Water Resources of the Sheboygan River Basin

Supplement to

The State of the Sheboygan River Basin

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GENERAL BACKGROUND

The Sheboygan River Basin drains 619 square miles, encompassing all of Sheboygan County and portions of Ozaukee, Fond du Lac, Caumet, and Manitowoc counties. The basin is bordered by the Manitowoc River Basin to the north, Lake Winnebago drainage to the west, the Milwaukee River Basin to the south, and on its eastern edge, Lake Michigan. The Sheboygan River, with its major tributaries the Onion and Mullet rivers, discharges into Lake Michigan. Other streams in the basin that drain directly into Lake Michigan include; Sauk Creek, Sucker Creek, Barr Creek, the Black River, and the Pigeon River as well as numerous small unnamed streams (WDNR 1988). There are 21 lakes and six river impoundments greater than 10 acres and over 45,000 acres of mapped wetlands are within the Sheboygan River Basin.

The topography of the basin ranges from low flat moraine in the east, to a central area of kettle moraine landscape. The western portion consists of abundant wetlands interspersed between the low rounded hills of the basin. Elevation of the basin varies from 50 feet to 150 feet above Lake Michigan. The basin is graded to the east at slopes that range from 0 feet to 21 feet per mile with the average grade being 7 feet per mile. Soils of the eastern basin are generally "heavy" clays that have lower permeability and tend to promote runoff of soil and animal wastes. The central moraine area has the associated glacial till or gravelly soil and the western soils are generally loamy and light textured (WDNR 1995).

Agricultural uses such as pasture land, cropland and vacant fields are the dominant land use in the Sheboygan River Basin. Natural areas, defined as open water, woodlands, wetlands, park lands, and undisturbed non-agricultural lands, account for the second largest type of land use in the basin. Urban, residential, and transportational land uses make up the remaining portion of the basin (WDNR 1995).

HISTORICAL WATER QUALITY

Runoff from both specific and diffuse sources, contaminated sediment, habitat modifications (e.g. channelization, dams) have degraded water quality throughout the Sheboygan River Basin. Construction site erosion and imperviousness (e.g. roads, roofs, parking lots, etc.) are emerging threats to water quality as much of the Sheboygan River Basin undergoes urbanization.

PRESENT HABITAT AND WATER QUALITY

Baseline water quality information for the Sheboygan River Basin were collected from 1994 to present from the basin's six watersheds; Sauk/Sucker Creeks, Black River, Sheboygan River, Onion River, Mullet River, and Pigeon River. Overall, the results show that the major streams in the basin, the Sheboygan River, Mullet River, Onion River and Pigeon River, had relatively good water quality— particularly in the headwaters. One of the greatest challenges which faces the Sheboygan River Basin are the ecosystem health effects from the PCB contaminated sediment in the lower fourteen miles of the Sheboygan River. The water quality conditions of specific streams and lakes are discussed in detail within the watershed sections. A summary of the overall water quality conditions for each watershed is shown in Table 1.

Table 1. Sheboygan River Basin Watershed Summary

Watershed	Area (sq. miles)	Drains to	Water Quality[1]
Sauk Creek and Sucker Creek (SH01)	58	Lake Michigan	Fair to Poor
Black River (SH02)	36	Lake Michigan	Poor
Sheboygan River (SH03)	260	Lake Michigan	Good in the headwaters and fair to poor in lower reaches. The last 14 miles of stream to Lake Michigan are very poor due to PCB contamination.
Onion River (SH04)	98	Sheboygan River	Good to Excellent in headwaters and fair to poor in lower sections.
Mullet River (SH05)	88	Sheboygan River	Good in the headwaters and good to fair in the lower reaches.
Pigeon River (SH06)	79	Lake Michigan	Good in the headwaters and fair to poor in lower reaches.

[1] Based on monitoring data collected since 1994.

METHODS

STREAM WATER QUALITY MONITORING ACTIVITIES

Water quality monitoring for the Sheboygan River Basin consisted of three general types: condition monitoring, problem assessment, and evaluation monitoring.

Condition Monitoring - Condition Monitoring was conducted to determine the general water quality characteristics of a basin's surface waters and to identify water quality problems within the basin. Sheboygan River Basin condition monitoring projects include:

- Trend Monitoring of Fixed Stations – Streams
- Trend Monitoring – Lakes
- Baseline Monitoring – Streams
- Baseline Monitoring – Lakes

Problem Assessment Monitoring - Problem Assessment Monitoring is conducted to assess the causes, sources and extent of a specific surface water quality problem. The main objective is to provide the information needed to determine management or regulatory actions for mitigation of specific problems. Problem Assessment Monitoring projects recently conducted in the Sheboygan Basin include:

- Sheboygan River Basin Sediment Survey
- Mullet River Assesment at the Northern Moraine Utility Wastewater Treatment Plant
- Contaminated Sediment Survey – East Branch Belgium Creek
- Sheboygan River Food Chain Contaminant Assessment (RAP)
- Stream Classifications

Evaluation Monitoring - Evaluation Monitoring is conducted to evaluate the effectiveness of management and regulatory actions taken to mitigate environmental problems or maintain existing beneficial uses. Evaluation Monitoring projects consisted of:

- Fish Contaminant Monitoring
- Otter Creek Nonpoint Source Evaluation Monitoring
- Water quality and biological monitoring at the Old Wade House State Park
- Volunteer Monitoring – Water Action Volunteers (WAV) and Testing The Waters

NR 195 - River Protection Grants

Beginning in 2000 River Planning and Management Grants have become available to units of local government, non-profit conservation organizations and qualified river management organizations. Cost sharing grant assistance (75%) is available for activities that will help provide information on riverine ecosystems, improve river system assessment and planning, increase local understanding of the causes of river problems, and assist in implementing management activities that protect and restore river ecosystems.

The purpose of the River Protection Grant Program is to assist these organizations or municipalities in protecting or improving natural river ecosystems. This grant program is also intended to provide assistance in the formation of river management organizations and provide support and guidance to local organizations that are interested in helping to manage and protect rivers, particularly where resources and organization capabilities may be limited.

With these goals in mind, the program provides assistance to a variety of project sponsors to undertake their chosen river protection projects. A wide array of activities are eligible for grant assistance, ranging from information gathering to land acquisition and management. The grants are given to support new projects, not subsidize current, ongoing operations or replace existing funds. The two types of grants that are available in the River Protection Grant Program are river planning grants and river management grants.

River planning grants up to $10,000 are available for organizational development projects that assist in the formation of a qualified river management organization or strengthen the capacity of an existing organization to protect or improve natural river ecosystems. These grants are also available for river improvement education projects and for river-related assessments and plan development.

River management grants up to $50,000 are available for projects that include purchase of land or a conservation easement, local ordinance development, installation of nonpoint source pollution control practices and river restoration activities. Management grant funds may also be used for education, planning and design activities necessary for completion of a management project.

Aquatic Resource Assesment Methods

Fish Community Assesments

Fish community assessments were conducted in the Sauk/Sucker Creeks, Onion River, Black River, Mullet River, and Pigeon River watersheds. The stream reaches were sampled with either backpack or

towed electroshocking equipment. Each survey consisted of a single pass from downstream moving upstream. All fish were collected then identified, enumerated and released. Some specimens were kept as voucher samples. Fish collections were assessed following protocols developed by Lyons (1992) to calculate an Index of Biotic Integrity (IBI) for each site. The IBI ratings and their descriptions are listed in Table 2.

Table 2. Guidelines for interpreting overall IBI scores (Lyons 1992)

Overall IBI Score	Biotic Integrity Rating	Fish Community Attributes
100-65	Excellent	Comparable to the best situations with minimal human disturbance; all regionally expected species for habitat and stream size, including the most intolerant forms, are present with a full array of age and size classes; balanced trophic structure.
64-50	Good	Species richness somewhat below expectation, especially due to the loss of intolerant forms; some species, especially top carnivores, are present with less than optimal abundance or size/age distributions; trophic structure shows some signs of imbalance.
49-30	Fair	Signs of additional deterioration include decreased species richness, loss of intolerant forms, reduction in simple lithophils, increased abundance of tolerant species, and/or highly skewed trophic structure (e.g., increasing frequency of omnivores and decreased frequency of more specialized feeders); older age classes of top carnivores rare or absent.
29-20	Poor	Relatively few species; dominated by, omnivores, tolerant forms, and habitat generalists; few or no top carnivores or simple lithophilous spawners; growth rates and condition factors sometimes depressed; hybrids sometimes common.
19-0	Very poor	Very few species present, mostly exotics or tolerant forms or hybrids; few large or old fish; DELT fish (fish with deformities, eroded fins, lesions, or tumors) sometimes common.
No Score	Very poor	Thorough sampling finds few or no fish; impossible to calculate IBI.

Aquatic Habitat Assessments

Riparian and in-stream habitat conditions were assessed using rating systems developed by Ball (1982). This rating system places a large emphasis on water quality and water resource values to develop a stream classification. In addition the Fish Habitat Rating - Streams system developed by Simonson *et al*. (1994) was used to provide a more quantitative site to site and year to year database for comparison. This scoring system was developed and intended to rate the ability of the physical habitat to support a diverse, healthy fish community. Variables used in this rating system included: substrate, cover for fish, channel features, riparian conditions, and pool/riffle quality (Simonson *et al*. 1994).

Macroinvertebrates

Macroinvertebrate samples were collected in all six watersheds to calculate a Biotic Index for each site. Using sampling protocols developed by Hilsenhoff (1987) samples were collected from riffle substrates using the "kick" method and a D-Frame net (WDNR 1987). The samples were then preserved in 80% ETOH and sent to the University of Wisconsin Stevens Point for identification and enumeration. This information was then entered into the state's macroinvertebrate data base and analyzed using the state's

macroinvertebrate program to determine HBI values, diversity indices and species abundance. The HBI water quality ratings are described in Table 5.

Table 3. Biotic Index Rating Descriptions (Hilsenhoff 1987)

Biotic Index (HBI)	Water Quality	Degree of Organic Pollution
0.00 - 3.50	Excellent	Organic pollution unlikely
3.51 - 4.50	Very Good	Possible slight organic pollution
4.51 - 5.50	Good	Some organic pollution likely
5.51 - 6.50	Fair	Fairly substantial pollution likely
6.51 - 7.50	Fairly Poor	Substantial pollution likely
7.51 - 8.50	Poor	Very substantial pollution likely
8.51 – 10.00	Very Poor	Severe organic pollution likely

Water Chemistry

Trend monitoring water chemistry sites were sampled quarterly at the Sheboygan River at Esslingen Park near the USGS gage station. Grab samples were taken at each water chemistry site from just under the surface in the main flow (thalweg) of the stream. Sample are collected following WDNR protocol and sent to the State Lab of Hygiene for analyses. Water chemistry samples were tested for nutrients (total phosphorus, ortho-phosphorus, nitrogen, ammonia), suspended solids, hardness, bacteria (MFFCC - membrane filtered fecal coliform counts), chlorophyll *a*, biochemical oxygen demand (BOD- 5 day), pH, conductivity, dissolved oxygen, turbidity, temperature, and stream flow.

Sediment Quality Assessments

Sediment samples were collected as part of the Sediment Screening Level Assessment Survey from the Mullet River, Sheboygan River, and Onion River watersheds. The sediment inventory sampling was intended to provide baseline sediment quality information from river impoundments throughout the basin and to identify potential impacts from specific pollutant sources. All samples were collected following the protocol identified in the Wisconsin DNR Field Procedures Manual (WDNR 1994). Samples were sent to the State Lab of Hygiene and analyzed for PCB's, PAH's and for ten heavy metals; cadmium, chromium, boron, copper, iron, lead, manganese, mercury, selenium, and zinc. A portion of the samples were also analyzed for total phosphorous, ammonia, total organic carbon, and particle size.

LAKE WATER QUALITY MONITORING ACTIVITIES

DNR's Lake Management Program is responsible for protecting and maintaining Wisconsin's lakes to provide a full complement of lake uses for all citizens. With 15,000 inland lakes to manage, the Lake Management Program shares responsibility for protecting lakes with University of Wisconsin - Extension, lake districts and associations, and lake-specific conservation and community groups. It acts as a catalyst to help produce the greatest benefit from coordinated action of the 20 or so DNR programs that affect

lakes. A major goal is ensuring adequate water quality database exists so present and future management programs are soundly developed.

Presently, there are seven sub-programs administered by the DNR Lakes Management Program that directly affect lakes across the state, as well as the Sheboygan River Basin. They include:

* Self-Help Monitoring
* Long-Term Trend Monitoring
* Aquatic Plant Management Program
* NR 190 - Lake Planning Grants
* Priority Lake Projects
* NR 191 - Lake Protection Grants
* EPA Clean Lakes Grants

The following are brief descriptions of these programs:

The **Self-Help Monitoring Program** gives citizens an active role in lake management activities and assists the DNR with basic data collection. The self-help volunteers are trained by a DNR lake management specialist. More than 300 volunteers statewide participated in the program during 1990. In the Sheboygan River basin, four volunteers participated, monitoring Big Elkhart, Wolf, and Crystal lakes.

The Self-Help volunteers are trained by a DNR lake management specialist to collect water quality data. There are three levels of monitoring within the program.

Basic: Volunteers are trained to collect water clarity data using a Secchi disk.

Trophic state: After successfully participating in the basic program for a couple of years, willing volunteers are taught how to collect water samples to determine total phosphorus and chlorophyll-*a* concentrations that can be used to generate a measure of the trophic state of the lake, or its nutrient enrichment.

Expanded: The expanded program is available to the senior volunteers who are interested in collecting even more data. Volunteers are trained how to measure the dissolved oxygen and temperature profile of a lake.

Each level requires additional training, time, and commitment from the volunteer.

DNR conducts intensive monitoring on 50 lakes statewide five times per year for the **Long-Term Trend Monitoring Program.** Water chemistry and biological and physical conditions will be monitored for about 10 years (begun in 1986) to evaluate trends in lake water quality. Chemical data will be supplemented by surveys of aquatic plants, fish, bottom-dwelling invertebrates, land use practices in the watershed, weather, and physical setting. Two lakes in the Sheboygan River Basin are part of the Long-Term Trend Monitoring Program: Crystal Lake and Wolf Lake.

Under NR 107, the **Aquatic Plant Management Program** (APM) regulates the use of chemical herbicides for the control of plants and algae in Wisconsin lakes and other water bodies. This program provides permits for applying herbicides to aquatic sites to abate nuisances caused by excessive plant growth, and ensures that the public is informed of herbicide treatments. The objective of the permit

procedure is to preserve the ecological benefits of aquatic communities, including fish and wildlife habitat, erosion prevention, and water quality maintenance. The program also disseminates information about the benefits of aquatic plants and alternative methods of control. Finally, the program regulates other chemical treatments of lakes for management purposes.

This basin plan identifies lakes that should be the highest priorities for designation of sensitive areas under the APM program. Sensitive areas are areas of aquatic vegetation offering critical or unique fish and wildlife habitat, water quality protection, or erosion control benefits to a lake. These areas are cooperatively designated by district water resources, fisheries, wildlife, and water regulation staff. Generally, APM permits are not granted for treatment of sensitive areas, or are granted for the control of exotic species only. Sensitive area designation may also affect the issuance of Chapter 30 permits by the Bureau of Water Regulation and Zoning.

NR 190 - Lake Planning Grants are available to lake districts, lake associations non-profit conservation organizations, counties, cities, villages, or towns, for collection of baseline data to provide information on the quality of water in lakes, delineation of watershed boundaries, land use practices within a lake's watershed, definition of local zoning and government authority to control pollution sources, or acquisition of sociological information important to long-term management of the lake. Lakes may receive up to $50,000 per lake per year with a 25-percent local cost-share.

Lakes which have been designated in this plan as Outstanding Resource Waters, either Class IA (phosphorus sensitive), Class IB and/or Class IIA, and that are affected by polluted runoff can apply to become **Small-Scale Nonpoint Source Priority Watershed projects**. These priority watershed projects will encourage, through financial incentives, voluntary implementation of best management practices in watersheds with documented water quality problems or threatened water quality as a result of nonpoint sources of pollution. Watersheds are selected, if the implementation of best management practices will result in improved water quality through a decrease in nutrient loading, or if they need to be protected from further degradation.

NR 191 - Lake Protection Grants are available to all counties, towns, villages, tribes, qualified lake associations, town sanitary districts, other local units of government and lake districts. These grants assist lake management organizations by helping to provide protection of critical watershed areas and lake use activities that benefit the water quality or natural ecosystem of the lakes. Eligible projects include:

* The purchase of property that will substantially contribute to the protection or improvement of a lake's water quality or its natural ecosystem,

* The restoration of wetlands, or lands draining to a wetland, that will substantially contribute to the protection or improvement of a lake's water quality, or its natural ecosystem,

* The development of local regulations or ordinances, which will prevent degradation of a lake's water quality or its natural ecosystem.

The Lakes Management Program acts as liaison with the U.S. Environmental Protection Agency (EPA) for the federal **EPA Clean Lake Grant Program**. Clean Lakes provides cost-sharing grants for the planning and implementation of lake protection and restoration projects for individual lakes. The awards are competitive and typically for 50 percent of the cost of the project. Phase I grants cover diagnostic and

feasibility studies while Phase II grants cover implementation work. Wisconsin has the opportunity to apply for grants on behalf of local project sponsors each year. District WRM is responsible for selecting and developing projects to be submitted to EPA. Applications are then coordinated and finalized by the lakes management program. Successful applications are administered jointly by central office and district staff.

Aquatic Plant Management

Abundant and unsightly plants--native or not--growing where unwanted are a concern for Wisconsin citizens. In some lakes, these "weeds" impair fishing and other recreational uses.

Yet the extreme opposite of excessive plant growth, a plant-barren lake bottom, is much worse. Aquatic plants play an essential and beneficial role in the life support systems of most lakes. They produce oxygen and organic material, which helps keep the lake and organisms in the lake alive. The leaves and stems of aquatic plants are home to insects and small attached plants. Plants provide spawning areas, food and protective cover for aquatic organisms. Their roots help stabilize lake bottoms and prevent shoreline erosion. Ducks, beaver and muskrat use plant roots, tubers and stems as food and building materials.

If weeds do become a concern in a lake, there are a variety of management techniques available, both mechanical and non-mechanical. Hand harvesting, raking, aquatic plant screens and mechanical harvesting have been successfully applied in Wisconsin lakes. These techniques are preferable to chemical herbicide application. Aquatic herbicides are not selective. They can destroy valuable vegetation along with less desirable plants. Lake biologists are concerned about the long- and short-term effects chemicals may have on lakes. WDNR can provide fact sheets on a number of chemical herbicides and their alternatives.

When choosing a plant management technique, lake property owners and lake management organizations should select the technique that offers the best control with the least potential for disrupting the balance of the lake's ecosystem. WDNR's aquatic plant management specialists can help concerned organizations find the best solution for managing an individual lake. Weed removal or screens may, however, provide only a temporary solution. The best way to thwart excessive plant growth is to cut off surplus nutrients and sediments flowing into a lake. Most lakes have so many nutrients in them already that stopping the inflow of nutrients won't cause change for many years. It will, however, keep problems from worsening, and help protect any investment in short-term management.

EXOTIC SPECIES CONCERNS

ZEBRA MUSSELS

The zebra mussel (*Dreissenia polymorpha)* is a tiny (1/8-inch to 2-inch) bottom-dwelling clam native to Europe. The mussel takes its name from its striped shell. Zebra mussels were introduced into the Great Lakes system in 1985 or 1986 and first turned up in Lake St. Clair. They have spread throughout the Great Lakes and are now found in Green Bay, Sheboygan and Kenosha counties. Zebra mussels were first found in Wisconsin waters of Lake Michigan in 1989. In August 1994, Elkhart Lake became the second inland Wisconsin lake infested with zebra mussels.

Although the mussels are small, they can cluster together to form colonies of thousands of individuals per square meter. Any hard underwater surface, such as rock substrate, piers, boat hulls, commercial fishing nets, buoys, water intake pipes, and even other invertebrates, can be covered by layers of mussels in a short time. Established zebra mussel colonies create a uniform gravel-cobble sized substrate.

The zebra mussel will most likely become a permanent part of the Great Lakes environment and most authorities consider the spread of zebra mussels across Wisconsin almost a certainty. The mussel is a prolific breeder and each mature female can produce 30,000-50,000 eggs per season. Zebra mussels can spread from the Great Lakes to inland waters either as veligers (larvae) transported in the live wells of boats, bait buckets, or engine cooling water, or as juveniles and adults attached to boat hulls, engines, fish cages or other items.

The efficient feeding habits of zebra mussels have the potential to alter the entire ecology of many of our inland lakes. One zebra mussel by itself is capable of filtering about one liter of water per day. When they are abundant, however, it is likely an intraspecific competition exists, reducing the mussels filtering capacity.

For additional information on zebra mussels in the Sheboygan River Basin contact Steve Galarneau, Wisconsin Department of Natural Resources, P.O. Box 12436, Milwaukee, WI 53212-0436 or by phone at (414)-229-0859 or via e-mail at GALARS@DNR.STATE.WI.US.

EURASIAN WATER MILFOIL

Eurasian water milfoil (*Myriophyllum spicatum*) is a submersed aquatic plant native to Europe, Asia and northern Africa. It is one of eight milfoil species found in Wisconsin and the only one non-native to the state. Of Sheboygan's 41 lakes, Eurasian water milfoil has turned up in five. The plant likely occurs in other Sheboygan lakes, but is not yet documented. Generally, the plant goes unnoticed until it has established itself in a lake and become a nuisance.

The problem with Eurasian water milfoil stems from its propensity for explosive growth and its ability to regenerate. Eurasian water milfoil is a biological pollutant that can outcompete important native aquatic plant communities, especially in disturbed areas. Eurasian water milfoil can form huge monocultural strands, diminishing recreational uses like swimming, fishing, and boating. In some cases, this exotic has grown dense enough to obstruct industrial and power generation water intakes.

The ecological repercussions include loss of plant diversity, degraded water quality, and reduced habitat for fish, invertebrates and wildlife. Native aquatic plants are the foundation of a healthy aquatic environment and must be protected.

Purple Loosestrife

Purple loosestrife (*Lythrum salicaria*), isa beautiful but aggressive invader that arrived in eastern North America in the early 1800's. Plants were brought to North America by settlers for their flower gardens and seeds were present in the soil used as balast on ships. Since it was introduced, purple loosestrife has spread westward and can be found across much of the United States and Canada.

Purple loosestrife is a very hardy perennial, which can rapidly spread into wetlands and degrade their value for wildlife habitat. Wetlands are one of the most biologically diverse, productive components of

our ecosystem with hundreds of species of plants, birds, reptiles, insects, mammals, fish and amphibians relying on a healthy wetland habitat for survival. Once purple loosetstrife gets a foothold, the wetland quickly becomes choked under a sea of purple flowers and the natural habitat that supported a diversity of plants and animals becomes simplified and degraded. Shelter and food sources are diminshed. Purple loosestrife has spread to all contiguous states (except Florida) and all Canadian provinces.

Controlling the spread of purple loosestrife in the Sheboygan River Basin is crucial to protecting vital fish, plant and wildlife habitat. If caught early, pulling, cutting and digging plants are viable control methods. All plant parts must be removed, because broken roots and seed heads may sprout new plants. Biological controls can be an effective method as well. Please see the Black River Watershed section for a discussion of the application of biological controls at a site in the lower Black River.

Wiscosin Department of Natural Resources Exotic Species Web-site

For additional information on these and other exotic species present in Wisconsin, please see our web-site at www.dnr.state.wi.us/org/water/wm/glwsp/index.htm.

Watershed Narratives

The watershed narratives to follow contain information on the lakes and streams of each watershed. The following give you information on how to read the tables found at the end of each watershed narrative.

HOW TO USE THE LAKE TABLES

Lake Name: All named and unnamed lakes greater than 10 acres for each county in the Sheboygan River Basin are listed on each county's lake table. Lake names are those found on U.S. Geological Survey (USGS) quadrangle maps unless the Wisconsin Geographic Names Council has established a different name. Some lakes are known locally by other names. Where available, those names have been listed along with the lake's official name.

Surface Area: The surface area is the size of the lake, in acres, as listed on the DNR Master Waterbody File.

Max/Mean Depth: Maximum depths are those listed in "Wisconsin Lakes," DNR. Mean depths, where available, are listed from each county's "Surface Water Resources."

Location (T-R-S): Lakes are identified by township, range, and section.

Watershed No.: The watersheds are identified for each lake listed using the DNR Master Waterbody File in conjunction with USGS seven minute topographic maps. The watersheds are listed for cross-reference with other sections of this plan.

Lake Type: Each lake type displays unique limnological characteristics based on physical and chemical properties. Production of plant and animal life generally varies in accordance with lake type. Basic classifications and qualifying criteria are:

drainage lake: impoundments and natural lakes whose main water source is from stream drainage. Has at least one inlet and one outlet.

drained lake: natural lake whose main water source is dependent on the groundwater table and seepage from adjoining wetlands. Seldom has an inlet but will have an outlet of very little flow similar to the seepage lake except for the outlet.

seepage lake: landlocked. Water level maintained by groundwater table and basin seal. Intermittent outlet may be present.

spring lake: seldom has an inlet, but always has an outlet of substantial flow. Water supply dependant upon groundwater rather than surface drainage.

The abbreviation "imp" following any lake type denotes that an impounding structure (dam) is located on that lake. NOTE: Shallow impoundments commonly exhibit similar physio-chemical characteristics; such as excess sedimentation, turbidity, excess vegetation and algae, rough fish, and water level fluctuations.

Phosphorus Sensitivity: The purpose of this analysis is to classify lakes according to their relative sensitivity to phosphorus loading and existing trophic condition. The screening identifies high quality lakes that should receive highest priority for nutrient control management. The analysis first separates lakes into two major categories; lakes that are sensitive to increased phosphorus loading (Class I) and lakes less responsive to changes in phosphorus loading (Class II). Lakes in each general classification are then subdivided into management groups based on data needs or existing water quality conditions.

Class I:	A	= existing water quality fair to excellent; potentially most sensitive to increased phosphorus loading
	B	= existing water quality poor to very poor; less sensitive to increased phosphorus loading than Group A
	Ins	= data inadequate or insufficient to assess trophic condition; classification monitoring recommended
	D	= stained, dystrophic lake, or aquatic plant-dominated lakes.
Class II:	A	= existing water quality fair to excellent; may not be as sensitive to phosphorus loading as Class I lakes
	B	= existing water quality poor to very poor; low sensitivity to increased phosphorus loading
	Ins	= data inadequate or insufficient to assess trophic condition
	D	= stained, dystrophic lake, or aquatic plant-dominated lakes.

These classification groups are used to establish appropriate management recommendations and priorities.

Fish Mercury: Numerous Wisconsin lakes have fish with elevated levels of mercury. Fish consumption advisories are issued semi-annually for lakes with fish mercury levels of 0.5 ppm or greater. Generally, predator fish from soft water, poorly buffered, low pH lakes have the highest concentrations of mercury.

Groups:	A,B	-determine adequacy of existing information and identify additional monitoring needs to verify or expand existing information.
	C	-fish mercury monitoring recommended, priority based on public use.

Acid Deposition: This column identifies lakes highly susceptible to acid deposition. Monitoring is recommended for lakes most susceptible and having inadequate water quality information.

NS	= not sensitive.
NS+	= lakes with alkalinities of 3-5mg/L as CaCO3; moderate priority for monitoring
A	= lakes most susceptible to acid deposition, recommend monitoring to confirm Group A status; high priority

Monitoring: These columns identify existing or recommended monitoring:

SH	= Self-Help Lake Monitoring Volunteer
LTTM	= Long-Term Trend Monitoring Lake
Hg	= Fish tissue mercury monitoring
AD	= Acid deposition monitoring
TS	= Trophic status monitoring
FEAS	= Lake District Feasibility Study conducted in 1970s

IM = Inventory monitoring (update Surface Water Inventory)

The following letters in each column signify that monitoring is:

R = recommended X = completed C = currently being done
NR= not recommended

Comments: Additional information that was available for the lakes has been included in the comments column. Abbreviations were used to conserve space as follows:

LMO = Lake Management Organization exists for this lake
FCA = Fish Consumption Advisory currently in effect (as of April 1991)
Mig Birds = Significant use/stop for waterfowl and migratory water birds
N = See the narrative section for this county for a more detailed description
NPS = Nonpoint source pollution impacts
ORW = Outstanding Resource Water
Rec = High quality recreational experience for listed activities: (eg. Rec: S, F, CA)

S - Swimming	B - Boating
H - Hunting	W - Waterfowling
F - Fishing	CA - Camping
C - Canoeing	

References: The reference material used to complete the table for each lake is indicated by a number. A corresponding list of references is provided at the end of the lakes report after the watershed lake narratives.

HOW TO USE THE STREAM WATERSHED TABLES

The following information will help you interpret the specific information included in the stream tables for each watershed.

Name of Stream: All named streams and some unnamed streams are listed. Stream names are those found on U.S. Geological Survey (USGS) quadrangle maps unless the Wisconsin Geographic Names Council established a different name. Unnamed streams are identified by location of the stream mouth as indicated by township, range, section and quarter-quarter section.

Length: Stream length is either the total length of the stream, or the starting and ending mile of the portion of the stream described. The stream mile at the stream mouth is zero ("0") and increases as one moves upstream.

Existing Use: This column indicates the existing biological use supported by the stream as defined in NR 102(04)(3) under fish and aquatic life uses. If the existing use is unknown, a blank space indicates the existing use is unassessed. The following abbreviations for stream uses are used in the tables:

> **COLD**; Cold Water Community; includes surface waters capable of supporting a community of cold water fish and other aquatic life or serving as a spawning area for cold water fish species.
>
> **WWSF;** Warm Water Sport Fish Communities; includes surface waters capable of supporting a community of warm water sport fish or serving as a spawning area for warm water sport fish.
>
> **WWFF**; Warm Water Forage Fish Communities; includes surface waters capable of supporting an abundant diverse community of forage fish and other aquatic life.
>
> **LFF;** Limited Forage Fishery (intermediate surface waters); includes surface waters of limited capacity because of low flow, naturally poor water quality or poor habitat. These surface waters are capable of supporting only a limited community of forage fish and aquatic life.
>
> **LAL;** Limited Aquatic Life (marginal surface waters); includes surface waters severely limited because of very low or intermittent flow and naturally poor water quality or poor habitat. These surface waters are capable of supporting only a limited community of aquatic life.
>
> **DEF**; Default; All streams not formally classified are assumed to meet the default federal Clean Water Act goals of supporting aquatic life and recreational uses. The DEF classification is the same as WWSF.

The table also includes the "class" of trout streams based on "Wisconsin Trout Streams" [DNR Publ. 6-3600(80)] and Outstanding/Exceptional Resource Waters, Wisconsin Administrative Code NR 102.10 and NR 102.11.

> **Class I** streams are high-quality streams where populations are sustained by natural reproduction.
> **Class II** streams have some natural reproduction but need stocking to maintain a desirable fishery.
> **Class III** streams sustain no natural reproduction and require annual stocking of legal-size fish for sport fishing. The approximate length or portion of stream meeting each of the use classes is indicated.

Potential Use: This column indicates the biological use, and trout stream class a stream or stream segment could achieve if it was well managed and pollution sources were controlled. In many cases potential use is the same as the existing use classification. In other streams potential use may be higher than the existing use. Abbreviations are the same as those used in the existing use columns. The sources of information are indicated by footnotes on each table. The classification for trout streams came from "Wisconsin Trout Streams" [DNR Publ. 6-3600(80)], Wisconsin Administrative Code NR 102.10 and NR 102.11 and the professional judgments of area Fish Managers. If the potential biological use is unknown, a blank space indicates the potential biological use is unassessed.

Supporting Potential Use: This column indicates whether a stream is threatened (THR), or is fully (FULL), partially (PART), or not (NOT) meeting its potential biological use. An entry in any of the columns indicates the relationship between actual stream use and potential use. For example, if the entire length of a stream is listed under the "Fully" column, the stream has no problems which can be controlled. When a portion or all of a stream length is listed under another heading, the stream is affected or threatened by some manageable factor and the biological use of the stream can probably be improved. If use support is unknown, a blank space indicates it is unassessed.

Codified Use (water quality standard designation): This column indicates the formal stream classification of a particular stream. Streams considered to be formally classified are those listed in Adm. Codes NR 102 and NR 104, all those referenced in Wisconsin Trout Streams, NR 102 and other formal stream classifications which will be added to the codes upon the next revision. This column also indicates if the stream is classified as an outstanding resource water (ORW) or an exceptional resource water (ERW) in NR 102.10 and NR 102.11. All streams not formally classified assume the default federal clean water act classification of FAL (full fish and aquatic waters).

Streams classified as Outstanding Resource Waters (ORW) or Exceptional Resource Waters (ERW) in NR102.10 and NR 102.11 are:

> **Outstanding Resource Waters** have the highest value as a resource, excellent water quality and high quality fisheries. They do not receive wastewater discharges and point source discharges will not be allowed in the future unless the quality of such a discharge meets or exceeds the quality in the receiving water. This classification includes national and state wild and scenic rivers and the highest quality Class I trout streams in the state.
>
> **Exceptional Resource Waters** have excellent water quality and valued fisheries but already receive wastewater discharges or may receive future discharges necessary to correct environmental or public health problems. This classification includes about 1,400 trout stream segments not classified as Outstanding Resource Waters.

Assessment Category/Monitored or Evaluated: It is important to detail what information was used to derive a potential biological use designation and the degree to which a stream meets that potential use. If the potential use decision was based upon site-specific data, then "M," for monitored, is entered. If the decision is based on information other than site-specific data (citizen complaints, best professional judgment of a biologist or fish manager) then "E," for evaluated, is entered. "Evaluated" includes decisions based on data more than five years old.

Use Problems, Source/Impact: This column indicates the probable sources of pollution in the stream and the types of water quality problems present (impact). Some streams shown as fully meeting potential use

may still show up in this column as having a use problem. When this occurs it may mean there is a problem but it cannot be managed for some reason, or there is a potential threat to the use. These situations are explained in the narrative or in the references.

Following is a key to the abbreviations in the watershed tables:

Source (cause of problem):

BDAM - Beaver dam
CM - Cranberry marsh
DCH - Ditched
DRDG - Dredging
GR.Pit - Gravel Pit Washing Operation
HM - Hydrologic modification
IRR - Irrigation
LF – Landfill
NMM - Non-metallic mining
NPS - Unspecified nonpoint sources
BY - Barnyard or exercise lot runoff
CL - Cropland erosion
CON - Construction site erosion
PSB - Stream bank pasturing
PWL - Woodlot pasturing
RS - Roadside erosion
SB - Stream bank erosion
URB - Urban storm water runoff
WD - Wind erosion
PSM - Point source, municipal treatment plant discharge
PSI - Point source, industrial discharge
SS - Storm sewer

Impact (effect or impact of source on a stream)

BAC - Bacteriological contamination
CL - Chlorine toxicity
DO - Dissolved oxygen
FAD - Fish advisory
FLOW - Stream flow fluctuations caused by unnatural conditions
HAB - Habitat (lack of cover, sedimentation, scouring, etc.)
HM - Heavy metal toxicity
MAC- Undesirable rooted aquatic plant (macrophyte) or algae growth
MIG - Fish migration interference
NH3 - Ammonia toxicity
NUT - Nutrient enrichment
ORG - Organic chemical toxicity or bioaccumulation
PCB - PCB bioaccumulation
pH - pH (fluctuations or extreme high or low)
PST - Pesticide/herbicide toxicity
SC - Sediment contamination
SED - Sedimentation
TEMP - Temperature (fluctuations or extreme high or low)

TOX - General toxicity problems
TURB – Turbidity

References (Ref.) The numbers listed in this column are the references cited on the page below the table. Please refer to the references section for the full citation.

Data Level: This indicates the type of data used for making the determinations listed in the table. **Phy** means physical data (such as flow and habitat) were used; **bio** indicates biological data (such as fish and macroinvertebrate surveys) were used, and **chem** means that chemical data (such as water samples) were used. The numbers (1-4) indicate the level at which the data were collected. **1** indicates that visual observations were used, but actual measurements were not taken. **2** means visual observations with some simple assessments were conducted. For biological and chemical measurements, one simple measurement, or examination of historical data were used. **3** means that some specific measurements were taken at the study sites and at reference sites. Usually a single measurement was recorded, sometimes two. **4** means a full assessment has been conducted using established procedures with strict protocols. Biotic and habitat measurements are conducted using study and reference conditions. These measurements are quantitative and collected over one or two season

SAUK AND SUCKER CREEKS WATERSHED (SHO1)

INTRODUCTION

The Sauk and Sucker Creeks Watershed includes a small portion of Sheboygan County, but is predominately in Ozaukee County. Sauk and Sucker Creeks flow southward entering into Lake Michigan in and near Port Washington respectively. Within this watershed lie all of Port Washington and portions of the villages of Fredonia, Belgium, and Cedar Grove. The watershed includes Harrington Beach State Park on Lake Michigan. There are a total of 37 unnamed tributary streams flowing to the Sauk or Sucker Creeks or directly to Lake Michigan within this subwatershed. All streams in the Sauk and Sucker Creeks Watershed ultimately reach Lake Michigan. There are two named Lakes; Ludowissi Lake and Grasser Lake, and one unnamed lake in the watershed. There are no impoundments in the watershed, but there is a remnant of an old dam on Spring Creek (a tributary to Sauk Creek) in Port Washington.

Agriculture is the dominant land use in the Sauk and Sucker Creek Watershed; however, this is an urbanizing watershed. Nonpoint source pollution and stream channelization are the primary causes of the degraded water quality and habitat throughout the watershed. Construction site erosion and imperviousness (e.g. roads, roofs, parking lots, etc.) are emerging threats to water quality as the watershed undergoes urbanization. Overall water quality is fair to poor in both Sauk and Sucker Creeks. Stream channel modifications and polluted runoff from agricultural activities contributes to the high concentration of nutrient and suspended solids in the streams and severe siltation problems in the watershed. Large sediment plumes into Lake Michigan are frequently observed at the mouths of Sucker and Sauk Creeks during spring melt and heavy rains (Galarneau 1998).

Five wastewater treatment facilities discharge into the watershed; one into Sauk Creek in Port Washington and four directly into Lake Michigan. A fly ash landfill is located at Druecker's Quarry along Sauk Creek at, NE1/4, Sec.9, Town of Port Washington, in Ozaukee County.

STREAMS OF THE SAUK CREEK SUBWATERSHED

SAUK CREEK

T11N R22E Sec. 28 Stream Length = 15.9 miles WBIC = 49500

Sauk Creek is the major waterway in this watershed and Ozaukee County. The stream flows south and enters Lake Michigan in Port Washington. Sauk Creek originates within Ozaukee County just north of Fredonia at T12N R21E Sec. 26, just west of STH 57. The convergence of three unofficially named branches, hereby named for descriptive purposes as; Ludowissi Lake Branch, Hickory Grove Branch, and Holy Cross Branch, make up the headwaters of Sauk Creek. The Ludowissi Lake Branch of Sauk Creek originates from Ludowissi Lake (T12N R21E Sec. 1) and flows southerly 5.9 stream miles to the main branch of Sauk Creek at T12N R22E Sec. 20. The Hickory Grove Branch of Sauk Creek originates north of Hickory Grove Road at T12N R21E Sec. 12 and flows southerly 2.3 stream miles to a confluence with the main branch of Sauk Creek at T12N R22E Sec. 19. The Holy Cross Branch of Sauk Creek originates south of Holy Cross at T11N R22E Sec. 6 and flows north 3.6 miles to a confluence with Sauk Creek at T12N R22E Sec. 20. All three headwater branches are confluent with the main branch of Sauk Creek within a 1.5 mile reach just south of CTH D near CTH B.

Sauk Creek is classified as a Warm Water Sport Fish communities stream. A review of all historical fish surveys identifies 26 species in Sauk Creek (Fago 1986). Trout and salmon from Lake Michigan are also found in the stream during their seasonal spawning runs. The endangered striped shiner (*Notropis chrysocephalus*), had been historically found here.

Fish Community, Habitat, and Water Quality

During 1994 and 1997, fish and macroinvertebrate surveys, habitat assessments and water quality collections were collected in Sauk Creek. These data were reported in the 1999 Sheboygan River Basin State of the Environment Report (WDNR 1999). During 1999 the fish and habitat assessments were focused on the four branches of the stream that make up the headwaters of Sauk Creek. The three headwater tributaries that feed the main branch are listed separetly below. The fish community assessments and tolerance to pollution for each fish species found during recent surveys on the main stem of Sauk Creek are summarized in Table 4. The Index of Biotic Integrity, Hilsenhoff Biotic Index and habitat rating scores are shown in Table 5.

Table 4. Sauk Creek Fish Community Assessments 1995 - 1999.

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Historical Fish Collections (Fago 1986)	1995 and 1999 Fish Collections		
				RM 0.1 (1995)	RM 11.6 (1995)	RM 13.3 (1999)
Large Scale Stonerollers	Intolerant		X			
Blacknose Dace	Intolerant	Tolerant	X	X	X	X
Creek Chub	Tolerant	Tolerant	X		X	X
Johnny Darter	Tolerant		X		X	X
Mottled Sculpin	Intolerant	Intolerant	X	X		
Golden Shiner	Tolerant	Tolerant	X			
Emerald Shiner	Tolerant		X			
Spotfin Shiner	Tolerant		X			
Fathead Minnow	Very Tolerant	Tolerant	X	X	X	X
Longnose Dace	Intolerant		X	X		
White Sucker	Tolerant	Tolerant	X	X	X	X
Central Stoneroller	Intolerant		X	X	X	X
Common Carp	Very Tolerant	Tolerant	X			
Brassy Minnow			X		X	
Hornyhead Chub	Intolerant		X			
Common Shiner	Tolerant		X			
Green Sunfish	Sport	Tolerant	X			
Southern Redbelly Dace	Intolerant		X		X	X
Bluntnose Minnow	Tolerant	Tolerant	X		X	X

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Historical Fish Collections (Fago 1986)	1995 and 1999 Fish Collections		
				RM 0.1 (1995)	RM 11.6 (1995)	RM 13.3 (1999)
Brook Stickleback	Tolerant		X		X	X
Central Mudminnow	Very Tolerant	Tolerant	X	X	X	X
Black Bullhead	Sport		X			
Pearl Dace	Intolerant		X			X
Pumpkinseed	Sport		X			
Largemouth Bass	Sport					X
Steelhead[3]	Sport			X		
Brown Trout[3]	Sport			X		
Brook Trout[3]	Sport	Intolerant		X		
Northern Pike	Sport		X			
Striped Shiner			X			

[1] Ball (1982)
[2] Lyons (1992)
[3] Lake Michigan run fish.

Table 5. Hilsenhof Biotic Index (HBI), and Index of Biotic Integrity (IBI) Results for Sauk Creek, 1994 - 1999.

Sauk Creek Sample Site	HBI [1]		IBI [2]	
	Avg. Score	Water Quality Rating	Score	Water Quality Rating
Upstream of S. Wisconsin Ave. at RM 0.1	n/a	n/a	32	Fair
1.1 miles upstream of Six Mile Road at RM 11.6 (HBI in 1994 & IBI in 1995)	6.41	Fair	15	Very Poor
Downstream of Kay-K Road at RM 13.3 (1999)	7.51	Poor	31	Fair

[1] Hilsenhoff Biotic Index (1987)
[2] Lyons (1992)

The macroinvertebrate community is comprised of taxa mainly tolerant to very tolerant of poor water quality. Poor habitat, caused by high turbidity, low flow and excessive sedimentation of course substrate, limits the macroinvertebrate community. Over the last twenty years, Sauk Creek in Port Washington has become very wide and shallow. Fish habitat, water quality and stability of the stream banks have been

significantly altered by urbanization in the area. During periods of low water, many sections are difficult for trout and salmon to navigate. During 1994 and 1995 a plan was put in place by WDNR, local sports clubs, city government and other entities to improve fish habitat, water quality and stabilize stream banks so that salmonids could be stocked in the stream (Eggold 1998). The main project objectives were 1) increase the carrying capacity of Sauk Creek; 2) improve the return of salmonids to Sauk Creek through improved imprinting of smolts at time of stocking; 3) improve water quality; and 4) increase fishing opportunities in Ozaukee County.

Sediment Quality

Sediment samples were collected in 1994 at three sites in Sauk Creek to obtain baseline sediment quality data for Sauk Creek and to assess the potential sediment quality impacts from the fly ash landfill adjacent Sauk Creek near Druecker's Quarry. The results for total PCBs for all sites came back less than detect at <0.05 ug/g. The heavy metals selenium, boron, and cadmium were higher in Sauk Creek near the former fly ash landfill. The levels are relatively low and not perceived to be at levels of concern based on the toxicity information that we have for these constituents at this time. Consequently, Sauk Creek adjacent the Druecker's Quarry does not require specific management activities (WDNR 1999).

SAUK CREEK TRIBUTARY STREAMS

LUDOWISSI LAKE BRANCH OF SAUK CREEK AT RM 11.6

T12N R22E Sec. 20 Stream Length = 5.1 miles WBIC = 49700

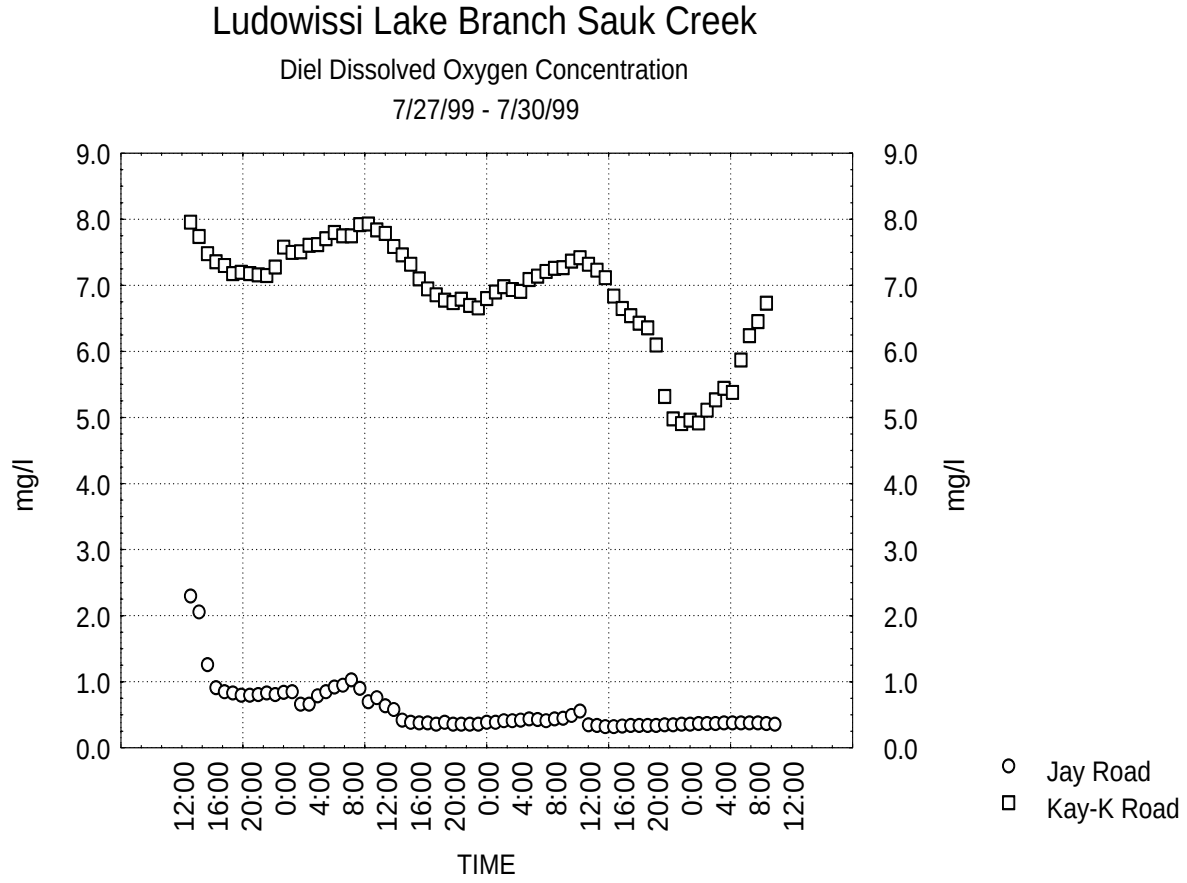
This branch of Sauk Creek has been unofficially called the Ludowissi Lake branch by the biologist for descriptive purposes (WDNR 1999). The Ludowissi Lake Branch of Sauk Creek originates from Ludowissi Lake (T12N R21E Sec. 1) and flows southerly 5.5 stream miles to the main branch of Sauk Creek at T12N R22E Sec. 20. In 1994 a macroinvertebrate sample was collected from this branch just upstream of the confluence with the main branch south of CTH D. The biotic index (HBI) rating indicated fair water quality at this site. A fish and habitat survey was conducted in 1999 upstream of CTH D. The fish community assessments and tolerance to pollution for each fish species are summarized in Table 6. The Index of Biotic Integrity, Hilsenhoff Biotic Index and habitat rating scores are shown in Table 7.

The very headwaters of Sauk Creek in the Ludowissi branch originates in a large drain tile at Jay road just east of STH 57. The water then flows north behind a barnyard and pasture then easterly to a confluence with the tributary from Ludowissi Lake. Cedar Valley Cheese is located at the southwest corner of Jay Road and STH 57 in Ozaukee County, discharges irrigated waste high in chlorides across Jay Road to the north, west of STH 57. In spring of 1998 water from the irrigated field was observed flowing from the drain tile under STH 57 (easterly direction) to a farm swale between the manure storage facility and barn, across the pasture to the headwaters of Sauk Creek. The water from the irrigated field was observed entering the headwaters of Sauk Creek (Ludowissi branch) at T12N R21E S1 NWSW (WDNR 1998). Chlorides are toxic to freshwater aquatic organisms. In 1999 the large drain tile that the stream originates from discharged organic rich sludge to the stream. Corrective actions were taken in late 1999 to stop the source, flush the tile line, and remove sludge from the stream.

Macroinvertebrate samples were colleceted at two sites in 1999, one just below the stream reach with the sludge and another 1.2 river miles downstream from there at CTH D. The HBI index, which is a measure

of the degree of organic pollution rated the water quality poor at the first site (HBI score 8.27) and the stream showed some improvement at the downstream site with a water quality rating of Fair (HBI score 6.06) upstream of CTH D. Diel (24 hour) dissolved oxygen concentrations were recorded for three days in late July 1999 from the same two stream reaches. The dissolved oxygen (DO) concentration recorded downstream of Jay Road below the drain tile and sludge shows very low DO concentartions at levels that are prohibitive of most aquatic life (Figure 1). The DO concentrations recovered to more normal levels within 1.2 miles downstream to Kay-K Road.

Figure 1. Diel Dissolved Oxygen Concentration in Ludowissi Branch Sauk Creek - 1999



HOLY CROSS BRANCH OF SAUK CREEK AT RM 12.0

T12N R22E Sec. 20 NWSW Stream Length = 3.6 miles WBIC = 49900

This branch of Sauk Creek has been unofficially called the Holy Cross branch for descriptive purposes. The Holy Cross branch of Sauk Creek originates south of the Town of Holy Cross and flows north 3.6 miles to a confluence with the main branch of Sauk Creek at T12N R22E Sec. 20. A fish and habitat

survey was conducted in 1999 upstream of CTH D. The fish community assessments and tolerance to pollution for each fish species are summarized in Table 6. The Index of Biotic Integrity, Hilsenhoff Biotic Index and habitat rating scores are shown in Table 7.

HICKORY GROVE BRANCH OF SAUK CREEK AT RM 13.1

T12N R22E Sec. 19 NWNE Stream Length = 2.3 miles WBIC = 50000

This branch of Sauk Creek has been unofficially called the Hickory Grove branch for descriptive purposes. The Hickory Grove Branch of Sauk Creek originates north of Hickory Grove Road at T12N R21E Sec. 12 and flows southerly 2.3 stream miles to a confluence with the main branch of Sauk Creek at T12N R22E Sec. 19. In December 1999 the water quality biologist observed a white liquid in the stream at Kay-K Road. The discharge was traced to a draintile that was determined to be connected to a milkhouse. The connection has since been corrected and no longer discharges to the stream.

A fish and habitat survey was conducted in 1999 upstream of CTH D. The fish community assessments and tolerance to pollution for each fish species are summarized in Table 6. The Index of Biotic Integrity, and Hilsenhoff Biotic Index rating scores are shown in Table 7.

Table 6. Ludowissi, Holy Cross, and Hickory Grove Branches of Sauk Creek Fish Community Assessments - 1999.

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Ludowissi Branch Upstream of CTH D	Holy Cross Branch Upstream of CTH D	Hickory Grove Branch Downstream of CTH D
Blacknose Dace	Intolerant	Tolerant	X	X	X
Creek Chub	Tolerant	Tolerant	X	X	X
Johnny Darter	Tolerant		X	X	X
Fathead Minnow	Very Tolerant	Tolerant	X	X	X
White Sucker	Tolerant	Tolerant	X	X	X
Central Stoneroller	Intolerant		X	X	X
Southern Redbelly Dace	Intolerant		X	X	X
Bluntnose Minnow	Tolerant	Tolerant	X	X	X
Brook Stickleback	Tolerant		X	X	X
Largemouth Bass	Sport			X	
Central Mudminnow	Very Tolerant	Tolerant	X	X	X
Pearl Dace	Intolerant		X		

[1] Ball (1982)
[2] Lyons (1992)

Table 7. Hilsenhoff Biotic Index (HBI), Index of Biotic Integrity (IBI) and Habitat Quality Results for Ludowissi Branch, Holy Cross Branch and Hickory Grove Branch Sauk Creek from 1999 assessments.

Fish and Habitat SITE	HBI [1]		IBI [2]	
	Score	Water Quality Rating	Score	Water Quality Rating
Ludowissi Branch	6.06	Fair	15	Very Poor
Holy Cross Branch	7.58	Poor	24	Poor
Hickory Grove Branch	7.00	Fairly Poor	19	Very Poor

[1] Hilsenhoff Biotic Index (1987)
[2] Lyons (1992)

UNNAMED TRIBUTARY TO SAUK CREEK AT RM 0.04 (SPRING CREEK)

T11N R22E Sec. 28 Stream Length = 1.4 miles

The unofficial local name for this stream is Spring Creek. This is a small perennial stream that drains the south and southwest side of Port Washington including the industrial park area. The outlet of the stream on the Wisconsin Electric Power Company property has been channelized and is lined with gabions to stabilize the stream banks. The stream is confluent with Sauk Creek just upstream of the mouth of Sauk Creek at the Port Washington harbor.

Fish and habitat assessments were done in 1999 at two sites on Spring Creek in Port Washington. A previously unknown dam was found at river mile (0.6) adjacent to the Trak Company parking lot. The dam appears to have failed a long time ago and does not impound any water; however, the remaining structure is a barrier to fish migration and Lake Michigan run fish cannot pass this site. The fish survey sites in 1999 were above and below the dam (downstream of South Park Street and adjacent Oakland Ave. Park respectively: Table 8). Trout and salmon from Lake Michigan are also found in the stream during their seasonal spawning runs and may provide some angling opportunities in pools although access is difficult due to steep stream banks. Lake Michigan run fish cannot pass the dam structure in the stream. The Index of Biotic Integrity, and Hilsenhoff Biotic Index rating scores are shown in Table 9.

Table 8. Spring Creek fish community assessment, 1999.

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Spring Creek adjacent Oakland Ave. Park	Spring Creek downstream of South Park Street
Blacknose Dace	Intolerant	Tolerant	X	
Creek Chub	Tolerant	Tolerant	X	
Fathead Minnow	Very Tolerant	Tolerant	X	
White Sucker	Tolerant	Tolerant	X	

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Spring Creek adjacent Oakland Ave. Park	Spring Creek downstream of South Park Street
Brook Stickleback	Tolerant		X	X
Pumpkinseed	Sport		X	X
Central Mudminnow	Very Tolerant	Tolerant	X	X
Green Sunfish	Sport			X

[1] Ball (1982)
[2] Lyons (1992)

Table 9. Hilsenhoff Biotic Index (HBI), Index of Biotic Integrity (IBI) and Habitat Quality Results for Spring Creek from the 1999 assessments.

Spring Creek Sample Site	HBI [1]		IBI [2]	
	Avg. Score	Water Quality Rating	Score	Water Quality Rating
Adjacent Oakland Ave. Park	4.87	Good	*	*
Downstream of S. Park Street	5.23	Good	20	Poor

[1] Hilsenhoff Biotic Index (1987)
[2] Lyons (1992)

* The average stream width for this fish community assessment site is below the current IBI model calibration. DNR Research is currently developing an IBI for samll streams and these data will be evaluated using that method when it becomes available.

Land use adjacent to the lower reaches of this stream is primarily industrial. A former Murphy (Spur) Gasoline Tank Farm is located adjacent to one of the branches of this stream. A water quality survey in 1982 identified potentially contaminated leachate from the site reaching the stream. A sediment sample was collected from the stream on June 25, 1998 in a depositional area just downstream from the former gas tank site (40 ft. upstream of S. Park St.). The concentrations of metals, PAHs, and PCBs are consistent with the concentrations observed in urban streams (Table 10).

Table 10. Sediment Screening Results for Spring Creek, 1998.

Parameters		Sample Site
		40 ft. upstream of S. Park Street
Total Organic Carbon (µg/g)		15,100
PCBs (total) (µg/g)		0.05
PAHs (ng/g)		3,400
Metals (mg/kg)	Cadmium	No detect

Parameters		Sample Site
		40 ft. upstream of S. Park Street
		13
		11
		9
		11
		0.02
	Zinc	60

UNNAMED TRIBUTARY TO SAUK CREEK AT RM 0.7

T11N R22E Sec. 28 Stream Length = 1.5 miles

This small tributary stream is located on the northwest side of Port Washington in what is referred to locally as the Mallinger property. The stream is adversely impacted by nonpoint source runoff from agricultural activities in the headwater reaches resulting in sedimentation of the substrate. Springs are present in a wetland that contributes a portion of the stream flow. The stream has been enclosed under Spring Street and remains in a culvert until it passes under the Chicago and Northwestern Railroad tracks east of Spring Street. The stream then flows in an open channel under CTH KK east to Sauk Creek.

A residential subdivision is currently planned and being constructed along this stream. The impact of the subdivision to the wetlands, small tributary stream and ultimately Sauk Creek will be determined by the adequacy of the construction site erosion practices during construction, and long term maintenance of stream bank buffers, and stormwater runoff management for water quantity and quality.

SUCKER CREEK SUBWATERSHED STREAMS

SUCKER CREEK

T11N R22E Sec. 14 NWSE Stream Length = 10 miles WBIC = 50100

Sucker Creek is the second largest stream in this watershed and originates just in Sheboygan County just north of the Ozaukee County line. Sucker Creek flows south (into Ozaukee County) along the I43 corridor past Lake Church, entering Lake Michigan north of the City of Port Washington. Fourteen species of fish, primarily consisting of forage fish species have been historically collected in Sauk Creek (Fago 1986). Trout and salmon from Lake Michigan are also found in the stream during their seasonal spawning runs. Recent fish and habitat surveys were conducted in Sucker Creek during the summers of 1994 and 1999 (Table 11).

Table 11. Sucker Creek Fish Community Assessments, 1995 and 1999.

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Historical Fish Collections (Fago 1985)	Downstream of Lake Drive at River Mile 2.0	River mile 0.7
Blacknose Dace	Intolerant	Tolerant	X	X	X
Creek Chub	Tolerant	Tolerant	X	X	X
Johnny Darter	Tolerant		X	X	X
Fathead Minnow	Very Tolerant	Tolerant	X	X	
Longnose Dace	Intolerant		X		X
White Sucker	Tolerant	Tolerant	X	X	X
Central Stoneroller	Intolerant		X		X
Common Carp	Very Tolerant	Tolerant	X		
Brassy Minnow			X		
Bluntnose Minnow	Tolerant	Tolerant	X	X	
Brook Stickleback	Tolerant		X	X	X
Southern Redbelly Dace	Intolerant			X	
Common Shiner					X
Pumpkinseed	Sport				X
Green Sunfish	Sport				X
Bluegill	Sport				X
Black Bullhead	Sport		X		
Slimy Sculpin	Intolerant	Intolerant	X		
Fantail Darter	Intolerant			X	

[1] Ball (1982)
[2] Lyons (1992)

Habitat quality, HBI and IBI data were also collected for Sucker Creek (Table 12). Water quality and habitat rankings ranged from fair to poor.

Table 12. Hilsenhoff Biotic Index (HBI) and Index of Biotic Integrity (IBI) for Sucker Creek, 1995 and 1999.

Sucker Creek Sample Sites	HBI [1]		IBI [2]	
	Avg. Score	Water Quality Rating	Score	Water Quality Rating
At River Mile 2.0	7.53	Poor	22	Poor
At River Mile 0.7	6.05	Fair	30	Fair

[1] Hilsenhoff Biotic Index (1987)
[2] Lyons (1992)

SUCKER CREEK TRIBUTARY STREAMS

We have no current water quality information about these streams. Please refer to the watershed table at the end of this chapter for information regarding stream location and length.

LAKE MICHIGAN TRIBUTARY STREAMS

UNNAMED TRIBUTARY TO LAKE MICHIGAN AT LM 66.3

T10N R22E Sec. 10. Stream Length = 0.9

This stream enters Lake Michigan south of Port Washington and is entirely on the lake side of CTH C. No information is available for this tributary.

PORT WASHINGTON HARBOR AT LM 69.2

T11N R22E Sec. 28

The city of Port Washington Harbor is a popular fishing location and marina for Lake Michigan. Seasonal fishing for perch, trout, salmon and smelt reslult in the nearly continuous presence of anglers. Fishing access is available in the marina and along the marina boardwalk. The chain link fence that separates the marina boardwalk from a public walkway is scheduled for removal this year and will improve access and aesthetics. Care should be taken during the construction of the marina and boardwalks to maintain adequate construction site erosion control practices.

Zebra mussels and other exotic species are present in all Lake Michigan harbors, so boaters are reminded to follow the precautions that are posted at the harbor to help prevent the spread of harmful exotic plants and animals.

UNNAMED TRIBUTARY TO LAKE MICHIGAN AT LM 69.7

T11N R22E Sec. 28 Stream Length = 2.8 miles

This small stream, locally called Valley Creek, originates on the northeast side of the City of Port Washington and flows south through the city along the bike path. The stream is then enclosed under a parking lot connected to Lake Drive, and flows through Lake Park to its outlet in Lake Michigan. Valley Creek is very flashy due to the topography and substantial existing stormwater runoff from curb and gutter direct conveyance to the stream. Excessive sedimentation and eroded, bare stream banks are common. The approximately 1500 ft. parking lot enclosure creates a barrier to fish passage between the lake and the stream. This stream is part of an environmental corridor through the City of Port Washington.

Residential development is occurring in the headwaters of this stream. The water quality of this small tributary stream will be determined by the effects of subdivision construction and the adequacy of the construction site erosion control practices and long term maintenance of stream bank buffers. Of particular importance for the health of this stream will be stormwater runoff management for water quality and quantity. No biological information is available for this tributary.

UNNAMED TRIBUTARY TO LAKE MICHIGAN AT LM 81.2

T12N R23E Sec. 6 Stream Length = 0.9 miles

This is the northern smallest tributary stream flowing to Lake Michigan within Ozaukee County. Eight small tributaries enter the lake within a two mile reach extending south of this stream. No information is available for this tributary.

UNNAMED TRIBUTARY TO LAKE MICHIGAN AT LM 82.1

T13N R233 E Sec. 31 Stream Length = 1.0 miles

This is the northern most Lake Michigan Tributary stream in the Sauk / Sucker Creeks Watershed and is the only one from this watershed in Sheboygan County. No information is available for this tributary.

LAKES OF THE SAUK AND SUCKER CREEK WATERSHEDS

LUDOWSISSI LAKE

T12N R21E Sec. 1, Ozaukee County
Surface Acres = 10.7, S.D.F. = 1.18, Maximum Depth = 25 feet.
This is a small, moderately deep seepage lake contained within a terminal moraine of red glacial till. This lake is in the headwaters of Sauk Creek, the Ludowissi Lake Branch of Sauk Creek. No recent information is available for this lake.

GRASSER (DECADA) LAKE

T13N R13N R22E Sec. 31, Sheboygan County
Surface Acres = 9.2, S.D.F. = 1.22, Maximum Depth = 33 feet

This is a small, moderately deep lake in the end moraine of the south central portion of the county. No recent information is available for this lake.

UNNAMED LAKE

T12N R23E Sec. 19, Ozaukee County

Surface Acres = 23.0, S.D.F. = 1.02, Maximum Depth = 47 feet

This is a small deep lake formed by dolomite quarrying. No recent information is available for this lake.

Table 13. Streams of the Sauk and Sucker Creeks Watershed.

Stream Name/Location (T, R, Sec., QQ, Q)	WBIC	Length	Biological Use		Codified	Supp.	Assess. Category	Use Impairments		Ref.	Data Level
			Existing	Potential				Source	Impact		
Sauk Creek (T11N R22E Sec.28 SWSE)	49500	15.9	WWSF	WWSF	DEF	PART	M	NPS, HM, URB, CON, LF, DCH	FLOW, TURB, SED		4
Unnamed Tributary to Sauk Creek at RM 0.04 (T11N R22E Sec. 28 SWSE)	49600	1.4	WWFF	WWFF	DEF	PART	M	CON, HM, URB,LF,SB, RS	FLOW, HAB, SED		4
Unnamed Tributary to Sauk Creek at RM 0.7 (T11N R22E Sec. 28 NWW)		1.5	LFF	LFF	DEF	PART	M	NPS, CON, CL, URB, HM	FLOW, SED, HAB, MIG		3
Unnamed Tributary to Sauk Creek at RM 3.1 (T11N R22E Sec.16 NWSW)		0.5	UNK	UNK	DEF	UNK					
Unnamed Tributary to Sauk Creek at RM 6.2		0.5	UNK	UNK	DEF	UNK					
Unnamed Tributary to Sauk Creek at RM 6.3		0.8	UNK	UNK	DEF	UNK					
Unnamed Tributary to Sauk Creek at RM 7.1		0.4	UNK	UNK	DEF	UNK					
Unnamed Tributary to Sauk Creek at RM 7.9		1.6	UNK	UNK	DEF	UNK					
Unnamed Tributary to Sauk Creek at RM 9.3		0.4	UNK	UNK	DEF	UNK					
Unnamed Tributary to Sauk Creek at RM 11.6 (Ludowissi Lake Branch) (T12N R22E Sec. 20 NWNW)	49700	5.1	WWFF	WWFF	DEF	PART	M	NPS, HM, BY, PSB, CL, IRR, PSI, CON	FLOW, NUT, SED, CL, MIG		4
Unnamed Tributary to Ludowissi Lake Branch Sauk Creek at RM 4.9		0.6	UNK	UNK	DEF	UNK					
Unnamed Tributary to Sauk Creek at RM 12.0 (Holy Cross Branch) (T12N R22E Sec. 20 SWNW)	49900	3.6	WWFF	WWFF	DEF	PART	M	NPS, HM, BY, CL	FLOW, NUT, SED		3
Unnamed Tributary to Holy Cross Branch Sauk Creek at		1.9	UNK	UNK	DEF	UNK					

Stream Name/Location (T, R, Sec., QQ, Q)	WBIC	Length	Biological Use		Codified	Supp.	Assess. Category	Use Impairments		Ref.	Data Level
			Existing	Potential				Source	Impact		
RM 1.2											
Unnamed Tributary to Sauk Creek at RM 13.1 (Hickory Grove Branch) (T12N R22E Sec. 19 NENW)	50000	2.3	WWFF	WWFF	DEF	PART	M	NPS, HM, BY, CL	FLOW, NUT, SED		3
Unnamed Tributary to Hickory Grove Branch Sauk Creek at RM 1.1		1.1	UNK	UNK	DEF	UNK					
Unnamed Tributary to Hickory Grove Branch Sauk Creek at RM 1.7		0.8	UNK	UNK	DEF	UNK					
SUCKER CREEK SUBWATERSHED STREAMS											
Sucker Creek T11N R22E Sec. 14 SWNW	50100	10.0	WWSF	WWSF	DEF	PART	M	NPS, HM, DCH, CON, CL, RS	FLOW, SED, NUT,		4
Unnamed Tributary to Sucker Creek at RM 0.3		0.7	UNK	UNK	DEF	UNK					
Unnamed Tributary to Sucker Creek at RM 1.0		1.2	UNK	UNK	DEF	UNK					
Unnamed Tributary to Sucker Creek at RM 2.0		1.1	UNK	UNK	DEF	UNK					
Unnamed Tributary to Sucker Creek at RM 3.0		0.5	UNK	UNK	DEF	UNK					
Unnamed Tributary to Sucker Creek at RM 3.3		0.7	UNK	UNK	DEF	UNK					
Unnamed Tributary to Sucker Creek at RM 3.7		0.5	UNK	UNK	DEF	UNK					
Unnamed Tributary to Sucker Creek at RM 5.9		0.5	UNK	UNK	DEF	UNK					
Unnamed Tributary to Sucker Creek at RM 7.0		0.7	UNK	UNK	DEF	UNK					
Unnamed Tributary to Sucker Creek at RM 8.4		1.0	UNK	UNK	DEF	UNK					
Unnamed Tributary to Sucker Creek at RM 9.1		0.6	UNK	UNK	DEF	UNK					
Unnamed Tributary to Sucker Creek at RM 9.7		0.6	UNK	UNK	DEF	UNK					

Stream Name/Location (T, R, Sec., QQ, Q)	WBIC	Length	Biological Use		Codified	Supp.	Assess. Category	Use Impairments		Ref.	Data Level
			Existing	Potential				Source	Impact		
Unnamed Tributary to Sucker Creek at RM 9.9		0.8	UNK	UNK	DEF	UNK					
LAKE MICHIGAN TRIBUTARY STREAMS IN THE SAUK & SUCKER CREEKS WATERSHED											
Unnamed Tributary to Lake Michigan at LM 66.3 T10N R22E Sec.10		0.9	UNK	UNK	DEF	UNK					
Unnamed Tributary to Lake Michigan at LM 69.7 (Valley Creek) T11N R22E Sec.28		2.8	WWFF	WWFF	DEF	PART	E	NPS, CON, HM, DCH, RS, URB, SS	FLOW, HAB, MIG, NUT, SED		2
Unnamed Tributary to Lake Michigan at LM 71.6		0.8	UNK	UNK	DEF	UNK					
Unnamed Tributary to Lake Michigan at LM 78.5		0.5	UNK	UNK	DEF	UNK					
Unnamed Tributary to Lake Michigan at LM 79.2		1.4	UNK	UNK	DEF	UNK					
Unnamed Tributary to Lake Michigan at LM 80.0		0.8	UNK	UNK	DEF	UNK					
Unnamed Tributary to Lake Michigan at LM 80.3		0.8	UNK	UNK	DEF	UNK					
Unnamed Tributary to Lake Michigan at LM 80.5		0.9	UNK	UNK	DEF	UNK					
Unnamed Tributary to Lake Michigan at LM 80.8		0.8	UNK	UNK	DEF	UNK					
Unnamed Tributary to Lake Michigan at LM 81.0		0.7	UNK	UNK	DEF	UNK					
Unnamed Tributary to Lake Michigan at LM 81.2 T12N R23E Sec.6		0.9	UNK	UNK	DEF	UNK					
Unnamed Tributary to Lake Michigan at LM 82.1 T13N R23E Sec.31		1.0	UNK	UNK	DEF	UNK					
TOTALS		**70.5**									

(1) Trout streams as defined in Wisconsin Trout Streams (1980) but not listed in NR 102. These streams may be classified as trout streams under 1.02(7) since publication of Wisconsin Trout Streams (1980), but are not formally classified as trout waters. These streams will be added to NR 102 and/or NR 104 during code revision.

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BLACK RIVER WATERSHED (SH02)

INTRODUCTION

The Black River watershed is entirely within Sheboygan County and encompasses most of the Village of Cedar Grove, all of the Village of Oostburg, and the southern portion of the City of Sheboygan. There are three named streams; Black River, Fisherman's Creek, Barr Creek, and 32 unnamed streams in the Black River watershed. There are no lakes or impoundments in this watershed.

The Black River Watershed is characterized primarily as natural lowlands with adjacent agricultural areas. Fisherman's Creek, which flows through the southern portion of Sheboygan, is primarily urban. The wastewater treatment facilities in the watershed include: two that discharge to the Black River, three that discharge to Barr Creek, two that discharge to Lake Michigan and one to Fisherman's Creek. Notable are the facilities in the villages of Oostburg and Cedar Grove, which are significant dischargers to the Black River and Barr Creek respectively (WDNR 1988, WDNR 1995). Rural and urban nonpoint source pollution, point sources, channel modification, construction site erosion, and increased imperviousness contribute to flashy flows, increased nutrients, bacteria, and sedimentation. The overall water quality in this watershed is fair to poor.

WATER RESOURCES OF THE BLACK RIVER WATERSHED

BLACK RIVER AT LM 93.8 - OVERVIEW

T14N R23E Sec. 2 SENE Stream Length = 11.4 WBIC = 50300

The Black River is the major waterway in this watershed. The Black River originates near the Village of Oostburg and flows west then north through Kohler-Andrae State Park along Lake Michigan before emptying into Lake Michigan in the City of Sheboygan. The river's average gradient drops 8.5 feet per mile in its 11.4 mile length. The primary land use in this watershed is natural lowlands with adjacent agricultural lands. Residential areas surround the river's very upper and lower reaches. The Oostburg Wastewater Treatment Plant is a permitted point source discharger to the upper reaches of the Black River.

BLACK RIVER, SEGMENT 1 (RM 0-1.6)

This reach of the Black River, extending upstream from the mouth to Indian Mound Road has poor to fair water quality. This segment of the river is primarily composed of low-flow wetlands, dominated by the introduced plant pest, purple loosestrife. The purple loosestrife severely out-competes native vegetation in the wetlands (Katsma, 1998). The Jerving Conservancy, located at the estuary with Lake Michigan, was once a highly valued bird migratory bird site, but is now being severely degraded by the overgrowth of purple loosestrife. The macroinvertebrate community has many tolerant taxa that are limited by poor habitat. Streambed sedimentation contributed by upstream sources of polluted runoff is moderate. Fish diversity is poor, but provides seasonal fishing opportunities during the spawning runs of smelt, trout and salmon.

BLACK RIVER, SEGMENT 2 (RM 1.6-11.0)

This reach extends from Indian Mound Road through the length of Kohler-Andrae State Park to the headwaters in Oostburg. Water quality is poor, with polluted runoff causing excessive sedimentation. As a result, habitat for fish, macroinvertebrates and periphyton is poor. The headwaters area receives

wastewater from the Oostburg sewage treatment plant. The historical stream classification for the Black River split the stream into two segments. The upper 9.4 river miles was classified as limited aquatic life and the lower 1.6 river miles as limited forage fish (the recent stream classification eliminates this segmentation WDNR 1995). A review of historical fish surveys identifies 20 species in the Black River (Fago 1985). Trout and salmon (coho salmon, chinook salmon, rainbow trout, brook trout) from Lake Michigan are also found in the stream during their seasonal spawning runs.

WDNR personnel conducted fish surveys in 1994, 1999 and 2000 on the Black River. Only three species (two tolerant, one very tolerant according to Ball 1982) were collected from the Black River in 1994 compared with the 20 species collected in the past (Table 14). WDNR personnel recently conducted fish surveys on the Black River in 1999, upstream of Indian Mound Road (river mile 1.6) and in 2000, downstream of CTH KK (Table 14). Stream habitat and available fish cover in these two areas of the Black River was rated as fair (Table 15). Bottom substrate primarily consists of sand and the riparian buffer is mainly wetlands and woodlands. Agricultural and residencial land use in the watershed contributes to poor water quality conditions.

Table 14. Black River Fish Community Assessments.

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Historical Fish Collections (Fago)	Upstream of Minderhaud Rd. at RM 10.0 8/9/1994	Upstream of CTH KK at RM 7.7 8/9/1994	Downstream of CTH KK At RM 7.5 7/12/2000	Upstream of Indian Mound Road at RM 1.8 8/16/1999
Black Bullhead	Sport		X				X
Black Crappie	Sport		X				
Bluegill	Sport		X				X
Bluntnose Minnow	Tolerant	Tolerant	X				X
Brassy Minnow			X			X	
Brook Stickleback	Tolerant		X	X	X	X	
Brook Trout	Sport	Intolerant	X				
Brown Bullhead	Sport		X				
Central Mudminnow	Very Tolerant	Tolerant	X	X	X	X	X
Chinook Salmon			X				
Coho Salmon	Sport		X				
Common Carp	Very Tolerant	Tolerant	X				
Creek Chub	Tolerant	Tolerant				X	X
Fathead Minnow	Very Tolerant	Tolerant	X				X
Golden Shiner	Tolerant	Tolerant	X				X
Green Sunfish	Sport	Tolerant				X	X
Johnny Darter	Tolerant						X
Largemouth Bass	Sport		X				X
Mirror Carp-(Carp	Very	Tolerant					X

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Historical Fish Collections (Fago)	Upstream of Minderhaud Rd. at RM 10.0 8/9/1994	Upstream of CTH KK at RM 7.7 8/9/1994	Downstream of CTH KK At RM 7.5 7/12/2000	Upstream of Indian Mound Road at RM 1.8 8/16/1999
Subspecies)	Tolerant						
Northern Pike	Sport		X				X
Pumpkinseed	Sport						X
Rainbow Trout	Sport		X				
Rock Bass	Sport	Intolerant	X				X
White Sucker	Tolerant	Tolerant	X	X	X	X	X
Yellow Bullhead		Tolerant					X
Yellow Perch	Sport		X				

[1] Ball (1982) [2] Lyons (1992)

Table 15. Hilsenhoff Biotic Index (HBI) and Index of Biotic Integrity (IBI) for the Black River, 1994, 1999 and 2000.

Black River Sample Sites	HBI [1]		IBI [2]	
	Avg. Score	Water Quality Rating	Score	Water Quality Rating
At River Mile 10.0			12	Very Poor
At River Mile 7.7	6.29	Fair	20	Poor
At River Mile 7.5	n/a		16	Poor
At River Mile 1.8	5.69	Fair	35	Fair

[1] Hilsenhoff Biotic Index (1987)
[2] Lyons (1992)

Sediment Quality

A sediment sample was collected in 1994, at a site between CTH A and the Oostburg WWTP outfall in the headwaters of the Black River as part of the Sheboygan River Basin Sediment Survey. The results for total PCBs were consistent with what the Department finds at control sites as a result of atmospheric deposition (0.05 ug/g). The PAHs, (acenaphthene, acenaphthylene, anthracene, benzo (A) anthracene, benzo (B) fluoranthene, benzo (K) fluoranthene, benzo (GHI) perylene, benzo (A) pyrene, benzo (E) pyrene, chrysene, dibenzo (A,H) anthracene, fluoranthene, fluorene, indeno (1,2,3-CD) pyrene, perylene, phenanthrene, and pyrene) came back as no detect (<160 ng/g). The metals data show values for cadmium, chromium, copper, lead, mercury, nickel and zinc consistent with the concentrations observed in urban impacted streams and do not require specific management activities at this time (WDNR 1999).

BLACK RIVER TRIBUTARY STREAMS

FISHERMAN'S CREEK TRIBUTARY TO BLACK RIVER AT RM 0.3

T14N R23E Sec. 2 SESW Stream Length = 2.1 WBIC = 50400

This creek is a 2.1-mile-long tributary of the Black River, originating in the City of Sheboygan and joining the Black River three tenths of a mile upstream of Lake Michigan. Urban land use dominates the downstream half of the stream, while industry and urban development in conjunction with limited agricultural uses are in the upstream portion. Urban stormwater runoff from the City of Sheboygan discharges into the creek. In addition, the stream receives leachate from the old town of Wilson landfill site as well as runoff via a small unnamed tributary through a fly ash tailings pond operated by the Edgewater Power Plant. Other potential impacts to water quality are the thermal discharge from Thomas Industries which may be impacting aquatic organisms in the upper reaches of Fisherman's Creek and runoff from the former Conoco Refinery property (WDNR 1988, 1995).

Wetlands at the headwaters of Fisherman's Creek were filled for industrial development. The creek was dredged and rerouted in 1991 to abate flooding problems caused by the loss of those wetlands. Channelized reaches with impervious surfaces within the creek still contribute to flooding downstream of the industrial parks. The results are severe streambank erosion and flooding, particularly in the lower reaches. A large-scale fish kill occurred in the summer of 1992, resulting from a fire-controlled spill at E&K Hazardous Waste Services. The fish died due to high biological oxygen demand. Fisherman's Creek is classified as a Warm Water Forage Fish community stream. Fish community assessments were conducted in Fisherman's Creek in 1985 and during the 1994 basin monitoring (Table 19). Fourteen fish species were identified in Fisherman's Creek during fish community assessments conducted during 1994 (Table 19). The brook trout we collected in 1994 is not a resident of Fisherman's Creek, but it along with other species of trout and salmon resident to Lake Michigan, migrate into Fisherman's Creek on a seasonal basis. Due to natural limiting conditions (i.e. warm water temperatures), trout and salmon are not capable of reproducing in Fisherman's Creek.

Table 16. Fisherman's Creek Fish Community Assessment

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	1985 WDNR Files	1994 Fish Collections
Central Mudminnow	Very Tolerant	Tolerant	X	X
White Sucker	Tolerant	Tolerant	X	X
Brook Stickleback	Tolerant		X	X
Creek Chub	Tolerant	Tolerant	X	X
Green Sunfish	Sport Fish	Tolerant	X	X
Fathead Minnow	Very Tolerant	Tolerant		X
Johnny Darter	Tolerant			X
Common Shiner	Tolerant		X	X
Bluntnose Minnow	Tolerant	Tolerant	X	X
Bullhead Minnow	Tolerant		X	

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	1985 WDNR Files	1994 Fish Collections
Sand Shiner	Tolerant			X
Hornyhead Chub	Intolerant			X
Common Carp	Very Tolerant	Tolerant		X
Rainbow Trout	Sport Fish		X	
Brown Trout	Sport Fish		X	
Golden Shiner	Tolerant	Tolerant	X	
Brook Trout	Sport Fish	Intolerant	X	X
Longnose Dace	Intolerant			X
Bluegill	Sport Fish			X

[1] Ball (1982) [2] Lyons (1992)

A fish survey conducted in the headwaters of Fisherman's Creek didn't find any fish upstream of the Indian Meadows Trailer Park's stormwater detention pond outlet upstream to the railroad tracks. The lack of fish in this reach is likely caused by a combination of poor habitat caused by stream modifications, riprap from the stormwater pond outlet structure washed into the stream blocking stream flow, and thermal stresses.

Habitat assessments were conducted as part of the three recent fish collections using the Fish Habitat Rating (FHR) (Simonson *et al.* 1994) and the Stream System Habitat Rating (SSHR) (Ball 1982) protocols. The macroinvertebrate community was sampled at four sites on Fisherman's Creek and was comprised of taxa mainly tolerant to very tolerant of poor water quality. Poor habitat caused by flashy flows, high turbidity, and excessive sedimentation of course substrate, limits the macroinvertebrate community. Table 17 summarizes the biotic indices and habitat ratings.

Table 17. Hilsenhoff Biotic Index (HBI), Index of Biotic Integrity (IBI) and Habitat Quality results for Fishermans Creek, 1994.

Stream	SITE	HBI[1]		IBI[2]		Habitat			
		Avg. Score	Water Quality Rating	Score	Biotic Integrity Rating	Ball[3]		Simonson et al.[4]	
						Score	Rating	Score	Rating
Fisherman's Creek	In Indian Meadows Mobile Home Park	6.88	Fairly Poor	11	Very Poor	238	Poor	20	Poor
	Downstream of CTH OK	7.29	Fairly Poor	4	Very Poor	182	Fair	45	Fair
	Upstream of CTH KK	6.63	Fairly Poor	29	Poor	154	Fair	47	Fair

	Downstream of CTH KK	6.38	Fair	

[1] Hilsenhoff Biotic Index (1987) [2] Lyons (1992) [3] Ball (1982) [4] Simonson *et al*. (1994)

Sediment Quality

Sediment samples were collected in 1994 at two sites in Fisherman's Creek and one site on an unnamed tributary to Fisherman's Creek (at river mile 0.3). Baseline sediment quality data for Fisherman's Creek were collected to assess the potential sediment quality impacts from the fly ash landfill on an unnamed tributary to Fisherman's Creek.

Total PCBs for all sites came back less than detect at <0.05 ug/g, and nine PAH compounds were observed in the sample collected in the headwaters of Fisherman's Creek (WDNR 1999). The source of the PAH contamination is unknown, but is probably from the former Conoco Refinery Property upstream from this site. Heavy metals show an increase in concentration from upstream to downstream consistent with increased urban runoff. The metals concentrations in Fisherman's Creek are consistent with urban environments and not perceived to be at levels of concern based on the toxicity information that we have for these constituents at this time. Consequently, Fisherman's Creek does not require specific management activities at this time.

However, a number of the metals tested from the unnamed tributary to Fisherman's Creek (at RM 0.3) from the Edgewater Power Plant fly ash landfill were higher than in Fisherman's Creek just upstream from the confluence of the streams. The concentration of boron in the sediment sample was 150 mg/kg, which was an order of magnitude higher than the sample from Fisherman Creek. Boron is an essential trace element and is required for plant and animal growth, but is toxic when present in excessive amounts. Boron is highly mobile in soils; hence, the observation of elevated levels of boron is indicative of landfill leachate contamination (McGinley and Kmet 1984). The impact of the contaminated sediment from the tributary to Fisherman's Creek is not known at this time.

UNNAMED TRIBUTARY TO FISHERMAN'S CREEK AT RM 0.3

T14N R23E Sec. 2 Stream Length = 0.8

This stream flows from the Edgewater Power Plant fly ash landfill and is tributary to Fisherman's Creek a third of a mile upstream of Fisherman's Creek's confluence with the Black River. The condition of the stream is discussed as part of the previous section. No biological surveys were conducted in this small stream. The stream is naturally limited due to low flows and minimal water depth.

LAKE MICHIGAN TRIBUTARY STREAMS

BARR CREEK AT LM 82.9 - OVERVIEW

T13N R23E Sec. 30 SWNE Stream Length = 7.2 WBIC = 50200

Barr Creek is a 7.2 mile-long Lake Michigan tributary originating northeast of Cedar Grove. Water quality is poor, influenced by three permitted dischargers, industrial storm water runoff in Cedar Grove, nutrients, bacteria, and cropland runoff from agricultural areas. Macroinvertebrate diversity is poor, with very tolerant organisms dominant, such as *Asellus* and *Oligochaeta*. The fish community lacks diversity, with white sucker, brassy minnow, fathead minnow, brook stickleback, black bullhead, and mudminnow dominant (Fago, 1985). Seasonal trout migration has been noted in spring fish surveys. Despite its steep

gradient and gravel-rubble bottom, Barr Creek lacks typical headwaters species such as daces, stonerollers, darters and creek chubs.

Barr Creek was previously classified in 1979 as a non-continuous marginal fish and aquatic life stream (Limited Aquatic Life). This 1979 classification was proposed without the benefit of any widely accepted and scientifically based stream classification guidelines, or the use of recent biological information (i.e. fish survey results).

In 1986 and 1987, a wasteload allocation survey and waste assimilative model was completed for two discharges to Barr Creek, the Larson Company and Cedar Grove wastewater treatment plant. This survey and model was used to predict the combined waste assimilative capacity of Barr Creek and their effects on stream water quality. Concurrent with this survey, a stream classification survey was completed according to the 1982 *Stream Classification Guidelines for Wisconsin*. Measurements of in-stream habitat characteristics and fish surveys were completed.

The results of the 1986 stream classification indicate that Barr Creek habitat is suitable to sustain a viable population of tolerant to very tolerant forage fish, and lesser numbers of tolerant sport fish. Habitat was generally rated as "fair". The results of fish surveys from 1986, and as early as 1976, confirmed this conclusion. The fish community was represented by seven species considered tolerant to very tolerant of degraded environmental conditions. The rainbow trout is not a resident of Barr Creek, but it along with other species of trout and salmon resident to Lake Michigan, probably migrate into Barr Creek on a seasonal basis. Due to natural limiting conditions (i.e. warm water temperatures), trout and salmon are not capable of reproducing in Barr Creek. Based on the results of the 1986 stream classification survey, it was recommended that Barr Creek be classified as a Limited Forage Fish Community. A subsequent Barr Creek fish survey in 1994 reinforced this stream classification (Table 18).

Table 18. Barr Creek Fish Assessments.

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Historical Fish Collections Fago (1985)	Downstream of I43 at RM 0.9 1986	Upstream of Smies Road at RM 2.9 1986	Upstream of Cedar Grove WWTP Access Rd. at RM 2.2 8/16/1999	Upstream of Sauk Trail Road at RM 1.4 10/5/1994	Upstream of Sauk Trail Road at RM 1.4 7/13/2000
Black Bullhead	Sport		X					X
Brassy Minnow			X					
Brook Stickleback	Tolerant		X		X	X	X	
Central Mudminnow	Very Tolerant	Tolerant	X	X		X	X	X
Common Carp	Very Tolerant	Tolerant		X				
Common Shiner	Tolerant			X				
Creek Chub	Tolerant	Tolerant	X	X		X	X	X
Fathead Minnow	Very Tolerant	Tolerant	X	X	X		X	
Green	Sport	Tolerant						X

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Historical Fish Collections Fago (1985)	Downstream of I43 at RM 0.9 1986	Upstream of Smies Road at RM 2.9 1986	Upstream of Cedar Grove WWTP Access Rd. at RM 2.2 8/16/1999	Upstream of Sauk Trail Road at RM 1.4 10/5/1994	Upstream of Sauk Trail Road at RM 1.4 7/13/2000
Sunfish								
Lake Chub			X					
Rainbow Trout	Sport		X					
White Sucker	Tolerant	Tolerant	X	X	X	X	X	X

[1] Ball (1982) [2] Lyons (1992)

WDNR personnel surveyed Barr Creek upstream of the Cedar Grove Wastewater Treatment Plant in 1999 (river mile 2.2) and upstream of Sauk Trail Road (river mile 1.4) in 2000. Fish community, stream habitat, and benthic macroinvertebrates were surveyed and it was determined that while the stream habitat and available fish cover were good, the fish and macroinvertebrate communities were poor. This can probably be attributed to agricultural and urban land use in the watershed and poor water quality conditions within the stream. The water quality habitat ratings determined from the biological monitoring and habitat assessments from the 1994, 1999 and 2000 surveys are shown in Table 19.

Table 19. Hilsenhoff Biotic Index (HBI) and Index of Biotic Integrity (IBI) for Barr Creek, 1994, 1999 and 2000.

Barr Creek Sample Sites	HBI [1]		IBI [2]	
	Avg. Score	Water Quality Rating	Score	Water Quality Rating
At River Mile 2.9	7.05 (1994)	Fairly Poor	n/a	n/a
At River Mile 2.2	6.97 (1999)	Fairly Poor	*	*
At River Mile 1.4	6.00 (1994) n/a (2000)	Fair n/a (2000)	20 (1994) 2 (2000)	Poor (1994) Very Poor (2000)
At River Mile 0.9	n/a	n/a	n/a	n/a

[1] Hilsenhoff Biotic Index (1987)
[2] Lyons (1992)
* The stream is below the IBI model calibration. A small stream IBI is being developed by WDNR Research and these data will be assessed using that protocol when it becomes available.

Sediment Quality

Sediment collections were taken from an unnamed tributary to Barr Creek on the eastern side of Cedar Grove, upstream of CTH D. These samples were collected as part of the basin sediment survey to obtain baseline sediment quality data for Barr Creek and to assess the potential sediment quality impacts from the foundries adjacent the stream. An extensive oil sheen and oil product was observed in the stream

during the sample collection despite the highly scoured substrate in the area (WDNR 1994). The results for total PCBs were just over the level of detect at 0.06 ug/g.

Eleven PAH compounds were detected in the sample collected in the unnamed tributary to Barr Creek in Cedar Grove (WDNR 1999). A storm water pollution prevention plan review of a foundry in Cedar Grove prompted a sediment survey of the stormsewer and tributary to Barr Creek (Triad Engineering Inc. 2000). No specific sediment management activities are planned at this time. Souce control will continue to be a focus.

UNNAMED TRIBUTARY TO BARR CREEK AT RM 2.1

T13N R22E Sec. 24 Stream Length = 0.6

This small stream flows north-northeast from the eastern of Cedar Grove. An industrial area including foundries are along this stream. A sediment sample was collected from this stream in 1994 and the sediment is contaminated with metals and PAHs. A full discussion of this stream is in the Barr Creek condition report (above). No biological information is available for this stream.

Table 20. Streams of the Black River Watershed.

.Stream Name/Location (T, R, Sec., QQ, Q)	WBIC	Length	Biological Use		Codified	Supp.	Assess. Category	Use Impairments		Ref.	Data Level
			Existing	Potential				Source	Impact		
Barr Creek T13N R23E Sec.30 SWNE	50200	7.2	LFF	LFF	LAL	PART	M	NPS, URB, SED, LF, CON, SB, PSM, PSI, SS, HM	FLOW, TURB, SED, NUT, HAB		4
Unnamed Tributary to Barr Creek at RM 0.2		1.1	UNK	UNK	DEF	UNK					
Unnamed Tributary to Barr Creek at RM 0.6		0.4	UNK	UNK	DEF	UNK					
Unnamed Tributary to Barr Creek at RM 0.8		0.7	UNK	UNK	DEF	UNK					
Unnamed Tributary to Barr Creek at RM 2.1		0.6	LFF	LFF	DEF	PART	M	NPS, URB, PSI, CON, SS, DCH, RS, SB, LF, HM	FLOW, SED, NUT, HAB, ORG		3
Unnamed Tributary to Barr Creek at RM 2.5		1.3	UNK	UNK	DEF	UNK					
Unnamed Tributary to Barr Creek at RM 3.5		1.2	UNK	UNK	DEF	UNK					
Unnamed Tributary to Barr Creek at RM 3.9		1.6	UNK	UNK	DEF	UNK					
Unnamed Tributary to Barr Creek at RM 4.4		0.5	UNK	UNK	DEF	UNK					
Unnamed Tributary to Barr Creek at RM 5.0		0.6	UNK	UNK	DEF	UNK					
Black River T14N R23E Sec.2 SENE	50300	11.4	LFF	WWSF	LFF RM 0-1.6 AND LAL RM 1.6-11.4	NOT	M	NPS, URB, SS, DCH, SB, HM, CL, PSM	FLOW, HAB, NUT, SED, TURB, MAC		4
Unnamed Tributary to Black River at RM 1.2		1.2	UNK	UNK	DEF	UNK					
Unnamed Tributary to Black River at RM 2.1		2.0	UNK	UNK	DEF	UNK					
Unnamed Tributary to Black River at RM 3.1		1.7	UNK	UNK	DEF	UNK					
Unnamed Tributary to Black River at RM 3.5		2.0	UNK	UNK	DEF	UNK					
Unnamed Tributary to Black River at RM 4.3		2.1	UNK	UNK	DEF	UNK					

.Stream Name/Location (T, R, Sec., QQ, Q)	WBIC	Length	Biological Use		Codified	Supp.	Assess. Category	Use Impairments		Ref.	Data Level
			Existing	Potential				Source	Impact		
Unnamed Tributary to Black River at RM 5.1		1.5	UNK	UNK	DEF	UNK					
Unnamed Tributary to Black River at RM 6.2		1.4	UNK	UNK	DEF	UNK					
Unnamed Tributary to Black River at RM 6.5		1.0	UNK	UNK	DEF	UNK					
Unnamed Tributary to Black River at RM 7.1		0.8	UNK	UNK	DEF	UNK					
Unnamed Tributary to Black River at RM 7.5 T14N R23E Sec.33 SWSW	50500	2.3	UNK	UNK	DEF	UNK					
Unnamed Tributary to Black River at RM 9.8		1.7	UNK	UNK	DEF	UNK					
Unnamed Tributary to Black River at RM 10.1		0.7	UNK	UNK	DEF	UNK					
Unnamed Tributary to Black River at RM 10.5		0.6	UNK	UNK	DEF	UNK					
Unnamed Tributary to Black River at RM 10.8 T14N R23E Sec.31 SWSW	50600	0.6	UNK	UNK	DEF	UNK					
Fisherman's Creek T14N R23E Sec.2 SESW	50400	2.1	WWFF	WWFF	DEF	PART	M	NUT, LF, SS, DCH, URB, CON, PSI, NPS	FLOW, HAB, NUT, SED		4
Unnamed Tributary to Fisherman's Creek at RM 0.3		0.8	LFF	LFF	DEF	PART	M	LF, NPS, HM	SC, MIG		3
Unnamed Tributary to Fisherman's Creek at RM 1.2		1.2	UNK	UNK	DEF	UNK					
Unnamed Tributary to Fisherman's Creek at RM 1.6		0.8	UNK	UNK	DEF	UNK					
TOTALS		**51.1**									

(2) Trout streams as defined in Wisconsin Trout Streams (1980) but not listed in NR 102. These streams may be classified as trout streams under 1.02(7) since publication of Wisconsin Trout Streams (1980), but are not formally classified as trout waters. These streams will be added to NR 102 and/or NR 104 during code revision.

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SHEBOYGAN RIVER WATERSHED (SH03)

INTRODUCTION

The Sheboygan River originates in east-central Fond Du Lac County and flows eastward into Sheboygan County, loops into Calumet and Manitowoc Counties near Kiel then flows back into Sheboygan County, ultimately entering Lake Michigan in the city of Sheboygan. Two major tributaries, the Onion and Mullet Rivers, enter the Sheboygan River in the city of Sheboygan Falls. The Onion River and Mullet River are treated as separate watersheds in the WQMP report. Trout streams in the Sheboygan River Watershed include Millhome, Schuett, and Feldner's Creeks. Warmwater streams, Otter, Gooseville, and Weedens Creeks and another 30 unnamed streams are also tributaries to the Sheboygan River. There are ten dams in the Sheboygan River Watershed: Sheboygan Marsh Dam, Kiel Dam, Rockville Dam, Millhome Dam, Franklin Dam, Johnsonville Dam, Sheboygan Falls Dam, Waelderhaus Dam, lower Kohler Dam, and Mischo's Dam. Primary land use in the watershed is agriculture with more urban areas characterizing the lower watershed.

Many different pollution sources impair the stream's biological and water quality integrity. They include inplace pollutants (principally PCBs), 31 industrial discharges to surface waters, three municipal WWTP discharges, urban storm water runoff, hydrologic modification (impoundments and tributary stream channelization), stream bank erosion, stream bank pasturing, cropland erosion and construction site erosion. This causes high stream turbidities, sedimentation, flow fluctuations, nutrient enrichment, dissolved oxygen fluctuations, loss of habitat, toxicity, PCB bioaccumulation (fish advisories in downstream sections) and fish migration interference.

In-place pollutants affecting the Sheboygan River's lower 14 miles include; polychlorinated biphenols (PCBs), heavy metals and polycyclic aromatic hydrocarbons (PAHs). Tecumseh Products has submitted a Feasibility Study for the remediation of this Superfund Site (BB&L 1998). A cleanup plan is being evaluated by U.S. EPA with assistance from the Natural Resources Trustees; WDNR, USFWS, and NOAA. A public meeting discussing the preferred cleanup action for the Sheboygan River and Harbor Superfund Project is planned for 1999. Additionally, high concentrations of PAHs were discovered in the sediment near an old coal gasification site upstream of Camp Marina in the city of Sheboygan.

VOLUNTEER MONITORING – TESTING THE WATERS PROGRAM

Students and teachers in Sheboygan and surrounding communities are learning to become active decision makers through an environmental education project called "Testing the Waters". Through "Testing the Waters" students receive an education in river ecology and responsible citizenship. Students learn to collect water quality data, research land influences affecting the river, and develop measures to protect waterways. In short, "Testing the Waters" introduces students to the basics of stream biology and environmental management.

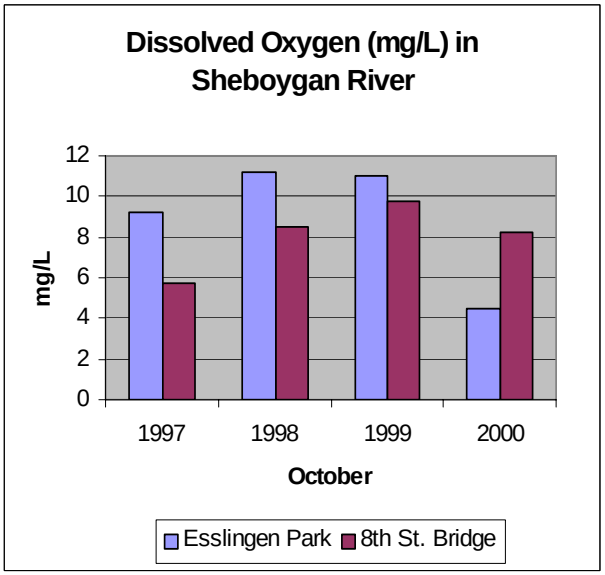
Since 1990, when "Testing the Waters" began, thousands of students in Kenosha, Milwaukee, Ozaukee, Racine, Sheboygan, Washington and Waukesha counties have tested water quality at sites throughout Southeastern Wisconsin. The number of students increases every year as more high schools and middle schools become involved.

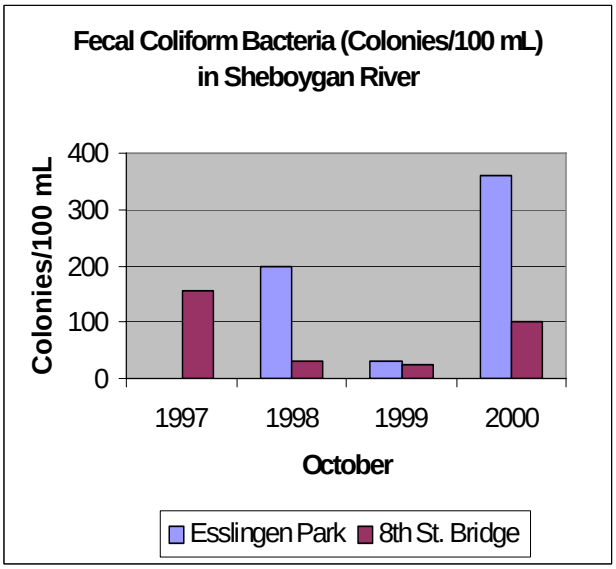
In Sheboygan County, a consortium of middle and high school teachers and students work together to collect water quality data on area rivers. Sample collection and analyses include: dissolved oxygen, fecal

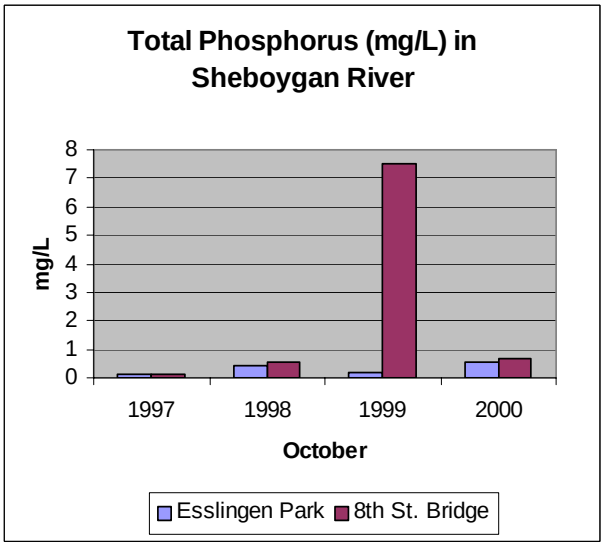
coliform bacteria, pH, biochemical oxygen demand (BOD), temperature, total phosphorus, nitrates, turbidity, total solids and benthic macroinvertebrates (water bugs).

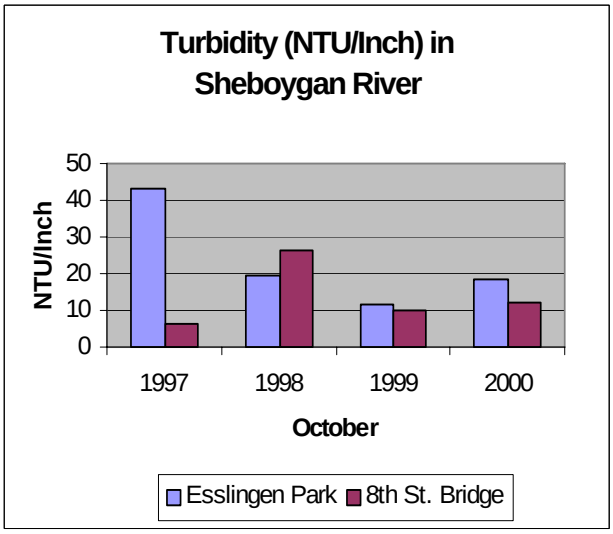
Data is interpreted, reported , and presented at an annual forum. The data the "Testing the Waters" students collect can be a valuable addition to water quality information compiled by the Wisconsin Department of Natural Resources (WDNR) (see figures below).

While the group works independently, students and teachers receive assistance and training from state and local groups such as the WDNR, Sheboygan County Land Conservation Department, Maywood Environmental Station and Cardinal Environmental, Inc.









STREAMS OF THE SHEBOYGAN RIVER WATERSHED

MEHLES SPRINGS, SHEBOYGAN COUNTY

T16N R21E Sec. 7 NWSE Stream Length = 1.0 WBIC = 58700

This tributary originates from a spring (Mehles spring) and flows westward through marshy wetlands before joining the Sheboygan River at T16N, R21E, S.7, SE, SW. This tributary is approximately 1 mile in length and is classified as a warmwater forage fish community stream with a fish population consisting primarily of forage minnows. At this time it is partially meeting this biological use classification.

Problems that may be limiting the aquatic habitat include the loss of fish and invertebrate habitat and low dissolved oxygen. The observed or potential problem sources include parent soils and excessive vegetation.

The habitat rating for this tributary is very good with excellent riparian cover and instream cover available. There seems to be very little if any human disturbance (Ball 1982). No macroinvertebrate or fish collections were made but this tributary would be expected to contain those species associated with typical marsh habitat. Fish observations indicate an abundant forage fish population and other fish species including yellow perch, sunfish, suckers and young carp.

FELDNER'S CREEK, FOND DU LAC COUNTY.

T16N R19E Sec. 35 NENW Stream Length = 1.8 WBIC = 61000

Feldner's Creek is a 1.8 mile stream originating in wetlands. The creek is spring fed, and classified as a Class II trout stream in its upper half. Flow is northerly and the stream's gradient is approximately 25 feet per mile. The stream is impounded at County Highway “CCC” to form Mischo’s Pond. Adjacent land use is primarily recreational with agricultural uses in the headwaters segments. Habitat and water quality are capable of supporting intolerant forage, cold water and warm water game fish species. Habitat historically has been limited as a result of streambank destruction from livestock access, headwaters channelization and sedimentation. The requirements of headwater gravel spawning areas for brook trout reaffirms headwaters habitat restoration as a priority for Feldner’s Creek. Downstream reaches support a tolerant to intolerant assemblage of forage species. The macroinvertebrate community is characterized by species intolerant of organic pollution, indicating very good water quality. Sedimentation is moderate in reaches upstream of CTH “CCC” and severe in reaches downstream of CTH “CCC”.

WDNR personnel conducted stream habitat analysis and fish and benthic macroinvertebrate surveys downstream of CTH “CCC” (river mile 0.6) in 2000. This stream reach is low gradient and flows through a natural wetland area. Fish and macroinvertebrate communities were poor and stream habitat was severely limited because of heavy sedimentation. Fish species present were central mudminnows and bullhead species. The impoundment upstream of CTH “CCC” is recognized as a potential source of the downstream sedimentation problems.

MT CALVARY BRANCH, FOND DU LAC COUNTY.

T16N R19E Sec. 21 Stream Length = 6.8 miles WBIC = 61400

The unnamed tributary to Sheboygan River (Mt. Calvary Branch) flows into the Sheboygan River within the St. Cloud State Wildlife Area, which is a large wetland complex with considerable wildlife habitat. The confluence is approximately 1.8 miles upstream of where the Sheboygan River crosses CTH CCC. The

stream is spring fed and has several small tributaries. Mt. Calvary Branch has a relatively low gradient and has several large wetland conplexes adjacent to its course. Land use in the watershed is primarily agricultural but does include natural areas and minor urban areas. The Village of Mt. Calvary has a municipal wastewater discharge to the stream downstream of Basswood Road.

WDNR personnel monitored the biological communites and habitat of the stream upstream of Basswood Road (river mile 2.2) in 1999. Historical fish collections were done upstream of CTH CCC (river mile 1.2) and upstream of STH 149 (river mile 3.9). The fish assessment data are shown in Table 21. Fish and macroinvertebrate communities rated fair at the site and stream habitat rated excellent (Table 22). The lower rating for the fish and macroinvertebrate may be attributed to poor water quality and periodic low dissolved oxygen levels associated with storm water runoff from agricultural land use.

Table 21. Fish Assessment on the Unnamed Tributary (Mt. Calvary Branch) to the Sheboygan River Upstream of Basswood Road.

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Historical Collection Upstream of STH 149 RM 1.2 1980	Upstream of Basswood Road at RM 2.2 1999	Historical Collection Upstream of CTH CCC RM 3.9 1980
Blacknose Dace	Intolerant	Tolerant		X	
Creek Chub	Tolerant	Tolerant	X	X	
Fathead Minnow	Very Tolerant	Tolerant	X	X	
Common Shiner			X		
White Sucker	Tolerant	Tolerant	X	X	
Brook Stickleback	Tolerant		X	X	X
Pumpkinseed	Sport			X	
Pearl Dace	Intolerant		X	X	
Southern Redbelly Dace	Intolerant			X	
Northern Redbelly Dace	Intolerant		X		
Largemouth Bass	Sport			X	
Yellow Bullhead	Sport		X		
Black Bullhead	Sport		X		
Golden Shiner			X		
Yellow Perch	Sport		X		
Bluegill	Sport			X	
Central Stoneroller	Intolerant			X	
Central Mudminnow	Very Tolerant	Tolerant	X	X	
Green Sunfish	Sport			X	

[1] Ball (1982)
[2] Lyons (1992)

Table 22. Hilsenhoff Biotic Index (HBI), Index of Biotic Integrity (IBI) and Habitat Quality Results for Mt. Calvary Branch from the 1999 assessments.

Mt. Calvary Branch Sample Site	HBI [1]		IBI [2]	
	Avg. Score	Water Quality Rating	Score	Water Quality Rating
Upstream of Basswood Road	5.94	Fair	32	Fair

[1] Hilsenhoff Biotic Index (1987)
[2] Lyons (1992)

* The average stream width for this fish community assessment site is below the current IBI model calibration. DNR Research is currently developing an IBI for samll streams and these data will be evaluated using that method when it becomes available.

UNNAMED TRIBUTARY TO SHEBOYGAN RIVER (GOOSEVILLE CREEK), MANITOWOC COUNTY

T17N R21E Sec. 21 SESE Stream Length = 1.0 mile WBIC = 57800

Gooseville Creek (local name) flows into the Sheboygan River approximately 500 feet upstream of County Highway AA. The 4.5-mile-long creek has a gradient of 6.3 feet per mile and drains a nine-square-mile area. Three intermittent tributaries influence the creek, one joining it in its perennial section and two flowing into Sy Lake from the north. Gooseville Creek is capable of supporting a warm water forage fish community, and is only partially meeting this biological classification. The fish community of the creek was documented in the fall of 1976, 1978 and spring of 1988 from Gooseville Creek (WDNR 1990). The samples collected during 1988 consisted of a total of 11 species. Three sport fish species, bluegill, unspecified sunfish, and rock bass, and eight tolerant and very tolerant forage fish species: creek chub, johnny darter, bluntnose minnow, brook stickleback, white sucker, mudminnow, fathead minnow, and carp. Overall, the most abundant species collected were the tolerant johnny darter and bluntnose minnow. The factors keeping this stream from reaching its full potential are the loss of fish and invertebrate habitat, streambank erosion and sedimentation leading to substrate embeddedness. Sources of water quality degradation include channelization, cropland runoff, and parent soils. Macroinvertebrate data indicate good to fair water quality in terms of organic enrichment. Dominant organisms include the caddisfly *Hydropsyche betteni*, the beetle *Optioservus sp*., and the diptera *Simulium vittatum* (WDNR 1990).

MILLHOME CREEK, MANITOWOC AND SHEBOYGAN COUNTIES

T16N R21E Sec. 2 NENE Stream Length = 1.7 WBIC = 57200

Millhome Creek is a 1.7 mile Class I brook trout stream that flows into the Sheboygan River approximately 0.2 miles downstream and east of the Highway 57 bridge in the north end of Sheboygan County. A large section of this creek and a number of its headwater springs are on publicly owned land, Manitowoc County's Walla Hi park. The county purchased the land in 1977 from individuals who had previously used the springs and spring pond near the creek's headwaters as a private fish hatchery from the 1930s to the mid-70s.

Water quality is considered fair, and is influenced by agricultural runoff, cattle access, and unauthorized dredging of an upstream segment and wetlands near Cedar Lake Road. The parties responsible for unauthorized dredging were ordered to restore wetland vegetation. Fish collections from Millhome Creek in 1956, 1977, and 1978 documented a diverse fish population, with six sport species, seven tolerant or very

tolerant species, and three intolerant forage species collected. The most important sport fish and the dominant fish collected was brook trout. The tolerant forage species were central mudminnow, common shiner, bluntnose minnow, common shiner, golden shiner, and brook stickleback. The three intolerant species were northern redbelly dace, longnose dace, and mottled sculpin (Fago 1985).

Macroinvertebrate diversity is good. The number of taxa found at this station, however, is low. Intolerant organisms dominate the community with *Gammarus* and *Baetis* comprising almost two-thirds of the community. Habitat is somewhat limited for fish and macroinvertebrates because of slow moving water and silt substrate (WDNR 1990).

OTTER CREEK, SHEBOYGAN COUNTY

T15N R22E Sec. 7 NWNW Stream Length = 4.2 WBIC = 56400

Otter Creek, which originates at the outlet of a small privately owned spring lake, is 4.2 miles long, drains about 11 square miles and has an average gradient of 12.4 feet per mile. It flows southeast for a quarter mile through a white cedar and tamarack swamp until entering an area dominated by agriculture. The main stem of Otter Creek receives additional flow from the Gerber Lake outlet about 0.75 miles from its headwaters, and also from Little Elkhart Lake through a human-made outlet at the headwaters.

Otter Creek is the site of three major interrelated studies involving polluted runoff. The U.S. Geological Survey and WDNR have established a Whole Stream Monitoring site on Otter Creek at Willow Road which provides continuous monitoring of flow, dissolved oxygen, and temperature, along with storm flow monitoring. The DNR Bureau of Research is also using Otter Creek to fine tune the index of biotic integrity (IBI) so it will be more useful when making management decisions regarding sources of polluted runoff. Southeast Region DNR has also used Otter Creek to evaluate the performance of nonpoint source best management practices on sources of polluted runoff. The study involved three years of intensive evaluation monitoring to establish baseline data from which the effectiveness of the Nonpoint Source Pollution Abatement program could be determined. In addition, data were collected throughout the five-year implementation phase of the controls and collected for three years after implementation to track effectiveness.

An overview of the water quality of Otter Creek is presented here. Numerous publications have resulted from these nonpoint source evaluation monitoring studies and the reader is encouraged to examine these reports for additional information (e.g. Wierl *et al*. 1996, Wang et al. 1996, Rappold *et al*. 1997, Corsi *et al*. 1997, and Stuntebeck and Bannerman 1998). Otter Creek has a limited sport fish community, and diverse, relatively abundant forage fish community including species tolerant and very tolerant of pollution and degraded habitat. Although intolerant forage species are present, they are represented by fewer species and are less abundant. Northern pike from the Sheboygan River have been reported to use the stream and adjacent wetlands for spawning. Hilsenhoff biotic index (HBI) values from macroinvertebrate samples indicate good to fair water quality with respect to organic forms of pollution. The creek is only partially meeting its biological use potential for supporting a warm water forage fish community. Factors preventing Otter Creek from meeting its full potential include loss of in-stream and riparian habitat, excessive algae growth, and high concentrations of bacteria. Sources responsible include erosion from uplands and banks, streambank pasturing, livestock access to the stream, channelization, barnyard runoff and failing septic systems. Excessive sedimentation may reduce fish production because of loss of cover, poor spawning substrate, and the presence of few fish food organisms.

Freshwater mussels are particularly sensitive to human induced changes in watersheds and are often used as one of many biological monitoring tools to assess the condition of the resource. WDNR conducted quantitative mussel surveys using the Random Point method in the Otter Creek subwatershed at sites

where water chemistry, habitat, fish and macroinvertebrate data have been collected (Galarneau 1998). The surveys were conducted using $1m^2$ quadrats randomly placed in three stream reaches. All mussels were collected within two quadrats randomly placed adjacent to each other across the stream channel. Both live and dead mussels (i.e. relict shells) were collected by hand, identified, enumerated and live specimens were returned to the stream. Environmentally sensitive mussel species (Endangered, Threatened or Special Concern) were measured and aged as well, and then returned to Otter Creek. Furthermore, a reference collection of shells was made to be used for educational benefits and to aid in future mussel identification. The non-environmentally sensitive mussel species collected at each site are identified below (Table 23). A population of the State Threatened Species slippershell mussel (*Alasmidonta viridis*) was found in the Otter Creek subwatershed. Specific collection sites are not reported for environmentally sensitive species (Endangered, Threatened, or Special Concern).

Table 23. Mussel species collected in Otter Creek (Sheboygan County)

Site	Common Name	Scientific Name
Upstream of Willow Road, Sheboygan County	creek heelsplitter fat mucket giant floater squawfoot	*Lasmigona compressa* *Lampsilis siliquoidea* *Anodonta grandis grandis* *Strophitus undulatus undulatus*
Downstream of CTH J in fenced pasture	giant floater	*Anodonta grandis grandis*
Upstream of STH 57, Sheboygan County	cylindrical papershell creek heelsplitter	*Anodontoides ferussacianus* *Lasmigona compressa*
State Threatened Species found (site not specified)	slippershell mussel	*Alasmidonta viridis*

SCHUETT CREEK, SHEBOYGAN COUNTY

T16N R21E Sec. 13 Stream length = 0.4 miles

Schuett Creek joins the Sheboygan River 0.1 mile downstream of CTH MM and is 0.4 miles long. The stream is classified as a Class I trout stream with a population consisting of small brook trout. Water quality in the lower 800 feet is threatened by barnyard runoff, and streambank mowing. Fish diversity is good but the number of taxa is low. Intolerant, tolerant and very tolerant taxa are equally represented in the fish community. Habitat is not considered limiting, but agricultural runoff may be a degrading factor for this stream. The Hilsenhoff biotic index (HBI) values of 4.58 downstream of a farm were "good," indicative of some degree of organic enrichment. In contrast, the spring 1992 samples upstream of the barnyard had an HBI value of 3.80, which is considered "very good," indicating very little organic enrichment. Macroinvertebrates collected in the spring of 1992 downstream of the feedlot were dominated by the very tolerant isopod, *Asellus intermedius*, and tolerant *Gammarus pseudolimnaeus*. The spring sample upstream of the feedlot was dominated by intolerant *Amphinemura delosa* and tolerant *Gammarus pseudolimnaeus*.

WEEDENS CREEK, SHEBOYGAN COUNTY

T15N R23E Sec. 32 SWSW Stream Length = 5.9 miles WBIC = 50800

Weedens Creek originates in a large wetland at T14N, R23E, S19 and 20, and flows north through agricultural land interspersed with a few small woodlots before it enters the Sheboygan River in the Blackwolf Run golf course north of STH 28 in Kohler. The Aldrich Chemical Company is near the headwaters, but does not discharge to surface waters. Weedens Creek has been reclassified in accordance

with the Sheboygan River Basin Areawide Water Quality Management Plan (1988) recommendations and previous triennial standards reviews for the Sheboygan River basin. Weedens Creek was previously classified in two segments; the first segment (stream miles 0.0-2.3) as a warm water sport fishery, and the second segment (stream miles 2.3-5.9) as capable of supporting limited aquatic life (WDNR 1980). After completion of the recent appraisal, the creek was reclassified as warm water forage fishery for its entire length (WDNR 1990).

On May 17, 1998 a major fish kill occurred on Weedens Creek. Manure spread in a field in the headwaters area reached the stream via a drain tile resulting in a complete kill of the stream all the way to the Sheboygan River (Galarneau 1998). Prior to this fish kill, 23 species of fish have been collected in Weedens Creek (Table 24).

Table 24. Weedens Creek Fish Community Assessment

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Fago 1985	1993 & 1997 Fish Collections
Central Mudminnow	Very Tolerant	Tolerant	X	
White Sucker	Tolerant	Tolerant	X	X
Brook Stickleback	Tolerant		X	
Yellow Bullhead	Sport	Tolerant	X	
Green Sunfish	Sport	Tolerant	X	X
Fathead Minnow	Very Tolerant	Tolerant	X	X
Black Bullhead	Sport Fish		X	X
Northern Pike	Sport Fish		X	X
Bluntnose Minnow	Tolerant	Tolerant	X	X
Common Shiner	Tolerant		X	X
Creek Chub	Tolerant	Tolerant	X	X
Smallmouth Bass	Sport Fish	Intolerant	X	
Largemouth Bass	Sport Fish			X
Sand Shiner	Tolerant		X	
Pumpkinseed	Sport Fish			X
Blacknose Dace	Intolerant	Tolerant	X	X
Bluegill	Sport Fish			X
Central Stoneroller	Intolerant		X	X
Largescale Stoneroller	Intolerant		X	
Johnny Darter	Tolerant		X	X

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Fago 1985	1993 & 1997 Fish Collections
Blackside Darter	Intolerant			X
Southern Redbelly Dace	Intolerant			X
Longnose Dace	Intolerant			X

[1] Ball (1982)
[2] Lyons (1992)

Collections of young of year smallmouth bass, largemouth bass, northern pike, and sunfishes indicate that Weedens Creek may be an important nursery for these game fish species. This creek also supports seasonal runs of salmon from the Sheboygan River.

The dominant invertebrates collected in the spring 1992, assessments were the beetle *Optioservus sp.*, the isopod *Asellus intermedius*, and blackfly *Simulium verecundum*. The macroinvertebrate community was nearly wiped out by the May 17, 1998 manure runoff as well. Macroinvertebrate sampling at numerous sites resulted in a few live sow bugs (*Asellus sp.*), riffle beetles, and a single live caddisfly. Leeches and crayfish were also killed.

Factors limiting the creek's potential include fish kills, loss of wildlife habitat, loss of fish and invertebrate habitat, sedimentation, nutrients, and flashy flows. Sources include improper manure spreading, channelization, wetland drainage, cropland runoff, streambank erosion, drain tiles, and low flow. Sedimentation is excessive and limits habitat for aquatic life.

UNNAMED TRIBUTARY TO SHEBOYGAN MARSH (ELKHART LAKE CREEK), SHEBOYGAN COUNTY

T16N R21E Sec. 30 Stream Length = 0.8 miles

Elkhart Lake Creek (local name) originates as an outlet from the northeast end of Elkhart Lake, adjacent to the public boat launch near County Highway "P". This low gradient stream, meanders approximately 0.8 miles through a large wetland complex that is part of the Sheboygan Marsh and discharges to the South Ditch of the marsh. The surrounding watershed is primarily wetland and provides an excellent buffer for the stream.

WDNR personnel surveyed approximately 200 meters of the stream's fish community and habitat in August 2000. Only 33 individuals were captured during the fish shocking survey; too few to calculate an index of biotic integrity. Fish species that were present included bluegill, pumpkinseed, johnny darter, central mudminnow, black bullhead, common carp, largemouth bass, and northern pike. Fish communities may be limited due to low dissolved oxygen (DO) levels at certain periods and lack of fish cover. Fish use the outlet area of Elkhart Lake as a refuge when DO levels are low in the Sheboygan Marsh. This typically occurs during the hot summer months.

Stream habitat was limited due to the lack of fish cover and habitat types. The bottom substrate consists primarily of sand and silt, and the number of riffles and pools are very few. Zebra mussels are abundant in this stream near the outlet of Elkhart Lake with the population diminsihing downstream towards the South Ditch. Zebra mussles extend the length of the stream and zebra mussels have been found in the Sheboygan Marsh South Ditch in low concentrations (pers. Comm. Galarneau).

SHEBOYGAN RIVER, SEGMENT 1 (RM 0-9.9)

T15N R23E Sec. 23 SESE Stream Length = 81 miles WBIC = 50700

This reach extends from the mouth of the river at Lake Michigan in the City of Sheboygan to the Waelderhaus Dam in Kohler. The reach is the focus of several recent and ongoing water resource planning and implementation efforts including the:

- Wisconsin Nonpoint Source Water Pollution Abatement Program's priority watershed project (WDNR 1991)
- Sheboygan River Remedial Action Plan (WDNR 1995);
- Sheboygan River and Harbor Superfund Project; the Sheboygan River Basin Areawide Water Quality Management Plan (WDNR 1988, 1995); and
- Kohler Landfill Superfund Project.

Cropland erosion and construction site runoff, in-place pollutants and upstream sources of polluted runoff limit water quality. The limiting factors for this reach are toxic contamination from polychlorinated biphenyls (PCBs), heavy metals, polycyclic aromatic hydrocarbons (PAHs), excessive sedimentation, and bacterial pollutants. In 1992, PAH contamination of the floodplain soils near Camp Marina was discovered during construction of floating piers. This site formerly contained a coal gasification facility, operational until the 1930s, a suspected source of the contamination. The next occupant of the site used one area to store fuels in tanks, providing another possible source of the floodplain contamination. The extent of PAH contamination in the river sediment is undetermined.

This reach is classified as a warm water sport fish community. The fishery consists of smallmouth bass, walleye, northern pike, crappie, channel catfish, rock bass, and assorted panfish. Smallmouth bass dominate the sport fishery in this segment. Tolerant forage species include common carp, common shiner, sand shiner and bluntnose minnow. This segment also exhibits seasonal runs of salmon and trout. In response to concerns about PCB contamination of the fish, salmon stocking in the Sheboygan River was suspended in 1987.

Four recent studies to investigate the impact of PCBs to biota in this segment of the Sheboygan River have recently been completed or are ongoing. Kathy Patnode et al. (1998) conducted studies on (1) snapping turtles, (2) mudpuppies (aquatic salamanders), and (3) tree swallows. Burzynski et al. (1999) conducted a food chain study to examine contaminant transport from contaminated sediments and water column to larval and emergent macroinvertebrates, and fish.

Snapping Turtles

Snapping turtles from contaminated rivers accumulate high body burdens of PCBs that are transferred to the eggs. Our objective was to incubate snapping turtle clutches from PCB-contaminated and reference site conditions to determine if reproduction is impacted (Patnode *et al*. 1998a). To date, clutches have been collected from 10 females within contaminated sites and 4 from reference sites. Egg composites from each clutch were analyzed for PCBs found in Great Lakes ecosystems. Half of each clutch was incubated at male-inducing and the other half at female-inducing temperatures. Hatching success was reduced in clutches with PCBs greater than 15 ppm, particularly in those incubated at male-inducing temperatures. In 1996 and 1997, gross deformities were observed in 2 turtles and bent tails were observed in 9. Growth curves diverged at 16-24 weeks resulting in significantly higher (+33%) final weights for hatchlings with 1-15ppm, while those with >15ppm did not differ from reference hatchlings. Responsiveness was inversely related to PCB exposure; turtles with the highest PCB concentration

performed the poorest. Turtles were necropsied at 15 days or 33 weeks to determine the sex of gonads, analyze blood samples for circulating hormone levels, and test liver enzyme activity for the effects of PCBs. Liver enzyme activity responsible for degrading PCBs in hatchling turtles is elevated in a dose-dependent manner by >1ppm PCB, while in juveniles turtles it is suppressed. PCB exposure appears to result in greater variability in estrogen to testosterone ratios at 15 days, but no relationship is evident in the data currently available. Data from 8-month-old juveniles suggests that increasing PCBs may suppress the female hormone (progesterone) to male hormone (testosterone) ratio.

Thus far, 162 juvenile turtles have been marked and released where the female was captured. We intend to resample released turtles through periodic trapping to monitor PCB accumulation, growth and survival. In addition, we are continuing the study for a third year. Investigating the health of these individuals over time will enable us to determine if PCBs are having a long-term impact on snapping turtle populations and evaluate the efficacy of remediation.

Mudpuppies

The upper Sheboygan River watershed and adjacent basins support healthy populations of mudpuppies. However, in the lower Sheboygan River, mudpuppies are absent. Since chronic exposure to contaminants can impair normal physiology, we suspect that their absence is due to discharge and accumulation of municipal, industrial and agricultural wastes in the river (Patnode 1998b). To test this hypothesis, we conducted a caged mudpuppy study in the Sheboygan River. Our first objective was to determine if contaminant exposure in mudpuppies is significantly higher in downstream than upstream segments of the river. Secondly, we wanted to determine if mudpuppy health is impacted by exposure to contaminants.

Thirty mudpuppies were placed in enclosures with mesh that permitted rapid water exchange. Funnel openings were created on the downstream side to allow prey to enter. Enclosures were placed at three sites in the Sheboygan River: one upstream reference site and two sites located within the downstream portion of the river. Necropsies were performed on 10 mudpuppies at the onset of the study to obtain baseline data. Approximately half of the specimens at each site were necropsied at day thirty and the remainder at day forty-five. Nine animals were found dead: 2 at the upper site and 7 at the lower sites. No significant differences were observed between sites for body weight or length, liver weight, or hepatosomatic index. Routine bacteriology did not identify any pathogenic conditions, but fungal infections were suspected to have occluded the gills of the dead animals. PCBs accumulated in mudpuppies over time in the contaminated portion of the river compared to the reference site. The highest concentrations were observed in pool habitat compared to fast-water riffles. Liver enzyme activity was elevated at 45 days in both contaminated sites relative to the reference site. This pilot study demonstrates that these aquatic carnivores rapidly take up PCBs. The potential role of PCBs in the absence of mudpuppies from the lower river requires controlled laboratory studies.

Tree Swallows

Tree swallows are insectivorous birds feeding primarily on emergent invertebrates from surface waters. Exposure to and bioaccumulation of PCBs is well documented in the aquatic food chain in this system, but movement of contaminants to avian and mammal species had yet to be established. Our objectives were to compare PCB accumulation above and below deposits, examine the screening capability of liver enzyme induction, and document impacts on reproduction (Patnode *et al*. 1998c). Study sites occurred along the lower river, while control sites were located upstream. Productivity was monitored and eggs, day 1 and day 12-15 nestlings were collected. Tissues were analyzed for PCBs. Liver enzyme activity from day 12-15 nestlings was determined. Hatching success rates differed between control and study sites

in 1995. Severe flooding in 1996 resulted in loss of nests and reduced nesting activity in all sites. Rate of growth in 1996 did not differ significantly, but was lower at contaminated sites. A few highly contaminated clutches in the control sites may be the result of relocation of unsuccessful, PCB-contaminated females that have relocated upstream. All nestlings at control nests had negative PCB accumulation rates. Day 1 nestlings at study sites had negative rates due to growth dilution of egg burden, but accumulated PCBs between days 1 and 12. PCB accumulation in study sites was congener and site-dependent reflecting exposure via egg deposition and prey. Liver enzyme activity was correlated with PCB concentration in study sites in 1995, but was not evident in 1996. When analysis is completed, data collected in 1997 will be compared to 1995 and 1996 to form the basis of pre-remediation biomonitoring. The study will be repeated immediately following remediation and 5 years thereafter.

Food Chain Study

A study to determine how PCBs, PAHs and heavy metals accumulate through the food chain was initiated in 1994 for the Sheboygan River Remedial Action Plan Area of Concern (WDNR, 1995). Data were collected for both abiotic (sediment and water column) and biotic (invertebrates and fish species) components of the ecosystem. A final report outlining results will be completed in the spring of 1999 and distributed to interested parties.

Other Studies

A number of other studies have been conducted on this reach of the Sheboygan River to investigate the extent of PCB contamination and the resulting environmental impacts as part of the Sheboygan River and Harbor Superfund Project (see Southeast Region WDNR files for complete record).

Macroinvertebrate collections made during the Tecumseh pilot studies of the Sheboygan River and Harbor Superfund investigation in 1992, showed Hilsenhoff biotic index (HBI) values of 5.155 for this segment of the Sheboygan River representing "fair" water quality with fairly substantial organic pollution. The segment is dominated by the *Cheumatopsyche sp.* This segment is only partially meeting its biological use potential, due to loss of fish and invertebrate habitat and toxic contamination. This segment has the potential to provide an excellent hunting and fishing environment, but due to toxic contamination and the subsequent fish and waterfowl consumption advisory, it is under-utilized.

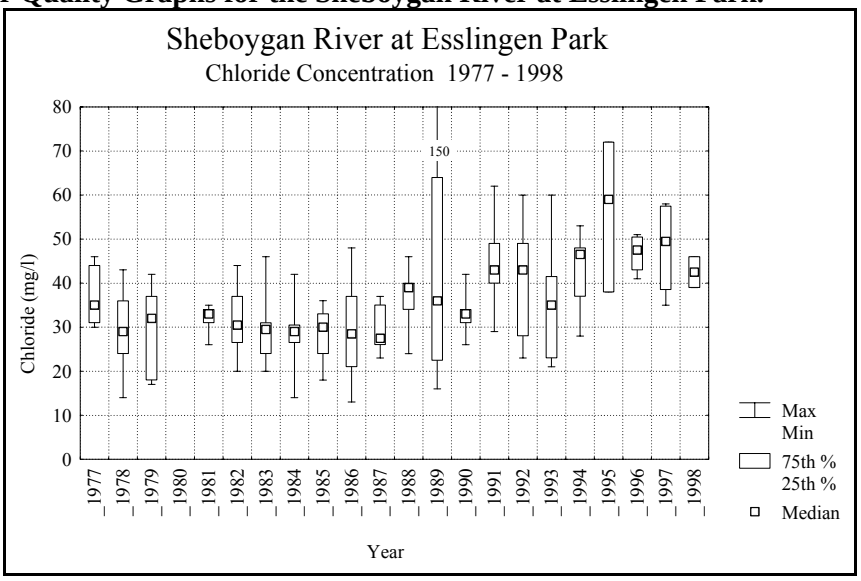
Surface water chemistry data examining conventional pollutants (i.e. nutrients, solids, bacteria etc.) have been collected regularly in the Sheboygan River when the Wisconsin Department of Natural Resources established long-term water quality monitoring stations in 1977. Sites were selected throughout the State to establish baseline conditions for major rivers and provide the data necessary to track water quality over time. Long-term water quality trend monitoring data serves as an indicator of the overall water quality for the watershed encompassing most of the nonpoint and point source contributions to the stream. Trend analysis is a statistical procedure to determine whether values of a particular water quality variable have changed over time. A long-term water quality monitoring station was established within this stream reach at Esslingen Park in 1977. This site has been sampled on a nearly monthly basis.

Galarneau (1996) conducted a trend analysis for water quality parameters measured at Esslingen Park for the period from 1977 through 1994. Suspended solids, total phosphorus, dissolved phosphorus, ammonia, nitrate plus nitrite, chlorides, and fecal coliform bacteria, had all been collected fairly consistently over the study period. Stream flow was obtained from a USGS gage station located just upstream of Esslingen Park near Interstate Highway I43. Water quality data collected from the Sheboygan River at Esslingen

Park showed downward trends in total phosphorus, dissolved phosphorus, nitrate plus nitrite, and fecal coliform bacteria. Chlorides displayed an upward trend over the same period.

Graphical representations of the water chemistry data collected to date are shown below (Figure 1). Box-whisker graphs show the median (50%), minimum, maximum, and percent of median for nutrients, suspended solids, chlorides and bacteria for the period 1977 - 1998. The 1998 data only include the winter and spring sampling periods.

Figure 1. Water Quality Graphs for the Sheboygan River at Esslingen Park.



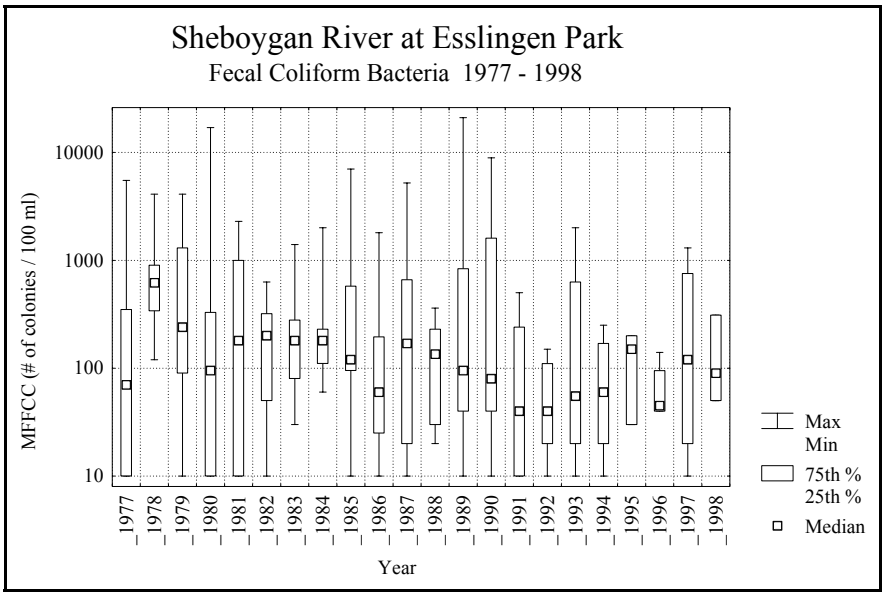
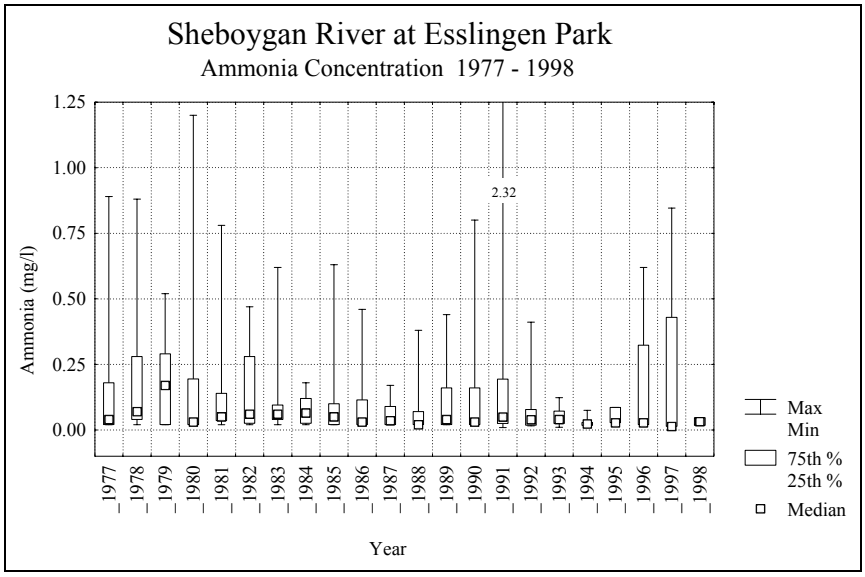


Figure 1 continued.



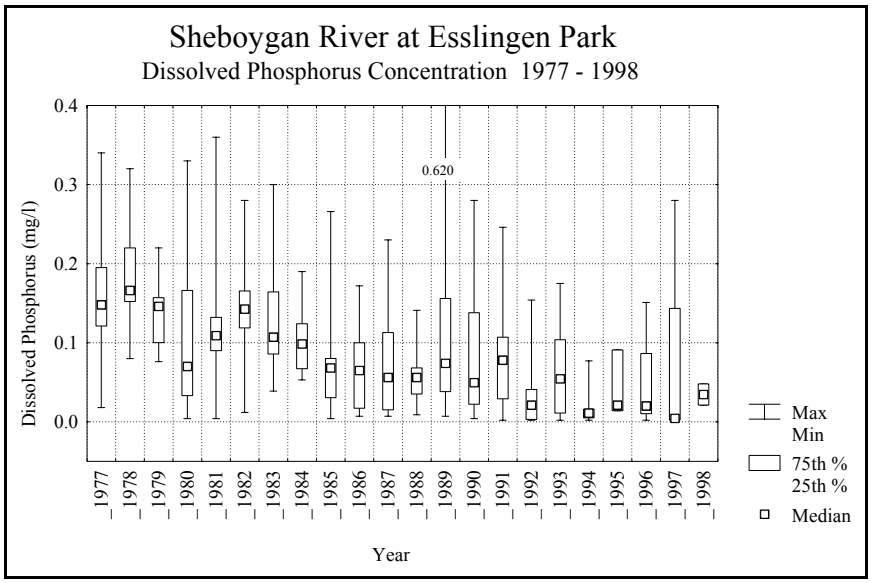
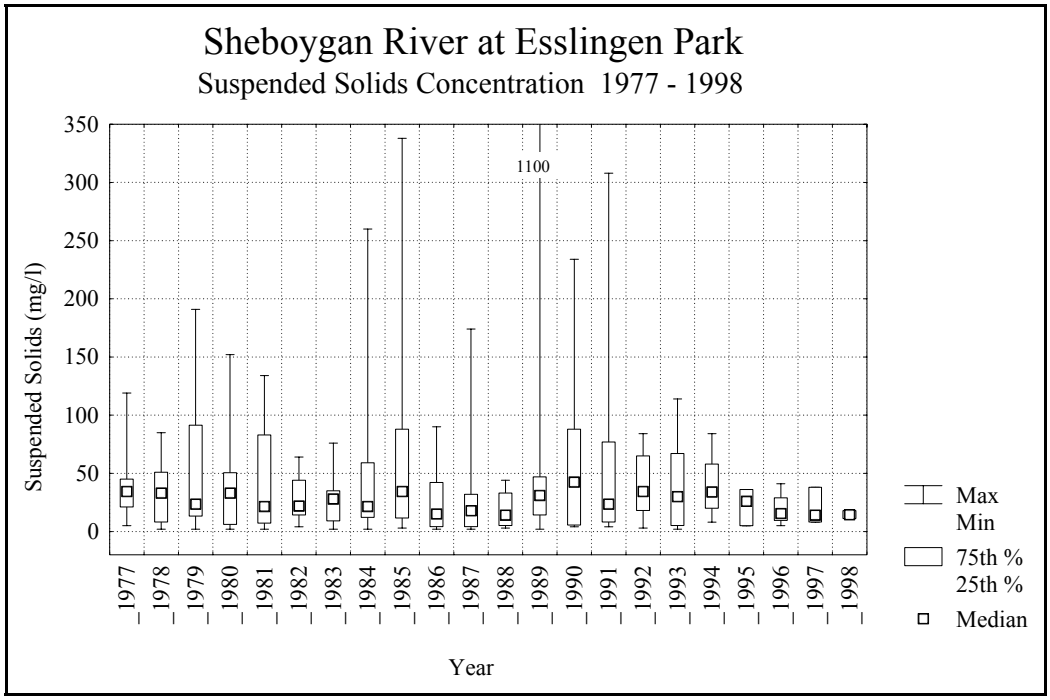
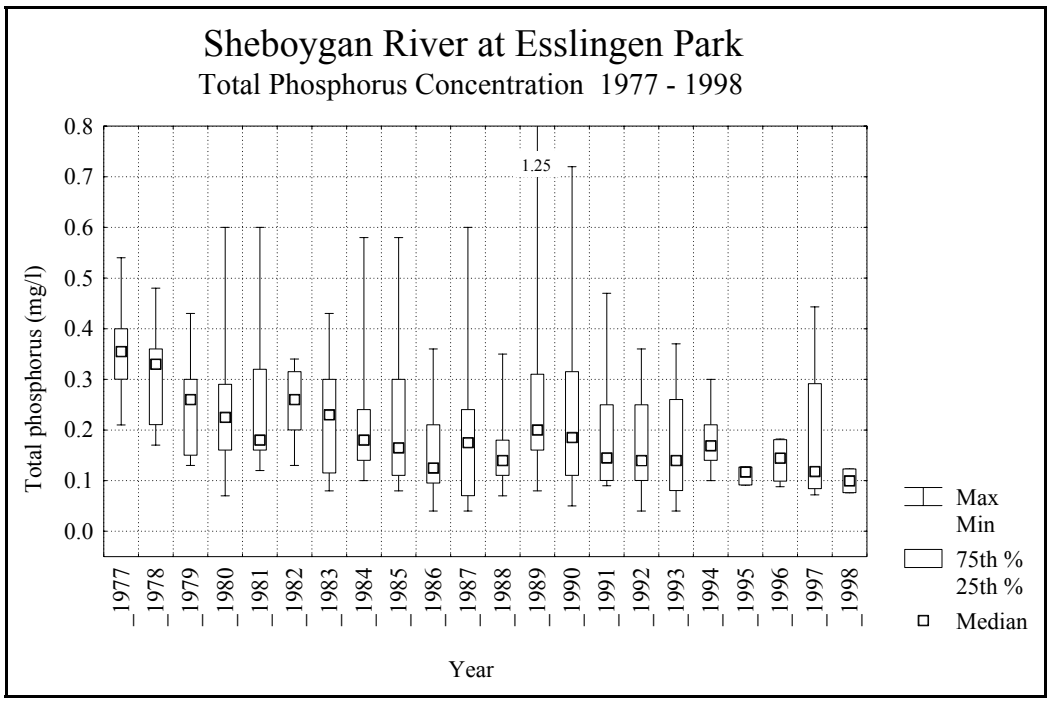


Figure 1 continued.





SHEBOYGAN RIVER SEGMENT 2 (RM 9.9-15.2)

This segment includes the Sheboygan River main stem from the lower Kohler Dam to its confluence with the Mullet River. This segment runs through east central Sheboygan County and is contained almost entirely within the city limits of Sheboygan Falls and the town of Kohler. Two major rivers flow into the

Sheboygan River within this river reach, the Mullet and Onion Rivers. The water quality conditions of these two rivers are discussed in separate sections in the WQMP. Three industries, Bemis Manufacturing, Tecumseh Products, and the Kohler Corporation, discharge directly or indirectly via storm sewers, to the Sheboygan River (DNR 1980). Tecumseh Products Company, working in cooperation with the U.S. Environmental Protection Agency, removed 5,000 cubic yards of PCB-contaminated sediment in three locations that contained concentrations of PCB between 890 and 4,500 ppm. Tecumseh and the U.S. EPA are deciding upon additional river cleanup activities for this Superfund site, with concurrence by the Natural Resources trustees, WDNR, NOAA, and USFWS. A public informational meeting will be held in 1999 to discuss the proposed cleanup activities.

This segment is classified as warm water sport fish community with smallmouth bass being the predominant sport species. The lower Kohler Dam prevents salmon and trout migration. Water quality conditions within this segment are considered to be poor to fair. Limiting factors include PCBs, heavy metals, excessive sedimentation, organic enrichment, and impoundment barriers. The pollutant sources for problems in the river segment include cropland runoff, streambank erosion or scour, urban runoff, construction site runoff, and in-place pollutants. High PCB content in tissues limit the potential for unrestricted fishery and wildlife uses.

Wisconsin DNR macroinvertebrate collections during the 1992 Tecumseh pilot studies project were dominated by *Cheumatopsyche sp.* This segment had an HBI value of 5.31 "fair" water quality with substantial pollution likely. During the 1978 basin study, periphyton samples were collected with the population equally dominated by both tolerant and intolerant species.

SHEBOYGAN RIVER SEGMENT 3 (RM 15.2-45.0)

This segment extends from the confluence of the Mullet River upstream to the Rockville Dam. Polluted runoff from agricultural activities is a major problem and particularly evident in downstream reaches. Water quality is limited by cropland runoff, streambank pasturing, turbidity, bioturbation, low flows, and the Franklin and the Millhome impoundments. Further discussion of the water quality problems associated with the dams is reported in the impoundment section of this report (page **Error! Bookmark not defined.**). The dams prohibit upstream movement of smallmouth bass, northern pike and other species from their winter habitat to spawning or summer habitat. The obstructions limit fish populations, especially into the upstream areas. There are no industries or municipalities having a serious point source impact on water quality in this stretch of the river, but it has been degraded in the past by effluent from the Kiel wastewater treatment plant and Johnsonville Sausage, Inc. discharges. Carp activity between May and October contributes greatly to chronic turbidity problems.

This segment of the Sheboygan River is classified as supporting a warm water sport fish community, with a fishery consisting of smallmouth bass, northern pike, crappie, and panfish. Other common species found in this segment include rock bass, walleye, and channel catfish. Tolerant species such as common carp, fathead minnows, creek chub, and johnny darter were also present. Intolerant species were present in reaches of this segment, and included hornyhead chub, longnose dace, stonecat and logperch (Fago 1985).

Macroinvertebrate collections taken during the Tecumseh pilot studies (Aartila 1992) were dominated by *Certopsyche morosa bifida*. The Hilsenhoff biotic index value for this segment is 5.43 indicating "fair" water quality with substantial organic pollution likely.

SHEBOYGAN RIVER SEGMENT 4 (RM 45.0-68.3)

This reach of the river extends from the Rockville Dam upstream to County Highway W. Marshlands adjacent to the channel throughout most of this reach have served as a natural filter for polluted runoff, lessening the impact from nonpoint source pollutants. Sediment collects behind all impoundments and limits in-stream habitat in this river reach. Municipal wastewater treatment plants at Kiel, Mount Calvary and St. Cloud discharge to this segment of the river.

Water quality is limited by sediment loads, nutrient excess, naturally occurring low dissolved oxygen, and high turbidity. Responsible factors include cropland runoff, feedlot runoff, streambank runoff, streambank pasturing, bioturbation, and human-made impoundments. Although these pollutants and sources limit water quality, the river segment displays a wide range of water quality. Water downstream of the marshes is filtered, while water upstream of the barriers displays the characteristics of impoundments. Although the Sheboygan Marsh Dam area is an impoundment, it was installed to restore a naturally occurring wetland. See the Sheboygan Lake/Marsh section (page **Error! Bookmark not defined.**) for additional information on the Sheboygan Marsh segment of the river.

This river reach is classified as supporting a warm water sport fish community, with the fishery consisting of northern pike, bullheads, crappie, largemouth bass, panfish, and yellow perch. Very tolerant species include common carp, and central mudminnow. Intolerant species such as Iowa darter, stoneroller, hornyhead chub, northern redbelly dace, and tadpole madtom were also found here (Fago, 1985; WDNR 1994). Macroinvertebrate populations varied with the quality of the water. "Fairly poor" to "poor" water quality is dominated by the chironomid *Cladotanytarsus sp.*, the Amphipod *Hyallela azteca* and caddisflies. Hydropsychid caddisfly, chironomid larvae, and blackfly larvae dominated “fair” water quality conditions. The excellent water quality reaches exhibited poor macroinvertebrate diversity with tolerant organisms dominating the community. Slow moving, deep water plus poor substrate is the limiting factor to a more diverse community.

The concentrations of PAHs, heavy metals, and PCBs were higher in the Sheboygan River in Kiel than downstream in the Rockville Impoundment (WDNR 1999). All concentrations are consistent with values observed in urban environments. The Sheboygan River near Kiel does not require specific sediment management activities at this time.

SHEBOYGAN RIVER SEGMENT 5 (RM 68.3-81.0)

This reach of the Sheboygan River originates at the headwaters and terminates 12.7 miles downstream at County Highway W. The Dotyville Sportsman's Club operates a trap range immediately north of Walnut Road and west of the river, located such that lead shot has the potential to drop into the river and along the banks. In addition, five small holding ponds comprising about five acres are adjacent to the river in the NW1/4, NE1/4, Sec.18, T15N, R19E. These ponds were constructed by the Tolibia Cheese Company and used to dispose of brine process wastewater. These ponds were constructed and used without DNR approval, and were therefore abandoned in 1986. A visual inspection conducted in the summer of 1987 confirmed that no surface water contamination was taking place from these ponds. There may, however, be a potential for groundwater contamination.

Sedimentation, nutrients, and loss of habitat degrade water quality in this segment. Responsible factors include cattle pasturing, cropland runoff, streambank erosion, and channelization. This segment is classified as supporting a warm water sport fish community. Habitat and water quality currently support an assemblage of tolerant forage and warm water game fish. Representative sport fish consist primarily

of northern pike, sunfish, yellow perch, and bullheads. Common forage species include shiners, white suckers, and creek chub.

Table 25. . Streams of the Sheboygan River Watershed.

Stream Name/Location (T, R, Sec., QQ, Q)	WBIC	Length	Biological Use		Codified	Supp.	Assess. Category	Use Impairments		Ref.	Data Level
			Existing	Potential				Source	Impact		
Feldner's Creek T16N R19E Sec.35 NENW	61000	1.8	COLD[1] CLASS II	COLD CLASS II	COLD	PART	M	NPS,HM, PSB	FLOW, TURB, SED		3
Unnamed Tributary to Sheboygan River at RM 43.7 T17N R21E Sec.28 NENE	57700	2.0	WWFF	WWFF	WWFF	PART	M	NPS, DCH, SB	SED, HAB		3
Unnamed Tributary (Gooseville Creek) to a tributary to Sheboygan River at RM 43.7 T17N R21E Sec.21 SESE	57800	1.0	WWFF	WWFF	WWFF	PART	M	NPS, DCH, SB	SED, HAB		3
Unnamed Tributary to Gooseville Creek T17N R21E Sec.21 SWNE	58100	1.0	UNK	UNK	DEF	UNK					
Millhome Creek T16N R21E Sec.2 NENE	57200	1.7	COLD[1] CLASS I	COLD CLASS I	ERW COLD	PART	M	NPS,HM, PSB, DCH	TURB, SED		3
Otter Creek T15N R22E Sec.7 NWNW	56400	4.2	WWSF	WWSF	DEF	PART	M	NPS, PSB, BY, DCH, SB	SED, NUT, BAC, TEMP, NH3		4
Unnamed Tributary to Otter Creek at RM 1.2 T15N R21E Sec.1 SESW	56410	2.0	UNK	UNK	DEF	UNK					
Unnamed Tributary to Otter Creek at RM 3.2 T15N R21E Sec.2 NENW	56500	2.0	UNK	UNK	DEF	UNK					
Schuett Creek T16N R21E Sec.13		0.4	COLD[1] CLASS I	COLD CLASS I	ERW COLD	PART	M	PSB, BY	TURB, SED		4
Sheboygan River Segment 1 RM 0-9.9 T15N R23E Sec.23 SESE	50700	81 total 9.9 mile reach	WWSF	WWSF	WWSF	PART	M	URB, PSI, RS, HM, NPS	SC, PCB, ORG, SED, TURB, HAB, TOX, FAD		4
Sheboygan River Segment 2 RM 9.9-15.2	50700	81 total 5.3 mile reach	WWSF	WWSF	WWSF	PART	M	URB, PSI, RS, HM, NPS	SC, PCB, ORG, SED, TURB, HAB, TOX, MIG, FAD		4
Sheboygan River Segment 3 RM 15.2-45.0	50700	81 total 29.8 mile	WWSF	WWSF	WWSF	PART	M	NPS, CL, SB	SED, TURB, MIG		4

Stream Name/Location (T, R, Sec., QQ, Q)	WBIC	Length	Biological Use		Codified	Supp.	Assess. Category	Use Impairments		Ref.	Data Level
			Existing	Potential				Source	Impact		
		reach									
Sheboygan River Segment 4 RM 45.0-68.3	50700	81 total 22.7 mile reach	WWSF	WWSF	WWSF	PART	M	URB, PSI, NPS, CL, HM	SED, NUT, TURB, MIG		4
Sheboygan River Segment 5 RM 68.3-81.0	50700	81 total 12.7 mile reach	WWSF	WWSF	WWSF	PART	M	URB, HM, NPS, CL, PSB	SED, HAB		4
Weedens Creek Tributary to Sheboygan River at RM 8.9 T15N R23E Sec.32 SWSW	50800	5.9	WWSF	WWSF	WWSF	PART	M	NPS, HM, CL, SB, URB, HAB	TURB, FLOW, NH3, NUT, SED, HAB		4
Mehles Springs Tributary to Sheboygan River at RM 51.9 T16N R21E Sec.7 NWSE	58700	1.0	WWFF	WWFF	DEF	FULL	E				2
Unnamed Tributary to Sheboygan River T15N R23E Sec.30 SESE	50950	2.5	LAL	LAL	LAL	PART	E	NPS, PSI, HM	TURB, SED, TOX		2
Unnamed Tributary to Sheboygan River at RM 23.1 T15N R22E Sec.16 SWSW	56300	2.0	UNK	UNK	DEF	UNK					
Unnamed Tributary to Sheboygan River at T16N R19E Sec.33 NWSE											
Unnamed Tributary to Sheboygan River at RM 61.1 T16N R20E Sec.31 NENW	60100	2.0	UNK	UNK	DEF	UNK					
Unnamed Tributary to Sheboygan River at RM 61.5 T16N R20E Sec.31 NWNW	60200	1.0	UNK	UNK	DEF	UNK					
Unnamed Tributary (South Ditch) to Sheboygan Marsh	59000	2.0	WWSF	WWSF	DEF	PART	M	HM, DCH, DRDG, NPS	DO, MAC, SED		4

Stream Name/Location (T, R, Sec., QQ, Q)	WBIC	Length	Biological Use		Codified	Supp.	Assess. Category	Use Impairments		Ref.	Data Level
			Existing	Potential				Source	Impact		
T16N R20E Sec.13 SWSE											
Unnamed Tributary (Elkhart Lake Outlet) to Sheboygan Marsh T16N R20E Sec.24 SWSE	59100	1.0	WWSF	WWSF	DEF	PART	M	HM	FLOW		4
Unnamed Tributary (North Ditch) to Sheboygan Marsh T16N R20E Sec.15 SESE	59400	2.0	WWSF	WWSF	DEF	PART	M	HM, DCH, DRDG, NPS	DO, MAC, SED		3
Unnamed Tributary to North Ditch at RM 1.7 T16N R20E Sec.16 NENW	59500	2.7	WWFF	WWFF	WWFF	PART	M	HM, DCH, NPS, PSI, SB	FLOW, SED, HAB		4
Unnamed Tributary to North Ditch at RM 2.9 T16N R20E Sec.8 NWSE	59600	5.0	UNK	UNK	DEF	UNK					
Unnamed Tributary (Vicks Ditch) to Sheboygan Marsh T16N R20E Sec.23 SWSW	59700	1.0	WWSF	WWSF	DEF	PART	E	HM, DCH, DRDG, NPS	DO, MAC, SED		2
Unnamed Tributary (Bergin Ditch) to Sheboygan Marsh T16N R20E Sec.22 NWSE	59800	1.0	WWSF	WWSF	DEF	PART	E	HM, DCH, DRDG, NPS	DO, MAC, SED		2
Unnamed Tributary (Main Ditch) to Sheboygan Marsh T16N R20E Sec.22 SENW	59900	1.0	WWSF	WWSF	DEF	PART	E	HM, DCH, DRDG, NPS	DO, MAC, SED		2
Unnamed Tributary (Main Ditch) to Sheboygan Marsh T16N R20E Sec.22 SENE	60000	3.0	WWSF	WWSF	DEF	PART	E	HM, DCH, DRDG, NPS	DO, MAC, SED		2
TOTALS		**127.2**									

(3) Trout streams as defined in Wisconsin Trout Streams (1980) but not listed in NR 102. These streams may be classified as trout streams under 1.02(7) since publication of Wisconsin Trout Streams (1980), but are not formally classified as trout waters. These streams will be added to NR 102 and/or NR 104 during code revision.

SHEBOYGAN RIVER IMPOUNDMENTS

There are ten dams in the Sheboygan River Watershed (Table 37). Many water quality, habitat, and biotic impacts are associated with the impoundments caused by dams on the river. The environmental concerns associated with dams are listed in Table 38.

Table 26. Sheboygan River Watershed Impoundments

Impoundments	County	Surface Area (Acres)	Max Depth (ft.)
Sheboygan Falls	Sheboygan	unknown	Unknown
Mischo's Pond Impoundment	20	23	5
Johnsonville Impoundment	Sheboygan	8.5	6
Franklin Millpond	Sheboygan	Dam removed	Free-flowing river.
Sheboygan Lake Impoundment	Sheboygan	674	4
Kiel Impoundment	36	250	8
Millhome Impoundment	36	51	6
Rockville Impoundment	36	110	6
Kohler Impoundment (Formed by the Waelderhaus and Lower Kohler Dams)	Sheboygan	21 (combined acreage)	8

Table 27. Water Quality, Biotic and Habitat Impacts Associated with the Placement of Dams on Streams.

Water Quality Impacts	Biotic Impacts	Habitat
» Increased water temperatures » Lower dissolved oxygen levels » Higher suspended solids (proliferation of planktonic algae) » Bioturbation-by carp and other bottom-dwelling fish, creating higher downstream turbidities	» Fish migration interference (segmentation of the Sheboygan River) » Loss of riffle spawning habitat » Covering of riffle-dwelling macroinvertebrates » Displacement of lotic mussel species	» Habitat fragmentation » Loss and coverage of coarse bottom materials » Loss of riverine habitat

Exotic species are a threat to the biological integrity of our surface waters in and as with carp, impoundments create habitat conducive to the proliferation of other exotic species. Two more exotic species found in the Sheboygan River Watershed that benefit from impoundments are the aquatic plant Eurasian water milfoil (*Myriophyllum spicatum*), and zebra mussel (*Dreissena polymorpha*). The

Eurasian milfoil plant is primarily a lentic (standing water) plant which grows and spreads rapidly out-competing the native species. It grows in thick mats, is poor fish habitat, and interferes with recreational uses.

Zebra mussels are small fingernail size clams that attach to firm surfaces including plants, rocks, gravel, wood, crayfish, native mussels and each other. Zebra mussels can have significant ecological impacts by altering water clarity and nutrient cycling, physically clogging intakes and may extirpate native mussels. The Sheboygan River Watershed is unique in the Sheboygan River Basin in that zebra mussels are present in the very headwaters (Elkhart Lake) and the mouth of the river (Sheboygan Harbor / Lake Michigan). Horvath et al. (1998) studied zebra mussel dispersal in lakes (lentic habitat) with outlet streams (lotic habitat). They found that the zebra mussel populations in small streams (< 30m) were supported by the continual source of zebra mussel veligers (free-swimming larvae) from a source lake. Zebra mussel veligers flow out of Elkhart Lake to the Sheboygan River and have reached the next downstream impoundment – Sheboygan Marsh (Nelson, 1998). The extent of the population of zebra mussels to this reach of the Sheboygan River, its impact to the native mussels, or the population concentration in the Sheboygan Marsh are not known at this time. There is the potential for the Sheboygan Marsh to be another source of zebra mussels supplying veligers to the next stream reach. The abundant number of impoundments on the Sheboygan River present the potential for a series of sources and sinks (i.e. alternative lentic and lotic reaches) for zebra mussel colonization. The removal of dams would reduce the habitat suitable for zebra mussel colonization. The observed presence of the Eurasian milfoil and zebra mussel in the Sheboygan River Watershed at this time are shown in Table 39.

Table 28. Observances of Eurasian water milfoil and zebra mussels in impoundments within the Sheboygan River Watershed.

Impoundment	Eurasian Water Milfoil	Zebra Mussel
Franklin Millpond – ***no longer exists; dam has been removed.***	n/a	n/a
Kiel Millpond	No	No
Millhome Millpond	No	No
Rockville Millpond	No	No
Sheboygan Falls	No	No
Johnsonville	No	No
Kohler Dams	No	No
Mischo's Pond	No	No
Sheboygan Marsh	Yes	Yes

MILLHOME IMPOUNDMENT

T17N R21E Sec. 34, Manitowoc County
Surface Acres = 51, S.D.F. = 3.61, Maximum Depth = 6 feet

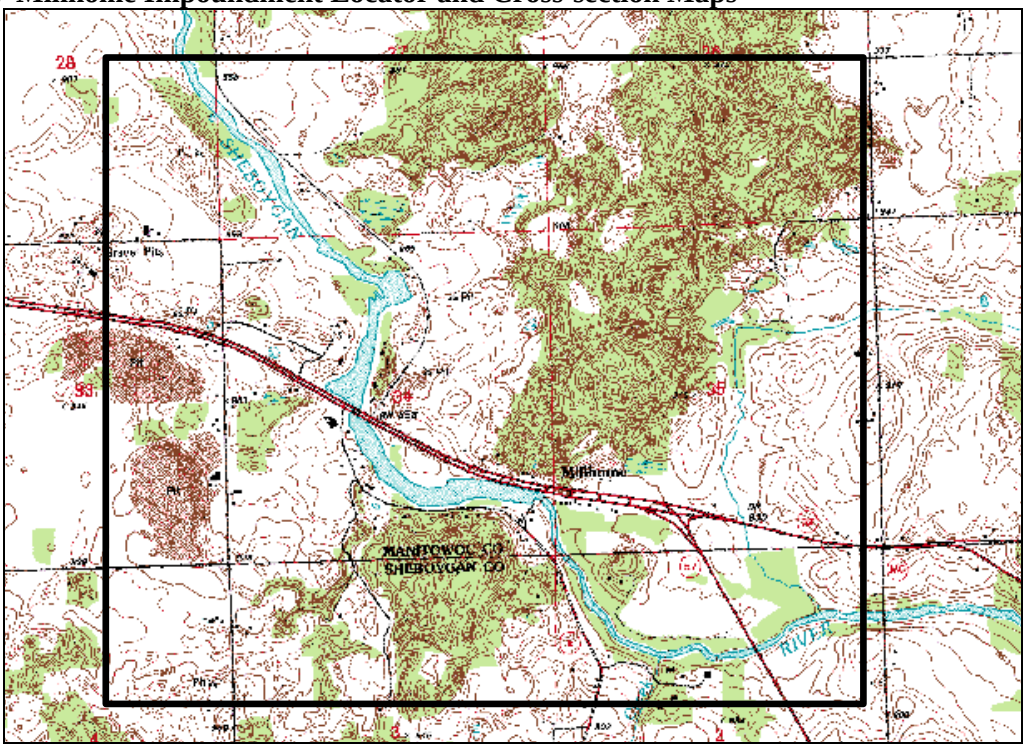
Millhome Flowage is a moderately long and narrow impoundment in the Sheboygan River lying in the terminal moraine, created by a dam with a six-foot head. Bottom materials are primarily muck and rubble. The water is hard, alkaline and of low transparency. Bullheads, crappies, channel catfish, and northern pike comprise the fishery. Use problems include algae, carp, stunted panfish, and fluctuating water levels. Land use adjacent to the impoundment is primarily agriculture. State Highway 57 parallels the north shore for one-half mile and provides public access via a wayside park. Hunting is permitted and a moderate number of ducks provide for hunting in fall.

The water quality of the Millhome Impoundment was sampled on May 4, and August 24, 1994. The sample location was approximately 150 feet upstream of the dam (Lat 43°53'41"N, Long 87°57'54"W), in the middle of the channel in 6 feet of water. Dissolved oxygen, and temperature profiles were obtained along with surface total phosphorus, and chlorophyll *a* samples and Secchi depth measurements.

The August temperature profile shows that the impoundment was not stratified. The total phosphorus and chlorophyll *a* results indicate that the impoundment is very productive. Total phosphorus concentrations were 0.107 and 0.115 mg/l in May and August respectively. The chlorophyll *a* concentration in August was 61.5 ug/l. Water clarity was poor (0.5 meters) during both sampling dates (Wakeman 1996).

The water depth of the Millhome Impoundment was measured across 17 transects between the dam and the top end of the impoundment. The maximum depth was 6.5 feet that was located along transect 16. Figures 2 and 3 show the cross section locations and the water depths along each transect. The main thalweg (stream channel) meanders across the width of the channel more so downstream of the HWY 57 bridge than upstream. No sediment samples or depth measurements were taken during the survey however there appeared to be a diversity of substrate types present in the impoundment. In some areas there was soft fine-grained sediment typical of impoundments and in other areas there appeared to be considerable deposits of rock and or sand and gravel. The coarser material was typically found in the thalweg. An estimate of the amount and distribution of the soft sediment should be made within the impoundment.

Figure 2. Millhome Impoundment Locator and Cross-section Maps



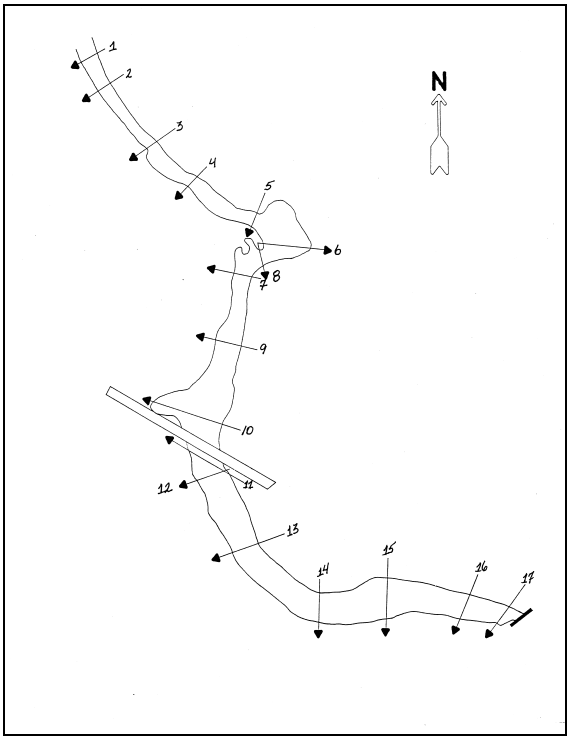
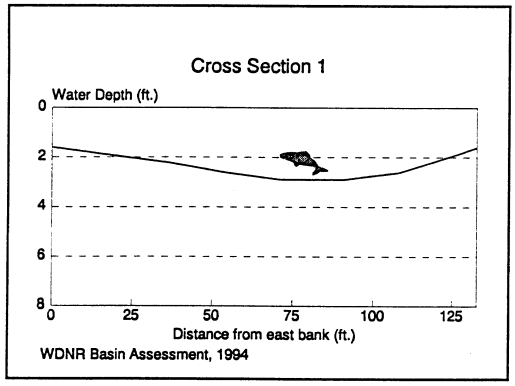
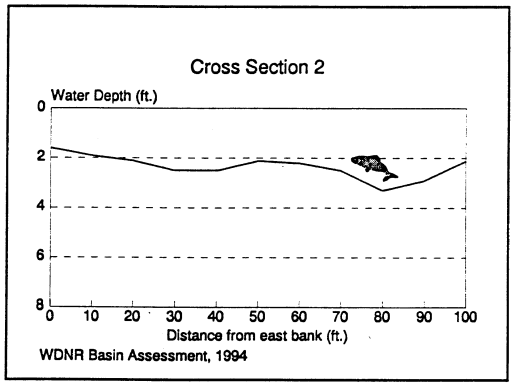
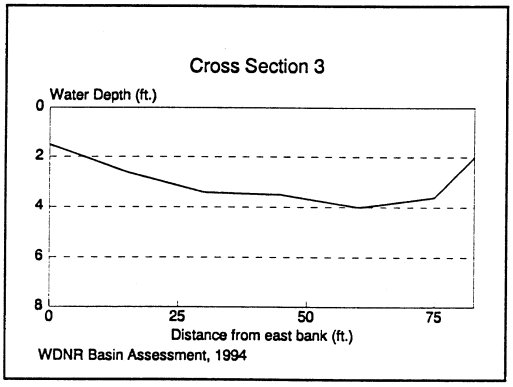
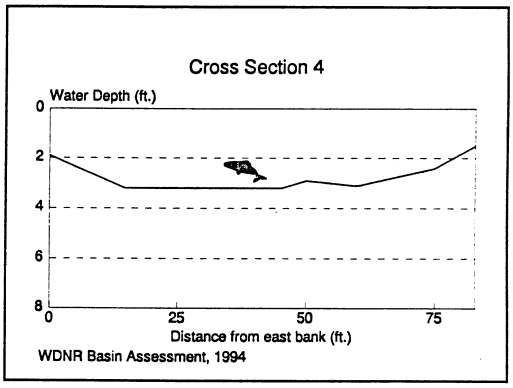


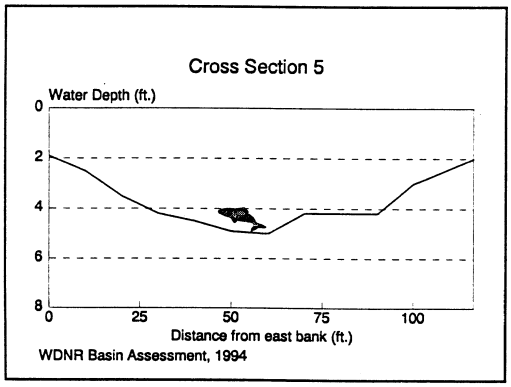
Figure 3. Millhome Impoundment Cross-section Graphs











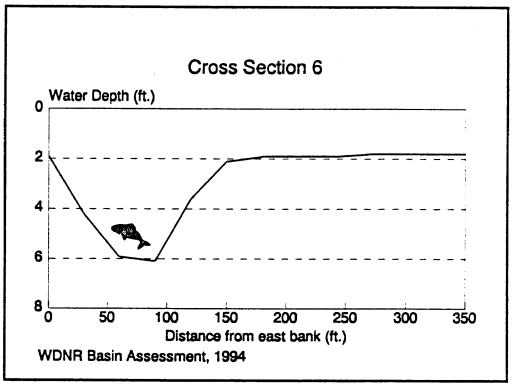
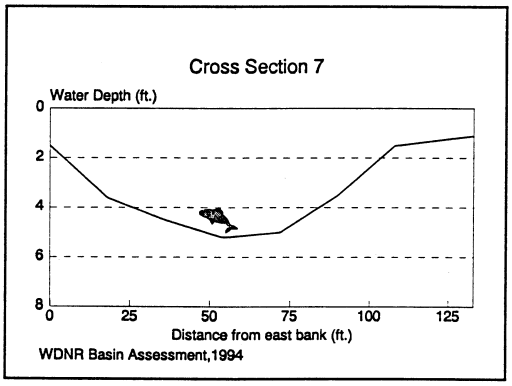
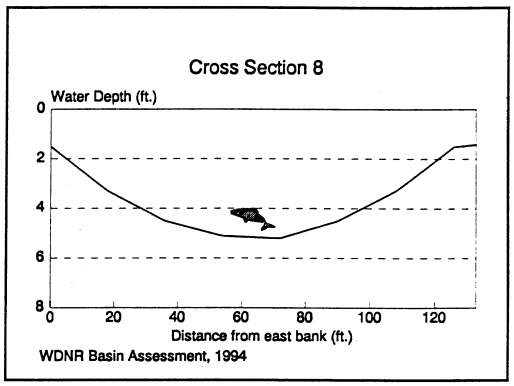
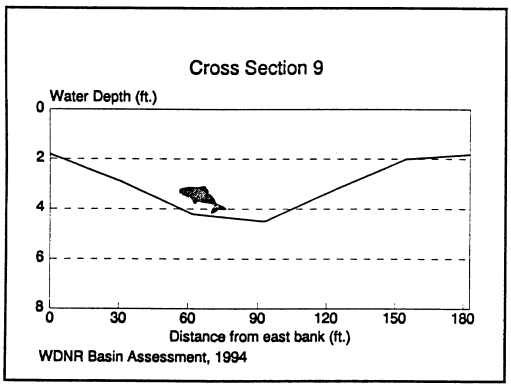
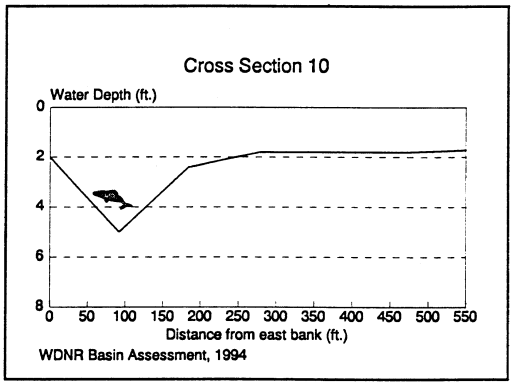


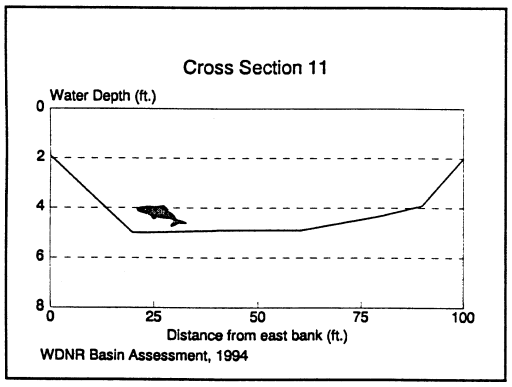
Figure 3. Millhome Impoundment Cross-sections, continued











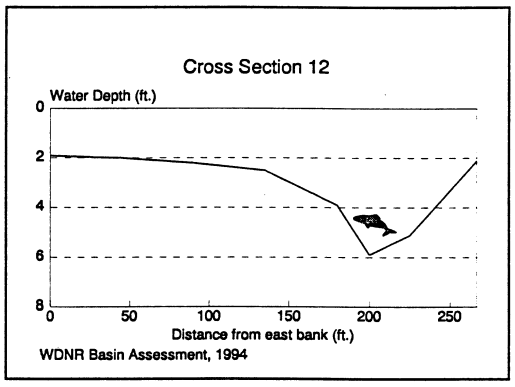
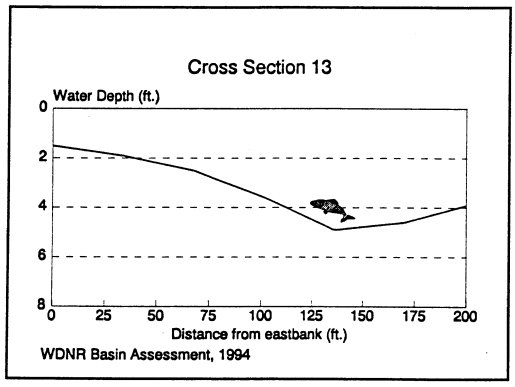
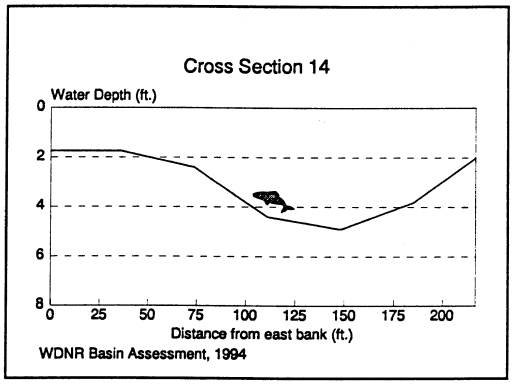
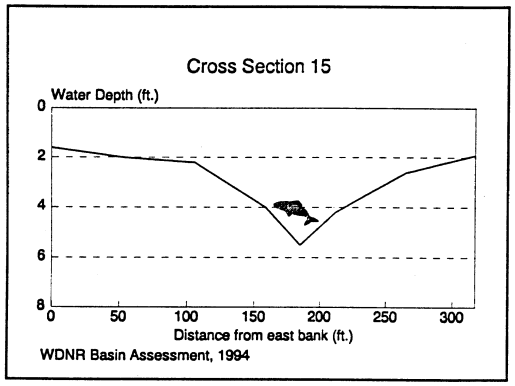
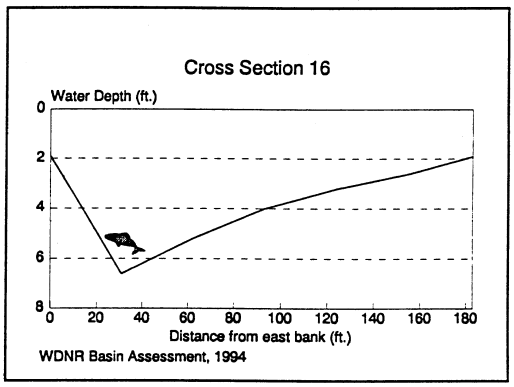


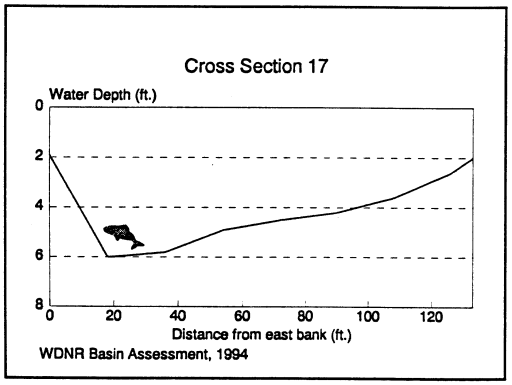
Figure 3. Millhome Impoundment Cross-sections, continued











Aquatic Plants

No detailed aquatic plant observations were made on the Millhome Impoundment. Generally the aquatic plant community was considered to be limited primarily due to poor water clarity. No aquatic plant beds were observed reaching the surface of the impoundment at any point during the monitoring period.

ROCKVILLE IMPOUNDMENT

T17N, R21E, Sections 18, 20, Manitowoc County, Sheboygan River Watershed
Surface acres = 136.9, S.D.F. = 1.79, Maximum depth = 7 feet

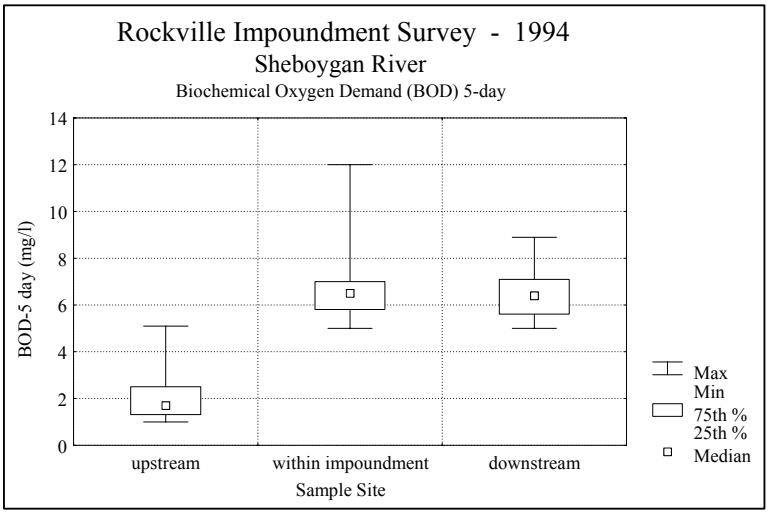
This is a shallow impoundment of the Sheboygan River and the second largest body of water in the county. The dam has a ten-foot head, which impounds the hard, alkaline water for almost a mile. Muck covers most of the bottom but some limited rocky and gravelly areas are present. Northern pike, panfish and bullheads constitute the fishery. An occasional winterkill has occurred in the past. About 85% of the shoreline is agricultural land. The shoreline is largely undeveloped and 10 acres of non-woody wetland adjoins the lake. Access exists via a county boat launch located at Sisson Park which is located adjacent to the Rockville Rd. bridge over the Sheboygan River.

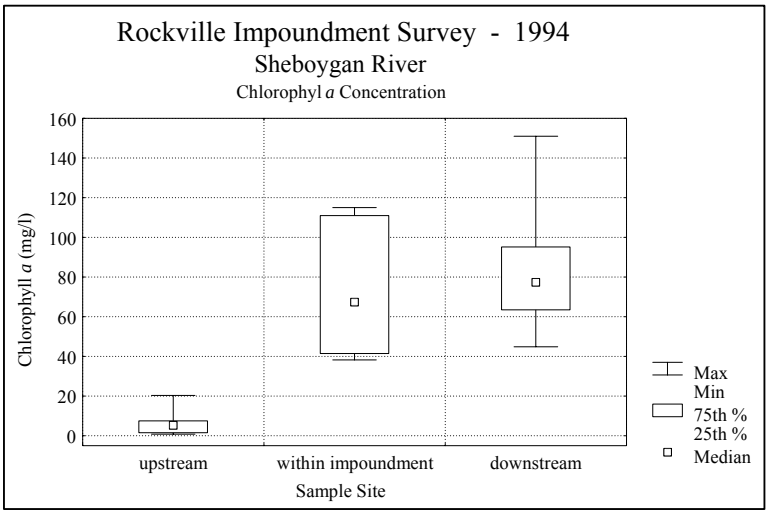
Water Quality

The water quality of the Rockville Impoundment was surveyed on May 5, and August 24, 1994. On May 5, samples were collected near the boat launch located at Sisson Park, which is located adjacent to Rockville Rd. (Lat 43°55'15"N, Long 88°00'30"W). On August 24, 1994 the samples were collected from the Steinthal Road bridge upstream of the dam.

The surface total phosphorus concentration was 0.111 and 0.248 mg/l on the corresponding May and August sampling dates. It should be noted that the sample collected on the May date was collected close to the City of Kiel wastewater treatment facility outfall. The exact location of the discharge was unknown by Water Resource Management staff until after the sample was taken. The chlorophyll *a* concentration in August was 148 µg/l which was the highest of the impoundments sampled in 1994. Water clarity during the May 5 sample date was 1.3 meters, however this was taken upstream of the large shallow section of the impoundment which is believed to generate a significant amount of suspended sediment due to carp activity and wave action. Additional water chemistry monitoring was conducted from the end of May through the beginning of October (n=11) at three sites - upstream of the impoundment, within the impoundment, and downstream of the impoundment. Figures 4 and 5 use box-whisker graphs to show the median (50%), minimum, maximum, and percent of median for nutrients, solids, chlorophyll *a*, and turbidity.

Figure 4. Rockville Impoundment Water Quality Graphs





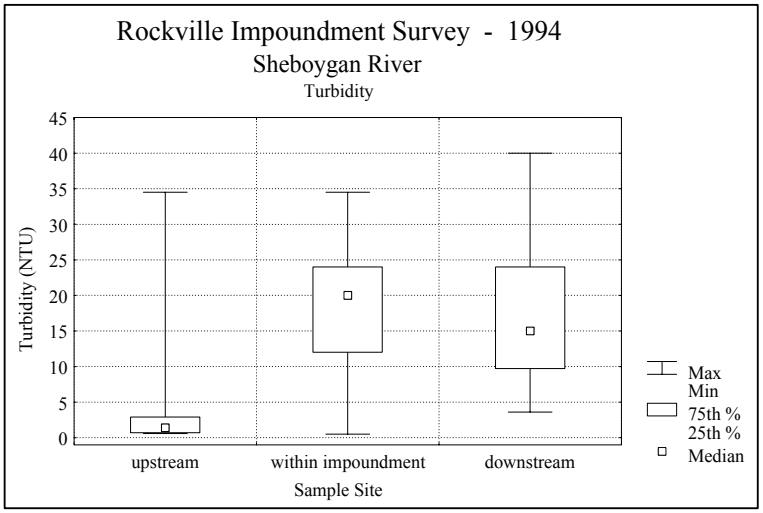
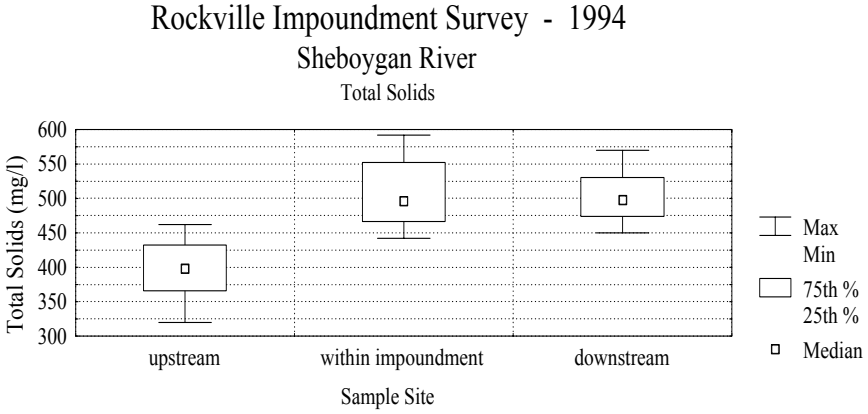
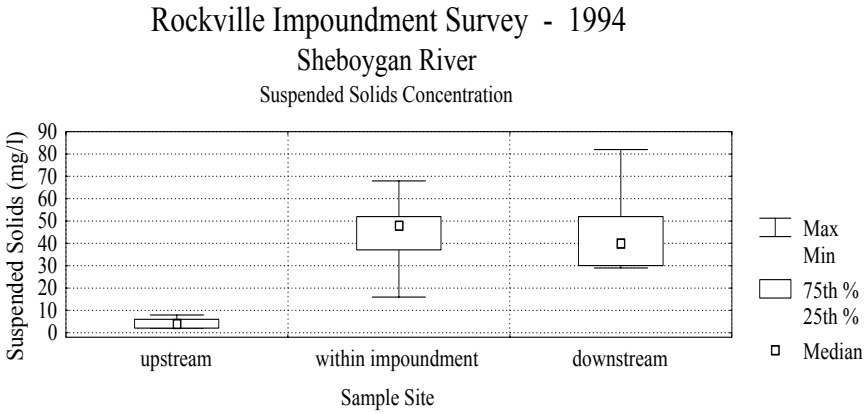
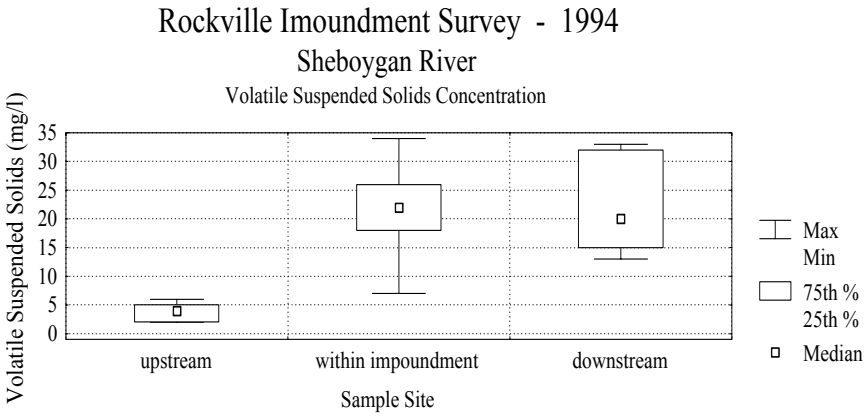


Figure 4 continued.







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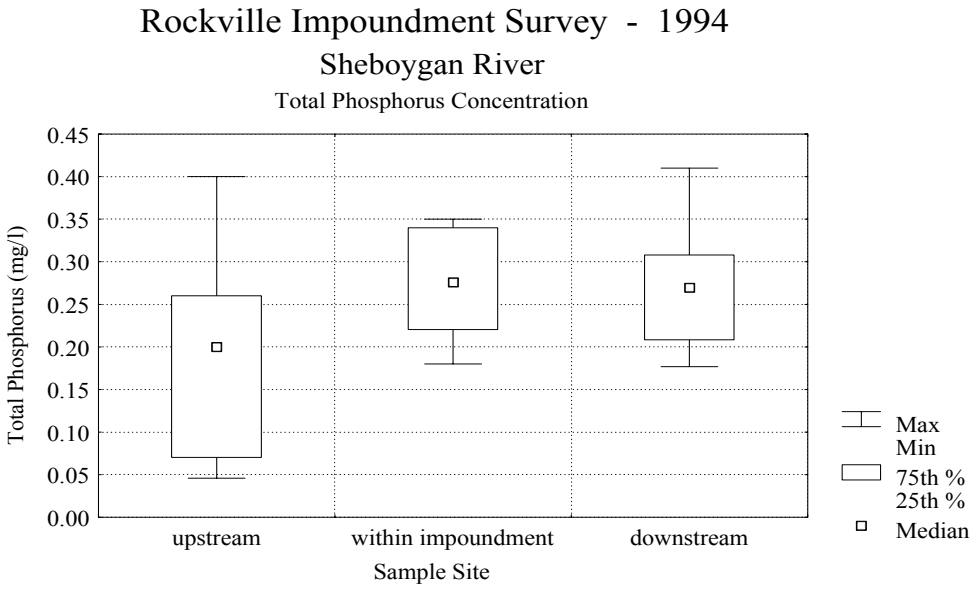

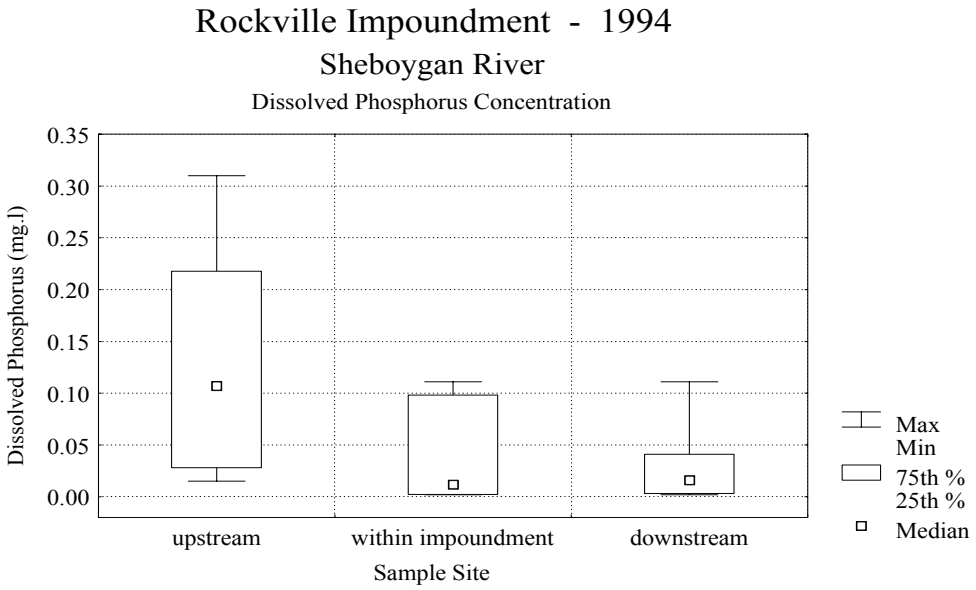

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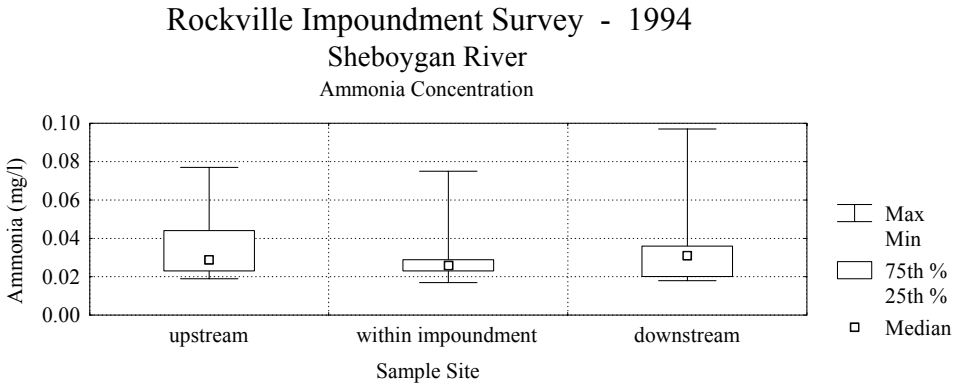
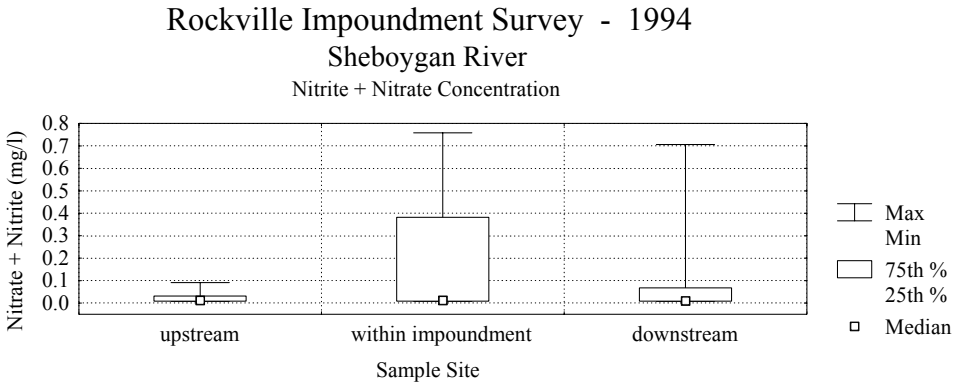
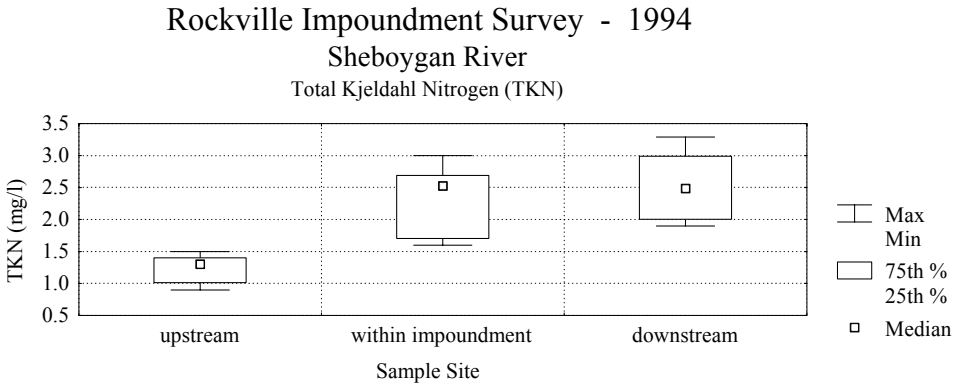






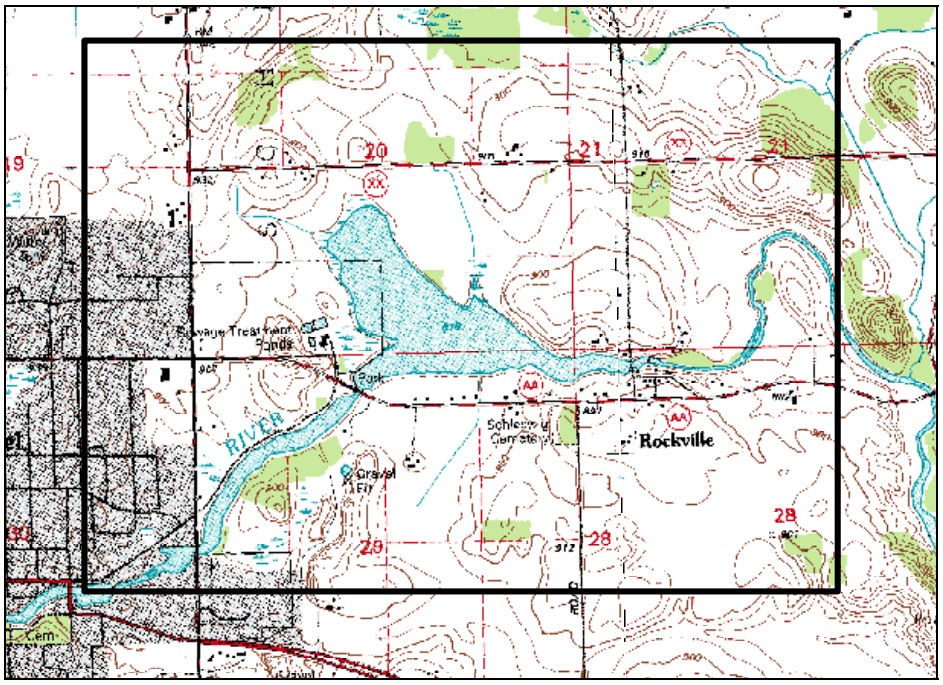
Water Depth

The water depth of the Rockville Impoundment was measured along 8 transects, between the Rockville Rd. bridge and the dam. The maximum depth within this section was discovered to be approximately 5.0 feet, although the majority of the impoundment in this section averaged between 2 and 3 feet. No sediment samples or depth measurements were taken during the survey however there was significant amounts of fine grained material overlaying a layer of coarser material. The water depth information and transect location are shown in Figures 5 and 6. The amount of soft sediment and sediment characteristics should be examined. Sediment quality should also be evaluated in zones of sediment deposition.

Aquatic Plants

A brief survey of aquatic vegetation was conducted on the Rockville Impoundment. The vegetation was limited to White Water Lily, sedges, cattails and bulrush. This growth was restricted to the shoreline.

Figure 5. Rockville Impoundment Locator and Cross-section Maps.



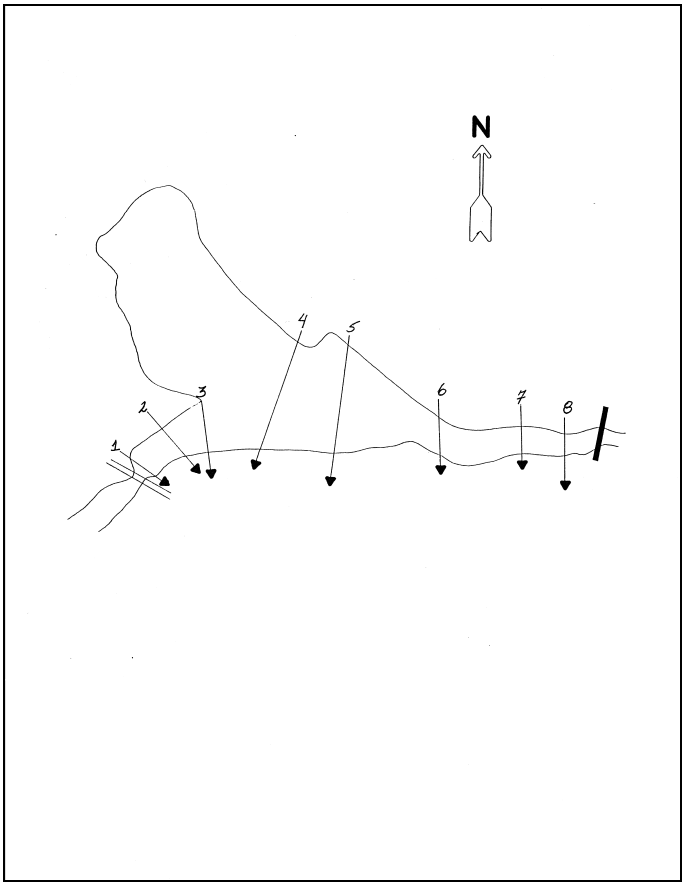


Figure 6. Rockville Impoundment Cross-section graphs

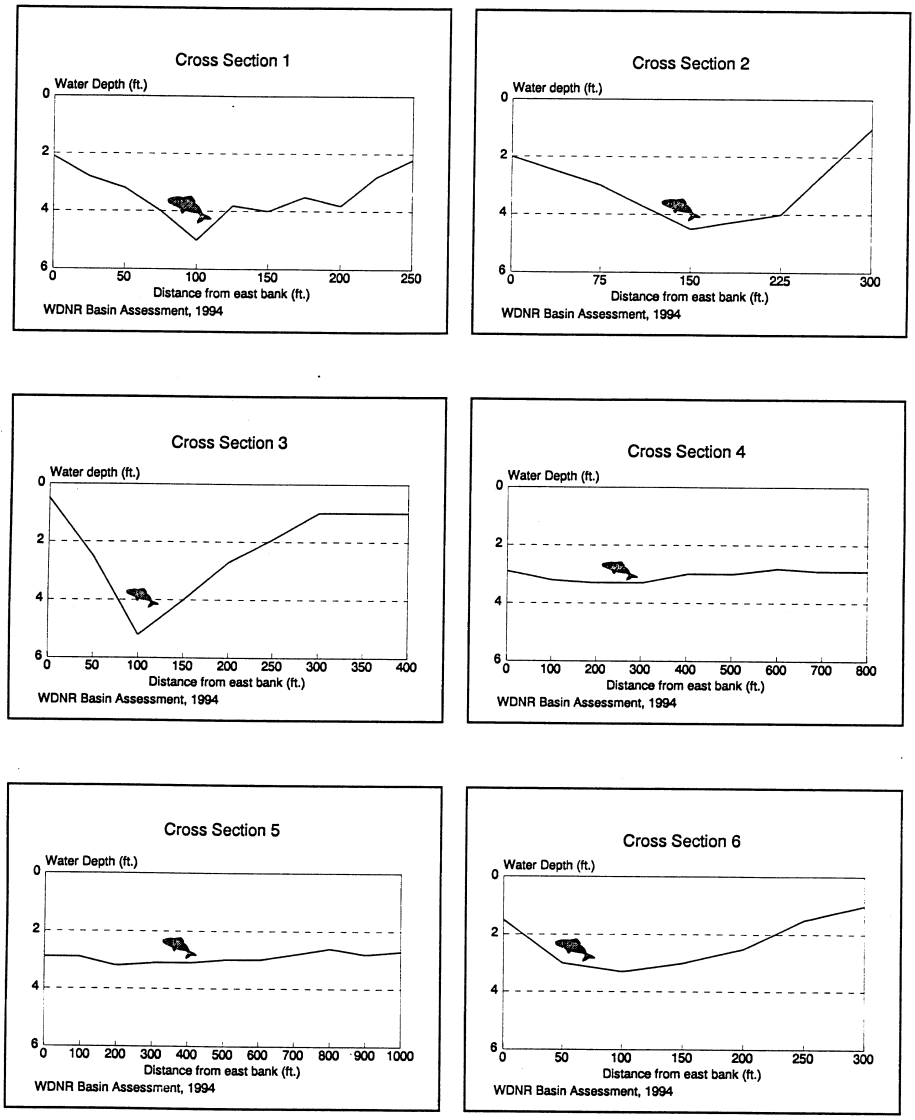
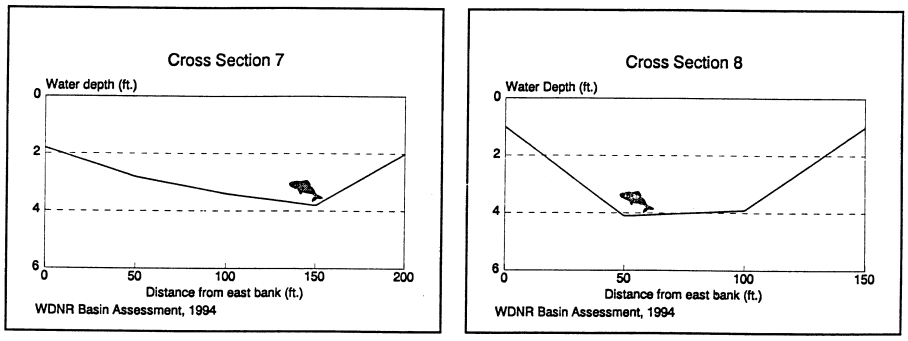


Figure 6. Rockville Impoundment Cross-section graphs, continued.



SHEBOYGAN LAKE/MARSH

T16N, R20E, Section 23, 26; MWBIC - 0058900, Sheboygan County, Sheboygan River Watershed
Surface Acres = 674, S.D.F. = 3.35, Maximum Depth = 3.5

Sheboygan Marsh is an extensive lake/impoundment within the Broughton Sheboygan County Marsh Area and Park. With over 14,000 acres of reclaimed land, the lake and marsh areas have become important recreational and hunting lands. As is characteristic of many marsh lakes, the water is light brown in color. Over 75 percent of the surface waters are less than three feet deep. Better known as Sheboygan Marsh, the area provides excellent habitat for waterfowl, muskrats, beaver, deer, grouse, and many other species of birds and mammals. The marsh area is attractive to not only sportsmen, but sightseers and naturalists as well. Two wildlife refuge areas are located on the south side of the marsh. Boats, picnic areas, camping facilities, other equipment and concessions are available on the grounds. During the summer months, boating, fishing and hiking are very popular, while hunting, trapping and ice fishing (northern pike) are enjoyed during the fall and winter.

A bypass tube was installed in 1968 and a draw down was conducted at the same time. Marsh vegetation responded and waterfowl use improved for several years. Between 1968 and the next draw down in 1984 the water was maintained at a higher level and it resulted in the erosion of the cattail mat. The partial draw-down to 18 inches below the spillway and removal of a six-inch I-beam extension on the dam was only partly successful in stabilizing the cattail mat.

Following a severe and unusual fish kill in the fall of 1986, the marsh was drawn down completely during the summer of 1987. Portions of the remaining channels were chemically treated with rotenone to control carp in August 1987. Subsequent stocking of northern pike, largemouth bass and panfish have had some success but the fishery has not returned to past levels. Carp may again become a management problem if not controlled.

Emergent vegetation increased and the cattail mat stabilized after the 1987 draw down and drought of 1988. Waterfowl use has increased as well as use by wading birds, black terns and yellow-headed blackbirds. It is fully expected that partial or complete draw downs will have to be conducted every five to seven years to maintain the cattail mat and other emergent vegetation in the marsh (Katsma and Nelson 1997).

The dissolved oxygen should be monitored on a diurnal basis to determine the extent to which the fishery may be stressed due to low dissolved oxygen levels.

Water Quality

The water quality of the Sheboygan Marsh was sampled on May 5, May 12, and September 13, 1994. Samples were collected approximately 100 feet upstream of the dam and approximately 0.5 mile upstream of the dam.

On May 5, 1995 dissolved oxygen and temperature was measured from the surface to the bottom (5 Feet). These measurements were made approximately 100 feet upstream of the dam. In addition a surface total phosphorus sample was taken at this location. Another temperature and dissolved oxygen profile was made on May 12, approximately 300 feet upstream of the dam. On September 13, 1994 the dissolved oxygen and temperature was measured at the surface in addition to chemical profiles samples taken 100 feet upstream of the dam. The dissolved oxygen of the surface water in September was low. The surface concentration was 5.72 mg/l and the bottom water was 3.34 mg/l. Typically 5.0 mg/l is needed to sustain a sport fishery.

Water Depth

No water depth survey was conducted on Sheboygan Marsh.

Aquatic Plants

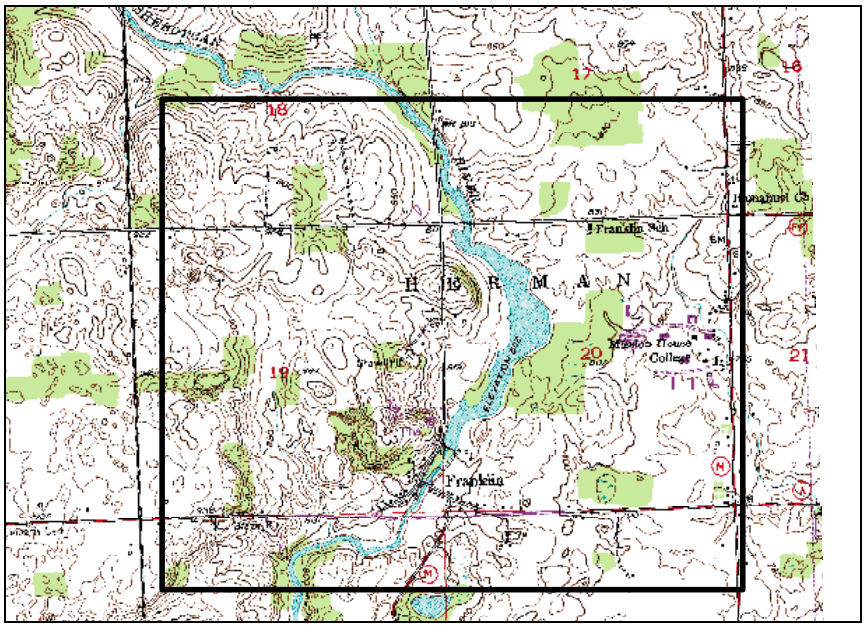
No concentrated effort was made to describe the aquatic plant community in the Sheboygan Marsh however some general observations were made. The open water areas of the marsh have typically become heavily infested with submergent aquatic vegetation to the point of making navigation difficult (Personal communication, Dale Katsma). Aquatic plant respiration may be significant enough to result in dissolved oxygen levels which are stressful to fish and aquatic life. The submergent aquatic vegetation present during the course of this investigation included Coontail (*Ceratophyllum demersum*), Water Milfoil (*Myriophyllum* sp.) and Duckweed (*Lemna* sp.). It should be noted that no Purple Loosestrife (*Lythrum salicaria*) was observed in the area. This is due to intensive efforts of the Department of Natural Resources, Wildlife Management program to aggressively control this exotic species. Eurasian Watermilfoil was not observed during this survey however it might be premature to conclude that it does not exist in the impoundment (Wakeman 1996).

FRANKLIN MILLPOND

T16N, R22E, Section 20; MWBIC - 0057100, Sheboygan County, Sheboygan River Watershed

The Franklin Dam is being removed at this time and this reach has been restored to a free flowing river.

Figure 7. Franklin Impoundment Locator and Cross-section Maps.



KIEL IMPOUNDMENT

T17N R21E Sec.30, Manitowoc County, Sheboygan River Watershed
Surface Acres = 250, S.D.F. = unknown, Maximum Depth = 7.5

It is recommended that the dissolved oxygen be monitored in this impoundment to determine if low dissolved oxygen conditions exist during the growing season that may stress the fishery. An estimate of the sediment volume and quality should also be made.

Water Quality

The water quality of the Kiel Impoundment was sampled in the spring and summer of 1994. The sample location was approximately adjacent to the boat launch at Hingiss Park, immediately downstream of the footbridge, in the center of the channel. Maximum depth was approximately 5.0 feet. Dissolved oxygen and temperature profiles were taken along with surface total phosphorus and water clarity measurements. The total phosphorus concentrations were 0.086 and 0.054 mg/l on May 5, and August 24, 1994 respectively. Water clarity was considered to be good on both dates since the Secchi disk could been easily seen on the bottom (5 Ft.) at the sampling location.

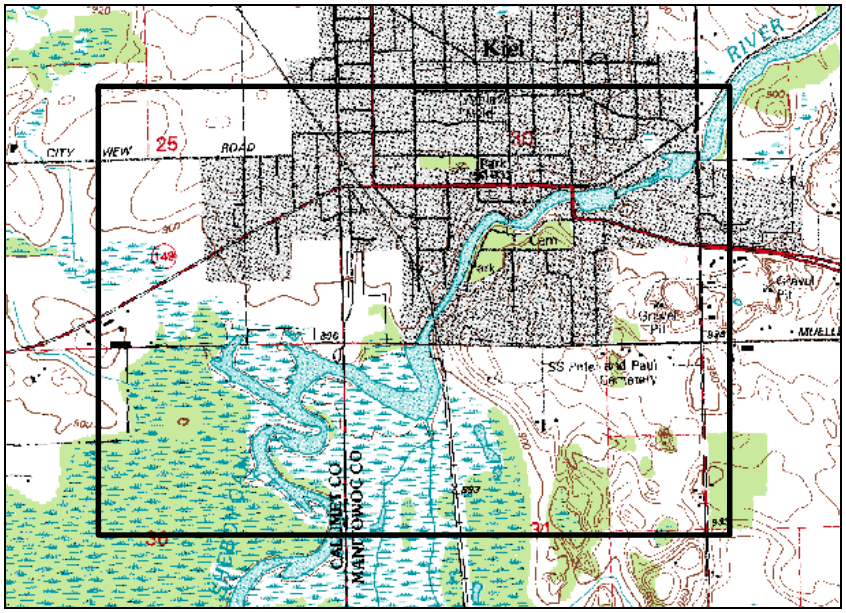
Thirteen cross section transects were made to measure the water depths of the Kiel Impoundment. The cross sections concentrated on the main channel or thalweg rather than the entire cross section of the wetted perimeter. Figures 9 and 10 show the locations of the cross sections and the water depths along each transect.

The maximum depth of the impoundment was approximately 7.5 feet which was recorded close to the dam in transect 8. The average depth of the evaluated section of the impoundment is estimated to be 3.0 feet. No sediment samples or depth measurements were taken during the survey however the sediment was considered to be highly organic and several feet deep outside of the thalweg.

Aquatic Plants

Coontail (*Ceratophyllum demersum*) dominated the aquatic plant community in the Kiel Impoundment. Coontail was present in dense concentrations along the shoreline in numerous places. Duckweed (*Lemna* sp.), Large Leaf Pondweed (*Potamogeton amplifolius*), Waterweed (*Elodea canadensis*), Flat-Stemmed Pondweed (*Potamogeton zosterformis*), Curly Leaf Pondweed (*Potamogeton crispus*) and Bushy Pondweed (*Najas* sp.) were observed in the impoundment. While no Eurasian water milfoil was observed during the survey it is premature to conclude that it does not exist in the impoundment.

Figure 9. Kiel Impoundment Locator and Cross-section Maps.



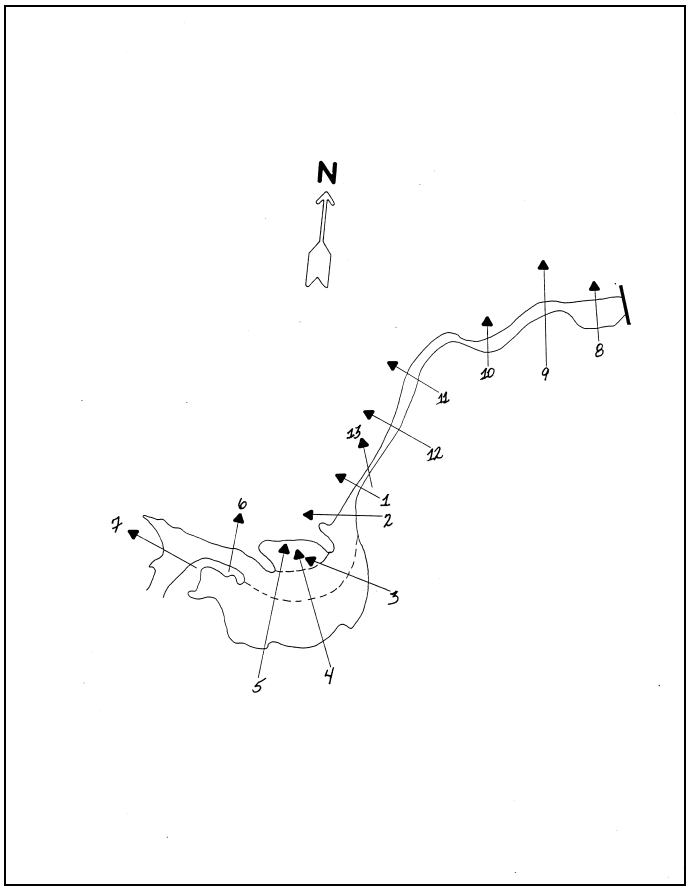


Figure 10. Kiel Impoundment Cross Sections

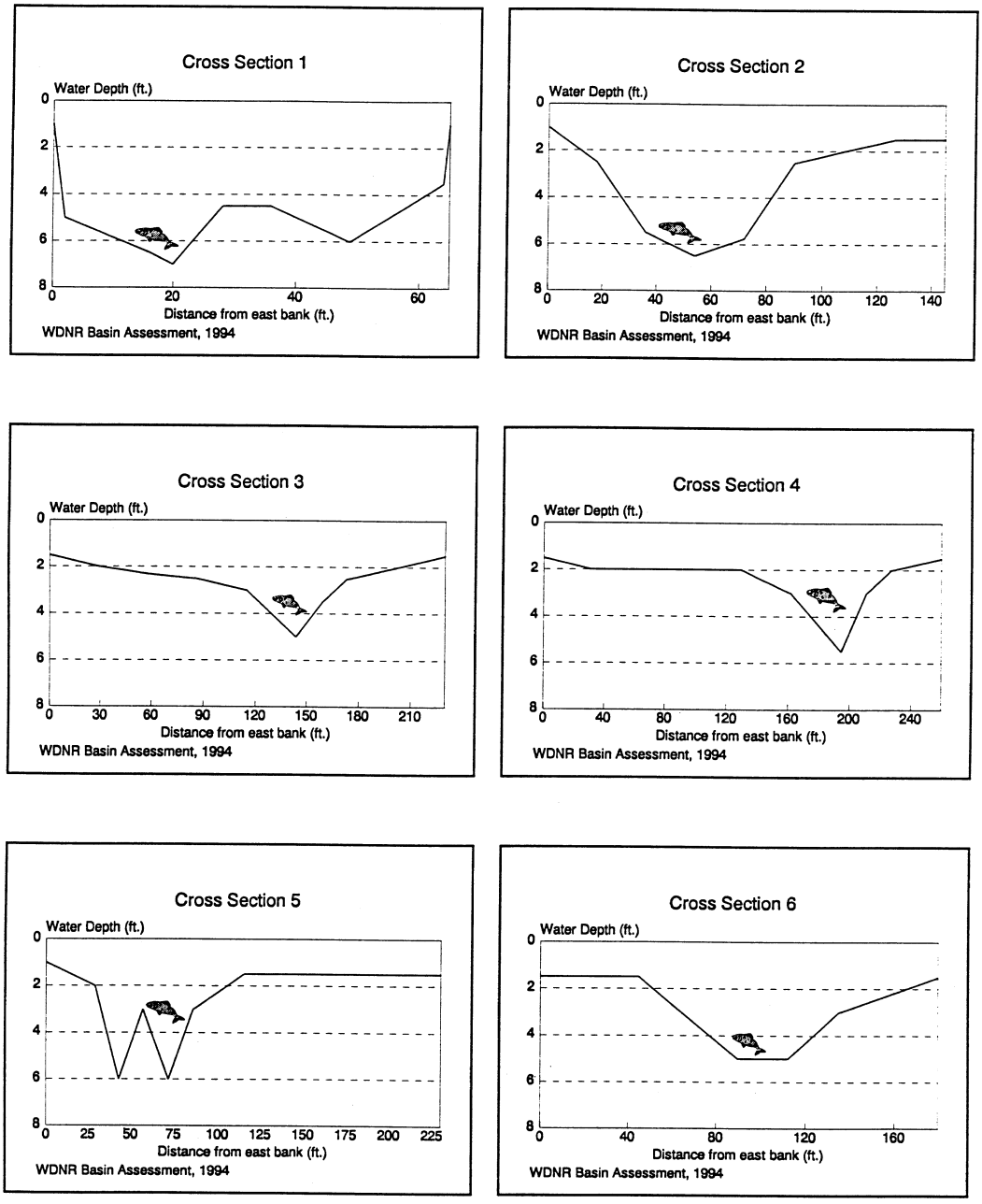
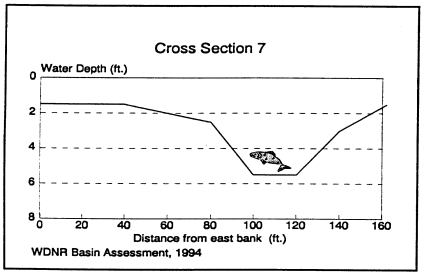
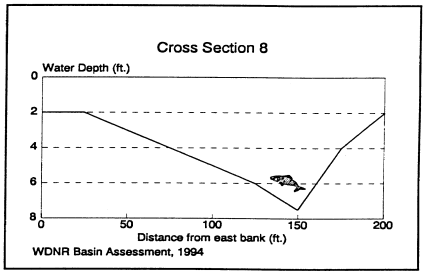
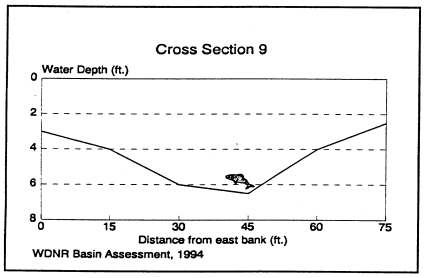
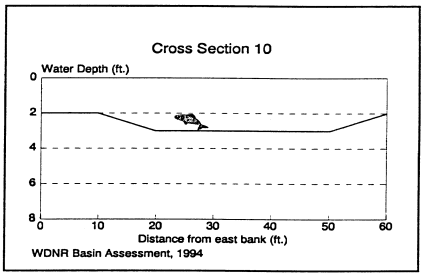


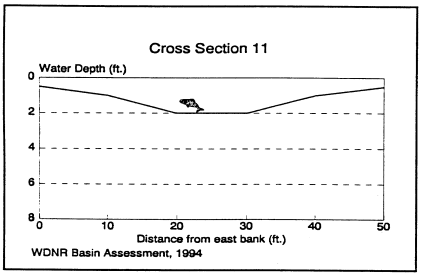
Figure 10 continued.

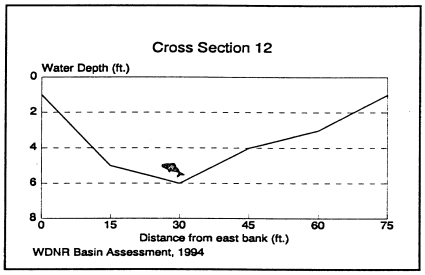


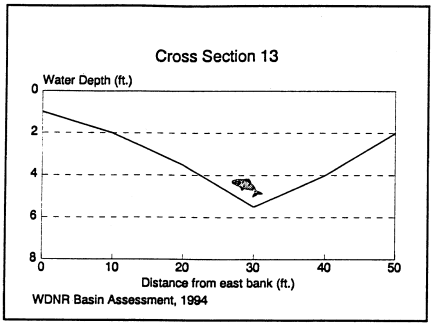












KOHLER IMPOUNDMENT, (WAELDERHAUS AND LOWER KOHLER DAMS)

T15N R23E Sec. 31, Sheboygan County
Surface Acres = 21, S.D.F. = 3.94, Maximum Depth = 8 feet

A long narrow impoundment formed by two dams, Waelderhaus and Lower Kohler Dams are located between Sheboygan Falls and Sheboygan within the Kohler Village limits. This impoundment is within the Sheboygan River and Harbor Superfund Project area. These dams are the first barrier to fish migration encountered moving upstream from Lake Michigan. These dams and the impoundments are more fully discussed in the reports discussing PCB contamination and the Superfund Project (e.g. BB&L 1990, BB&L 1998, WDNR 1995). There are fish and wildlife consumption restrictions due to PCB contamination in this impoundment and free flowing river above and below the dams.

JOHNSONVILLE IMPOUNDMENT

T15N R22E Sec. 6, Sheboygan County
Surface Acres = 9, S.D.F. = 1.94, Maximum Depth = 6 feet

This is a small impoundment formed by a six-foot head dam. No recent water quality data have been collected for this impoundment. A sediment quality assessment was conducted by WDNR on June 29, 1999 on the Johnsonville Impoundment, Sheboygan River (Table 29). Three sample sites were sampled in the soft sediment that has accumulated behind the dam. Samples were collected 120, 180 and 305 meters upstream from the dam.

Table 29. Sediment quality assessment *for the Sheboygan River within the Johnsonville Impoundment. Collected June 29, 1999.*

Parameter	120 m upstream	180 m upstream	305 m upstream
	mg/kg (ppm)	mg/kg (ppm)	mg/kg (ppm)
Arsenic	ND	ND	ND
Cadmium	0.5	0.6	0.5
Chromium(total)	19	17	23
Copper	21	16	23
Lead	19	13	20
Mercury	0.33	0.14	0.26
Nickel	13	11	15
Zinc	59	51	68
PAHs (total)	0.222	0.150	0.162
PCBs (total)	<0.05	<0.05	<0.05
Ammonia-N	201	119	115
Phosphorus (total)	981	699	692
TOC (Total Organic Carbon)	57600	53000	64000
% solids	38.4%	40.0%	34.2%

The pesticides (Aldrin, Alpha BHC, C-chlordane, Chlordane Alpha, Chlordane Gamma, Dieldrin, Endrin, Gamma BHC, Heptachlor, Nonachlor Cis) were all less than the level of detection.

SHEBOYGAN FALLS IMPOUNDMENT

T14N R22E Sec. 36, Sheboygan County
Surface Acres = unknown, S.D.F. = unknown, Maximum Depth = unknown

This is a small impoundment located in Sheboygan Falls. The dam had been used for generating electricity. This impoundment is upstream of the PCB contaminated section of the Sheboygan River and has been used by WDNR as a background-sampling site for studies on the Sheboygan River and Harbor Superfund project.

MISCHO'S IMPOUNDMENT

T16N R19E Sec. 35, Fond Du Lac County
Surface Acres = 23, S.D.F. = 1.28, Maximum Depth = 5 feet

This is a shallow impoundment of Feldner's Creek at CTH CCC, located southwest of St. Cloud. Feldner's Creek is classified as a Class II trout stream upstream of Mischo's Impoundment. . No recent water quality data have been collected for this impoundment.

LAKES OF THE SHEBOYGAN RIVER WATERSHED

There are fourteen named lakes and two unnamed lakes in the Sheboygan River Watershed. Table 40 identifies lake locations, type, size, depth, and trophic status index (TSI). Table 41 gives a summary of trophic status, exotic species and self-help monitoring efforts for the watershed. The trophic state of a lake is a indicator of a lakes productivity as measured in terms of water clarity, algal biomass and phosphorus concentration. There is a well-established relationship between water clarity, algae biomass and phosphorus concentration that has been used to develop models capable of determining the trophic state of a lake. There are three trophic levels, each of which has different characteristics. An oligotrophic lake generally has clear water, is deep and has sparse aquatic vegetation. They are low in nutrients and do not support a large fish population. Additional nutrients will cause an oligotrophic lake to become more productive and change its trophic state. A mesotrophic lake has poorer water clarity, some accumulation of organic matter, good fishery and occasional algae blooms. The aquatic plant community is generally diverse, abundant and may cause recreational use problems during some years. Increased nutrient loading to a mesotrophic lake will again raise the productivity of the lake and change its trophic state. A eutrophic lake is a very productive lake, shallow, nuisance levels of aquatic vegetation or frequent algae blooms, support a large fish population, susceptible to oxygen depletion, and high in nutrient concentration.

The trophic state models are used to determine the response of a lakes water quality (trophic state) to nutrient loading. Discrepancies between observed and predicted water quality then provide the resource manager with insight into factors that can influence each of the three parameters. Such factors might include an abundant rough fish population, or significant internal nutrient load. The model can also be used to determine the external phosphorus load based upon observed in-lake water quality.

Table 30. Trophic Status of Lakes in the Sheboygan River Watershed

Lake Name (Location T/R/S)	Lake Type	County Code	Surface Area (Acres)	Max Depth (ft.)	TSI T-P	TSI S D	TSI CHL	TSI Class	P Sens	Class
Wolf Lake (16N/19E/10)	Drainage	20	76	47	48	45	44	Meso	1	1A
Giltner's Lake (16N/19E/15)	Seepage	20	17	13					2	2C
Cedar Lake (17N/21E/24)	Seepage	36	142	21				Meso	2	2C
Bullet Lake (16N/21E/35)	Seepage	60	15	72						
Pauly's Lake (16N/19E/25)	Seepage	20	12	6						
Wilke Lake (17N/21E/2)	Seepage	36	95	21					1	1C
Elkhart Lake (Big Elkhart) (16N/21E/30)	Seepage	60	286	119	54.6	53.2	55	Meso	1	1B
Big Gerber (16N/21E/11)	Seepage	60	15	37	52.8	49	48		2	2A
Little Elkhart Lake (16N/21E/34)	Seepage	60	54	25	54	45.5	49.8	Meso	1	1A
Little Gerber (16N21E/11)	Seepage	60	7	21						
Shoe Lake (17N/21E/16)	Seepage	36	10	34						
Graf (Long) Lake (17N/21E/15)	Seepage	36	8	17						
Praeder Lake (17N/21E/15)	Seepage	36	9	17						
Sy Lake(17N/21E/11)	Seepage	36	17	33						
Little Sy Lake (17N/21E/11)	Seepage	36	5	20						
Unnamed Lake (17N/21E/23)	Seepage	36	15	14						
Unnamed (16N/21E/35)	Seepage	60	11.6	25						

For key to abbreviations, please see "How to Use the Lakes Tables" section

Table 31. Summary of trophic Status, presence of exotic species, and presence of a Self-Help Program.

Waterbody	Trophic Status Index	Eurasian Water Milfoil	Zebra Mussel	Self - Help Program
Cedar Lake	Mesotrophic	Unknown	No	No
Big Elkhart Lake	Mesotrophic	Yes	Yes	Yes
Little Elkhart Lake	Mesotrophic		No	
Upper Gerber	Mesotrophic	Yes	No	No
Lower Gerber	Mesotrophic	Yes	No	No
Giltner's Lake	Eutrophic	No	No	No
Wilke Lake	Meso-Eutrophic	Yes	No	No
Wolf Lake	Mesotrophic	Unknown	No	Yes
Shoe Lake	Eutrophic	Yes	Unknown	No
Graf (Long) Lake	eutrophic	Unknown	Unknown	No
Praeder Lake	Undetermined	Unknown	Unknown	No
Sy Lake	Undetermined	Unknown	Unknown	No
Little Sy Lake	Undetermined	Unknown	Unknown	No
Pauly's Lake	Undetermined	Unknown	Unknown	No
Bullet Lake	Undetermined	Unknown	Unknown	No

GERBER'S LAKE

T16N, R21E, Section 35 (11, 12, 9); MWBIC - 0056600, Sheboygan County, Sheboygan Watershed
Surface Acres = 22, S.D.F. = 1.78, Maximum Depth = 37 feet

In actuality, the lake consists of two contiguous basins connected by a navigable channel. They are often referred to as Big Gerber (15.2 acres, 37 feet deep) and Little Gerber (6.8 acres, 21 feet deep). The lakes are spring fed, with some intermittent seepage from a nearby spring pond and a small tributary which drains the majority of the watershed. A wide navigable outlet on the south side gradually narrows to a small stream, which enters Otter Creek which drains to the Sheboygan River.

Moderate to severe amounts of agricultural runoff is contributing to the water quality problems of Little Gerber and is creating optimum conditions for carp. The water in the smaller basin is turbid compared to relatively clear water in the larger lake. However, both experience moderately heavy algae blooms in most summers. Both lakes were monitored between 1990 and 1992 as part of the Sheboygan River Priority Watershed Project. Based upon limited dissolved oxygen and temperature profiles the two lakes do not appear to turnover in the spring or fall of the year (i.e. amictic) (Wakeman 1996). This unusual characteristic may actually be helping to protect the water quality from the nonpoint source loadings which are entering the lakes.

The lakes are reputable for excellent largemouth bass and bluegill fishing; especially utilized since development of a public access on the north shore of Little Gerber. A local ordinance prohibits outboard motors. Surrounding lands are nearly in one ownership, limiting development to a point where the waters have attributes of wilderness lakes. Migratory waterfowl probably utilize the area during the spring and fall.

Aquatic Plants

The aquatic plant community was not evaluated as part of this study.

Water Quality

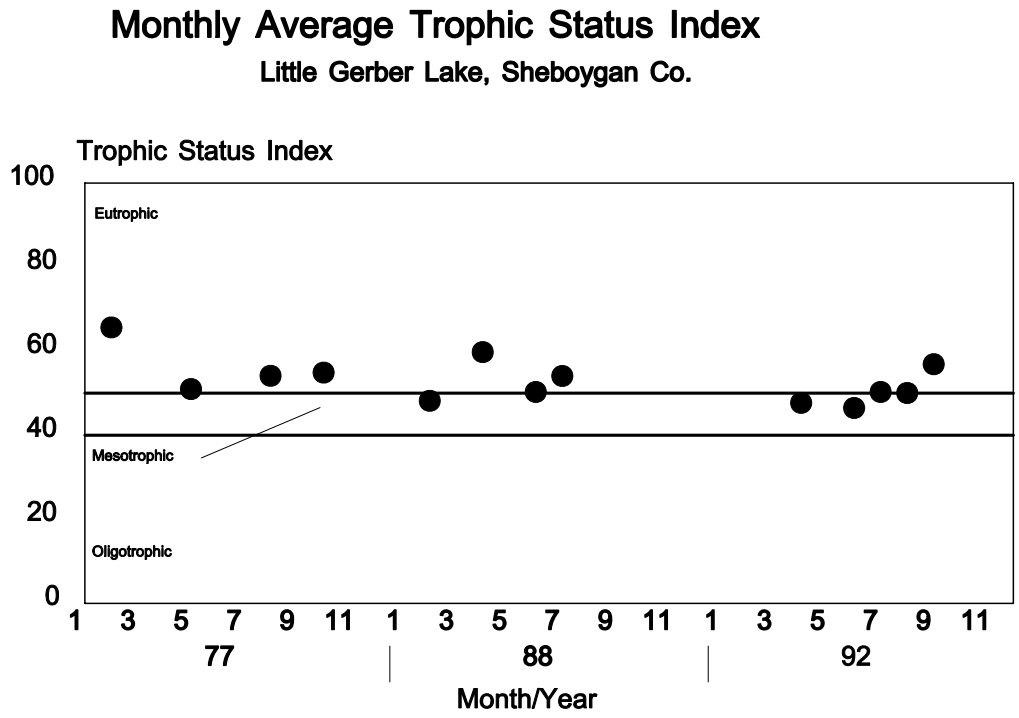
The dissolved oxygen and temperature profile of Upper and Lower Gerber Lakes was surveyed in 1994. A significant amount of monitoring was completed as part of the Sheboygan River Priority Watershed Appraisal Process (WDNR 1993).

The water quality of Upper Gerber Lake is significantly influenced by the fact that the lake is amictic (does not turnover) which is atypical of the lakes in southeastern Wisconsin. Temperature and dissolved oxygen profiles of Upper and Lower Gerber Lake were measured on May 4, 1994. Typically during the spring the lakes should be well mixed, however the profiles indicated that the lake was still stratified. This characteristic has a strong influence on the overall observed water quality of Upper Gerber Lake.

Trophic Status Index

The Trophic Status Index of Upper Gerber Lake is shown in Figure 11. Based upon historical water quality information Upper Gerber Lake is considered to be Meso-Eutrophic. However because of amictic nature of this small lake the true level of productivity may be masked by the permanent stratification.

Figure 11. TSI values for Upper (Little) Gerber Lake



CEDAR LAKE

T17N, R21E, Sections 23,24, Manitowoc County, Sheboygan Watershed
Surface acres - 139, S.D.F. = 1.97, Maximum depth = 26 feet

Cedar Lake is the largest lake in Manitowoc County, with a maximum depth of 21 feet and an average depth of nine feet. It is a landlocked seepage lake in the terminal moraine of the Lake Michigan glacier. The water is clear, hard and alkaline. The littoral bottom is composed of both gravel and muck. The lake is managed for largemouth bass, pan fish and northern pike. Panfish species include bluegill, crappie and common sunfish. This is the largest lake in Manitowoc County and the shoreline is highly developed. Access is available by two town roads, one of which has parking. About 70% of the 18 acres of adjoining wetland are wooded. Waterfowl make limited use of the lake.

Aquatic Plants

A general survey of the aquatic vegetation was conducted by boat. The aquatic plant community is considered to be moderate although there are some areas that have moderate to dense growth of submergents. The aquatic plant community is considered to be moderately diverse with a mixture of tolerant to intolerant species. Bulrushes are present in a limited number of areas, as are both yellow and White Water Lilies. The submergent community includes a variety of pondweeds (Potamogeton sp.), Eel

Grass (Valisneria sp.), Najas sp., Water Buttercup (Ranunculus sp.), and Muskgrass (Chara sp.). Table 42 summarizes the species observed during the survey.

Table 32. Aquatic Plants in Cedar Lake, Manitowoc County

Common Name	Scientific Name
Pondweed	*Potamogeton sp.*
Flatstemmed Pondweed	*Potamogeton zosterformis*
Largeleaf Pondweed	*Potamogeton amplifolius*
Robinson Pondweed	*Potamogeton robinsii*
Sago Pondweed	*Potamogeton pectinatus*
Eel Grass	*Valisneria sp.*
Bushy Pondweed	*Najas sp.*
Water Buttercup	*Rannunculus sp.*
Bulrush	*Juncus sp.*
Sedges	*Eleocharis sp.*
Yellow Water Lily	*Nuphar sp.*
White Water Lily	*Nymphaea sp.*
Musk Grass	*Chara sp.*

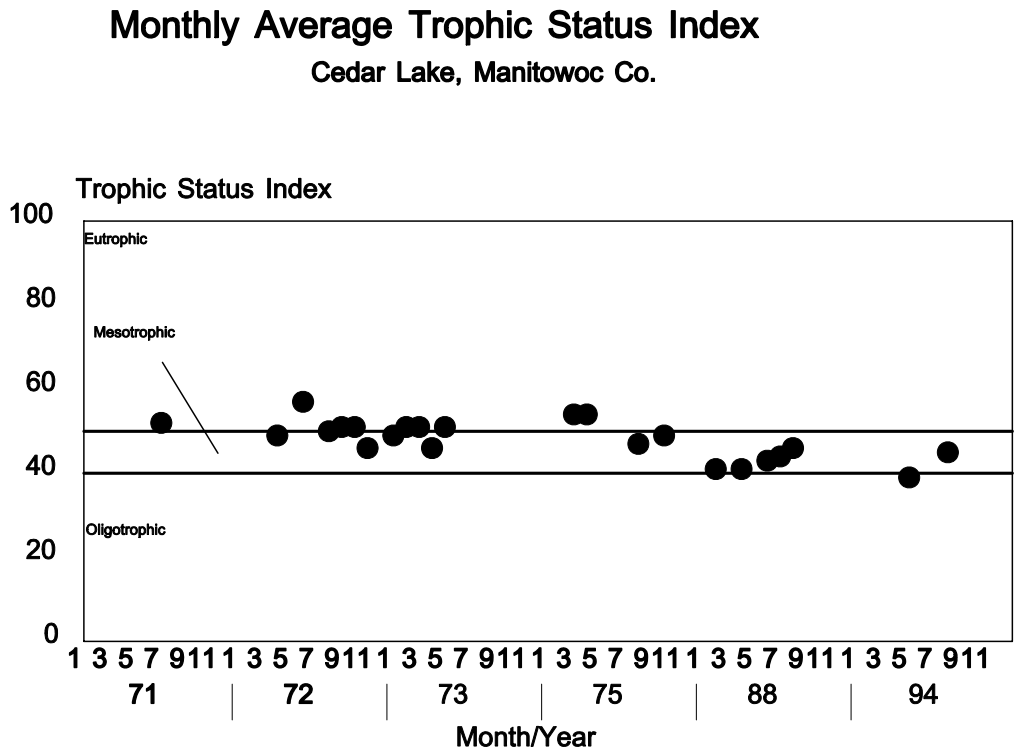
Water Quality

The water quality of Cedar Lake was monitored on May 4 and August 24, 1994. Temperature, dissolved oxygen, specific conductance, pH, and total dissolved solids were measured in the water column. The temperature profiles showed only a slight temperature difference from top to bottom in May and August (Wakeman 1996). The dissolved oxygen profile is slightly more stratified in August than in May however the bottom water had a concentration of 4.2 ppm. The lack of any strong stratification during the summer and the aerobic conditions in the bottom waters will minimize the internal phosphorus load to the lake. The water clarity of Cedar Lake on May 4, 1994 was excellent, the secchi disk could be seen on the bottom in 6.5 meters (20 ft) of water. On August 24, 1994 the water clarity was still very good with a secchi disk reading of 3.5 meters (11.5 ft) (Wakeman 1996).

Trophic Status Index

The Trophic Status Index of Cedar Lake was calculated based upon the existing water quality data. The trophic status index for Cedar Lake is considered to be mesotrophic. A slight downward trend can be observed (Figure 12), however additional monitoring needs to be conducted to determine the significance of this trend.

Figure 12. Monthly average TSI values for Cedar Lake.



ELKHART LAKE

T16N, R21E, Section 29, 30; MWBIC - 0059300, Sheboygan County, Sheboygan River Watershed
Surface Acres = 300, S.D.F. = 1.83, Maximum Depth = 113 feet

At 300 acres, Elkhart Lake is the largest kettle moraine lake in Sheboygan County and the fourth deepest natural lake in the state. A fair sized, submerged island separates the lake into two major basins. A fixed crested weir at the outlet maintains the water level of the lake. The greatest attraction of the lake is its clear water, which provides excellent swimming, boating, water-skiing, and aesthetic enjoyment. Septic tank seepage and isolated surface runoff from adjacent cropland and farm operations has resulted in gradual increases in nutrients in the Lake. These sources could trigger major use problems in the future if control efforts are not expanded.

A two-story fishery exists in Elkhart Lake with the presence of both warmwater and coldwater fish (trout) species. Walleye, panfish, and smallmouth bass, are the mainstays of the fishery. This lake is well known for producing trophy size walleye and northern pike. True muskellunge were introduced in 1987 and are growing at an extremely fast rate due to an abundant forage base. Efforts are underway to increase the amount of fish cover in the lake. In August 1994, Elkhart Lake became the second inland lake in Wisconsin to become infested with zebra mussels. A launch site adjacent to the outlet currently provides public access. Parking is adequate and toilet facilities are provided.

In 1987, the Sheboygan River was selected as a Priority Watershed Project. As a part of this project the land uses and polluted runoff loading to Big Elkhart Lake were inventoried by the Sheboygan County

Land Conservation Department. The appraisal report and recommendations for the Big Elkhart Lake area are summarized in the Sheboygan River Priority Watershed Report (WDNR 1993).

A nutrient and water budget sponsored by the Elkhart Lake Improvement Association, and moneys obtained from the DNR through the Wisconsin Lake Management Planning Grant Program, has been completed for the lake by the University of Wisconsin-Milwaukee and the U.S. Geological Survey (Edgington *et al*. 1996). It is recommended that a detailed fishery survey be conducted to determine the community structure of the fishery. This is recommended since the existing zebra mussel study is not going to be evaluating this portion of the food chain and additional information on the fish community structure on Big Elkhart Lake would augment that study. It is also recommended that the general water quality condition of the lake be evaluated on a recurring basis. Water use objectives are also found in the Nonpoint Source Control Plan for the Sheboygan River Priority Watershed Project, (WDNR 1993). The water resource objectives for this lake need to be reevaluated in light of the modeling results that are being completed by the Center for Great Lake Studies and the discovery of the zebra mussel in the lake. These two elements will guide and influence the future of Big Elkhart Lake.

Aquatic Plants

The aquatic plant community in Big Elkhart Lake can best be described as sparse. In addition to the field survey conducted in 1994 aerial photographs of the lake were taken in 1993 to assist in the development of a Eurasian Water milfoil (EWM) control program for the Big Elkhart Lake Property Owners Association. The photographs from the aerial survey are archived in the Big Elkhart Lake file in the Southeast District headquarters, a duplicate set was given to the Proper Owners Association.

Eurasian Water milfoil was present in approximately 15 locations around the lake in 1993. There were 3 areas with EWM in 1994. There appeared to be a significant decrease in the overall plant growth in Big Elkhart Lake in 1994 compared to 1993, which was substantiated by conversations with local residents. Table 43 lists the species present during the general survey.

Table 33. Aquatic plants in Big Elkhart Lake Sheboygan Co., 1994.

Common Name	Scientific Name
Musk Grass	*Chara sp.*
Pondweed	*Potamogeton sp.*
Richardson Pondweed	*Potamogeton richardsonii*
Bulrush	*Eleocharis sp.*
Sago Pondweed	*Potamogeton pectinatus*
Eurasian Watermilfoil	*Myriophyllym spicatum*
Coontail	*Ceratophyllum demersum*
White Water Lily	*Nymphaea sp.*

Water Quality

The water quality of Big Elkhart Lake was monitored once in May and again in September during 1994. Temperature and dissolved oxygen profiles were made in the northern basin in May and the southern basin in September. The temperature in September shows a normal thermal profile with a 16-degree stratification factor. The dissolved oxygen profile can be characterized as a typical clinograde profile

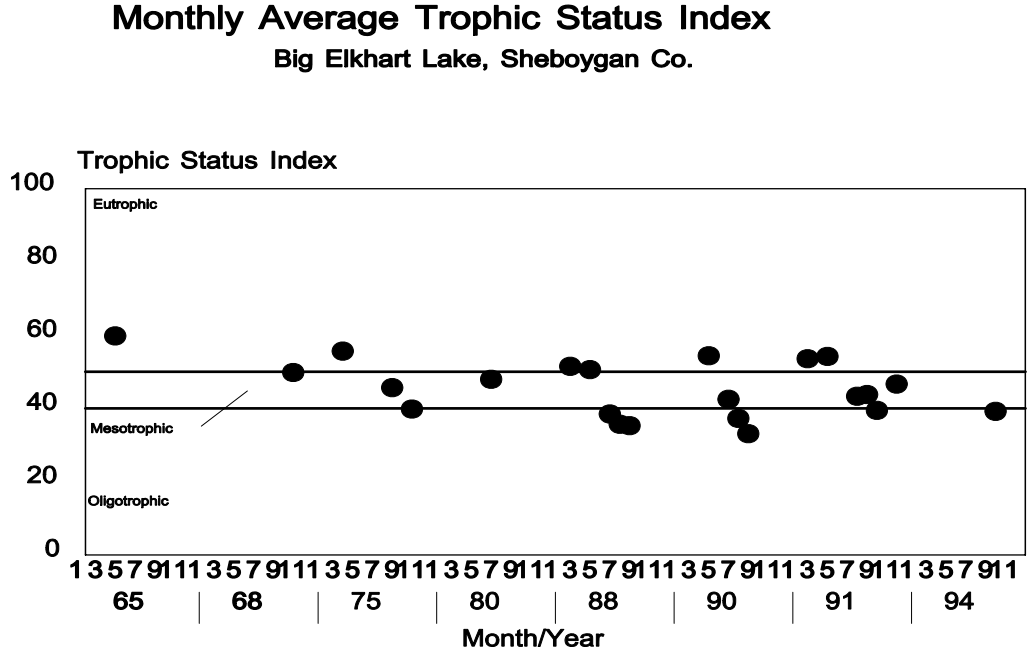
except it has a dissolved oxygen peak in the metalimnion. This dissolved oxygen peak is very strong and has been documented during other limnological surveys of the lake. The dissolved oxygen in the metalimnion has been measured to be greater than 20 ppm during earlier surveys. The lake is well stratified by September with a thermocline at a depth of approximately 35 feet. The hypolimnion was anoxic at a depth of 60 feet, and there was greater than 5 ppm dissolved oxygen to a depth of 45 feet (Wakeman 1996).

During water quality surveys conducted in 1994, the pH, specific conductance and total dissolved solids were 8.4 su, 470 (mS/cm), and 0.201 (g/l) respectively, at the surface in September. At the thermocline the same parameters were 8.1 su, 495 (mS/cm), and 0.317 (g/l) respectively. At 115 feet, the pH was 7.2 su, specific conductance was 549 (mS/cm) and total dissolved solids were 0.351 (g/l).

Trophic Status Index

The trophic status index for Big Elkhart Lake indicates a seasonally variable trend. Within one year the trophic status can go from Eu-Mesotrophic to Meso-Oligotrophic as indicated in Figure 13. The spatial distribution of primary producers in the lake results in an underestimation of productivity by conventional trophic status indices. It is believed that the spring Trophic Status Index is an accurate measure at that time however the summer values significantly underestimate the productivity of the lake.

Figure 13. Monthly average TSI values for Big Elkhart Lake.



GILTNER'S LAKE

T16N, R19E, Section 15, Fond Du Lac County, Sheboygan River Watershed
Surface Acres = 17.3, S.D.F. = 1.30, Maximum Depth = 13 feet

Giltner's is a small, hard water lake with a maximum depth of 13 feet. It is a shallow, fertile, marshy lake with an intermittent outlet to Wolf Lake. Although fish kills occur occasionally from both winter kill and summer kill, the lake is restocked by migration of native species entering from Wolf Lake during periods of high flow. Perch and bullheads are commonly harvested but fishing pressure is light due to lack of public access and intermittent fishing quality. Cattle watering and pasturing create a fertility problem and the lake frequently experiences heavy blooms of algae. Mallard and teal nest in the 30 acres of associated marsh, which is also home to numerous muskrats. There is no public access to the lake, although the owner allows fishing by permission. Waterfowl uses are significant and hunting is common. Very little management occurs at present. Preservation of the existing undeveloped status is desirable. Public ownership would prevent development from occurring and the recreational potential could be greatly enhanced.

Management of small shallow eutrophic lakes poses significant problems for managers. The inherent qualities of Giltner's Lake should direct management efforts. Because of the history of winterkill the lakes fishery may be considered either boom or bust. The wildlife value and aesthetic quality of the lake is perhaps its most permanent asset.

Water quality monitoring was conducted as part of the 1994 Sheboygan Basin Monitoring. Permission to monitor Giltner's Lake as obtained from Mr. Vic Steffas who is the local property owner. Mr. Steffas indicated that the lake had a substantial winterkill during the 1993-94 winter. Prior to the winterkill the lake supported a good yellow perch fishery. Several small bullheads were observed dead on the shore on the May sample date.

The private launch site is located at the end of a gravel road leading to the lake. While there is no ramp the substrate is solid and supported the Departments boat and trailer without any difficulty. The water depth at the launch site is adequate however the launch site periodically gets plugged with cattail mats that are broken from the adjacent shoreline.

Aquatic Plants

An unidentified narrow leaf pondweed (Potamogeton sp.), Coontail (Ceratophyllum demersum), and Yellow Water Lily (Nuphar sp.) were observed during a general survey of aquatic vegetation. The shoreline has extensive Cattail growth which provides good wildlife habitat.

Water Quality

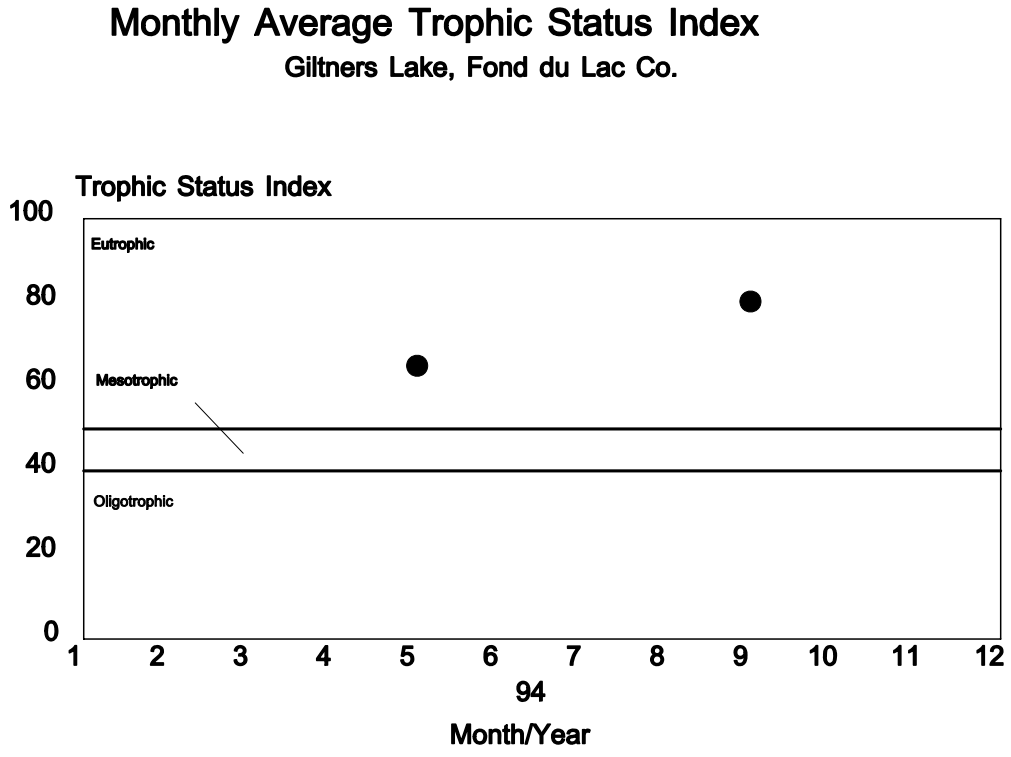
The water quality of Giltner's Lake was monitored on May 12, and September 13, 1994. In May, the lake was slightly stratified with only a 1.8-degree difference from top to bottom. In May, the dissolved oxygen profile ranged from 10.3 ppm at the surface to 4.0 on the bottom. In September, the lake was moderately stratified with a 4.0-degree stratification factor and a thermocline between 5 and 10 feet. Dissolved oxygen was 0.1 ppm at 10 feet and 0 at the bottom (13-ft). The water clarity was 0.7 meters and 0.1 meters in May and September respectively. The chlorophyll *a* was 43.6 ug/l at the surface in May and 325 ug/l in September (Wakeman 1996).

Trophic Status Index

There is very limited water quality data available on Giltner's Lake. Based upon the spring and summer sampling conducted in 1994 the trophic status index of Giltner's Lakes is classified as Eutrophic (Figure

14). This classification is reflective of the tremendous algae bloom, poor secchi depth and nutrient levels observed in the lake. Depending upon the extent of the fish kill observed by the property owner during the 1993-94 winter, the water quality condition of the lake during the 1994 monitoring year would likely be affected by the fish kill. The trophic status index may be very different following a year without a fish kill.

Figure 14. Monthly average TSI values for Giltners Lake.



WILKE LAKE

T17N, R21E, Section 2, Manitowoc County, Sheboygan River Watershed
Surface acres - 97, S.D.F. = 1.30, Maximum depth = 22 feet
Drainage area - 0.73 sq. mi., Mean depth = 8.35 feet,
Lake volume = 810 ac·ft.

Wilke is a 97-acre, 21-foot-maximum-depth seepage lake located in the terminal moraine part of the state. This lake has hard water and a bottom composed of gravel and muck. It is a heavily used and intensively developed lake. Largemouth bass, panfish and northern pike provide good fishing. Weeds and stunted bluegills are the major management problems. A town road with parking provides access to 50 feet of public frontage. Two boat liveries on the lake increase fishing access. There are 32 acres of non-woody adjoining wetland. A moderate number of ducks may visit the lake during the spring and fall. Water use objectives and recommendations have been developed for Wilke Lake, and are summarized in the Nonpoint Source Control Plan for the Sheboygan River Priority Watershed Project (WDNR 1993).

Aquatic Plants

A general survey of the aquatic vegetation of Wilke Lake was conducted. Table 44 lists the aquatic vegetation that was observed in Wilke Lake during the 1994 survey. The lake association owns and operates a mechanical harvester which was operating during the survey.

Table 34. List of aquatic plants found in Wilke Lake, Manitowoc County

Common Name	Scientific Name
Muskgrass	*Chara sp.*
Bulrush	*Juncus sp.*
Naiad	*Najas sp.*
Richardson Pondweed	*Potamogeton richardsonii*
Large Leaf Pondweed	*Potamogeton amplifolius*
Floating Leaf Pondweed (Unid.)	*Potamogeton sp.*
Unknown pondweed	*Potamogeton sp.*
Water Milfoil	*Myriophyllum sp.*
Bladderwort	*Utricularia sp.*
Yellow Water Lily	*Nuphar sp.*
White Water Lily	*Nymphaea sp.*

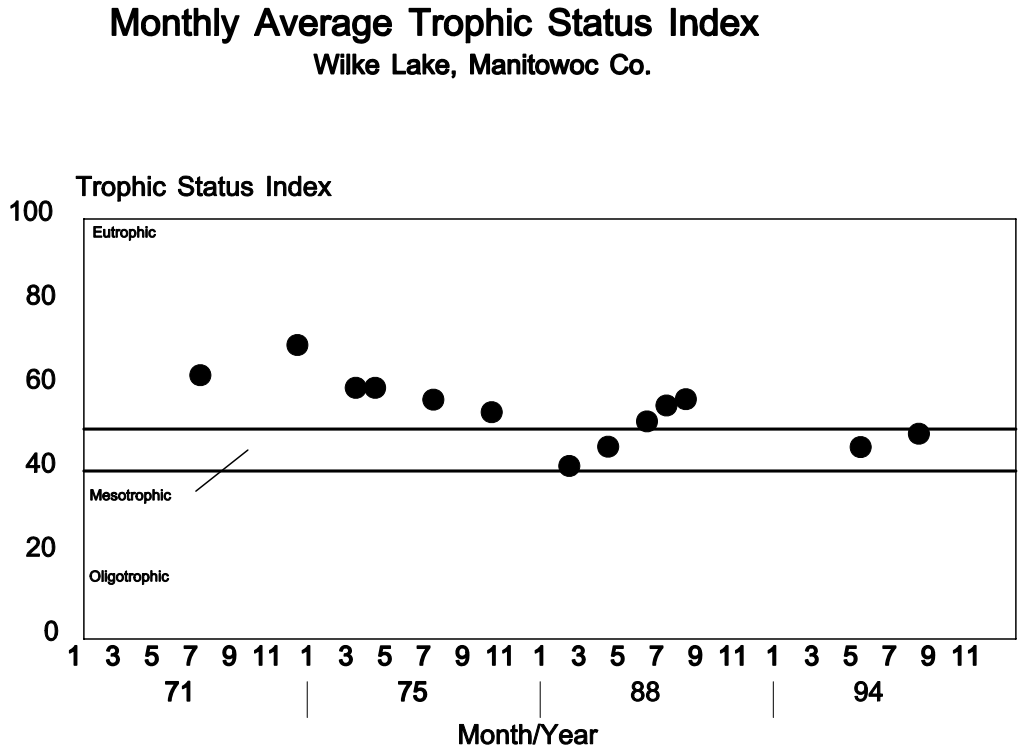
Water Quality

The water quality of Wilke Lake was monitored on May 4, and August 24, 1994. In May, the lake was weakly stratified with only a 2.5 degree difference from top to bottom (15 ft), and the dissolved oxygen ranged from 10.6 at the surface to 10.0 at the bottom. In August, the lake was only slightly more stratified with a 2.6-degree difference from top to bottom (20 ft), however the dissolved oxygen was 1.4 ppm at 20 feet. Water clarity was measured to be 2.5 meters and 1.4 meters in May and August respectively (Wakeman 1996). Additional water quality information and water quality goals for Wilke Lake can be found in the Nonpoint Source Control Plan for the Sheboygan River Priority Watershed Project (WDNR, 1993).

Trophic Status Index

Figure 15 summarizes the trophic status of the lake. Based upon the past and present water quality information Wilke Lake is considered to be meso- to eutrophic. There appears to be some significant changes in the Trophic Status Index based upon the available information (Wakeman 1996).

Figure 15. Monthly average TSI values for Wilke Lake.



WOLF LAKE

T16N, R19E, Sections 10, 15, Fond Du Lac County, Sheboygan River Watershed
Surface Acres = 77.0, S.D.F. = 1.76, Maximum Depth = 47 feet

This is a relatively small lake, but is heavily used for swimming, boating, and fishing, due to its good water quality and the scarcity of other lakes nearby. The water remains clear throughout the year and aquatic vegetation is found in a relatively narrow band along shore. A small stream from Giltner's Lake is intermittently draining to Wilke Lake. Water quality is good and excessive aquatic plants or algae are not a problem, although agricultural ditching and wetland drainage in the sub-watershed are threats. Lake levels have fluctuated, causing use problems, but the recent construction of a control levee at the outlet has improved the condition. Direct drainage from lawn areas and groundwater impacts from septic systems may be nutrient threats.

The lake contains a good fish population, with walleye, northern pike, largemouth bass, perch and bluegill in the fishery. Carp are present in the lake, but are not expected to interfere with present management. There is a county-owned public use area which offers good swimming, boat rental, picnic area, and public boat launching, which was partly developed under the state cost-sharing program for public access.

This is a 77-acre seepage/drainage lake with a maximum depth of 47 feet. Swimming, fishing and boating are common. Walleye, perch, bluegill and largemouth bass provide a good fishery. Wildlife uses are moderate as the shore zone is largely developed and contiguous wetlands are minimal.

Additional information on Wolf Lake is available within U.S. Geographical Survey lake monitoring reports, self-help program data and the Sheboygan River Priority Watershed Resource Appraisal Report (WDNR 1993). Recommendations have been developed for Wolf Lake, and are summarized in the Nonpoint Source Control Plan for the Sheboygan River Priority Watershed Project.

Aquatic Plants

A survey of aquatic plants was conducted on Wolf Lake. Table 45 lists the species observed during the survey. The lake appeared to be evenly populated with a mixture of Brittle Naiad (*Najas marina*), Eel Grass (*Valisneria americana*), Sago Pondweed (*Potamogeton pectinatus*), and an unidentified pondweed (*Potamogeton sp*.)

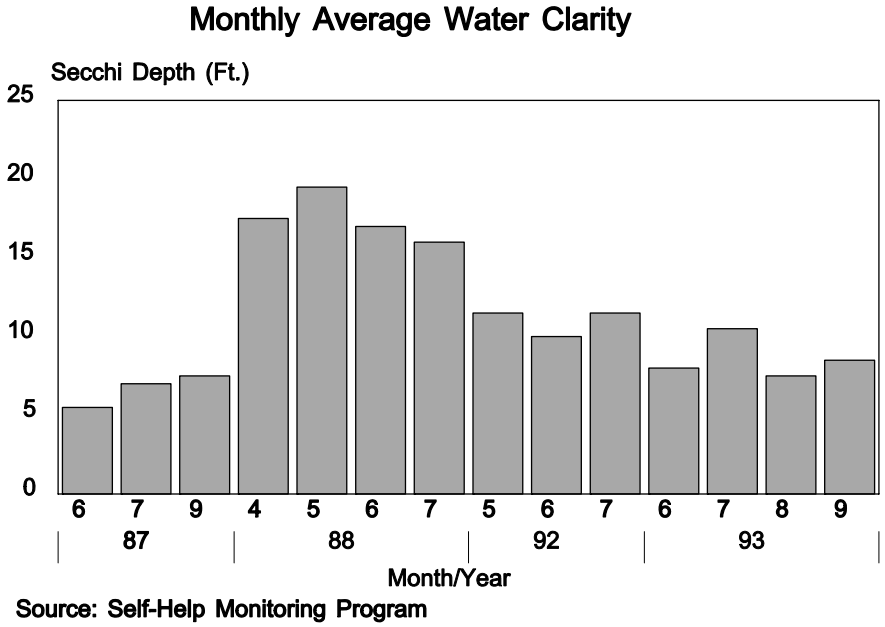
Table 35. List of aquatic plants found in Wolf Lake, Manitowoc County

Common Name	Scientific Name
Water Lily (Unidentified)	
Yellow Water Lily	*Nuphar sp.*
White Water Lily	*Nymphaea sp.*
Eel Grass	*Valisneria americana*
Eurasian Watermilfoil	*Myriophyllum spicatum*
Watermilfoil (native)	*Myriophyllum sp.*
Brittle Naiad	*Najas marina*
Richardson Pondweed	*Potamogeton richardsonii*
Curly Leaf Pondweed	*Potamogeton crispus*
Narrow Leaf Pondweed	*Potamogeton sp.*
Unidentified Pondweed	*Potamogeton sp.*
Bulrush	*Juncus sp.*
Musk grass	*Chara sp.*
Naiad (unidentified)	*Najas sp.*
Sago Pondweed	*Potamogeton pectinatus*
Coontail	*Ceratophyllum demersum*

Water Quality

The water quality of Wolf Lake was sampled on May 12, and September 13, 1994. On May 12, the lake was slightly stratified with a 5-degree stratification factor and a dissolved oxygen profile, which resembled the beginning of a typical clinograde profile. In September, the lake was well stratified with a 12.9-degree stratification factor: the thermocline was located between 20 and 30 feet, and the dissolved oxygen was 0.1 ppm at 25 feet and 0.0 ppm to the bottom. The secchi depth was 6.1 and 3.0 meters in May and September respectively (Wakeman 1996). The water clarity data collected by the Self-Help Volunteer is summarized in Figure 16. The spring and fall water clarity measurements in 1994 are similar to those collected by the volunteer.

Figure 16. Monthly average water clarity for Wolf Lake measured by the volunteer for the Self-Help Monitoring Program.

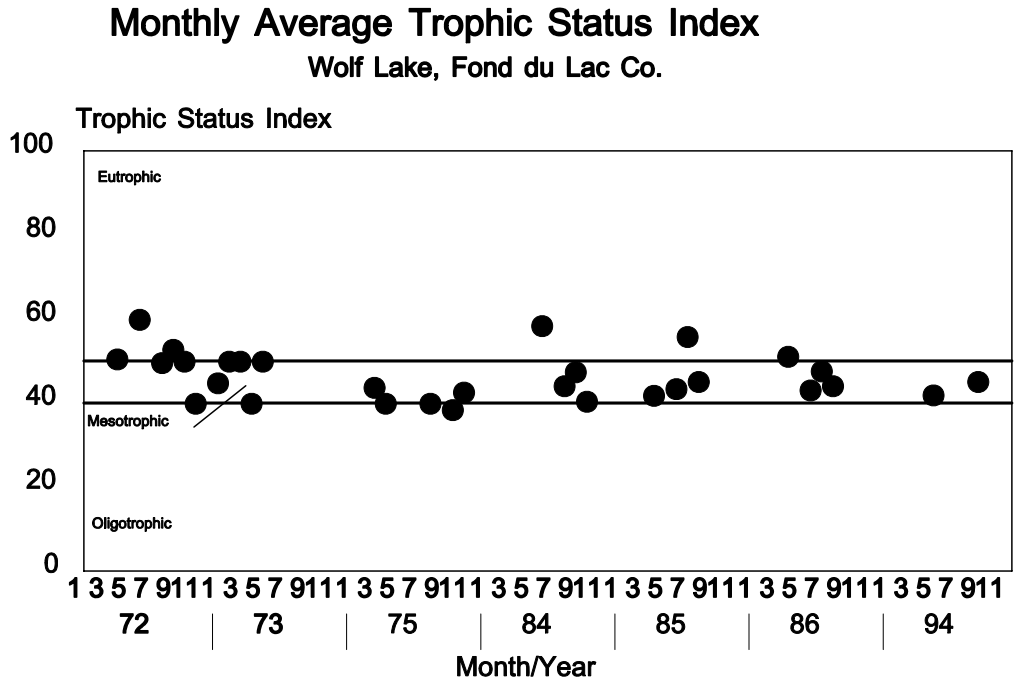


Source: Self-Help Monitoring Program

Trophic Status Index

The Trophic Status Index for Wolf Lake was calculated based upon the existing water quality information. Based upon the seven years of water quality information Wolf Lake can be classified as Mesotrophic (Figure 17).

Figure 17. Monthly average TSI values for Wolf Lake.



LITTLE ELKHART LAKE

T16N R21E Sec. 34, Sheboygan County, Sheboygan River Watershed
Surface Acres = 54, S.D.F. = 2.27, Maximum Depth = 25 feet

Little Elkhart Lake is a 54-acre seepage lake, with an irregular shape, bordering an end moraine. In 1986, a water control device was permitted to deal with severe high water conditions. A pipe was inserted about 25 feet underground to create an overflow outlet, which drains to the headwaters of Otter Creek. The lake underwent two complete chemical treatments, in 1961 and 1981, to eradicate an unbalanced fish population. The lake was stocked with northern pike, largemouth bass, walleye, perch, and golden shiners following the 1961 treatment. Largemouth bass and bluegill were restocked after the 1981 treatment.

Currently, the fishery is composed of moderate to undersized largemouth bass, bluegills, perch and crappies. The YMCA of Racine, Wisconsin, which operates a camp on the lake, owns more than half of the shoreline. One public access site, with parking, toilets and a picnic area, is available. Hunting is allowed in the area with permission.

Major problems with the lake are the ever-present possibility of winterkill and an abundant aquatic plant community. In 1990, the DNR conducted a Sensitive Area Survey of the lake and identified areas of aquatic vegetation that provide unique fish and wildlife habitat and or had benefits to the water quality. As a result of the survey there are limitations on the use of aquatic herbicides and algaecides. The Little Elkhart lake Sanitary District has recently constructed sewers around the lake, with treatment provided by the Plymouth wastewater treatment plant.

SHOE LAKE

T17N R21E Sec. 16, Manitowoc County
Surface Acres = 10.2, S.D.F. = 1.34, Maximum Depth = 34 feet

Shoe Lake is a small alkaline, hardwater seepage lake with a surface area of 10.17 acres and watershed of 1 sq. mile. The lakes maximum depth is 34 feet with a approximately 50% of the lake deeper than 20 feet. The lakes fishery consists of largemouth bass and panfish but had historically been stocked with rainbow trout. A survey conducted in 1975 collected 10 fish species, all of which were sport species except for one, the golden shiner. The sport species included northern pike, bullheads, largemouth bass, black crappie, yellow perch, pumkinseed, and bluegills (Fago 1985). The lake has 64 acres of adjoining wetlands with only a few residences. There is public access with parking facilities on this lake (WCD 1968). No recent water quality data have been collected for this lake.

GRAF LAKE (LONG LAKE)

T17N, R21E, Sect. 15, Manitowoc County
Surface Acres = 7.8, S.D.F. = 1.53, Maximum Depth = 17 feet

Graf Lake is a small alkaline, hardwater land locked seepage lake with a surface area of 7.82 acres and a maximum depth of 17 feet. The lake is bordered by 69 acres of wetland. The lake may have largemouth bass and panfish but winterkill and macrophytes are a major problem. The lake may also be a nesting area for mallards and blue-wing teal (WCD 1968). No recent water quality data have been collected for this lake.

PRAEDER LAKE

T17N, R21E, Sec. 15, Manitowoc County
Surface Acres = 9.2, S.D.F. = 1.15, Maximum Depth = 17 feet

Praeder Lake is a small hardwater alkaline lake with a surface area of 9.24 acres and a maximum depth of 17 feet. This lake is a seepage lake with outflow (LC006) located on its southern shore and during high water periods this flow connects with Gooseville Creek 0.7 miles north of its confluence with the Sheboygan River. The lake's fish population consists of panfish but problems exist due to the presence of aquatic macrophytes and fluctuating water levels. The lake has 10 acres of adjoining wetlands, which may provide nesting areas for blue-wing teal. There is no public access to this lake (WCD 1968). No recent water quality data have been collected for this lake.

SY LAKE

T17N, R21E, Sec. 11, Manitowoc County

Surface Acres = 16.6, S.D.F. = 1.40, Maximum Depth = 33 feet

Sy Lake is a hardwater, alkaline seepage lake with a surface area of 16.57 acres. It has both an inlet and an outlet, both of which are perennial. The outflow is also the beginning of Gooseville Creek. The lake has a maximum depth of 33 feet and a fishery consisting of largemouth bass, panfish and northern pike. In the past it has had a problem with carp and stunted panfish. Much of the shoreline (90%) is wild with 5 acres of adjoining wetlands, which may provide nesting areas for mallards and teal. There are 8 dwellings on this lake and no public access (WCD 1968). No recent water quality data have been collected for this lake.

LITTLE SY LAKE

T17N, R21E, Sec. 11
Surface Acres = 4.5, S.D.F. = 1.11, Maximum Depth = 20 feet

Little Sy Lake is a small land locked seepage lake with a surface area of 4.48 acres. It has hard alkaline water and a maximum depth of 20 feet. The lake is managed for largemouth bass and panfish but has had problems with stunted fish (panfish) and macrophytes. There is 5 acres of adjoining wetland and approximately 10% of the shoreline is bordered by agricultural land. Mallards and blue-wing teal may nest here. There is one residence and no public access to this lake. No recent water quality data have been collected for this lake.

BULLET LAKE

T16N R21E Sec. 35, Sheboygan County
Surface Acres = 14.8, S.D.F. = 1.19, Maximum Depth = 72 feet

This is a deep wilderness kettle lake that has no public access and is located just east of Gerber Lakes. The lake is clear, moderately fertile and surrounded by a tamarack-spruce swamp. It has a surface area of 14.8 acres and a maximum depth of 72 feet. It has a fishery consisting of largemouth bass, panfish and trout (WDNR 1968).
This lake receives inflow from an unnamed stream, which may be carrying nutrients from surrounding agricultural fields. No recent water quality data have been collected for this lake.

PAULY'S LAKE

T16N, R19E, Sec. 25, Fond Du Lac County
Surface Acres = 12.2, S.D.F. = 1.61, Maximum Depth = 6 feet

This is a small 12-acre seepage lake of natural origin located west of St. Cloud. Pauly's Lake is shallow with abundant aquatic vegetation. While not documented, it is very likely that this lake has periodic fish winterkills (WDNR 1990). There are no known water quality problems and the shoreline is undeveloped. Adjacent land use is wooded / shrub wetlands, which are recommended for protection to ensure the aesthetic qualities of the lake are preserved. The land around the lake is recreational and is contained within the St. Cloud State Public Hunting Grounds. Access is limited to light watercraft.

UNNAMED LAKE

T17N, R21E, Sec. 10, Manitowoc County

Little information is available for this lake but from the USGS topographical map, it is approximately 5 acres in size and surrounded by wetlands. This lake is located near the Hillside Grove School and has a bad feedlot located on its eastern shoreline. No recent water quality data have been collected for this lake.

UNNAMED LAKE

T17N, R21E, Sec. 23
Surface Acres = 15.4

This lake is a hardwater seepage lake with a surface area of 15.36 acres and a maximum depth of 13.5 feet. This lake has experienced winterkill problems and does not have a viable fishery. The lake also has problems with nuisance macrophyte growth. It has 2 acres of adjoining wetlands that may provide nesting areas for ducks and muskrats. There are no home sites or public frontage on this lake (WCD 1968). No recent water quality data have been collected for this lake. No recent water quality data have been collected for this lake.

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ONION RIVER WATERSHED (SH04)

INTRODUCTION

The Onion River drains 99 square miles of the southernmost portion of the Sheboygan River Basin tributary to the Sheboygan River. The junction of Ben Nutt Creek and Mill Creek in the kettle moraine region, west and southwest of the City of Plymouth form the river. The Onion River flows southerly for more than half of its length then turns northward and flows into the Sheboygan River at Rochester Park in Sheboygan Falls. Belgium Creek is the only major tributary in the watershed. The Onion River flows freely except for two shallow impoundments at Waldo and Hingham. Land use in the watershed is primarily agricultural.

Tributaries to the Onion River include; Mill Creek, Ben Nutt Creek, Belgium Creek, and ten unnamed tributaries (WDNR 1995). The condition of the surface waters within the watershed ranges from trout stream quality, with intolerant macroinvertebrates in the upstream reaches, to communities that show a dramatic decrease in species diversity. This translates into an increase in tolerant species as a result of habitat and water quality limitations in the downstream reaches of the river (WDNR 1988, 1995). Metal and PAH contaminated sediment has been found in the East Branch of Belgium Creek.

The Onion River Watershed was one of the early Nonpoint Source Priority Watershed Projects in the state (WDNR 1981). In 1984, USGS and WDNR (Field and Lidwin 1984) conducted a study of the water quality of the Onion River. A follow-up report on the Onion River Priority Watershed Project (WDNR 1992) found that the nonpoint source pollution continues to be a major detriment to water quality. Water quality is also affected by point source discharges. In all, eleven municipal and industrial dischargers are in the watershed. Three discharge directly to groundwater and five are wastewater treatment facilities (WDNR 1995).

STREAMS OF THE ONION RIVER WATERSHED

ONION RIVER - OVERVIEW

T15N R22E Sec. 36 NESE Stream Length = 44.0 miles WBIC = 51200

The Onion River discussion is segmented into two sections to represent the different stream classifications and biological characteristics of the stream from its' headwaters downstream. The Onion River is classified as a Cold Water Fish Community stream, Class II trout stream from the headwaters downstream to the top of the Waldo Dam impoundment. A Warm Water Sport Fish Community classification exists from the Waldo Impoundment downstream to the confluence with the Sheboygan River.

ONION RIVER COLD WATER SEGMENT (RM 31.9-44.0)

This segment of the Onion River extends form the headwaters downstream to the top of the pool formed by the Waldo Dam. The potential fishery is currently limited by increased water temperature due to the impoundment and presence of private fish ponds on major spring sources, and siltation from agricultural runoff. This segment is classified as a cold water fish community, Class II trout stream but has the potential of being a Class I stream. The headwaters, Ben Nutt Creek maintains a good diversity of intolerant fish species with tolerant and very tolerant fish species present. Intolerant species include brook and brown trout. Tolerant and very tolerant species include green sunfish, stonecat, and carp.

The diversity of macroinvertebrates is only moderate and decreases in the downstream reaches of this segment. Tolerant stream bottom insects dominate, but the HBI falls in the range of "excellent" to "fair" water quality. This segment supports the most balanced fish and aquatic life community in the watershed.

WDNR personnel surveyed the Onion River upstream of County Highway "U" in July 2000. The survey was conducted upstream and downstream of a large dairy farm operation for a total of two sample sites. This was done to collect baseline data for a future stream relocation project that is designed to reduce nonpoint source pollutant loading to the stream and improve the stream ecosystem. Downstream areas did appear to be impacted from the farm runoff when compared to the upstream site.

Downstream of the dairy farm the fish community rated poor. Fish species included white sucker, mottled sculpin, brown trout, creek chub, northern brook lamprey, rainbow trout, brook stickleback, common carp, brook trout, central mudminnow, and golden shiner. Stream habitat was impacted by the dairy farm with inadequate buffer areas along the streambank, sedimentation on the bottom substrate, bank erosion, and lack of fish cover.

Upstream of the dairy farm the fish community rated fair. Fish species included brown trout, mottled sculpin, white sucker, northern brook lamprey, and rainbow trout. Stream habitat had an excellent buffer of woodland, shading was higher, bank erosion was minimal, bottom substrate had more rock and gravel, and fish cover was better, but still limited.

ONION RIVER WARM WATER SEGMENT (RM 0.0-31.9)

The lower Onion River extends from the Waldo Dam downstream to its confluence with the Sheboygan River at Rochester Park. It does not completely achieve its potential to support a warm water sport fish community because of water quality and habitat limitations. The reach flows through vast acreage of farmland, where intensive pasturing contributes to erosion and sedimentation. Even light rains, or during periods when the carp are active, the stream becomes turbid, resulting in heavy siltation, and increased nutrient levels due principally to agricultural pollutants (pers. comm. Galarneau). The lower Onion River supports a tolerant warm water fishery with carp, bullhead, northern pike, and green sunfish present.

Overall the Onion River's water quality has changed little from the information presented in the Onion River Priority Watershed Plan (WDNR 1981) as compared to our monitoring in 1994. Water quality is still good to excellent in the river's upstream reaches (above Waldo) and poor in the river's lower reaches. The river's tributary streams, specifically Belgium Creek and Lima tributary, are severely degraded due to both point and nonpoint sources and ultimately effect the water quality in the Onion River.

The Onion River Priority Watershed Plan (WDNR 1981) reported that both the biotic index samples and the water chemistry samples above the Hingham impoundment were indicative of good to excellent water quality. While samples collected at the downstream end of the watershed (Ourtown Road) rated the river's water quality as poor. Similar results were observed from our 1994 Onion River water quality monitoring (WDNR 1999).

WDNR personnel surveyed the Onion River approximately 1.6 miles downstream of Ourtown Road in July 2000 (River mile 2.8). The stream reach that was surveyed was within the boundaries of the Pinehurst ("The Bull") Golf Course. The fish community rated good and included the following species: sand shiner, common shiner, white sucker, greater redhorse, longnose dace, hornyhead chub, smallmouth bass, bluntnose minnow, rock bass, common carp, green sunfish, bigmouth shiner, johnny darter, northern pike, stonecat,

blackside darter, black bullhead, black crappie, and bluegill. Stream habitat consisted of a good variety of bottom substrates and habitat types. There were numerous riffle, pool and run areas within the sample reach. However, fish cover was fairly limited. Vegetated buffer areas were good within the stream reach, but heavy agricultural land use within the watershed does contribute a large portion of the sediment and nutrient loading to the Onion River. Future monitoring will be done to determine if the new golf course will have an impact on the stream ecosystem.

ONION RIVER IMPOUNDMENTS

There are numerous water quality impacts associated with dams on rivers. The change in stream classification for the Onion River is associated with the water quality changes brought about by the Waldo dam. Table 41 is a summary of the water quality impacts commonly observed with dams.

Table 36. Water quality, biotic and habitat impacts associated with the placement of dams on streams.

Water Quality Impacts	Biotic Impacts	Habitat
» Increased water temperatures	» Fish migration interference (segmentation of the Sheboygan River)	» Habitat fragmentation
» Lower dissolved oxygen levels	» Loss of riffle spawning habitat	» Loss and coverage of coarse bottom materials
» Higher suspended solids (proliferation of planktonic algae)	» Covering of riffle-dwelling macroinvertebrates	» Loss of riverine habitat
» Bioturbation-by carp and other bottom-dwelling fish, creating higher downstream turbidities	» Displacement of lotic mussel species	

ONION RIVER WALDO MILLPOND AT RM 31.9

T14N R21E Sec. 14 Surface Acres = 40 Maximum Depth = 7 ft.

The Waldo millpond is located at Waldo just east of STH 57 and is created by a dam with an 8 1/2 foot high sill. As part of a study conducted in 1994, the Waldo millpond was used to assess the impacts associated with impoundments on river systems (Aartila, 1995). The Onion River from its headwaters to the Waldo Impoundment is classified as cold water community stream and as a warm water sport fish community downstream of the impoundment.

The effects of slower current velocities and no stream side shading resulted in dramatic increases in the maximum air temperature and water temperature recorded from both the Waldo millpond and STH 57 (which is just downstream of the Waldo millpond) sites. In comparison, the shady upstream site at CTH E displayed much cooler air and water temperatures (Aartila 1995). During August of 1994, the maximum daily air temperature at the shady site was approximately 5^{o}C cooler than the downstream sites. Likewise maximum water temperatures were also much cooler at CTH E than the Waldo millpond and STH 57 sites by approximately 5^{o}C. Streamside shading on the Onion River reduces the warming effect of direct sunlight on the water surfaces at these shaded sites and reduces maximum air temperatures.

Not only does the Waldo millpond slow current velocities and expose surface waters to direct sunlight, it also increases algae productivity and provides optimal habitat for bottom feeding fishes (e.g. carp).

Increases in algae concentrations (statistically significantly different at $p<0.05$, $n=12$) and increases in suspended solid concentrations (although not statistically significant) through bioturbation are both real threats to water quality downstream of the millpond (Aartila 1995). Increases in the geometric mean concentration of chlorophyll *a* (3.4 µg/l to 27.2 µg/l) and suspended solids (10 mg/l to 31 mg/l) upstream and below the Waldo millpond document these effects. Samples collected for the study from the Mullet River provide a point of reference for a typical free-flowing river system and are reported on in the Mullet River Watershed section (and fully in the Aartila 1995 report).

ONION RIVER HINGHAM MILLPOND AT RM 28.3

T14N R22E Sec. 31 Surface Acres = 38 Maximum Depth = 6 ft.

This is the downstream-most dam on the Onion River and has a sill height of six feet. The dam is located on the north side of Hingham just upstream of CTH I. The condition of the dam is undergoing an evaluation by WDNR dam safety personnel. No recent water quality information has been collected on the Hingham impoundment.

A sediment quality assessment was conducted by WDNR on June 29, 1999 on the Hingham Impoundment, Onion River (Table 36). Three sample sites were sampled in the soft sediment that has accumulated behind the dam. Samples were collected 30, 45 and 60 meters upstream from the dam.

Table 37. Sediment quality assessment for the Onion River within the Hingham Impoundment. Collected June 29, 1999.

Parameter	30 m upstream	45 m upstream	60 m upstream
	Mg/kg (ppm)	mg/kg (ppm)	mg/kg (ppm)
Arsenic	ND	ND	ND
Cadmium	0.7	0.7	0.6
Chromium(total)	27	22	25
Copper	26	22	24
Lead	18	14	14
Mercury	0.095	0.078	0.083
Nickel	17	13	14
Zinc	70	58	62
PAHs (total)	0.198	0.029	0.117
PCBs (total)	<0.05	<0.05	<0.05
Ammonia-N	151	59.7	89.0
Phosphorus (total)	817	659	724
TOC (Total Organic Carbon)	37900	47700	42400
% solids	41.6%	39%	39.1%

The pesticides (Aldrin, Alpha BHC, C-chlordane, Chlordane Alpha, Chlordane Gamma, Dieldrin, Endrin, Gamma BHC, Heptachlor, Nonachlor Cis) were all less than the level of detection.

TRIBUTARIES TO THE ONION RIVER

UNNAMED TRIBUTARY TO WALDO MILL POND (ONION RIVER) AT RM 32.3

T14N R21E Sec. 14 NWSE Stream Length = 2.7 miles WBIC = 52600

This is a small perennial stream that flows northeast from the Cascade Swamp, along the west side of Waldo into the Waldo impoundment. Channelization and lack of stream buffer in the upper reaches of this stream result in the stream being flashy. An undersized culvert in the lower reaches combined with flashy flows result in moderate to severe bank erosion and sedimentation. Tables 52 and 53 show the fish and habitat information collected during the 1994 basin monitoring.

Table 38. Unnamed Tributary to Onion River at the Waldo Millpond Fish Community Assessment (1994)

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Historical Fish Collections (Fago 1985)	1994 Fish Collections
Creek Chub	Tolerant	Tolerant	NO DATA AVAILABLE.	X
White Sucker	Tolerant	Tolerant		X
Brook Stickleback	Tolerant			X
Johnny Darter	Tolerant			X
Central Mudminnow	Very Tolerant	Tolerant		X

[1] Ball (1982)
[2] Lyons (1992)

Table 39. Hilsenhoff Biotic Index (HBI), Index of Biotic Integrity (IBI), and Habitat Quality results for the unnamed tributary to Onion River at the Waldo Millpond.

Stream	SITE	Spring - HBI [1]		Fall – HBI [1]		IBI [2]		Habitat			
		Avg. Score	Water Quality Rating	Avg. Score	Water Quality Rating	Score	Biotic Integrity Rating	Ball [3]		Simonson et al. [4]	
								Score	Rating	Score	Rating
Unnamed Tributary	OR-7	No data available				32	Fair	199	Fair	55	Good

[1] Hilsenhoff Biotic Index (1987)
[2] Lyons (1992)
[3] Ball (1982)
[4] Simonson et al. (1994)

UNNAMED TRIBUTARY TO ONION RIVER AT RM 31.2

T14N R21E Sec. 13 SWSE Stream Length = 3.3 miles

This is a small perennial stream that flows southeast from north of Waldo then southerly to a confluence with the Onion River north of CTH V, east of Waldo. Lowflows and shallow water depths naturally limit this stream. This small tributary serves as a rearing area and a source of forage fish for the Onion River. Tables ? and ? show the fish and habitat information collected during the 1999 baseline monitoring.

Table 40. Unnamed tributary to Onion River upstream from CTH V fish community assessment, 1999.

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Spring Creek downstream of South Park Street
Creek Chub	Tolerant	Tolerant	X
White Sucker	Tolerant	Tolerant	X
Central Mudminnow	Very Tolerant	Tolerant	X

[1] Ball (1982)
[2] Lyons (1992)

Table 41. Hilsenhoff Biotic Index (HBI), Index of Biotic Integrity (IBI) and Habitat Quality Results for Spring Creek from the 1999 assessments.

Spring Creek Ssmple Site	HBI [1]		IBI [2]	
	Avg. Score	Water Quality Rating	Score	Water Quality Rating
Downstream of S. Park Street			*	*

[1] Hilsenhoff Biotic Index (1987)
[2] Lyons (1992)

* The average stream width for this fish community assessment site is below the current IBI model calibration. DNR Research is currently developing an IBI for samll streams and these data will be evaluated using that method when it becomes available.

BELGIUM CREEK AT RM 17.1

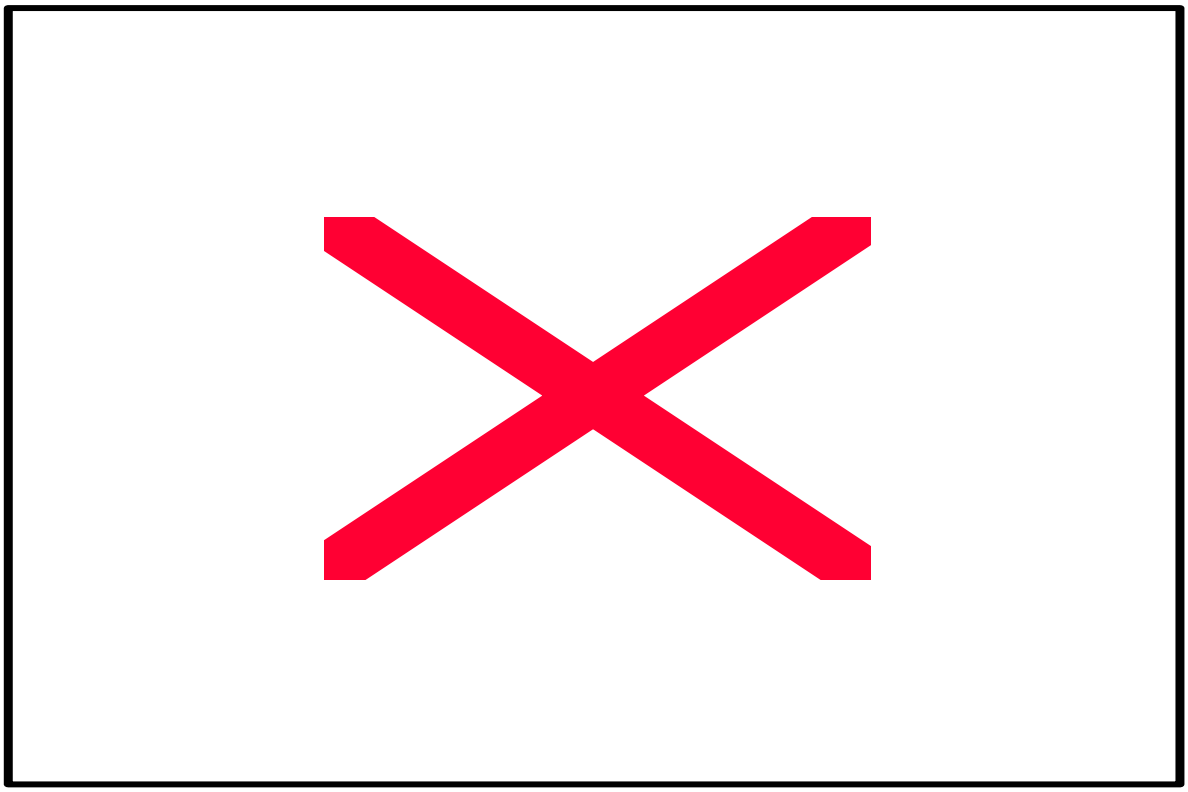
T13N R22E Sec. 22 NWSE Stream Length = 22.2 miles WBIC = 51400

Belgium Creek consist of two major branches, the East Branch that is approximately four miles long and the West Branch is 22 miles. The West Branch is the largest branch consisting of three separate tributaries. The northern-most tributary originates at T13N R22E S31 SWNE and will be referred to as the Grasser Branch of the West Branch for descriptive purposes. The middle branch will be referred to as the Dacada Branch of the West Branch and originates at T13N R22E S32 NWSW. The main branch, of the West Branch of Belgium Creek, will referred to as the Village Branch and originates near the Village of Belgium at T12N R22E S16 SESE. The headwaters of Belgium Creek are primarily in northern Ozaukee County and the stream flows north to a confluence with the Onion River in Sheboygan County. Belgium Creek receives wastewater discharges from the Belgium Wastewater treatment plant and Lakeside Food Co. located on the East Branch of Belgium Creek.

As part of the Sheboygan River Basin monitoring and stream classification review for the East Branch of Belgium Creek; fish, macroinvertebrates, habitat, and, water and sediment chemistry have been collected since 1994. Eleven water chemistry samples were collected between May and October 1994 and analyzed for nutrients, solids and bacteria. These samples were collected as part of the Onion River Bacteriological Study: Assessment of Point and Nonpoint Source Pollution. A bacteriological survey by WDNR in 1990 identified the Onion River downstream of the confluence with Belgium Creek to have appreciably higher fecal coliform bacteria concentrations than upstream (WDNR 1990). In 1994, WDNR sampled two sites on Belgium Creek plus two sites on the Onion River to identify the source(s) of bacteria found in a previous study.

The West Branch of Belgium Creek was identified as the source of the high levels of bacteria to the Onion River (WDNR 1995). The large number of barnyards and pastures along this section of Belgium Creek were most likely the source (Aartila and Galarneau 1998). In contrast, this study found that nutrients, suspended solids and turbidity were higher on the East Branch which are probably from the point source discharges to this branch. Figure 18 depicts the water quality data from the eleven samples collected during 1994 using box-whisker plots showing the maximum and minimum values, median, and the 75th and 25th percentiles. The percentile is the percentage of analyses equal to or less than indicated values with the 50th percentile being the median value.

Figure 18. Belgium Creek Water Quality Graphs



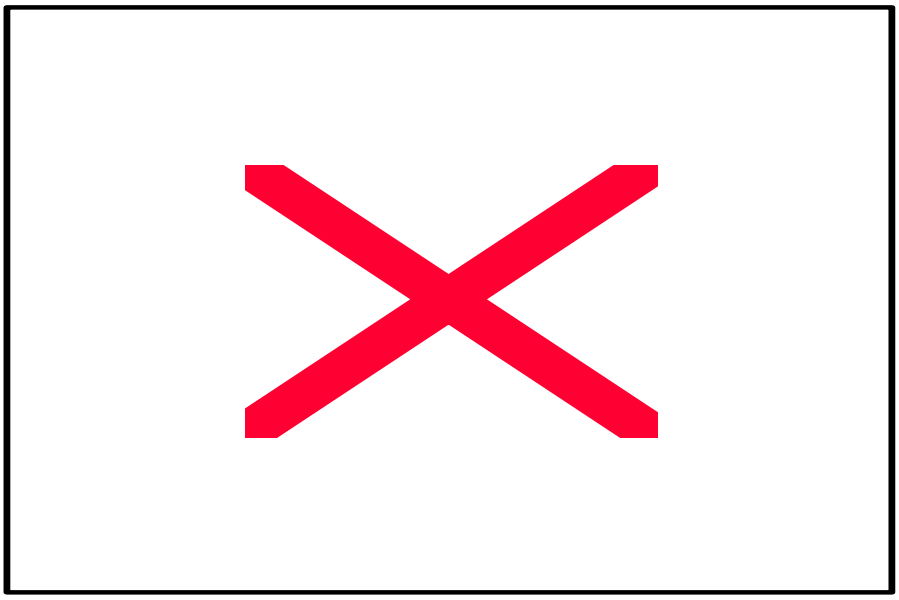
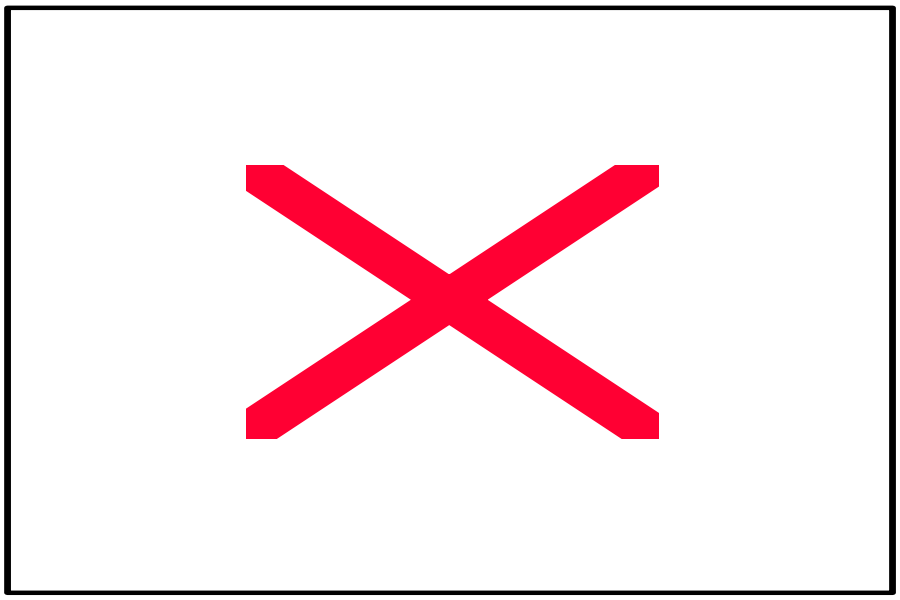


Figure 18. continued



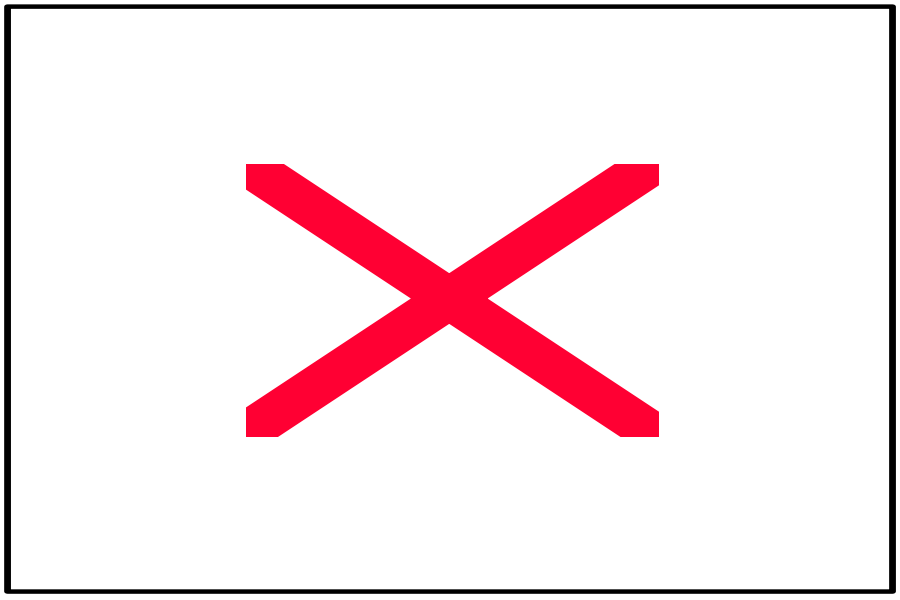
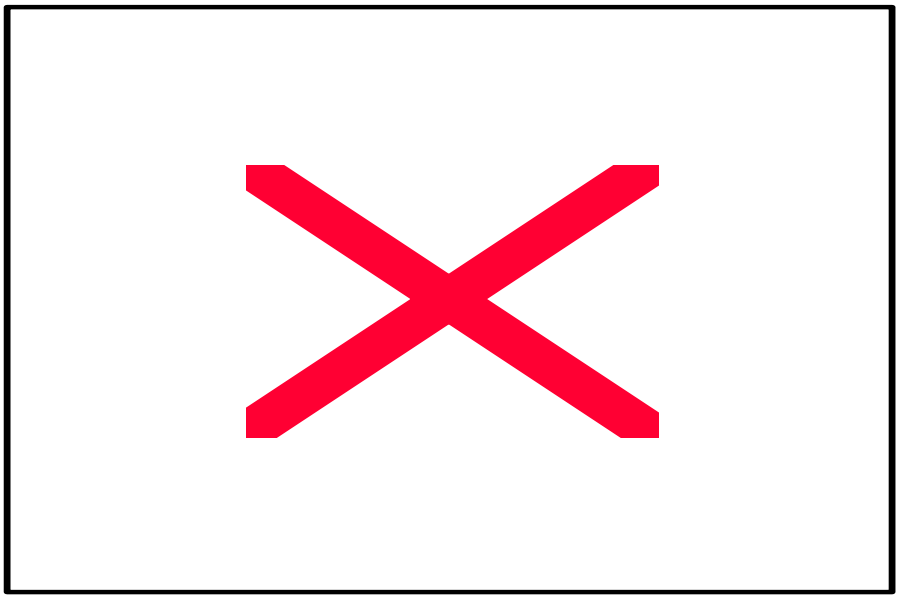


Figure 18 Continued.



Nine recent fish surveys have been conducted on the various branches of Belgium Creek. Twelve fish species of fish were collected during the recent fish surveys in the West Branch Belgium Creek and 17 species of fish have been recorded in this branch including earlier fish surveys (Table 55). Recent fish surveys in the East Branch of Belgium Creek observed seven native species and one exotic (carp) (Table 43).

Table 42. Fish surveys for Belgium Creek (Main Branch, East Branch, West Branch, North Branch of the West Branch, and South Branch of the West Branch), Onion River Watershed, Sheboygan River Basin.

Fish Species (common name)	Belgium Creek		East Branch Belgium Creek				West Branch Belgium Creek					
	at CTH D		at CTH RR			at Jay Rd.	at CTH RR				North Br. at Six Mile Rd.	South Br. at Six Mile Rd.
	06/17/76	09/13/94	06/17/76	11/02/78	09/09/94	09/09/94	10/16/73	06/17/76	11/02/78	09/13/94	09/13/94	09/19/94
Common Shiner	X		X	No Fish Captured			X	X	X			X
White Sucker	X	X			X	X	X	X	X	X	X	X
Black Bullhead	X							X				
Green Sunfish	X						X	X			X	
Creek Chub			X		X	X	X	X	X	X	X	X
Northern Pike								X	X			

Sand Shiner		X					X	X	X			
Bluntnose Minnow							X	X				
Brook Stickleback		X			X	X	X	X		X	X	X
Johnny Darter		X			X		X	X	X	X	X	X
Blacknose Dace					X		X			X	X	X
Common Carp		X			X				X			
Longnose Dace										X	X	X
Fathead Minnow											X	
Southern Redbelly Dace											X	

An Index of Biotic Integrity (Lyons 1992) was calculated for each of the fish collection sites with ratings ranging form 17 (very poor) at the site on the main stem of Belgium Creek to 37 (fair) from the site on the north tributary of the west branch of Belgium Creek (shown in Table 3). These sites were limited from achieving a higher classification due to the high number of tolerant fish, the low number of darter species and lithophylic (riffle) spawning species.

Table 3. Fish community assessment station locations and IBI results for Belgium Creek and tributaries to Belgium Creek sampled during 1994.

STREAM	SAMPLE SITE	IBI
Belgium Creek	at CTH D	Very Poor (17)
East Branch of Belgium Creek	at CTH RR	Poor (29)
	at Jay Road	Fair (30)
West Branch of Belgium Creek - North Branch of the West Branch - South Branch of the West Branch	at CTH RR	Fair (32)
	at Six Mile Road	Fair (32)
	at Six Mile Road	Poor (29)

Hilsenhoff Biotic Index samples were collected from the same sites that the chemistry samples were collected in 1994. These sites contained less than optimal HBI sampling substrates due to extensive historical channelization. Since no cobble riffles were present, samples were collected from logs and debris in the stream channel. HBI values recorded from these sites were 7.435 for the West Branch and 7.918 for the East Branch. These values are indicative of fairly poor water quality (West Branch) and poor water quality on the East Branch. Chironomids (39%) and *Asellus intermedius* (51%) on the West Branch and *A. intermedius* (74%) on the East Branch dominated the samples.

Sediment samples were collected in 1994 at three sites in the East Branch Belgium Creek to obtain baseline sediment quality data and to assess the potential sediment quality impacts from chromium contaminated groundwater cleanup site in the Village of Belgium. Based on the data results and observations during subsequent field visits of oil sheens in the river, additional sites were sampled in 1997 and 1998. Table 42 shows elevated levels of PAHs, heavy metals, and low levels of PCBs. The full extent of the contaminated sediment in the East Branch of Belgium Creek, its impact on the Onion River, and the source(s) of the contamination are unknown at this time and will require further investigation.

Table 43. East Branch Belgium Creek Sediment Sample Site Locations

Stream	SITE INFORMATION		
	STORET #	**Site Description**	**Sample Type**
East Branch	463125	Upstream of Cedar Beach Rd. (South of Belgium)	Sediment
	463122	At Stormsewer Outlet (North of Belgium)	Sediment
	463123	Downstream of north edge of HGI Plating Co. HGI	Sediment
	463146	Upstream of drain-tile from behind Belgium Foundry	Sediment
	463147	10 ft. Downstream of drain-tile from behind Belgium Foundry	Sediment
	463124	Downstream, North edge of Belgium Foundry	Sediment
	463145	300 yds. Downstream of Belgium Foundry (near snowmobile bridge)	Sediment
	463143	Upstream of Silver Beach Rd (and upstream of WWTP outfall)	Sediment
	463144	Upstream of CTH K	Sediment
	603208	Upstream of CTH RR	Sediment

Table 44. Sediment Survey Results - Belgium Creek

Parameters		Sites										
		463125	463122	463123	463124	463146	463147	463145	463143	463144	603208	
											Top 6" of core	>6"
Total Organic Carbon (ug/g)		61900	11400	13800	6710	38600	20600	57100	41000	74600	193000	84600
Particle Size	% Solids	28.1	68.6	69	63.4							
	% Sand	27	89	85	84							
	% Silt	48	4	8	10							
	% Clay	25	7	7	6							
	Soil Texture	Loam	Sand	Loamy Sand	Loamy Sand							
PCBs (total) (ug/g)			0.24	0.3	0.08	0.30	0.33	0.57				
PAHs (ng/g)	Acenaphthene	<100	<800	<800	<400	<1000	<400	<1000	<200	<200	<220	<100
	Acenaphthylene	<100	<800	<800	<400	<1000	<400	<1000	<200	<200	<220	<100
	Anthracene	<100	<800	<800	<400	<1000	<400	<1000	<200	<200	<220	<100
	Benzo (A) Anthracene	<100	1600	<800	<400	<1000	450	<1000	<200	<200	<220	<100
	Benzo (B) Fluoranthene	<100	2500	<800	<400	<1000	<400	1000	<200	<200	<220	<100
	Benzo (K) Fluoranthene	<100	900	<800	<400	<1000	<400	<1000	<200	<200	<220	<100
	Benzo (GHI) Perylene	<100	1100	<800	<400	<1000	<400	<1000	<200	<200	<220	<100
	Benzo (A) Pyrene	<100	1500	<800	<400	<1000	<400	<1000	<200	<200	<220	<100
	Benzo (E) Pyrene	<100	1100	<800	<400	<1000	<400	<1000	<200	<200	<220	<100

Parameters		Sites										
		463125	463122	463123	463124	463146	463147	463145	463143	463144	603208	
											Top 6" of core	>6"
	Chrysene	<100	1600	<800	<400	<1000	550	<1000	<200	<200	<220	<100
	Dibenzo (A,H) Anthracene	<100	<800	<800	<400	<1000	<400	<1000	<200	<200	<220	<100
	Fluoranthene	<100	4200	<800	590	1500	1500	1900	430	<200	<220	<100
	Fluorene	<100	<800	<800	<400	<1000	<400	<1000	<200	<200	<220	<100
	Indeno (1,2,3-CD) Pyrene	<100	1200	<800	<500	<1000	<400	<1000	<200	<200	<220	<100
	Perylene	<100	<800	<800	<400	<1000	<400	<1000	<200	<200	<220	<100
	Phenanthrene	<100	3200	<800	<400	1100	1300	1800	260	<200	<220	<100
	Pyrene	<100	2900	<800	430	1200	1300	1700	370	<200	<220	<100
Metals (mg/kg)	Mercury					0.69	0.074	0.49				
	Cadmium	1.4	0.6	ND	0.5	0.6	0.5	1.2	ND	ND	0.5	0.4
	Chromium	20	30	34	38	120	62	350	400	100	160	67
	Copper	39	24	18	21	47	25	67	55	24	39	18
	Nickel	21	8	6	8	13	8	19	24	13	16	11
	Lead	20	35	67	28	50	43	69	43	9	20	9
	Zinc	83	83	85	73	190	130	330	250	82	120	57
Ammonia (mg/kg)		210	490	94	140							

MILL CREEK

T14N R21E Sec. 5 Stream Length = 2.0 miles

Mill Creek is one of two major headwater tributaries to the Onion River, originating in the extreme northwest section of the town of Lyndon as a series of springs. The development of hatchery ponds and raceways on the two major feeder springs has reduced the water quality and eliminated natural reproduction in the brook trout population. Brown trout naturally reproduce in Mill Creek. Some portions of the stream are heavily silted. The fishery consists mainly of brook and brown trout, sucker and minnow populations. Mill Creek is classified as a Class II trout stream. The WDNR is currently working with local organizations to remove the hatchery ponds and raceways to restore the trout stream to its original condition. This will improve both the water quality and biological integrity of Mill Creek, resulting in one of the better trout stream in Sheboygan County.

WDNR personnel surveyed the stream downstream of County Highway "S" in August 2000. The fish community rated good with populations dominated by brown trout. Brook trout, brook stickleback and white sucker were also present. The stream habitat appeared to be in good condition with excellent buffer areas, stable banks, rocky substrate, and abundant fish cover.

BEN NUTT CREEK

T15N R21E Sec. 30 Stream length = 6.0 miles

As the major headwater tributary to the Onion River, this creek drains an area of about nine square miles in the southwest corner of the town of Plymouth. Although classified as a Class II trout stream, brown trout reproduction has been reduced by the presence of dams, ponds, and raceways that cause temperature fluctuations in the headwater springs. Brown trout are planted annually, and the stream experiences heavy fishing pressure. The Hilsenhoff biotic index (HBI) value for the creek was 5.88 indicating "fair" water quality (WDNR 1991). The fishery is composed of brown trout, bluntnose minnow, blacknose dace, creek chub, pearl dace, white sucker, brook stickleback, johnny darter, and mottled sculpin.

UNNAMED TRIBUTARY TO ONION RIVER (PINEHURST CREEK) AT RM 2.8

T14N R22E Sec. 1 Stream length = ??? miles

This unnamed tributary originates in the Town of Lima and flows north to the Onion River. The primary land use in the watershed is agricultural with portions of wetlands and wooded areas. The stream meanders through a cedar swamp that has numerous springs. Therefore, portions of the stream are cold water. The lower areas of the stream have been channelized in the past, possibly to allow for farming. These areas now are dominated by wetland plant species and appear to be valuable to wildlife.

WDNR personnel surveyed the stream upstream of the confluence with the Onion River in August 2000. Fish species included brook stickleback, creek chub, white sucker, central mubminnow, and fathead minnow. Stream habitat analysis showed good buffer areas and shading, minimal streambank erosion, sand and gravel substrate, and limited fish cover. The limited fish cover would account for the low numbers of fish collected in the survey.

UNNAMED TRIBUTARY TO ONION RIVER (HAND CREEK) AT RM 19.2

T13N R22E Sec. 16 Stream Length = 5.5 miles WBIC = 51900

"Hand Creek" is an unnamed tributary to the Onion River that primarily flows to the southeast. This stream is located in the Township of Holland. Land use in the watershed is primarily agriculture with wooded areas along the river cooridor. WDNR personnel surveyed a downstream portion of the stream in July 2000. The fish community rated good and species are listed in Table ???? Stream habitat showed minimal streambank erosion; modertae buffer area; rock, gravel, and sand substrate; and minimal fish cover. Water quality is probably limited throughout the year due to runoff and sediment and nutrient loadings. This section of the stream was channelized, therefore any habitat improvements would probably improve the fishery.

Table. Unnamed tributary to Onion River (Hand Creek) fish community assessment, 2000.

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Hand Creek ** 2000
Creek Chub	Tolerant	Tolerant	X
Blacknose Dace	Intolerant	Tolerant	X
Johnny Darter	Tolerant		X
Central Mudminnow	Very Tolerant	Tolerant	X
Bigmouth Shiner			X
Common Shiner	Tolerant		X
Bluegill	Sport		X
Bluntnose Minnow	Tolerant	Tolerant	X
Brook Stickleback	Tolerant		X
Longnose Dace	Intolerant		X
Northern Hog Sucker	Tolerant	Intolerant	X
Rock Bass	Sport	Intolerant	X
White Sucker	Tolerant	Tolerant	X

[1] Ball (1982)
[2] Lyons (1992)
** Stream width below IBI model calibration (<2.5m or 8.2 ft.)

UNNAMED TRIBUTARY TO "HAND CREEK" (SIX-MILE ROAD CREEK) AT RM 0.7

T13N R22E Sec. 16 SWSW Stream Length = 3.7 miles WBIC = 51800

"Six-Mile Road Creek is an unnamed tributary to the "Hand Creek" that flows to the north and is located in the Township of Holland. Land use in the watershed is primarily agriculture with wooded areas along the river cooridor. WDNR personnel surveyed a portion of the stream in July 2000. The fish community is listed in Table ???? Stream habitat showed streambank erosion; inadequate buffer areas; gravel and sand substrate; and minimal fish cover. The stream does appear to be flashy and this would account for streambank erosion problems. Water quality is probably limited throughout the year due to nonpoint source runoff and sediment and nutrient loadings. This section of the stream was channelized, therefore any habitat improvements would probably improve fish cover.

Table. Unnamed tributary to Hand Creek (Six-Mile Road Creek) fish community assessment, 2000.

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Six-Mile Road Creek ** 2000
Creek Chub	Tolerant	Tolerant	X
White Sucker	Tolerant	Tolerant	X
Brook Stickleback	Tolerant		X
Central Mudminnow	Very Tolerant	Tolerant	X

[1] Ball (1982)
[2] Lyons (1992)
** Stream width below IBI model calibration (<2.5m or 8.2 ft.)
** Too few fish to calculate IBI

UNNAMED TRIBUTARY TO ONION RIVER (LIMA TRIB) AT RM 6.4

T14N R22E Sec. 13 Stream Length = 13.0 miles

This unnamed tributary to the Onion River originates in the Town of Lima and flows east to the Onion River. The predominant land uses in this watershed are pasture, barnyards, and croplands which are contributing a high bacterial, nutrient, and sediment load to the stream (WDNR 1988 and WDNR 1995). Two industrial dischargers are located in the stream's headwaters: Sheboygan County Health Center and Schneider Cheese Inc. Three fish surveys were conducted on the unnamed tributary during 1994 (Tables 59 and 60.

Table 45. Unnamed Tributary to Onion River Lima Trib) Sample Site Locations - 1994

Stream	SITE INFORMATION	
	Site	Site Description
Lima Tributary to the Onion River	OR-8	At CTH VN
	OR-9	At CTH I
	OR-10	Upstream of STH 32

Table 46. Lima Tributary to Onion River Fish Community Assessment

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Historical Fish Collections (Fago 1985)	1994 Fish Collections
Northern Pike	Sport Fish		X	X
Creek Chub	Tolerant	Tolerant	X	X
White Sucker	Tolerant	Tolerant	X	X
Brook Stickleback	Tolerant			X

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Historical Fish Collections (Fago 1985)	1994 Fish Collections
Green Sunfish	Sport Fish	Tolerant		X
Johnny Darter	Tolerant			X
Blacknose Dace	Intolerant	Tolerant		X
Longnose Dace	Intolerant			X
Fathead Minnow	Very Tolerant	Tolerant		X
Central Mudminnow	Very Tolerant	Tolerant		X
Common Carp	Very Tolerant	Tolerant		X

[1] Ball (1982)
[2] Lyons (1992)

Habitat assessments and macroinvertebrate community assessments were conducted in 1994 for Lima Trib. as part of the basin monitoring. Water quality ratings associated with these assessments are shown in Table 61.

Table 47. Hilsenhoff Biotic Index (HBI), Index of Biotic Integrity (IBI), and Habitat Quality results for the Unnamed Tributary (Lima) to Onion River

Stream	SITE	Spring - HBI [1]		IBI [2]		Habitat			
		Avg. Score	Water Quality Rating	Score	Biotic Integrity Rating	Ball [3]		Simonson et al. [4]	
						Score	Rating	Score	Rating
Lima Tributary	OR-8			10	Very Poor	235	Poor	38	Fair
	OR-9			10	Very Poor	239	Poor	28	Fair
	OR-10	7.17	Fairly Poor	32	Fair	205	Poor	53	Good

[1] Hilsenhoff Biotic Index (1987)
[2] Lyons (1992)
[3] Ball (1982)
[4] Simonson et al. (1994)

Based on the existing fish community the unnamed tributary (Lima Trib.) to the Onion River was classified as a Warmwater Forage Fish communities stream (WDNR 1995).

Table 48. Streams of the Onion River Watershed.

Stream Name/Location (T, R, Sec., QQ, Q)	WBIC	Length	Biological Use		Codified	Supp.	Assess. Category	Use Impairments		Ref.	Data Level
			Existing	Potential				Source	Impact		
Belgium Creek T13N R22E Sec.22 NWSE	51400	22.2	WWFF	WWFF	LFF	PART	M	HM, PSB, CL, SB, NPS	FLOW, NUT, SED, HAB, TURB, BAC		4
East Branch Belgium Creek T13N R22E Sec.27 NESW	51500	4.0	LFF	WWFF	LAL	PART	M	HM, DCH, PSM, PSI, URB, SB, NPS	FLOW, NUT, SED, HAB, TURB, MIG, HM, TOX		4
Mill Creek T14N R21E Sec.5 SESW	52700	2.0	COLD[1] CLASS II	COLD CLASS I	ERW COLD	PART	M	NPS,HM	TEMP, SED		3
Ben Nutt Creek (Headwaters of Onion River) T15N R21E Sec.30		6.0	COLD[1] CLASS I	COLD CLASS I	ERW COLD	NOT	M	NPS,HM, DCH	TEMP, FLOW		4
Unnamed Tributary to Ben Nutt Creek (Kamrath Trib) T15N R21E Sec.30 SESE		1.0	COLD[1] CLASS II	COLD CLASS I	DEF	NOT	M	NPS,HM, DRDG	TEMP, SED, MIG		4
Onion River Segment 1 RM 0.0-31.9	51200	Total 44.0 Reach 31.9	WWSF	WWSF	DEF	PART	M	NPS, HM, PSM, PSI, SB, URB	TURB, SED, HAB, MIG		4
Onion River Segment 1 RM 31.9-44.0	51200	Total 44.0 Reach 12.1	COLD[1] CLASS II	COLD CLASS I	ERW COLD	PART	M	NPS,HM	TEMP, SED		4
Unnamed Tributary (Lima Trib) to Onion River T14N R22E Sec.13		13.0	LFF	WWFF	LAL	NOT	M	NPS, HM, PSI, PSM	SED, NUT, FLOW		3
Unnamed Tributary to Onion River in Waldo Impoundment T14N R21E Sec.14 NWSE	52600	2.7	LFF	WWFF	DEF	NOT	M	HM, SB, URB	FLOW, HAB, SED		3
Unnamed Tributary to Onion River T14N R21E Sec.13 SWSE	52300	3.3	LFF	LFF	DEF	PART	M	HM, CL, NPS	FLOW, HAB		4
Unnamed Tributary to Onion River T14N R21E Sec.10		0.5	UNK	UNK	DEF	UNK					

Stream Name/Location (T, R, Sec., QQ, Q)	WBIC	Length	Biological Use		Codified	Supp.	Assess. Category	Use Impairments		Ref.	Data Level
			Existing	Potential				Source	Impact		
Unnamed Tributary to Onion River T14N R21E Sec.24		2.2	UNK	UNK	DEF	UNK					
Unnamed Tributary to Onion River T14N R22E Sec.30 SWNW	51300	2.2	UNK	UNK	DEF	UNK					
Unnamed Tributary to Onion River T14N R22E Sec.30		1.0	UNK	UNK	DEF	UNK					
Unnamed Tributary to Onion River T14N R22E Sec.31		0.4	UNK	UNK	DEF	UNK					
Unnamed Tributary to Onion River T14N R22E Sec.31		1.0	UNK	UNK	DEF	UNK					
Unnamed Tributary to Onion River T14N R22E Sec.33		0.8	UNK	UNK	DEF	UNK					
Unnamed Tributary to Onion River T14N R22E Sec.4		0.7	UNK	UNK	DEF	UNK					
Unnamed Tributary (Hand Creek) to Onion River T13N R22E Sec.16 SWSW	51900	4.9	WWFF	WWFF	DEF	PART	M	NPS, CL, HM, NPS	HAB, FLOW, SED		4
Unnamed Tributary to Hand Creek T13N R22E Sec.16 NWSE	51800	3.7	LLF	WWFF	DEF	NOT	M	NPS, BY, CL	HAB, SED, FLOW		4
Unnamed Tributary to Hand Creek at RM 1.3 T13N R22E Sec.17 NENW	52000	1.4	UNK	UNK	DEF	UNK					
Unnamed Tributary to Onion River T13N R22E Sec.22		1.3	UNK	UNK	DEF	UNK					
Unnamed Tributary to Onion River T13N R22E Sec.14		0.8	UNK	UNK	DEF	UNK					
Unnamed Tributary to Onion River T14N R22E Sec.35		1.1	UNK	UNK	DEF	UNK					

Stream Name/Location (T, R, Sec., QQ, Q)	WBIC	Length	Biological Use		Codified	Supp.	Assess. Category	Use Impairments		Ref.	Data Level
			Existing	Potential				Source	Impact		
Unnamed Tributary to Onion River T14N R22E Sec.35		0.6	UNK	UNK	DEF	UNK					
Unnamed Tributary to Onion River T14N R22E Sec.35		2.5	UNK	UNK	DEF	UNK					
Unnamed Tributary to Onion River T14N R22E Sec.26		1.7	UNK	UNK	DEF	UNK					
Unnamed Tributary to Onion River T14N R22E Sec.1		1.1	UNK	UNK	DEF	UNK					
TOTALS		**126.1**									

Trout streams as defined in Wisconsin Trout Streams (1980) but not listed in NR 102. These streams may be classified as trout streams under 1.02(7) since publication of Wisconsin Trout Streams (1980), but are not formally classified as trout waters. These streams will be added to NR 102 and/or NR 104 during code revision.

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MULLET RIVER WATERSHED (SH05)

INTRODUCTION

The Mullet River originates at the outlet of Mullet Lake in Fond du Lac County, running northeast into Sheboygan County through the Old Wade House State Park at the village of Greenbush in Sheboygan County. The river further flows through five impoundments: Glenbulah Mill Pond, Camp Evelyn, Plymouth Mill Pond, Meyer Park, and New Paris. The river then runs east and drains into the Sheboygan River near Sheboygan Falls. Tributaries to the Mullet River in its 98 square mile watershed include two trout streams; La Budde Creek, and Jackson Creek, and nine unnamed tributaries.

The watershed includes 1.9 miles of Class I trout water, 9.9 miles of Class II trout water, and 34.8 miles of warm water sport fishery. Land use in the Mullet River watershed is primarily agricultural with municipal and industrial discharges in Plymouth and in the lower reaches near Sheboygan Falls. Water quality is impacted by rural and urban nonpoint source pollution along with the problems associated with human-made impoundments.

STREAMS OF THE MULLET RIVER WATERSHED

MULLET RIVER - OVERVIEW

T15N R22E Sec. 35 Stream Length = 39.7 miles

The Mullet River originates from the outflow of Mullet Lake and the Mullet River State Wildlife Area in Fond du Lac county and flows in an easterly direction for approximately 40 miles to its confluence with the Sheboygan River in the Town of Sheboygan Falls, 17 miles upstream of Lake Michigan. The water quality of the Mullet River is considered good from its headwaters to Plymouth (approximately 25 miles) and fair from Plymouth downstream to its confluence with the Sheboygan River (approximately 15 miles) (WDNR 1968, 1995). The middle of the river, from Plymouth to Glenbeulah, has an increase in spring flow that lowers stream water temperatures and is classified as a Cold Water Community stream (trout). Upstream of Glenbeulah, and downstream of STH 67 near Plymouth, the Mullet River is classified as a Warm Water Sport Fish Community stream. This classification difference is due primarily to the increase in spring flow between Glenbeulah and Plymouth. The Mullet River is unique in that it flows from the warm water headwaters into a cold water segment. All of the other major tributaries in the Sheboygan Basin, including the Sheboygan and Onion Rivers, originate as coldwater streams and change over to warm water further downstream. The existing chemical and biological water quality information support the Mullet River's current biological classification. The river segment that flows through the Kettle Moraine State Forest Northern Unit, the Mullet Creek State Wildlife Area, and the Old Wade House State Park are located within the warmwater sport fish community segment.

MULLET RIVER WARM WATER SEGMENT DOWNSTREAM OF STH67 (RM 0-18.1)

This reach extends from the confluence of the Mullet and Sheboygan Rivers upstream to State Highway 67 north of Plymouth. This 18.1-mile reach of the Mullet River is classified as a Warmwater Sport Fish Community stream. Water quality in this segment of the Mullet River is fair to good. Water chemistry and macroinvertebrate samples collected during 1994 indicate an increase in nutrients and solids from upstream to downstream but overall are not limiting the stream's biological potential. Point source dischargers as well as stormwater runoff, and cropland runoff result in increased nutrients, sedimentation, and bacteria to the stream. Fish barriers and water quality impacts from the New Paris, Meyer Park, and Plymouth dams present the greatest impact to the water quality of the Mullet River in this reach.

NEW PARIS IMPOUNDMENT

T15N R21E Sec. 27 Surface Acres = unknown Maximum Depth = unknown

This is the downstream-most dam on the Mullet River located in the Village of New Paris just south of Plymouth. No water quality data is available for this impoundment.

MEYER PARK IMPOUNDMENT

T15N R21E Sec. 28 Surface Acres = 5.3 Maximum Depth = 4 feet

This relatively small impoundment is located in Meyer Nature Park in the City of Plymouth. Sedimentation has resulted in a shallow, nutrient enriched impoundment. No recent water quality data is available for this impoundment.

Table 49. Sediment Survey Results for Meyer Impoundment on the Mullet River collected in 2000.

Parameters		SITES		
Total Organic Carbon (µg/g)		33100	26400	21200
Particle Size	% Solids	43.8	49.1	45.8
	% Sand	44	70	67
	% Silt	33	18	19
	% Clay	23	12	16
	Soil Texture	Loam	Sandy Loam	Sandy Loam
PCBs (total) (µg/g)		<0.05	<0.05	<0.05
PAHs (ng/g)		<100	<160	<100
Metals (mg/kg)	Selenium	ND	5	ND
	Boron	<11	18	<11
	Cadmium	0.5	1.6	0.7
	Chromium	17	19	18
	Copper	17	20	18
	Nickel	15	18	17
	Lead	16	21	17
	Mercury	0.048	0.043	0.056
	Zinc	49	64	68

Parameters	SITES		
Total Phosphorus (mg/kg)	891.0	797.4	1107.6
Ammonia (mg/kg)	120	53	50

PLYMOUTH MILL POND

T15N R21E Sec. 22 Surface Acres = 36 Maximum Depth = 6 feet

Plymouth Millpond is a moderately sized impoundment within the city of Plymouth on the Mullet River. The impoundment is very shallow with a soft mud bottom and very little rooted aquatic plant life. Periphytic blue-green algae are a problem as is high turbidity during months when carp activity is high. Carp have dominated the fish community and carp numbers are currently very high (pers. comm. John Nelson).

Up to 1,000 Canada Geese roost on the pond causing some nuisances to riparian landowners and providing some hunting opportunities during feeding flights. Several broods of geese are produced on the pond each year (pers. comm. Steve Klock).

Public access is available by several city streets, navigable water from the upper end of the pond, approximately two acres of city property at the dam site, and by approximately 1,000 feet of shoreline on city school property.

A sediment quality assessment was conducted by WDNR on June 29, 1999 on the Plymouth Impoundment, Mullet River. Samples were collected at two sample sites in the soft sediment that has accumulated behind the dam. The first site was 15m upstream from the dam and consisted of two cores. The top half from each core were composited for a single sample and the bottom of each core were composited for a second sample. This enables us to look at sediment quality that represents different time periods. Obviously the sediment that is buried to the greatest depth represents deposition that would have settled at an earlier date. A third sample was collected 100m upstream in the mid-channel of the impoundment. Two cores were collected and composited to make a single sample.

Table 50. Sediment quality assessment for the Mullet River within the Plymouth Impoundment. Collected June 18, 1999.

Parameter	15 m upstream Top of core	15 m upstream Bottom of core	100 m upstream
METALS	mg/kg (ppm)	mg/kg (ppm)	mg/kg (ppm)
Arsenic	ND	ND	ND
Cadmium	0.8	0.8	1.0
Chromium(total)	25	27	25
Copper	30	25	26

Lead	39	23	25
Mercury	0.1	0.099	0.1
Nickel	12	14	13
Zinc	100	81	170
PAHs (total)	0.775	0.717	18.55
PCBs (total)	<0.05	<0.05	<0.05
pp-DDE	0.01	ND	ND
pp-DDD	0.02	ND	0.01
Ammonia-N	58.3	112	39.6
Phosphorus (total)	622	615	523
TOC (Total Organic Carbon)	68800	59900	70400
% solids	31.7	36.3	33.9

The pesticides (Aldrin, Alpha BHC, C-chlordane, Chlordane Alpha, Chlordane Gamma, Dieldrin, Endrin, Gamma BHC, Heptachlor, Nonachlor Cis) were all less than the level of detection.

MULLET RIVER COLD WATER SEGMENT (RM 18.1-23.0)

The trout water reach of the Mullet River extends upstream from State Highway 67 to the confluence with Otter pond just downstream from Glenbeulah. This section of the Mullet River is the most heavily fished trout stream in Sheboygan County. Some agricultural pollution occurs within this segment, but is not considered limiting.

Water quality within this segment is rated as generally good, but is limited by a dam located at the Camp Evelyn Girl Scout facility. This impoundment alters the natural water temperature regime. The Northern Moraine Utility Commission wastewater treatment plant discharges to the groundwater of the Mullet River watershed. It is believed that after some treatment by the soil, the effluent mixes with the groundwater, which discharges directly to the Mullet River during part or all of the year. It is uncertain whether this occurrence is having an impact on surface water quality and bears investigation.

The fishery is represented by a good diversity of intolerant species, including brook and brown trout. The section of stream from Glenbeulah Springs to State Highway 67 is a Class II stream for brown trout and the diversity and number of individuals indicates a good fishery. The macroinvertebrate community is represented by a wide diversity of both intolerant and tolerant genera. The high water temperatures in the Camp Evelyn impoundment impair the trout habitat.

WDNR personnel surveyed the Mullet River downstream of the Crystal Lake Golf Course in August 1999. The fish community rated poor with species listed in Table ??? Stream habitat analysis showed excellent buffer area and shading; moderate streambank erosion; bottom substrate with a mixture of rock, gravel, and sand; and moderate fish cover. Benthic macroinvertebrate rating for this location were good to very good.

WDNR personnel surveyed a portion of the stream, upstream of County Highway "CJ" in July 2000. Land use in the area is heavily wooded with wetland areas in the riparian cooridor. The fish community rated fair with species listed in Table 51. Stream habitat analysis showed excellent buffer areas and shading, rocky substrate, and very little streambank erosion. Fish cover was limited due to shallow water depths.

Table 51. Mullet River fish community assessment, 1999 & 2000.

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Mullet River upstream of Camp Evelyn Impoundment 1999	Mullet River downstream of Camp Evelyn Impoundment 2000
Common Shiner	Tolerant		X	X
Longnose Dace	Intolerant			X
Creek Chub	Tolerant	Tolerant	X	X
Hornyhead Chub	Intolerant		X	
White Sucker	Tolerant	Tolerant	X	X
Blacknose Dace	Intolerant	Tolerant		X
Stonecat	Intolerant			
Brown Trout	Sport		X	
Brook Trout	Sport	Intolerant		
Largemouth Bass	Sport		X	
Rock Bass	Sport	Intolerant	X	X
Bluegill			X	
Bluntnose Minnow			X	
Johnny Darter			X	

[1] Ball (1982)
[2] Lyons (1992)

CAMP EVELYN IMPOUNDMENT

T15N R21E Sec. 6 Surface Acres = 2.8 Maximum Depth = 6 feet

This is a small impoundment in the trout water section of the Mullet River. The dam at the Camp Evelyn Girl Scout facility creates a fish barrier and increases water temperatures which are detrimental to trout and other cold water species. No recent water quality data have been collected in this impoundment.

MULLET RIVER WARM WATER SEGMENT UPSTREAM OF GLENBEULAH (RM 23.0-39.7)

This segment starts at Otter Pond near Glenbeulah and terminates at Mullet Lake. The segment runs through the Kettle Moraine State Forest Northern Unit, the Mullet Creek State Wildlife Area, and Old Wade State Park.

Water quality conditions are good. There are fewer springs in this reach, combined with altered flows resulting from channelization and impoundments. Because of these limiting factors the fishery changes from trout stream to warm water sport fish. A dam forms the Glenbeulah Millpond, and two additional impoundments are present in the Mullet Creek Wildlife area to provide habitat for waterfowl.

The Wisconsin State Historical Society in conjunction with the Kohler Foundation is actively pursuing the restoration of The Historic Old Wade House's former sawmill, which is located along the Mullet River in

Greenbush, Sheboygan County. The sawmill site was researched and an archeological dig was conducted during the last few years. The information collected will be used in the proposed reconstruction of the mill by providing insight into the construction of the original structure. In addition to the construction of the sawmill, the State Historical Society has proposed that this be a functioning sawmill, which would include reconstruction of the dam once located on the Mullet River. The current project proposal calls for the construction of the dam at the original site, but not an impoundment of the Mullet River (WWC 1997). An impoundment would be constructed adjacent to the Mullet River from which the mill would be operated. The Old Wade House project proposal and the Environmental Assessment (WDNR 1998) were discussed in a public meeting in 1998. The reports are available at the WDNR Plymouth Service Center.

The Department of Natural Resources (WDNR) had agreed to assist the State Historical Society in collecting information required for the environmental assessment of the project on the Mullet River. The WDNR conducted an aquatic resource survey of the Mullet River at the Old Wade House site, which included chemical and biological data collections (Aartila 1995), and stream flow (Galarneau 1998). Table 65 depicts the Mullet River sample sites for the basin monitoring and aquatic resource study.

Table 52. Mullet River Watershed Sample Site Locations

Stream	SITE INFORMATION		
	Site	Site Description	Sample Type
Mullet River	MR-1	At Spring Valley Dr	Water Chemistry, Macroinvertebrates
	MR-2	At Plank Rd	Water Chemistry, Macroinvertebrates, Fish, Mussels
	MR-3	At CTH A	Water Chemistry, Macroinvertebrates, Fish, Mussels
	MR-4	At CTH PP	Water Chemistry, Macroinvertebrates

A mussel survey identified eight species of mussels (WDNR 1995, Cummings and Mayer 1995, WWC 1997) including two statewide threatened species which inhabit the Mullet River at this site (Table 66).

Table 53. Mullet River Mussel Community Assessment in the Vicinity of the Old Wade House

MUSSEL SPECIES		
Common Name	Scientific Nomenclature	State Threatened Species
Slippershell Mussel	*Alasmidonta viridis* (Rafinesque, 1820)	X
Ellipse	*Venustaconcha ellipsiformis* (Conrad, 1836)	X
Wabash Pigtoe	*Fusconaia flava* (Rafinesque, 1820)	
Fat Mucket	*Lampsilis siliquoidea* (Barnes, 1823)	
Creek Heelsplitter	*Lasmigona compressa* (Lea, 1829)	
Fluted Shell	*Lasmigona costata* (Rafinesque, 1820)	

Giant Floater	*Anodonta grandis* form *grandis* (Say, 1829)	
Cylindrical Papershell	*Anodontoides ferussacianus* (Lea, 1834)	

The fish community in the Mullet River upstream from Glenbulah was assessed as part of the Old Wade House Project in 1994 and 1997 (Table 67). No recent surveys have been conducted in the trout river section nor lower river reaches.

Table 54. Mullet River Fish Community Assessment Upstream of Glenbulah

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Historical Fish Collections (Fago 1985)	1994 and 1997 Fish Collections
Blacknose Shiner	Intolerant	Intolerant	X	X
Blacknose Dace	Intolerant	Tolerant	X	X
Creek Chub	Tolerant	Tolerant	X	X
Johnny Darter	Tolerant		X	X
Rock Bass	Sport	Intolerant		X
Golden Shiner	Tolerant	Tolerant	X	
Largemouth Bass	Sport			X
Smallmouth Bass	Sport	Intolreant		X
Fathead Minnow	Very Tolerant	Tolerant	X	X
Iowa Darter	Intolerant	Intolerant	X	X
White Sucker	Tolerant	Tolerant	X	X
Hornyhead Chub	Intolerant		X	X
Common Shiner	Tolerant		X	X
Green Sunfish	Sport	Tolerant		X
Southern Redbelly Dace	Intolerant		X	
Northern Redbelly Dace	Intolerant		X	X
Bluntnose Minnow	Tolerant	Tolerant	X	X
Brook Stickleback	Tolerant		X	X
Central Mudminnow	Very Tolerant	Tolerant	X	X
Black Bullhead	Sport		X	X

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Historical Fish Collections (Fago 1985)	1994 and 1997 Fish Collections
Brown Bullhead	Sport		X	
Pumpkinseed	Sport		X	
Rainbow Trout	Sport			X
Northern Pike	Sport		X	X

[1] Ball (1982) [2] Lyons (1992)

According to the results of the Hilsenhoff Biotic Index (HBI) This reach of the Mullet River has good water quality and very good biological diversity including rare mussel species (Table 68). The WDNR continues to work cooperatively with the State Historical Society with their proposed project at the Old Wade House State Park to help them obtain their unique project while protecting this special resource.

Table 55. Hilsenhoff Biotic Index (HBI) values for the Mullet River - 1994

Stream	SITE	Spring - HBI [1]		Fall - HBI[1]	
		Avg. Score	Water Quality Rating	Avg. Score	Water Quality Rating
Mullet River	MR-1	6.53	Fairly Poor	5.83	Fair
	MR-2	5.55	Fair	4.55	Good
	MR-3	5.29	Good	4.48	Very Good
	MR-4	4.75	Good		

[1] Hilsenhoff Biotic Index (1987)
[2] Lyons (1992)
[3] Ball (1982)
[4] Simonson et al. (1994)

GLENBEULAH MILLPOND, SHEBOYGAN COUNTY

T15N R20E Sec. 1 Surface Acres = 6.9 Maximum Depth = 11 feet

Glenbeulah Millpond is an impoundment of the Mullet River in Glenbeulah at the site of an old sawmill formed by a 12 foot-head dam. The water quality problems identified in the 1968 Water Resources of Sheboygan report (WDNR 1968) likely still exist today; nutrient enrichment, sedimentation, and abundant carp are consistent with impounded rivers. Thermal increases associated with this impoundment and the Camp Evelyn impoundment warm the trout water portion of the Mullet River, which is a short distance downstream. No recent water quality data are available for this impoundment.

MULLET RIVER STATE WILDLIFE AREA, FOND DU LAC COUNTY

T15N R19E Sec. 24 Surface Acres = unknown Maximum Depth = unknown

A dam was placed on the Mullet River just west of CTH G in Fond du Lac County at river mile 34.5 to restore wetlands lost by drainage practices. This wetland impoundment is located in the headwater reaches of the Mullet River that originates in Mullet Lake (at RM 39.7). No recent water quality data exist for this impounded reach of the Mullet River.

TRIBUTARIES TO THE MULLET RIVER

JACKSON CREEK

T15N R21E Sec. 16 Stream Length = 1.8 miles

Jackson Creek originates from a spring area in the northeast quarter of section 20. The stream flows northeasterly, crossing Highway 23, through a small marsh, and eventually draining into the Mullet River. In 1978 the stream was downgraded from a Class I trout stream to a Class II for its entire length. Increased silt entering the stream and the resulting impacts were responsible for the classification change. The silt comes from poor erosion control practices related to the construction of a housing subdivision and an industrial park northwest of the city of Plymouth. There is also concern that two abandoned gravel pits located in sections 17 and 20 of the town of Plymouth may be contributing to the pollutant load of the creek. The DNR owns 20 acres of land bordering a tributary to Jackson creek in the town of Plymouth T15N R21E S17.

LABUDDE CREEK

T15N R21E Sec. 5 Stream Length = 5.1 miles

Class II Trout Reach (RM 0-3.2)

This reach of the creek is classified as a Class II trout stream, and extends from its confluence with the Mullet River to Badger Road. Water quality is rated as good. The low gradient of the stream and some sedimentation from upstream agricultural runoff limit fish and aquatic life habitat.

Class I Trout Reach (RM 3.2-5.1)

This reach of LaBudde Creek originates as a series of small springs southwest of Rhine Center. The 1.9 mile segment is Class I trout stream and has good water quality for the entire reach. Stream improvements have upgraded the trout habitat and encouraged natural brook trout reproduction.

UNNAMED TRIBUTARY (SUMAC CREEK) TO MULLET RIVER, RM 13.3

T15N R21E Sec. 34 NE SE Stream Length = 1.0 miles WBIC = 54100

This cold water stream originates from two, small, spring-fed ponds and flows to the north before discharging to the Mullet River. Land use in the area is primarily agriculture, however the stream is well buffered by woods and a significant wetland. WDNR personnel surveyed the site upstream of Sumac Road in July 2000. Fish community was limited to five creek chubs and four unknown darter species. Habitat analysis showed an excellent buffer area of woods and wetlands with good shading; mixed bottom substrate of rocks, gravel, sand, and silt; moderate streambank erosion; very shallow water depths and very little fish cover. The shallow water depths limit the amount of fish cover available and account for the low fish abundance and diversity.

UNNAMED TRIBUTARY TO MULLET RIVER, RM 8.6

T15N R22E Sec. 31 NW NE Stream Length = 6.0 miles WBIC = 53600

This stream originates in the Town of Plymouth and flows to the southeast before its confluence with the Mullet River. Land use for the watershed is primarily agriculture, however the stream cooridor does contain numerous wooded and wetland areas. WDNR personnel surveyed the site upsteam of County Highway "PP" in August 1999. The fish community rated poor with fish species listed in Table 56.

Stream habitat rated good with excellent habitat types of riffles, pools, and runs; excellent buffer areas; bottom substrates primarily comprised of rock, gravel, and sand; and minimal streambank erosion. Fish cover in the habitat analysis rated poor due to relatively shallow water depths and lack of physical cover. The benthic macroinvertebrate community rated fair. Water quality may be limited due to low dissolved oxygen levels and nonpoint source pollution from agricultural runoff.

Table 56. Unnamed Tributary to Mullet River fish community assessment, 1999.

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Tributary to Mullet River 1999
Creek Chub	Tolerant	Tolerant	X
Bluntnose Minnow	Tolerant	Tolerant	X
Johnny Darter	Tolerant		X
White Sucker	Tolerant	Tolerant	X
Common Shiner	Tolerant		X
Brook Stickleback	Tolerant		X
Central Mudminnow	Very Tolerant	Tolerant	X
Longnose Dace	Intolerant		X
Fathead Minnow	Very Tolerant	Tolerant	X
Green Sunfish	Sport	Tolerant	X
Rock Bass	Sport	Tolerant	X

[1] Ball (1982)
[2] Lyons (1992)

Table 57. Streams of the Mullet River Watershed.

Stream Name/Location (T, R, Sec., QQ, Q)	WBIC	Length	Biological Use		Codified	Supp.	Assess. Category	Use Impairments	
			Existing	Potential				Source	Impac
Jackson Creek T15N R21E Sec.16 NESW	54700	1.8	COLD[1] CLASS II	COLD CLASS I	DEF	NOT	M	CON, NPS,HM	SED
LaBudde Creek Segment 1 RM 0.0-3.2 T15N R21E Sec.5	54800	Total 5.1 Reach 3.2	COLD[1] CLASS II	COLD CLASS II	DEF	PART	M	NPS	SED
LaBudde Creek Segment 2 RM 3.2-5.1 T15N R21E Sec.5	54800	Total 5.1 Reach 3.2	COLD[1] CLASS I	COLD CLASS I	ERW / COLD	THR	M	NPS	
Mullet River Segment 1 RM 0-18.1 T15N R22E Sec.35 NWSE	53400	Total 39.7 Reach 18.1	WWSF	WWSF	DEF	PART	M	NPS, PSM, PSI URB	TEMP, M TURB, S FLOW
Mullet River Segment 2 RM 18.1-23.0	53400	Total 39.7 Reach 4.9	COLD[1] CLASS II	COLD CLASS II	DEF	PART	M	NPS, HM, PSI, URB	SED, TU TEMP, M FLOW
Mullet River Segment 3 RM 23.0-39.7	53400	Total 39.7 Reach 16.7	WWSF	WWSF	DEF	PART	M	NPS, HM	TEMP, M SED, FL
Unnamed Tributary to Mullet River T14N R22E Sec.4 NESE	53500	1.0	UNK	UNK	DEF	UNK			
Unnamed Tributary to Mullet River at RM 8.6 T15N R22E Sec.3 NWNE	53600	6.0	WWFF	WWFF	DEF	PART	M	NPS, HM, CL	SED, FL TURE
Unnamed Tributary to Tributary (53600) to Mullet River T15N R22E Sec.30 NWNW	53700	3.0	UNK	UNK	DEF	UNK			
Unnamed Tributary to Tributary 53700 T15N R21E Sec.24 SWSW	53800	2.0	UNK	UNK	DEF	UNK			
Unnamed Tributary to Mullet River at RM 9.6 T15N R22E Sec.31 NWNW	53900	1.0	UNK	UNK	DEF	UNK			
Unnamed Tributary to Mullet River at RM 12.3 T15N R21E Sec.35	54000	1.0	UNK	UNK	DEF	UNK			
Unnamed Tributary to Mullet River at RM 13.3 T15N R21E Sec.34 NESE	54100	1.0	UNK	UNK	DEF	UNK			
Unnamed Tributary to Mullet River T15N R20E Sec.11 SWSW	55700	1.0	UNK	UNK	DEF	UNK			
TOTALS		**62.6**							

Trout streams as defined in Wisconsin Trout Streams (1980) but not listed in NR 102. These streams may be classified as trout streams under 1.02(7) since publication of Wisconsin Trout Streams (1980), but are not formally classified as trout waters. These streams will be added to NR 102 and/or NR 104 during code revision.

LAKES OF THE MULLET RIVER WATERSHED

The Mullet River Watershed Contains two named lakes, Mullet Lake in Fond du Lac County, and Crystal Lake in Sheboygan County. Tables 69 and 70 contain summary information for these two lakes.

Table 58. Trophic Status of Lakes in the Mullet River Watershed

Lake Name (Location T/R/S)	Watershed	Lake Type	County Code	Surface Area (Acres)	Max Depth (ft.)	TSI T-P	TSI S D	TSI CHL	TSI Class	P Sens	Class
Mullet Lake (15N/19E/33)	Mullet (SH05)	Seepage	20	200	7					2	2C
Crystal Lake (16N/21E/32)	Mullet (SH05)	Seepage	60	152	61	42.8	33.6	41.2	Oligo/ Meso	1	1A

For key to abbreviations, please see "How to Use the Lakes Tables" section (page 19).

Table 59. Summary of Lakes in the Mullet River Watershed

Lake Name	Watershed	Lake Type	Surface Area (Acres)	Max. Depth	History of Winter Kill 1=YES; 2=NO	ALK (mg/l)	Fish Mercury	Monitoring							Comments
								SH	LTTM	Hg	AD	TS	FEAS	IM	
Mullet Lake	Mullet (SH05)	Seepage	200	7	1	133	A,B	R		R		R		R	Mig Birds Rec: W,H
Crystal Lake	Mullet (SH05)	Seepage	152	61	2	164	A,B	C	C	X	C	C		R	Rec: B,P

For keys to abbreviations, see "How to use the Lakes Tables" section (page 19).

CRYSTAL LAKE, SHEBOYGAN COUNTY

T16N R21E Sec. 31 Surface Acres = 113.7 S.D.F. = 1.87 Maximum Depth = 61 feet

At 113.7 acres, Crystal Lake is a moderately fertile, natural lake, heavily used for fishing and boating. The lake's shoreline is intensively developed with residential dwellings. Many property owners have reinforced the shoreline with seawalls that have detracted from the aesthetic quality as well as the fisheries value. In the autumn of 1966, a sanitary district was organized and sewers were installed in the late 1970s.

The lake's fishery has undergone several major changes over the past 35 years due to shifts in management philosophy. Over time it has been managed for walleye and northern pike, then trout and panfish, then largemouth bass and panfish. It is currently being managed for the native fish community: largemouth bass, panfish and with limited walleye due to stocking by private organizations. The existing bass and panfish community is improving due in part to the new bass size limit restrictions.

Historically, the lake was chemically treated to control aquatic plants and algae. In 1989, the DNR conducted a Sensitive Area Survey of the lake and as a result prohibited the use of aquatic herbicides and algicides in an attempt to protect the fish habitat and the water quality.

Since 1986, the water quality, aquatic plant community, and phyto- and zooplankton have been surveyed to obtain baseline water quality data and to assess trends. The results from this survey indicate that the water quality is excellent. The lake boasts some of the clearest water found in southeastern Wisconsin. A significant amount of Eurasian water milfoil is present in Crystal Lake. The DNR, in cooperation with the Crystal Lake Property Owners Association, attempted to displace the Eurasian water milfoil with a native species, Large Leaf Pondweed during the summer of 1994. The control program was effective for only a few years. By 1997 Eurasian water milfoil had again moved into the area displacing the newly planted native species (Wakeman 1998).

A public boat launch with adequate parking is available in the southwest bay. A unique boating ordinance on the lake prohibits the use of motors on Sundays. This is strongly supported by residents on the lake.

MULLET LAKE, FOND DU LAC COUNTY

T15N R19E Sec. 33 Surface Acres = 200 S.D.F. = 1.41 Maximum Depth = 7 feet

This is a shallow 200-acre lake valued primarily for waterfowl hunting and wildlife. Its shallow depth of about seven feet and abundance of rooted aquatic plants contribute to annual winterkill conditions that limit the fishery to an occasional northern pike and perch. A few property owners recently installed a small aeration system, which may promote fish carryover during the winter months. The outlet stream, the Mullet River, drains north to the Sheboygan River. The shoreline is associated with 350 acres of wetlands, mainly tamarack swamp and cattails. Considerable numbers of ducks use the lake all year and the lake receives moderate hunting pressure during the open season. Public access is absent.

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PIGEON RIVER WATERSHED (SH06)

INTRODUCTION

The Pigeon River originates as numerous spring-fed tributaries in Manitowoc and Sheboygan Counties. The thirty-mile stream flows south to a point above the city of Sheboygan Falls, and then northeast to its confluence with Lake Michigan in the northern part of the city of Sheboygan. Tributaries to the Pigeon River include Meeme River, Fisher Creek, Grandma Creek, and nine unnamed tributaries. Four named lakes; Jetzers Lake, Spring Lake, Pigeon Lake, and Horseshoe Lake, and numerous unnamed lakes are also in this watershed.

Extensive water quality studies have recently been completed in the Pigeon River watershed as part of the nonpoint source Priority Watershed Project and Integrated Environmental Monitoring (IEM) project. Aartila (1997) did the stream appraisal report, and the companion lake appraisal report is by Olson and Helsel (1997). *The Nonpoint Source Control Plan for the Pigeon River Watershed Priority Watershed Project* (WDNR *et al*. 1997) was cooperatively prepared by WDNR, DATCP, UWEX, Sheboygan Land Conservation Department, Manitowoc Soil and Water Conservation Department, and Pigeon River Watershed Citezen's Advisory Committee. These reports should be consulted for complete write-ups on the condition of the resource with regards to nonpoint source pollution.

Water quality in the Pigeon River Watershed is described as poor to fair (WDNR 1995). High turbidity, nuisance algae and vegetative growth, low dissolved oxygen, high levels of fecal coliform bacteria, sedimentation, and channelization have all contributed to the poor water surface water conditions in the watershed (Aartila 1997). Numerous reports have documented the water quality problems from nonpoint sources and point source effluent discharge (WDNR 1980, 1988, 1994, 1995).

As a result of these limiting factors, macroinvertebrate and periphyton communities are generally pollution-tolerant. A recreational fishery for resident warm water and Lake Michigan migratory sport species is present. Migratory species include smelt, rainbow trout, and salmon. The majority of the river and its tributaries support warm water species including panfish, forage fish, and northern pike.

A Pigeon River Priority Watershed Plan has been developed and BMPs are actively being implemented throughout the watershed (WDNR 1998). The counties of Sheboygan and Manitowoc Land Conservation Departments are the lead agencies for implementation of BMPs and are working cooperatively with WDNR.

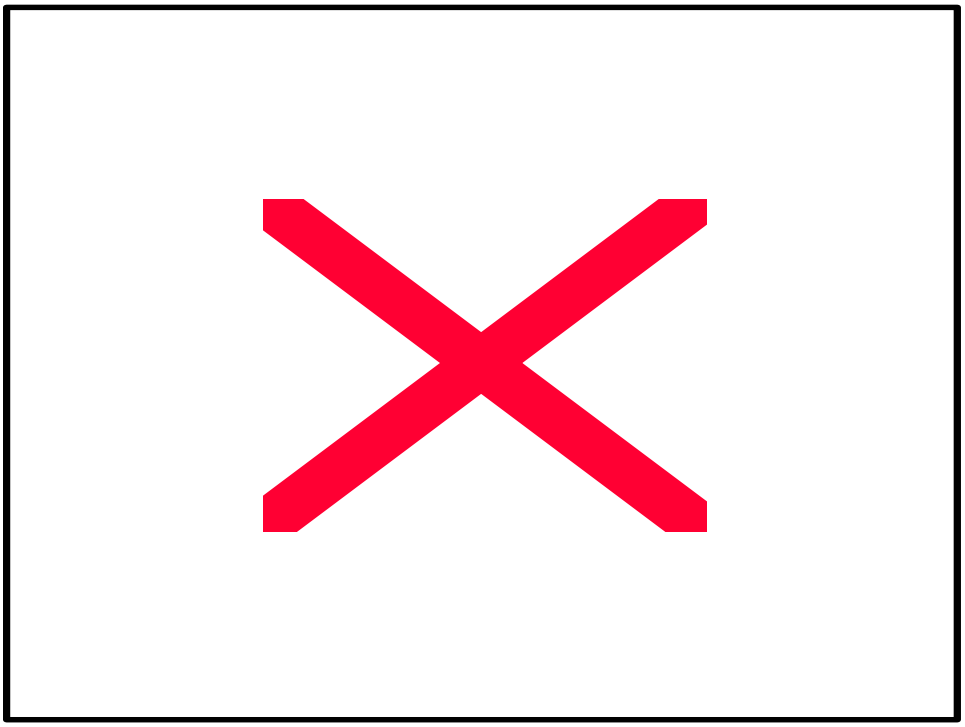
STREAMS OF THE PIGEON RIVER WATERSHED

Spring Lake Creek

As part of the Pigeon River Priority Watershed project, a stream appraisal study was recently completed on the streams in the Pigeon River Watershed (Aartila 1997). This report should be consulted for a detailed assessment of the condition of these lakes. The Pigeon River Watershed was selected as the IEM project for 1998, which enabled the WDNR to augment the studies already conducted for the Priority Watershed. This report has recently been completed (WDNR 1999) and includes additional stream and lake monitoring data for the watershed. As such, the conditions of the resources listed below are brief summaries of these more extensive reports. I encourage the reader to review Aartila (1997), Olson and Helsel (1997), and WDNR (1998, 1999) reports for a more extensive review.

Volunteer stream monitoring efforts continue to flourish in the Pigeon River Watershed with students participating in the Testing The Waters Program, and adults and young alike make up a team of water quality monitors as part of the Water Action Volunteers (WAV). The WAVs have numerous sites throughout the Pigeon River Watershed (Figure 19).

Figure 19. Volunteer Monitoring Sites in the Pigeon River Watershed.



Water quality data including temperature, flow, turbidity, habitat and macroinvertebrates were collected during 1998. UWEX and WDNR have worked together with the Pigeon River Water Action Volunteers to establish a monitoring program that will meet their needs and be beneficial to the agencies (pers. comm. Galarneau). Figures 20 and 21 show the macroinvertebrate and habitat rating scores recorded by the WAVs during the 1998 field season.

Figure 20. Habitat Ratings for Pigeon River Watershed WAV Monitoring Sites.

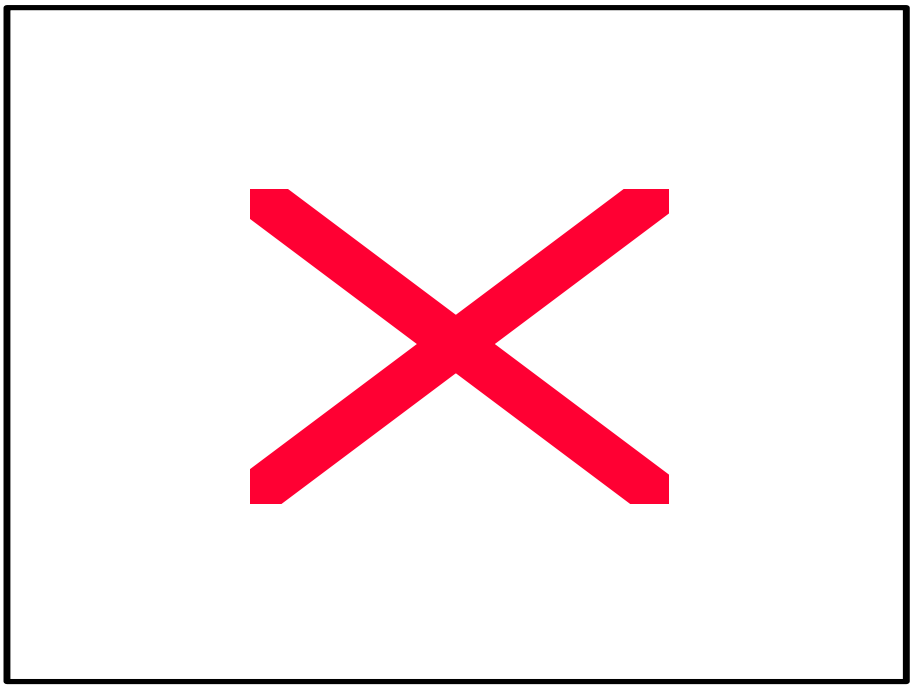
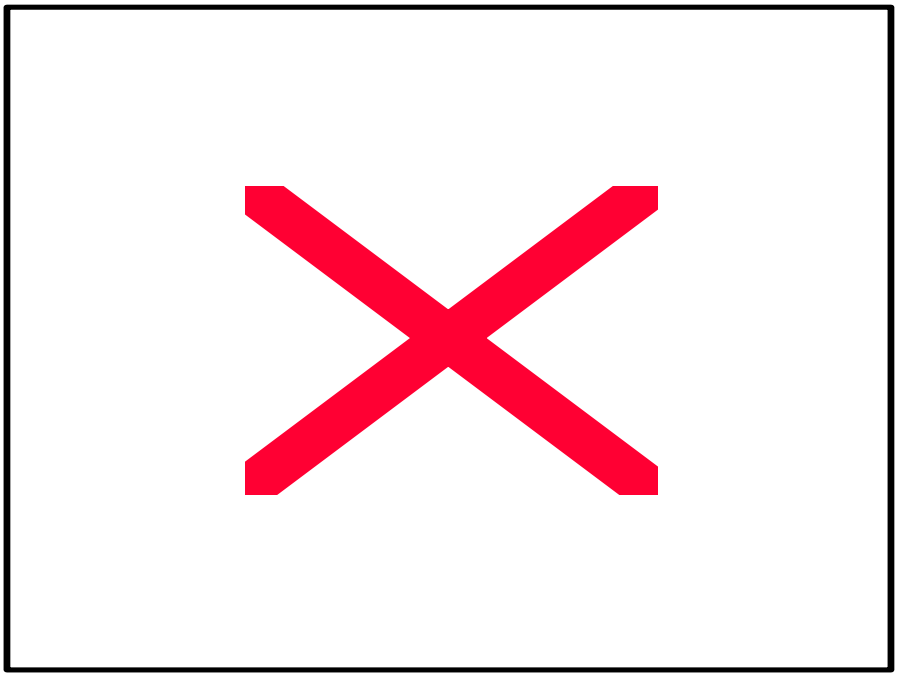


Figure 21. Macroinvertebrate Ratings for Pigeon River Watershed WAV Monitoring.



These data benefit the Department by enabling more extensive and ongoing coverage of the waters in this active Priority Watershed Project. The Pigeon River WAVs are encouraged to continue their monitoring and WDNR personnel are committed to working with them towards improving the water quality in the Pigeon River Watershed (pers. Comm. Galarneau).

FISHER CREEK, SHEBOYGAN COUNTY

T16N R22E Sec. 26 Stream Length = 4.4 miles

Fisher Creek originates in a large wetland complex upstream of CTH MM in the Town of Herman in northern Sheboygan County. The creek flows southeasterly to its confluence with the Pigeon River east of STH 32 in the Village of Howards Grove. Land use is agriculture with increasing urbanization downstream. Lakeland College tributary flows to Jetzers Creek, which is tributary to Fisher Creek. These streams are discussed separately. Fisher Creek is classified as a Warm Water Forage Fish community stream and is partially meeting its full potential use (Aartila 1997). Fish historically found in Fisher Creek include, blacknose dace, bluntnose minnow, central mudminnow, common shiner, creek chub hornyhead chub, largescale stoneroller, white sucker, yellow bullhead, and northern pike (Fago 1985). A recent fish survey conducted in 1997 collected six species (Table 74).

Table 60. Small-stream fish surveys for Fisher Creek, Jetzers Creek, and Grandma Creek.

Fish Species (common name)	Fisher Creek	Jetzers Creek	Grandma Creek
	Upstream of	Upstream of	at Range Line Road
	9/17/97	9/17/97	9/17/97
Common Shiner	2	47	
White Sucker	13	57	3
Black Bullhead		1	3
Central Mudminnow	82	32	13
Creek Chub	13	23	
Northern Pike			3
Brook Stickleback	170	55	
Johnny Darter	20	44	
Blacknose Dace		20	
Common Carp			12

The HBI values from the macroinvertebrate sampling conducted in 1996 show fair to fairly poor water quality in Fisher Creek. The stream is limited by sedimentation, excessive nutrients, and stream flow fluctuations. This is caused by channelization, wetland drainage, cropland and barnyard runoff, and stream bank erosion (Aartila 1997).

JETZERS CREEK TRIBUTARY TO FISHER CREEK, SHEBOYGAN COUNTY

T16N R22E Sec. 26 Stream Length = 3.7 miles

Jetzers Creek is also refered to as Jetzers Lake Outlet and has an existing biological use of Warm Water Forage Fish communities. The stream has the potential to support a sport fish community (Aartila 1997). Fish collections during 1996 included creek chub, blacknose dace, white sucker, johnny darter, fathead minnow, common shiner, and central mudminnow. A subsequent fish survey conducted during 1997 is shown above in Table #.

The HBI rating from the macroinvertbrate community samples indicated a fairly substantial organic pollution. The stream is limited by sedimentation, excessive nutrients, wetland drainage, channelization, cropland runoff, barnyard runoff, and urban runoff (Aartila 1997). The Lakeland College tributary has a point source discharge in its headwaters from Lakeland College WWTP. This stream had been historically classified as a limited forage fish (LFF) community stream although the existing and potential biological classification is warmwater forege fish community (Aartila 1997). This point source discharge has resulted in increase nutrients and solids in the past to Jetzers Creek.

GRANDMA CREEK, SHEBOYGAN COUNTY

T15N R23E Sec. 18 Stream Length = 4.5 miles

Grandma Creek originates in a large wooded complex in the Town of Sheboygan Falls. The creek flows south and east to its confluence with the Pigeon River in the Town of Sheboygan near CTH Y. Landuse is primarily agricultural with increasing residential development in the lower reaches. The existing biological use for the stream is limited forage fish community, but the stream shows evidence of providing important spawning habitat for northern pike in the wetland headwater reaches. Consequently the stream is classified as a warmwater sport fish community stream (Aartila 1997). A stream survey conducted during 1997 collected northern pike (Table # above).

The macroinvertebrate community had HBI ratings of poor indicating very substantial sources of organic pollution (Aartila 1997). Adequate stream-bank buffers are scarce for most of the stream length. Limiting factors for the stream are sedimentation, stream bank erosion, urban runoff, barnyard runoff, cropland runoff, wetland drainage, channelization, low dissolved oxygen, excessive nutrients, and flashy flows (Aartila 1997).

MEEME RIVER, MANITOWOC AND SHEBOYGAN COUNTIES

T17N R22E Sec. 36 Stream Length = 5.7 miles

The Meeme River joins the Pigeon river in the southeast corner of Manitowoc County. The river's name is derived from a local Native American name for the now-extinct passenger pigeon, which once used the area. The Meeme River is classified as a Warmwater Sport Fish community stream (WWSF). The fish community includes, largemouth bass, white sucker, creek chub, johnny darter, bluntnose minnow, brook stickleback, central mudminnow, fathead minnow, blacknose dace, bluegill, and walleye (Aartila 1997).

The macroinvertebrate samples collected during 1996 had Hilsenhoff Biotic Index (HBI) ratings of fair to very good water quality. The headwater reaches have been extensively channelized. Minimal stream bank buffers, tributary channelization, and runoff from agricultural practices has resulted in the loss of fish and macroinvertebrate habitat, embedded substrate, turbidity, low dissolved oxygen and stream bank erosion (Aartila 1997).

OSMAN TRIBUTARY TO MEEME RIVER, MANITOWOC COUNTY

T17N R22E Sec. 14 Stream Length = 5.1

The Osman tributary to the Meeme River is located west of the intersection of CTH X and STH 42. The stream consists of the main stem (1.3 miles), the East Branch (2.1 miles) and the West Branch (1.7 miles) for a total stream length of 5.1 miles. The stream currently supports a limited forage fish (LFF) community, but has the capability to support a warmwater forage fish (WWFF) community (Aartila 1997). The fish community collected during the 1996 stream appraisal monitoring included brook stickleback, central mudminnow, creek chub, fathead minnow, white sucker and blacknose dace.

The macroinvertebrate community samples collected during 1996 had HBI ratings of "fairly poor" indicating the presence of significant organic pollution. The factors keeping this stream from meeting it's full potential use are loss of fish and macroinvertebrate habitat, embedded substrates, nuisance algae, and low dissolved oxygen. The sources are channelization, barnyard and cropland runoff, roadside erosion, streambank erosion, and drain tiles.

PIGEON RIVER - OVERVIEW

T15N R23E Sec. 18 Stream Length = 30.0 miles

The Pigeon River originates from a spring fed tributary in an area dominated by wetlands and woodlots in southern Manitowoc County. The Pigeon River flows south into Sheboygan County, through Howards Grove and then turn east to a confluence with Lake Michigan on the north side of Sheboygan. The land use is dominated by agricultural uses, with urban influences in Howards Grove and near the mouth of the river in Sheboygan.

PIGEON RIVER DOWNSTREAM OF THE CONFLUENCE WITH MEEME RIVER (RM 0-18.1)

Water quality in this reach, which extends from the mouth to the confluence with the Meeme River, is fair. Agriculture is the dominant land use in the areas upstream of Howards Grove and watershed becomes increasingly urbanized downstream to the city of Sheboygan. The fishery consists of northern pike, rock bass, black crappie, common shiner, bluntnose minnow, blacknose dace, longnose dace, creek chub, and white sucker (Fago, 1985). Trout and salmon from Lake Michigan are also found in the stream during their seasonal spawning runs.

Macroinvertebrate samples collected during 1996 had HBI ratings indicating fair water quality. The stream has been historically channelized in the agricultural areas, but currently has a fairly good stream buffer in many sections. The problems in this river reach include barnyard runoff, cropland runoff, stream bank pasturing, construction site erosion, streambank erosion, stormwater runoff, and point source effluent.

WDNR personnel surveyed two sites on this reach of the Pigeon River in July 2000. The first site was located upstram of State Highway 42 in the Village of Howards Grove and the second site was within the boundaries of the Maywood Environmental Park in the City of Sheboygan. The Howards Grove site is within a residential area and the Maywood site is within a natural park cooridor that consists of woods and wetlands.

Fish communities rated excellent for both the Howards Grove and Maywood sites. Fish species are listed in Table 61. Stream habitat analysis for the Howards Grove site showed limited streambank erosion; moderate buffer areas and limited shading; bottom substrate of mainly sand and gravel; and limited fish cover. Habitat improvements in this area would improve the fish cover and abundance of fish. The WDNR did install LUNKER type fish habitat structures at this site and is described in more detail below. Stream habitat analysis for the Maywood site showed limited streambank erosion; excellent buffer areas and limited shading; bottom substrate of rock, gravel, and sand; and good fish cover.

Table 61. Pigeon River Fish Community Assessment, 2000.

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Pigeon River Howards Grove	Pigeon River Maywood
Common Shiner			X	X
Hornyhead Chub			X	X
Rock Bass			X	X
Smallmouth Bass			X	X
Green Sunfish			X	X
Bluntnose Minnow			X	X
Longnose Dace				X
Stonecat			X	X
Central Stoneroller				X
White Sucker			X	X
Johnny Darter			X	X
Logperch				X
Northern Pike			X	X
Rainbow Trout				X
Bluegill				X
Sand Shiner			X	X
Black Bullhead			X	X
Blackside Darter			X	X
Brown Trout				X
Central Mudminnow			X	X
Common Carp				X

Fish Species	Ball Tolerance[1]	Lyons IBI Tolerance[2]	Pigeon River Howards Grove	Pigeon River Maywood
Northern Hog Sucker			X	
Yellow Bullhead			X	
Pumpkinseed			X	
Creek Chub			X	
White Crappie			X	
Blacknose Dace			X	
Brook Stickleback			X	
Largemouth Bass			X	

[1] Ball (1982)
[2] Lyons (1992)

Installation of Streambank Stabilization Structures

The purpose of this project is to control streambank erosion and develop fish habitat in selected sections of the Pigeon River (Nelson 1998b). The Pigeon River is a warmwater fishery stream that also receives seasonal runs of anadromous fish from Lake Michigan. The fish include salmonids, northern pike, white suckers and longnose suckers. The watershed has been identified as a priority watershed that will be funded in 1998 and beyond. Streambank erosion is severe at the two proposed sites. At the Farmer's and Sportsman's Club site alone, 325 feet of eroding bank loses 53.4 tons of soil each year. Fish habitat is poor due to the eroding banks.

During the summer of 1998, we plan to install LUNKER type fish habitat structures, place rip rap and grade banks to eliminate these erosion sources and to provide bank cover. We plan to install at least 325 feet of structure at the Farmer's and Sportsman's Club and at least 500 feet of structures at Howard's Grove municipal park. This work will take place during the growing season (May 1st to September 15th) in 1999 so vegetation becomes established on graded banks. These sites will be accessible to the public and will receive heavy fishing use. Erosion control will be very significant as demonstrated at a downstream site on the Pigeon River where such work was completed several years before.

PIGEON RIVER UPSTREAM OF THE CONFLUENCE WITH MEEME RIVER (RM 18.1-30.0)

This segment extends from the Meeme River confluence upstream to the headwaters area. Agricultural pollution is the major limiting factor in this segment. The stream is flashy because of the extensive wetland drainage and channel modification. The only point source discharging to this segment is the Howards Grove wastewater treatment plant.

Water quality is characterized as fair. There is good diversity of fish species for a headwaters reach, which indicates that a good variety of habitat exists in this segment. The fish species include common shiner, creek chub, white sucker, central mudminnow, fathead minnow, blacknose dace, longnose dace, pearl dace, black bullhead, black crappie, bluegill, green sunfish, johnny darter, sand shiner, brook stickleback and

largemouth bass (Aartila 1997). Macroinvertebrate samples collected in 1996 have HBI ratings that indicate good to fair water quality rating. Cropland and barnyard runoff, bank erosion, channelization and wetland drainage are limiting the Pigeon River water quality in this reach (Aartila 1997).

Pigeon River Watershed Mussel Distribution Surveys

Qualitative mussel surveys were conducted in 1997 throughout the Pigeon River Watershed using both the inventory method and incremental collection method. The inventory method was conducted at nearly all bridge crossings and varies from brief collection efforts to one-hour surveys. The incremental collection method was conducted at eleven sights longitudinally from the headwater reaches down to near the mouth of the river. The incremental collection method for mussels is done by collecting a specific number of mussels after the last "new" species is collected. For example, twenty mussels were collected during a sample run, then those are identified. Sampling runs would continue until 100 mussels are collected without identifying a species that had not already been collected. Live mussels were collected by hand, identified and returned to the stream. Dead mussels (i.e. relict shells) were collected of species from which live organisms weren't found. Live environmentally sensitive mussel species (Endangered, Threatened or Special Concern) were measured and aged then returned. Furthermore, a reference collection of shells was made to be used for educational benefits and to aid in future mussel identifications. The non-environmentally sensitive mussel species collected at each incremental collection site are identified below. Two environmentally sensitive species were collected in the Pigeon River watershed as part of the incremental and inventory collections. The locations of these collections are reported by subwatershed (Table 75).

Table 62. Pigeon River Watershed Mussel Survey Results.

Common Name	Scientific Name
Pigeon River at CTH AB, Sheboygan Co.	
white heelsplitter	*Lasmigona complanata complanata*
fat mucket	*Lampsilis siliquoidea*
cylindrical papershell	*Anodontoides ferussacianus*
Pigeon River at Range Line Road, Sheboygan Co.	
white heelsplitter	*Lasmigona complanata complanata*
fat mucket	*Lampsilis siliquoidea*
cylindrical papershell	*Anodontoides ferussacianus*
spike	*Elliptio dilatata*
giant floater	*Anodonta grandis grandis*
Wabash pigtoe	*Fusconaia flava*
squawfoot	*Strophitus undulatus undulatus*
creek heelsplitter	*Lasmigona compressa*
Pigeon River at Orchard Road	
white heelsplitter	*Lasmigona complanata complanata*
Wabash pigtoe	*Fusconaia flava*
fat mucket	*Lampsilis siliquoidea*
squawfoot	*Strophitus undulatus undulatus*
cylindrical papershell	*Anodontoides ferussacianus*
giant floater	*Anodonta grandis grandis*
spike	*Elliptio dilatata*

Common Name	Scientific Name
creek heelsplitter	*Lasmigona compressa*
Pigeon River at South Cleveland Road	
cylindrical papershell	*Anodontoides ferussacianus*
white heelsplitter	*Lasmigona complanata complanata*
creek heelsplitter	*Lasmigona compressa*
Pigeon River at County Line Road (above confluence with Meeme River)	
creek heelsplitter	*Lasmigona compressa*
fat mucket	*Lampsilis siliquoidea*
squawfoot	*Strophitus undulatus undulatus*
white heelsplitter	*Lasmigona complanata complanata*
cylindrical papershell	*Anodontoides ferussacianus*
Pigeon River at Pigeon River Road	
creek heelsplitter	*Lasmigona compressa*
cylindrical papershell	*Anodontoides ferussacianus*
Spring Lake Creek upstream of Point Creek Road	
cylindrical papershell	*Anodontoides ferussacianus*
Meeme River upstream of Point Creek Road	
cylindrical papershell	*Anodontoides ferussacianus*
Meeme River downstream of Spring Valley dam at Spring Valley Road	
white heelsplitter	*Lasmigona complanata complanata*
cylindrical papershell	*Anodontoides ferussacianus*
squawfoot	*Strophitus undulatus undulatus*
creek heelsplitter	*Lasmigona compressa*
giant floater	*Anodonta grandis grandis*
Wabash pigtoe	*Fusconaia flava*
Meeme River downstream of West Washington Road	
white heelsplitter	*Lasmigona complanata complanata*
Wabash pigtoe	*Fusconaia flava*
fat mucket	*Lampsilis siliquoidea*
squawfoot	*Strophitus undulatus undulatus*
cylindrical papershell	*Anodontoides ferussacianus*
giant floater	*Anodonta grandis grandis*
spike	*Elliptio dilatata*
creek heelsplitter	*Lasmigona compressa*
STATE THREATENED SPECIES	
The slippershell mussel (*Alasmidonta viridis*) was found in the following subwatersheds: Pigeon Creek Subwatershed Howards Grove Subwatershed Meeme River Subwatershed	
The Ellipse (*Venustaconcha ellipsiformis*) was found in the following subwatersheds: Pigeon Creek Subwatershed Meeme River Subwatershed	

The mussel survey was determined to be very useful for assessing the overall water quality by involving another aquatic organism that is relatively immobile, long-lived, and dependent on host species. Furthermore, it is beneficial to identify unique resources that have existing populations of environmentally sensitive species. Based on the experience of the mussel surveys conducted as part of the Pigeon River IEM project (WDNR 1999), mussel surveys are being incorporated into our "routine" water quality monitoring to the extent possible (pers. comm.Galarneau).

Table 63. Streams of the Pigeon River Watershed.

Stream Name/Location (T, R, Sec., QQ, Q)	WBIC	Length	Biological Use		Codified	Supp.	Assess. Category	Use Impairments		Ref.	Data Level
			Existing	Potential				Source	Impact		
Fisher Creek Tributary to Pigeon River T16N R22E Sec.26 SESE	62500	4.4	WWFF	WWSF	DEF	NOT	M	NPS, PSM, HM, URB, RS, SB, BY, CL	TURB, SED, BAC, NUT, HAB, FLOW		4
Unnamed Tributary (Jetzers Creek) to Fisher Creek T16N R22E Sec.26 NESW	62600	3.7	WWFF	WWSF	WWFF	NOT	M	NPS, HM, URB, BY, CL	TURB, SED, NUT, HAB, TOX		4
Unnamed Tributary Lakeland College) to Jetzers Creek		1.9	WWFF	WWSF	WWFF	NOT	M	NPS,URB, CL	TURB, SED, NUT, HAB, TOX		4
Meeme River T17N R22E Sec.36 NWSE	62900	11.9	WWSF	WWSF	DEF	PART	M	HM, SB, RS, CL, PSB, BY	TURB, SED, DO, BAC		4
Spring Lake Creek Tributary to Meeme River T17N R22E Sec.9 NENE		2.2	COLD	COLD	DEF	PART	M	BY, PSB, CL,	SED, NUT		4
Unnamed Tributary to Meeme River T17N R22E Sec.3 SENW		0.2	UNK	UNK	DEF	UNK					
Unnamed Tributary to Meeme River T17N R22E Sec.9 SWSW	63300	0.2	UNK	UNK	DEF	UNK					
Unnamed Tributary to Meeme River T17N R22E Sec.9 SESW	63200	0.2	COLD	COLD	DEF	PART	M	CON, RS, HM	SED, HAB, FLOW		3
Unnamed Tributary to Meeme River T17N R22E Sec.15 SESW		1.1	LAL	LFF	DEF	NOT	E	HM, CL, BY, PSB	HAB, FLOW, SED, TURB, NUT, BAC		2
Unnamed Tributary (Osman Trib) to Meeme River T17N R22E Sec.14 NENE	63000	1.3	LFF	WWFF	DEF	NOT	M	HM, CL, BY, RS	HAB, MIG, DO, BAC, NUT, SED		4
Unnamed Tributary (East Branch Osman Tributary) to Meeme River T17N R22E Sec.14		2.1	LFF	WWFF	DEF	NOT	E	HM, CL, BY, RS	HAB, MIG, DO, BAC, NUT, SED		2

Stream Name/Location (T, R, Sec., QQ, Q)	WBIC	Length	Biological Use		Codified	Supp.	Assess. Category	Use Impairments		Ref.	Data Level
			Existing	Potential				Source	Impact		
Unnamed Tributary (West Branch Osman Tributary) to Meeme River T17N R22E Sec.14		1.7	LAL	LFF	DEF	NOT	E	HM, CL, BY, RS	HAB, MIG, DO, BAC, NUT, SED, FLOW		2
Unnamed Tributary to Meeme River T17N R22E Sec.25		0.4	UNK	UNK	DEF	UNK					
Pigeon River Segment 1 RM 0-18.1 T15N R23E Sec,2 SWSW	62300	Total 30.0 Reach 18.1	WWSF	WWSF	DEF	PART	M	HM, CL, SB, PSM, URB, CON	TURB, SED, NUT		4
Pigeon River Segment 1 RM 18.1-30.0	62300	Total 30.0 Reach 11.9	WWSF	WWSF	DEF	PART	M	HM, CL, SB, PSM, URB, CON	TURB, SED, NUT		4
Unnamed Tributary to Pigeon River T17N R22E Sec.31 NWNE	64400	0.8	LFF	LFF	DEF	PART	E	HM	MIG, HAB, FLOW		2
Unnamed Tributary to Pigeon River T17N R22E Sec.32 SWNE	64100	2.1	WWSF	WWSF	DEF	PART	E	HM, CL, SB	SED, BAC, NUT, MIG, HAB		2
Unnamed Tributary to Pigeon River T17N R22E Sec.32		0.2	UNK	UNK	DEF	UNK					
Grandma Creek T15N R23E Sec.18 NESE	62400	4.5	LFF	WWSF	DEF	NOT	M	CL, SB, RS, BY, URB	HAB, SED, MIG, FLOW, BAC, TOX, DO, NUT		4
TOTALS		**68.9**									

Trout streams as defined in Wisconsin Trout Streams (1980) but not listed in NR 102. These streams may be classified as trout streams under 1.02(7) since publication of Wisconsin Trout Streams (1980), but are not formally classified as trout waters. These streams will be added to NR 102 and/or NR 104 during code revision.

LAKES OF THE PIGEON RIVER WATERSHED

As part of the Pigeon River Priority Watershed project, a lake appraisal study has recently been conducted on the four larger lakes with public access; Pigeon Lake, Spring Lake, Jetzers Lake, and Horseshoe Lake (Olson and Helsel 1997). This report should be consulted for a detailed assessment of the condition of these lakes. The Pigeon River Watershed was selected as the IEM project for 1998, which enabled the WDNR to augment the studies already conducted for the Priority Watershed. This report has recently been completed (WDNR 1999) and includes additional lake and stream monitoring data for the watershed. As such, the conditions of the resources listed below (Tables 76 and 77) are brief summaries of these more extensive reports. I encourage the reader to review Aartila (1997), Olson and Helsel (1997), and WDNR (1998, 1999) reports for a more extensive review.

Table 64. Trophic Status of Lakes in the Sheboygan River Watershed

Lake Name (Location T/R/S)	Lake Type	County	Surface Area (Acres)	Max Depth (ft.)
Jetzers Lake (16N/22E/28)	Seepage	Sheboygan	15	42
Pigeon Lake (18N/22E/33)	Seepage	Manitowoc	77	68
Spring Lake (17N/22E/5)	Seepage	Manitowoc	8	23
Horseshoe Lake (17N/22E/20)	Drainage	Manitowoc	22	54

For key to abbreviations, please see "How to Use the Lakes Tables" section (page 19).

Table 65. Summary of trophic Status, presence of exotic species, and presence of a Self-Help Program.

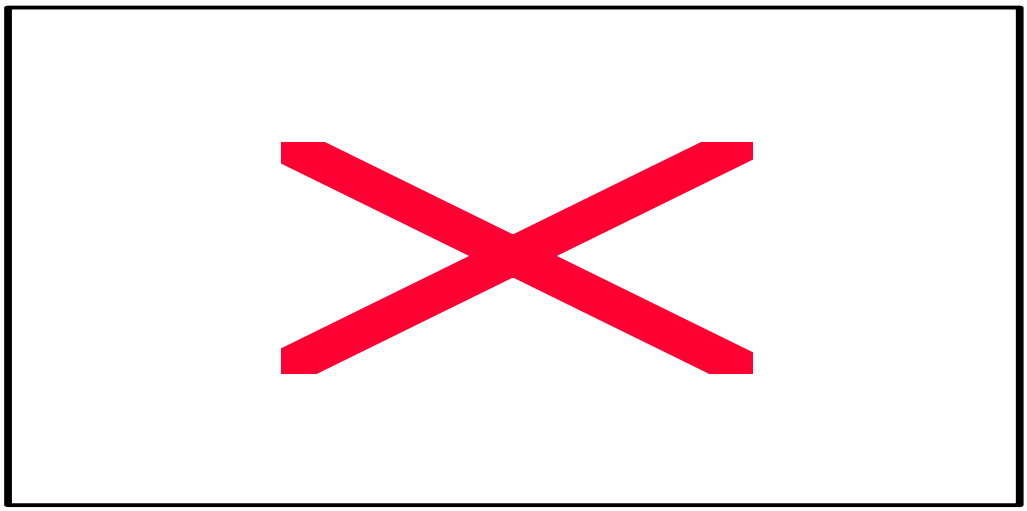
Waterbody	Trophic Status Index (TSI Range)	Eurasian Water Milfoil	Zebra Mussel	Self - Help Program
Jetzers Lake	Eutrophic (50-70)		No	No
Pigeon Lake	Mesotrophic (45-55)			
Spring Lake	Mesotrophic (40-50)		No	
Horseshoe Lake	Mesotrophic (35-50)			

JETZERS LAKE

T16N, R22E, Section 28 (1, 2); Sheboygan County
Surface Acres = 15, S.D.F. = 1.45, Maximum Depth = 42 feet

Jetzers Lake is located within a 146-acre direct drainage basin. The lake encompasses approximately 15 acres of surface water with a maximum depth of 42 feet, an average depth of 20 feet and a lake volume of 300-acre feet. The dominant land uses within the Jetzers Lake subwatershed are agriculture and forest (Olson and Helsel 1997). Jetzers Lake has been classified as a nutrient rich eutrophic lake with relatively poor water clarity (Olson and Helsel 1997). The lake receives heavy fishing pressure from the nearby communities of Howards Grove and Sheboygan (Nelson 1998). Trophic State indices range between 50 and 70 (Figure 31).

Figure 22. Trophic State Indices for Jetzers Lake.



Water Quality Survey

Olson and Helsel (1997) estimated the annual total phosphorus load to the lake from the watershed and deposition at 150 lbs/yr. They determined that agriculture is estimated to contribute the greatest percentage of the approximately 20% external phosphorus load to the lake. Olson and Helsel (1997) used models to estimate pre-development phosphorus load of 14 lbs/yr assuming only the direct watershed drained to the lake. The models indicate best management practices should be implemented throughout the entire watershed and an alum treatment conducted to achieve the greatest improvements in water quality. The duration of effectiveness of the alum treatment is related to both dose and watershed load of phosphorus (Olson and Helsel 1997). To be effective, direct watershed BMPs, at a minimum, need to be implemented prior to treatment with alum.

Fish Community Survey

Fish Management surveyed the fish community of Jetzers lake in spring, 1998 with fyke nets and electrofishing (Nelson 1998a). Northern pike were numerous, had a desirable size structure, and grew at average rates. Black crappie were over-abundant, had a poor size structure and were slow-growing. Bluegill were abundant, had a good to fair size structure and grew slower than the regional rate but, similar to the statewide rate.

Jetzers Lake has a long history of poor water quality from past and present agricultural contributions. Aluminum sulfate (alum) application has been recommended to reduce phosphorus levels along with controls on current phosphorus loading from the watershed. The lake has a long history of poor water

quality and slow-growing panfish. A July 1954 survey of the lake described very green water color caused by an algae bloom with a 1 ft. secchi disc reading, indicating poor water clarity (pers. comm. John Nelson). A barnyard extended into the lake and low oxygen levels were found at the 10 ft. depth and deeper. A subsequent survey took place in July 1960. That survey included fish collection with a boom shocker. Agricultural pollution from a barnyard and pasturing around the lake was noted. It was also noted that "excess fertility causes algae blooms - caused by pasturing and barnyard drainage." The author noted that "bluegill and black crappie appear to be stunted" and that there "may be a fair carp population." Jetzers Lake was electrofished again in May 1975. No report was written but the data indicated that small crappies were abundant. The secchi disc reading was 2.5 feet.

Water quality has remained poor in Jetzers Lake. A July 21, 1997 water quality survey documented no oxygen present at the 10' depth and a secchi disc reading of 1.3 feet. Further, phosphorus levels up to 910 micrograms/liter were reported in a June 10, 1994 preliminary draft of a Jetzers Lake Protection Plan. Phosphorus levels of 30 micrograms/liter or more are indicative of poor water quality lakes.

The impacts of poor water quality on the fish community are many and significant at Jetzers Lake. The lake is susceptible to both winter and summer fish kills. The heavy algae blooms can cause poor quality flavor in the fish flesh. Also, the food chain is disrupted, affecting especially the quality of zooplankton populations that transfer food energy up the food chain to the fishes.

Therefore, the greatest management need for Jetzers Lake and its fishery is to improve and protect water quality. Fortunately, the lake has a very small watershed. The deep nature of the lake is also an attribute since is may be possible to apply aluminum sulfate (alum) to the lake to reduce the availability of phosphorus which would reduce the amount of algae production and improve the overall quality of the lake.

Jetzers Lake was stocked with several species of fish in 1993 following a major fish kill in March of that year. WDNR stocked 15,000 northern pike fry, 2,400 bluegill and 107 largemouth bass.

Electrofishing samples were collected from the lake in 1996, 1997 and 1998. I will discuss the 1998 sample in this report. That electrofishing took place on May 12, 1998 using a large boom shocker unit with two people netting fish after dusk. We also fished the lake with three fyke nets from March 26 through March 31, 1998

Northern pike were the most common gamefish in the samples (Table 78). Black crappie were the most common panfish. We captured a total of twelve species of fish.

Table 66. Catch per unit effort of fish captured with fyke nets and electrofishing from Jetzers Lake, Sheboygan County

Species	Fyke #	#/Net Night	Electr. #	#/hr	#/mile
Northern Pike	109	7.3	1	2.5	1.7
Black Crappie	984	65.6	152	380.0	633.3
Bluegill	228	15.2	111	277.5	185.0
Pumpkinseed	103	6.9	30	75.0	50.0
Green Sunfish	1	0.1	***0***	---	---
Largemouth Bass	9	0.6	1	2.5	1.7
Yellow Perch	1	0.1	0	---	---
Yellow Bullhead	64	4.3	1	2.5	1.7

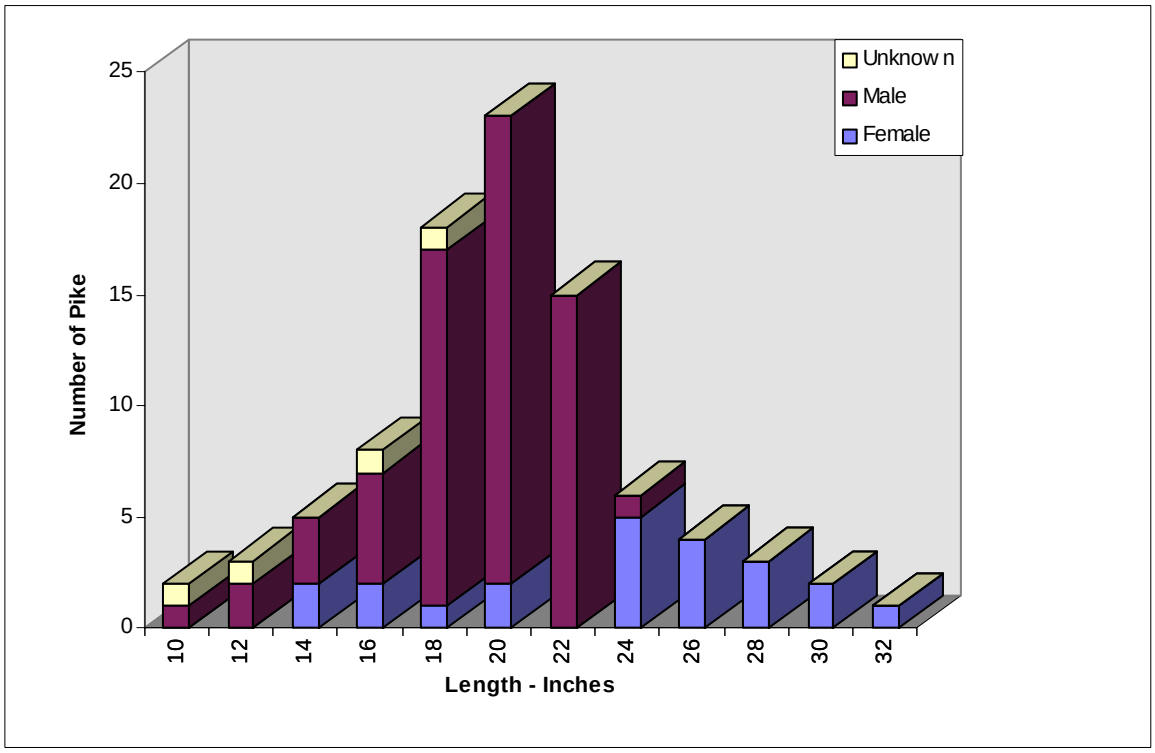
Species	Fyke #	#/Net Night	Electr. #	#/hr	#/mile
Black Bullhead	12	0.8	0	---	---
White Sucker	43	2.9	1	2.5	1.7
Carp	4	0.3	2	5.0	3.3
Golden Shiner	3	0.2	1	2.5	1.7

Northern Pike

We captured 109 northern pike in fyke nets at a rate of 7.3/net night (NN). The population estimate for the lake was 119 pike or 7.9/acre with a standing crop of 294 lbs. or 19.6 lbs./acre.

The pike ranged in size from 10.0" - 32.1" (Figure 23). Females and males averaged 24.5" and 20.2", respectively. Legal length fish (≥ 26") made up 12.3% of the catch and included only females. The length mode peaked at the 20" - 21" length which represents largely age 3 and 4 fish.

Figure 23. Length frequency distribution of northern pike captured in fyke nets from Jetzers Lake



Growth of northern pike in Jetzers Lake was below the regional average in general except for age 5 and 6 fish (Table 79). Growth was similar to the statewide average at most ages.

Table 67. Average length at age of northern pike from Jetzers Lake compared to regional and statewide averages

Age	Female		Male		All		Reg.	State
	#	Mean	#	Mean	#	Mean	Avg.	Avg.
2	---	---	2	13.6	4	14.0	17.9	14.2
3	3	19.9	3	17.0	7	18.3	19.8	18.4
4	3	24.4	6	19.9	9	21.4	22.9	20.4
5	6	27.6	9	21.7	15	24.1	24.2	22.8
6	4	28.7	7	22.5	12	24.7	24.5	25.0

The density and size distribution of northern pike in the lake was surprisingly good considering the small size of the lake and the intensity of the fishing activity. Forage is very abundant and the population should continue to expand under the current 26" minimum size limit. No further management specifically for northern pike is planned or needed at this point.

Largemouth Bass

We caught only 9 largemouth bass in fyke nets and one while electrofishing. In 1997 we caught 12 largemouth bass while electrofishing. The 1998 sample probably does not reflect the true abundance of largemouth bass in Jetzers Lake.

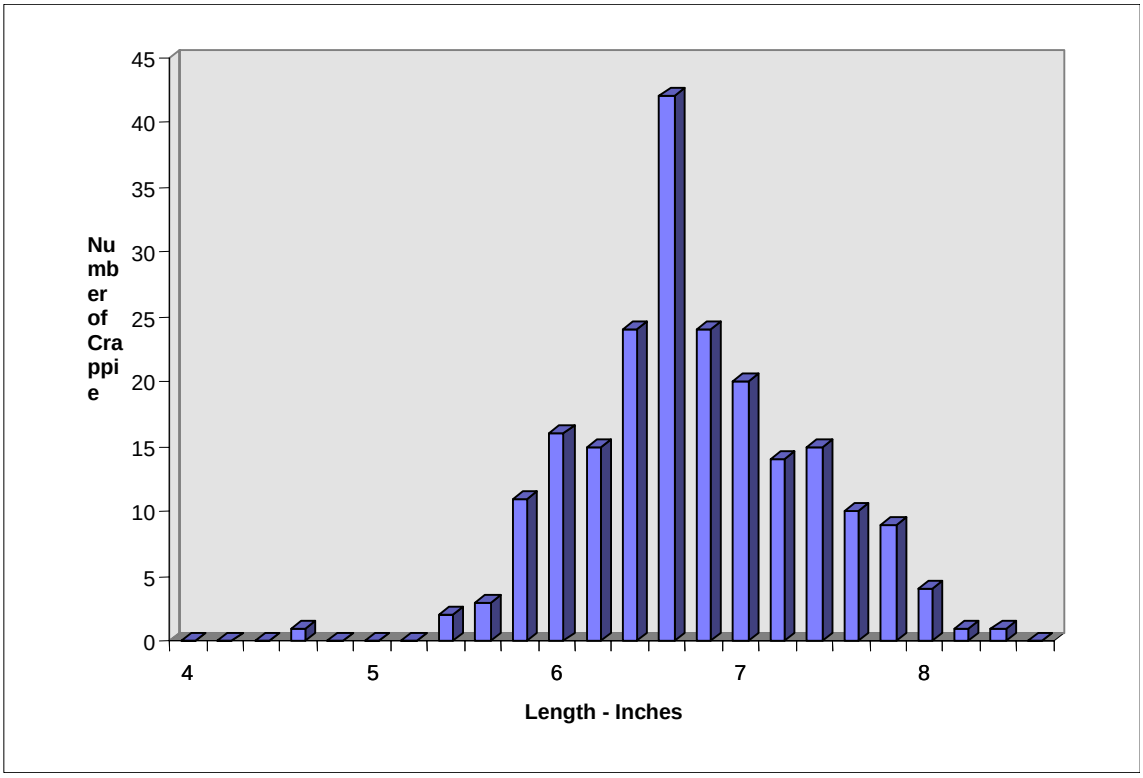
The lake has produced some large bass in the past and has potential to do so in the future. We caught bass up to 18.8" long in 1997 and 19.5" in 1998 during the surveys. Small bass were present though they may be highly vulnerable to predation by northern pike. No additional management is needed for largemouth bass in the lake beyond the current 14" minimum size limit.

Black Crappie

We caught 984 black crappie in fyke nets (65.6/NN) and 152 while electrofishing (380.0/hr) in 1998 (Table 79). I consider the population to be over-abundant as indicated by this and previous surveys.

In fyke net samples, the crappie ranged in size from 4.7" - 8.4" long with an average of 6.8" and a PSD of 1.9%. The very low PSD indicates a poorly structured fish population that is dominated by either a large year class of young fish or fish that are slow growing. In the case of Jetzers Lake, it indicates slow growth. The peak length mode was at 6.6" (Figure 24). The electrofishing data were similar with a mean length of 6.9" and a PSD of 1.3%.

Figure 24. Length frequency distribution of black crappie captured in fyke nets from Jetzers Lake



Only two year classes of crappie were captured in the survey. Their growth rate was well below either the regional or statewide averages (Table 80).

Table 68. Average length at age of black crappie, bluegill and pumpkinseed sunfish from Jetzers Lake compared to regional and statewide averages

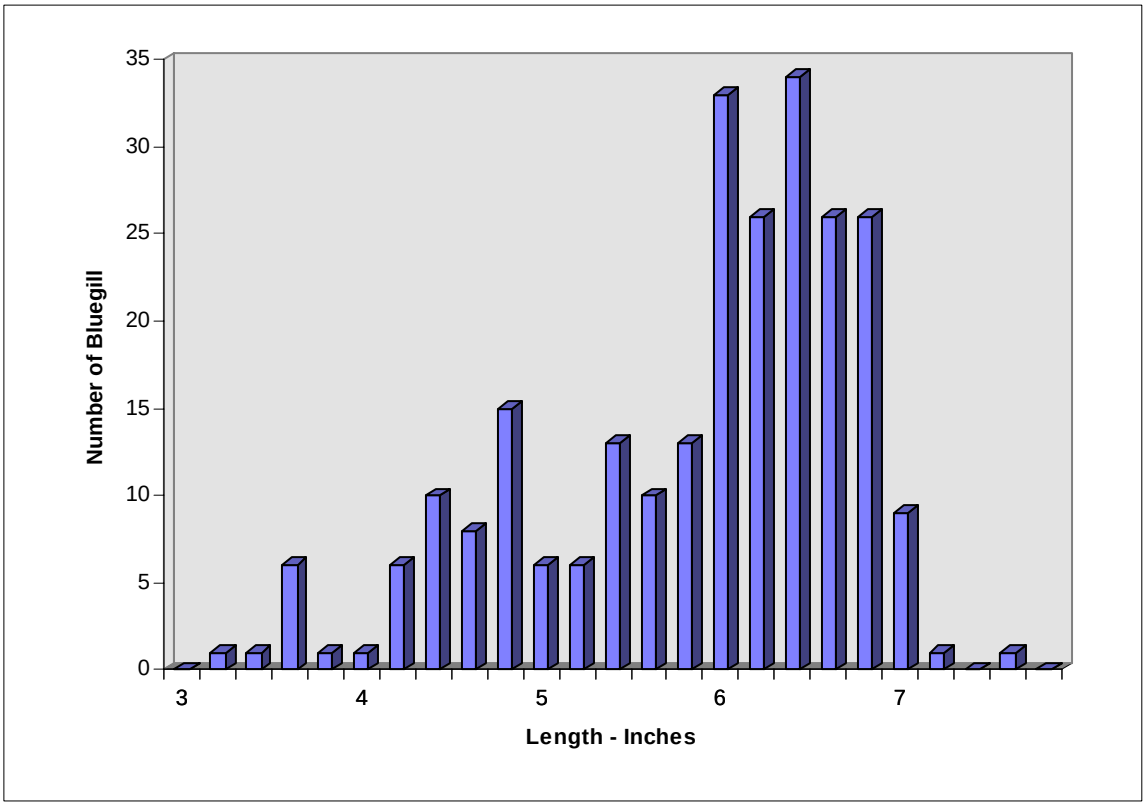
Black Crappie					
Age	**#**	**"98" Ave.**	**"97" Ave.**	**Reg. Ave.**	**State Ave.**
3	---	---	6.1	7.9	7.2
4	41	6.7	7.2	9.0	8.6
5	10	7.9	---	10.2	9.5
Bluegill					
2	11	3.4	---	4.6	3.8
3	7	4.9	4.6	5.6	4.8
4	22	6.0	6.0	6.5	5.8
5	19	6.6	---	7.3	6.6
6	4	6.2	---	7.8	7.2
Pumpkinseed					
2	6	3.7	3.3	3.8	3.5
3	18	4.8	4.5	5.7	4.6
4	4	5.2	---	6.2	5.5
5	3	5.8	---	5.8	6.1

Bluegill

We caught 228 bluegill in fyke nets at a rate of 15.2/NN (Table 80). A total of 111 were caught with electrofishing gear at a rate of 277.5/hr.

The size structure of bluegill from the lake was fairly good with many of the bluegill in the 6.0" - 7.0" range (Figure 25). The fyke net sample ranged in size from 3.3" - 7.6" with a mean of 5.9" and a PSD of 61.7% which is considered very high compared to other lakes. The RSD_7, or proportion over 7" long, was 4.3% which is low compared to many bluegill populations.

Figure 25. Length Frequency distribution of bluegill captured in fyke nets from Jetzers Lake - 1998.



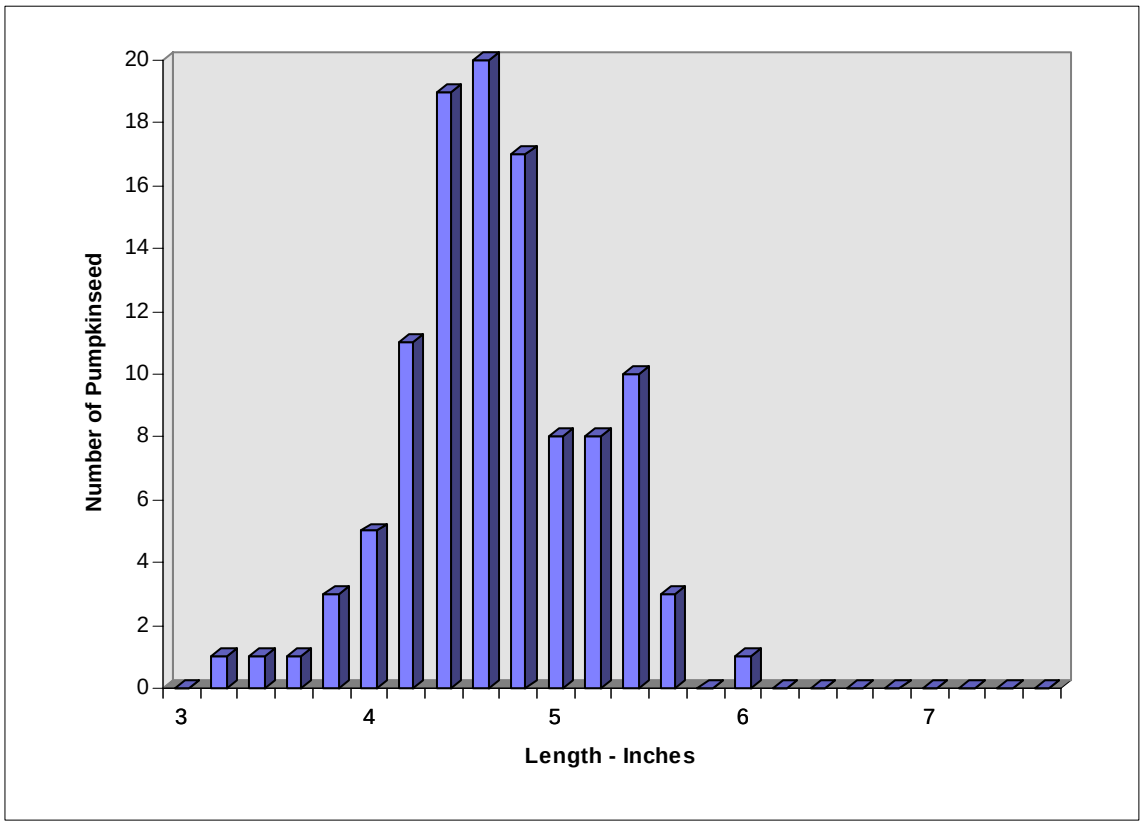
The growth rate of bluegill from Jetzers lake was below the regional average but, similar to the statewide average for that species (Table 80). The key to managing bluegill in the lake is to convert the high fertility of the lake to fish flesh. Water quality improvements are the key to improve energy transfer through the food chain.

Pumpkinseed Sunfish

Pumpkinseed sunfish were fairly common in the lake. We captured them at rates of 6.9/NN in fyke nets and 75.0/hr while electrofishing (Table 80). Pumpkinseed are generally common in waters which experience low oxygen conditions.

The size structure of pumpkinseed sunfish was very poor (Figure 26). Most of the fish were in the 4.4 - 4.9" range. They ranged in size from 3.2 - 6.0" with a mean of 4.7" and a PSD of 1.0%.

Figure 26. Length frequency distribution of pumpkinseed sunfish captured in fyke nets from Jetzers Lake



The growth of pumpkinseed was below the regional average and similar to the statewide average (Table 80). The pumpkinseed likely compete with bluegill for the same food resources and similar growth patterns would be expected as observed in this survey.

Yellow Bullhead

Both yellow and black bullhead were present but, yellow bullhead were the most common of the two species in both the fyke net and electrofishing samples. We caught 64 yellow bullhead in fyke nets at a rate of 4.3/NN (Table 78, page **Error! Bookmark not defined.**).

The yellow bullhead fyke net samples ranged in size from 5.1 - 10.6" with a mean of 8.2". The bullheads could provide some good fishing opportunities for local anglers.

Other Species

The other species captured during the survey included green sunfish, yellow perch, white sucker, carp and golden shiner. White suckers were fairly common. We caught few carp though, several more were observed which avoided capture. Carp did not appear to be over-abundant and did not constitute a serious management problem.

The low number of yellow perch captured was unexpected. Yellow perch are normally a dominant species in waters, which experience low oxygen conditions. Perhaps predation by the abundant northern pike keeps the population at low levels.

The most serious management problem for Jetzers Lake is high phosphorus levels which foster heavy algal blooms and depress overall water quality. I recommend that we immediately explore and seek funding for a whole-lake treatment with aluminum sulfate (alum) to tie up much of the phosphorus load. Some runoff from cropped lands still contributes phosphorus to the lake yet, it is evident that resident phosphorus loads are very excessive and require immediate attention.

The fishery of Jetzers Lake is generally in fair to good condition. The slow growth of crappie will be difficult to alter. However, improvements in water quality may help to improve zooplankton populations and increase panfish growth. It may be desirable to attempt to establish a healthy fathead minnow population in the lake and physically remove some crappie from the lake.

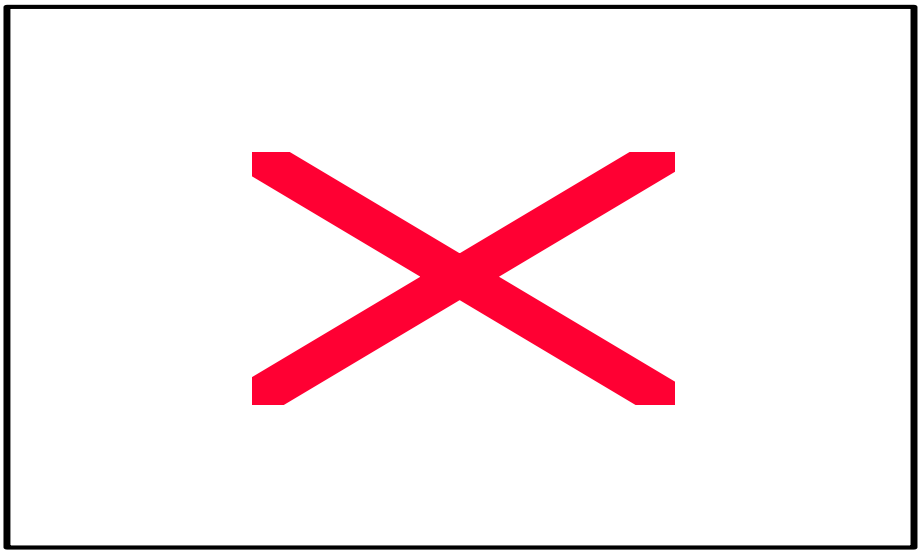
HORSESHOE LAKE

T17N, R22E, Section 20; Manitowoc County
Surface Acres = 22, S.D.F. = 2.08, Maximum Depth = 54 feet

Horseshoe Lake is a small, hard water drainage lake with spring sources in terminal moraine. The lake surface area is approximately 22 acres with a maximum depth of 54 feet, an average depth of 25 feet and a lake volume of 550 acre feet. The lake is located in an 847-acre direct drainage basin. The dominant land uses within the Horseshoe Lake subwatershed are agriculture and forest (Olson and Helsel 1997). The fish community in Horseshoe lake is primarily largemouth bass and panfish. Access is available via a public park (WDNR 1968).

Horseshoe Lake is classified as a mesotrophic lake with relatively low nutrient and chlorophyll *a* concentrations and good water clarity. The 1996 spring total phosphorus was 40 ug/L with surface summer phosphorus concentrations ranging from 11 ug/L to 16 ug/L. TSI values typically range between 35 and 50 (Figure 27).

Figure 27. Trophic Status Indices for Horseshoe Lake



Water Resource Objectives and Management Recommendations

The water resource objectives and management recommendations for Horseshoe Lake reduce phosphorus loading overall 62% from existing conditions (114 lbs/yr) to best managed conditions (43 lbs/yr) (Olson and Helsel 1997). Specific best management practices should target lake protection and nutrient sources from agricultural land.

SPRING LAKE

T17N, R22E, Section 5; Manitowoc County
Surface Acres = 8, S.D.F. = 1.51, Maximum Depth = 23 feet

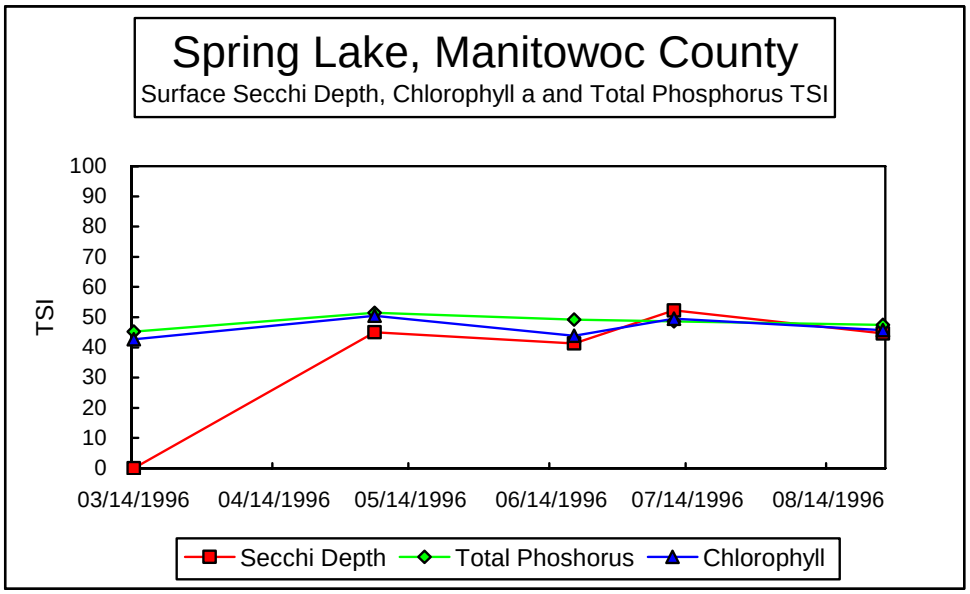
Spring Lake is a small, seepage lake in terminal moraine encompassing approximately 8 acres of surface water. The maximum depth of the lake is 23 feet with an average depth of 11 feet and lake volume of 88 acre-feet. Spring Lake is located in a 48-acre direct drainage basin. The fish community is comprised of largemouth bass, panfish, and northern pike. Access and parking is available by a town road (WDNR 1968).

The dominant land uses within the Spring Lake subwatershed are agriculture and forest (Olson and Helsel 1997). The estimated annual total phosphorus load to the lake from the watershed and deposition is estimated at 13 lbs. Olson and Helsel (1997) determined that agriculture and urban land uses are estimated to contribute the greatest percentage of phosphorus of 46% and 20%, respectively to the lake; while no other sources contribute more than 17% to the annual phosphorus load.

Water Resource Conditions

Spring Lake is classified as a mesotrophic lake with relatively low nutrient and chlorophyll *a* concentration and good water quality (Olson and Helsel 1997). The 1996 spring total phosphorus reading was at 20 ug/L with the average surface summer phosphorus concentrations ranging from 12 ug/L to 15 ug/L. The TSI values are classified as mesotrophic ranging between 40 and 50 (Figure 28).

Figure 28. Trophic Status Indices for Spring Lake



Water Resource Objectives and Management Recommendations

The water resource objectives and management recommendations for Spring Lake are to reduce the existing phosphorus load 50% overall from the existing conditions (13 lbs/yr) to best managed conditions (6.5 lbs/yr) (Olson and Helsel 1997). Specific best management practices should target nutrient sources from adjacent agricultural land.

PIGEON LAKE

T18N, R22E, Section 33; Manitowoc County
Surface Acres = 77, S.D.F. = 1.32, Maximum Depth = 68 feet

Pigeon Lake is a 77-acre seepage lake located in southwestern Manitowoc County, Wisconsin. The lake has a maximum depth of 68 feet, an average depth of 35 feet and a single perennial outlet. The area is developed with residential dwellings and a recreational camp along the 1.6 miles of shoreline. The residences are served by sanitary sewer, which is treated at the Town of Liberty Wastewater Treatment Plant.

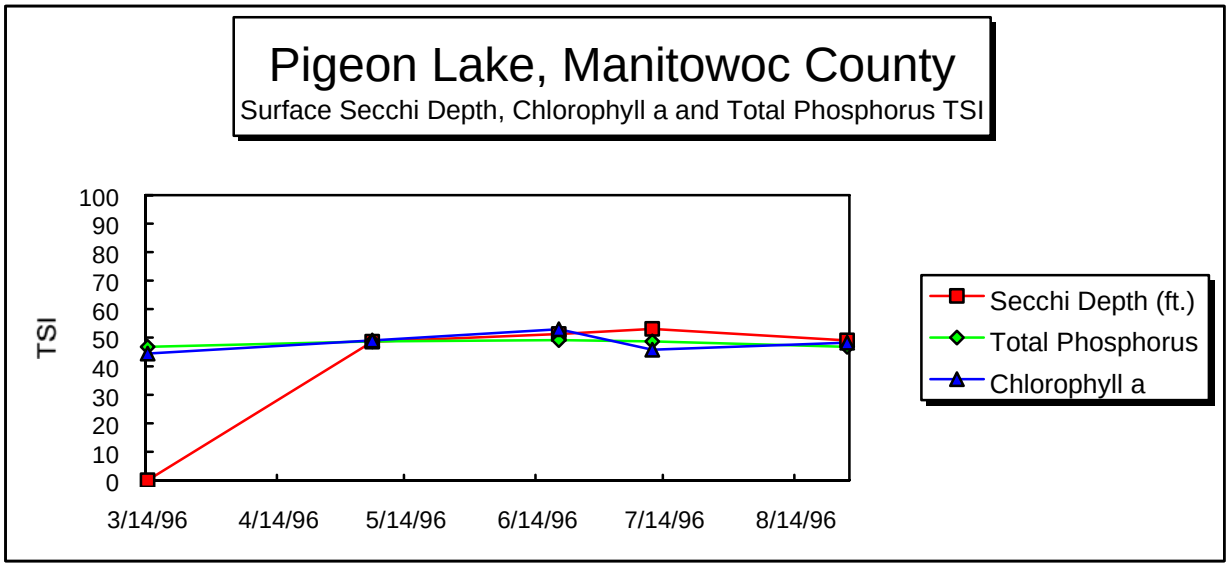
The fishery consist of largemouth bass, panfish, northern pike, and brown trout. Public access and parking is available by a town road (WDNR 1968).

Pigeon Lake has a 216 acre, primarily agricultural, watershed (Olson and Helsel 1997). Based upon the average annual run-off of 7.3 inches, the lake's flushing rate is .06 water volumes per year or about 17 years to flush the complete lake volume. The dominant land uses within the Pigeon Lake subwatershed are agriculture and forest. The estimated annual total phosphorus load to Pigeon Lake from the watershed and deposition is estimated at 133 lbs. Olson and Helsel (1997) found that, agriculture land use is estimated to contribute the greatest percentage of external phosphorus (48%) to the lake; while no other sources contribute more than 10% to the annual phosphorus load.

Water Resource Conditions

Pigeon Lake stratifies during the summer months during which the hypolimnion is anoxic (lack of oxygen in the bottom waters). Pigeon Lake is classified as a mesotrophic lake, with moderately clear water and relatively low nutrient and chlorophyll-*a* concentrations and good water clarity with TSI values between 45 and 55 (Figure 29).

Figure 29. Trophic Status Indices for Pigeon Lake.



Water quality samples collected during 1996 showed average spring total phosphorus ranged from 14 – 20 µg/L with surface summer phosphorus concentrations ranging from 11 - 15 µg/L. The hypolimnion develops anoxia (no oxygen), which results in higher phosphorus concentrations as phosphorus is released from the substrate. Generally hypolimnetic phosphorus concentrations above 200-300 µg/L are indicative of increased internal loading; although the hypolimnetic volume, lake morphology and stratification intensity also affect the amount of internal load (Olson and Helsel 1997).

Water Resource Objectives and Management Recommendations

The water resource objectives and management recommendations for Pigeon Lake are to reduce phosphorus loading overall by 47% from existing conditions (133 lbs/yr) to best managed conditions (70 lbs/yr) (Olson and Helsel 1997). This should result in improvements in water column phosphorus and long-term protection of water quality.

Specific best management practices should target lake protection and nutrient sources from agricultural land and residential properties. Assessment of the internal loading should be continued by collection of in-lake water quality data.

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