State of Wisconsin
DEPARTMENT OF NATURAL RESOURCES
101 S. Webster Street
Box 7921
Madison WI 53707-7921

Scott Walker, Governor
Cathy Stepp, Secretary
Telephone 608-266-2621
Toll Free 1-888-936-7463
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September 24, 2015

Mr. Chris Korleski, Director
Great Lakes National Program Office
U. S. Environmental Protection Agency
77 West Jackson Boulevard (G-17J)
Chicago, Illinois 60604-3507

Dear Mr. Korleski:

I am writing to request the U. S. Environmental Protection Agency (U.S. EPA) Great Lakes National Program Office's (GLNPO's) concurrence with the removal of the Eutrophication or Undesirable Algae Beneficial Use Impairment (BUI) in the Sheboygan River Area of Concern (AOC).

The Wisconsin Department of Natural Resources (DNR) has assessed the status of the Eutrophication or Undesirable Algae BUI in accordance with the Delisting Target for the Sheboygan River AOC, which was published in 2008 and clarified in a formal review process in 2014. We are pleased to report that all actions associated with this impairment have been completed and a public review of the recommendation has been conducted. A public comment period was held from September 2 through 17, 2015. The draft document was provided for review on the DNR's web page and a hard copy was made available at the Mead Public Library in Sheboygan. Information about the review period was distributed to over 2,600 individuals through OGL's GovDelivery distribution list. A news release was distributed and was picked up by several media outlets, including the Sheboygan Press and Appleton Post-Crescent newspapers. The AOC Coordinator met with representatives of the City of Sheboygan, Sheboygan County, and Sheboygan River Basin Partnership to share information about the proposed BUI removal and seek feedback. Overall the comments were supportive of BUI removal. As a result, we are recommending that the Eutrophication or Undesirable BUI be removed from the list of impairments in the Sheboygan River AOC.

Please find documentation to support this recommendation enclosed, including the Eutrophication or Undesirable Algae Beneficial Use Impairment Removal Recommendation document prepared by DNR and correspondence from Sheboygan County and the Sheboygan River Basin Partnership supporting this recommendation.

We value our continuing partnership in the AOC Program and look forward to working closely with the GLNPO in the removal of BUIs and the delisting of Wisconsin's AOCs.

If you need additional information, please contact Camille Bruhn, DNR, at (920) 893-8527, or you may contact me.

Sincerely,

Stephen Galarneau, Director
Office of the Great Lakes
Wisconsin Department of Natural Resources
608-266-1956
Stephen.Galarneau@Wisconsin.gov

Enclosures

cc: Mr. John Perrecone, USEPA
Mr. Ted Smith, USEPA
Mr. Thomas Short, USEPA
Ms. Elizabeth Hinchey-Malloy, USEPA
Ms. Kendra Axness, DNR
Mr. Victor Pappas, DNR
Ms. Camille Bruhn, DNR

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

2 4 NOV 2015

REPLY TO THE ATTENTION OF:

Mr. Stephen Galarneau, Director
Office of the Great Lakes and Sediment Management Unit
Wisconsin Department of Natural Resources
101 S. Webster Street, Box 7921
Madison, Wisconsin 53707-3507

Dear Mr. Galarneau:

Thank you for your September 24, 2015 request to remove the "Eutrophication or Undesirable Algae" Beneficial Use Impairment (BUI) at the Sheboygan River Area of Concern (AOC) located in the Sheboygan, WI area. As you know, we share your desire to restore all of the Great Lakes AOCs and to formally delist them.

Based upon a review of your submittal and the supporting data, the U.S. Environmental Protection Agency hereby approves your BUI removal request at the Sheboygan River AOC. In addition, EPA will notify the International Joint Commission of this significant positive environmental change at this AOC.

We congratulate you and your staff, as well as the many federal, state, and local partners who have worked so hard and been instrumental in achieving this important environmental improvement. This progress will benefit not only the people who live and work in the Sheboygan River AOC, but all the residents of Wisconsin and the Great Lakes basin as well.

We look forward to the continuation of this important and productive relationship with your agency and the Sheboygan River Basin Partnership as we work together to delist this AOC in the years to come. If you have any further questions, please contact me at (312) 353-8320, or your staff may contact John Perrecone, at (312) 353-1149.

Sincerely,

for Chris Korleski, Director
Great Lakes National Program Office

cc: Kendra Axness, WDNR
Camille Bruhn, WDNR
Vic Pappas, WDNR
Matthew Child, IJC
Marc Tuchman, EPA, GLNPO
Ted Smith, EPA, GLNPO
John E. Nelson, Sheboygan River Basin Partnership

Sheboygan River Area of Concern

Beneficial Use Impairment Removal Recommendations

[Eutrophication or Undesirable Algae]

Submitted to

U.S. EPA-GLNPO
77 W. Jackson Boulevard
Chicago, IL 60604

By

Wisconsin Department of Natural Resources

September 2015

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Purpose

This document provides background information and summarizes progress made on the Eutrophication or Undesirable Algae Beneficial Use Impairment (BUI) in the Sheboygan River Area of Concern (AOC). It also provides documentation supporting the determination that the target for this beneficial use impairment has been achieved. The Wisconsin Department of Natural Resources is recommending the removal of this impairment.

Background

The Sheboygan River, like many rivers of the nation, suffered from severe water pollution from agricultural and urban point and nonpoint sources of pollution. These sources of pollution contain excess nutrients, which can cause undesirable algae blooms. The Sheboygan River Basin generates the pollutants contributing to the AOC. This 448 square mile area includes the Sheboygan River mainstem, the Mullet River, and the Onion River watersheds (WDNR, 1989 and 2015). The land and water areas that make up the Sheboygan River, the Onion River, and the Mullet River watersheds and the location of the AOC are shown in Figure 1.

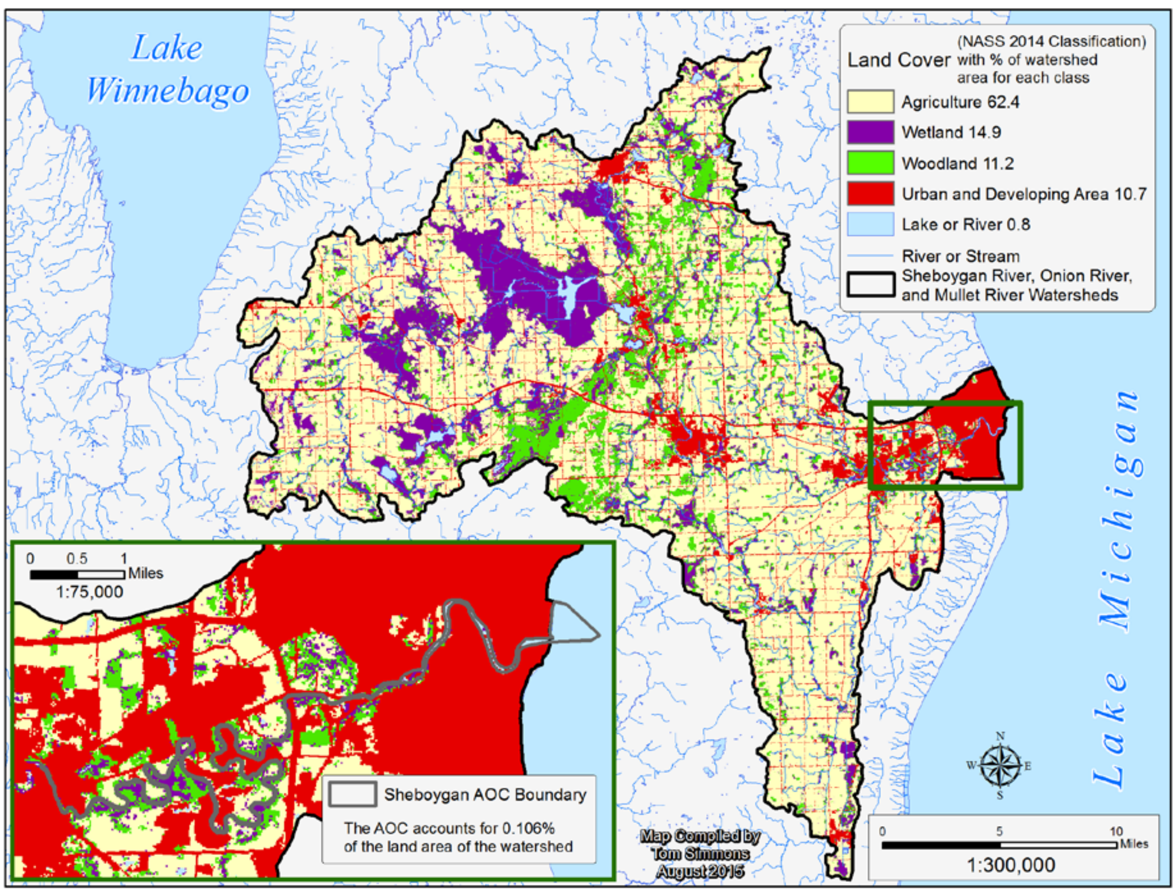


Figure 1. Land use in the Sheboygan, Onion, and Mullet Rivers Watersheds. (WDNR Map, Tom Simmons)

Congress addressed severe water pollution issues in the nation, including nutrient related pollution from wastewater, detergents, and runoff, through the Clean Water Act (CWA) of 1972. Improvements in water quality were in progress and correspondingly the Great Lakes Water Quality Agreement (GLWQA) was also signed in 1972, by the United States and Canada to “restore and protect the waters of the Great Lakes” (U.S. EPA, 2015a). The Agreement offers an outline “for identifying binational priorities and implementing actions that improve water quality” (U.S. EPA, 2015a). In 1987, the lower 14 miles of the Sheboygan River from the Sheboygan Falls Dam to the harbor of Lake Michigan were designated as an Area of Concern (AOC) under the Great Lakes Water Quality Agreement due to pollutants including polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), heavy metals, phosphorus, nitrogen, suspended solids, and fecal coliform bacteria. The primary sources of pollution identified at that time included discharges from industrial manufacturing and wastewater treatment plants, along with agricultural and urban runoff.

A 1989 Stage I Remedial Action Plan (WDNR, 1989) identified the following nine beneficial use impairments (BUIs) in the AOC:

- Restrictions on fish and wildlife consumption
- Eutrophication or undesirable algae
- Degradation of fish and wildlife populations
- Fish tumors or other deformities
- Bird or animal deformities or reproduction problems
- Degradation of benthos
- Degradation of phytoplankton and zooplankton populations
- Restrictions on dredging activities
- Loss of fish and wildlife habitat

The nutrient enrichment of water, or eutrophication, is typically due to excess nutrients loading to surface water, which can in turn lead to increased algae and macrophyte production (WDNR, 1989). Phosphorus is a natural component of aquatic ecosystems. This nutrient supports algae and aquatic plant growth, which in turn provides the food and conditions that aquatic organisms need to survive. Water with excess nutrients causes algae to grow faster than ecosystems can support. Excessive growth of algae can cause impairments in water quality, including altered food web dynamics and aquatic habitats, and reduce the amount of oxygen that is necessary for fish and other aquatic organisms (U.S. EPA, 2015b). Although nitrogen concentrations can also affect algae growth temporally or spatially, phosphorus is often the nutrient that limits productivity in the natural freshwater environment. As a result, Wisconsin focused on this nutrient and enacted statewide surface water quality criteria for total phosphorus in 2010 (Wisconsin State Legislature, 2010). Because the State of Wisconsin does not currently have water quality standards for total nitrogen, the focus for meeting nutrient standards in the AOC has been on phosphorus and some other water quality metrics (dissolved oxygen, chlorophyll-a and relative health of the aquatic biological community).

This document will focus on the Eutrophication or Undesirable Algae BUI. Historical data and accounts demonstrate the severity of the eutrophication problem that had been caused by excess nutrients enriching the waters of the Sheboygan River AOC. There have been significant improvements in water quality since the AOC was listed in 1987. Water quality conditions in the Sheboygan River watershed will continue to improve with continued implementation of programs to address point and non-point pollution.

Rationale for BUI Listing

The 1989 Remedial Action Plan (RAP) was drafted by the Wisconsin DNR with broad public input. The following information is excerpted from multiple sections of the 1989 RAP regarding eutrophication and undesirable algae. The industries and the citizens manufactured, used, and produced materials that became pollutants. Sources of these pollutants to the river were "municipal treatment plants, industries, and agricultural and urban runoff." Water quality data collected from 1977 to 1987 for the Lower Sheboygan River indicated "that suspended solids, fecal coliform bacteria, and the nutrients phosphorus and nitrogen" were elevated above levels that were determined acceptable. In the original Great Lakes Water Quality Agreement signed in 1972, emphasis was placed on controlling phosphorus contributions and therefore reducing eutrophication issues. Eutrophication may cause water quality problems and historical water quality data showed values above the acceptable levels. The Lower Sheboygan River regularly exceeded EPA's suggested phosphorus concentrations of 0.1 mg/L. It was because of the nutrient loading to the Sheboygan River, in addition to the negative impacts that eutrophication can have on "water supplies, recreational and aesthetic uses, and water quality needed to sustain fish and other aquatic life communities," that the Eutrophication or Undesirable Algae BUI was listed for the Sheboygan River AOC.

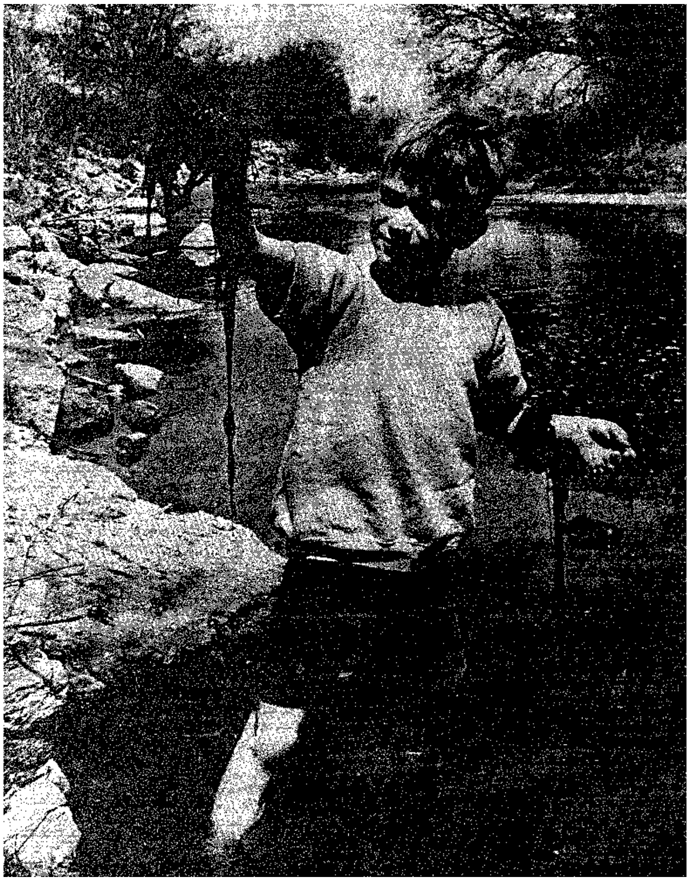
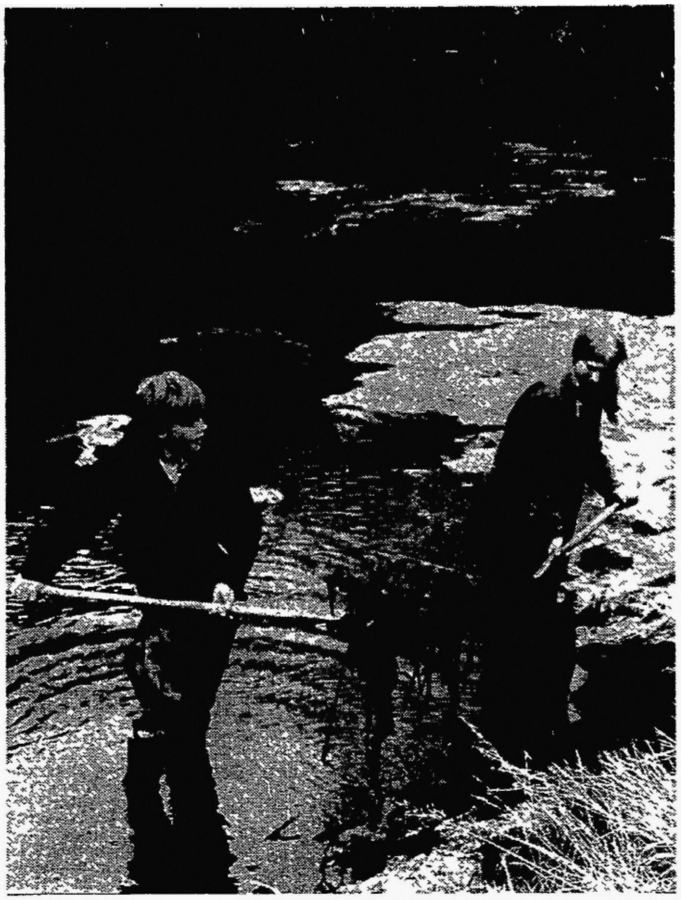


Figure 2. Newspaper article showing the degraded conditions of the Sheboygan River in 1970. The article caption read, "Handsful of Rotted Algae Can Be Scooped Anywhere Along The Sheboygan River." (Used with permission from Sheboygan Press Media) (Photo courtesy of Sheboygan County Historical
Research Center, Sheboygan Falls, WI)

The communities dotting the Sheboygan River shoreline inevitably caused problems for the natural resource they centered around. There were newspaper reports of raw sewage being dumped into the Sheboygan River and its tributaries by sewage plants, cheese factories, dairies, and other industries (Sheboygan Press, 1970). In March of 1965, Sheboygan Falls received national press because of the Sheboygan River. In the article, a picture depicted a foam mountain on and around the Sheboygan River that was larger than half a block long, about 25 feet high and 75 feet wide, and extended almost 15 feet on either side of the river banks (The Blade, 1965). This giant foam mass was believed to be caused by detergent pollution (The Blade, 1965 http://news.google.com/newspapers?nid=1350&dat=19650303&id=07pOAAAAIBAJ&sjid=UwEEAAAAIBAJ&pg=6675,4939943). Conditions of the river had gotten so bad that the Rotary Club published an entire "Conservation Tabloid" in the Sheboygan Press in 1970 "to create greater public awareness of pollution in the Sheboygan River basin." The following accounts are from the "Conservation Tabloid" in the Sheboygan Press Newspaper on May 23, 1970. In one section of the tabloid, a reporter stated, "the murky, brown Sheboygan River may flow to hell if ignorance and neglect of its condition are allowed to persist." It was also stated that man's demands on nature began to surpass nature's ability to sanitize the water resources. In addition to all of the industrial waste, human waste also contributed to the water quality problems that were becoming apparent throughout the Sheboygan River. There was a very large fish kill of "hundreds of big walleyed pike and catfish" in 1967 that was traced to human sewage pollution when Sheboygan diverted sanitary sewage waste into the river in order to “clear the city sewage treatment plant for a construction project.” Another article from the Conservation Tabloid referred to the Sheboygan River’s conditions while a man was fishing. An observer noted that every time the man cast his bait into the water it would come out “cloaked in a scummy, dark green algae.” The article mentions that people were ignorant of the problem and that they kept “spreading more dirt on the river floor each time a wash machine or a sink full of detergents [was] drained into a sewage system that [emptied] into the Sheboygan River.” They noted that nutrients going through sewage treatment plants without proper treatment were high in phosphates, which led to over-fertilization and killing of lakes and streams. In addition to sewage, industrial wastes and drainage from fertilized fields were also sources of phosphorus and nitrogen in water.

People were starting to realize that the negative effects that were occurring in the river were caused by their activities. Certain citizens and conservation groups highlighted the eutrophication issues of the Sheboygan River, which later became an Area of Concern. Although community involvement was slow to start, a few key people noticed the poor conditions that surrounded the river and they provided opportunities for citizens to become more involved with cleanup efforts and programs. A Kohler High School biology teacher witnessed the despicable conditions of the Sheboygan River and organized a river project intended to clean up the river (Sheboygan Press, 1971). The main idea behind the river project was to increase the water flow so the river could “flush itself,” and this work included constructing wing dams (Sheboygan Press, 1971). Despite the teacher’s gallant commitment and effort, only about 150 of the 700 needed volunteers showed up to provide the manpower to perform cleanup efforts (Sheboygan Press, 1971). In early 1972, the same teacher enlisted the Sheboygan Army Reserve to help with cleanup along the river (Sheboygan Press, 1972). He hoped this would be the spark that initiated the community to commit to helping improve conditions on the river (Sheboygan Press, 1972).



DEAD ALGAE was thrown from the Sheboygan River with pitchforks Saturday by young persons who participated in the first river clean-up in the area of the Kohler dam. Shown here are Bob Desotelle, of New Holstein, and Mary Rowe, of 527 Center Ave., Kohler. — (Sheboygan Press Photo.)

Figure 3. Newspaper article showing the first cleanup efforts in the Sheboygan River in 1971. The effort drew fewer people than anticipated and "the project director said that the people of Sheboygan County 'missed a good opportunity Saturday to see just how bad the river really is.'" (Used with permission from Sheboygan Press Media)

Summary of Watershed Remedial Actions

Since the Sheboygan River was designated as an AOC, considerable progress has been made to address sources of pollution. In addition to the Remedial Action Plan of 1989, which laid out efforts to improve water quality issues, Water Quality Management Plans and Priority Watershed projects have also been implemented to assess problems, and recommend improvements and management within the Sheboygan River Basin (WDNR, 1989). Summary actions to help control eutrophication of the Sheboygan River are as follows:

1972- Clean Water Act provided the structure for regulating pollutant discharges into waters and regulating surface water quality standards (U.S. EPA, 2015c).

1972- Great Lakes Water Quality Agreement identifies goals and objectives for improving water quality (WDNR, 1989).

1978- Wisconsin's Nonpoint Source (NPS) Pollution Abatement Program established. The program improves and protects water quality in many different resources by reducing pollutants from nonpoint sources. (WDNR, 1995)

1978- City of Sheboygan wastewater treatment plant upgraded and expanded to provide treatment for Sheboygan Falls, Kohler, and other nearby areas, including the Townships of Lima and Wilson (WDNR, 1989).

1980- Onion River Priority Watershed implemented nonpoint source control measures (WDNR, 1989).

1985- Sheboygan River Priority Watershed created with a goal to reduce surface and groundwater pollution caused by nonpoint pollution sources (WDNR, 1989).

1988- Sheboygan River Basin Water Quality Management Plan identified "water quality goals, problems, improvements, and management needs for lakes and streams in the Sheboygan River Basin." This plan also studied wastewater treatment facility and management needs for existing and future plants. (WDNR, 1989)

1989- Remedial Action Plan (RAP) included a specific goal to "control eutrophication (nutrient enrichment of water) for the protection of Lake Michigan" (WDNR, 1989).

1996- Sheboygan County Animal Waste Storage and Feedlot Facility Ordinance was enacted to regulate permitting of "animal waste storage facilities, nutrient management planning, and proper closure of abandoned waste storage facilities" (Sheboygan County, 2010).

2000- The Sheboygan County Land and Water Conservation Department implemented a stream buffer program to improve water quality. Since the project began, the department has worked with 53 landowners and installed 95 acres of buffer strips that help reduce sediment and agricultural runoff from entering streams. (SEH and ECT, 2008)

2001- State of the Sheboygan River Basin Report provided an update on water quality conditions in the Sheboygan River Basin including objectives for future actions that would further improve water quality, fisheries, and wildlife (Burzynski, et al., 2001).

2004- The Sheboygan County Land and Water Conservation Department worked with WDNR and others on an update to the Sheboygan County Land and Water Resources Management Plan. This plan is required for funds to be used for implementing agricultural best management practices. (SEH and ECT, 2008)

2004- "Municipal WPDES storm water permits were issued for the Village of Kohler, Town of Sheboygan, and Town of Wilson." These communities are taking actions to control urban runoff according to their permits. (SEH and ECT, 2008)

2006- Sheboygan County adopted an erosion control and storm water management ordinance (SEH and ECT, 2008).

2010- The Mullet River Watershed Plan was updated in 2010. The plan includes a detailed assessment of water quality conditions and recommended actions for restoring wetlands and establishing stream buffers. This plan was developed by the WDNR, UW Extension, and local partners. (WDNR, 2010)

2010- The Sheboygan County Land and Water Conservation Department worked with WDNR and others on an update to the Sheboygan County Land and Water Resources Management Plan.

2015- The Sheboygan County Land and Water Conservation Department worked with WDNR and others on an update to the Sheboygan County Land and Water Resources Management Plan.

Agricultural Runoff

The Sheboygan River Priority Watershed program, implemented in 1985, aimed to decrease surface and groundwater contamination that was caused by nonpoint pollution (WDNR, 1989). The program also provided cost sharing for best management practices that were implemented to improve nonpoint sources of pollution that were affecting water quality (WDNR, 1989). As part of the program, the numerous sources of urban and rural nonpoint contamination were inventoried and assessed within the watershed (WDNR, 1989). An appraisal of all water resources in the watershed was conducted to determine the use the resource supported, what the potential use for the resource could be, and how much reduction of specific pollutants was required in order to reach the potential use (WDNR, 1989). This information along with data on the sources of nonpoint pollution was used to devise a management strategy for each resource by controlling nonpoint pollution sources (WDNR, 1989).

Since Sheboygan County's Erosion Control Plan was published, many programs have helped to bring down the number of acres over the soil loss tolerance value (Sheboygan County, 2010). First, the state Sheboygan River Priority Watershed program was successful in obtaining landowner cooperation with conservation planning for soil loss reduction (Sheboygan County, 2010). Soil loss on steeper fields was reduced by the 1985 Federal Farm Bill's HEL and CRP provisions (Sheboygan County, 2010). The Farmland Preservation Program (FPP) was adopted in Sheboygan in 1979 and participation rose during the late 1980's and early 1990's (Sheboygan County, 2010). An Animal Waste Storage Ordinance was enacted in 1996 and amended in 2004 in Sheboygan County to regulate permits regarding animal waste storage facilities, nutrient management plans, and closure of waste storage facilities (Sheboygan County, 2010).

The Sheboygan County Land and Water Conservation Department collaborated with WDNR and other contributors in 2004, 2010, and 2015 to update the Sheboygan County Land and Water Resources Management Plans. These plans allow for the use of funds for implementing agricultural best management practices (SEH and ECT, 2008). These plans include cooperative strategies for implementing nonpoint pollution regulations in the state and establish "priorities for agricultural runoff practices near impaired waters and outstanding or exceptional waters in the county" (SEH and ECT, 2008).

In addition to these best management practices, a number of large farms (known as "concentrated animal feeding operations" or "CAFOs") obtained Wisconsin Pollutant Discharge Elimination System (WPDES) permits from the state in recent years, which has contributed to reductions in phosphorus from agricultural areas. Efforts to reduce nutrient loads are ongoing with the USDA Natural Resources Conservation Service (NRCS) and the Sheboygan County Land Conservation Department continuing to work with land owners to implement a variety of agricultural best management practices through programs such as Wisconsin Administrative Code NR 151, Conservation Reserve Program (CRP), Conservation Reserve Enhancement Program (CREP), Wetland Reserve Program (WRP), and Environmental Quality Incentives Program (EQIP). Sheboygan County continues to run its own buffer strip program as well. (Pappas, 2015).

The Nature Conservancy, working with Sheboygan County and other stakeholders, has undertaken a nutrient pollution study in a small tributary watershed to the Sheboygan River. Nature Conservancy staff are working closely with landowners to target sites and practices that could further reduce nonpoint pollution. It is hoped that this study will provide valuable information for other agricultural landowners in the area in the future. (Pappas, 2015).

In addition, numerous wetland restorations and enhancements have been completed in the Sheboygan River watershed, which help to increase water quality. These restorations are often conducted by landowners, state and federal programs, nature centers, and foundations. The USDA NRCS provides resources to landowners to restore and protect wetlands (Burzynski, et al., 2001). The Wetland Reserve Program (WRP) coordinates cost sharing payments to landowners who restore wetlands on their property (Burzynski, et al., 2001). The Conservation Reserve Program (CRP) also allows the NRCS to form contracts with farmers to "remove cropped wetlands and highly erodible cropland from production for 10 year periods" (Burzynski, et al., 2001).

Wastewater Improvements

Major improvements in wastewater treatment have occurred over the decades. The City of Sheboygan constructed their first wastewater treatment plant in 1937, where primary treatment was conducted, and it was upgraded to deliver secondary treatment in 1957 (City of Sheboygan, 2015). The city outgrew the upgraded facility by 1970 and a feasibility study was then performed after 1972, in which it was recognized "that a single wastewater treatment plant would be the most cost effective and environmentally sound method of treating wastewater produced in the region" (City of Sheboygan, 2015). When the City of Sheboygan constructed the new regional wastewater treatment plant in 1979, it served "the Cities of Sheboygan, Sheboygan Falls, the Village of Kohler, the Town of Sheboygan, and portions of the Towns of Sheboygan Falls, Lima, and Wilson" (WDNR, 1989). Before 1979, Sheboygan Falls and Kohler operated their own wastewater treatment plants and discharged directly into the Sheboygan River (WDNR, 1989). The larger regional plant that now treats wastewater from many communities discharges directly to Lake Michigan south of the harbor (WDNR, 1989). With the inception of the regional plant, pollution sources directly to the Sheboygan River were reduced, which helped to lessen water quality issues in the AOC. Sheboygan County has also worked with private landowners to identify and replace failing septic systems, which has helped improve water quality in more rural areas of the county.

Nutrient loadings from urban areas have also been reduced. A bill was introduced in 2009 that would reduce phosphorus in household products, which in turn reduces pollution in wastewater (Wisconsin Lakes, 2015). As wastewater discharge requirements strengthened and populations grew over the years there have been significant upgrades in municipal wastewater treatment at all plants since the 1970's. In addition, strengthening regulation led to decreased nutrient discharges from industrial sources. There has been lots of progress from the time when the Sheboygan Press was reporting that raw sewage and dairy related discharges plagued the river leading up to AOC designation.

Storm water- Municipal, Industrial, and Construction Site Improvements

Wisconsin Pollutant Discharge Elimination System (WPDES) storm water permits were issued for the Village of Kohler, Town of Sheboygan, and Town of Wilson in 2004 (SEH and ECT, 2008). These communities are all taking actions to comply with their permits and control urban runoff (SEH and ECT, 2008). Municipalities are required by Wisconsin Administrative Code to have a Municipal Separate Storm Sewer System (MS4) permit if they meet one of three criteria (WDNR, 2014a). These permits require municipalities to implement "storm water management programs with best management practices" in order "to reduce polluted storm water runoff" (WDNR, 2014a). There are seven MS4s in Sheboygan County and they include the Town of Sheboygan, the City of Sheboygan, the City of Sheboygan Falls, and Sheboygan County, all of which drain to the Sheboygan River (Yanke, 2015). In addition to municipal storm water permits, phosphorus fertilizer was banned for display, use, or sale, with certain exceptions, which was effective starting in 2010 (Wisconsin Lakes, 2015).

The City of Sheboygan has spent over $4.7 million in the past ten years on reducing phosphorus runoff to the Sheboygan River by performing storm water maintenance activities within the city limits. From 2005 to 2014, annual street sweeping removed 5,638 tons of road debris. For the same ten year period, 36,429 tons of leaves were collected from city streets. Catch basin cleaning has prevented 382 tons of debris from entering the river through storm water drains from 2005 to 2014. Nearly 123,000 gallons of waste oil was also collected from city residents from 2005 to 2014. These municipal activities have helped improve water quality conditions and also helped keep phosphorus from polluting the Sheboygan River. (Isaacs, 2015).

Many industrial sites are required to have Industrial Storm Water permits under which they "develop and implement storm water pollution prevention plans." The goal of these permits is to help identify and avoid pollutant sources or treat the storm water before it is discharged to surface waters if contact with pollutants cannot be avoided. Various specific industries are required to obtain these permits, "including: dismantling vehicles for parts selling and salvage, recycling of scrap and waste materials, and nonmetallic mining," as well as "other light and heavy industries." The Sheboygan Watershed has 124 active Industrial Storm Water permits and MS4 permit holders help oversee industrial activities as well. (Yanke, 2015).

The City of Sheboygan Falls, Village of Kohler, Town of Sheboygan, the City of Sheboygan, and Sheboygan County have adopted construction site erosion control ordinances, which are now subject to regulation as well. A landowner has to develop best management practices to be implemented on site to "control erosion and prevent contamination of storm water" (WDNR, 2012). Inspections are performed weekly throughout the project as well as after storm water events (WDNR, 2012). Sheboygan County had 170 active construction site permits at the time of writing (Yanke, 2015).

BUI Removal Objectives

The 1989 RAP for the Sheboygan River AOC identified long term goals and objectives to restore beneficial uses in the AOC (WDNR, 1989). The specific goal for restoring the eutrophication use impairment was to "control eutrophication (nutrient enrichment of water) for the protection of Lake Michigan" (WDNR, 1989). The 1995 RAP Update provided specific objectives to accomplish each goal (WDNR, 1995). Objectives for this goal included controlling nutrient inputs to the Sheboygan River, reducing suspended solids and deposited solids, protecting waterway areas and restoring banks to prevent erosion, and increasing public and official support of nonpoint source issues (WDNR, 1995).

2008 Delisting Target to Final 2014 Delisting Target

Defined delisting targets determine when impaired beneficial uses can be considered restored in an AOC. The delisting targets for the Sheboygan River AOC were developed with considerable input from local partners. All of the delisting targets are effectively combined to address a greater strategy and plan for restoring the AOC (SEH and ECT, 2008). The 2008 *Delisting Targets for the Sheboygan River Area of Concern: Final Report,* states that delisting of the Eutrophication or Undesirable Algae BUI can occur when:

- In-river total phosphorous concentrations meet Wisconsin criteria when promulgated; and
- There are no violations of the minimum dissolved oxygen concentrations established in NR 102 within the AOC due to excessive sediment deposition or algae growth; and
- No water bodies within the AOC are included on the list of impaired waters due to nutrients or excessive algal growths in the most recent Wisconsin Impaired Waters list submitted to U.S. EPA every two years.

Additionally, the document called for the following action:

- Develop a scientifically based monitoring program to establish when targets have been met.

An objective of the 2008 Eutrophication or Undesirable Algae Delisting Target was that the Sheboygan River AOC must not be listed on the Impaired Waters List. The methods to determine if a water body should be included on Wisconsin's Impaired Waters 303(d) List may change over time as policy and management change to adapt to the latest science. Currently, the Sheboygan River AOC is meeting the water quality target developed in 2008 (WDNR, 2014b). However, a clarification was introduced in 2014 to separate the AOC's 2008 water quality target "from the regulatory process used to add or remove waterways from Wisconsin's Impaired Waters List" (WDNR, 2014b). This means that the 2008 Sheboygan AOC water quality criteria will be used as the standard to assess if AOC goals are being met rather than tying the objectives to Wisconsin's Impaired Waters 303(d) Listing process. The difference between the AOC listing and the 303(d) listing in regards to water quality conditions is described below:

> Beneficial use impairments in AOCs are applied in order to identify the "worst of the worst" situations within the Great Lakes basin and their removal indicates that conditions have been substantively improved. Other programs (such as the 303(d) listing process) may have goals that differ from the AOC program. For example, in the 303(d) program, waterbodies can be designated as impaired if they are not fully meeting their designated uses regardless of the magnitude of the impairment. (Fayram, 2014)

A modification to the target wording as stated in the 2014 RAP Update is as follows:

- In-river total phosphorous concentrations meet Wisconsin AOC criteria of 100 ug/L with a 95% level of confidence; and
- There are no violations of the minimum dissolved oxygen concentrations established in NR 102 within the AOC due to excessive sediment deposition or algae growth; and
- The Wisconsin AOC target criteria will be considered to have been met when the sample population does not exceed nutrient targets or evidence indicates the lack of biological impairment (as determined by fish and macroinvertebrate Indicators of Biological Integrity, or IBIs)

Referring to "nutrient targets" in the third bullet rather than the Wisconsin Impaired Waters List provides the mechanism to separate the target from the Impaired Waters 303(d) program methods, which may change with proposed updates to administrative rules and agency guidance related to water quality assessment methods. Adding the option to consider evidence indicating biological impairment allows consideration of the natural variance among streams and rivers (i.e., streams and rivers can sometimes be healthy systems even if phosphorus levels exceed a certain numeric criteria). (Pappas, 2015).

Attainment of Goals and Targets- Achievement of Delisting Target

The following is a summary of actions taken to address the delisting target developed in 2008 for the removal of the Eutrophication or Undesirable Algae BUI and the fulfillment of these goals:

1) In-river total phosphorus (TP) concentrations meet Wisconsin AOC target criteria with a 95% level of confidence

Total phosphorus data were collected at the Esslingen Park site on the Sheboygan River from 1977 through October of 2014 (Data shown in Appendix A, Shupryt, 2015). Mean total phosphorus concentrations showed a steep decrease in concentration from about 0.4mg/L in 1977 to about 0.1mg/L in 2015 (Figure 4). EPA's suggested level for phosphorus was 0.1mg/L in 1967, which was exceeded in 1977-1980 with a level of about 0.3mg/L, which is shown in Figure 1 of Appendix A (WDNR, 1989). Phosphorus decreased considerably over time and was significantly lower post 1991 than pre 1991 (Appendix A, Figure 1, Shupryt, 2015).

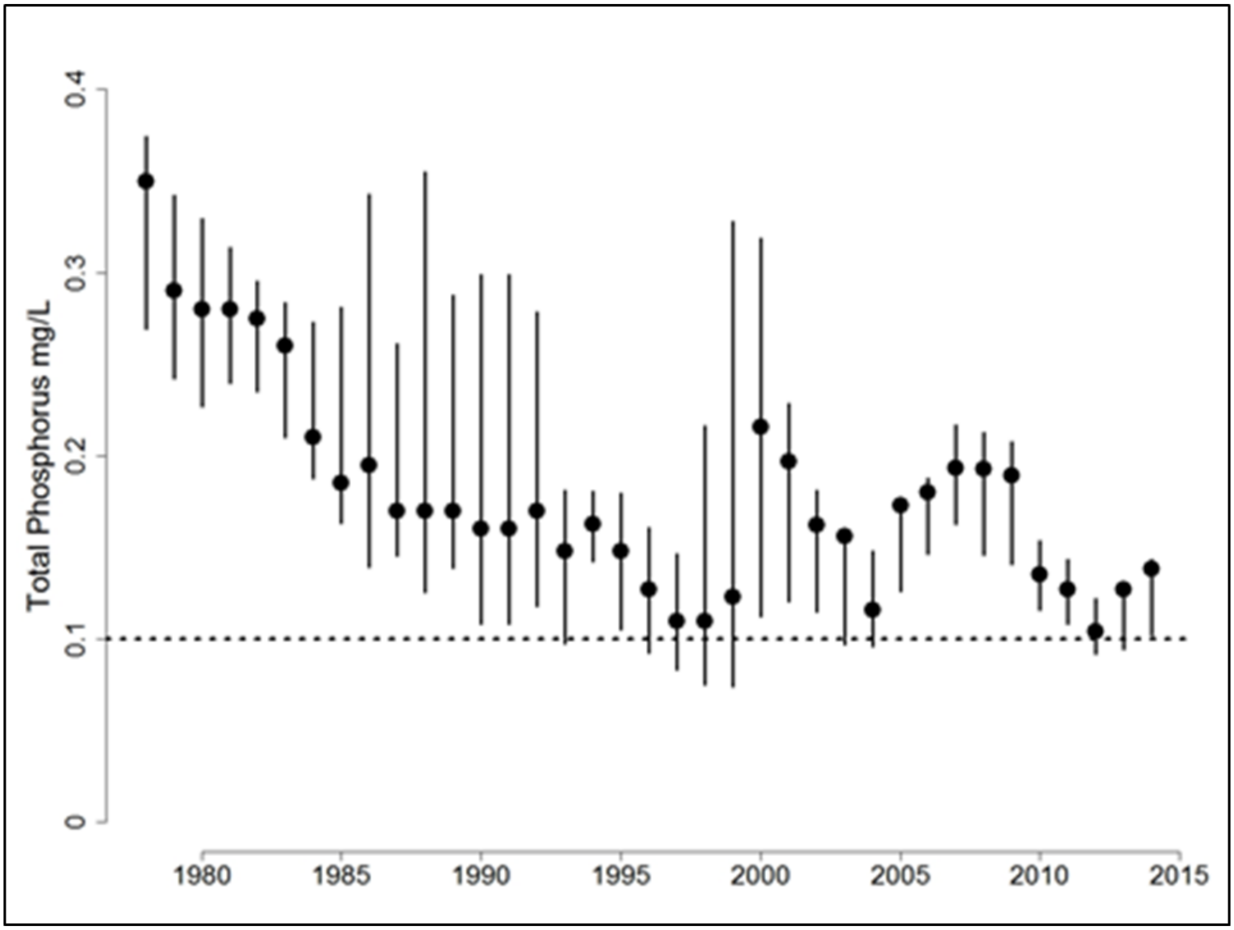


Figure 4. Mean total phosphorus concentration and variability over time for The Sheboygan River at Esslingen Park from samples collected March-October. Points are the three year rolling median concentration while the lines indicate the 95% confidence interval of the mean. The horizontal dashed line indicates the current water quality standard for total phosphorus of 0.1 mg/l. Graph also shown in Appendix A (Shupryt, 2015).

Data were also collected at the 14th Street site, which is located farther downstream in the AOC in a more urban setting, between October 2008 and September 2009 (Appendix B, Figure 3, Fayram, 2014). The mean and range were calculated for these data, and they were also examined for evidence of a temporal trend using simple linear regression, $\alpha = 0.05$ (Fayram, 2014). Recent data from the growing season were also observed to determine if the Sheboygan River met the total phosphorus target of 100 ug/L (Fayram, 2014). Data collected during the growing season (May-October, WDNR index period for total phosphorus assessments) indicated that the total phosphorus target was being met with a 95% level of confidence (Fayram, 2014). “Although the total phosphorus levels approached the target, there was no evidence that conditions were deteriorating with respect to total phosphorus levels over the last decade and these levels are much lower than levels experienced by the Sheboygan River at the time of AOC designation” (Fayram, 2014).

2) There are no violations of the minimum dissolved oxygen concentrations established in NR 102 within the AOC due to excessive sediment deposition or algae growth

Wisconsin Administrative Code NR 102.04(4)(a) lists 5mg/L as the minimum value for dissolved oxygen content in surface waters. Dissolved oxygen data shown in Appendix B, were collected at the Esslingen Park site on the Sheboygan River from March of 2000 to September of 2010. Data were also collected at the 14th Street site from October 2008 to September 2009. The mean and range were calculated for the data at each site and evidence of a temporal trend was also observed using a simple linear regression, $\alpha = 0.05$. The Esslingen Park site dissolved oxygen measurements ranged from 5.7 to 18.0mg/L with a mean value of 10.9mg/L for the time period from March 2000 to September 2012 (Figure 5). The 14th Street site dissolved oxygen measurements ranged from 7.8 to 14.6mg/L with a mean value of 12.5mg/L for the time period from October 2008 to September 2009 (Appendix B, Figure 5, Fayram, 2014). There was no evidence of a temporal trend in dissolved oxygen at the Esslingen Park site or the 14th Street site. The data did not show evidence of impairment in regards to dissolved oxygen. The lowest recorded value was 5.7 mg/L, which is still above the minimum criteria.

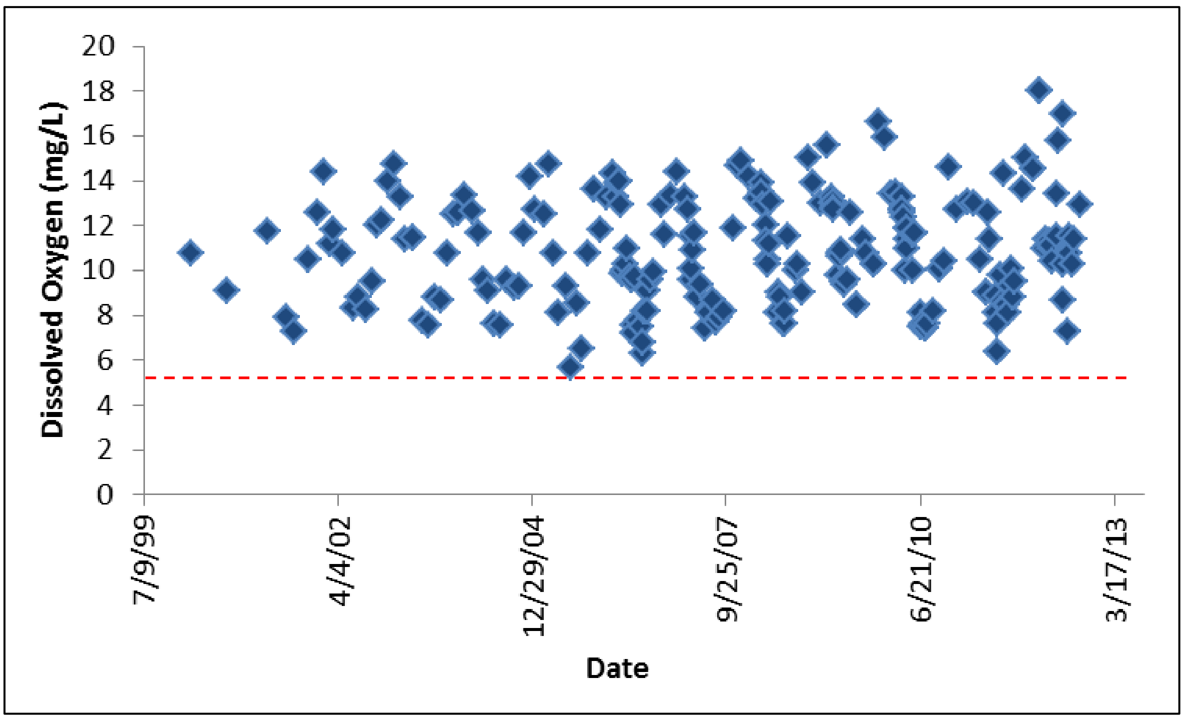


Figure 5. Dissolved oxygen values (mg/L) for the Esslingen Park location of the Sheboygan River March 2000- September 2010. Dissolved oxygen target criterion of 5 mg/L shown as dashed line. (Graph also shown in Appendix B, Fayram, 2014)

3) The Wisconsin AOC target criteria will be considered to have been met when the sample population does not exceed nutrient targets or evidence indicates the lack of biological impairment (as determined by fish and macroinvertebrate Indicators of Biological Integrity, or IBIs)

Total phosphorus levels did approach the Sheboygan AOC Target level, which prompted the examination of biological and physical habitat data at eight locations along the Sheboygan River in 2011 (Appendix C, Masterson and Motl, 2013). "Macroinvertebrate IBI and fish IBI scores indicated that the overall biological condition was not impaired as a result of elevated phosphorus levels" (Fayram, 2014).

Biological data indicate the absence of impairment (Table 1). Seven of eight sample locations within the AOC boundary have fish and macroinvertebrate IBI ratings of fair, good, and excellent (Masterson and Motl, 2013). These seven locations also had stream habitat ratings of fair, good, and excellent (Masterson and Motl, 2013). These IBI ratings indicated biological conditions that are not degraded and are even in excellent condition at certain locations. One site had a macroinvertebrate IBI score of "very poor," which is most likely due to degraded habitat in the lower reach of the Sheboygan River from the abundance of fine sediment on the stream bed (Masterson and Motl, 2013). A habitat rating was not available for this site, because WDNR does not currently have a protocol for assessing and ranking nonwadeable habitat in rivers (Masterson and Motl, 2013).

Site	Fish Community IBI	Macroinvertebrate IBI	Stream Habitat Rating
SR 01	Good	Very Poor	NA
SR 02	Good	Fair	Fair
SR 04	Excellent	Fair	Good
SR 05	Excellent	Fair	Excellent
SR 06	Excellent	Fair	Good
SR 07	Excellent	Excellent	Fair
SR 08	Fair	Good	Good
SR 09	Excellent	Fair	Excellent

Table 1. Fish community and benthic macroinvertebrate index of biotic integrity (IBI), and stream habitat ratings for Sheboygan River in 2011. NA = Not Available. (Appendix C, Table 2, Masterson and Motl, 2013).

Conditions at the Esslingen Park location within the Sheboygan River AOC exceeded EPA's suggested levels in the past. Levels of phosphorus, total suspended solids, and chlorophyll-a were all historically high and have significantly decreased over time. Suspended chlorophyll-a has been collected regularly since 1986 at the Esslingen Park location. Chlorophyll-a shows a decreasing trend since 2006, but the change is only statistically significant post 2010 (Appendix A, Figure 4, Shupryt, 2015). Although not part of the AOC target criteria, total suspended solids (TSS) have been collected at the AOC since 1977. TSS is measured as the weight of particles suspended in water and is generally considered an indicator of runoff from the upstream watershed. TSS concentrations appear steady over most of the life of the AOC, although there is a small but significant decrease post 2010 (Appendix A, Figure 3, Shupryt, 2015). However, TSS is strongly related to flow and runoff events and when corrected for differences in flow during the sampling evens it appears that TSS is variable, but clearly decreasing over time (Appendix A, Figure 7, Shupryt, 2015).

All of the watershed remedial actions previously discussed have contributed to attaining the determined goals and target in order to delist the Eutrophication or Undesirable Algae BUI. “Our results are not meant to indicate that further improvements with regard to TP, DO, CHL-a, or eutrophication in general cannot or should not be made” (Fayram, 2014). Our determination does satisfy targets specific to the AOC, but it does not necessarily indicate that the Lower Sheboygan River will meet all future regulatory water quality standards that may be more stringent than the AOC program targets. Broader habitat projects that are currently ongoing to address other BUIs in the Sheboygan River AOC will most likely improve the status of the AOC in regards to eutrophication as well (Fayram, 2014). As detailed above, there has been very significant, measured improvement in water quality in AOC waters over the last 30 years. Further improvements in water quality can be realized through continued implementation of wastewater, non-point, storm water and impaired waters programs and by efforts of local watershed groups.

BUI Removal Process

The process includes preparation of a draft BUI removal document with review by Wisconsin Department of Natural Resources staff and U.S. EPA staff, consultation with external partners, and a public comment period. Below is the timeline for which actions were completed:

August 1st: internal review

August 12th: submit to U.S.-EPA GLNPO for comment

August 25th: TAC stakeholder meeting to discuss package—get feedback

September 2nd: draft out for public comment

September 17th: public comment period ends

September 23rd: final package completed – sent to Madison for official approval/submission

A draft BUI removal document was reviewed internally by Wisconsin Department of Natural Resources staff. It was then reviewed by U.S. EPA. After WDNR and U.S. EPA reviews were completed, a Technical Advisory Committee stakeholder meeting was held on August 25th to discuss the package and receive feedback. The document was then released for broad public review and comment on September 2nd. The public was notified through a GovDelivery message and a statewide press release. Over 2,600 subscribers received the GovDelivery message regarding the public input opportunity period. The draft document and a public handout were also placed on the WDNR Sheboygan AOC webpage and at the Mead Public Library. WDNR also met with the Sheboygan River Basin Partnership, the City of Sheboygan, and Sheboygan County to discuss the draft document and receive input and feedback. WDNR responded to all questions and comments received. Comments received related to adding key activities performed by the City and County in support of reducing phosphorus contributions. All comments were generally supportive of addressing eutrophication and removing the BUI. A final document addressing all comments was prepared. All input actions were completed and WDNR is recommending removal of the impairment. A final package was sent to the Madison DNR office and U.S. EPA for consideration.

Recommendation

Based upon the information collected, analyzed and reported and the feedback that was received, the Wisconsin Department of Natural Resources recommends that the Sheboygan River AOC beneficial use impairment (BUI) for Eutrophication or Undesirable Algae can be removed. Substantial improvements in water quality have been achieved since the 1970's and 1980's when the eutrophication or undesirable algae impairment was identified for this AOC. The removal recommendation was shared and discussed with the Technical Advisory Committee and several external partners, including the Sheboygan River Basin Partnership, the City of Sheboygan, and Sheboygan County. Support for this BUI removal was provided by Sheboygan County and the Sheboygan River Basin Partnership (Appendix D).

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Appendices

Appendix A: Sheboygan River Water Quality Data Analysis at Esslingen Park 1977-2015 (Shupryt, 2015)

Appendix B: Sheboygan River Area of Concern Eutrophication Beneficial Use Impairment Assessment (Fayram, et al., 2014)

Appendix C: Aquatic Baseline Monitoring of Select Streams within the Sheboygan River Area of Concern (Masterson and Motl, 2013)

Appendix D: Letters of Support

Appendix A

Sheboygan River Water Quality Data Analysis at Esslingen Park 1977-2015
(Shupryt, 2015)

Sheboygan River Water Quality Data Analysis at Esslingen Park 1977-2015

Mike Shupryt
Wisconsin Department of Natural Resources
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Methods:

All water quality data used for analysis were downloaded from the WDNR SWIMS database for the Sheboygan River at Esslingen Park (Station ID: 603095, N43.740273, W-87.75094). There were a total of 433 grab samples for total phosphorus ranging from 1977-2015. There were also 383 samples for total nitrogen (1979-2015), 445 samples for total suspended solids (1977-2015) and 247 samples for suspended chlorophyll a (1988-2015). Any samples recorded as non-detect were assigned 0.5 times the detection limit.

In order to evaluate trends for each of the four constituents analyzed we performed a one-way ANOVA. Parameters were grouped into discrete bins that each spanned a five year period. Any constituents that did not approximate normality were transformed. Many water quality constituents have a strong seasonal pattern in concentration that need to be accounted for when conducting trend analysis. By grouping datasets spanning multiple years the effects of seasonality on long term trends can be reduced by analyzing the central tendency of the groups, which includes data from all seasons. We followed any significant ANOVA with a Tukey's Honest Significantly Difference (HSD) test to determine which groups were different from each other. The HSD will determine which groups are different from each other but will not explicitly determine if there is a trend. However, if there is a pattern in the among-group differences (e.g. all the past years groups are different than the most recent years groups) then we can conclude that there is a trend in the data.

Secondly we analyzed trends in water quality using the weighted regression on time, discharge and season (WRTDS) approach from the EGRET package. The WRTDS approach builds a regression on the relationship among a water quality parameter and discharge. The EGRET package is intended to explore the change in a water quality constituent over time by controlling for the effects of discharge. As many water quality parameters vary predictably with discharge (especially those that have a large non-point source origin) changes in water quality can be confused with changes in frequency or duration runoff events. Therefore, any trends in water quality parameters should represent true changes in concentration instead of weather or sampling schedule related anomalies. The EGRET trends are explicitly for exploratory analysis and therefore do not have readily calculated estimates of significance for inference (Hirsch and De Cicco 2015). Discharge measurements for the WRTDS approach to trends in water quality were obtained from USGS gauge at Esslingen Park 04086000.

In order to evaluate if the Sheboygan River can be delisted for the TP impairment we calculated a rolling average of TP concentrations and the 95% confidence interval (CI) of all samples collected from May-October, following WisCALM index period guidance. TP impairments are assessed against the median value of TP and the upper or lower 95% CI of the data to determine if the waterbody is clearly meeting or clearly exceeding the nonwadeable river criterion of 100 ug/L TP. We used a rolling average approach in order to have enough data per year to make an assessment. For impairment decisions assessments are traditionally made on the most recent five or ten years of data. For each year analyzed we included all of the samples taken the year before and after that year (i.e. three year sample window). For any sampling window that had fewer than five TP samples we included a fourth year of data in order to reach an acceptable number of samples to calculate the 95% CI. This occurred at 11% of the years and was most common for the early 1990's when there were fewer samples taken per year. All analyses were conducted in R version 3.1.1 (R Development Team 2015).

References:

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Results:

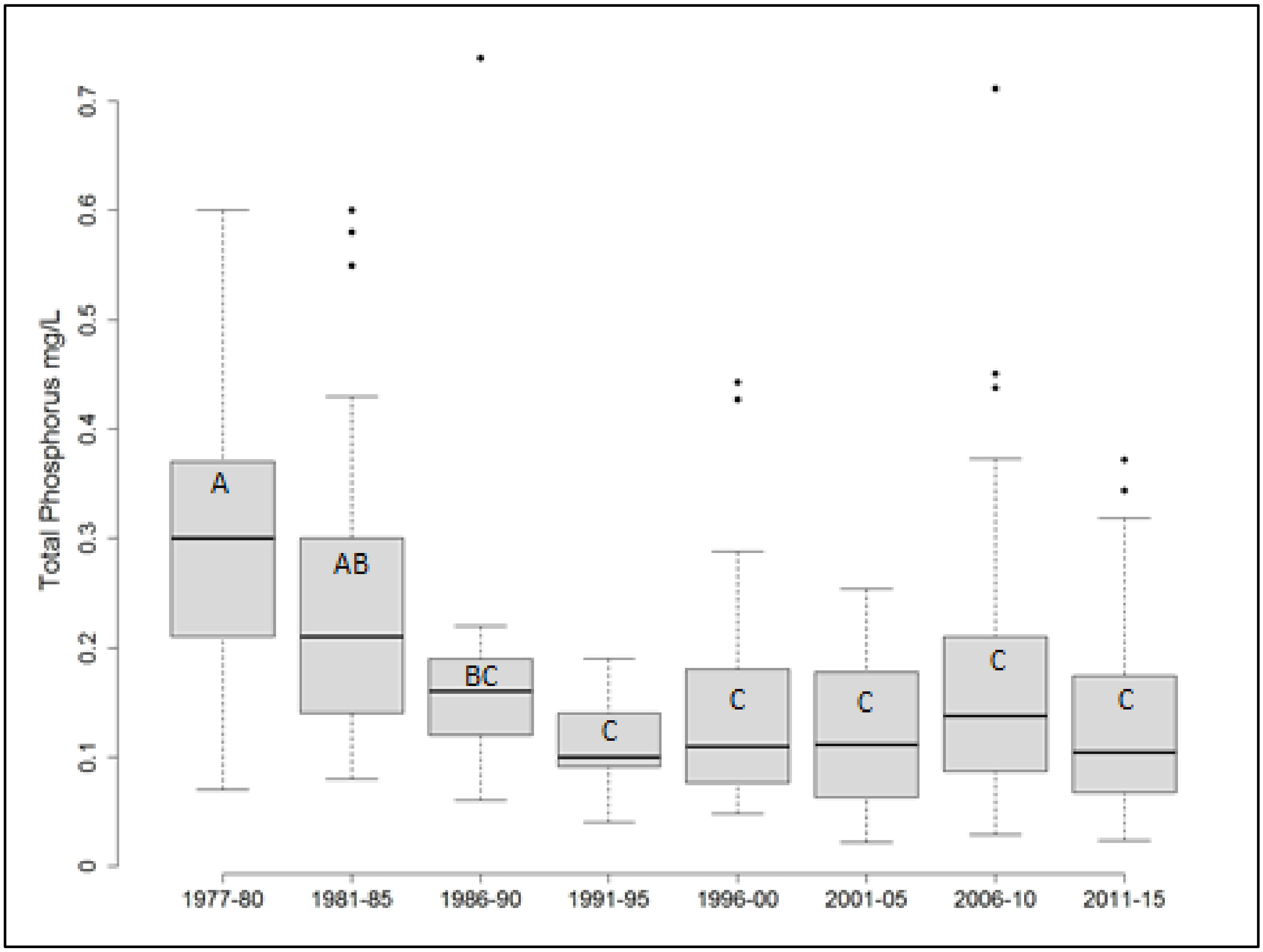

Figure 1. Boxplots of total phosphorus data at the Sheboygan River at Esslingen Park grouped into five year increments. Boxplots that do not share a common letter indicate a significant difference as determined by a one-way ANOVA and a post-hoc Tukey's HSD.

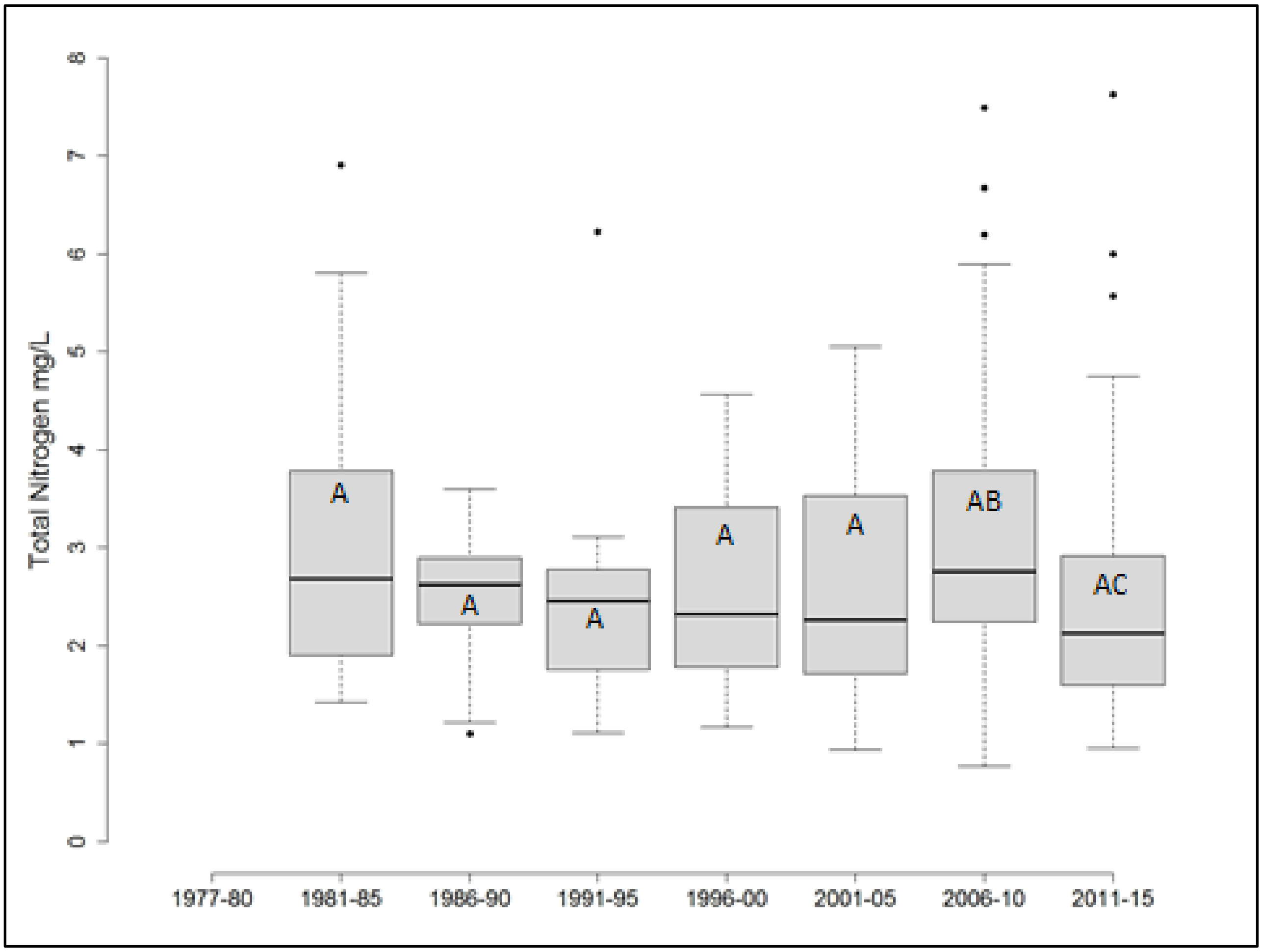

Figure 2. Boxplots of total nitrogen data at the Sheboygan River at Esslingen Park grouped into five year increments. Boxplots that do not share a common letter indicate a significant difference as determined by a one-way ANOVA and a post-hoc Tukey's HSD.

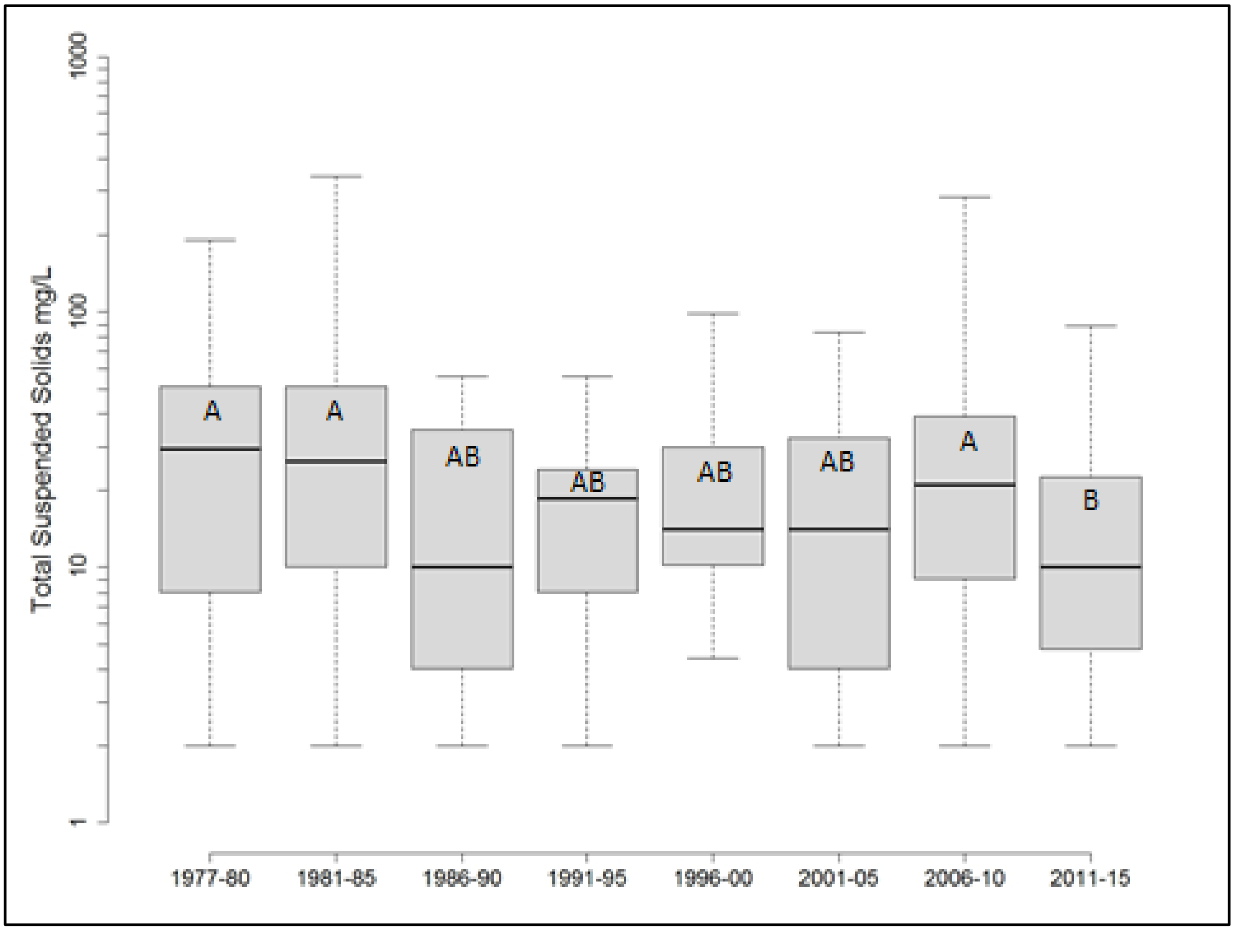

Figure 3. Boxplots of total suspended solids data at the Sheboygan River at Esslingen Park grouped into five year increments. Boxplots that do not share a common letter indicate a significant difference as determined by a one-way ANOVA and a post-hoc Tukey's HSD.

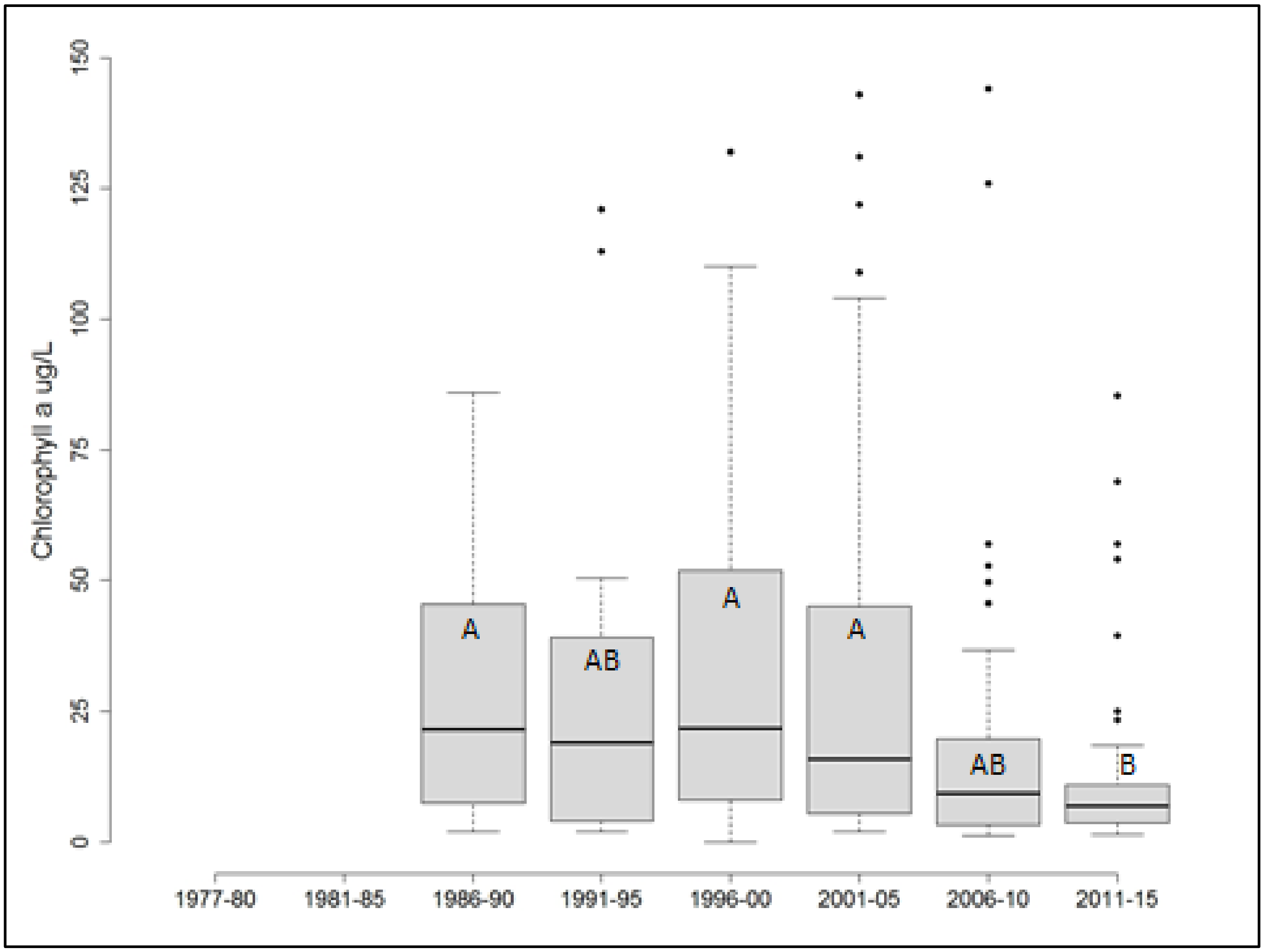

Figure 4. Boxplots of suspended chlorophyll a data at the Sheboygan River at Esslingen Park grouped into five year increments. Boxplots that do not share a common letter indicate a significant difference as determined by a one-way ANOVA and a post-hoc Tukey's HSD.

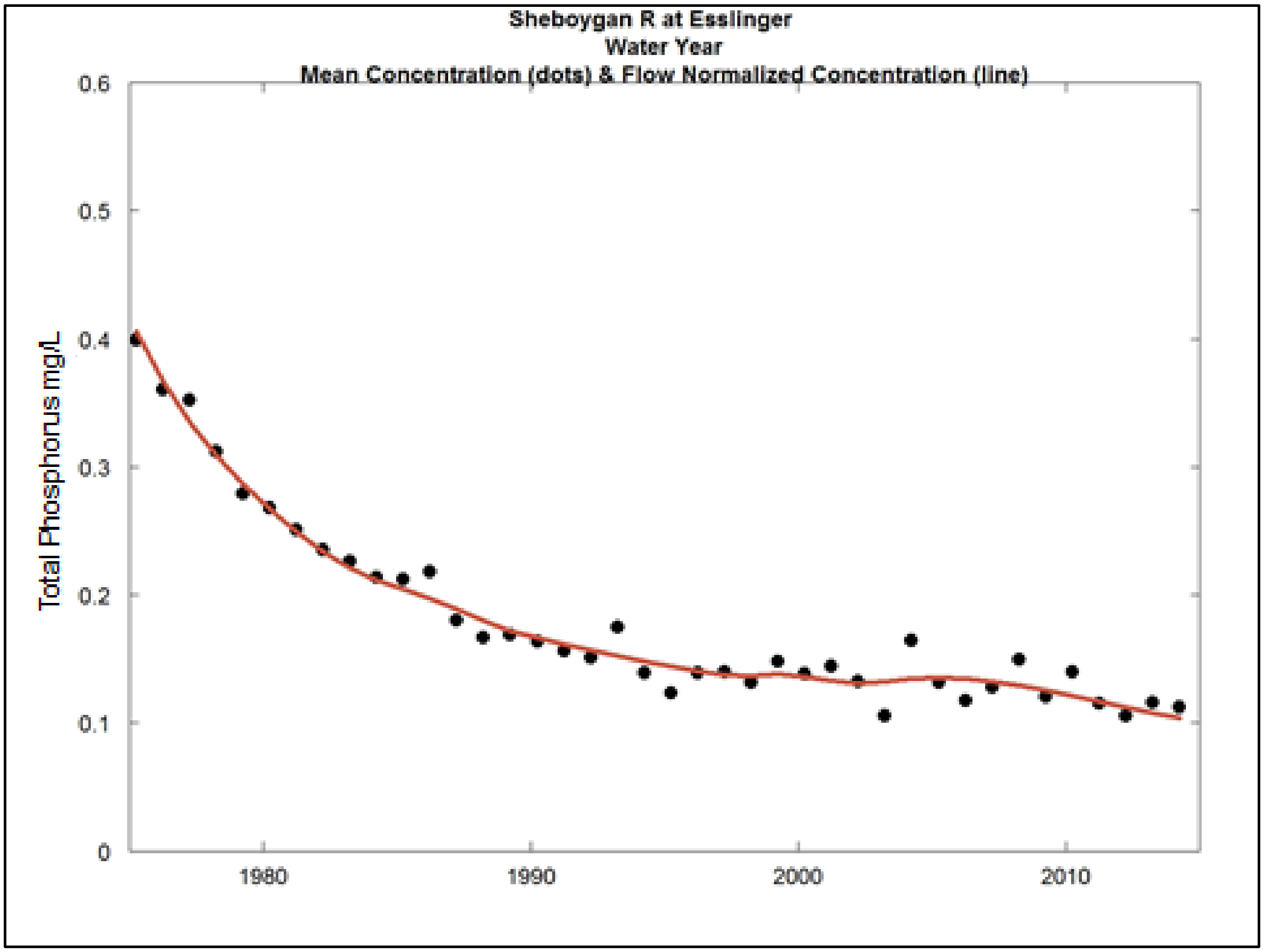

Figure 5. Flow weighted regression on time, discharge and season (WRTDS) with total phosphorus data at the Sheboygan River at Esslingen Park. Red line indicates flow weighted concentration over time.

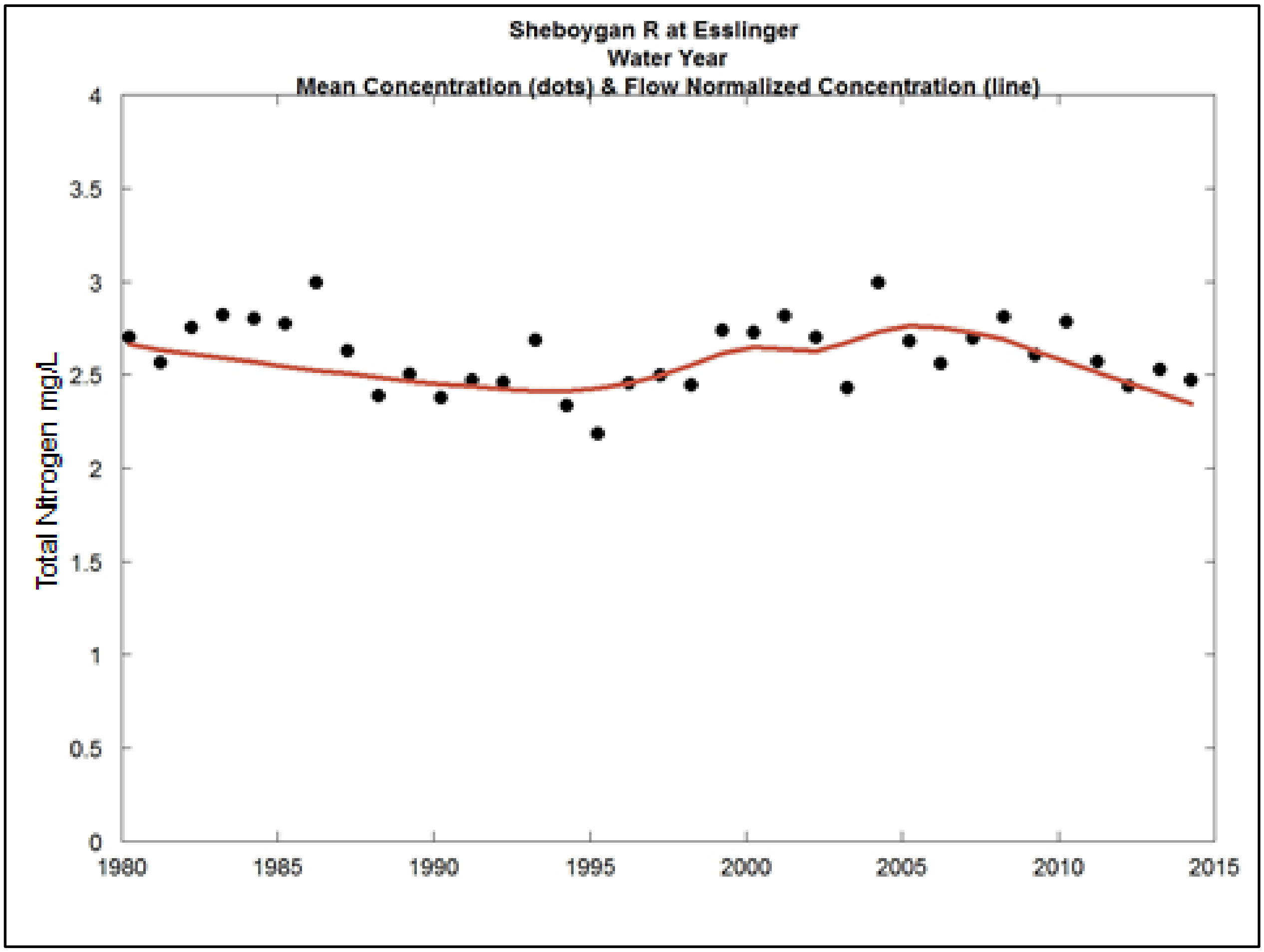

Figure 6. Flow weighted regression on time, discharge and season (WRTDS) with total nitrogen data at the Sheboygan River at Esslingen Park Red line indicates flow weighted concentration over time.

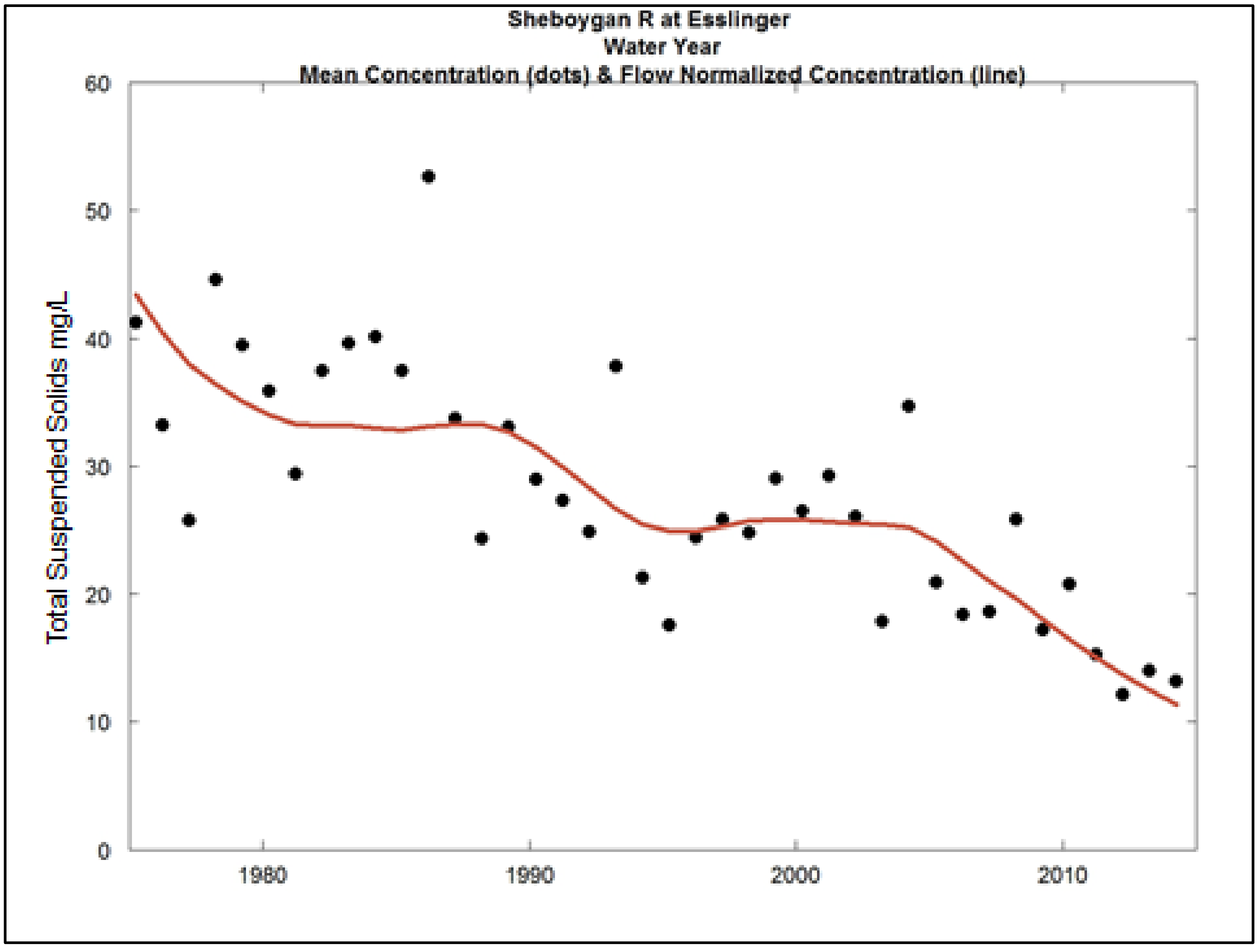

Figure 7. Flow weighted regression on time, discharge and season (WRTDS) with total suspended solids data at the Sheboygan River at Esslingen Park Red line indicates flow weighted concentration over time.

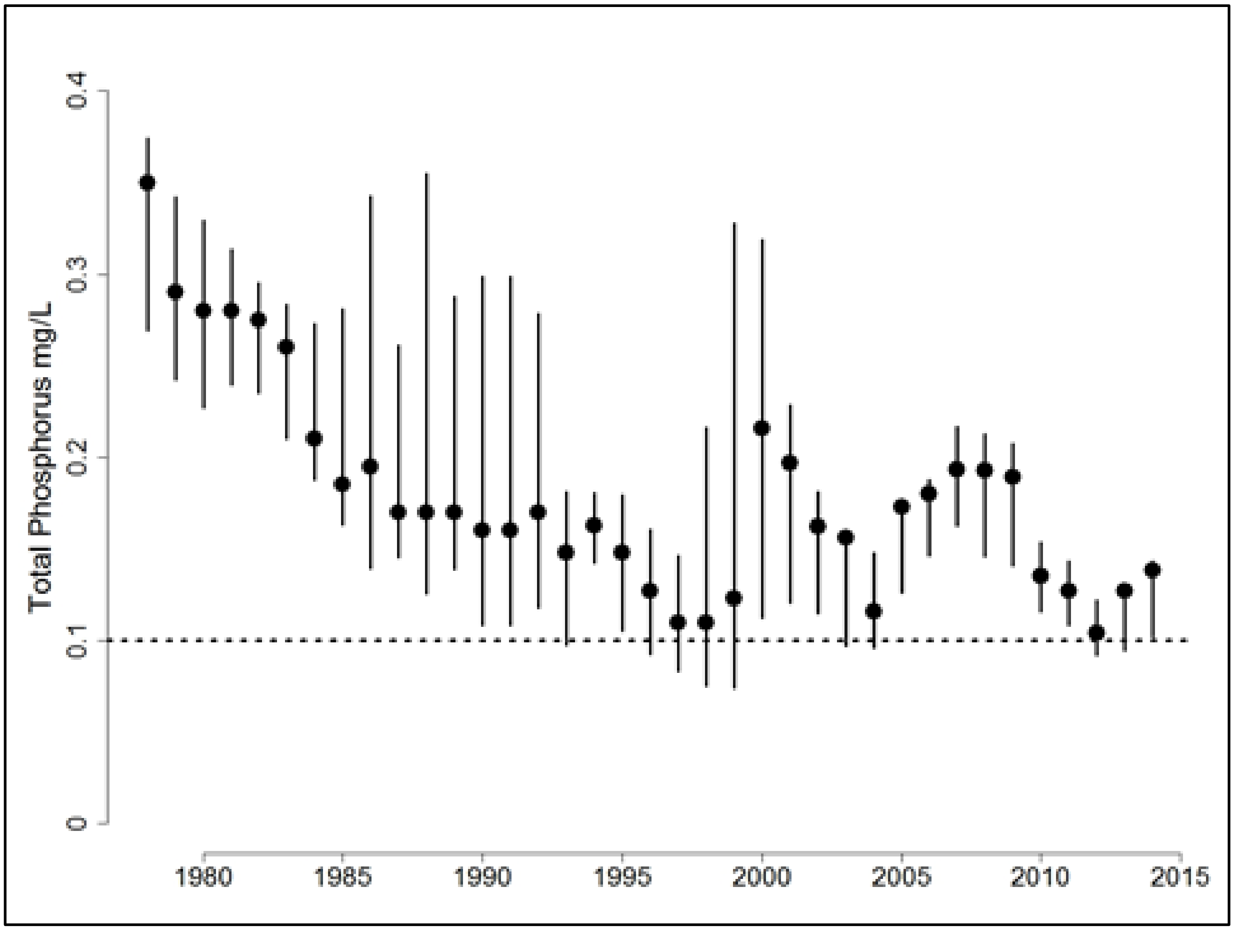

Figure 8. Mean total phosphorus concentration and variability over time at The Sheboygan River at Esslingen park from samples collected march-October. Points are the three year rolling median concentration while the lines indicate the 95% confidence interval of the mean. Horizontal dashed line indicates the current water quality standard for total phosphorus of 0.1 mg/l.

Appendix B

Sheboygan River Area of Concern Eutrophication Beneficial Use Impairment Assessment
(Fayram, et al., 2014)

Sheboygan River Area of Concern Eutrophication Beneficial Use Impairment Assessment
October 2014

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Introduction

The International Joint Commission recognizes that 9 of the possible 14 beneficial use impairments (BUIs) exist in the Sheboygan River and Harbor Area of Concern (AOC). Here, we are centrally concerned with the current status of the BUI "eutrophication or undesirable algae."

We examine the likelihood that the Sheboygan River and Harbor AOC remains impaired with regard to total phosphorus (TP), dissolved oxygen (DO), and chlorophyll-a (CHL-a) concentrations, which are strongly associated with eutrophication. High levels of TP and CHL-a, and low levels of DO are indicators of eutrophic conditions. Certainly, improvements above and beyond the current status can and should be made with regard to TP, DO, CHL-a, and other water quality parameters but our focus here is on the AOC BUI designation. Our objectives were to determine whether the delisting targets have been achieved. Specifically, we sought to determine whether TP and DO were substantially impaired in the Sheboygan River AOC relative to target levels. Although there is currently no generally accepted target level for CHL-a impairment in rivers, it is an indication of eutrophic conditions and we felt that examination of levels and trends would be supportive in our assessment of the degree of impairment. Beneficial use impairments in AOC are applied in order to identify the "worst of the worst" situations within the Great Lakes basin and their removal indicates that conditions have been substantively improved. Other programs (such as the 303(d) listing process) may have goals that differ from the AOC program. For example, in the 303(d) program, waterbodies can be designated as impaired if they are not fully meeting their designated uses regardless of the magnitude of the impairment. We feel that great improvement has been made in the Sheboygan River. It is the opinion of the Department that there has been significant improvement in water quality with respect to eutrophication and undesirable algae and this beneficial use impairment can be removed for AOC purposes.

Methods

The current regulatory targets for TP and DO by the WDNR in river systems such as the Sheboygan River are as follows: TP $\geq$ 100 ug/L, DO < 5.0 mg/L. There is no generally accepted target criterion for CHL-a levels for river systems, however we examined levels with reference to 303(d) listing criteria for unstratified lakes "fish and aquatic life use" impairment.

Phosphorus

We examined TP data obtained from within the Sheboygan River Harbor AOC in two manners. First, we calculated the mean and range of samples collected from the Esslingen Park location between March 2000 and Ocotober 2014 (238 samples (replicates excluded), SWIMS station 603095, Figure 1) and from the 14th Street location between October 2008 and September 2009 (7 samples, SWIMS station 10010954, Figure 1). In addition, we examined these data for evidence of a temporal trend using simple linear regression, $\alpha = 0.05$. Second, we examined recent data from the growing season (May-October and the most recent 18 monthly samples) to determine if the Sheboygan River met the TP target of 100 ug/L.

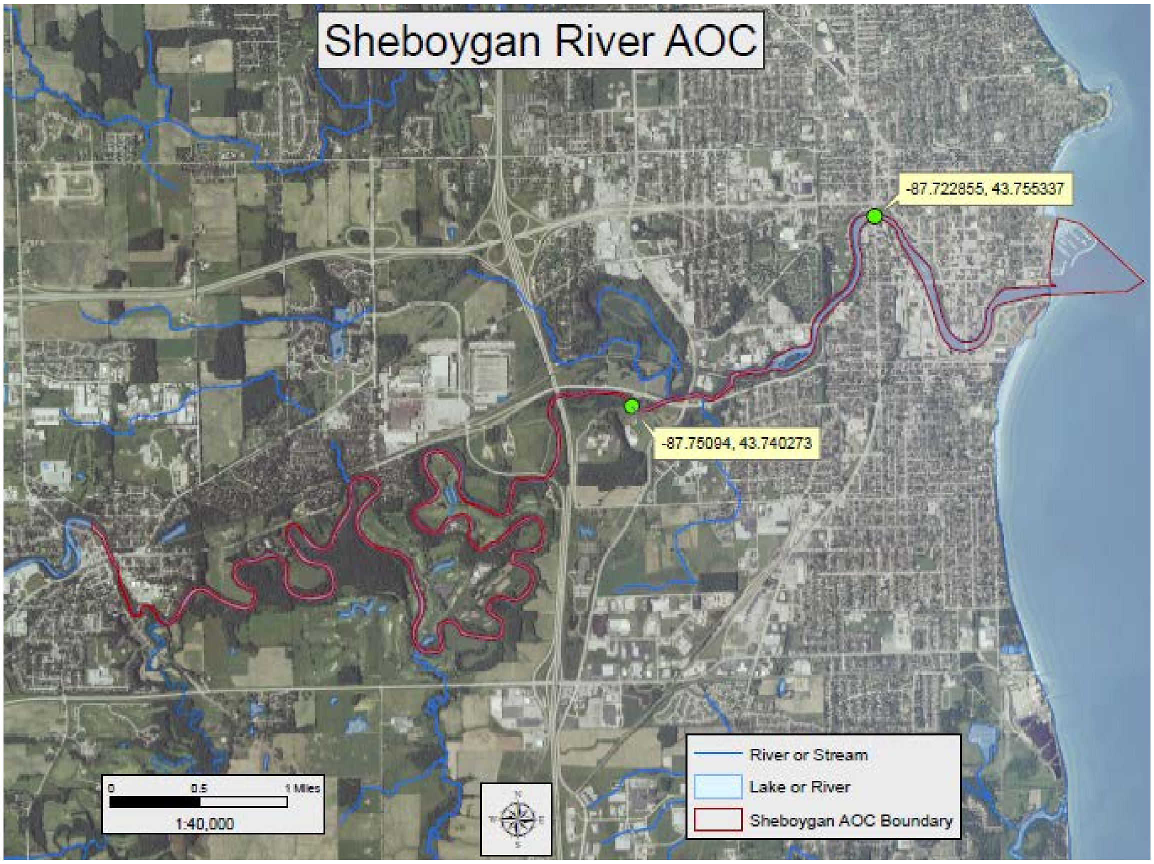

Figure 1. Sampling locations within the Sheboygan River AOC for TP and DO.

Dissolved Oxygen
We examined available DO measures in a similar fashion to TP measurements. Dissolved oxygen levels were sampled at the same two stations where historic TP data were collected. We considered levels of DO <5 mg/L as an indication of impairment. This level is considered marginal for some fish species and can result in stress and potential mortality for some fish species. First, we calculated the mean and range of samples collected between 2000 and 2012 from the Esslingen Park location (220 samples, SWIMS station 603095, Figure 1). Similarly, we calculated the mean and range from samples collected from the 14th Street location, although samples were only available between October 2008 and September 2009 (11 samples, SWIMS station 10010954, Figure 1). Then, we examined these data for evidence of a temporal trend using simple linear regression, $\alpha = 0.05$. Additionally, in an effort to document daily fluxes in DO concentrations, we measured DO on an hourly basis for 5 days at a station near 8th Street between 7/29/11 and 8/2/11.

Chlorophyll-a
We examined available CHL-a data collected between 2002 and 2010 at the Esslingen Park location. There is currently no codified criterion for an impairment targets for CHL-a in Wisconsin rivers. However, we chose to examine Sheboygan River CHL-a values with regard to

"deep lake" and "shallow lake" targets for 303(d) listing to provide an indication of the relative level of impairment. Exceedance targets are an annual average (for at least three years) of $\geq$ 60 ug/L for shallow lakes and $\geq$ 27 ug/L for deep lakes. Deep lakes and shallow lakes are differentiated by their likelihood to stratify as defined by Lathrop and Lillie (1980). Samples included in this analysis were collected between July 15 and September 15. We compared annual values to guidance exceedance targets with one-tailed t-tests. We also examined data for significant decreases or increases over time using linear regression analysis ($\alpha = 0.05$)

Results

Phosphorus

Phosphorus levels within the Sheboygan River AOC do not currently exceed the target of 100 ug/L with a 95% level of confidence, when analyzed using methods described in Appendix 1. Although the TP levels approached the target, we found no evidence that conditions were deteriorating with respect to TP levels over the last decade and these levels are much lower than levels experienced by the Sheboygan River at the time of AOC designation. Total phosphorus levels from the Esslingen Park location measured from March 2000 to October 2014 ranged from 2.2 to 712 ug/L with a mean value of 141 ug/L (Figure 2). There was no significant temporal trend in TP values for the Esslingen Park samples (Figure 2) (d.f. = 237, t = 0.52, p = 0.60). Utilizing only the most recent data[1] , we obtained a median value of 128 ug/L and an associated nonparametric 95% confidence interval of 76-181 ug/L for the Esslingen Park location (Table 1). Total phosphorus levels at the 14th Street location measured from October 2008 to September 2009 ranged from 53 to 224 ug/L with a mean value of 108 ug/L (Figure 3). There was no significant temporal trend in TP values for the 14th Street samples (Figure 3) (d.f. = 11, t = 1.62, p = 0.14). Utilizing only the most recent data[2] we obtained a median value of 123.5 ug/L and an associated nonparametric 95% confidence interval of 55-224 ug/L for the 14th Street location (Table 1).

[1] The 18 total phosphorus estimates included in our recent data set were sampled in May-October in 2012, 2013, and 2014.

[2] The 6 total phosphorus estimatethat met our inclusion criteria and were included were sampled May-September 2009 and October 2008.

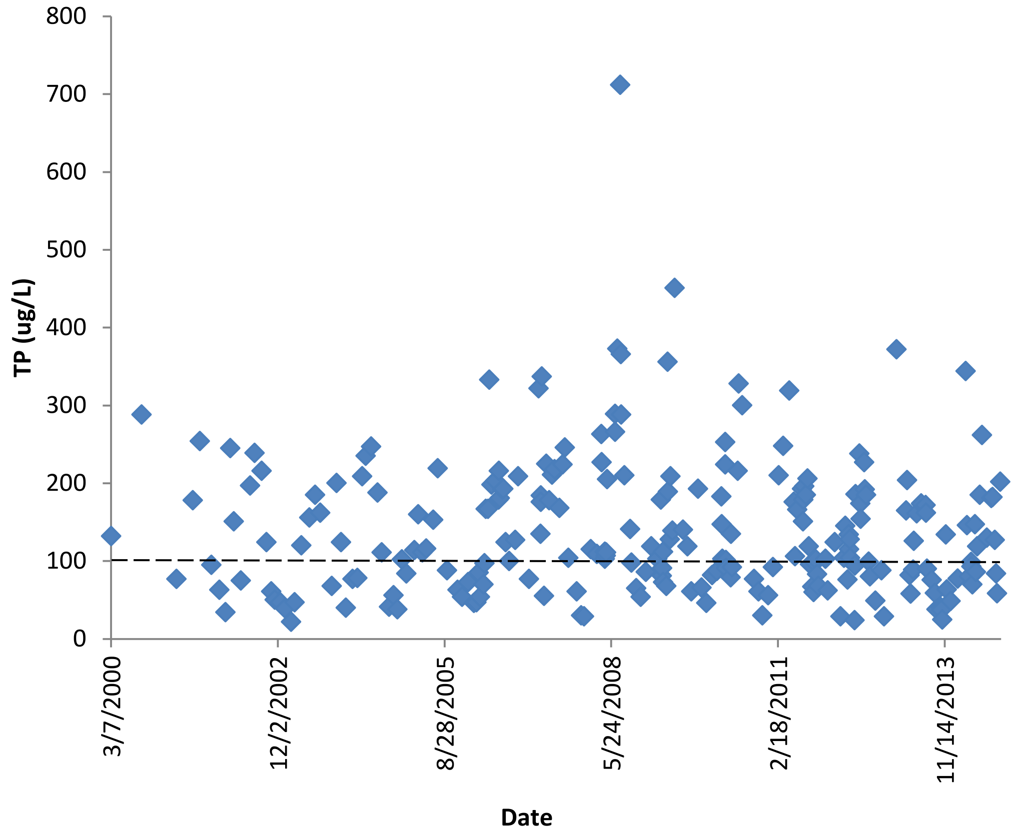

Figure 2. Total phosphorus values (ug/L) for the Esslingen Park location of the Sheboygan River March 2000-September 2014. Dashed black line = TP target.

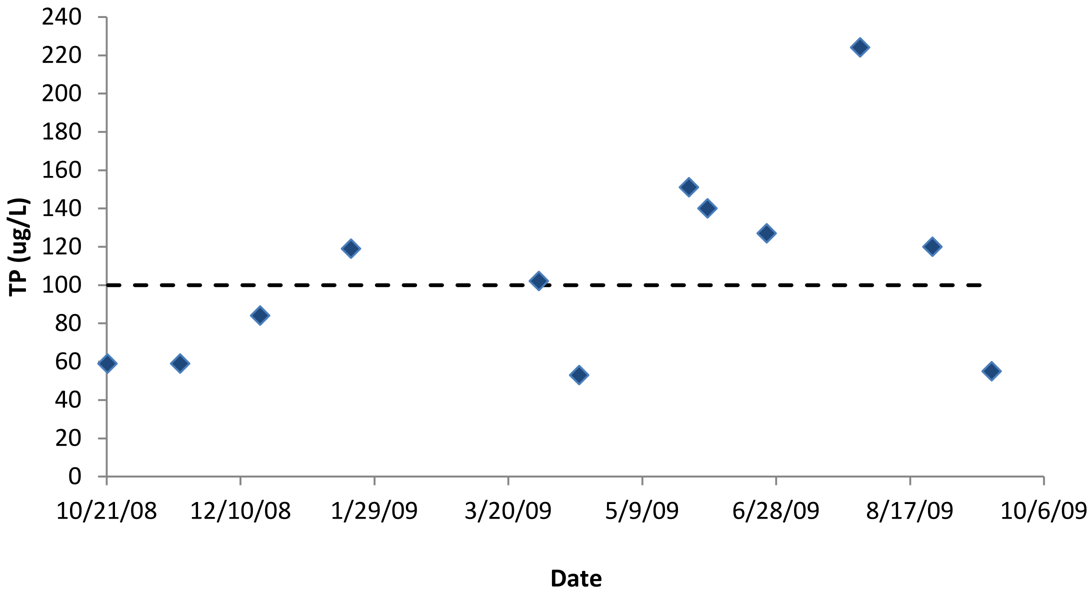

Figure 3. Total phosphorus values (ug/L) for the 14th Street location of the Sheboygan River October 2008-October 2009. Dashed black line = TP target.

When we examined recent data using the methods described in Appendix 1, TP levels met the Sheboygan AOC target since the non-parametric lower 95% confidence interval is below the 100 ug/L target for both sites within the Sheboygan AOC (95% confidence interval = 79 -181185) (Table 1).

Table 1. Recent total phosphorus results for the Esslingen Park site within the Sheboygan River AOC.

Date	TP (ug/L)
5/22/2012	24
6/21/2012	238
7/19/2012	227
8/14/2012	99
9/24/2012	49
10/30/2012	88
5/13/2013	126
6/26/2013	174
7/23/2013	172
8/28/2013	75.8
9/17/2013	58.8
10/23/2013	40.3
5/15/2014	147
6/12/2014	185
7/24/2014	130
8/21/2014	181
9/18/2014	83.9
10/14/2014	202

Given that TP levels approach the Sheboygan AOC target level, we also examined the available and relevant biological data, as an independent basis for determining impairment.

Biological data indicate the absence of impairment (Table 3). However, Site SR 01 has a Macroinvertebrate IBI rating of "very poor" (Table 3). This rating is most likely due to degraded habitat in the lower reach of the Sheboygan River from the abundance of fine sediment on the stream bed. The seven additional sample locations within the AOC boundary have fish and macroinvertebrate bioconfirmation ratings of fair, good, and excellent. The bottom substrate in these areas is not limited by fine sediment and supports a higher quality biological community.

The Sheboygan River AOC boundary, which includes the lower 14 miles of the river, is located entirely within the 12-digit HUC 40301011109 and Assessment Unit (AU) 11354. This stream reach entends from the mouth upstream to the City of Sheboygan Falls Dam. This AU delineates the area that is being assessed for delisting of the Eutrophication or Undesirable Algae BUI.

Table 2. Site locations and information for Sheboygan River, Sheboygan County, Wisconsin. SR 03 had aquatic plant survey only.

Stream Site	Location	USGS Quad Map	Legal Description	Latitude Longitude*	Stream Order
SR 01	Upstream of 8TH Street.	Sheboygan South	T15N, R23E, Sec. 26, NE1/4 of NW1/4	43.74451 -87.71285	5
SR 02	Upstream of New Jersey Avenue.	Sheboygan South	T15N, R23E, Sec. 27, NE1/4 of NW1/4	43.74463 -87.73079	5
SR 03	SE Corner of Taylor and Indiana Avenue.	Sheboygan South	T15N, R23E, Sec. 28, SE1/4 of NE1/4	43.73970 -87.74424	5
SR 04	Upstream of CTHY PP at Esslingen Park.	Sheboygan South	T15N, R23E, Sec. 28, SE1/4 of NW1/4	43.74027 -87.75094	5
SR 05	Upstream of Village of Kohler Municipal Garage.	Sheboygan Falls	T15N, R23E, Sec. 32, NE1/4 of NW1/4	43.72987 -87.76962	5
SR 06	Upstream of Weedens Creek Confluence.	Sheboygan Falls	T15N, R23E, Sec. 32, SW1/4 of SW1/4	43.72083 -87.77571	5
SR 07	Upstream of Walderhaus Dam.	Sheboygan Falls	T15N, R23E, Sec. 30, SE1/4 of SE1/4	43.73442 -87.78287	5
SR 08	Adjacent to Kohler Stables Property.	Sheboygan Falls	T15N, R23E, Sec. 31, NE1/4 of SW1/4	43.72825 -87.79589	5
SR 09	Upstream of Onion River Confluence.	Sheboygan Falls	T15N, R22E, Sec. 36, NW1/4 of SE1/4	43.72372 -87.80483	5

Table 3. Fish community and benthic macroinvertebrate index of biotic integrity (IBI), and stream habitat ratings for Sheboygan River in 2011.

Site	Fish Community IBI	Macroinvertebrate IBI	Stream Habitat Rating
SR 01	Good	Very Poor	NA
SR 02	Good	Fair	Fair
SR 04	Excellent	Fair	Good
SR 05	Excellent	Fair	Excellent
SR 06	Excellent	Fair	Good
SR 07	Excellent	Excellent	Fair
SR 08	Fair	Good	Good
SR 09	Excellent	Fair	Excellent

Dissolved Oxygen

There is no evidence that DO levels are impaired in the Sheboygan River AOC. Of the samples available, none were below the impairment criterion of 5.0 mg/L. Between March 2000 and September 2012, the Esslingen Park point measurements of DO concentration ranged between 5.7 and 18.0 mg/L with a mean value of 10.9 mg/L. There was no evidence of a temporal trend in DO at the Esslingen Park station (d.f. = 219, t = 1.36, p = 0.17). The 14th Street DO level ranged between 7.8 and 14.6 mg/L with a mean value of 12.5 mg/L (Figure 5). There was no evidence of a temporal trend in DO at the 14th Street location (d.f. = 10, t = -0.008, p = 0.99)

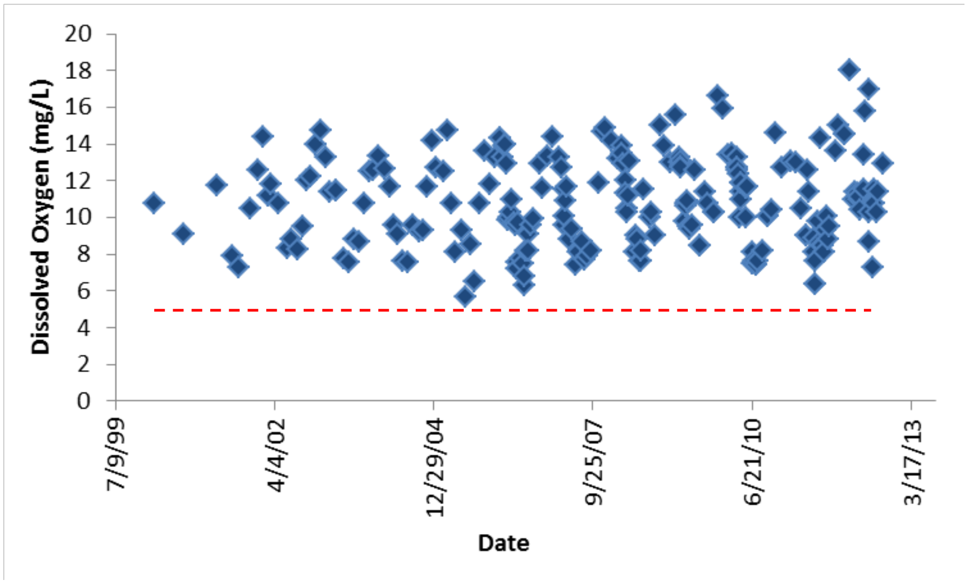

Figure 4. Dissolved oxygen values (mg/L) for the Esslingen Park location of the Sheboygan River March 2000- September 2010. Dissolved oxygen target criterion shown as dashed line.

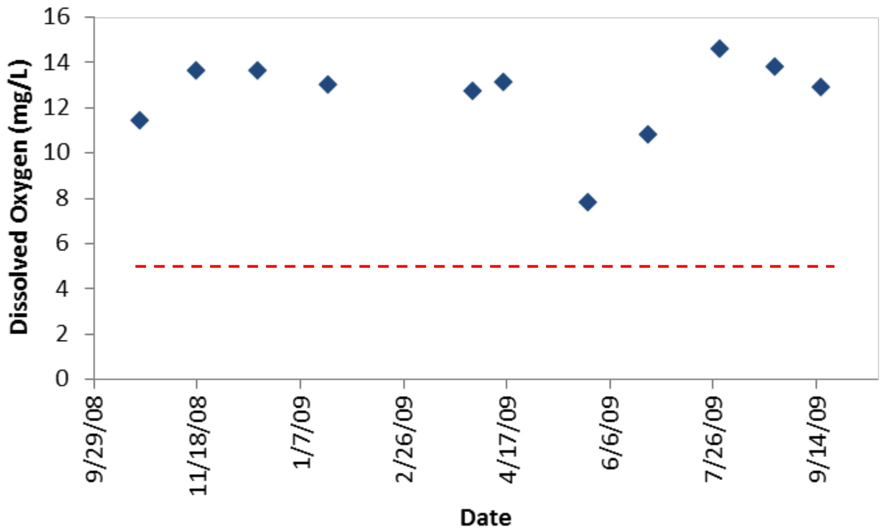

Figure 5. Dissolved oxygen values (mg/L) for the 14th Street location of the Sheboygan River October 2008-September 2009. Dissolved oxygen target criterion shown as dashed line.

Similarly, continuous hourly DO samples did not indicate any instances of violating the 5.0 mg/L criterion. Dissolved oxygen levels ranged from 8.17 mg/L to 21.42 mg/L and were generally lowest in the early morning (Figure 6).

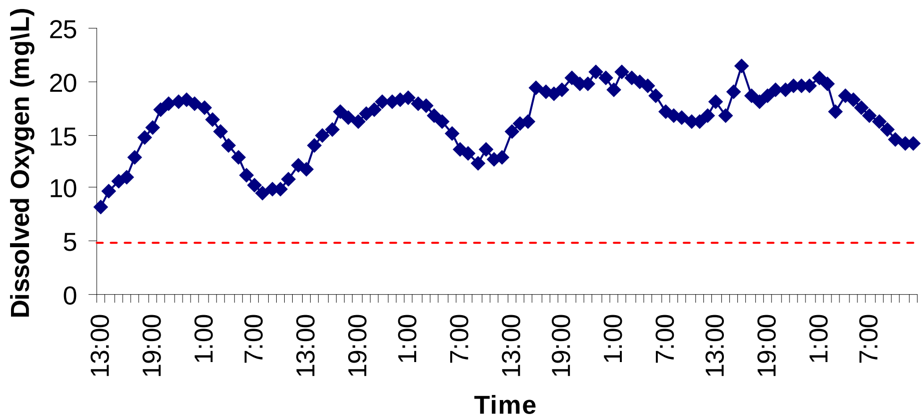

Figure 6. Dissolved oxygen values (mg/L) for the 8th Street location of the Sheboygan River July 29, 2011-August 2, 2011. Dissolved oxygen target criterion shown as dashed line.

Chlorophyll-a

Our results suggest that the target criterion for 303(d) listing criteria for unstratified lakes "fish and aquatic life use" impairment was not exceeded in the Sheboygan AOC (Table 5). The mean value of samples taken from 2002 to 2010 was 39.2 ug/L but was not significantly higher than either 27 ug/L ($t = 1.61$, $p = 0.06$, d.f. = 22) or 60 ug/L ($t = -2.93$, $p = 0.99$, d.f. = 22). There was a significant decline in CHL-a values utilizing all data collected between July 15 and September 15 2002-2010 ($t = -2.08$, $p = 0.05$, d.f. = 22)(Figure 7).

Table 5. Values for CHL-a samples (ug/L) taken from the Sheboygan River Esslingen Park location sampled between July 15 and September 15, 2002- 2010.

Year	CHL-a
2002	143.0
2002	69.5
2003	104.0
2003	55.4
2004	45.2
2004	5.4
2005	21.1
2005	20.6
2006	30.5
2006	10.4
2007	30.6
2007	25.0
2008	2.5
2008	49.7
2009	36.7
2009	20.0
2010	52.8
2010	31.5
2011	2.1
2011	39.5
2011	8.9
2012	85.4
2012	11.1

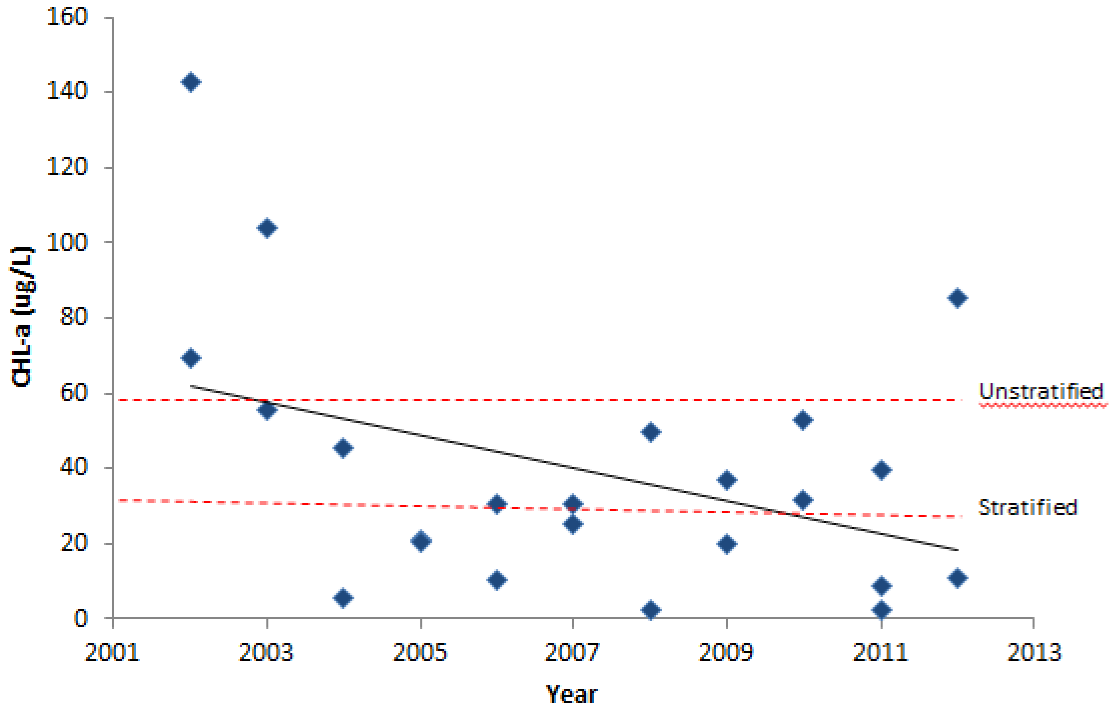

Figure 7. Chlorophyll-a values for the Esslingen Park location of the Sheboygan River July 2002-September 2010 and regression line. 303(d) lake target criterion shown as dashed lines.

Conclusions

Our results generally suggest that the "eutrophication or undesirable algae" BUI is not supported in the Sheboygan River AOC by current TP, DO, or CHL-a data and that the removal targets have been met.

Dissolved oxygen levels appear to be consistently above the target level in both long term trend data and hourly samples acquired over a 5 day period in 2011. The long term trend samples were generally not obtained during the time period when DO levels reach their daily minimum (i.e. just prior to dawn) (Goldman and Horne 1983). Therefore, it is possible that additional samples taken during this time period might have indicated an occasional measurement below the target criterion. However, given the large number of samples which indicate that the DO level is generally considerably above the target criterion, it is unlikely that DO levels drop below the impairment criterion on any regular basis. This conclusion is supported by the results of the hourly DO sampling results.

Our results are not meant to indicate that further improvements with regard to TP, DO, CHL-a, or eutrophication in general cannot or should not be made or that other analyses may suggest results that do not support our conclusions here. Broader habitat alterations currently underway to address other BUIs in the Sheboygan River AOC will most likely improve the status of this AOC relative to the eutrophication BUI as well.

Acknowledgements

Thanks to Tom Simmons for providing GIS assistance and to Travis Motl for providing biological data and interpretation. Particular thanks to Elizabeth Hinchey Malloy who critically reviewed this document and provided helpful comments.

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Lathrop, R. C., and R. A. Lillie. 1980. Thermal stratification of Wisconsin lakes. Transactions of the Wisconsin Academy of Sciences, Arts, and Letters 68: 90-96.

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Appendix 1.
Total Phosphorus – Rivers and Streams Assessment Tool – 2/7/2011
Version 2.1a (Write-Up Updated 3/2/2011)

Parameters, Timeframe
1. Search and find all total phosphorus data (DNR_STORET 665) for all non-lake stations over the years of 2001 – 2010 (previous year and preceding 10 years).
Note: Run analysis by station, not waterbody identification code (wbic), and display with results searchable by assessment Unit (au), wbic and station. If a station is assigned to multiple AUs it will appear more than once in that particular dataset.
2. Summarize only the May - October data from stations with at least a full year of data Note: use May through Oct. data for a year and use previous year data to fill gaps if needed.
3. In many months with more than one sample use the value closest to the middle of the month. For a 30-day month use midnight between the 15th/16th and for 31-day months I use noon of the 16th.

Find Full Growing Seasons within a given year
4. Within the previous 10 years, first use the years that have a full set of growing season data (May to October) (use the most recent full year first, then the 2nd most recent). Once all the full seasons of data have been used, run through the bucket rule, which is described below.

Bucket Rule
5. Begin with the most recent year where an incomplete growing season of data is available. Put acceptable months in a "bucket" or "set" of data and continuing searching in previous years for the missing months of the growing season until a full year of data is compiled.
Run through the bucket rule until a full set of data is available for up to 3 years (this includes the use of full growing season data from item #4 above). In other words, where sampling did not occur over all six months in a single year, add data from the missing months in the previous year. For example, at the 14th St. site we used data from May - September 2009, but no October data were available so we added results from October 2008.
To fill in missing months, the rule can uses data within the 10 year time frame prior to the assessment year (i.e., for the 2011 assessment process (now), we used 2000-2010 growing seasons). Datasets can be completed with results from a gap of more than just the previous year. The previous tool (V1.0) pulled out "full" years first, then ran the bucket rule, ie., it simply starts with the most recent samples and work our way backward as needed to get up to three full 6-month sets. This version (V 2.1a) does pull a full year of data first moving backward before filling the "bucket sets". Samples where a newer one was collected within 15 days were discarded once the tool grabs samples closest to the middle of the month. So, if the representative September sample is collected 9/22/2010 and the October sample is on 10/1/2010, the 9/22/2010 sample gets discarded.

Minimum Datasets
6. Use the most recent 3 years of data for this calculation (based on the bucket rule).

Presentation of Results

7. Results closest to the middle of each month for the most recent 3 years of data are presented based on whether they clearly meet, may meet, may exceed, or clearly exceed 0.1 mg/L using the protocols.

Confidence Interval Creation Logic:

- For the 6-sample set we use the lowest (rank 1) and highest (rank 6) values.
- For the 12-sample set, we narrow the 95% CI range by "discarding" the lowest two values and the highest two values (leaving us with everything from rank 3 through rank 10). This is completely symmetric in "discarding" values from the low and high ends.
- For the 18-sample set, we narrow the 95% CI range by "discarding" the lowest four values and the highest four values (leaving us with everything from rank 5 through rank 14).
- The 24 sample size scenario isn’t used right now because we only use three years of data.

Appendix C

Aquatic Baseline Monitoring of Select Streams within the Sheboygan River Area of Concern
(Masterson and Motl, 2013)

Aquatic Baseline Monitoring of Select Streams within the Sheboygan River Area of Concern

John Masterson and Travis Motl
Wisconsin Department of Natural Resources
Plymouth Service Center

March 2013

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ABSTRACT

Aquatic surveys of the Sheboygan River Area of Concern (AOC), as well as tributaries within its project boundaries, were done in order to establish a baseline for biological and physical characteristics of these waters. Surveys included fish, benthic macroinvertebrate, and macrophyte communities, and stream habitat. Data derived from these surveys provide valuable information on the physical, chemical, and biological condition of streams. Aquatic plant surveys were done at two locations to determine the potential to support northern pike spawning. Monitoring was done from April through November of 2009, 2010, and 2011. Overall, the stream sites rated fair to excellent for fish and invertebrate communities and stream habitat. There were a few sites that rated poor for fish and invertebrate communities. These "poor" ratings may be attributed to degraded habitat. Aquatic plant surveys were also limited because of degraded habitat.

INTRODUCTION

The Sheboygan River Area of Concern (AOC) encompasses the lower 14-miles of the Sheboygan River, downstream from the Sheboygan Falls Dam including the entire harbor and nearshore Lake Michigan. Areas of Concern (AOCs) are severely degraded geographic areas within the Great Lakes. These areas – 43 within the Great Lakes region – were designated as AOCs primarily due to contamination of river and harbor sediments by toxic pollutants. The Sheboygan River AOC is one of five Areas of Concern in Wisconsin.

It was designated as an AOC primarily due to polychlorinated biphenyl (PCB) and polycyclic aromatic hydrocarbon (PAH) contamination in Sheboygan River sediments. One primary source of PCBs was an industrial facility operated by Tecumseh Products Company; a primary source of PAHs was a manufactured gas plant (MGP) operated by Wisconsin Public Service Corporation (WPSC) (WDNR 2012).

Cleaning up these severely degraded areas is a first step toward restoring the chemical, physical, and biological integrity of the lakes as required by the Great Lakes Water Quality Agreement. When the areas have been cleaned up to the point where they are not more degraded than other, comparable non-AOC areas, they are "delisted" as AOCs. Since designation as an AOC, much progress has occurred to address pollutant sources.

These sources of impairment led to designation of nine of the possible fourteen beneficial use impairments (BUIs) as applicable to the AOC (WDNR 2012). Two of the nine BUIs, "degradation of fish and wildlife populations" and" loss of fish and wildlife habitat", are being addressed through monitoring and habitat improvement projects within the AOC.

Efforts to improve the Sheboygan River accelerated in 2010 when the United States Environmental Protection Agency (USEPA) selected the Sheboygan River AOC as a focus for BUI removal. Careful planning throughout 2011 led to a great deal of activity in 2012 to remove contaminated sediments and enhance navigation through dredging, enhance habitat, and assess the status of selected BUIs.

Assessing the current status of biological and physical conditions of the Sheboygan River AOC will help determine the current health of the ecosystem and aid in choosing habitat improvement projects that are best suited to improve the aquatic resource. Fish and benthic macroinvertebrate assemblages and stream habitat were assessed to determine baseline ecosystem health of select streams.

MATERIALS AND METHODS

<u>Site Selection</u>

Site selection was done to allow for spatial coverage within the AOC area and include the tributaries where fish passage existed. Four individual water bodies were chosen for the study and included the lower 14-miles of the Sheboygan River, from the confluence with Lake Michigan upstream to the Sheboygan Falls Dam; Willow Creek; Weedens Creek; and the Onion River, from the confluence with the Sheboygan River upstream to the Hingham Dam. Sixteen individual sites were monitored for fish, macroinvertebrate, and habitat; two sites for aquatic plant community; and data from 2009 and 2010 was included for three sites on the Onion River. This was done to provide better spatial coverage of the Onion River. Therefore, a total of 20 sites were monitored or data included in the survey (Figure 1 and Table 1).

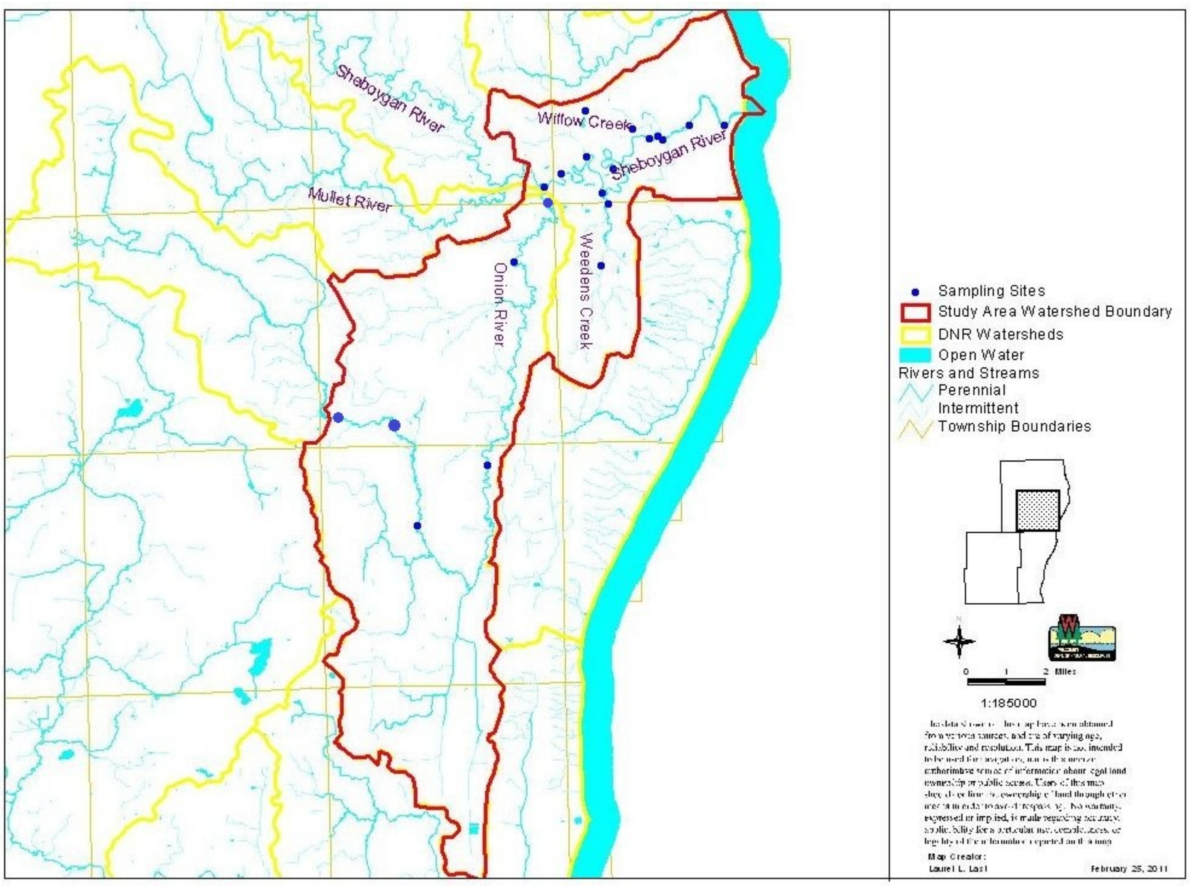


Figure 1. Sample site locations for fish, benthic macroinvertebrates, stream habitat, and aquatic macrophyte surveys.

Table 1. Site locations and information for Sheboygan River AOC monitoring stations, Sheboygan County, Wisconsin. SR 03 is small wetland and had aquatic plant survey only. NA – Not Applicable. * indicates sites that were monitored in 2009 or ** for 2010.

Site	**Stream**	**Location**	**Legal Description**	**Latitude Longitude ***	**Stream Order**
SR 01	Sheboygan River	Upstream of 8TH Street.	T15N, R23E, Sec. 26, NE1/4 of NW1/4	43.74451 -87.71285	5
SR 02	Sheboygan River	Upstream of New Jersey Avenue.	T15N, R23E, Sec. 27, NE1/4 of NW1/4	43.74463 -87.73079	5
SR 03	Sheboygan River	SE Corner of Taylor and Indiana Avenue.	T15N, R23E, Sec. 28, SE1/4 of NE1/4	43.73970 -87.74424	NA
SR 04	Sheboygan River	Upstream of CTHY PP at Esslingen Park.	T15N, R23E, Sec. 28, SE1/4 of NW1/4	43.74027 -87.75094	5
SR 05	Sheboygan River	Upstream of Village of Kohler Municipal Garage.	T15N, R23E, Sec. 32, NE1/4 of NW1/4	43.72987 -87.76962	5
SR 06	Sheboygan River	Upstream of Weedens Creek Confluence.	T15N, R23E, Sec. 32, SW1/4 of SW1/4	43.72083 -87.77571	5
SR 07	Sheboygan River	Upstream of Walderhaus Dam.	T15N, R23E, Sec. 30, SE1/4 of SE1/4	43.73442 -87.78287	5
SR 08	Sheboygan River	Adjacent to Kohler Stables Property.	T15N, R23E, Sec. 31, NE1/4 of SW1/4	43.72825 -87.79589	5
SR 09	Sheboygan River	Upstream of Onion River Confluence.	T15N, R22E, Sec. 36, NW1/4 of SE1/4	43.72372 -87.80483	5
WC 01	Willow Creek	Upstream of confluence with Sheboygan River.	T15N, R23E, Sec.28, SW1/4 of NE1/4	43.74105 -87.74696	2
WC 02	Willow Creek	Upstream of Greendale Road.	T15N, R23E, Sec.28, NW1/4 of NW1/4	43.74423 -87.75937	1
WC 03	Willow Creek	Upstream of Woodlake Road.	T15N, R23E, Sec.19, SE1/4 of SE1/4	43.75103 -87.78274	1
WE 01	Weedens Creek	Upstream STHY 28	T14N, R23E, Sec. 05, NE1/4 of NW1/4	43.71708 -87.77284	3
WE 02	Weedens Creek	Upstream of CTHY A	T14N, R23E, Sec. 08, NW1/4 of SW1/4	43.69432 -87.77714	3
OR 01*	Onion River	Upstream of Broadway Avenue.	T15N, R22E, Sec. 36, SW1/4 of SE1/4	43.72117 -87.80590	4
OR 02	Onion River	Upstream of Ourtown Road.	T14N, R22E, Sec. 11, SE1/4 of SW 1/4	43.69667 -87.82086	4
OR 03	Onion River	Upstream of CTHY A	T13N, R22E, Sec. 02, NW1/4 of SW1/4	43.62282 -87.83698	4
OR 04	Onion River	Upstream of Risseeuw Road.	T13N, R22E, Sec. 09, SE1/4 of SW1/4	43.60161 -87.87305	3
OR 05*	Onion River	Upstream of CTHY W	T14N, R22E, Sec. 32, SE1/4 of NE1/4	43.63817 -87.88370	3
OR 06**	Onion River	Downstream of CTHY I	T14N, R22E, Sec. 31, SE1/4 of NW1/4	43.64120 -87.91029	3

* WGS 84 Datum

Fish Surveys

Representative fish community samples were collected at each site using backpack-mounted, towed-barge, or boat-mounted electrofishing units. Individuals were counted, weighed and measured as appropriate and data was applied to an index of biotic integrity (IBI) (Lyons 1992; Lyons 2006; Lyons et al. 2001; WDNR 2001). The fish IBI relates community structure to community health and water quality.

All fish observed were collected with small nets. Fish were identified to species and the number of each species was recorded. Fish that could not be identified in the field were placed into 10% formalin for later identification.

A fyke netting survey was also executed near the intersection of Taylor Drive and Indiana Avenue at site SR 04. This survey was carried out following Spring Netting I protocols from WDNR Lakes Sampling Procedures (WDNR 2008). The goal of this netting was to establish presence/absence of adult northern pike in a targeted project area. A backwater area was netted at this location with a 2 foot X 6 foot fyke net for a total of 6 net nights.

Benthic Macroinvertebrates Surveys

Macroinvertebrates were collected using standard WDNR protocols for wadable streams (WDNR 2000). One sample was collected at each site using a D-framed kick net. Specimens were preserved in ethanol for later identification. Samples were collected during October and November of 2010. Identification and enumeration of invertebrate taxa (generally genus and species) were done by the Benthic Invertebrate Laboratory at the University of Wisconsin – Stevens Point, Stevens Point, Wisconsin. Data was applied to several biotic indices.

One site (SR 01) was nonwadable and the following sampling approach was used for this site (Weigel and Dimick, 2011). We collected macroinvertebrates using modified Hester-Dendy (H-D) artificial substrate samplers during summer 2011, basing sampler construction and deployment upon Ohio EPA (1987). Each sampler used an eyebolt to hold eight 7.6 cm x 7.6 cm (3 inch x 3 inch) plates made of 3.2 mm (1/8 inch) thick masonite hardboard. Spacing between the plates allowed for colonization; spacing was 3.2 mm between each of the first three plates, 6.4 mm between each of the next three plates, and 9.6 mm between the last two plates. We fastened three samplers to an 18 kg cinder block and suspended it 1.5 m below the water surface, at low flow. The sampler was suspended by a rope off of a wooden piling upstream of the bridge crossing. We avoided placement of the samplers on the bottom substrate so the device would not be inundated with sediment, for example, shifting sand or soft substrates. Velocity should be 0.09 - 0.5 m/sec. Samplers were placed to maintain 0.75 – 1.5 m of water above the sampler at low flow. Samplers were left to colonize macroinvertebrates for six-weeks within the window from mid-June through September. After six weeks, we retrieved the samplers, scraped/rinsed off the organisms, combined the sample contents, and preserved them in ethanol. All samples were delivered to the lab for identification and enumeration.

Water quality was assessed at 19 sites by examining the biological communities and their characteristics, such as number of individuals, number and types of taxa, pollution tolerance, and other traits. Computed metrics for invertebrate samples included the number of invertebrate taxa, Shannon Diversity Index, the percentage of invertebrate individuals or genera in the orders Ephemeroptera-Plecoptera-Tricoptera (EPT), and an invertebrate Index of Biotic Integrity (IBI) (Weigel, 2003). Assemblage information and metrics for invertebrate samples were provided in the BUG database from the Benthic Invertebrate Laboratory at the University of Wisconsin – Stevens Point, Stevens Point, Wisconsin.

Habitat Assessment

Stream habitat was evaluated at 19 sites using qualitative procedures (WDNR 2007) during August and September, 2011. Seven different variables for stream less than 10 meters wide are visually estimated for qualitative habitat assessment. Each habitat parameter is given a rating of excellent, good, fair, or poor, and the associated individual numeric scores are summed to provide an overall rating of stream habitat quality. Variables measured included riparian buffer width, bank erosion, pool area, width:depth ratio, riffle:riffle or bend:bend ratio, fine sediment, and cover for fish. For streams greater than 10 meters wide, variables measured included bank stability, maximum thalweg depth, riffle:riffle or bend:bend ratio, rocky substrate, and cover for fish.

Aquatic Macrophytes Surveys

Two individual aquatic plant surveys were done at sites SR 02 and SR 03. SR 02 was done using the point-intercept (PI) method protocol (Hauxwell et al, 2010). The PI method was designed for lake surveys, so the method was slightly modified for use on this section of the Sheboygan River. Monitoring was done on September 20, 2011 on 106 sample points, spaced 20 meters apart. Sample points were identified using GPS (Figure 3). Depth, substrate type, aquatic plant species, and individual species density (rake fullness) were recorded at each sample point. SR 03 was a small wetland, approximately three acres in size, and the PI method could not be applied at the site. Therefore, a simple visual inspection was applied to this site, also on September 20, 2011.

RESULTS AND DISCUSSION

The assessment of biological and physical stream conditions can be used to assess the overall health of a given water body. Individual species and assemblages may determine biological integrity and water quality conditions. Stream habitat also has a major role in supporting fish, macroinvertebrate, and macrophyte communities.

Fish

The Sheboygan River fish community assessments included nine of the 20 monitoring locations. Two of these survey sites (SR 01 and SR 02), were located within the lower portion of the River in the City of Sheboygan. These sites were within the proposed dredging project boundaries and were also not wadable due to deeper water depths. Non-wadable protocols were followed at these sites (WDNR 2003). Both sites scored 60/100, resulting in a rating of “good” using a warmwater IBI (Table 2). Smallmouth bass catch rates were 1.7 per mile for site SR 01 and 7 per mile for site SR 02. These catch rates are relatively average when considering species potential based on physical criteria of the river (Lyons 2006). The other fish from these sites had intermediate tolerance and were characterized as warmwater/transitional species (Table 3). One introduced species, the common carp, was found at these sites.

It should be noted that hydraulic dredging operations were occurring during the survey period which may have affected catch. For comparison, previous surveys occurred in 2003 and 2010 in the same river reach as SR 02 following the same sampling protocols. In 2003 the survey resulted in a score of 75/100 or a rating of “excellent” using a warmwater IBI. A total of 23 smallmouth bass were caught yielding a catch rate of 25.6 per mile which is above statewide average when referencing the criteria discussed previously. In 2010 survey results were very similar to 2011 with a score of 65/100 or a rating of “excellent” and a smallmouth bass catch rate of 1 per mile. The 2010 survey may have been influenced by the salmonid run which was occurring during the sampling period.

The Sheboygan Harbor, including lower reaches of the Sheboygan River, were the subject of another survey from 2003 and 2005 (Hirethota and Burzynski 2006). This survey compared smallmouth bass distribution and abundance among 4 harbors of Lake Michigan in southeastern Wisconsin. Of the 4 harbors compared, Sheboygan Harbor was noted as having the highest abundance of smallmouth bass.

Table 2. Fish community and benthic macroinvertebrate index of biotic integrities (IBIs), and stream habitat ratings for Sheboygan River AOC and tributaries. * indicates cold water IBI, ** indicates cool water IBI. NA – Not Assessed. SR 01 is nonwadable site.

Site	Fish Community IBI	Macroinvertebrate IBI	Stream Habitat Rating
SR 01	Good	Very Poor	NA
SR 02	Good	Fair	Fair
SR 04	Excellent	Fair	Good
SR 05	Excellent	Fair	Excellent
SR 06	Excellent	Fair	Good
SR 07	Excellent	Excellent	Fair
SR 08	Fair	Good	Good
SR 09	Excellent	Fair	Excellent
WC 01	Very Poor*	Fair	Good
WC 02	Very Poor*	Good	Good
WC 03	Good	Fair	Fair
WE 01	Fair	Fair	Good
WE 02	Poor	Fair	Fair
OC 01	Good	Fair	Fair
OC 02	Excellent	Good	Excellent
OC 03	Good	Poor	Fair
OC 04	Good	Fair	Fair
OC 05	Good**	Fair	Fair
OC 06	Fair**	Poor	Good

During 2011 six other sites were surveyed in the Sheboygan River AOC using either warmwater wadeable or non-wadeable protocols (Figure 1) (Table 1). In general the upstream habitat was significantly different with more course substrate and narrower stream widths. These differences carried over to fish survey results with 5 of 6 sites having an average score of 87/100 or a rating of "excellent" using a warmwater IBI (Table 2). Smallmouth bass catch rates at these 5 sites were all above statewide average again considering species potential based on physical criteria of the river (Lyons 2006). One of the five sites (SR 09) even yielded an impressive 652.8 smallmouth bass per mile. The one site that was an outlier scored a 45 placing it in the "fair" category and no smallmouth bass were found there. This site (SR 08) was unique likely because of influences from what is locally known as Riverbend Dam. A total of 3 intolerant fish species were documented in these upstream sites (northern hog sucker, rock bass and smallmouth bass). There were 26 native fish species found at these sites that were tolerant/intermediate, warmwater/transitional species (Table 3). Two exotic species were also sampled from these upstream sites, the common carp and round goby.

When considering smallmouth bass as the focal species of the fishery only 3.4% of the fish sampled would meet the 14 inch minimum length regulation in place on the Sheboygan River (Figure 2). Another metric used to summarize length data is Relative Stock Density (RSD). RSD is a ratio of the total catch of relatively large fish to the total catch of all medium and large fish. For this analysis we compared the total number of fish 14 inches and greater to the total number of fish 8 inches and greater. An RSD of

10.67% was calculated for all smallmouth bass surveyed in 2011. This falls within the "acceptable" range for southern warmwater wadable streams and "below average" for southern non-wadable rivers (Lyons 2006). Currently no harvest should be occurring because of the "do not eat resident fish" consumption advisory so we might expect these numbers to be higher. However it should again be noted that surveys of the lower reaches of the river where we might expect to find some of the larger individuals may have been affected by hydraulic dredging operations.

Looking at length ranges broken down by river section the length frequencies showed distinct variation (Figure 2). In the lower river sites (SR01 and SR02) lengths ranged from 7 inches to 11 inches. These sites were sampled with non-wadable protocols and non-wadable surveys are biased against small and nocturnal species. This fact coupled with difference in habitat with upstream reaches may account for the lack of smaller individuals. Larger individuals may be absent because of the previously mentioned dredging operations. In the middle river sites (SR04, SR05 and SR06) sizes ranged from our overall minimum of 1 inch to our overall maximum of 17 inches. All of these sites were surveyed with wadable warmwater protocols and included excellent habitat variation which probably accounts for the wide range of observed sizes. In the upper river sites (SR07, SR08 and SR09) sizes ranged from 2 inches to 13 inches. These sites were surveyed with a combination of wadable and non-wadable protocols. The survey site furthest upstream (SR 09) includes a riffle area that yielded the highest smallmouth bass catch rates of any of the 2011 surveys. That survey accounts for most of the 3-6 inch fish surveyed and points to the fact that this riffle may be an important nursery habitat.

Downstream portions of the AOC also serve as a corridor for migratory fish in spring and fall. Although no quantitative data exists, qualitative observations of numerous species stacking up at the Waelderhaus Dam (the 1st barrier upstream of Lake Michigan) do exist. In the spring these species include: northern pike, walleye, white sucker, steelhead and three redhorse species. The fall run would include brown trout, chinook salmon, coho salmon and steelhead.

A fyke netting survey was also executed near the intersection of Taylor Drive and Indiana Avenue (SR 03). This survey was carried out following Spring Netting I protocols from WDNR Lakes Sampling Procedures (WDNR 2008). The goal of this netting was to establish presence/absence of adult northern pike in a targeted project area. A backwater area was netted at this location with a 2 foot X 6 foot fyke net for a total of 6 net nights. A total of 14 northern pike were documented, 3 juveniles of unknown sex, 5 males and 6 females. Sex differentiation was possible due to the expression of reproductive product. The presence of spawning size northern pike in this backwater area supports the idea that the creation of spawning marshes along the Sheboygan River may be of great benefit to this species.

In summary, based on these recent surveys and observations, the fish communities of the Sheboygan River proper within the AOC are relatively healthy based on species abundance and diversity. However consumption advisories for certain fish species with the Sheboygan River remain due to elevated PCB levels found in fish tissue.

Willow Creek has portions of the headwaters that have been impacted from past development. This includes filling of wetlands, straightening of the stream channel for flood control, storm sewer discharges, thermal impacts, nutrient and sediment loading from nonpoint source runoff, and diversion of groundwater discharge to the stream.

Poor water quality and excess stream flows are factors that can influence the type of fish community found in a stream. In this basin, past land use practices have degraded the water quality and biological integrity of Willow Creek. Future development in the watershed may further impact the stream. However, sufficient evidence based on monitoring, shows that sections of Willow Creek meet the criteria for classification as a Class II trout stream (Masterson, 2006 and 2008). Therefore, the lower 1.6 miles of Willow Creek and its tributaries were reclassified as a Class II trout stream in 2008 to protect the biological integrity of this unique stream.

Past fishery surveys have documented smolt from all three salmonid species stocked into Lake Michigan and its tributaries. These species include chinook salmon, coho salmon and steelhead trout. Native brook trout have also been documented previously (Masterson 2006 and 2008). The presence of these species indicates Willow Creek has the potential to support a coldwater fishery.

The survey included three electrofishing samples using a backpack shocker following coldwater protocols (WDNR 2001). This survey documented only one coldwater species, a salmonid smolt, at the three sites sampled. The remainder of the 11 species found were tolerant/intermediate, warmwater/transitional fish (Table 3). One introduced, exotic species, the round goby, was found at the site nearest the confluence with the Sheboygan River (WC 01). Using a Coldwater Index of Biotic Integrity (IBI) (Lyons 1996), two sites, WC 01 and WC 02, rated very poor with scores of zero (Table 2). The Small Stream IBI (Lyons 2006) was used for Site WC 03 and resulted in a rating of good.

The documentation of a salmonid smolt by this survey is encouraging and confirmed by a separate survey conducted by WDNR staff from the Southern Lake Michigan Fisheries Team. They took two electrofishing samples from consecutive weeks in August, 2011 and found a total of 27 steelhead smolts. This survey will be repeated for one more year and will be a valuable baseline as changes occur on the property surrounding Willow Creek. This survey only documents the presence or absence of salmonid smolts; it does not utilize standard protocols or the fish IBI.

In a true coldwater community the expectation is to find relatively few fish species with trout and sculpin dominating. As discussed previously this type of community was not documented at any of the 2011 survey sites. Coldwater streams are best described as flowing waters with maximum summer water temperatures that are typically below 22 degrees Celsius. The watersheds of these streams are usually less than 100 square miles, and the streams exhibit mean annual flow rates of less than 50 cubic feet per second. Most of these conditions have been documented at Willow Creek (Masterson 2006 and 2008). However, portions of the Willow Creek watershed are developed from agriculture and urban land use and this does contribute to a flashy flow regime which has degraded stream habitat and the biological community of Willow Creek.

Weedens Creek is generally characterized as a warmwater resource. Its official classification is that of cool-warm transition headwater. Two sites were surveyed within Weedens Creek (Figure 1) (Table 1).

This survey included two electrofishing samples using a backpack shocker following warm water protocols (WDNR 2001). At the downstream site (WE 01) steelhead smolt were documented for the first time. Young of the year northern pike were also found indicating Weedens Creek may function as a nursery area for certain species. Future monitoring would be important to determine the significance of these findings.

Of the remaining fish one intolerant warmwater species, the banded darter, was documented at the downstream site (WE 01). The remaining 11 species documented were tolerant/intermediate, warmwater/transitional fish (Table 3). Using a warmwater IBI, the two sites scored 35/100 and 20/100 or ratings of "fair" and "poor" respectively moving upstream (Table 2). Only one introduced species, the steelhead, was documented.

In summary, the fish communities of Weedens Creek are somewhat degraded. Upstream reaches of the stream are impacted by agricultural practices and downstream reaches are subject to a severely flashy regime causing erosion issues. However the presence of young of the year fish is encouraging and future monitoring would be warranted.

The Onion River is the largest of the three tributaries surveyed within the Sheboygan River AOC. The lower Onion River extends from the Village of Waldo Dam downstream to its confluence with the Sheboygan River at Rochester Park. Six sample sites were included in this survey (Figure 1) (Table 1). All monitoring sites were located downstream of the Village of Hingham Dam. This dam is located downstream of the Village of Waldo Dam and is the first major impairment to fish passage.

Overall the Onion River's water quality is fair to poor in the lower reach below Waldo Dam. Water quality is still good to excellent in the river's upstream reaches (above Waldo). The upper portions do have coldwater segments that support a healthy, naturally reproducing brown trout community. The lower section of the Onion River flows through vast acreage of farmland, where intensive cropland and pasturing contributes to erosion and sedimentation of the stream substrate. Soil type mainly consists of clays. Water clarity is typically turbid during the growing season, because of runoff from farm fields and bioturbidation, from carp feeding on the stream bottom.

In 2011, three sites on the Onion River were surveyed with a stream shocker following warmwater wadable protocols (WDNR 2001). The site farthest downstream (OR 02) yielded the best results with a warmwater IBI score of 90/100 or a rating of "excellent" (Table 2). This was the only site where smallmouth bass were documented with a total catch of 41 or a catch rate of 82.5 per mile. This catch rate is above exceptional when considering species potential based on physical criteria of the river (Lyons 2006). The habitat at this site was significantly different than the two upstream sites. There was abundance of course substrate with good gradient and run – riffle – pool sequences.

When considering smallmouth bass as the focal species of the fishery only 1 fish, or 2.4% of the fish sampled, would meet the 14 inch minimum length regulation in place on the Onion River (Figure 3). Another metric used to summarize length data is Relative Stock Density (RSD). RSD is a ratio of the total catch of relatively large fish to the total catch of all medium and large fish. For this analysis we compared the total number of fish 14 inches and greater to the total number of fish 8 inches and greater. An RSD of 7.1% was calculated for all smallmouth bass surveyed in 2011. This section of the Onion River is designated as southern wadable smallmouth bass nursery waters. As such, the RSD value is somewhat non-applicable, but does allow comparison with the Sheboygan River RSD discussed previously.

The upstream sites were dominated by fine substrate and lacked both gradient and geomorphic diversity as they were more closely bordered by agricultural lands. The sites upstream (OR 03 and OR 04) yielded warmwater IBI scores of 70/100 and 50/100 or a ratings of "excellent" and "good", respectively. As noted previously no smallmouth bass were documented at either site but northern pike were found at both in low abundance.

In total two intolerant warmwater species (rock bass and smallmouth bass) were found in this survey. The remainder of the species were tolerant/intermediate, warmwater/transitional species (Table 3). All of the species documented in the Onion River survey were native to waters of Wisconsin.

A comparison of other recent surveys allows increased spatial and temporal coverage of results. The sites are comparable as they were sampled with a stream shocker following warmwater wadable IBI protocols without the gamefish extension (WDNR 2001). The farthest downstream site (OR 01) was surveyed in 2009 and scored a 52/100 or a rating of "good" with a warmwater IBI. Smallmouth bass were not documented in any of the previous surveys, however largemouth bass were found at every site. A total of two largemouth bass were documented at OR 01, yielding a catch rate of 8 per mile.

The final 2 sites (OR 05 and OR 06) were surveyed in 2009 and 2010, respectively, and located farther upstream than any of the 2011 sites. A cool – warmwater transition IBI (Lyons et al, 2009) was used to evaluate these sites as it represented the best fit for natural community type. They scored 60/100 and 50/100 or ratings of good and fair respectively. A total of 5 largemouth bass were captured at OR 05 for a catch rate of 25 per mile. A total of 9 largemouth bass were captured at OR 06 for a catch rate of 37.44 per mile.

In general, results from these recent surveys indicate fish communities in the Onion River represent a relatively healthy and balanced warmwater fishery. Throughout this stretch of the river habitat changes related to land use practices probably have the largest impact on the health of fish communities. This issue is an overriding one throughout the Sheboygan River watershed

Table 3. Individual fish species and classifications (Origin/Tolerance/Temperature) from all sample sites. (N=Native, I=Introduced/I=Intolerant, IM=Intermediate Tolerance, T=Tolerant/W=Warmwater, T=Cold-Warm Transitional).

SPECIES	**SR 01**	**SR 02**	**SR 04**	**SR 05**	**SR 06**	**SR 07**	**SR 08**	**SR 09**	**WC 01**	**WC 02**	**WC 03**	**WE 01**	**WE 02**	**OC 01**	**OC 02**	**OC 03**	**OC 04**	**OC 05**	**OC 06**
BANDED DARTER (N/I/W)												11							
BIGMOUTH SHINER (N/IM/W)								18									1	1	2
BLACK BULLHEAD (N/T/W)			2						2	1	2								
BLACKSIDE DARTER (N/IM/W)			5		17			17						13	2		4		14
BLUEGILL (N/IM/W)			8	3	5				1	3	15	10	3	2					1
BLUNTNOSE MINNOW (N/T/W)				26	8			10	5		1	9		1				22	142
BROOK STICKLEBACK (N/T/T)									3	1	9	1	6						
CENTRAL MUDMINNOW (N/T/T)			3						2		5		4					2	
CENTRAL STONEROLLER (N/IM/W)					2														
CHANNEL CATFISH (N/IM/W)			5		1														
CHINOOK SALMON SMOLT (I/IM/W)									2										
COMMON CARP (I/T/W)	5				2	2	5	2											29
COMMON SHINER (N/IM/W)	2		15	3	28			434	1					1	490	8	25	24	305
CREEK CHUB (N/T/T)										14	3		57		8		29	95	124
FANTAIL DARTER (N/IM/W)													1						
FATHEAD MINNOW (N/T/W)												2	1						2
GIZZARD SHAD (N/IM/W)	27	127	42																
GOLDEN REDHORSE (N/IM/W)			1	6	7	7	1	43						10	30	9			
GREEN SUNFISH (N/T/W)			10	2	13									30	12			1	6
HORNYHEAD CHUB (N/IM/W)					5			55						6	243				1
JOHNNY DARTER (N/IM/T)			2	4	22			9	6			73	8	12	9		1	52	5
LARGEMOUTH BASS (N/IM/W)			4		1									2				5	9
LOGPERCH (N/IM/W)					5			48							12				
LONGNOSE DACE (N/IM/T)			8	3	124			40	1	4					278		2	17	18
NORTHERN HOG SUCKER (N/I/T)								2											
NORTHERN PIKE (N/IM/T)		1	18		3			1				2	10			4	2	2	
PUMPKINSEED (N/IM/W)								1										4	12
PUMPKINSEED X UNKNOWN (N/IM/W)												1							
RAINBOW TROUT SMOLT (I/IM/C)												4							
ROCK BASS (N/I/W)			12	9	13	1		14						41	37	7	2		
ROUND GOBY (I/IM/W)			422	55	23				5										
SAND SHINER(N/IM/W)					4			26						13				58	1
SHORTHEAD REDHORSE (N/IM/W)			2		7														
SMALLMOUTH BASS (N/I/W)	2	9	21	16	40	3		143							41				
SPOTFIN SHINER (N/IM/W)			2		5			2								3			
STONECAT(N/IM/W)			5	5	10			14						6	8		1		15
WESTERN BLACKNOSE DACE (N/T/T)			1							4	6	10					3		
WHITE SUCKER (N/T/T)			17	1	5	3	1	76	7	9		4		2	98	15	54	86	285
YELLOW BULLHEAD (N/T/W)																			1
YELLOW PERCH (N/IM/T)	1																		
Total Number of Fish	**37**	**137**	**658**	**133**	**350**	**16**	**7**	**955**	**35**	**36**	**41**	**127**	**92**	**139**	**1268**	**46**	**124**	**369**	**972**
Total Individual Species	**5**	**3**	**21**	**12**	**23**	**5**	**3**	**19**	**11**	**7**	**7**	**11**	**9**	**13**	**13**	**6**	**11**	**13**	**18**

Figure 2. Length frequency of smallmouth bass from 2011 surveys broken down by survey reach.

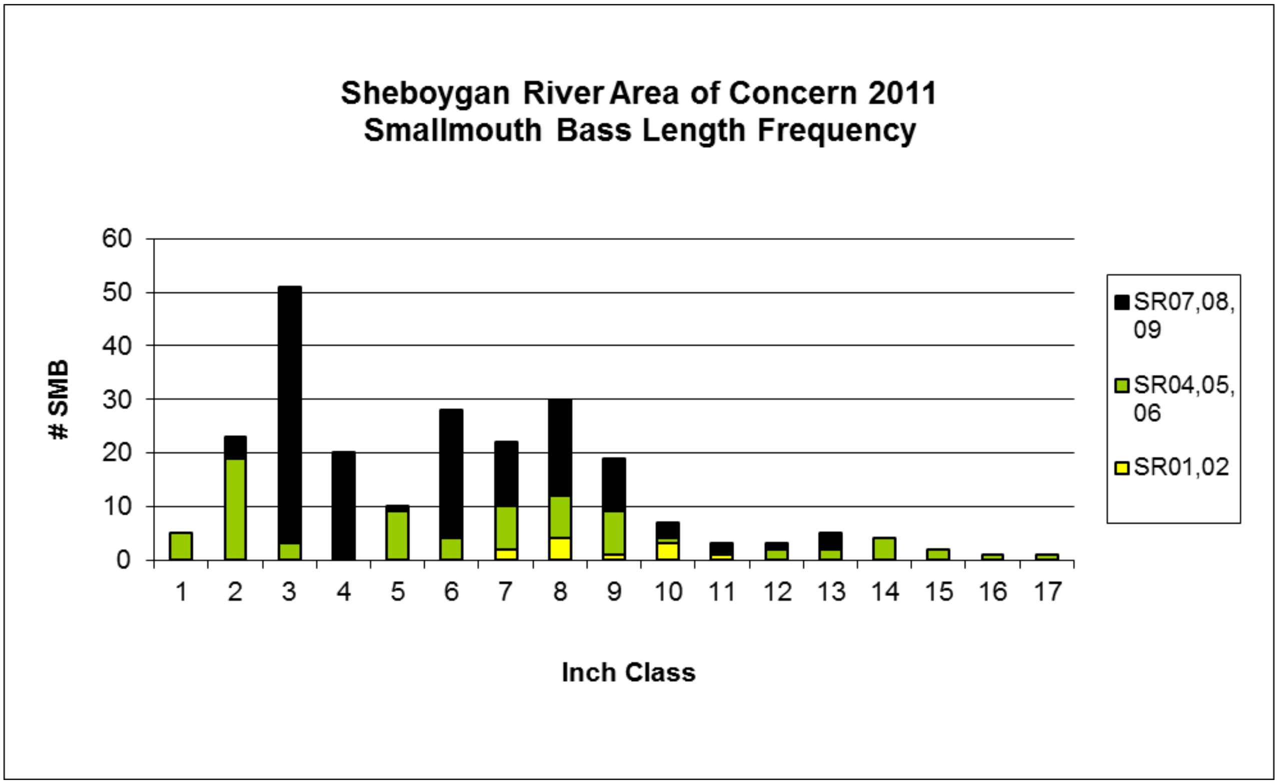
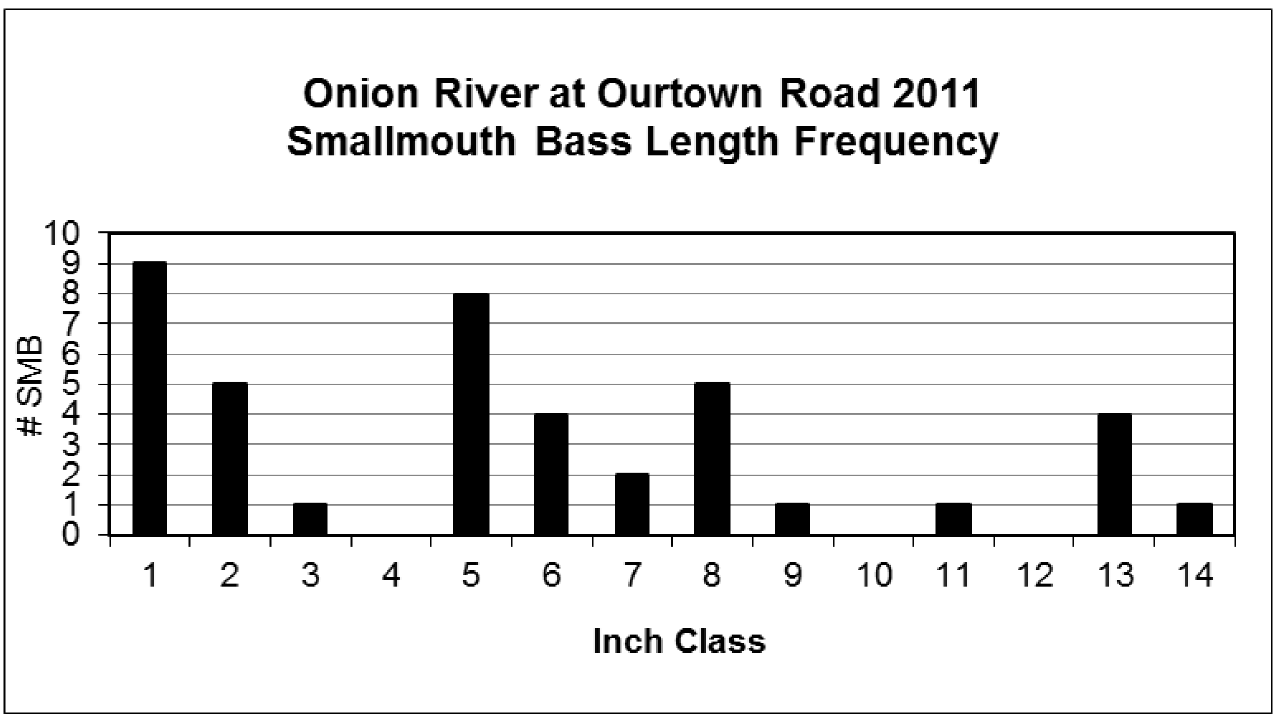


Figure 3. Length frequency of smallmouth bass from 2011 Onion River surveys at Ourtown Road.



Benthic Macroinvertebrates

Benthic macroinvertebrate communities are used as indicators of water quality. For this study, we evaluated the number of invertebrate taxa, Shannon Diversity Index, percentage of taxa or individuals in the insect orders Ephemeroptera-Plecoptera-Tricoptera (EPT; also known as mayflies, stoneflies, and caddisflies), and the Index of Biotic Integrity (Table 4).

The number of taxa and Shannon Diversity Index scores generally decrease with degrading water quality. The highest number of taxa (50 species and 46 genera) were found on the Onion River at OR 02. The highest Shannon diversity score was 4.37 on the Sheboygan River at SR 07. The lowest number of taxa (12 species and 11 genera) were found on Willow Creek (WC 02). The lowest Shannon diversity score was 1.45 and was found on Weedens Creek (WE 02). Higher numbers of taxa and higher diversity are typically found on larger streams compared to smaller streams, if conditions are the same. We do see that trend for the data. Site OR 06 on the Onion River had lower number of taxa (13 species and 13 genera) and a low Shannon diversity score of 1.74. One possible explanation for this is that this site is downstream and relatively close to the Village of Hingham dam and impoundment.

EPT invertebrates are generally considered to be relatively intolerant of degraded water quality (Lenat 1988). Therefore, the percentages of EPT individuals and genera tend to decrease as water quality degrades. The highest percentages of EPT taxa were found on the Onion River (OR 02) and Sheboygan River (SR 09), and were 42 percent and 40 percent, respectively. The lowest percentages of EPT taxa were 6 percent for both the Sheboygan River (SR 01) and Willow Creek (WC 03). The low percentages for these two sites may be attributed to the fine sediments and that dominate the stream substrate at both locations.

The biotic index used to assess invertebrate assemblages was an Index of Biotic Integrity (IBI) developed by Weigel (2003) for the wadable sites, and Weigel and Dimick (2011) for the one nonwadable site (SR 01). Invertebrate IBI values can range from 0.00 ("very poor" water quality) to 10.00 ("excellent" water quality). Ratings for the sites ranged from "very poor" on the Sheboygan River (SR 01) to "excellent" on the Sheboygan River (SR 07) and Onion River (OR 02). The majority of the sites (12 of 19) rated "fair". Two sites on the Onion River rated "poor" (OR 03 and OR 06). These two sites are in an area that is dominated by agricultural land use and this may account for the 'poor" rankings.

Stream Habitat

Stream habitat is important when assessing the biological integrity of streams. The physical environment can play an important role in supporting fish and macroinvertebrate populations. Loss of fish cover and sedimentation can have severe impacts on biological communities. All wadable sites rated "fair" to "excellent" (Tables 5 and 6). One site (SR 01) was non-wadable and habitat assessment was not done because protocols are not available at this time.

Table 4. Benthic macroinvertebrate assemblage information from one-time surveys conducted in November 2011 at 19 stream sites within the Sheboygan River AOC. EPT, Ephemeroptera, Plecoptera, and Trichoptera; IBI, Index of Biotic Integrity; * indicates samples that were collected in 2009 or ** for 2010; SR 01 is a nonwadable site.

Site	**Species Richness**	**Genera Richness**	**Shannon's Diversity Index**	**% EPT Individuals**	**% EPT Genera**	**HBI** Max 10	Rating	IBI	Rating
SR 01	20	18	2.32	0	6	7.23	Fairly Poor	2.56	Fair
SR 02	37	36	4.32	41	25	5.94	Fair	4.28	Fair
SR 04	19	18	2.95	81	39	5.18	Good	2.88	Fair
SR 05	26	25	3.78	19	28	7.04	Fairly Poor	4.61	Fair
SR 06	39	37	3.07	66	38	5.22	Good	4.49	Fair
SR 07	46	45	4.37	10	13	7.1	Fairly Poor	7.78	Excellent
SR 08	27	26	3.21	64	38	5.39	Good	5.01	Good
SR 08 (2)	31	29	3.62	41	31	5.4	Good	5.62	Good
SR 09	27	25	2.94	40	40	5.05	Good	4.27	Fair
OR 01*	30	29	3.93	41	21	5.24	Good	4.43	Fair
OR 02	33	31	3.95	63	42	5.38	Good	6.59	Good
OR 02 (2)	50	46	4.23	49	28	5.17	Good	8.16	Excellent
OR 03	31	31	3.79	28	10	6.68	Fairly Poor	2.36	Poor
OR 04	23	23	3.13	43	22	6.78	Fairly Poor	2.63	Fair
OR 05*	23	23	2.84	30	30	4.72	Good	3.23	Fair
OR 06**	13	13	1.74	87	31	5.52	Fair	1.62	Poor
WC 01	15	15	2.55	82	27	5.03	Good	2.92	Fair
WC 02	12	11	2.52	63	36	4.71	Good	5.4	Good
WC 03	32	32	2.78	1	6	7	Fairly Poor	3.76	Fair
WE 01	17	16	2.62	44	31	5.26	Good	3.55	Fair
WE 02	15	15	1.45	3	13	6.6	Fairly Poor	3.85	Fair

[1] Weigel, 2003.
Weigel and Dimick, 2011 (Site SR 01)

For most sites less than 10 meters wide, the limiting factor for habitat appears to be bank erosion, lack of pool areas, and fine sediments. Ranking for these sites were “fair to “good”. For stream sites that were greater than 10 meters wide, ranking ranged from “fair” to “excellent”. For sites that rated “fair”, limiting factors for habitat were bank stability, riffle:riffle or bend:bend ratio, lack of rocky substrate and cover for fish.

Table 5. Stream habitat scores and ratings for sites that are < 10 meters wide. * site surveyed in 2009.

Site	**Riparian Buffer Width**	**Bank Erosion**	**Pool Area**	**Width: Depth Ratio**	**Riffle: Riffle or Bend: Bend Ratio**	**Fine Sediments**	**Cover for Fish**	**Total Score**	**Rating**
OR 04	10	5	3	5	5	0	10	38	Fair
OR 05*	15	5	0	5	15	5	0	45	Fair
WC 01	15	5	3	5	10	10	5	53	Good
WC 02	15	5	3	5	10	10	10	58	Good
WC 03	15	10	3	10	5	0	5	48	Fair
WE 01	15	0	7	10	15	10	10	67	Good
WE 02	5	5	0	10	5	10	10	45	Fair
Top Score	15	15	10	15	15	15	15	100	Excellent

Table 6. Stream habitat score for sites that are > 10 meters wide. * site surveyed in 2009. ** site surveyed in 2010. NA – Not Assessed.

Site	**Bank Stability**	**Maximum Thalweg Depth**	**Riffle:Riffle or Bend:Bend Ratio**	**Rocky Substrate**	**Cover for Fish**	**Total Score**	**Rating**
SR 01	12	25	0	0	8	45	Fair
SR 02	8	16	0	16	8	48	Fair
SR 04	8	16	12	25	16	77	Good
SR 05	8	16	12	25	25	86	Excellent
SR 06	8	8	12	25	25	78	Good
SR 07	4	25	4	8	16	57	Fair
SR 08	4	8	8	16	25	61	Good
SR 09	4	16	12	25	25	82	Excellent
OR 01*							Good
OR 02	12	8	12	25	25	82	Excellent
OR 03	4	8	0	8	8	28	Fair
OR 06**	8	8	12	25	16	69	Good
Top Score	12	25	12	25	25	99	Excellent

Aquatic Macrophytes

Aquatic macrophyte surveys were conducted at two locations (SR 02 and SR 03) to determine their potential to support annual Northern Pike spawning in the spring. Figure 4 and Table 7 summarizes select data for the SR 02 site survey. Figure 5 further illustrates site locations for the two sites. Only 76 of 106 sample points were included in the data collection, because 30 of the sample points were located in upland areas. This was due to the number of small islands within the sample site. Two species of aquatic plants were found within the sample site, filamentous algae and sago pondweed. Filamentous algae (*Cladophora* sp.) were the main species found at the site, located in 37 percent of the sample sites, but in low density. Rake density or fullness, was one out of three. This is the lower of the ratings for density. Sago pondweed (*Potamogeton pectinatus*) was only found at one sample point and accounted for 1.3 percent aquatic plant coverage. Rake density was also one. SR 03 was a small wetland, approximately three acres in size, and the PI method could not be applied at the site. Therefore, a simple visual inspection was applied to this site. This wetland (SR 03) was dominated with broad-leaved cattail and reed canary grass. Neither of the two sites appears to have a macrophyte community that would support natural reproduction and a nursery for Northern Pike spawning.

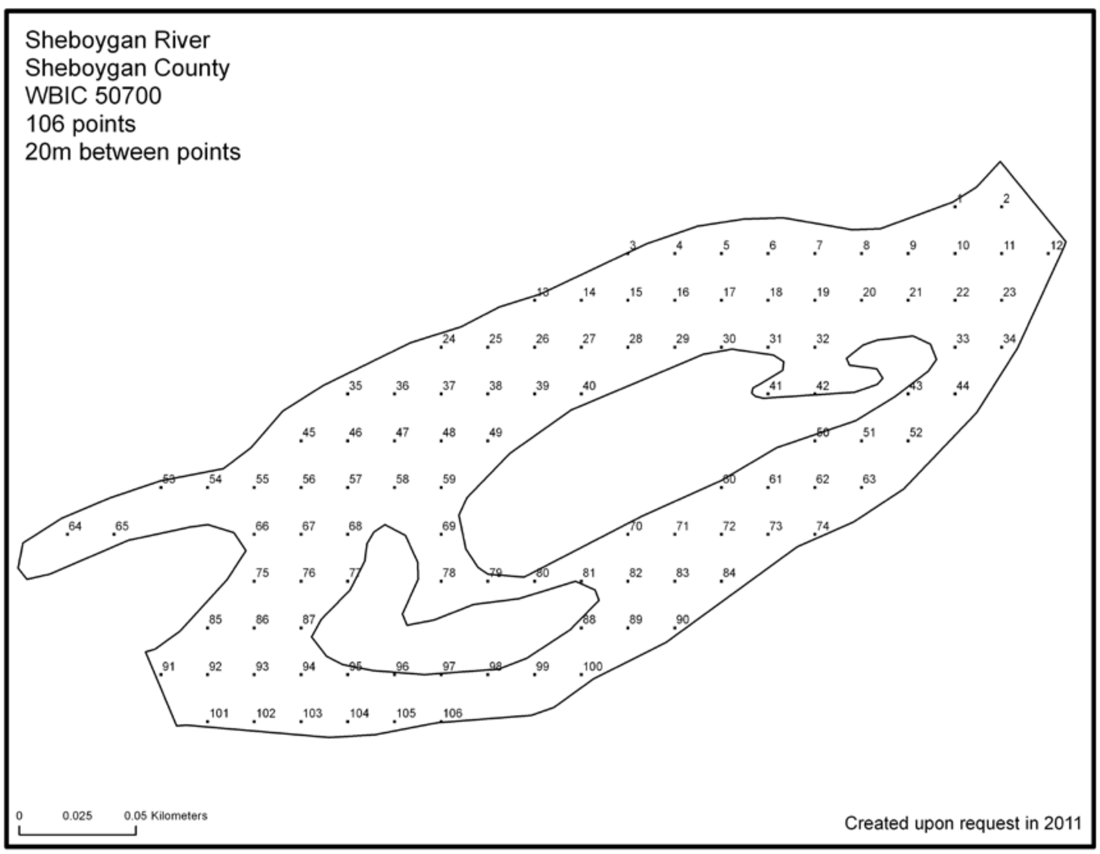


Figure 4. Aquatic plant survey sample locations, using point-intercept method, for Wildwood Island Area on the Sheboygan River (SR 02), Sheboygan, Wisconsin.

Figure 5. Aerial photos and locations for Sheboygan River sites SR 02 (top) and SR 03 (bottom).

Table 7. Summary of aquatic plant survey data for site SR 02 on the Sheboygan River. Sample points within upland areas were not included in survey.

Total sample points	**106**
Sample points within upland areas	**30/106 (28%)**
Sample points included in survey	**76**
Filamentous algae	**28/76 (37%)**
Sago pondweed	**1/76 (1.3%)**
Gravel substrate	**48/76 (63%)**
Sand substrate	**13/76 (17%)**
Muck substrate	**15/76 (20%)**
Depth range	**0.1 – 4.5 feet**
Average depth	**1.6 feet**

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Appendix D

Letters of Support

Sheboygan County
Planning & Conservation Department

Administration Building | 508 New York Avenue | Sheboygan, WI 53081-4126
P: (920) 459-3060 | P: (920) 459-1370 | F: (920) 459-1371
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Director
Aaron C. Brault

September 21, 2015

Ms. Camille Bruhn, Sheboygan River Area of Concern Coordinator
Wisconsin Department of Natural Resources
1155 Pilgrim Road
Plymouth, WI 53073

Dear Ms. Bruhn,

Sheboygan County supports the Wisconsin Department of Natural Resources' (WDNR) efforts to remove the Eutrophication or Undesirable Algae Beneficial Use Impairment (BUI) for the Sheboygan River Area of Concern (AOC).

Many local, state and federal agencies, non-governmental organizations, property owners, business groups, community leaders, and volunteers have partnered over the past decades to improve the overall water quality of the Sheboygan River in general and the AOC in particular.

The Sheboygan County Planning & Conservation Department (PCD) along with many partners including the Natural Resource Conservation Service and The Nature Conservancy (TNC) have spearheaded efforts to improve the water quality of the Sheboygan River. A successful large scale Priority Watershed Project was implemented in the 1990's. Another project now entering its fifth year has been conducted to reduce the phosphorus contribution from Otter Creek to the Sheboygan River. This project was funded by the Kohler Foundation, sponsored by TNC and implemented by the Sheboygan County PCD.

Other accomplishments over this period have included the County's efforts to identify and replace failing septic systems, development of an Animal Waste Storage and Feedlot Facility Ordinance and also the implementation of the Sheboygan County's Erosion Control and Stormwater Management Ordinance. Our Grass Buffer Program has resulted in the installation of 38 miles of riparian buffers; over 60% of these occurring within the Sheboygan River Watershed.

We believe that these efforts as well as numerous others not detailed here have resulted in a significant overall improvement in water quality. Thus, we concur with the WDNR's decision to seek removal of the Eutrophication or Undesirable Algae BUI.

We appreciate all that the WDNR, EPA and many other partners have done to help achieve this goal.

Sincerely,

Aaron Brault,
Sheboygan County Planning & Conservation Department Director

Cc: Roger TeStroete, Sheboygan County Board Chairman
Adam Payne, Sheboygan County Administrator

Sheboygan River Basin
PARTNERSHIP
Improving the Health of our Rivers and Lakes

Camille Bruhn,
Sheboygan River AOC Coordinator
Wisconsin Department of Natural Resources
1155 Pilgrim Road
Plymouth, WI 53073

September 17, 2015

Subject: Removal of Eutrophication/Algae BUI

Dear Ms. Bruhn,

The Sheboygan River Basin Partnership (SRBP) has discussed the subject of removing eutrophication and algae as a Beneficial Use Impairment (BUI) at its September 17, 2015 meeting. We support the Wisconsin Department of Natural Resources action to remove eutrophication and algae as a beneficial use impairment in the watershed.

The actions of Wisconsin DNR, other agencies, and organizations to reduce nutrient input and soil erosion into the Sheboygan River and its tributaries have had a positive impact on the environmental health of those waters. While there are still problem areas in need of attention, the water quality in the river has improved dramatically since the initiation of the Clean Water Act and subsequent legislative actions. Fish kills and associated use problems have substantially diminished.

We, the SRBP, will continue to monitor water quality in the watershed and support actions to make further improvements. We thank you and the Wisconsin Department of Natural Resources for your diligence in improving use of the river.

Sincerely,

John E. Nelson,
President - SRBP

Sheboygan River Basin Partnership
P.O. Box 3 Sheboygan Falls, WI 53085-0003
www.sheboyganrivers.org