improve outdated or faulty septic systems. They also should comply with existing regulations for riparian property management. Existing projects such as the Bony Lake woody habitat restoration are great first steps to improve near-shore and riparian habitat. Similar efforts should be considered for other area lakes. Additional projects that improve or protect water quality, riparian habitat and critical habitat also would be valuable on these waterbodies. This could

include additional projects for restoration of riparian buffer areas for riparian property, protection of critical habitat designations and restoration of submergent and emergent aquatic vegetation in shallow water areas. Protection of wetlands in the drainage area is also important for water quality, habitat and surface water detention.

Upper St. Croix Lake

The watershed area around Upper St. Croix Lake appears to be a high priority location for future focus. Existing development is greater here than other places in the watershed, with potential for future development. Although USCL remains below phosphorous thresholds, concern has been expressed by stakeholders regarding its water quality. This water quality could be further degraded by development within its relatively large and steep drainage area. The lake riparian corridor also is fairly disturbed. The lake is fed by high gradient, high quality coldwater streams, with fairly extensive wetlands in this area of the SCHW. Development in this area could threaten the quality of these streams and wetland areas. It could also lead to increased stormwater run-off, which could exacerbate flooding concerns for properties along USCL.

Efforts could be considered to limit extensive development in this area of the watershed. Within this focus area, Tier 1 locations directly connected to surface waters draining into USCL are most critical for protection. If development is allowed, it should be carefully managed to minimize potential disturbance and impervious surface. This can include efforts to both reduce the quantity of stormwater runoff from developed areas, as well as improving the quality of that stormwater runoff.

Existing projects such as the Solon Springs wastewater system improvements are important first steps for water quality protection. Continued emphasis should be placed on ensuring septic system compliance for all residencies, particularly those in direct drainage areas. Homeowners should improve outdated or faulty septic systems. They also should comply with existing regulations for riparian property management. Projects such as the USCL woody debris habitat restoration should continue in the future. Additional projects that improve USCL water quality, riparian habitat and near-shore habitat also would be valuable. This could include additional projects for restoration of riparian buffer areas for USCL property, protection of critical habitat designations and restoration of submergent and emergent aquatic vegetation in shallow water areas. Protection of wetlands in the drainage area is also important for water quality, habitat and surface water detention. Where possible, wetland restoration, including actions to improve wetland function, could be pursued in this area.

St. Croix Flowage

As mentioned above, changes to how Gordon Dam is operated would come at considerable risk. While changes could be made, they would come at a potentially significant risk to reservoir water quality, aquatic vegetation and fishery resources. Impacts to wild rice populations could be especially problematic as they provide valuable habitat and are an important tribal resource. Changes to existing water level management protocols may not be advisable at this time for the flowage. Existing management appears to maintain a high quality environment. Altered reservoir management would have a fair risk of long-term impacts to reservoir water and habitat quality. However, future goals for the flowage should be discussed further with key resource managers and input from public users. This could be done through meetings of the Watershed Coordination Team or through formation of a separate (but linked) Steering Committee for St. Croix Flowage Management. This would bring various interested parties together to bring their view on desired conditions for the future of St. Croix Flowage.

While identifying a unified vision will be difficult, this group would at least help with coordination of these issues, and should help reach some understanding on why the flowage will be managed with a certain philosophy moving forward into the future.

6.4 Resource Monitoring Needs

Extensive monitoring has occurred in the SCHW to assess conditions of water quality, fish populations, aquatic habitat, aquatic vegetation, AIS, and other resources. Such monitoring will certainly continue in the future. Watershed managers should be sure that monitoring is based on clearly defined monitoring goals and objectives, with an understanding of how such data will be used in the future. Monitoring needs should be established and prioritized collaboratively so that efforts are focused in appropriate areas. This can change as needs change and will need to be flexible in the future. Future goals and monitoring needs can be identified collaboratively through the Watershed Coordination Team. Possible monitoring needs could include the following:

- Phosphorous concentrations from priority lakes, including those with identified impairments.
- Periodic estimates of phosphorous loading at key points in the watershed, to include loading estimates at Gordon Dam to verify if the SCHW is meeting the goals of the Lake St. Croix TMDL.
- Impervious surface estimates for the watershed
- Presence and abundance of AIS
- Presence of rare or sensitive aquatic plants

Monitoring also could be performed to confirm that existing land use activities are in compliance with appropriate laws, regulations and statutes. Precise sampling locations, methodologies, frequency, etc. should be developed by watershed managers based on best available information. Existing practices often use local volunteers for monitoring activities. This is a great way to collect data on a limited budget, engage the public with participation and help ensure strong public interest. Public involvement should continue in the future.

7. COORDINATION AND VIEWS

7.1 Study Coordination and Public Review

Members of the public were engaged throughout the study through discussions at periodic local meetings. The majority of interested participants were from a local NGO, and/or local property owners with strong environmental interests.

The public will be offered the opportunity to review the final watershed report. The sponsor has also requested a strong "outreach" component to the watershed study. This would entail meeting with local and county government officials to review study results, and discuss opportunities for implementing study recommendations.

7.2 State and Federal Agencies

State and federal agencies have been directly involved throughout the study. The project sponsor is the natural resource agency for the State of Wisconsin. WiDNR utilized a State University to perform large portions of the hydrology and water quality analysis. The USFWS has been coordinated with and specifically participated with several aspects of the wetlands analysis. USACE Regulatory staff also was heavily involved with the wetlands analysis. The USGS participated with aspects of the hydrology and water quality evaluation, including working directly with the local sponsor to complete select field work and perform a layer of quality control.

7.3 Nongovernmental Organizations

Nongovernmental organizations participated heavily during the study. Namely, Friends of the St. Croix Headwaters was extremely active in study participation and input. Members of the Eau Claire Lakes Area Property Owners Association, St. Croix Flowage Association, and the Upper St. Croix Lake Association also participated.

7.4 Tribal Interests

Tribal interests were a consideration during this study. Study evaluations and recommendations are primarily focused on environmental protection. This includes the protection of wild rice which is an important tribal resource and is abundant in areas of the SCHW. Areas with abundant wild rice include the St. Croix River between the St. Croix Flowage and Upper St. Croix Lake. Areas with wild rice were mapped during critical habitat surveys which will offer them additional protection from the State of Wisconsin. Additionally, recommendations for maintaining current water level operations on St. Croix Flowage should help to maintain rich wild rice resources upstream of the dam. Other study recommendations aim to maintain or improve water quality, riparian and aquatic habitat, and wetland areas..

A draft of this watershed study was posted to the internet earlier in 2013 for public review. The final report also will be made available to the public, including the tribes, for consideration and use toward future management.

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Appendix A

Evaluations of Hydrology, Groundwater and Water Quality

Appendix A1

Limnological and Loading Response Analysis of St. Croix Flowage, Upper St. Croix River Watershed, Wisconsin

Appendix B

Wetland Resources

Appendix C

Critical Habitat Assessments for Select Water Resources

Appendix D

Invasive Species

Appendix E

Watershed Build-Out Analysis

Appendix F

Additional Project Data