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Manistique River Assessment

George Madison
and
Roger N. Lockwood

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EXECUTIVE SUMMARY

This is one in a series of River Assessments being prepared by the Michigan Department of Natural Resources, Fisheries Division for Michigan rivers. This report describes the physical and biological characteristics of the Manistique River, details those human activities that have influenced the Manistique River basin, and serves as an information base for future management goals.

River assessments are intended to provide a comprehensive reference for citizens and agency personnel seeking information about a river. The information contained in this assessment is a compilation of not only river related problems but opportunities as well. The relationship between human influence and river status necessitates public awareness and involvement. This river assessment serves as a tool which can be used to assist the management decision process and increase public understanding and foster their involvement in management decisions. This cooperative stewardship by professional managers and the public will benefit the resource, and ultimately, the future generations of people that will live and recreate within the river basin.

This document consists of four parts: an Introduction, a River Assessment, Management Options, and Public Comments (with our Responses). The River Assessment is the nucleus of the report. It provides a description of the Manistique River and its watershed in thirteen sections: Geography, History, Geology, Hydrology, Soils and Land Use, Channel Morphology, Dams and Barriers, Water Quality, Special Jurisdictions, Biological Communities, Fisheries Management, Recreational Use, and Citizen Involvement.

The Management Options section identifies a variety of actions that could be taken to protect, restore, rehabilitate, or better understand the Manistique River. These management options are organized according to the main sections of the river assessment. They are intended to provide a foundation for public discussion, priority setting, and ultimately planning the future of the Manistique River.

The Manistique River basin is located in the east-central portion of the Upper Peninsula of Michigan and drains an area of 1,471 square miles. It lies within five counties: Alger, Delta, Luce, Mackinac, and Schoolcraft. For analysis and descriptive purposes, the Manistique River and its tributaries will be discussed in terms of ecologically similar subwatersheds. These subwatersheds characterize distinct sections of the watershed that share common physical, hydrological, and biological characteristics. These seven subwatersheds are: Mainstem-upper, which extends 31 miles from the headwaters at Locke Lake to the confluence of Boucher Creek; Mainstem-middle, from the confluence of Boucher Creek downstream 23 miles to the confluence of the West Branch Manistique River; Mainstem-mouth, from the confluence of the West Branch Manistique River downstream 21 miles to Lake Michigan; Tributaries-Fox River, this system consists of the East Branch Fox, Little Fox, and the main Fox rivers which collectively flow 68 miles to the mainstem Manistique River; Tributaries-central basin, the central basin consists of numerous drainages from lands in the northern portion of the watershed and collectively include 296 miles of river; Tributaries-upper Indian River, which extends from its origin in Hovey Lake 65 miles downstream to the confluence with Big Murphy Creek; and Tributaries-lower Indian River, beginning at the confluence with Big Murphy Creek and extends 15 miles downstream before entering the mainstem.

The final glacial retreat approximately 10,500 years ago formed the present day Manistique River watershed. Native Americans first inhabited the watershed following the glacial retreat. The Manistique River was an important source of food and materials for Native Americans. The first documented exploration by Europeans began in the early 1600s and fur trade was the first economic enterprise in the region. Timber harvest began in the late 1830s with large scale logging developing by the 1880s. Major logging operations occurred in two sequences known as the pine era and the hardwood era. During the pine era, red and white pine were cut in winter and driven down rivers during spring thaws. The town of Manistique was an important community to the lumbering industry and was the principle port of destination for wood harvested within the watershed. Railroads were constructed during the hardwood era and were the primary mode of transportation. By the 1930s, logging focused on secondary growth pulpwood timer for paper production and transportation shifted from rail to motorized vehicle roads. Settlement patterns shifted with transportation modes. Concentrations of people lived around mills during the pine era, along railroads during the hardwood era, and then at road intersections.

During the early 1900s failed farming attempts resulted in state and federal ownership of much of the land within the Tributaries-central basin. In 1935 the 96,000 acre Federal Seney Wildlife Refuge was established.

Since 1937 the United States Geological Survey has maintained as many as 14 stream flow gauges within the Manistique River watershed. These gauges provide the necessary information to measure a river's groundwater inflow, flood potential, and its dynamic nature. No gauge sites were located on the Fox River system or in the upper Indian River.

Geology of the Manistique River watershed is characterized by highly permeable materials along the south-east portion of the watershed, and across the northern and western edges of the watershed. These areas of coarse-textured materials provide high groundwater inflow to the river creating stable water flows and temperatures. The Mainstem-upper and -middle subwatersheds are stable with good groundwater inflow and hydraulic stability. Much of the river within these sections has sufficient power to move sand and adjust the channel (e.g., lateral movement of the river channel), and channel adjustments occur almost annually.

The Mainstem-mouth is the only area within the mainstem having excessive peak flows. These flows are a result of the Manistique Paper Inc. dam. The river area within the influence of the dam is artificially constricted with poor aquatic habitat. In addition, bank armoring to contain abnormal flows has resulted in poor aquatic habit.

The Tributaries-Fox River flows through areas of coarse-textured materials. Groundwater inflow is high and flows are quite stable.

Much of the central watershed, primarily Tributaries-central basin, is an area of lacustrine sand and gravel with medium permeability. Groundwater inflow to river channels is modest and rivers within this area have less stable flows with varying amounts of groundwater inflow. Many factors contribute to the unstable nature of this subwatershed. Surficial geology and soil types hinder groundwater inflow and numerous dams and extensive channelization have further degraded this subwatershed.

The Tributaries-upper Indian River flows through areas of coarse-textured materials. Groundwater inflow is high and flows are quite stable. The Tributaries-lower Indian River includes Indian Lake. Groundwater inflow is modest and surficial geology is primarily materials of medium to low permeability. Run of the river flows are not maintained during summer months below the Indian Lake Dam. The resulting low flows within the affected portion of Indian River reduce available aquatic habitat.

The Tributaries-lower Indian River is quite stable with good groundwater inflow. This river has limited ability to transport sand and alter its channel. Indian Lake Dam negatively influences river low flows. This lake-level control structure further reduces stream flow during periods of low flow.

The Manistique River watershed is predominately sandy soil materials with minimal gravel-cobble deposits. Specifically, three major soil types are found within the watershed. Wet sand – organic soils are the dominant group and cover 70% of the watershed; coarse sand – sand cover 22%; and loamy sand – loam cover 8%. Coarse sand – sand soils, which provide high inflow are found in headwater areas along the south-east, north, and west edges of the watershed. Loamy sand – loam soils are primarily in the eastern edge and along the mainstem and provide modest inflow. The Tributaries-central basin is dominated by wet sand – organic soils. These wet soils prevent newly fallen precipitation from readily moving through the soil profile and river water temperatures are easily influenced by ambient air temperatures. The Indian River subwatersheds are comprised of 98% sand and less than 2% gravel-cobble. Recognizing the sandy composition of the Manistique River watershed is essential to understanding and properly managing its waters.

Much of the land within the watershed is wetland (57%), and forested upland covers an additional 32.8%. Minimal farming occurs and is limited, mostly, to the Mainstem-upper and Mainstem-middle and generally occurs in areas of loamy soils. Only 1.6% of the watershed is in agricultural use. Poor soils and a short growing season inhibit agriculture. Growing degree-days average 2,201°F days and soils have a frigid temperature regime. Forest and recreational habitats dominate.

Gradient, measured in ft/mi (ft per mi), is an indicator of fish habitat quality. Fish habitat improves as gradient increases to 69.9 ft/mi and declines as gradients exceed 69.9 ft/mi. Gradient within a river system varies with land form and areas of good and poor habitat can occur within a system. Average gradient of the Manistique River is 1.3 ft/mi and is characterized as mostly run habitat with low hydraulic diversity. Tributaries-Fox River has a mean gradient of 4.4 ft/mi and is characterized as having some riffles with modest hydraulic diversity. Approximately 4% of habitat in this subwatershed is rated as excellent. Habitat within the Tributaries-central basin is variable, with most rated good. Mean gradient varies from 3.0 to 9.1 ft/mi. Gradient within the Indian River system varies from 2.8 ft/mi in the lower subwatershed to 3.3 ft/mi in the upper. Most of the habitat found in this subwatershed is rated as good.

Fish habitat quality may also be evaluated by comparing channel cross-section measures with expected measures. Channels that are overly wide result from frequent flood events. Such events may be caused by dams, impoundment draw downs, or from channelization or similar land use practices that rapidly move water from the surrounding landscape into the channel. Dams impound river segments and provide limited storage capacity to moderate flows downstream. Dams also increase river surface area by impounding the river. When precipitation exceeds storage capacity, river flow below the impoundment is amplified due to increased surface area. Similarly, channels that are too narrow may result from channelization, bank armoring, bulkheads, or similar artificial constructs that constrict channel width.

Much of the mainstem has appropriate channel width. The area of exception is below the Paper Mill Dam in Manistique. Here, the river is artificially constrained and forced to remain within boundaries resulting in poor habitat quality.

Most sites within the Tributaries-central basin had appropriate channel widths. However, areas of the Driggs River and Marsh Creek are overly narrow. Both areas have been affected by dredging and channeling. These actions have reduced groundwater recharge and drained adjacent marshlands.

Channel width below Indian Lake Dam on the Indian River was found to be excessively wide. This area is affected by the Indian Lake Dam. During low flow this structure dramatically decreases flow. During high flow Indian Lake provides limited storage capacity and excess water is passed downstream, resulting in excessive channel width.

There are 54 dams located within the watershed. Only one dam has historically served to generate electricity (Paper Mill Dam), the remaining dams serve as water-level control structures, fish barriers, or to create waterfowl habitat. Paper Mill Dam has a hazard rating of 1 (failure of dam would result in loss of life), Indian Lake Dam has a hazard rating of 2 (failure of dam would result in severe property damage), and the remaining dams have lesser hazard ratings.

Dams exert many influences on river systems and the fish communities within them. By impounding rivers, dams reduce water movement. This changes the system from a riverine to a lake environment. Reducing or halting water movement allows for the sediment load, which was naturally carried by the river current, to fall out and deposit on the streambed. Direct solar radiation and surrounding ambient air temperatures serve to warm water within these lake environments. Warm surface water from impoundments thermally dominates stretches for considerable distance before cooler groundwater can restore water temperatures. In these artificially warmed stretches fish communities are limited to species tolerant of warm water. Naturally occurring coldwater species, such as trout, are less likely to inhabit these areas which have been negatively influenced by dams. Warm water has less physical potential to carry dissolved oxygen than cold water, therefore fish communities within the impoundment waters are often characterized by the presence of fishes that survive in less oxygenated waters. Fish communities found within impounded waters rarely include coldwater species but often include largemouth bass, northern pike, brown bullhead, yellow perch, and white sucker.

Dams prevent downstream passage of woody structure. The natural in-stream deposition of logs, trees, and root-wad materials is halted. Woody material provides important over-head cover for fish, hydraulic diversity, and attachment sites for invertebrates. Biological communities below dams are negatively affected by the lack of woody structure.

Dams act to impede upstream and downstream fish movements. Barriers to fish movements prevent fish from accessing their spawning grounds or from reaching holding pools. Preventing fish, reptiles, amphibians, and insects from free access throughout a river system fragments the river and its biological communities. In the Manistique River system, potamodromous fish seeking to spawn can only migrate up to the Manistique Paper Co., Inc. (MPI) dam, which is located approximately one mile upstream from the river mouth. This same dam acts to prevent sea lamprey from ascending the river during their spawning run and blocks them from 1,400 miles of potential lamprey spawning habitat.

For the most part, the water quality of the Manistique River system is good and relatively undisturbed. The waters originate from surface water run-off or groundwater springs. There are no large industrial or human settlements in the upper watershed, so degradation of the chemical parameters of the water quality is minimal until the river reaches the City of Manistique. Thermal degradation (warming) of the water quality occurs from the various dams within the watershed.

Non-point source sedimentation to the river is one of the biggest affects on water quality in the watershed. Run-off from road building, and wetland ditching and draining has resulted in large inflows of sediment to stream channels. Airborne mercury contamination affects the watershed and is manifested within the fish of the Manistique River system.

The lower Manistique River has been identified as an area affected by pollution. During the 1950s a biosurvey of the river documented heavy accumulations of wood fibers, bark, and wood splinters. In the 1960s kerosene, used as a foam depressant in the pulp de-inking process, was routinely released into the river. During the 1970s an oil film on the river, and extensive concentrations of bark and paper fibers were documented. The largest and most publicly known pollution issue within the Manistique River watershed is the presence of polychlorinated biphenyls (PCBs) and heavy metals in he lower 1.5 mile reach of the river. The Michigan Department of Public Health (now known as the Michigan Department of Community Health) issued a no-consumption advisory on common carp within the Manistique River in 1995 due to PCBs. The International Joint Commission, the Great Lakes National Program Office, and the State of Michigan have designated the lower Manistique

River from the Paper Mill Dam in town to the mouth of the harbor at Lake Michigan as one of the 42 Areas of Concern in the Great Lakes.

Several federal and state government agencies have jurisdictional responsibility within the watershed. The United States Fish and Wildlife Service owns and manages the Seney Wildlife Refuge, one of the largest wetland areas in Michigan. Within the Seney Wildlife Refuge, the United States Department of Interior Park Service has designated the Strangmoor Bog as a National Natural Landmark. The Michigan Department of Natural Resources (MDNR) is the primary land owning state government entity. Within the MDNR various aspects of management are administered by Fisheries Division, Wildlife Division, Forest, Mineral and Fire Management Division, and Parks and Recreation Division. The Fox River and its selected tributaries are designated as a Wild-Scenic river by MDNR. The Indian River is a federally designated Wild and Scenic River and is on the state's "proposed" list for Natural River designation.

Since the 1920s, fish surveys within the Manistique River watershed have documented 61 species of fish. Before human settlement there were no physical barriers, such as dams or falls, that prevented movement of fish. Fish distribution and abundance were determined by habitat suitability for each particular species and thermal regime within habitat. Brook trout occupied riverine areas that received cold groundwater inflows, as well as spring fed ponds and thermally stratified lakes connected to these rivers. Coolwater fishes occupied the lower reaches of subwatersheds as well as the connecting lakes that possessed lentic environments. Interior lakes that did not connect with the river system were typically occupied by coolwater fish species.

Pre-settlement fish spawning migrations from Lake Michigan provided for establishment of fish species such as lake sturgeon, lake herring, lake whitefish, round whitefish, lake trout, white sucker, and shorthead redhorse. Great Lake fish spawning runs were blocked in 1919 by the construction of the MPI dam.

Human settlement of the watershed significantly changed the character of the river and the aquatic habitats that many fishes used. No turn of the century quantitative survey data exist to document the population levels of fish species at that time. Modifying factors (such as sedimentation, damming, and loss of woody structure) lessen the biological productivity of the resource.

Ditching and draining of interior wetlands, to foster farming, contributed sediment to the river system and altered groundwater flows. River straightening to facilitate logging, combined with effects of ditching, led to more extreme high and low flows, which further caused streambed scouring and sedimentation.

Currently, 61 species of fish inhabit the Manistique River watershed. The riverine community of fishes has a fairly predictable composition of species. Brook trout generally inhabit upper riverine reaches while brown trout occupy middle and lower riverine reaches. In addition, riverine fish communities typically include: blacknose dace, creek chub, Iowa darter, johnny darter, logperch, and mottled sculpin.

Groundwater inflow is not as strong in the lower portions of the subwatersheds, and fish communities found here are more characteristic of lentic species including northern pike, brown bullhead, largemouth bass, smallmouth bass, pumpkinseed sunfish, and rock bass. Lake dwelling fish species show a similar distribution with lake trout and rainbow trout occupying deeper coldwater lakes, while centrarchids, esocids, and percids inhabit shallow coolwater lakes. No naturally reproducing stocks of lake trout or rainbow trout exist in the inland lakes. Coolwater species typically include: northern pike, muskellunge, walleye, and yellow perch; and warm water species: largemouth bass, smallmouth bass, bluegill, pumpkinseed, and black crappie.

Lake herring, a member of the trout family, are found in the three Manistique Lakes and in Indian Lake. The populations of lake herring in the watershed are self sustaining and fluctuate according to annual year-class spawning success.

Lake sturgeon accessed the Manistique River watershed from Lake Michigan until 1919 when the MPI dam was constructed. Historical data on lake sturgeon distribution is minimal. However, photographic evidence from the logging era during the late 1800s and archeological evidence from Indian campsites have documented lake sturgeon along the Indian River and Manistique River. Lake sturgeon are currently found in Big and South Manistique lakes and in Indian Lake.

Lake sturgeon and lake herring are the only fish species state listed as threatened. Other fishes of the watershed include: white sucker, brown bullhead, burbot, and various minnow species. Many of these fishes are an important food for piscivorous birds and other wildlife.

Aquatic invertebrate evaluations conducted on the Fox, East Branch Fox, and Driggs rivers indicated that habitat deficiencies, primarily lack of woody structure, limit macroinvertebrate potential. These systems have good groundwater inflows and stable flow regimes which should foster macroinvertebrate diversity and abundance. Aquatic invertebrate survey data are minimal or lacking throughout the remainder of the watershed.

Eighteen species of freshwater mussels occur within the watershed. No records exist of historic commercial harvest of mussels in the watershed. Zebra mussels have not been found within the watershed above the Paper Mill Dam.

Seven species of snakes and one lizard, the five lined skink, are found within the watershed. Four species of turtles have been recorded; two, the wood turtle and the Blanding's turtle are listed as being of "Special Concern" by the Michigan Natural Features Inventory. Wood and Blanding's turtles are not protected under state endangered species legislation, but are protected under the Director's Order on Regulations on the Take of Reptiles and Amphibians. The land snail (*Vertigo paradoxa* and *Vertigo hubrichti)* is the only family of mollusks/gastropods to occur in the watershed that is ranked as a state species of special concern.

Ten species of frogs and toads and seven species of salamanders, are found within the watershed. None are listed as endangered, threatened, or of special concern by the Michigan Natural Features Inventory.

The Michigan Wildlife Habitat Database documents 194 species of birds that inhabit or use the Manistique River watershed. Twelve species of birds are listed as state threatened, four species are listed as endangered, and seventeen species are listed as special concern species.

The Michigan Wildlife Habitat Database documents 49 species of mammals that inhabit the Manistique River watershed. One species, gray wolf, is considered both state threatened and federal threatened. Moose is the only mammal listed as species of special concern.

Sea Lamprey are present below the Paper Mill Dam during spawning periods. Historically this dam effectively blocked sea lamprey from ascending the Manistique River. Structural leaks in the face of the dam have recently allowed for limited passing of lamprey through the structure and upstream into the River's mainstem reaches.

Fisheries management is primarily the responsibility of Michigan Department of Natural Resources (MDNR). Additional fisheries programs were developed in the latter half of the 1900s by the United States Forest Service, Hiawatha National Forest and the United States Fish and Wildlife Service, Seney Wildlife Refuge. Much of MDNR fisheries management over the years has focused on lake management duties such as fish stocking, habitat restoration, and establishing a balanced predator/prey relationship within inland lakes and streams.

Beginning in the 1980s, fish management began to employ a holistic ecosystem approach. Management direction gave more emphasis to issues such as watershed dynamics, connectivity of rivers, forage and non-game fishes, reptiles and amphibians, and a departure from managing for single species lakes. More attention was given to appropriate system functionality and a lessening of biological manipulation to enhance sport fisheries. The annual number of lakes chemically treated to eradicate fish species has declined. Walleye, tiger muskellunge, and trout stockings were discontinued in waters with poor angler catch rates and/or less than desirable habitat.

Future management will continue to focus on restoring connectivity of the river system and removal of barriers such as the Paper Mill Dam. Appropriate habitat manipulation practices will continue to play an important role in restoration and stabilization projects. Land use practices within the watershed are an essential component to successful management. Properly constructed and maintained road crossings are essential for preserving aquatic habitat.

The abundance of publicly owned land in the Manistique River watershed allows for many types of recreation opportunities. Recreation activities here are typical of those found in any forest-stream-lake landmass and include: hunting, fishing, fur trapping, berry and mushroom picking, swimming, camping, snowmobiling, ORV trail riding, canoeing, boating, cross-country skiing, hiking, bike riding, sight seeing, bird and wildlife viewing, and numerous other activities. The free access to state and federal land enables recreation seekers to pursue their venture in all parts of the watershed, except where special regulations are in effect.

The future of the Manistique River watershed depends not only on the actions of federal and state agencies, but also on the involvement of citizen groups. Cooperative efforts between these groups have resulted in numerous habitat improvement and watershed management projects. Continued involvement of these groups is essential to maintaining and enhancing the Manistique River watershed.

INTRODUCTION

This river assessment is one of a series of documents being prepared by Fisheries Division, Michigan Department of Natural Resources, for rivers in Michigan. We have approached this assessment from an ecosystem perspective, as we believe that fish communities and fisheries must be viewed as parts of a complex aquatic ecosystem. Our approach is consistent with the mission of the Michigan Department of Natural Resources, Fisheries Division, namely to "protect and enhance the public trust in populations and habitat of fishes and other forms of aquatic life, and promote optimum use of these resources for benefit of the people of Michigan".

As stated in the Fisheries Division Strategic Plan, our aim is to develop a better understanding of the structure and functions of various aquatic ecosystems, to appreciate their history, and to understand changes to systems. Using this knowledge we will identify opportunities that provide and protect sustainable fishery benefits while maintaining, and at times rehabilitating, system structures or processes.

Healthy aquatic ecosystems have communities that are resilient to disturbance, are stable through time, and provide many important environmental functions. As system structures and processes are altered in watersheds, overall complexity decreases. This results in a simplified ecosystem that is unable to adapt to additional change. All of Michigan's rivers have lost some complexity due to human alterations in the channel and on surrounding land; the amount varies. Therefore each assessment focuses on ecosystem maintenance and rehabilitation. Maintenance involves either slowing or preventing losses of ecosystem structures and processes. Rehabilitation is putting back some structures or processes.

River assessments are based on ten guiding principles of Fisheries Division. These are: 1) recognize the limits on productivity in the ecosystem; 2) preserve and rehabilitate fish habitat; 3) preserve native species; 4) recognize naturalized species; 5) enhance natural reproduction of native and desirable naturalized fishes; 6) prevent the unintentional introduction of exotic species; 7) protect and enhance threatened and endangered species; 8) acknowledge the role of stocked fish; 9) adopt the genetic stock concept, that is protecting the genetic variation of fish stocks; and 10) recognize that fisheries are an important cultural heritage.

River assessments provide an organized approach to identifying opportunities and solving problems. They provide a mechanism for public involvement in management decisions, allowing citizens to learn, participate, and help determine decisions. They also provide an organized reference for Fisheries Division personnel, other agencies, and citizens who need information about a particular aspect of the river system.

The nucleus of each assessment is a description of the river and its' watershed using a standard list of topics. These include:

Geography - a brief description of the location of the river and its' watershed; a general overview of the river from its headwaters to its mouth. This section sets the scene.

History- a description of the river as seen by early settlers and a history of human uses and modifications of the river and watershed.

Geology and Hydrology - patterns of water flow, over and through a landscape. This is the key to the character of a river. River flows reflect watershed conditions and influence temperature regimes, habitat characteristics, and perturbation frequency.

Soils and Land Use Patterns - in combination with climate, soil and land use determine much of the hydrology and thus the channel form of a river. Changes in land use often drive change in river habitats.

Channel Morphology - the shape of a river channel: width, depth, sinuosity. River channels are often thought of as fixed, apart from changes made by people. However, river channels are dynamic, constantly changing as they are worked on by the unending, powerful flow of water. Diversity of channel form affects habitat available to fish and other aquatic life.

Dams and Barriers - affect almost all river ecosystem functions and processes, including flow patterns, water temperature, sediment transport, animal drift and migration, and recreational opportunities.

Water Quality - includes temperature, and dissolved or suspended materials. Temperature and a variety of chemical constituents can affect aquatic life and river uses. Degraded water quality may be reflected in simplified biological communities, restrictions on river use, and reduced fishery productivity. Water quality problems may be due to point source discharges (permitted or illegal) or to nonpoint source runoff.

Special Jurisdictions - stewardship and regulatory responsibilities under which a river is managed.

Biological Communities - species present historically and today, in and near the river; we focus on fishes, however associated mammals and birds, key invertebrate animals, threatened and endangered species, and pest species are described where possible. This topic is the foundation for the rest of the assessment. Maintenance of biodiversity is an important goal of natural resource management and essential to many fishery management goals. Species occurrence, extirpation, and distribution are also important clues to the character and location of habitat problems.

Fishery Management - goals are to provide diverse and sustainable game fish populations. Methods include management of fish habitat and fish populations.

Recreational Use - types and patterns of use. A healthy river system provides abundant opportunities for diverse recreational activities along its mainstem and tributaries.

Citizen Involvement - an important indication of public views of the river. Issues that citizens are involved in may indicate opportunities and problems that the Fisheries Division or other agencies should address.

Management Options follow and list alternative actions that will protect, rehabilitate, and enhance the integrity of the watershed. These options are intended to provide a foundation for discussion, setting priorities, and planning the future of the river system. Identified options are consistent with the mission statement of Fisheries Division.

Copies of the draft assessment were distributed for public review beginning May 1, 2004. Three public meetings were held June 15, 2004 in Manistique's Hiawatha Township Hall, June 16, 2004 in Wetmore Township Hall, and June 17, 2004 in Curtis Township Hall. Written comments were received through July 31, 2004. Comments were either incorporated into this assessment or responded to in the Public Comment and Response section.

A fisheries management plan will be written after completion of this assessment. This plan will identify options chosen by Fisheries Division, based on our analysis and comments received, that the Division is able to address. In general, a Fisheries Division management plan will focus on a shorter time period, include options within the authority of Fisheries Division, and be adaptive over time.

Individuals who review this assessment and wish to comment should do so in writing to:

Fisheries Division
Michigan Department of Natural Resources
6833 Hwy. 2, 41 & M-35
Gladstone, Michigan 49837

Comments received will be considered in preparing future updates of the Manistique River Assessment.

RIVER ASSESSMENT

Geography

The Manistique River basin is located in the east-central portion of the Upper Peninsula of Michigan and occupies parts of Alger, Delta, Mackinac, Luce, and Schoolcraft counties. It ranks as the eleventh largest watershed in Michigan with a drainage area of 1,471 square miles. The basin lies approximately 779 ft above mean sea level. Relative to the elevation of Lake Michigan, the watershed has an average height of 202 ft and a maximum height of 575 ft (E. Baker, Michigan Department of Natural Resources (MDNR), Fisheries Division, personal communication). The mainstem begins at Locke Lake in southwestern Luce County and flows in a southwestern direction 75 miles to its confluence with Lake Michigan.

There are 673 lakes within the Manistique River watershed. Most (324) are greater than 10 acres (Table 1). These lakes range in character from shallow groundwater filled depressions to deep spring-fed kettlehole basins. Fish communities within these lakes include sport fish populations of: lake trout, rainbow trout, walleye, northern pike, muskellunge, largemouth bass, smallmouth bass, yellow perch, bluegill, sunfish, and black crappie as well as non-sport fish populations of white sucker, brown bullhead, and various minnow species.

The Manistique River watershed contains 444 miles of tributaries comprised of the subwatersheds of the Fox River system, a central tributary system, and the Indian River system (Figure 1). The Fox River system originates in the northeast corner of the watershed and flows southeasterly. The central tributary system originates in the north-central portion of the watershed and drains in a southeastern direction towards the mainstem. The central tributaries include: Stutts Creek, Hickey Creek, Star Creek, Creighton River, Driggs River, Stoner Creek, Grays Creek, Holland Ditch, and numerous smaller named and un-named systems. The Indian River system originates in the northwest corner of the watershed in Hovey Lake and also flows in a southeast direction towards the mainstem.

For analysis and descriptive purposes, the Manistique River and its tributaries will be discussed in terms of ecologically similar subwatersheds. These subwatersheds characterize regions of a watershed that share common physical and hydrological characteristics, and are similar in concept to the valley segment units described by Seelbach et al. (1997). These subwatersheds describe broader landscape regions sharing similar groundwater inflow potential (Figure 2). These groundwater inflow potentials (see also **Geology)** are directly related to fish species composition. For example, river segments flowing through highly permeable surficial materials are more likely to contain trout and other coldwater species. Thus, the subwatersheds described within this report share common groundwater recharge types. Identification of these surficial materials was done using the Geographical Information System database and permeability rates given by Morris and Johnson (1967).

Mainstem – upper

The headwaters of the Manistique River originate in Locke Lake located in Township 45N, Range 11W, Section 22, Luce County. Locke Lake discharges to Locke Creek, which flows west before joining Helmer Creek, and then into the east end of Big Manistique Lake. Big Manistique Lake discharges at its west end into the Manistique River (sometimes referred to as the Lake Branch of the Manistique River). The Fox River enters the mainstem approximately 3 miles below Manistique Lake. The Manistique River flows 31 miles southwesterly from this point to the confluence of Boucher Creek.

Mainstem–middle

This portion of the mainstem flows 23 miles from the confluence of Boucher Creek to the confluence of the West Branch Manistique River. The central tributary streams join the mainstem river within this middle mainstem subwatershed.

Mainstem–mouth

This portion runs 21 miles from the confluence of the West Branch Manistique River downstream to Lake Michigan. The Indian River joins the mainstem within this lower mainstem subwatershed.

Tributaries–Fox River

The Fox River drains lands located in the northeast section of the watershed and originates in Township 48 N., Range 14 W., Section 21 west of Deadman Lake, Alger County. This system consists of the East Branch Fox, Little Fox, and the main Fox rivers. These waters flow a combined 68 miles in a southeasterly direction to the mainstem Manistique River.

Tributaries–central basin

The central basin consists of numerous drainages from lands in the northern portion of the watershed. Collectively, it includes 296 miles of streams. Alger County's Pelican Lake, located in Township 48N, Range 15W, Section 14, marks the northern most latitudinal point of this tributary system, but all central tributary streams do not originate in Pelican Lake. These drainages primarily flow in a southeasterly direction to the mainstem.

Tributaries–upper Indian River

The Indian River drainage originates in Alger County's Hovey Lake located in Township 45N, Range 19W, Section 17 and flows 65 miles, southeast to the confluence with Big Murphy Creek.

Tributaries–lower Indian River

Beginning at the confluence of Big Murphy Creek, the lower Indian River continues 15 miles in a southeasterly direction. The Indian River enters Indian Lake along its northwest edge and then flows out of the lake at its central eastern shore. It then flows easterly before entering the mainstem.

History

The final glacial advance, Valders Stadial, began in Michigan approximately 12,000 years ago. During the next 1,500 years a series of glacial advances and retreats formed the present day Manistique River watershed (see also **Geology**). Crustal rebound slowly defined the shape of the land and lakes of Michigan. Thus, the watershed that we see today is relatively young and its characteristics are probably much different than during the pre-Pleistocene Epoch. We also know that Northern Michigan’s flora and fauna were influenced by glacial activity. For example, during the Two Creeks Period vegetation flourished in Michigan’s Upper Peninsula only to be removed from the landscape by the next glacial advance (Broecker and Farrand 1963).

Sometime prior to Valders Stadial, the first humans arrived in the Americas and spread throughout the Americas. This pre-historic era is divided into three periods: the Paleo-Indian Hunter Period, the Archaic Period, and the Woodland Period (Santer 1993). The Paleo-Indian Hunter Period extended from 11,000 BP to 4,500 BP. During this period these people moved in and out of the Great Lakes region as they hunted, fished, and gathered. Archeological findings indicate that the human population in the Great Lakes region was relatively small and may have declined during this period. The Archaic Period lasted from 4,500 BP to 2,500 BP. Lake levels stabilized following crustal rebound and food sources were more plentiful. Migration into the region increased, primarily from the south. Artifacts including tools made from Michigan copper and shell gorgets from the Gulf Coast of Florida indicate that both nomadic and settled stages existed for these early inhabitants. The Woodland Indian Period extended from 2,500 BP until contact with Europeans. Chippewa/Ojibway tribes occupied the Manistique area (Tanner 1987; Santer 1993).

The Manistique River was an important source of food and materials for Indians. Numerous camps and villages existed within the watershed.

> The remains of these early camps and villages are found throughout the region. Archaeologists have only examined parts of the western half of the watershed, so we do not have a complete picture. An important site is located in the Wyman Nursery near the mouth of the Manistique. People camped here in spring and summer for at least 3000 years. Over 130 other sites are known, but none have been excavated.
>
> In 1766 James Stanley Goddard noted in his journal. "…there is a river called Amanistick which the Indians winter in, and has a communication by several small carrying places with Lake Superior." This early mention of the Manistique emphasizes the importance of the river to the Chippewa for winter camps, and for travel between Lake Superior and Lake Michigan (the 'carrying places' referring to canoe portages). In the early nineteenth century the Chippewa village at Indian Lake was under the leadership of Ossawinamake. It was here that Father Baraga built his first church in 1832. (B. Mead, Department of State, Office of the State Archaeologist, personal communication).

Fish resources were available to tribal communities and provided a valuable subsistence food commodity. Spring runs of fish approached shallow near-shore areas during spawning period, which made these fish easy to gather by Indians. Fish collected after ice-out included lake sturgeon, white sucker, shorthead redhorse, brown bullhead, yellow perch, walleye, northern pike, and various members of the bass family (Cleland 1982). Fall spawning fish also gathered in shallow water and provided additional food supplies important for the winter tribal diet. Fish species collected during fall included lake trout, lake whitefish, round whitefish or "menominee", lake herring, and chubs.

The Frenchman Etienne Brulè was one of the first documented Europeans to explore the region near the Manistique River watershed (Santer 1993). Brulè wintered near Sault Ste. Marie in 1618-19. Brulè made numerous trips to the Great Lakes region and ultimately died there. From Santer (1993):

> In 1632, a quarrel with members of the Huron tribe with whom he was living, resulted in his death. His remains perhaps were eaten by some of them.

European exploration of the region continued. Most early explorers were government officials, religious missionaries, surveyors, or entrepreneurs. Initially though, fur trade was the first economic enterprise in the region. Exploration in the Upper Peninsula was earlier and more extensive than in the Lower Peninsula, because of hostile Iroquois Indians, and prior to 1669 no European had visited the Lower Peninsula (Bald 1961). The most accurate map of the period was published in 1672 in the "Jesuit Relations" by Father Alouez and Father Dablon. It showed all of Lake Superior, the Sault and the northern part of Lakes Michigan and Huron (Bald 1961).

On June 14, 1671, St. Lusson took possession of the Northern Michigan lands for France's Louis XIV declaring (Bald 1961):

> and of all other countries, rivers, lakes, and tributaries contiguous and adjacent thereunto, as well discovered as to be discovered, which are bounden on the side by the Northern

> and Western seas and on the other side by the south Sea including all its length and breadth.

With the end of the French and Indian war in America in 1760, Great Britain became the principal colonial power in North America, and on November 29, 1760 Major Robert Rogers and troops took control of Detroit (Bald 1961).

The fur trade, which brought European trappers to Michigan's Upper Peninsula, also brought about a change in life for its Indian population. Many changed from subsistence hunter/gatherers to trappers, selling or trading their pelts to European traders. Mammalian fauna in the watershed included numerous migratory waterfowl, white-tail deer, elk, moose, black bear, ruffed grouse, beaver, mink, muskrat, raccoon, eastern timber wolf, and pine marten (Santer 1993). However, the demand for pelts was so great that by the early 1800s fur-bearing animals were greatly diminished. Following the fur-trade era Michigan entered the logging and mining era (Bald 1961).

Anglo Saxon settlement of the Manistique River watershed, and the Upper Peninsula of Michigan, was primarily in Great Lakes coastal areas during the fur trade era. However, with the shift from fur trading to lumber, settlement moved inland and occurred at a faster rate. Human settlement developed in association with the type of logging that was predominant for the particular point of time, location of timber, type of timber being harvested, and method of timber transportation. Upper Peninsula timber harvesting began in the late 1830s with large scale logging developing in the 1880s (Benchley et al. 1993; Dunbar 1970).

United States Government Land Office notes from 1841 through 1855 stated that pre-logging vegetation in the central Upper Peninsula was comprised of "white, yellow and spruce pines, fir, hemlock, spruce tamarack, beech, white and yellow birch, cedar, maple and sugar" (Benchley et al. 1993).

Logging occurred in two sequences known as the "pine era" and the "hardwood era". The pine era was the first of the logging efforts and focused on harvest of white and red pines. Pines were cut in winter and driven down rivers during spring thaws to mills and distribution centers. Logging dams were constructed along many sections of the rivers to facilitate these river log drives. Pine era logging fostered a settlement pattern represented by small logging camps developing along pine stands and rivers, with logging towns developing around the mills at the river mouth. In 1860 C. T. Harvey, engineer of the Soo Locks, constructed a dam near the mouth of the Manistique River to power a sawmill (B. Mead, Department of State, Office of the State Archaeologist, personal communication).

Manistique was an important community to the lumbering industry and was the principle port of destination for wood that was harvested within the watershed. The Chicago Lumber Company formed in 1863 and built a sawmill at Manistique. That same year a lumber schooner operated out of the port of Manistique. In the next 20 years additional sawmills, owned by other firms, were built at Manistique (Benchley et al. 1993).

The hardwood era was the second phase of the logging era and focused on harvest of hardwoods and remaining pines. Transportation of hardwoods was accomplished by railroads. Railroads were extended into the Upper Peninsula of Michigan during the late 1800s. Rail transportation proved valuable to the timber industry for hauling supplies to lumber camps and moving personnel between settlements. Rail made it possible to harvest and haul hardwoods year round. The era of hardwood logging also created a different type of settlement pattern with settlements developing near rail lines.

Rail connected the Upper Peninsula to an interstate and international travel network. Two rail branches cut across the Manistique River watershed. Along the north, the Duluth South Shore and

Atlantic ran from Marquette to Sault Ste. Marie. The Minneapolis St. Paul & Sault Ste. Marie connected Escanaba to the Sault and ran across the southern edge of the watershed (Dunbar 1970).

One primary use of hardwoods was to produce charcoal for the iron smelting industry. Charcoal was shipped by wagon and rail to kilns and iron furnaces. The iron industry, charcoal production, and hardwood logging helped fuel the need for a strong rail infrastructure.

In the 1880s, the Alger-Smith Company played a large role in the logging of Schoolcraft County. The Manistique Railway was built from Manistique to Seney in 1886 (Benchley et al. 1993). By 1893 the railroad was extended to the town of Grand Marais on Lake Superior. In that year, the town of Manistique had 3 large sawmills, a planing mill, lath mills, a barge line, river improvement and boom operation, a charcoal furnace, dams, camps, stores, boarding houses, and a farm at Indian Lake (Benchley et al. 1993). Alger-Smith reopened a sawmill at the town of Grand Marais and the resulting town and port became quite busy. Soon after, Alger-Smith hauled logs by rail to Grand Marais and the population of the town grew to approximately 3,000 by the late 1890s. The company moved its operations from Grand Marais in 1911 and the population fell to 300 people.

> By the 1920s lumbering was in decline. Some of the small towns that depended on the industry disappeared. Attempts to farm cutover lands were only marginally successful. Some of the lands abandoned in the 1930s were incorporated into the Hiawatha National Forest and the Seney Wildlife Refuge. CCC camps were established to replant depleted forests. Camping, sightseeing and bird watching in the forests and enormous wetlands, coupled with the hunting and fishing, began to draw growing numbers of tourists. Some logging camps and towns like Blaney Park were converted into resorts and hunting camps. The Manistique River, its tributaries and wetlands supported the first inhabitants thousands of years ago with its fish and game, and continues to play an important role in the economy of Schoolcraft and neighboring counties. (B. Mead, Department of State, Office of the State Archaeologist, personal communication).

In the 1930s, logging focused on secondary growth pulpwood timber for paper production. The transportation mode for timber shifted from railroads to motorized vehicle roads (Benchley et al. 1993). Settlement patterns began to shift with communities developing where roads intersected.

Following pine and hardwood logging, much of the area was sold as prospective farming lands. In the 1910s, a land development company dug many miles of ditches in the watershed to drain water in an effort to promote this land as farmable. Most farming efforts failed within a year and much land reverted to state ownership for failed tax payments (Dufresne 1988). Upper Peninsula farming is generally restricted by weather and soil (see also **Climate** and **Soils**). By the early 1950s, the average farm had only 30 tillable acres. Agricultural production was predominately cattle, forage (e.g., hay), and potatoes (Dunbar 1955).

In 1934, the Michigan Conservation Department recommended to the federal government that the lands in eastern Schoolcraft County be designated and developed as a wildlife refuge. The federal government adopted this recommendation and in 1935 the Seney Wildlife Refuge was established. This refuge encompasses approximately 96,000 acres and provides habitat for numerous species of wildlife (Anonymous 1998a).

The State Forest system was created around 1946 and Forest Management areas were established. What is now the Lake Superior State Forest began as the Manistique River State Forest and Grand Sable State Forest. The Manistique River State Forest was managed out of the Wyman State Tree Nursery near the town of Manistique and the Grand Sable State Forest was managed out of the Cusino Field Station located on Cusino Lake. Later (date unknown), the Manistique River State Forest Management Office was moved to the Thompson Field Station and then back to Wyman. The

Grand Sable State Forest office was moved to the Cusino Wildlife Research Station located at Shingleton. The Lake Superior State Forest is currently divided into 3 management units located at Newberry, Sault Ste. Marie (with offices at Naubinway and Sault Ste. Marie), and Shingleton (with offices at Shingleton and Wyman). Today about 70% of the land within the watershed is in state or federal ownership.

Much of the Manistique River watershed history continues to be discovered at archeological sites.

> Traces of the past remain as archaeological sites throughout the watershed. Archaeologists working on national forest lands have located over 130 prehistoric and over 300 historic sites. The historic sites include 162 logging camps, 14 logging dams, 11 CCC camps, and assorted homesteads, bridges, and dumps. Some of these are eligible for listing on the National Register of Historic Places. State historic markers commemorate the past at Father Baraga's mission at Indian Lake, and the White Marble Lime Company kilns a few miles west of Manistique. Blaney Inn, the Manistique Pumping Station and Seul Choix Pointe Lighthouse are other historic structures listed on the State Register of Historic Sites or the National Register of Historic Places. (B. Mead, Department of State, Office of the State Archaeologist, personal communication).

Geology

Some 2 million years ago the earth entered the Pleistocene Epoch or Ice Age. This was a period of extreme cold and exceptional snowfall, with over one-third of the earth's surface covered by glaciers up to 10,000 ft deep. Approximately 5,000,000 mi^2 of North America were covered by the Laurentide Ice Sheet, which extended south to 37° N latitude (roughly mid-Kentucky). Over the years, glaciers advanced and retreated across the North American landscape some 20 times. These phases occurred as temperatures dipped then moderated. The final phase of glaciation, Wisconsinian, lasted some 70,000 years. Throughout the Wisconsinian glaciation, many glacial advances and retreats occurred.

The last major ice advance ended about 13,000 years ago with the Port Huron terminal moraine (Dorr and Eschman 1970). Following this glacier's retreat, the northern Lower Peninsula of Michigan and the Upper Peninsula from Green Bay east were ice free. During this temperate period vegetation flourished and much of Northern Michigan became covered with spruce, pine, and birch forests. Known as the Two Creeks Period (also referred to as the Great Lakean Advance), temperatures remained moderate for some 1,000 years (Broecker and Farrand 1963). A final glacial re-advance, referred to as Valders Stadial, covered the Upper Peninsula and the northern Lower Peninsula of Michigan. Most of northern Michigan was glacier free by about 10,000 years ago (Farrand and Eschman 1974).

As glaciers advanced and retreated on an approximate north-south route throughout Michigan, soils and rocks were pushed, carried, and redeposited. Similarly, bedrock and limestone layers were scoured, ground into sand and gravely materials, and redeposited. In addition, the tremendous weight of the ice mass had depressed the earth's surface (crustal depression) roughly one foot for every three ft of ice depth. Following each glacial retreat, the land slowly rebounded.

The repeated, minor advances and retreats of glaciers during Valders Stadial and the upheaval of land formed the diverse landscape of Michigan's Upper Peninsula and the landscape within the Manistique River watershed. A principal advance extended to the southern half of the watershed (Figure 3). Water-sorted coarse materials were deposited along the southern watershed boundary as water and debris poured from the edge of the glacier. Following a retreat back to the north, successive glacial advances extended to the approximate western, northern, and northeastern edges of the watershed. At that time most of the present-day watershed was submerged beneath the elevated waters of Lake

Michigan. Water-sorted coarse materials were deposited along the face of these glaciers while finer materials were washed across the submerged land. As water levels dropped and the land rebounded in elevation, the Manistique River watershed drained, forming the many rivers and streams that flow into the Manistique River and eventually into Lake Michigan (K. Kincare, Michigan Department of Environmental Quality (MDEQ), personal communication).

Surficial materials play an important role in determining river water source and ultimately define river systems. Rivers receive water as surface runoff and as groundwater, with only minor contribution from direct precipitation. Systems with very permeable surficial materials are primarily groundwater-fed rivers while systems with less permeable materials are primarily surface runoff-fed rivers. Groundwater-fed rivers are hydrologically and thermally more stable than rivers dominated by surface run off. Rainwater and snowmelt flowing across the surface of the land (surface runoff-fed) reach rivers quite fast, increasing variability in flow. When permeability rates are such that water infiltrates the ground (groundwater-fed), rivers receive water at a steady rate, thus decreasing variability in flow. Only when the permeable soils of groundwater systems become saturated, or they receive water faster than infiltration, does water run across the land surface and directly into the river (Wiley and Seelbach 1997).

The water flow rate, as it percolates through a ground profile, is affected by many physical parameters. Material texture (fineness or coarseness), type (sand, silt, clay) and amount of organic matter affect the degree of permeability. Sandy materials typically are more porous than organic materials and allow for faster water percolation rates. Organic materials, clay, or rock have very slow percolation rates and water moves over the surface of these materials before reaching a river channel.

Land that is well drained allows precipitation to move quickly through the profile in the form of groundwater. The temperature of groundwater at a given latitude is ±1.8°F of the mean annual air temperature (Collins 1925). Thus, groundwater temperatures in the watershed range from 40.1°F to 43.7°F. Groundwater reaching the river channel acts to cool the river during summer and warm the river during winter. Groundwater is a benefit to cold and coolwater fish species as it provides thermal buffering during the temperature extremes of summer and winter. Materials that are not well drained have slow percolation rates and excess water moves overland as surface runoff. Surface water run-off is more influenced by local ambient air temperature. This water may often be warmer in the summer than the underlying groundwater, or frozen and unavailable to a river during winter.

Surficial materials in the watershed are characterized as having a frigid temperature regime (see also **Climate**). Frigid soils have a mean annual soil temperature of less than 47°F at the 20 in depth and the difference between mean winter and mean summer soil temperature is more than 9°F (Anonymous 1974b).

Surficial material compositions were derived from Farrand (1982). Rates of permeability for each of the surficial materials found in the Manistique River watershed follow values given in Morris and Johnson (1967). Relationship of soils to land use and vegetation (e.g., forest type) are described in **Soils and land use**. Highly permeable surficial materials cover 41.9% of the watershed. These materials are found along the northern, western, and southeastern watershed edges (Figure 4). Groundwater inflow to tributaries is greatest in areas containing these highly permeable materials (Wiley and Seelbach 1997) (see also **Hydrology**).

Percent of the Manistique River watershed covered by various surficial materials and permeability rates.

Material	Percent of watershed	Permeability ([ft/day]*1,000)
High permeability		
Glacial outwash sand, gravel & postglacial alluvium	28.3	98.43
Coarse-texture glacial till	11.0	98.43
End moraines of coarse-texture till	2.6	98.43
Medium permeability		
Lacustrine sand & gravel	34.4	32.81
Low permeability		
Thin to discontinuous till over bedrock	2.5	0.02
End moraines of medium-texture till	2.2	1.64
Peat & muck	18.6	3.28
Medium-texture glacial till	0.4	1.64

Landscape diversity plays an important role in defining river characteristics. Flatter landscapes with minimal elevation variability decrease horizontal movement of precipitation. Hilly landscapes with more elevation variability increase horizontal movement of precipitation. Permeable landscapes provide groundwater inflow to river, moderate flooding events, cool temperatures, and minimize temperature variability. Less permeable landscapes increase surface runoff, flooding is more prevalent and water temperatures are more variable.

Variability of landscape elevation (measured in ft) was calculated for each category of surficial material permeability. Elevation was measured at 2 mile intervals with the original starting location within the watershed randomly selected. For each permeability type then, coefficient of variation (*CV*) was estimated for elevation (*E*) and calculated as:

$$CV = \overline{E}^{-1}\sqrt{\frac{\sum_{i=1}^{n}(E_i - \overline{E})^2}{(n-1)}},$$

with *n* elevations measured and having mean elevation $\overline{E}$. As variability in elevation increases, CV increases. Landscapes with less variability in elevation have less hydraulic head and consequently less groundwater inflow to river.

Coefficients of variation and mean elevation for each permeability type within the watershed.

Material	Coefficient of variation	Mean elevation (ft)
High permeability	0.1112	830
Medium permeability	0.1041	763
Low permeability	0.0766	706

Materials of high permeability occurred in areas with greater variation in landscape elevation and had greater mean elevation. These were predominately headwater regions within the watershed. Materials of medium permeability are in areas with slightly less variation in landscape elevation and mean elevation. Materials with low permeability are in areas with the least variation in landscape elevation and mean elevation. Consequently materials of high permeability had greatest groundwater inflow potential due to porosity of materials and hydraulic head. As permeability decreased, variability in elevation decreased resulting in less potential groundwater inflow (see also **Gradient**).

Descriptions and measures of surficial materials within subwatersheds are described in the following sections. Surficial materials for the watershed are presented in Figure 4. These characteristics are fundamental to understanding individual river processes.

Mainstem – upper

Surficial materials are of low permeability from Locke Lake to Manistique Lake, providing minimal potential for groundwater inflow to river. Manistique Lake is bordered by highly permeable materials on the east and south shores, and along the southern half of its western shore. Materials of low permeability border the remaining shoreline. After leaving Manistique Lake, the Manistique River flows along the edge of highly permeable materials bordered by materials of low and medium permeability. While this section of the Manistique River is fed with numerous tributary streams flowing from the north and northwest, the greatest groundwater inflow comes from the highly permeable materials lying along the southeast edge of the river. The Mainstem-upper ends at Boucher Creek where material types along the southeast river edge change from high to low permeability.

Mainstem – middle

The Mainstem-middle subwatershed of the Manistique River continues in a southwest direction flowing along the border of medium and low permeability materials. Therefore, there is minimal groundwater inflow from land bordering the river along its southeast bank. Here, primary water inflow comes from tributary streams flowing from the northwest. The Mainstem-middle subwatershed of the Manistique River ends at the confluence with the West Branch of the Manistique River.

Mainstem – mouth

Groundwater inflow is quite variable in this section. The Manistique River meanders extensively and flows through areas containing materials of medium and low permeability and also along the edge of an area comprised of highly permeable materials.

Tributaries–Fox River

The Fox River and the East Branch of the Fox River both originate in areas of high permeability. Approximately one half of their upper waters flow through or immediately adjacent to areas of high permeability and groundwater inflow. The lower half of the East Branch of the Fox River flows through soils of low permeability with minimal groundwater inflow. Similar to the Tributaries-central basin, the lower half of the Fox River flows through soils of medium permeability. These rivers join approximately 1 mile above their confluence with the mainstem. Within this 1-mile section, the Fox River borders medium and low permeability soils.

Tributaries–central basin

Major rivers and creeks within the Tributaries-central basin originate along the northern edge of the watershed. Groundwater inflow in their headwaters varies. Marsh Creek, Creighton River, West Branch Manistique River, and Hickey Creek all originate in areas of low permeability. The North and South Branches Stutts rivers and the Driggs River originate in areas of high permeability. Regardless of their origins, rivers and creeks in the Tributaries-central basin all flow through an area of lacustrine sand and gravel with medium permeability before entering the mainstem.

Tributaries–upper Indian River

Originating at Hovey Lake, the upper Indian River flows along the western edge of the watershed through an area of high permeability and groundwater inflow. This section of river continues flowing through highly permeable soils until Big Murphy Creek enters from the west.

Tributaries–lower Indian River

Beginning with the confluence of Big Murphy Creek, the Indian River enters an area dominated by lacustrine sand and gravel. The Indian River enters Indian Lake along the northwest edge. Indian Lake is bordered along its northern and southern edges by soils of medium permeability. The eastern and western shorelines are adjacent to areas of low permeability. After leaving Indian Lake, the Indian River flows along a border of low and medium permeable soils before entering the mainstem Manistique River.

Hydrology

Since 1937 the United States Geological Survey (USGS) has maintained 14 stream flow gauges, for varying periods, within the Manistique River watershed (Figure 5 and Table 2). Seven of these gauges were operated for only 3-4 years prior to World War II. However, 5 gauges remained in operation from the late 1930s into the 1950s, 3 gauges into the 1970s, and 1 remains in operation today. No gauges were located on the Fox River tributary (Anonymous 2001c).

River discharge recorded at these sites was measured in cubic ft per second (ft^3/s). Yield is reported here in cubic ft per s per mi^2 of watershed drainage area ($ft^3/s/mi^2$). Both discharge and yield data presented are by water year, October 1 to September 30 of the following year. To characterize discharge and discharge stability in the Manistique River system, river discharge and yield data from the 14 gauge sites are presented as flow stability index and yield exceedence curves.

Flow stability index is the ratio of the mean (average) annual mean monthly maximum (*max*) discharge and the mean annual mean monthly minimum (*min*) discharge. Because not all data sets were in complete water years, weighted discharge indices were calculated. Thus, the flow stability index F for m water years with j months recorded within a water year is:

$$F = \frac{\sum_{k=1}^{m} j_k \left[\frac{\sum_{i=1}^{j_k} \max_{kj}}{\sum_{i=1}^{j_k} \min_{kj}} \right]}{\sum_{k=1}^{m} j_k}.$$

Flow indices allow characterization of a river system in comparison to other systems (Table 3). For example, rivers with stable flow indices of 1.0-2.0 are typical of self sustaining trout streams, rivers with flow indices >10.0 are described as very flashy warm-water rivers.

Yield exceedence measures discharge per area (i.e., standardized by area) at 5-95% exceedence discharges, in 5% increments, and allows direct comparisons to sites of differing drainage areas. Yield exceedence Y' for yield Y at f % with X mi^2 of drainage area is:

$$Y' = \frac{Y_f}{X\ mi^2}.$$

Yield exceedence is similar to standardized exceedence reported by Wesley and Duffy (1999) and other river assessment authors. Both yield and standardized exceedence provide indicative measures of base flow (95% exceedence). Yield exceedence is advantageous since it allows direct comparison with other river systems. Comparisons of standardized exceedence across systems are not always as useful since each has been standardized by the 50% exceedence discharge of their system. However, both yield exceedence and standardized exceedence display similar trends within a river system.

Measures of base flows are essential to determining characteristics of a river system. For example, to support trout populations Lower Peninsula rivers in Michigan require base flows in excess of 0.2 $ft^3/s/mi^2$ (P. Seelbach, MDNR, Fisheries Division, personal communication). When 95% yield exceedence is less than 0.2 $ft^3/s/mi^2$, inadequate groundwater enters the stream. Groundwater buffers warm summer air temperatures and cold winter air temperatures (Wehrly et al. 1998). Groundwater inflow, as a proxy for water temperature, affects growth (Brett 1979), survival (Smale and Rabeni 1995), and distribution of fishes (Peterson and Rabeni 1996). In addition, high flow measures (5% yield exceedence) are indicators of hydraulic stability. Increased high flow is typically coupled with minimal base flow. Unstable peak flows can limit recruitment (Lockwood et al. 1995).

Annual water flow pattern is expressed as discharge, yield, and yield exceedence. Yield exceedence indicates overall stability of a river system. Rivers with high groundwater inflow and minimal surface runoff are stable with minimal 5% yield exceedence. Similarly, 95% yield exceedence values are moderated by consistent flows. Rivers with high surface runoff inflow have high values for 5% yield exceedence and low values for 95% yield exceedence. Dams serving as lake-level control structures play an important role in a river’s overall stability. During low water periods lake-level control structures hold back water and minimum yield exceedence values (e.g., 90%) are substantially lower than median yield exceedence. Downstream habitat is reduced for aquatic biota and recreational users during these dam-induced low-water periods.

Seasonal water flow is expressed as daily yield. Representative years were selected to describe differences in monthly yield. Yield is typically greatest during spring when snow melt and rain occur. During fall evapotranspiration declines and more precipitation is now available as surface runoff and to recharge groundwater systems. During this period, yield increases. Lake-level control structures also influence monthly yield. When these structures hold back more than run of the river discharge, lesser amounts of water are available downstream. This typically occurs during summer months when evapotranspiration is greatest. Also, dam boards are often pulled when yields are higher – increasing peak flow below the dam.

We make comparisons of yield exceedence with 2 river systems outside of the watershed (Seelbach et al. 1997) for 14 Manistique River watershed sites. Those 2 rivers are the Sturgeon River (Cheboygan and Otsego counties) and the Shiawassee River (Saginaw and Shiawassee counties). The Sturgeon River is a cold-water trout stream with substantial groundwater inflow. The Shiawassee River is a warm-water stream with minimal groundwater inflow. These rivers characterize the diversity of rivers in Michigan and serve as classification benchmarks for Manistique River watershed rivers. Rivers receiving substantial groundwater inflow have similar 5% and 95% yield exceedence values. The 95% yield exceedence values are high and 5% yield exceedence values are low. Conversely, rivers with minimal groundwater inflow have greater difference between 5% and 95% yield exceedence values. The 95% yield exceedence values are low and 5% yield exceedence values are high. Yield exceedence values for these two types of rivers cross at approximately 12% yield exceedence (Seelbach et al. 1997).

Within the following sections, measures of annual water flow and seasonal water flow are given by subwatershed. These flow measures describe long term trends in variation, and monthly differences in flow. Hourly flow is given for Mainstem – mouth.

Mainstem – upper

The upper mainstem gauge station, Manistique River at Germfask (USGS station no. 04049500), measures drainage over an area of 341 mi^2 (Table 2). During 1937-70 the mean discharge was 448.4 ft^3/s with mean yield of 1.32 $ft^3/s/mi^2$. Flow stability index was 1.8 with a classification of "very good" (Table 2).

Yield varied from 2.6 $ft^3/s/mi^2$ at 5% exceedence to 0.6 $ft^3/s/mi^2$ at 95% exceedence (Figure 6). Values were similar to the Sturgeon River and representative of rivers with good groundwater inflow and hydraulic stability.

Peak daily yields in water year 1969 began in April and ended by June (Figure 7). Maximum peak yield of 4.5 $ft^3/s/mi^2$ occurred on April 16. These periods of peak yield correspond to snow melt and spring rain events. A short period of peak yields occurred in late June and early July, and corresponded to summer rain events, with a peak yield of 3.8 $ft^3/s/mi^2$ on June 28.

Mainstem – middle

The Mainstem-middle gauge station, Manistique River at Blaney (USGS station no. 04055000), measures drainage over an area 704 mi^2 (Table 2). During 1938-70 the mean discharge was 835.5 ft^3/s with mean yield of 1.19 $ft^3/s/mi^2$. Similar to the Mainstem–upper, the Mainstem–middle also has a stable flow. Flow stability index was 2.3 with a classification of "good" (Table 2).

This river segment is less stable than the Mainstem–upper. Yield varied from 3.2 $ft^3/s/mi^2$ at 5% exceedence to 0.4 $ft^3/s/mi^2$ at 95% exceedence (Figure 6). Yield values indicate good groundwater inflow and increased hydraulic stability. Values were intermediate to the Shiawassee and Sturgeon rivers. The 95% yield exceedence for this Manistique River site was less than the Sturgeon River and the 5% yield exceedence was greater than the Shiawassee River.

Peak daily yields in water year 1969 began in April and ended by June (Figure 8). Maximum peak yield of 5.8 $ft^3/s/mi^2$ occurred on April 16. A short period of peak yields occurred in late June and early July, and corresponded to summer rain events. Here a peak yield of 4.9 $ft^3/s/mi^2$ occurred on June 29.

Mainstem – mouth

Two gauge sites have been located within the Mainstem–mouth.

- Manistique River at Manistique (USGS station no. 04056500):
  This gauge station has been in operation from 1938 until present (Table 2). In this report we present instantaneous discharge data for water year 2000 only, all other data are for 1938-99. This station measures drainage over an area of 1,100 mi^2 (75% of the watershed). Mean discharge during 1938-99 was 1,421.5 ft^3/s with mean yield of 1.29 $ft^3/s/mi^2$. Flow stability index was 2.4 with a classification of "good" (Table 2).

  Yield data indicate good groundwater inflow and modest hydraulic instability (Figure 6). Similar to the Mainstem-middle, exceedence values were intermediate to the Sturgeon and Shiawassee rivers.

  Daily yield values are reported for water year 1993. Peak daily yield period extended from late-March to mid-May (Figure 9) and corresponded to snow melt and spring rain events.

Maximum peak yield of 4.6 $ft^3/s/mi^2$ occurred on May 6. Mean daily yield for the period March 30 – May 20 was 3.2 $ft^3/s/mi^2$.

Maximum recorded discharge occurred on February 28, 2000 between the hours of 0100 and 2300 (Figure 10). During this period discharge increased 400 ft^3/s, from 2,370 ft^3/s to 2,770 ft^3/s. This followed an extended warm period. Mean daily high temperatures of 47.5°F for the period February 21-28 were recorded in nearby Marquette and ground snow depth dropped from 31 in to 15 in (Anonymous 2001b).

- Manistique River above Manistique (USGS station no. 04057004):
  This gauge site was in operation from 1994-95 and measures drainage over an area of 1,445 mi^2 (98% of the watershed) (Table 2). Mean discharge during this period was 1,495.4 ft^3/s with mean yield of 1.03 $ft^3/s/mi^2$. Flow stability index was 2.5 with a classification of “good” (Table 2).

  Yield varied from 2.6 $ft^3/s/mi^2$ at 5% exceedence (Figure 21) to 0.5 $ft^3/s/mi^2$ at 95% exceedence and indicated good groundwater inflow and modest hydraulic instability (Figure 6). Yield exceedence values were also intermediate to the Sturgeon and Shiawassee rivers.

Tributaries – central basin

Nine gauges were operated for varying periods in the Tributaries – central basin (Table 2). All gauges went into operation in 1938. Most (7) ceased operation between 1941-42, Duck Creek (USGS station no. 04054500) remained in operation until 1954, and West Branch Manistique River (USGS station no. 04056000) until 1956. Flow data are presented for all nine sites, however only 4 gauge sites will be used to characterize the central basin. They are: Driggs River at Seney (USGS station no. 04052000), Driggs River at Germfask (USGS station no. 04053000), Marsh Creek at Shingleton (USGS station no. 04053500), and West Branch Manistique River at Manistique (USGS station no. 04056000). These sites characterize variability of central basin tributaries and serve as samples of tributaries within the central basin. They extend from east to west across the central basin.

- Driggs River at Seney (USGS station no. 04052000):
  This gauge site was in operation from 1938-42 (Table 2) and measured 70 mi^2 of drainage area. Mean discharge was 73.2 ft^3/s with yield of 1.05 $ft^3/s/mi^2$ and flow stability index of 2.0 (Table 2). Flow stability index classification is “very good”.

  Yield varied from 2.2 $ft^3/s/mi^2$ at 5% exceedence to 0.6 $ft^3/s/mi^2$ at 95% exceedence and indicated stable flows (Figure 11). Exceedence values were very similar to the Sturgeon River.

- Driggs River at Germfask (USGS station no. 04053000):
  This gauge was in operation from 1938-41 (Table 2) and measured 114 mi^2 of drainage area. Mean discharge was 100.7 ft^3/s with yield of 0.88 $ft^3/s/mi^2$ and flow stability index of 2.5 (Table 2). Flow stability index was classified as “good”.

  Yield varied from 2.2 $ft^3/s/mi^2$ at 5% exceedence to 0.4 $ft^3/s/mi^2$ at 95% exceedence and indicated stable flows (Figure 12). Yield exceedence values for this site were intermediate to the Sturgeon and Shiawassee rivers at 45-95% exceedence, and similar to the Shiawassee River for 5-40% exceedence.

- Marsh Creek at Shingleton (USGS station no. 04053500):
  This gauge was in operation from 1938-42 (Table 2) and measured 20 mi^2 of drainage area. Mean discharge was 11.5 ft^3/s with yield of 0.58 $ft^3/s/mi^2$ and flow stability index of 9.4 (Table 2). Flow stability index was classified as “fair”.

  Yield varied from 2.6 $ft^3/s/mi^2$ at 5% exceedence to 0.0 $ft^3/s/mi^2$ at 95% exceedence (Figure 12). Yield of 0.185 $ft^3/s/mi^2$ at 50% exceedence was the lowest for any site within the Manistique River watershed. Yield exceedence values were very similar to the Shiawassee

River and characteristic of a warmwater river. Flow stability index indicates the substantial difference between high flow (*max*) and low flow (*min*) yields.

Daily yield values are reported for water year 1941. Peak daily yield occurred during April (Figure 13) and maximum peak yield of 6.1 $ft^3/s/mi^2$ occurred on April 15. Mean daily yield for the period April 6 – April 27 was 3.1 $ft^3/s/mi^2$.

- West Branch Manistique River at Manistique (USGS station no. 04056000):
  This gauge was in operation from 1938-56 (Table 2) and measured 322 mi^2 of drainage area. Mean discharge was 413.5 ft^3/s with yield of 1.28 $ft^3/s/mi^2$ and flow stability index of 2.8 (Table 2). Flow stability index classification was "good".

  Yield varied from 4.1 $ft^3/s/mi^2$ at 5% exceedence to 0.4 $ft^3/s/mi^2$ at 95% exceedence and indicated stable flows (Figure 11). Yield exceedence was intermediate to the Sturgeon and Shiawassee rivers at 35-95% exceedence and more characteristic of a warmwater river at 5-30% exceedence.

  Daily yield values are reported for water year 1956. Peak daily yield occurred during April – May (Figure 14) and corresponded to snow melt and spring rain events. Maximum peak yield of 6.8 $ft^3/s/mi^2$ occurred on April 12. Mean daily yield for the period April 7 – May 7 was 3.8 $ft^3/s/mi^2$.

Tributaries – lower Indian River

The lower Indian River gauge (USGS station no. 04057000) measured drainage from 302 mi^2 (Table 2). During 1992-93 the mean discharge was 385.6 ft^3/s with mean yield of 1.28 $ft^3/s/mi^2$. Similar to the Driggs River (USGS station no. 04052000) and Manistique River gauge (USGS station no. 04049500), the lower Indian tributary also has a very stable flow. Flow stability index was 1.9 with a classification of "very good" (Table 2).

Yield varied from 2.0 $ft^3/s/mi^2$ at 5% exceedence to 0.5 $ft^3/s/mi^2$ at 95% exceedence and indicated stable flows (Figure 15). Yield exceedence was characteristic of rivers with good groundwater inflow (e.g., Sturgeon River) at 5-90% exceedence and intermediate to cold (e.g., Sturgeon River) and warmwater (e.g., Shiawassee River) rivers at 90-95% exceedence.

Daily yield values are reported for water year 1993. Peak daily yields were minimal during period (Figure 16). Maximum peak yield of 2.4 $ft^3/s/mi^2$ occurred on July 9 and was similar to 1992-93 gauge mean of 1.28 $ft^3/s/mi^2$. However, minimum yield values occurred during the end of June – beginning of July, and later part of August. On June 30 yield dropped to 0.4 $ft^3/s/mi^2$, and to 0.4 $ft^3/s/mi^2$ again on July 26.

Yield exceedence and specific power (see **Channel morphology**) all indicated a dramatic decrease in flow measures for flows below 85% exceedence. Daily yield shows these decreases occur during summer months. This area of the river is affected by the lake-level control structure on Indian Lake (see **Dams and Barriers**). To maintain lake-level of 613.27 ft above sea level, run of the river flow is not maintained during summer months.

Climate

Climate within the Manistique River watershed varies with proximity to Lake Superior or Lake Michigan. When winds off the lakes converge near the center of the peninsula, atmospheric moisture condenses and late afternoon storms can occur. As a result, slightly higher frequency of summer precipitation occurs in the mid-latitudes of the Upper Peninsula compared to locations closer to the lakeshores. This same influence of the Great Lakes, during fall and winter, increases cloudiness and snowfall and also moderates air temperatures during late fall and early winter. The approximate west-to-east movement of weather systems across the Upper Peninsula controls day-to-day weather. Thus, prolonged periods of hot, humid weather or extreme cold are rare. These prevailing westerly winds average about 9 mph (Anonymous 2000).

Temperature averages for the period 1951-80 have been selected from the weather site at Seney located in the approximate center of the watershed (established January 10, 1912). This site characterizes variations in temperature throughout the watershed. During summer months only 3 days exceed 90°F per year, on average. Year-around temperature was at or below 32°F for 178 days, with 28 days at or below 0°F. The average annual air temperature during this period was 41.9 °F. The average last date for freezing temperature in the spring was May 26 with the first freezing fall temperature on September 25. Maximum high and low of 100°F and -41°F, respectively, occurred in July 1975 and February 1979. The freeze-free period was 122 days. Growing degree-days (days between 86°F and 50°F) was 2,201 °F days (Anonymous 2000).

Five weather stations, within or near (less than 11 miles) the watershed, provide measures of precipitation. The towns of Manistique and Seney are located within the watershed (Figure 1). Newberry is located approximately 5 miles northeast of Locke Lake. Munising is 2 miles north-north west of Wetmore and Grand Marais is 11 miles north northeast of the Fox River headwaters.

Annual precipitation by weather station within or near the Manistique River watershed.

	Precipitation (inches)				
Form	Manistique	Seney	Newberry	Munising	Grand Marais
Rain	31.7	33.1	32.9	33.4	31.3
Snow	70.7	131.5	108.3	148.1	143.2
Total liquid	38.8	46.2	43.7	48.2	45.6

Precipitation varies substantially within the watershed. The lower and middle mainstem and lower Indian River tributary are most closely located to Manistique and receive, on average, 31.7 in of rainfall and 70.7 in of snowfall annually. The Mainstem-upper, Tributaries-Fox River, Tributaries-central basin, and Tributaries-upper Indian River also receive similar amounts of rainfall (31.3-33.4 in). However, these subwatersheds receive substantially more snowfall. Annual snowfall averages for the four weather stations located in or near these upper watersheds vary from 108.3-148.1 inches (Anonymous 2000). The heavy snowfall in the upper watershed contributes to increased groundwater inflow as compared to the lower portion of the watershed, which receives less snow.

Drought conditions sporatically occur during mid-summer periods. During 1951 through 1980, evaporation exceeded precipitation from May through October by about 17% (Anonymous 2000) and drought conditions existed during this period. Using the Palmer Drought Index, conditions reached extreme severity during 4% of the year. Soil moisture replenishment, the period when precipitation exceeds evaporation, occurred during fall and winter months. Heavy snowfalls occurring along the north edge of the watershed coupled with soil permeability provide groundwater inflow that moderates river flows and temperatures. These groundwater moderation influences help minimize instream mortality for coldwater fish communities, during drought periods.

Soils and land use

Soil types and basin composition presented in this section were derived from USDA-Natural Resources Conservation Service, STATSGO Soil Association Map (Anonymous 2001e). Agricultural data were supplied by R. Quint (personal communication, Natural Resources Conservation Service, Schoolcraft County).

The Manistique River watershed is comprised predominately of sandy materials with minimal gravel-cobble deposits. Specifically, there are three major soil types (Figure 17). Wet sand - organic soils are the dominate group and cover 70.0% of the watershed, with coarse sand - sand covering 21.9%, and loamy sand – loam covering 8.1%. Recognizing the sandy composition of the Manistique River watershed is essential to understanding and properly managing its waters. The Indian River subwatersheds, for example, are comprised of 98% sand and less than 2% gravel-cobble (Benchley et al. 1993).

The Manistique River watershed is comprised primarily of undeveloped land, with only 0.2% developed (Table 4 and Figure 18). Most of the land (57.1%) is wetland, with 12.2% covered by emergent herbaceous wetland and 44.8% covered by woody wetlands. Conifer, deciduous, and mixed conifer and deciduous upland forests cover 32.8%. Minimal land use (1.6%) is agricultural and occurs in areas of loamy soils. Agriculture is further limited by the watershed’s frigid climate and short growing season.

Mainstem – upper

Areas within this subwatershed are dominated by loamy soils interspersed with sandy soils. The headwaters originate in an area of wet sand and organic soils and flow through loamy soils before entering Manistique Lake. Immediately below the lake, the river flows through an area of wet sand and organic soils. This mix of soil types provides low to moderate capacity to hold water, and rapid to moderately slow permeability. Groundwater inflows are steady and favorable to the river.

This subwatershed is dominated by herbaceous and woody wetland (49.3%) and upland forests (31.5%). Hardwood woodlots, conifer plantations, and large tract mixed vegetation stands are used for timber production. Open water covers a large portion of the subwatershed (13.2%) due to North, Big, and South Manistique lakes. Agriculture is lightly scattered (5.1% of subwatershed) with annual production of alfalfa, oats, corn, barley, potatoes, and spring wheat. No tiling is incorporated into the farm fields. Beef cattle are reared in low numbers at farm sites interspersed in the area. Horses are seen on occasional farms that dot the countryside.

Mainstem – middle

Wet sandy soils dominate the area surrounding the upper portion of this subwatershed. The lower portion flows through a corridor of loamy soils surrounded by wet sandy soils. Due to loamy soils immediately surrounding the river, direct groundwater inflow is variable with much of the river flow derived from groundwater-fed tributaries.

Land use is predominately wetland (67.0%) and upland (27.8%). Because much of the land is low wetland, timber harvest is light with winter cutting for conifers. Farming is limited and occurs on only 2.7% of the subwatershed. Farming is practiced near the village of Germfask and south to Highway US-2 with production of alfalfa, oats, corn, barley, potatoes and spring wheat. There are low numbers of beef cattle reared on an occasional farm. Open water occupies 1.7% of the subwatershed.

Mainstem – mouth

The Mainstem – mouth continues through the loamy corridor. The land north of the river is primarily wet sand and organic soils with a modest area of sand west of the lower West Branch Manistique River. The area along the south boundary of the Mainstem – lower is dominated by loamy and sandy soils on bedrock. These soils are shallow, well to moderately drained, and are underlain by limestone bedrock on nearly level to gently sloping topography. Soils have low or very low water holding capacity and moderate permeability. These shallow soils do not contribute to deeper groundwater aquifers, but do produce shallow groundwater seeps that provide thermal buffering benefits.

Most (84.8%) of this subwatershed is wetland. This land is poor for farming or timber production. Farming (2.8%) is practiced in the south east portion of this valley segment with light production of corn, alfalfa, a few beef cattle, and occasional horses. Timber harvest (8.3%) is moderate with winter harvests of lowland conifers and year round harvests of upland hardwoods. Homes and cabins front portions of the Manistique River while hunting camps are common within private tracts of land. Open water occurs on 2.8% of the subwatershed.

Tributaries – Fox River

The headwaters originate in coarse sandy soils. The remainder of this tributary flows through soils of wet sand and organic materials, with an area of loamy soils to the east. This one is dominated by soils having low to very low capacity to hold water with rapid permeability rates. Groundwater inflow is high and this tributary is well buffered thermally.

Land is poor for agriculture and limited farming is practiced (1.5%). Present land uses include conifer plantations and hardwood forestry (45.7%). Similar to the other subwatersheds, a high proportion of the Tributaries-Fox River Subwatershed is wetland (42.8%). Barren land (e.g., abandon sand or gravel mining areas, etc.) occupies 5.2% and 3.5% is grassland.

Tributaries – central basin

The headwaters of most tributaries within the central basin originate in coarse sandy soils. However, most of the Manistique River watershed lies within areas dominated by wet sandy and organic soils. The underlying geology of impervious limestone bedrock, combined with the low relative gradient of the Tributaries-central basin, enables groundwater levels to remain high (in elevation) within the soil profile. Soils here are relatively wet. Because most of the Tributaries-central basin is saturated with water, newly fallen precipitation does not readily move through the soil profile. Movement of groundwater is stagnated which enables in-stream water temperatures to be influenced by ambient air temperatures. One small area of loam exists along the far northwest edge of this basin.

Land in the upper reaches of this subwatershed is well drained, however, its sand character makes it unsuitable for farming. Currently, only 0.6% is used for farming. Within most of the lower segment the land is wetland (66.8%). Primary land uses are forestry (25.7%) and wetland wildlife management. Open water occupies 5.0% of the subwatershed.

The lower portion of this subwatershed, south of Highway M-28 is characterized by a flat, wetland topography. Standing water is common within this segment. The Seney National Wildlife Refuge, through a system of dikes and canals, maintains waterfowl breeding ponds along the eastern side of this area.

The west and southwest portions of this valley segment are characterized by a linear delineation of small northwest to southeast oriented ridges and ponds. These linear ponds and ridges are a unique land type and are classified by the USFWS as a patterned bog. This pattern develops on a gently sloping landmass that is underlain with post-glacial sand knolls and sand dunes. In Europe the term given to the linear pond area of the patterned bogs is “strangs” while the dry ridge portion of these patterned bogs is referred to as “flarks”. Patterned bogs are most commonly found in northern latitudes. Warmer climates and longer growing seasons of more southerly latitudes allows for vegetation to cover the pond/ridge character of patterned bogs. The patterned bogs found in this valley segment are an example of one of the most southerly found systems in the world. Because of this patterned bog’s southerly uniqueness and the roadless, remote character of this valley segment, in 1975 the USFWS designated 9,700 acres as the Strangmoor Bog National Natural Landmark.

In the early 1900s, a large ditch was constructed to drain this bog area to in an attempt to drain the bog for farming. The Walsh Ditch was excavated from the north portion of the bog, extending south to Duck Creek. Marsh Creek, located in the northwest portion of the patterned bogs, was intercepted by the Walsh Ditch which resulted in the Marsh Creek flow being diverted southerly through the Walsh Ditch. Water movement from north to south increased in volume and velocity as the Walsh Ditch shortened the distance and increased gradient slope. The sand soils of the Walsh Ditch were unstable for the hydraulic flows that were within the Walsh Ditch channel. The hydraulic forces caused the Ditch to incise and to transport significant amounts of in-stream sand bedload. The Ditch was incapable of holding the mobile in-stream sediment, resulting in streambed blowouts and sand discharge in the middle portions of the Walsh Ditch. The high flows of the Walsh Ditch also destabilized the stream channel of Duck Creek which resulted in bank scouring, incising, and an alteration of channel morphology.

As Walsh Ditch continued to incise between 1910 and 1975, the streambed elevation was lowered. This caused the surrounding groundwater table to lower, which resulted in drying out the flarks. Vegetation types changed on the flarks from water tolerant plant to herbaceous growth that was tolerant to dryer soils. The thin organic mat, over the sand soils, was allowed to dry as a result of the lowered water table and this organic material was susceptible to oxidation and wind erosion.

In June 1975, summer thunderstorm lightning strikes ignited a remote wildfire in this dried area. The flarks, being dryer due to the lowered water table, were able to burn at a more intense level than if they were saturated. The fire was able to migrate very low into the peat mat substrates here, which allowed the fire to burn throughout summer and fall. Efforts by firefighters to put out the fire were hampered due to the deepness of the fire and the fire’s ability to migrate underground through the peat mats. This fire is known as the Seney Fire of 1975.

The Seney National Wildlife Refuge in 2003 began efforts to block the Walsh Ditch and to restore the flow of Marsh Creek to the Driggs River. This flow restoration will return the natural pattern of surface water movement over the landscape and of the Driggs River. This should help maintain the health and integrity of the patterned bog area.

Tributaries – upper Indian River

The Tributaries-upper Indian River and portions of the Mainstem-middle, north of the river channel, are dominated by sandy soils and only 0.3% is suitable for agriculture. These soils have a low water volume holding capacity and a rapid permeability. Groundwater inflows through these soils are rapid and favorable. This area is primarily used for conifer plantations, and mixed upland forestry (51.0%). Wetlands occupy 41.7%. Open water covers 4.7% of this subwatershed. Much of the land area is publicly owned by the Hiawatha National Forest, which has allowed much of the land to remain in wooded character. Homes, cottages and camps are at a low density here.

Tributaries – lower Indian River

This subwatershed is dominated by wet sand and organic soils, with pockets of coarser sand to the west. Land use is primarily forestry (23.9%) and recreation. Wetlands cover 58.3% of this subwaterwshed and open water (primarily Indian Lake) covers 13.6% of the subwatershed.. The wet, sand soils here are generally poor for farming (3.0%) and farming occurs north of the City of Manistique along Highway M-95. Agricultural production includes corn, oats, alfalfa, barley, and spring wheat. One dairy farm with approximately 100 head of cattle operates in this area. No field tiling occurs.

Channel morphology

All rivers naturally erode and deposit materials. This process is necessary to control water energy within the system. A system is at equilibrium when river channel margins and the energy of the water flowing through it are in balance. As energy increases, the channel is reshaped. For example, streambank materials may be eroded, carried downstream, and redeposited on point bars. The result of this action increases sinuosity and decreases energy. As sinuosity increases, river length increases, which in turn decreases slope and consequently rate of flow (energy).

Two river characteristics are presented in this section: gradient and channel cross section. Each of these measures helps to describe flow characteristics and stability of the river system.

Gradient

Gradient is a measure of the change in river elevation over distance. Typically, as land elevation increases so does river gradient. However, localized changes in river gradient can appear dramatic relative to the more smooth changes in land elevation. River gradient is also influenced by soil types, surficial and bedrock geology, land use, and dams and barriers. As a river runs through areas of varying erodibility, gradient changes. For example more erodible areas (e.g., sand) tend to have less gradient due to channel down cutting. Dams and barriers artificially alter gradient as well. Dams cause poor and atypical habitat types (see **Dams and Barriers**). Relationships between gradient and fish species diversity and abundance are well documented (see extensive list of references in Wesley and Duffy (1999)).

Stream habitat diversity is related to gradient. The table below ranks gradient by gradient class and describes typical channel characteristics for each gradient value (G. Whelan, MDNR, Fisheries Division, unpublished data). River segments with low or excessive gradient have minimal channel diversity and limited fish habitat. River gradients of 10.0-69.9 ft/mile, which provide the best habitat, are rare in Michigan and especially so in the Manistique River. Areas with these characteristics have typically been impounded. Due to their high power, these areas were useful to early mills and hydro-electric dams. The negative influence of dams on these areas of high gradient with good channel characteristics is very evident. Michigan’s Au Sable River, a world class trout river, has numerous dams within areas of high gradient (Zorn and Sendek 2001). The impoundments support only mediocre warmwater fisheries rather than the superb trout fisheries seen in nearby free flowing segments (Lockwood 2000b; 2001).

Gradient class, slope and channel characteristics used to classify river by gradient range.

Gradient class	Value (ft/mi)	Channel characteristics
Low	0.0-2.9 ft/mi	Mostly run habitat with low hydraulic diversity
Fair	3.0-4.9 ft/mi	Some riffles with modest hydraulic diversity
Good	5.0-9.9 ft/mi	Riffle-pool sequences with good hydraulic diversity
Excellent	10.0-69.9 ft/mi	Established, regular riffle-pool sequences with excellent hydraulic diversity
Fair	70.0-149.9 ft/mi	Chute and pool habitats with only fair hydraulic diversity
Poor	>150 ft/mi	Falls and rapids with poor hydraulic diversity

The mainstem Manistique River drops 107 ft from 688 ft above sea level at river mile 81.2, Locke Lake, to 581 ft above sea level at river mile 0, mouth of Manistique River (Figure 19). Mean river gradient is 1.3 ft/mi and varies from 0.6 ft/mi to 12.0 ft/mi (Figure 20). Minimum and maximum gradient both occur in the Mainstem – mouth. The river drops rapidly at the site of the Paper Mill Dam, which was constructed on a fractured limestone riffle, set upon the Niagara Escarpment. The Niagara Escarpment (also known as Lake Ridge) arcs from the Door Peninsula in Wisconsin 650 miles to the southwest end of Lake Ontario.

Specific power

The specific power of a stream relates to slope, discharge, and gradient. Specific power is an important measurement necessary to understanding a river system. Specific stream power measures the rate at which potential energy is supplied to a river channel and its banks, and is in units of watts/m^2. Power is the rate at which work is done (e.g., move a rock weighing 1 lb, 50 ft in 10 min). Specific stream power is a function of discharge Q at f %, channel slope s in meters, cross-sectional width w in meters, water density (p), and gravitational acceleration (g). It is expressed as:

$$\omega = \frac{pgQ_f s}{w},$$

with a value of 10 used to approximate *pg* (Wiley and Gough 1995).

Specific stream power is useful for measuring a river's stability and for measuring its dynamic nature. River systems are rarely static and move laterally within their meander belt (valley or stream corridor). The location of a present day streambed is different from its location 500 or 1,000 years previous. Remnants of previous streambed locations, in the form of oxbow lakes and silted oxbows, may be found within the boundary of a meander belt (Schiefer 2001). Rivers typically contain sections of straight, meandering, or braided channel; and the channel type within a section may change over time.

Because of Michigan's glacial history, much of the landscape is comprised of sand. Thus, Michigan rivers by nature contain sand. The greatest deposition of glacially-deposited sand in North America is found in the northern Lower Peninsula around Gaylord (K. Kincare, MDEQ, personal communication). Similarly, soils within the Tributaries-upper Indian River and Tributaries-lower Indian River are predominately sand (98%) with little gravel (Benchley et al. 1993). Excess amounts of sand carried by rivers are deposited within a channel and at points (bars) on bends. River systems may be quite dynamic or in dynamic equilibrium. When a river is in a state of dynamic equilibrium, the amount of sand entering the river is equal to the amount of sand being transported and discharged. Coarse materials in their headwaters and fine materials near their mouth typify most rivers (Schiefer 2001).

Particles, whether they are rocks or clays, may be eroded by a river. Sand particles are approximately 0.1 – 1.0 mm in size and are more erodible than larger particles (e.g., gravel or cobble) (Hjulstrom 1935). Because of this sand composition and the predictable nature of its erodibility, specific stream power measures indicate the dynamic nature of a river. For Michigan rivers, when specific stream power reaches 15 watts/m^2, stream bed movement occurs (M. Wiley, University of Michigan, personal communication). A river may, for example, downcut or it may move laterally and increase sinuosity. Both actions result in a reduction of power.

As rivers move laterally, the outside bank is eroded. Easily transported materials (sand, etc.) are carried and deposited within the river system. Coarser materials, such as rock or gravel, are deposited in the streambed. As a river moves laterally off of its present channel within the meander belt, these coarse materials form veins. Through time a river rediscovers these older veins and the coarse materials are once again deposited in the riverbed (Hansen 1971).

Bank stabilization and sediment removal are important management practices around areas of artificially introduced materials such as road crossings. The negative effects of increased bedload on cold-water fish species and aquatic invertebrates are well documented (Alexander and Hansen 1983, Hansen et al. 1983, Alexander and Hansen 1986). However, the common practice of bank stabilization or sediment removal in areas of naturally occurring sand bedload may not be an appropriate course of action. The effect of these changes is a reduction in power. Rivers naturally reduce power during floods by overflowing their banks, down cutting, or increasing sinuosity (meanders) – each of which can increase sand bedload. When rivers overflow their banks, the width changes (increases), thus reducing power. In addition, this flooding process deposits nutrients on the flood plain and recharges the bank groundwater – which in return seeps back into the river as groundwater when water levels recede. When down cutting occurs, river power is decreased by reducing gradient. Increased sinuosity lengthens the river channel thus reducing slope and power. Similarly, when power becomes excessive (>15watts/m^2) a river may erode its banks, decreasing power by widening and using energy to carry the eroded materials (reducing discharge). Management removal of sand bedload increases power, which in turn precipitates a change in the physical characteristics of the river (e.g., increases lateral movement). Measuring specific power within a river system indicates the potential that river has for change. Rivers with high frequency of specific power measures >15watts/m^2 have a much greater potential for change than rivers with low frequency of specific power >15watts/m^2. This measurement aids resource managers in determining when and where stabilization and sediment removal projects are appropriate.

An extensive evaluation of logging effects on the Indian River watershed was conducted by Benchly et al. (1993). Essential to this project was a thorough evaluation and quantification of surficial materials present within the watershed. The Indian River watershed is comprised almost exclusively of sand (98%) with less than 2% gravel-cobble. Sand, while more difficult to transport than fine or medium textured materials such as clay, is easily eroded due to its non-cohesive nature. Consequently, this system always (since the glacial period) carried a sand bedload. "The river was not more rocky at an earlier time." (Benchley et al. 1993).

Awareness of surficial materials within the Indian River watershed, and the Manistique River watershed, are essential to realizing river system potential. Sandy materials, while easily eroded, provide greater infiltration rates than finer materials (e.g., clay) and consequently minimal surface runoff. However, sand dominated systems may not benefit from protective bank or sand trap structures. Again, from Benchley et al. (1993):

> Current protection structures such as revetments composed of rip rap or wooded bank protection structures are temporarily devices to stop erosion in one place. The effect of such structures is to divert water flow to another area where erosion will occur.

The following sections contain gradient and specific stream power characteristics for each subwatershed.

Mainstem – upper

The river drops 56 ft from 688 ft above sea level at Locke Lake to 632 ft above sea level at Boucher Creek (Figure 19). Gradient averages 1.6 ft/mi and varies from 1.1 ft/mi (25.3% of the river) to 2.6 ft/mi (11.2%) (Figure 20). Thirty-five percent of this river segment has gradient from 2.0-2.6 ft/mi and gradient class is rated low.

Specific power was 13.4 watts/m^2 at 5% exceedence and 3.0 watts/m^2 at 95% exceedence (Figure 21). Specific power at 5% exceedence was below 15 watts/m^2. Specific power is 15 watts/m^2 at flow of 1,010 ft^3/s. Channel adjusting flows occur in 8-of-10 years. This river segment is able to transport sand and the channel adjusts almost annually.

Mainstem – middle

This segment drops 17 ft from 632 ft above sea level from Boucher Creek to to 615 ft above sea level at West Branch Manistique River (Figure 19). Gradient is very low, 0.7 ft/mi, and gradient class is rated low (Figure 20).

Specific power was 5.7 watts/m^2 at 5% exceedence and 0.7 watts/m^2 at 95% exceedence (Figure 22). A decrease in specific power is expected in this section. Specific power is lower in downstream sections relative to upstream sections and is a result of a general widening of the stream channel (Wiley and Gough 1995). Specific power is 15 watts/m^2 at 5,808 ft^3/s. Channel adjusting flows occur in 1-of-10 years. This river segment has the ability to transport sand and adjusts the channel occasionally.

Mainstem – mouth

The river drops 34 ft from 615 ft above sea level from the West Branch Manistique River and to 581 ft above sea level at mouth (Figure 19). Mean gradient is 1.8 ft/mi and varies from 0.6 ft/mi (91.4% of segment) to 12.0 ft/mi (8.6%) (Figure 20). Steep gradient near river mouth is due to a naturally occurring limestone riffle. However, quality of fish habitat has been diminished by the Paper Mill Dam (see **Dams and Barriers**). Dams are often constructed on areas of steep gradient and excellent fish habitat. Resulting gradient class is poor and quality of river habitat in mouth segment is low.

Yield was measured at two USGS stations within the Mainstem-mouth segment (see **Hydrology**).

- Manistique River at Manistique (USGS station no. 04056500)
  Specific power was 11.1 watts/m^2 at 5% exceedence and 1.3 watts/m^2 at 95% (Figure 23). Similar to Mainstem - middle, specific power continues to decrease downstream. Specific power is 15 watts/m^2 at flow of 5,383 ft^3/s. Channel adjusting flows occur in 8-of-10 years. This river segment has the ability to transport sand and the channel adjusts almost annually.
- Manistique River above Manistique (USGS station no. 04057004)
  The Paper Mill Dam at Manistique influenced specific power. Specific power was 28.3 watts/m^2 at 95% exceedence and 159.3 watts/m^2 at 5% exceedence (Figure 24). Specific power is 15 watts/m^2 at flow of 354 ft^3/s. These excessive power values are due to greater discharge and to narrowing of the channel at the dam. Armoring of the river below the dam prevents lateral channel damage from the excessive power. This armoring retains excessive power (>15 watts/m^2) and results in poor fish habitat. However, the high specific power values illustrate the negative influence of the Paper Mill Dam.

Tributaries – Fox River

The Fox River drops 179 ft from 864 ft above sea level between head waters to 685 ft above sea level at the confluence with mainstem (Figure 25). Mean gradient is 4.4 ft/mi and varies from 1.7 ft/mi (7.1%) to 17.5 ft/mi (1.4%) (Figure 26). Gradient class is good in 14.2% of the Fox River and excellent in 4.1% of the river.

No USGS gauge stations were located within the Tributaries-Fox River segment and specific power could not be measured.

Tributaries – central basin

Driggs River drops 161 ft from 810 ft to 649 ft above sea level (Figure 27). Mean gradient is 3.7 ft/mi and varies from 1.7 ft/mi (6.6%) to 7.8 ft/mi (1.4%) (Figure 28). Gradient class is rated good in 18.3% of the Driggs River.

Two USGS gauge sites were located on the Driggs River and specific power was measured at each.

- Driggs River at Seney (USGS station no. 04052000):
  Specific power was 14.9 watts/m^2 at 5% exceedence and 4.0 watts/m^2 at 95% exceedence (Figure 29). Specific power was 15 watts/m^2 at flow of 156 ft^3/s. Groundwater inflow is good. However, specific power exceeds 15 watts/m^2 annually. This river segment is very dynamic, easily transports sand, and the channel reshapes annually.
- Driggs River at Germfask (USGS station no. 04053000):
  Specific power was 17.0 watts/m^2 at 5% exceedence and 2.6 watts/m^2 at 95% exceedence (Figure 30). Specific power was 15 watts/m^2 at flow of 227 ft^3/s. Good groundwater inflow continues in this section. However, specific power increases and a flow of 227 ft^3/s occurs annually. This river is very dynamic, easily transports sand, and the channel reshapes annually.

Marsh Creek drops 192 ft from 832 ft to 640 ft above sea level (Figure 31). Mean gradient is 9.1 ft/mi and varies from 2.7 ft/mi (8.9%) to 11.7 ft/mi (2.0%) (Figure 32). Gradient class is rated good in 72.9% of Marsh Creek and excellent in 2.0% of the river.

Specific power was 24.2 watts/m^2 at 5% exceedence and 0.0 watts/m^2 at 95% exceedence (Figure 33). Specific power was 15 watts/m^2 at flow of 32 ft^3/s. Specific power is greater at this site than at most other Manistique River watershed sites. Minimum necessary flow (32 ft^3/s) to reshape channel occurs annually. This river is very dynamic, easily transports sand, reshapes the channel annually, and is more dynamic than the Driggs River.

West Branch Manistique River drops 143 ft from 758 ft to 615 ft above sea level (Figure 34). Mean gradient is 3.0 ft/mi and varies from 1.8 ft/mi (5.8%) to 9.7 ft/mi (1.1%) (Figure 35). Gradient class is rated good in 7.3% of the river.

Specific power was 11.2 watts/m^2 at 5% exceedence and 1.0 watts/m^2 at 95% exceedence (Figure 36). Specific power was 15 watts/m^2 at flow of 1,786 ft^3/s. Good groundwater inflow occurs in this section. However, specific power in excess of 15 watts/m^2 and minimum channel forming flow of 1,786 ft^3/s occur 9-out-of-10 years. This river is very dynamic, easily transports sand and the channel reshapes annually.

Tributaries – upper Indian River

Upper Indian River drops 161 ft from 776 ft above sea level from Hovey Lake to 615 ft above sea level at Big Murphy Creek (Figure 37). Mean gradient is 3.3 ft/mi and varies from 0.6 ft/mi (6.9%) to 6.7 ft/mi (3.1%) (Figure 38). Gradient class is rated fair in 36.9% of segment and good in 14.4% of the river.

No USGS gauge sites were located in this subwatershed and specific power was not measured.

Tributaries – lower Indian River

Lower Indian River drops 13 ft from 613 ft above sea level at Big Murphy Creek to 600 ft above sea level at confluence with Mainstem–mouth (Figure 37). Mean gradient is 2.8 ft/mi and varies from 1.6 ft/mi (38.8%) to 3.5 ft/mi (60.2%) (Figure 38). Gradient class is rated fair in 60.2% of the segment.

Specific power was 5.3 at 5% exceedence and 1.2 at 95% exceedence (Figure 39). Specific power was 15 watts/m^2 at flow of 1,750 ft^3/s. Good groundwater inflow occurs in this section. Specific power was always well below 15 watts/m^2. Maximum recorded flow of 716 ft^3/s resulted in specific power of 6.1 watts/m^2. However, these are measures for the lower Indian River. The river's ability to transport sand and alter its channel in upstream sections was not measured due to lack of gauge sites.

Channel Cross Section

Fish habitat quality may also be evaluated by comparing channel cross section measures with expected measures (Leopold and Wolman 1957). Actual channel cross section measures are compared with expected measures using 5% and 95% exceedence flow rates:

$$Width_e = 10^{(0.741436 + (0.498473 \log Q_e))},$$

where Q is flow rate at exceedence e. When actual measure exceeds $Width_{5\%}$, the channel is excessively wide. Excessive channel width results from unusually frequent flood events that widen a natural channel. Such events may be caused by dams, channelization, or similar land use practices that move water into the channel at too fast a rate. When actual measure is less than $Width_{95\%}$, the channel is more narrow than expected. This may be due to channelization at the site, bank armoring, bulkheads, or similar artificial constructs that restrict channel width.

Comparisons of actual and expected widths at 14 USGS gauge sites are given (Table 2). Results by subwatershed follow.

Mainstem – upper

Channel width measures at USGS gauge site 04049500 indicate appropriate channel width during period of record.

Mainstem – middle

Channel width measures at USGS gauge site 04055000 indicate appropriate channel width during period of record.

Mainstem – mouth

Channel widths at USGS gauge sites 04056500 and 04057004 were less than expected. At gauge 04056500 actual channel width was 114.0 ft and $Width_{95\%}$ was 120.0 ft. At gauge 04057004 actual channel width was 129.0 ft and $Width_{95\%}$ was 141.1 ft. This area is affected by the MPI dam (see **Dams and Barriers**). Because of development and dam construction, the river is artificially constrained and forced to remain within boundaries. As previously noted, fish habitat quality is low (see **Gradient**).

Tributaries – central basin

Channel width measures at USGS gauge sites on Holland Creek (no. 04049000), Walsh Creek (no. 04052500), Driggs River (no. 04053000), Marsh Creek (no. 04053500), Duck Creek (no. 04054500), Creighton River (no. 04055500), and West Branch Manistique River (no. 04056000) all indicated appropriate channel widths during period of record.

Channel widths were less than expected at Driggs River gauge site (no. 04052000) and Marsh Creek gauge site (no. 04054000). Actual channel width at Driggs River was 27.3 ft and $Width_{95\%}$ was 35.5 ft. Actual channel width at Marsh Creek was 5.0 ft and $Width_{95\%}$ was 5.5 ft. Dredging and channeling have affected these sites (see **History**). These actions have drained marshlands.

Tributaries – lower Indian River

Indian River gauge site (no. 04057000) was wider than expected. Actual channel width was 189.0 ft and $Width_{95\%}$ was 135.3. This area is affected by the Indian Lake Dam (see **Dams and Barriers**). This dam serves as a lake-level control structure. During low flow this structure dramatically decreases downstream flow (see **Hydrology**).

Dams and Barriers

There are 51 dams registered with MDEQ and 3 additional barriers not registered with MDEQ, within the watershed (Table 5, and Figures 40 and 41). Additionally, several small private dams and barriers are present. Their condition and effects on the watershed are not known. The 3 barriers not listed with MDEQ are located in the Tributaries-upper Indian River and Tributaries-lower Indian River subwatersheds. Unless specifically noted, references to purpose, condition, and hazard rating will apply only to the 51 dams registered with MDEQ.

Only one dam has historically served to generate electricity (Paper Mill Dam). The remaining dams serve as water-level control structures, fish barriers, or to create waterfowl habitat. Thirty-two dams are federally owned (6-United States Department of Agriculture, Forest Service (USFS), 26-Department of the Interior Fish and Wildlife Service), 9 by private individuals or clubs, 5 by the MDNR, 3 by counties or municipalities, 2 with unknown owners, and 1 by a corporation (Manistique Paper Co., Inc. {also known as Manistique Pulp and Paper Co.}).

Dam ages vary from 20 to more than 100 years of age. One was constructed prior to 1900, 2 between 1900 and 1919, 17 between 1920 and 1949, 3 during the 1950s, and 10 between 1961 and 1983. Most of the dams are small, 18 have a height less than 10 ft, 14 with a height between 10 – 20 ft, and 1 dam at 25 ft. (Table 5).

Dams are hazard rated by the Dam Safety section of MDEQ, Land and Water Management Division. Failure of dams with a hazard rating of 1 would result in the loss of human life, those with a hazard rating of 2 would result in severe property damage, and those with a hazard rating of 3 are low head dams located in remote areas. One dam in the watershed has a hazard rating of 1 (Paper Mill Dam owned by Manistique Paper Co., Inc.), one has a hazard rating of 2 (Indian Lake Dam owned by Schoolcraft County Drain Commission), and the remaining 50 dams have a hazard rating of 3.

Dams in the Manistique River watershed impound various sized water bodies. Sixteen dams impound less than 10 acres, 10 impound waters 10 – 99.9 acres, 23 impound waters 100-999.9 acres, and 3 create impoundments greater than 1,000 acres in size.

Dams alter river systems and the fish communities within them. From Mistak (2001):

> The effects of dams have been well documented (Hammad 1972, Ligon et al. 1995, Shuman 1995, Petts 1980, Cushman 1985, Doppelt 1993, Benke 1990, Bain et al. 1988, and Ward and Stanford 1989). The damming of a river or stream has been called a cataclysmic event in the life of a riverine ecosystem (Gup 1994). Dams interrupt and alter most of a river's ecological processes by changing the flow of water, sediment, nutrients, energy and biota (Ligon et al. 1995). Some of the main ecological issues regarding effects of dams include temperature change, prevention of fish migration, and altered flow regimes. In many streams, discharge is artificially regulated by dams. Dams transform long reaches into impoundments and change downstream reaches, resulting in streambed degradation (Kohler and Hubert 1993).

By impounding rivers, dams reduce water movement. This changes the system from a riverine to a lake-like environment. Reducing or halting water movement allows for the sediment load, which is naturally carried by a river current, to fall out and deposit on the streambed. Direct solar radiation and surrounding ambient air temperatures serve to warm water within these lake-like environments during summer. Warm surface water from impoundments thermally dominates stretches for a considerable distance before cooler groundwater can restore water temperatures (Newcomb and Coon 1997, Lockwood et al. 1995). Fish communities are limited in these artificially warmed stretches to species tolerant of warmer water. Coldwater species, such as trout, are less likely to inhabit these areas.

Warm water has less physical potential to carry dissolved oxygen than cold water, therefore fish communities within impoundment waters are often characterized by the presence of fishes that survive in less oxygenated waters.

Dams prevent downstream passage of woody structure. The natural downstream movement of logs, trees, and root-wad materials is halted. Wood provides important overhead cover for fish and attachment sites for invertebrates. Biological communities below dams are negatively affected by lack of woody structure.

Dams act to impede upstream and downstream movement of fish. Barriers to fish movement prevent fish species from accessing their spawning grounds or from reaching holding pools. The blocking of fish, reptiles, amphibians, and insects from free access throughout a river system fragments a river and its biological communities. In the Manistique River, potamodromous fish (including sea lamprey) can only migrate from Lake Michigan up to the MPI dam, which is located approximately one mile upstream from the river mouth. This dam acts to prevent Great Lake fishes from ascending the river during their spawning run and blocks 1,400 miles of potential sea lamprey spawning habitat.

Mainstem – upper

Nine dams are located in the upper mainstem. Six are in private ownership, one is county owned, one is owned by the MDNR, and ownership of the ninth is unknown. Since the early 1940s, three dams have been installed on the Manistique Lakes system to elevate water levels for summer-boating (Portage Creek, Tressler, and Manistique Lake dams). The water level is normally raised for summer months to accommodate boating, and lowered in winter months to alleviate shoreline ice scouring and damage to recreational docks. In recent years, property owners have requested higher summer-time water levels to accommodate larger sized boats. South Manistique and North Manistique lakes each have their own water control structure and are operated independently. These two lakes drain into centrally located Big Manistique Lake.

Tressler Dam (North Manistique Lake) at low flow with all boards removed.

Tressler Dam controls water levels of North Manistique Lake and is located on Helmer Creek which is the outlet stream located along the southeast shore. This dam is situated in the back yard lot of a private residence. In 1948 the first lake-level control was placed at this location with upgrades and improvements made to the dam during recent years. The dam's purpose is to raise the North Manistique Lake level to facilitate recreational boating. Boards are removed from the dam each year in early October to lower water levels and to prevent winter shoreline ice scouring. After spring ice-melt, boards are replaced in the dam to raise the water approximately 2.5 ft above the level of Helmer Creek.

Portage Creek Dam (South Manistique Lake) at low flow with all stop boards removed.

Portage Creek Dam regulates the water level of South Manistique Lake and is positioned on Portage Creek and is the lake's outlet stream. Portage Creek is located on the north end of the lake within the town of Curtis. This dam is situated on private property in the downtown business district and is visible from the main street. Private individuals originally constructed the Portage Creek Dam in 1947. A financial maintenance fund designated for this dam still exists at the local bank. The dam is downstream of a resort, thereby providing sufficient water depth to enable resort users to boat upstream to the lake. The elevated water level provided by this dam is important to the boating needs of this resort, as well as the boaters on South Manistique Lake. Seasonal operation of the dam has typically been with boards removed for winter months and boards put in immediately after ice break-up in spring. The winter drawdown is conducted to minimize ice damage to shoreline (e.g., docks, vegetation, private shoreline structures, etc.). Each year the lake is to be fully impounded by early May to restore boat mooring and navigational needs. Annual water level fluctuations between full storage and low flow are approximately 2.5 ft.

Manistique Lake Dam

The Manistique Lake dam is located approximately 4 miles downstream from Big Manistique Lake and is situated just west of the 10-Curves Road (County Road 498). This dam's purpose is to maintain lake water levels that accommodate summer boating. In 1948, the first lake-regulating dam was built. The present structure was constructed in 1985. The dam is set to maintain a legal lake level on Big Manistique Lake at 686.0 ft above mean sea level. A Luce County appointee is responsible for operation of this dam. Operation of the dam occurs with approximately 2.8 ft of stop boards being put in place anytime between early April and mid July, depending on spring rains and snow-melt. The stop-boards are removed in late fall before ice up occurs. Often, during fall draw down, all boards are removed at one interval, which creates a peaking-flush flow. Downstream of the dam, the stream banks show evidence of scouring attributable to peaking-flush flows.

The Big Manistique Lake dam is located immediately downstream of the confluence of the Fox River, the East Branch Fox River, and the Big Manistique Lake outlet. Fish migrating upstream from the mainstem Manistique River are blocked from upstream passage. Fish are free to move in or out of Big Manistique Lake into the Fox River systems. Occasionally, during high spring snowmelt periods, flows from the Fox River system cause Big Manistique Lake outlet to reverse and flow back into Big Manistique Lake.

Comparison of water levels in Big Manistique Lake, with all stop boards in the dam or all boards removed, has shown that the dam only affects the water levels on Big Manistique Lake by approximately 2 in. An abundance of woody structure and sediment lying in the four-mile river channel between the lake and the dam acts to maintain current lake level. A water gauging staff was placed in Big Manistique Lake south shore Township Park, during the summer of 2001 to provide a more accurate measure of the influence of Big Manistique Lake Dam on the lake level. Results have not yet been compiled.

The Big Manistique Lake dam has various negative effects on the associated fish and wildlife habitats of the mainstem and Big Manistique Lake. During a dry spring, the stop boards are placed in the dam during mid-April shortly after ice break-up on the lake. Spring migrating fish species such as walleye, northern pike, muskellunge, yellow perch, and white suckers are blocked from ascending the river. If spring rainfall is excessive, boards are removed from the dam to alleviate flooding. The Big Manistique Lake shoreline is very flat and the springtime lowering of the lake level by 2 in can de-water northern pike spawning habitats as well as juvenile nursery habitat for newly hatched fish. Fall draw-down can have negative effects on bank burrowing reptile, mammal, and amphibian species in the Big Manistique River. Fur trappers who target the river often have to re-set their traps after fall draw down.

Mainstem – middle

No dams are found within the Mainstem–middle of the Manistique River.

Mainstem – mouth

The dam within this subwatershed, Paper Mill Dam, was constructed in 1919. This dam was originally designed for hydroelectric generation purposes but was decommissioned in summer 1991. The Paper Mill Dam is the first dam upstream from the mouth of the river and impedes Great Lakes and aquatic nuisance fish species movement up the river. In recent years, leaks in the dam have allowed sea lamprey to pass and gain access to spawning habitat upstream (see *sea lamprey*). With 22 ft of head, Paper Mill Dam is the only dam on the watershed with a hazard rating classification of 1.

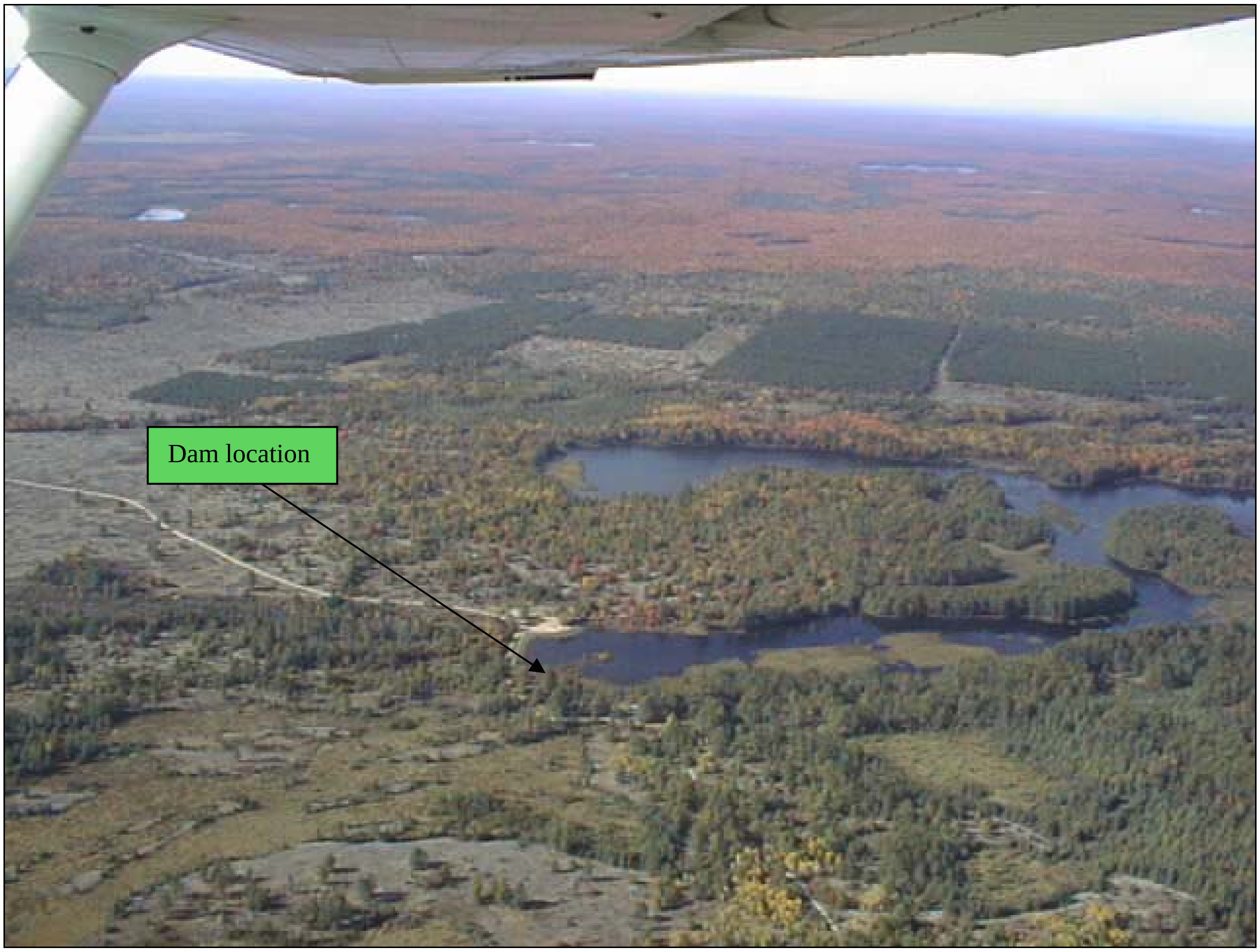
Upstream View of MPI Dam

Downstream View of MPI Dam

Tributaries – Fox River

Three dams exist within this subwatershed. Each dam is owned and operated by the MDNR. The MDNR, Fisheries Division manages the Kings Pond (9 ft high) and Spring Creek Pond (13 ft high) dams to maintain 6 acre trout ponds.

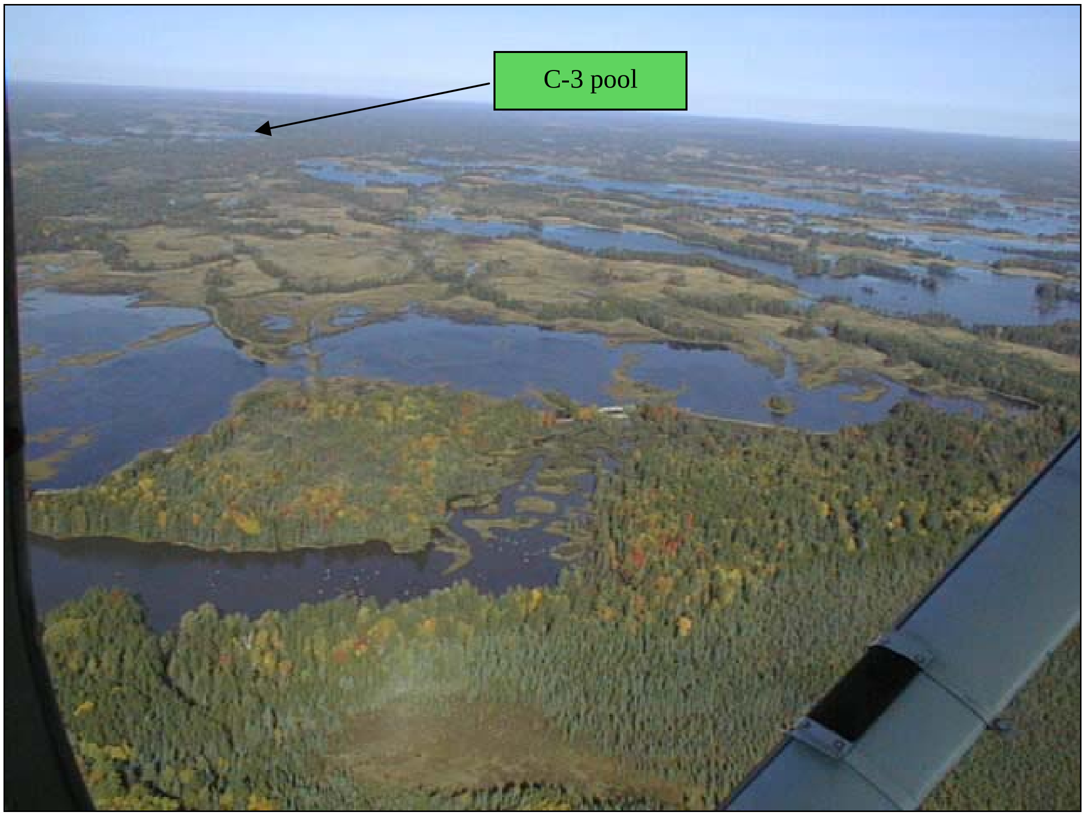
The MDNR, Wildlife Division manages the Stanley Lake Dam for waterfowl nesting habitat. The Stanley Lake dam maintains a head of 5 ft and creates a 50-acre pond. This impoundment lies at the head of the Fox River system and there is minimal watershed drainage that flows into this impoundment. Soils here are sandy and low in fertility. The low productivity of the soils has hindered fish and wildlife management in this pond. While an attractive vegetation composition for waterfowl exists, the low productivity of the environment discourages waterfowl use. Michigan Department of Natural Resources, Wildlife Division surveys indicate minimal waterfowl nesting occurs here (T. Minzy, personal communication). Stanley Lake supports a fishery consisting of numerous sub-legal northern pike, small yellow perch, brown bullheads, and white suckers.



Stanley Lake with dam at outlet.

Tributaries – central basin

Thirty-one dams are located within the central basin. Of these, the Department of Interior Fisheries and Wildlife Service (USFWS) maintains 28 dams on the Seney National Wildlife Refuge to provide pool habitats for waterfowl nesting. These impoundments are periodically flooded and drawn down to facilitate fish population control, pond shoreline oxidation, and vegetation management. Dam regulation is programmed and directed by the manager of the Refuge at the Seney office.



Seney ponds, Seney National Wildlife Refuge.

The C-3 pool in the northern portion of the Seney Refuge collects water from North Marsh Creek and Walsh Creek. Two water control-structures exist on the C-3 pool. The western most water control structure provides water to the lower portion of Marsh Creek, while the eastern most structure provides water to the marsh complex south of the C-3 pool.

Immediately east of the C-3 pool, a water control structure on the Driggs River is used to shunt water eastward, providing water for pools along the eastern portion of the Refuge. Driggs River water flows east through the Diversion Ditch canal where two other control structures function to move water either south or further east to Holland Ditch. Water flow in the Holland Ditch is the main water transport canal that supplies water to the eastern complex of pools within the Refuge.

The Seney ponds provide habitat for many different species of waterfowl, mammals, reptiles, amphibians, and a variety of birds. The Seney Refuge once provided a critical role in the restoration of the once endangered Canada goose (*Branta canadensis*). With current abundant populations of Canada geese, the role of the Refuge has shifted from goose restoration to management of other threatened and endangered species, as well as general waterfowl development.

The Refuge dams and their respective impoundments have altered natural biotic communities of the Seney area relative to pre-impoundment development. Many ponds block upstream movement of fish species and prevent free passage through the Driggs River, Sand Creek, Pine Creek, Gray's Creek, and Marsh Creek. Additionally, the ponds become warmer than area creeks and discharge warm water into these streams. The warmer ponds provide habitat and access to trout waters for predaceous fishes such as northern pike and brown bullheads. Repetitive seasonal opening and closing of water control structures creates an abnormal flow pattern with peaking flows followed by total dam closure resulting in no flows. Streambed scouring and sediment transport has resulted from peak flow occurrences.

Two dams located in this subwatershed are in private ownership. The Herb Musselman Dam maintains a 10 foot head of water to create a two-acre pond. The dam is located on the headwaters of a tributary to Stewart Creek. The Kinnunen Dam is located on a tributary of the Driggs River.

Tributaries – upper Indian River

Six dams are located in the Tributaries-upper Indian River subwatershed. Four dams are registered with MDEQ; United States Department of Agriculture (USDA), Hiawatha National Forest owns three; and one dam is privately owned. These four registered dams are in place to maintain water levels of impoundments. The Council Lake and Kettlehole Pond dams are in federal ownership and are not registered with MDEQ. The Council Lake dam maintains the water level in a complex of four lakes known as Council, Redjack, Scout, and Lion lakes.

Council Lake Dam

The Kettlehole Pond dam was a wooden 2 inch by 6 inch tongue and groove structure. This dam was constructed in 1984 and served as a fish barrier to the upstream Kettlehole Pond which was managed for brook trout. The Kettlehole dam washed out in the mid 1990s and it no longer blocks fish passage.

Tributaries – lower Indian River

Four dams exist in this subwatershed. The county owned Indian Lake Dam is located on the outlet of Indian Lake and maintains a legal lake level of 613.27 ft above mean sea level. This is the only dam within this subwatershed that has a hazard rating classification of 2. Constructed in 1878, the Indian Lake Dam is one of the oldest dams in the watershed. It is the only dam in the Tributaries-lower

Indian River that has a controlled spillway that allows for manipulation of water levels. Elevation of dam has increased the base level of Indian Lake and consequently reduced water velocity in the Indian River immediately above Indian Lake (Benchley et al. 1993).

Indian Lake Dam

Intake Park Dam was constructed in 1917, and is owned by the City of Manistique. This dam was designed to provide water for the Manistique Paper Co., Inc.

Carr Creek Barrier is owned by MDNR and was constructed in 1978. This dam was constructed to block non-trout species of fish from migrating to managed trout lakes. MDEQ dam safety inspection reports in 1989, 1993, 1996, and 2001 documented that the structure is in poor condition. The left concrete abutment has structurally failed, causing settlement of the abutment and severe cracking of the concrete slab. A synthetic membrane liner was placed along the upstream face of the barrier to reduce seepage through the embankment and structure. The structure is still effective at blocking fish. The dam safety report conducted by MDEQ in 2001 states that water is entering the existing cracks and will continue to undermine and erode the supporting soil underneath the slab. Over time, the structure will continue to settle and will probably experience additional settlement, cracking, and structural failure (Pawloski 2001).

Carr Creek fish barrier dam.

Bear Lake Barrier is owned by MDNR and is located on USFS land, and is not listed with MDEQ. It serves as a fish barrier and blocks non-trout species from migrating upstream into Bear Lake, which is presently managed and stocked with trout. This is a wooden barrier constructed with tongue and groove 2 inch by 6 inch lumber, jetted vertically into the streambed. Water has periodically eroded the abutments to this structure which has necessitated occasional repairs.

Water Quality

For the most part, the water quality of the Manistique River system is excellent and relatively undisturbed. The waters originate from surface water run-off or ground-fed springs. There are no industries or human settlements in the upper watershed, so degradation of the chemical parameters of the water is minimal until the river reaches the City of Manistique. Thermal degradation results from the various dams within the watershed (see **Dams and Barriers**).

Airborne mercury contamination affects the watershed, as it does most state waters, and is manifested within the fish of the Manistique River system (Anonymous 2001f). The State of Michigan Department of Community Health (MDCH) recommends that northern pike, located upstream from the dam at Manistique, should only be consumed in limited quantities because of mercury. The MDCH, 2001 Fish Advisory booklet (Anonymous 2001f) recommended that women and children should restrict their consumption of northern pike to no more than one meal per month of fish 22 inches and larger. The same booklet advises that the general population should restrict their consumption of northern pike to no more than one meal per week of fish larger than 22 in.

The chemical parameters of the waters vary from the upper to the lower portions of the watershed and from subwatershed to subwatershed. The United States Environmental Protection Agency maintains water chemistry data sets on the Storet database system (Anonymous 2001g). Storet information details many chemical parameters of the water and includes information such as, but not limited to (United States Environmental Protection Agency):flow, dissolved oxygen, nutrients, metals, chemical compounds, and solids.

Mainstem – mouth

For many years, the lower Manistique River has been identified as an area affected by pollution. In 1954 a biosurvey of the river documented heavy accumulations of wood fibers, bark, and wood splinters (Surber 1954).

In 1964, the Michigan DNR responded to angler complaints regarding fish taint (off-flavored fish). The report from this investigation documented that the Manistique Paper Co., Inc. was using approximately 40 gallons of kerosene per day, as a foam depressant in the pulp de-inking process (Anonymous 1969). Further Michigan DNR biological studies were conducted in the lower river in August 1968 and September 1969. These surveys were conducted as follow ups to the bio-surveys and wastewater surveys that were conducted in 1954 and 1964. Five key points were noted in each survey (Anonymous 1969). First, the lower river was found to be severely degraded, Second, the entire substrate of the lower river was adversely modified by deposits of wood chips and paper fibers. Third, the benthic community above the mill was non-affected and normal. Fourth, the benthic community below the mill was severely degraded. Fifth, There were continued reports of oily or kerosene off-flavored fish.

A MDNR netting effort on December 19-20, 1977, with three 125 foot experimental mesh gill nets, in the lower river, documented an oil film on the river and the nets were heavily coated with paper fibers and bark. Further netting in May and June of 1978 documented heavy and abundant paper fibers within the stream (Kenga 1977).

The largest and most publicly known pollution issue within the Manistique River watershed is the presence of polychlorinated biphenyls (PCBs) and heavy metals in the lower 1.5 mile reach of the river. Polychlorinated biphenyls were first discovered in Manistique River sediments during field work conducted by MDNR in 1976 (Kenga 1978).

The International Joint Commission (IJC), the Great Lakes National Program Office (GLNPO), and the State of Michigan have designated the lower Manistique River from the MPI dam in town to the mouth of the harbor at Lake Michigan as one of the 42 Areas of Concern (AOC) on the Great Lakes (Anonymous 1997b). Areas of Concern are waters in which the environmental quality is degraded and beneficial uses of the water or biota are adversely affected (Anonymous 1987). The AOC program is part of the Great Lakes Water Quality Agreement between the United States of America and Canada that requires a Remedial Action plan be written to address restoration and protection of an ecosystem using beneficial use impairments as a guide. Remedial Action Plans are joint efforts between federal and state agencies and the stakeholders in AOC to identify problems, to prepare and implement remedial action recommendations, and to report successes. Once these 3 general components of remedial action have occurred and results indicate that beneficial uses have been restored, the site can be de-listed by the federal government.

The Manistique River AOC committee was established in 1993, and consists of 13 individuals representing a variety of governmental and community persons (Anonymous 1987). This AOC falls into the jurisdiction of the MDEQ Act 307 site regulations due to PCB contamination of sediments. The RAP states that the AOC ranks 44 on a scale of 0-48 under the Michigan Act 307 Site Assessment Model (0-least concern, 48-greatest concern) (Anonymous 1987). The AOC also ranks as a site of USEPA Superfund activity.

In 1993, the USEPA identified several potentially responsible parties for the PCB contamination, including Manistique Paper Co., Inc. and Edison Sault Electric.

The Manistique River RAP summarizes the status of the PCB issue as of 1997 (Anonymous 1997b):

> Sampling conducted in June and December 1993, April 1994 and May, June and July 1995, included most of the navigation channel along with other harbor and upstream locations. Cores were generally taken to bedrock. Sampling in the navigation channel showed surface (0”-3”) concentrations of PCBs with a peak value of 120 ppm and an average of 16 ppm. PCB concentrations up to 810 ppm were also found at depths of 3” to 2’. Average PCB concentrations in the navigation channel at this depth were 73 ppm. At the 2’ to 6’ depth, in an area just north of the US 2 highway bridge, on the west side of the river, maximum PCB concentrations were 2310 ppm. In the navigation channel, contaminated sediments at depths of 2’ to 4’ had a maximum PCB concentration of 810 ppm and average of 180 ppm. It is estimated that there are about 54,000 cubic yards of material in the harbor contaminated by levels of PCBs exceeding 50 ppm, covering 13 acres. There are approximately 8 tons of PCBs in the river and harbor sediments.
>
> A temporary weighted plastic cover was placed over an area of PCB contamination just downstream from the city marina. This 110’ x 240’ cap covers a spot where PCBs were found up to 120 ppm at the surface. EPA completed this time critical ”removal” action in November 1993 because the site is considered a possible source of PCBs to Lake Michigan, especially if a major flooding event were to scour the PCB contaminated bottom sediments.
>
> Sampling included analysis for oil and grease. Sediments in the navigation channel were found to be contaminated with oil and grease, with an average value in the sample of 2900 ppm and a maximum of 8900 ppm.
>
> Discussions between the community, the potentially responsible parties, and EPA throughout 1994 and most of 1995 lead to a final determination by EPA regarding remediation for PCB contaminated sediments. EPA determined that it would dredge an area mostly north of the U.S. 2 highway bridge on the west side of the river by hydraulic dredging, including diver-assisted dredging. De-watered PCB contaminated sediments are being disposed of at a PCB disposal facility, sediments with low PCB concentrations are being disposed of at an in-state sanitary landfill. Treated water from dredging is being returned to the river after analysis indicates it to be clean.
>
> It is currently expected that PCB contaminated areas in the navigation channel downstream from U.S. 2 will be capped by the potentially responsible parties. The engineered cap will consist of a layer of geotextile membrane, 20” of clean sand, and 12” of stone armor. In areas of very high PCB concentrations, activated carbon will be added to the sand. This action will be completed by fall, 1996.

The Michigan Department of Public Health (now known as the Michigan Department of Community Health) issued a no-consumption advisory on common carp within the Manistique River in 1995 due to PCBs (Anonymous 1995). In 2001 the advisory remains as no consumption for common carp and restricted channel catfish consumption for women and children (one meal per month), and no restrictions for channel catfish consumption for the general population.

The MDEQ, Surface Water Quality Division is the lead regulatory agency for water quality in Michigan. Following is a brief summary of the programs they administer (Anonymous 2001d):

Nonpoint Source Control Program

The Nonpoint Source Control Program addresses pollution from diffuse or "nonpoint" sources, such as runoff from agricultural and urban areas during storm events. This is a non-regulatory program that provides technical and financial assistance to local units of government and other sources.

NPDES Permit and NPDES Permit Compliance Programs

Point source discharges are regulated through the National Pollutant Discharge Elimination System (NPDES) permitting program. Discharges to state waters from point sources such as municipal, industrial, or commercial facilities must be authorized by permit under the National Pollutant Discharge Elimination System. This is a federal permit system that has been delegated to Michigan. The permits specify limits on the amount of various pollutants that can be discharged as well as establish other conditions. The permits are valid for no more than five years, after which they must be renewed.

Michigan Department of Environmental Quality staff conducts a number of activities to assure that permittees remain in compliance with the permits. The permittees are required to sample their discharges and report to the state. Staff reviews these reports. In addition, staff inspect the facilities.

Storm Water Program

Storm water from urban areas and running off industrial and construction sites can carry pollutants to the receiving water. Also, when there is a high degree of impervious cover, storm drainage systems concentrate and transport the runoff to the receiving water much more rapidly, causing flashy flow conditions and an increase in erosion of stream banks. The Storm Water Program regulates discharges from large urban areas, some industries and construction sites of five acres or more through NPDES storm water permits that place conditions on the permittee.

As of 2001, there are five active NPDES permits issued in the Manistique River watershed under the Storm Water Program (Table 6). MDEQ, SWQD reports no afftects from these permitted discharges on the waters of the Manistique River system (Rich Corner, MDEQ, SWQD, personal communication).

Other Programs

Under the NPDES Permit Compliance Program, MDEQ SWQD also issues three individual permits to facilities for wastewater discharge into the watershed. These three facilities include the Manistique Paper Co., Inc., the City of Manistique, and the State of Michigan Camp-Cusino Correctional Facility. These sites are considered point source discharges and the MDEQ permits set discharge limits for each facility (R. Raisanen (MDEQ SWQD, personal communication):

> Manistique Papers had no wastewater treatment at all until 1960 when they installed settling ponds for the de-inking process, which came on line in 1959. In 1973 settling (primary treatment) was provided for all process waters. In 1977 the current biological treatment system was put on line.
>
> Manistique City installed primary treatment in 1958. In 1979 secondary treatment was installed. The Combined sewer overflows existed until 1990 when two were eliminated. One still exists but has not discharged since 1999.

> Camp Cusino did not have an impact on Hickey Creek until May 1998 when it first discharged. Prior to that the prison camp had a ground water system that did not discharge to the creek. They currently discharge treated effluent in the spring and fall and have had no compliance problems.

Laws Administered by the SWQD

Most state laws administered by the Surface Water Quality Division alone, or in conjunction with other Divisions of the DEQ, are contained in Parts 31 (Water Resources Protection), 41 (Sewerage Systems), and 88 (Water Pollution Prevention and Monitoring)of the Natural Resources and Environmental Protection Act, Act 451 of 1994. Details of Public Act 451 can be viewed on the DEQ Surface Water Quality Home Page available at: www.deq.state.mi.us/swq.

The DEQ SWQD also administers parts of the Federal Clean Water Act (CWA) including the National Pollutant Discharge Elimination System and Section 319 (Figure 42). The CWA is a 1977 amendment to the Federal Water Pollution Control Act of 1972, which set the basic structure for regulating discharges of pollutants to waters of the United States. The law gave EPA the authority to set effluent standards on an industry basis (technology-based) and continued the requirements to set water quality standards for all contaminants in surface waters. The CWA makes it unlawful for any person to discharge any pollutant from a point source into navigable waters unless a permit (NPDES) is obtained under the Act. The 1977 amendments focused on toxic pollutants. In 1987, the CWA was reauthorized and again focused on toxic substances, authorized citizen suit provisions, and funded sewage treatment plants (POTWs) under the Construction Grants Program.

The CWA contains provisions for the delegation of many permitting, administrative, and enforcement aspects of the law by EPA to state governments. In states with the authority to implement CWA programs, EPA still retains oversight responsibilities.

Stream Classification

In 1967, MDNR Fisheries Division developed a statewide stream classification system based on stream temperature, habitat quality, stream size, and riparian zone development. This classification system was developed to establish water quality standards for Michigan streams; assess stream recreational values; for designation of “wild and scenic” rivers; administering stream and stream frontage improvement and preservation; identification of dam and impoundment issues; administering fishing and boating access; and targeting fishing regulations, research planning, stream land acquisition, and potamodromous fisheries. The 1967 Fisheries Division classification of Manistique River watershed streams is presented in Figure 43. Minimal temperature data exist for many of the Tributaries-central streams and Mainstem-middle segment.

Special Jurisdictions

Portions of the Manistique River watershed are governed by agencies that have special jurisdiction over the use of water or lands associated with the water.

U.S. Army Corps of Engineers

The United States Army Corps of Engineers, Detroit District, exercises navigation jurisdiction over United States waters, laterally of the entire water surface and bed to the Ordinary High Water Mark elevation of 581.5 ft above Mean Water Level at Rimouski, Quebec.

The U.S. Army Corps of Engineers has been regulating the Nation's waters since 1890 (Anonymous 1985). The Corp's authorities are based upon the following laws:

> **Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403)** prohibits the obstruction or alteration of navigable waters of the United States without a permit from the Corps of Engineers.
>
> **Section 404 of the Clean Water Act (33 U.S.C. 1344).** Section 301 of this Act prohibits the discharge of dredged or fill material into the waters of the United States without a permit from the Corps of Engineers.

The Manistique River, from the mouth of the river at Lake Michigan upstream to the upper end of lumber slips at Manistique and 0.75 miles above the mouth, falls under both these jurisdictions.

Navigability

A navigable inland stream is (1) any stream declared navigable by the Michigan Supreme Court; (2) any stream included within the navigable waters of the United States by the U.S. Army Engineers for the administration of the laws enacted by Congress for the protection and preservation of the navigable waters of the United States; (3) any stream which floated logs during the lumbering days, or a stream of sufficient capacity for the floating of logs in the condition which it generally appears by nature, notwithstanding there may be times when it becomes too dry or shallow for that purpose; (4) any stream having an average depth of about one foot, capacity of floatage during spring seasonal periods of high water limited to loose logs, ties and similar products used for fishing by the public for an extended period of time, and stocked with fish by the state; (5) any stream which has been or is susceptible to navigation by boats for the purposes of commerce or travel; (6) all streams meandered by the General Land Office Survey in the mid 1800s (Anonymous 1993).

Log drives were regular occurances on many sections of the Manistique streams during the late 1800s (see **History**). The Michigan Supreme Court, in opinions rendered in 1886, indicated that the portion of the Manistique River in Schoolcraft County was suitable for floating logs on a commercial basis. The Indian River, Fox River, and portions of the Tributaries-central basin subwatershed also supported log drives.

Federal Energy Regulatory Commission (FERC)

The Federal Energy Regulatory Commission (FERC) has the right to exercise jurisdictional authority over waters that have been determined navigable by the Michigan Supreme Court by the test of floating logs. Any hydroelectric dams proposed for such waters would be required to obtain an operating license from FERC, under the Federal Power Act of 1935. There are no active hydroelectric dams on the Manistique River watershed as of the year 2001 and there are no proposals for the construction of any. Historically the Manistique Paper Co., Inc. dam, located in Manistique, generated hydroelectric power. This dam was decommissioned in the summer of 1991.

Natural and Scenic River Designation

The Fox River and its selected tributaries were designated as a Wild-Scenic River by the MDNR, Natural Resources Commission on November 3, 1988. A Fox River Natural River Plan, developed by MDNR, Land and Water Management Division, was adopted for use at that same time. This document states that the Fox River Natural River Plan will serve as a basis for preserving and enhancing the river's aesthetic, flood plain, ecologic, historic, and recreational values and uses. These objectives will be accomplished through state land and program management, as well as through local and state zoning.

The following portions of the Fox River system are designated and managed as a Wild-Scenic River under authority of Act 23, P.A. 1970 (see Appendix 1 for further details on development standards):

MAINSTREAM–All channels from its source above Casey Lake (T48N, R14W, Section 21) to the confluence with Lake Branch of the Manistique River (T45N, R13W, Section 25).

Casey Creek–From its source (T48N, R14W, Section 20) to its confluence with the Fox River.

West Branch–From the confluence of Pelican Creek (T48N, R15W, Section 26) to its confluence with the Fox River.

Spring Ponds (2)–One mile below the West Branch (T47N, R14W, Section 16).

Little Fox–From the outlet of Stanley Lake (T47N, R15W, Section 11) to its confluence with the Fox River.

Hudson Creek–From its source (T46N, R14W, Section 2) to its confluence with the Fox River (all channels).

EAST BRANCH–All channels from its source above the Reservoir (T47N, R14W, Section 1) to its confluence with the Mainstream.

Clear Creek–From its source (T47N, R13W, Section 15) to its confluence with the East Branch.

The plan also lists the special watercraft restrictions that are in effect through a combination of Marine Safety Act ordinances and state land use rules regarding launching and retrieval of watercraft. On the entire Fox River system, except the East Branch between M-28 and the mouth of Cold Creek (the Spreads) motorized watercraft will be prohibited. Motorized watercraft five (5) HP or less will be allowed on the East Branch between M-28 and the mouth of Cold Creek, subject to a SLOW-NO WAKE speed limit.

All local units of government in the Fox River watershed, except Burt Township in Alger County, have adopted local Natural River zoning ordinances. All zoning decisions are made at the local level. State zoning rules have not been adopted for the portion of river located in Burt Township. Implementation of these zoning recommendations is voluntary.

The Indian River is on the State of Michigan's "proposed" list for Natural River designation, but currently there is no active study ongoing. The Indian River is a federally designated Wild and Scenic River. This designation does not affect most private land, but does affect federal land management (details in Appendix 2). The USFS has developed an Indian National Wild and Scenic River management plan. The Escanaba USFS office oversees implementation of this management plan, and the Wild and Scenic River program makes zoning and management recommendations. The USFS has no zoning authority to mandate management actions, but recommends actions.

County Drain Commissions

Through the authority of individual County Drain Commissions, under the Drain Code (P.A. 40 of 1956), County Drain Commissioners have the authority to establish Designated County Drains. Schoolcraft County is the only county within the Manistique River watershed that has a specifically designated Drain Commissioner. Each of the other counties delegates the drain issues through their respective Road Commission office or addresses these issues during County board meetings. Luce and Mackinac counties delegate a person to be responsible for issues pertaining to the dams that affect the Manistique Lakes.

The Schoolcraft County Drain Commissioner is in charge of the Manistique River watershed dams that are located on Indian Lake and the Paper Mill Dam located on the mainstem at Manistique. This office is responsible for the annual dam inspection and with regulating lake levels.

Federal Government

Two primary federal agencies maintain land ownership and management within the Manistique River watershed. The USFS owns and manages the Hiawatha National Forest while the USFWS owns and manages the Seney Wildlife Refuge. Within the confines of the Seney Wildlife Refuge, the United States Department of Interior Park Service has designated the Strangmoor Bog National Natural Landmark.

The USFS, Hiawatha National Forest was established in 1931 and encompasses an East and West unit, collectively approximating about 880,000 acres of land. The East Unit is located east of the Manistique River watershed, while approximately half of the West Unit is located within the Manistique River watershed. Principle activities on the Forest include logging and recreation. Forest activities are managed from a supervisory office located in Escanaba Michigan, with three District Ranger Stations located at the Michigan towns of Munising, Manistique, and Rapid River.

The Hiawatha National Forest maintains management jurisdiction over seven campgrounds and fourteen developed boat launches within the Manistique River watershed (Tables 7 and 8). The Forest Service also governs the management of dispersed camping and undeveloped boat launches within the watershed.

The USFWS, Seney Wildlife Refuge was established in 1935 and encompasses an area 92,150 acres in size. The Refuge was founded to provide breeding and migration habitat for migratory birds including the Canada goose. The Refuge provides important habitat for ducks, bald eagles, osprey, loons, trumpeter swan, otter, beaver, black bear, moose, and timber wolves. Public use of the Refuge includes hiking, bicycling, hunting, fishing, wildlife observation, environmental education, and tours. The Refuge has 26 major pools that impound over 7,000 acres of open water.

Within the property boundary of the Seney Wildlife Refuge lays the Strangmoor Bog National Natural Landmark. The Strangmoor Bog is a 9,700 acre Federal Wilderness Area that is classified as a patterned bog. Patterned bogs develop differently than the bogs succession that is found in typical lake-filled depressions. Patterned bogs have a coarse elongated patterning in which string bog formations alternate with elongated strings of swamp forest. This pattern develops on a gently sloping landmass that is underlain with post-glacial sand knolls and sand dunes. While this bog is listed by the United States Department of Interior as a National Natural Landmark, the bog is owned by the USFWS and is managed by the Seney Wildlife Refuge. The Strangmoor Bog was designated as a National Landmark on October 29, 1975.

State Government

Michigan Department of Natural Resources

Within the Manistique River watershed, the influence of state government on land management activities and special jurisdictions occurs primarily through the MDNR and MDEQ.

The MDNR is the primary state government entity owning land within the Manistique River watershed. However, various MDNR Divisions manage aspects of this land. MDNR offices located in Newberry, Shingleton (Cusino Station), Thompson, Naubinway, Sault Ste Marie, and Escanaba each hold some management jurisdiction within the watershed.

The MDNR, Forest, Mineral and Fire Management Division manages the forest recreation programs the Lake Superior State Forest. Forest recreation programs are administered by the MDNR and include campgrounds (Table 8), pathways, water access, snowmobile trails, off-road vehicle trails, state trailways, and a marine safety program. Nine State Forest campgrounds are managed from the Shingleton Forest Management Unit and include: North Gemini Lake, South Gemini Lake, Ross Lake, Canoe Lake, Cusino Lake, Fox River, East Branch of Fox River, Merwin Creek, and Mead Creek. The Shingleton Forest Management Unit also manages three state pathways known as the Gemini Lake, Fox River, and Indian Lake pathways. The Sault Ste Marie Management Unit operates one campground within the watershed, the South Manistique Lake campground.

The MDNR, Wildlife Division, in addition to overseeing the broad range of wildlife issues on state lands, also operates the Cusino Wildlife Research Station. The original function of the Cusino Station was focused on the study of deer that were housed in penned in enclosures. Later wildlife studies included research on sharptail grouse, bobcat, bear, snowshoe hare, red fox, porcupine, woodcock, pine martin, otter, muskrat, and other wildlife species (Verme 1994).

The MDNR Parks and Recreation Division operates the Indian Lake State Park and Palms Brook State Park. The Indian Lake State Park consists of two campground units and the day use Palms Brook State Park. Palms Brook State Park is home to the Kitch-iti-kipi, also known as "The Big Spring". The Big Spring is Michigan's largest spring with a flow of over 10,000 gallons per minute of 45ºF groundwater (Anonymous 1997c). The spring pond is over two hundred ft across, approximately forty ft deep, and has a self guided observation raft for visitors to overlook the pond.

The Parks and Recreation Division also maintains jurisdiction over public boating access sites on 19 water bodies within the Manistique River watershed (Table 7).

The MDNR Law Division enforces Michigan annual fishing regulations (e.g., Anonymous 2002b). Law Division also works with Fisheries Division to develop these annual fishing regulations that are biologically and legally protective to the resource.

Michigan Department of Environmental Quality

The MDEQ is the lead regulatory agency for water quality in Michigan. Water Quality Standards following the Natural Resources and Environmental Protection Act (P.A. of 1994) have been developed to protect water quality of Michigan’s streams (Anonymous 1997a). Identified water quality standards for specific designated uses of Michigan streams are governed by law (Anonymous 1998b). Specifically, the MDEQ mission statement is "to drive improvements in environmental quality for the protection of public health and natural resources to benefit current and future generations" (Anonymous 2001d). As the lead regulatory agency, the MDEQ monitors river water quality and water uses within a watershed to ensure standards are met, to determine compliance with the law, and to document water quality conditions. Through this monitoring and their authority, the MDEQ supports various divisions that administer programs focusing on the protection of environmental quality (Table 9). Michigan Department of Environmental Quality Field Offices in Negaunee and Newberry facilitate state programs administered by MDEQ's Lansing main office.

Local Governments

Local governments maintain certain levels of jurisdictions within the watershed. Some recreational programs are operated at County, City, and Township campgrounds (Table 8). The MDNR has assisted these governmental units with grant monies and physical maintenance (e.g., dredging).

Biological Communities

Original Fish Communities

The glacial activity that shaped Michigan and the Manistique River watershed also played an important role in re-populating the area with numerous fish species. The Great Lakes region has 153 species of native fish. Connecting glacier-free refugia served as sources for re-population following glacial retreats. Three such areas of particular importance to the Great Lakes region were the Bering, Atlantic, and Mississippi refugia. The Great Lakes region was connected to the Bering drainage (refuge) by a lake and river system created along the face of the retreating Laurentide glacier. Current day Great Slave Lake and Great Bear Lake are part of this system. Lake trout, Arctic grayling, and northern pike were some of the fish species that used the Bering refugia (Bailey and Smith 1981). The Atlantic refugia extended east from the northern Great Lakes region to the Atlantic Ocean. Fossil remains of walruses discovered near the Straits of Mackinac (Handley 1953) are linked to the North Bay outlet that drained northern Michigan waters into the Atlantic Ocean. Fourteen species of fish populated the region solely from the Atlantic refugia. However, the primary source for re-population of fish species came from the Mississippi refugia. This refugia supplied 122 species of fish to the region (Bailey and Smith 1981).

These separate sources of re-population also account for discrete fish stocks within the region. For example, northern pike are native to the St. Lawrence drainage (Atlantic refugia) and the Bering drainage, but not the Mississippi drainage (Bailey and Smith 1981). Differences in northern and southern populations of northern pike suggest that they originated from different refugia (McPhail and Lindsey 1970; Morrow 1980).

Since the 1920s, surveys within the Manistique River watershed have documented 61 species of fish (MDNR, Fisheries Division, files). Before human settlement there were no physical barriers, such as dams or falls that prevented movement of fish. Fish distribution and abundance were determined by habitat suitability for each species, as well as thermal regime within habitat (Zorn 2002; Wichert and Lin 1996). Brook trout occupied riverine areas that received cold groundwater inflows, as well as spring fed ponds and thermally stratified lakes that connected to these rivers. Coolwater fishes occupied the lower reaches as well as the connecting lakes that possessed lentic environments. Interior lakes that did not connect with the river system were typically occupied by coolwater fish species. Fish communities found within impounded waters rarely include coldwater species but often include largemouth bass, northern pike, brown bullhead, yellow perch, and white suckers

Pre-settlement fish spawning migrations from Lake Michigan provided for establishment of fish species such as lake sturgeon, lake whitefish, round whitefish, lake herring, lake trout, white sucker, longnose sucker, and shorthead redhorse. Great Lake fish spawning runs were blocked in 1919 by the construction of the MPI dam. Landlocked lake sturgeon, lake herring, and sucker species have been able to sustain their populations (MDNR, Fisheries Division, files).

Factors Affecting Fish Communities

Human settlement of the watershed significantly changed the character of the river and the aquatic habitats that many fishes used. Modifying factors, such as sedimentation, damming, and loss of woody structure have lessened the biological productivity of the resource.

River logging drives contributed to extensive scouring of river channels and sedimentation of river beds (Bassett 1988), and removed large woody structure (Benchley et al. 1993). Ditching and draining of interior wetlands, to foster farming, further contributed sediment to the river system and altered groundwater flows (see **History and Hydrology**). The straightening of rivers to facilitate logging, combined with effects of ditching, increased the extremes of an alternating high and low flow regime, which further caused streambed scouring or sedimentation. An example of this type of affect is seen on lower Duck Creek (T43N, R14W, Section 28) where spring peak flows have caused river incising and stream bank scouring.

On the Indian River removal of large woody structure during logging greatly reduced habitat and aquatic invertebrates necessary for survival of coldwater fishes (Benchley et al. 1993). This loss of large woody structure significantly reduced abundance of trout. While sedimentation increased in immediate areas of dams used for log drives, this river system is predominately (98%) sand and no credible evidence indicates that additional sedimentation occurred elsewhere due to logging, nor has the river channel changed location from immediate pre-logging period.

Dam construction fragments rivers and interrupts free movement of fish (see **Dams and Barriers**). These barriers often prevent fish from accessing habitats required for spawning, nursery development, or thermal refuge during warm or cold periods. The lowermost dam on the system, the MPI dam, has had a negative affect in blocking spawning runs of important game and forage fishes, however it has also blocked spawning runs of pest sea lamprey (*Petromyzon marinus*).

Dam construction has also allowed coolwater predator fish to occupy waters that were historically unavailable to them, such as coldwater trout streams. Ponds within the Seney National Wildlife Refuge have provided habitat for northern pike and have enabled them to access to the Driggs River system. Similarly the Stanley Lake impoundment has facilitated the establishment of northern pike and enabled them to access the Fox River system. Water impounded behind dams is typically warmer than their respective streams and the discharged water often degrades the thermal character of the stream below the impoundment.

Increasing human access to the watershed has influenced the character of the biological communities that reside within. Early settlers and Native American Indians once accessed the watershed only by river routes or foot trails. Logging encouraged development of roads and trails into interior reaches. Trains, logging equipment, and motorized vehicles all crossed rivers and streams by bridge, culvert crossings, or open water fords. Throughout the 1900s road construction improved access and provided paved, gravel, and dirt roads to many areas not previously accessable by the rivers and railroads. The development of off-road vehicles (ORVs): snowmobiles, dirt-bike motorcycles, three and four wheel ORVs, and four wheel drive vehicles, all lead to improved access throughout the watershed. Some ORVs contributed to erosion when they crossed open areas of streams. Other forms of erosion are evident where these ORVs brought human foot-traffic to a steep streamside banks. Erosion and sedimentation resulted from many of these crossings or stream crossings that were improperly designed. Occasionally stream crossings were constructed with multiple or undersized culverts that became perched above the water level on the discharge end. Perched culverts prevent upstream movement of fish, crustaceans, and invertebrates which further fragments the river.

Human access to the Manistique River watershed has allowed for the introduction of non-native plant and animal species. Invasive species include plants (e.g., dandelion and phragmites), birds (e.g., European starling and English sparrow), and fish (e.g., brown trout and rainbow trout). Some introduced species are well integrated and accepted members of Michigan's flora and fauna (e.g., brown trout and rainbow trout), while others are considered a nuisance (e.g., sea lamprey). Both accepted and nuisance species will be discussed (see also **Pest Species**).

The USFWS, Seney Wildlife Refuge has altered flow regimes and consequently abundance of fish species within the Refuge. Damming of rivers to create impoundments have resulted in discharge of warm water into coldwater systems thus increasing abundance of species such as northern pike and brown bullheads (see **Dams and Barriers**). Channeling, dredging, and straightening of rivers (prior to acquisition by USFWS) have resulted in draining of wetlands and altering of surrounding land (see **Soils and Land Use**).

The most significant human-induced factors that have affected fish communities in the Manistique River watershed are removal of large woody structure, stream bank erosion, water quality (sedimentation, contaminants in lower zone, temperature), dams, ditching within the Seney Wildlife Refuge, human access, and road crossings. These issues will remain prominent in future resource planning.

Present Fish Communities

Currently, at least 60 species of fish inhabit the Manistique River watershed. Biological surveys since the early 1900s have documented the distributions of these various species of fish (Table 10). However, these data are sparse. Good, detailed survey information does exist for waters that are accessible, such as the Indian River. In many cases, no data exist for portions that are difficult to access such as the Tributaries-central basin.

Some fish species in the MDNR records have the potential for being misidentified. Redside dace (*Clinostomus elongatus*) were documented in the East Branch Fox River and Little Fox River, but are most likely northern redbelly dace that were incorrectly reported as redside dace. Occasionally individuals conducting fish surveys will refer to specific fish species by a common name and not the correct scientific name. Black bullhead (*Ameiurus melas*) was occasionally the term given to brown bullheads (*Ameiurus nebulosus*) that were collected in fisheries surveys in Straits Lake and Mead Creek. Lake herring (*Coregonus artedi)* in the Manistique lakes were referred to as whitefish. Similarly, the correct alternate name cisco was used for lake herring in the Manistique lakes and Indian Lake. Blacknose dace (*Rhinichthys atratulus*) and blackchin shiners (*Notropis heterodon*) are occasionally given the wrong name when observed in the field.

Michigan DNR fish collection data show that the riverine fish community follows fairly predictable distributions. Throughout the headwaters, the fish communities include: brook trout, blacknose dace, creek chub, Iowa darter, johnny darter, log perch, and mottled sculpin. Groundwater inflow is not as strong in the downstream reaches and fish communities found here are more characteristic of coolwater lentic habitats: northern pike, brown bullhead, largemouth bass, smallmouth bass, pumpkinseed sunfish, and rock bass. Lake dwelling fish species show a similar distribution with trout occupying deeper coldwater lakes, while centrarchids, esocids, and percids inhabit shallow coolwater lakes.

Coolwater fish communities are found in most waters not managed for trout. Typically coolwater lakes are waters that are thermally unable to support trout, or may be stream systems with minimal groundwater inflow. Coolwater fish communities are usually more diverse than coldwater fish communities. Coolwater species typically include: northern pike, northern muskellunge, largemouth bass, smallmouth bass, walleye, bluegill, pumpkinseed, black crappie, and yellow perch.

Brown and brook trout are the two trout species that occupy the river. Brook trout generally inhabit upper riverine reaches while brown trout occupy middle and lower riverine reaches of the Indian River and lower reaches of the East Branch Fox River. The Schoolcraft County section of Indian River is known to hold brown trout that range into the mid twenty-inch size.

Lake and rainbow trout occupy cold lake environments. No naturally reproducing stocks of these fish exist in the inland lakes. Lake trout are found in North Manistique Lake and Big Spring. Rainbow trout have occupied Schoolcraft County's Banana, Bear, Dodge, and Island lakes.

Lake herring, also part of the trout family, are found in the three Manistique Lakes and also in Indian Lake. Often, survey data will refer to these fish as cisco. Lake herring were a part of the original fish community of the Great Lakes and may have had free access to the watershed before the construction of dams. The populations of lake herring in the watershed are self sustaining and fluctuate according to annual year-class spawning success.

Lake sturgeon accessed the Manistique River watershed from Lake Michigan up until 1919 when the MPI dam was constructed. Historical data on sturgeon distribution are minimal, however photographic evidence from late 1800s logging and archeological evidence of Indian campsites have documented lake sturgeon along the Indian River and Manistique River (J. Franzen, United States Department of Agriculture, Forest Service, personal communication). Currently an occasional lake sturgeon is caught in Big or South Manistique lake or in Indian Lake.

Non-game fishes of the watershed include: white sucker, brown bullhead, burbot, and various minnow species. Non-game fishes are important forage for piscivorous fishes and birds and other wildlife. The abundance of these fish varies with annual spawning success and environmental conditions. While these species are occasionally sought by anglers, resource managers and the angling public often refer to these non-game fish as "rough fish".

Aquatic Invertebrates (except mussels)

Aquatic invertebrates and their abundance are indicators of stream habitat and water quality. Since many aquatic macroinvertebrates have long complex life cycles and specific ecological needs, their presence at sites within a watershed provides insight into the character of the water at that site (Merritt and Cummins 1996). Tolerances of invertebrate species to temperature, sediment, nutrients, and stream velocities are indicators of habitat quality and water quality.

As part of the non-point source surveillance program of MDEQ, staff of the Great Lakes and Environmental Assessment Section (GLEAS) conducted qualitative biological surveys on parts of the watershed in 1992, 1994, and 1999. These surveys followed GLEAS Procedure #51 survey methods. The GLEAS Procedure #51 is designed to assess the abundance and diversity of fish and macroinvertebrate communities present at a survey site, compared with an evaluation of physical habitat. The four habitat metric scores derived from Procedure #51 are: excellent, good, fair, and poor. Revised Procedure #51, modified in 1996, ranked macroinvertebrate diversity and abundance as excellent, acceptable, or poor.

In July 1991 and 1994, the Fox, East Branch Fox and Driggs rivers received GLEAS biological surveys. The Fox and Driggs river surveys showed that aquatic macroinvertebrate community densities were low. This ranking indicated reduced habitat quality, sedimentation, and low stream productivity (Taft 1992, 1994). These same surveys ranked macroinvertebrate community from "good" (Slightly Impaired) to "fair" (Moderately Impaired). Habitat data rated these sites from "fair" to "good", principally due to the detrimental effects of sedimentation (Taft 1992, 1994).

In fall 1999, GLEAS biological surveys were conducted on the Manistique, Fox, Little Fox, Indian, Little Indian, and Driggs rivers, and Big Murphy, Stutts, Mead, Delia's, and Mezik creeks. Macroinvertebrate sampling on these waters rated all sites as "acceptable" (Alexander and Goodwin 1999). Habitat at these sites was rated "fair" to "good". Alexander and Goodwin (1999) stated:

> Stations rated "fair" generally displayed higher levels of embeddedness and bottom deposition, and poorer bottom substrate/available cover, indicating an overall lack of usable habitat for macroinvertebrates and fish. The large amounts of bedload in these streams apparently limits colonizable macroinvertebrate habitat to woody structure, undercut banks, and vegetation rather than stable mineral substrate.

The most significant influence on invertebrate species composition, abundance, and distribution in the watershed is from sedimentation and lack of woody habitat (W. Taft, Michigan Department of Environmental Quality, Surface Water Quality Division, personal communication). Most of the watershed lacks in-stream woody structure. Lack of woody structure produces a uniform stream bottom, with few scours or unimpeded gravel stretches. Streams that lack woody structure have laminar flows and a homogeneous bottom comprised primarily of sand. Presently most available in-stream woody structure consists of tag alder branches and alder root wads. The watershed has good groundwater inflows and a stable flow regime, which should foster good macroinvertebrate diversity and abundance, however habitat deficiencies limit macroinvertebrate potential.

Aquatic invertebrate survey data are minimal or lacking throughout the remainder of the watershed. A complete inventory of the river's aquatic invertebrate community is needed to further document problem areas.

Mussels

Data from MDNR files suggest eighteen species of freshwater mussels could reside within the watershed (Table 11). No records exist of commercial harvest of mussels in the watershed, however freshwater mussel harvest operations once existed in lower Michigan (Wesley and Duffy 1999). It is unlawful to harvest or attempt to harvest living or dead mussels (except zebra mussels) in Michigan without a scientific collectors permit. A thorough inventory of mussels within the river system is needed.

Zebra mussels have not been found within the watershed above the Paper Mill Dam. Zebra mussels are present locally in the northern Green Bay waters of the Bays de Noc. Boating traffic from the Bays de Noc, or other zebra mussel infested areas, could transfer zebra mussels or their veligers to the Manistique River watershed (see **Pest Species**).

Amphibians and Reptiles

Ten species of frogs and toads, and seven species of salamanders are found within the watershed (Table 12). None are listed as endangered, threatened, or of special concern by the Michigan Natural Features Inventory. A thorough inventory of amphibians and reptiles within the watershed is needed.

Seven species of snakes and one lizard, the five lined skink, are found within the watershed (Table 12). Four species of turtles (Table 12) have been recorded. Two turtle species, the wood turtle and the Blanding's turtle are listed as being of "Special Concern" by the Michigan Natural Features Inventory (Anonymous 2002c).

Wood turtles (*Clemmys insculpta*, state special concern status) are known to occur within the watershed (Harding and Holman 1990; Anonymous 2002c). Wood turtles are found along rivers with sandy banks and nest on gently sloping sandbars. Wood turtles are not protected under state endangered species legislation, but the species is protected under the Director's Order on regulations on the take of reptiles and amphibians. The land snails (*Vertigo paradoxa* and *Vertigo hubrichti)* are the only species of mollusks/gastropods to occupy the watershed that are ranked as state species of special concern (Anonymous 2002c).

Birds

The Michigan Wildlife Habitat Database, developed by Michigan State University, documents 194 species of birds that inhabit or use the Manistique River watershed (Doepker et al. 2001) (Table 13**)**. These birds are linked to the watershed by habitats that they find favorable for their survival or they migrate through the watershed on their way to or from their breeding grounds. Twelve species of birds are listed as state threatened, four species are listed as endangered, and seventeen species are listed as special concern species (Tables 13 and 14).

Mammals

The Michigan Wildlife Habitat Database documents 49 species of mammals that inhabit the Manistique River watershed. One species, gray wolf, is designated as proposed to be delisted as state threatened status and federal threatened status. Moose is the only mammal listed as species of special concern (Table 15). Canada lynx is reported to have occupied the landscape until the mid 1960s, but no reported sightings have been documented since then.

Beaver are a valuable furbearer in Michigan, both economically as furbearers and ecologically as manipulators of riparian corridors. Beaver interact with lake and stream environments through feeding, damming, and colony development. Where desireable food supplies are available, such as aspen or birch, beaver colonys have often developed. In areas such as the Scotts Marsh on the Middle Branch of the Stutts River, beaver impoundments have provided valuble habitat for waterfowl such as Canada Goose, ducks, and other water obligate communities. In headwater streams, beaver damming of rivers can degrade trout habitat as the dams can act to warm water temperatures, block upstream migration of fish, and promote upstream channel sedimentation. Streams less than 50 feet wide, in the Tributaries – upper Indian River, and Tributaries – Fox River, are succeptible to trout habitat degradation through beaver damming. Beaver activity within the Tributaries – central basin, particularly on the Walsh Ditch, can act to prevent stream channel incising and capture of groundwater (see **Soils and land use *Tributaries – central basin***).

Wildlife Division actively manages beaver populations primarily through trapping. Wildlife Division and Forest, Mineral and Fire Management Division through habitat management for beaver or other species may also directly or indirectly manage beaver. Administration of beaver activity is accomplished through vegetation management along stream corridors and through the fur harvest trapping season. When beaver activity is problematic (i.e, damming of culverts or flooding of high value timber stands) MDNR Fisheries Division does not believe the status of beaver should be degraded to that of a nuisance animal that can be taken at any time. Fisheries Division supports that taking of beaver outside of the trapping season by a regulated permitting process. The MDNR beaver policy, guides State resource managers with land management procedures on headwater streams. The MDNR beaver policy states that all divisions, except for Fisheries Division, may issue permits for the control of nuciense beaver (Anonymous 2001a). Wildlife and Law Divisions typically issue control permits for private and agency requests.

Other Natural Features of Concern

The Michigan Natural Features Inventory (MNFI) maintains a list of state endangered, threatened or otherwise significant plant and animal species, plant communities, and other natural features (Table 14). The MNFI database lists seventy-five special concern species in the watershed. These include: thirty-two birds, two fish, one turtle, five butterflies, two snails, six land types, twenty-five plants, and two natural features (one bird nesting community and one of geographic nature) (Table 14). Lake sturgeon and lake herring are state listed as threatened.

The Strangmoor Bog National Natural Landmark, located in the Seney National Wildlife Refuge, is a natural feature of concern with respect to the uniqueness of the treeless string bogs. String bogs are more commonly found in northern boreal and subarctic regions. Strangmoor Bog marks the southern limit of patterned bogs on the North American continent (Heinselman 1965). Construction of Walsh Ditch in early 1900s bisected the Strangmoor bog and caused a dewatering of the south eastern portion of the bog. Dewatering caused changes in vegetation growth and breakdown of the thin peat surface soils found on these bogs.

At a size of two hundred ft in diameter and forty ft deep Big Spring (also known as Kitch-iti-kipi) is the state's biggest spring and a natural feature of concern. This spring delivers 10,000 gallons per minute of 45°F water to Palms Brook which flows a short distance into Indian Lake.

Aquatic Nuisance Species

Nuisance species are organisms that have been introduced into the watershed that negatively affect the equilibrium of biological communities. Pest species normally do not pose a problem unless their numbers become abundant.

Sea Lamprey

Ellie Koon, USFWS, Sea Lamprey Barrier Coordinator, provided the following summary of sea lamprey history and dynamics in the Manistique River.

> Sea Lampreys in the Manistique River
>
> Larval assessment and chemical treatment
>
> The first sea lamprey recorded in Lake Michigan was taken in 1936 from a commercially-netted lake trout near Milwaukee, Wisconsin (Smith and Tibbles, 1980). Sea lamprey were first noted in the Manistique River below the Manistique Paper Co., Inc. dam in 1956, when USFWS personnel electroshocked 13 larvae in the main river and 3 larvae in Weston Creek, a seepage channel that originates in bedrock faults above the dam and flows along the west side of the paper mill flume. These surveys were repeated between 1957 and 1963, and areas above the dam were also examined for sea lamprey reproduction, but no larvae were found.
>
> When the river was again surveyed in 1969, more than 100 sea lamprey larvae from several year classes were found in the main river below the dam and in Weston Creek. This prompted the first lampricide treatment in September, 1970. A combination of TFM (3-trifluoromethyl-4-nitrophenol)) and the additive Bayer 73 wettable powder (the 2-aminoethanol salt of 2',5-dichloro-4'-nitrosalicylanide) was applied to the main river from the railroad trestle just above the dam, and to Weston Creek at the railroad crossing west of Bear Avenue. Additionally, the granular formulation of Bayer 73 was applied to backwaters near the mouth.

During the 1971 to early 1974 field seasons, an extensive survey of the entire watershed was undertaken, consisting of a total of 278 stations. Sea lampreys had bypassed the dam and reproduced upstream. Larval distribution was restricted to the mainstream up to the vicinity of Germfask, a stream length of about 47 miles. In August of 1974, the Manistique River received its second lampricide treatment, this time including the reach upstream of the dam. Due to the complexity of the system, 23 separate lampricide applications were required. Treatment of Weston Creek was repeated in June of 1975, when surveys revealed that the 1974 treatment had not been completely effective.

Since the main dam appeared to be a sea lamprey barrier, it was postulated that sea lamprey were escaping upstream via Weston Creek. In 1974 an alternating-current electrical barrier was installed on Weston Creek on the east side of the main paper mill building. The electrical barrier was replaced in 1979 by a low-head dam to eliminate failures due to power outages. A temporary electrical barrier was installed upstream to evaluate the effectiveness of the low-head dam. There was no evidence to indicate that lampreys bypassed the dam. A portable assessment trap operated below the Weston Creek low-head dam captured 146 adult lampreys in 1979, confirming that adult lampreys were still trying to move upstream via Weston Creek.

During the 1976 to early 1981 field seasons, extensive surveys of the system continued. Only 4 sea lamprey larvae were found in the mainstream above the dam, hence the 1981 lampricide treatment included only the lower river and Weston Creek. The mainstream was treated with a combination of TFM and Bayer 73 wettable powder, Weston Creek was treated with TFM, and areas of the harbor and lower river received applications of granular Bayer 73.

Following the 1981 treatment, the stream continued to be closely monitored. There was no lamprey reproduction detected above the dam until June of 1985, when a few larvae were found in the vicinity of M77. The numbers of larvae were not considered sufficient to justify treatment above the dam, therefore the 1985 treatment included only the lower river and Weston Creek, and was conducted much as it had been in the past.

In the ensuing years, a similar pattern was seen, that is, larvae were fairly abundant below the dam with only a few individuals restricted to the mainstream above the dam. During the 1989 treatment of the lower river, treatment supervisors attempted to improve the distribution of lampricide by shutting off water to the flume and directing all flow through the east channel. This attempt had to be aborted due to a large volume of leakage through the east side of the flume wall, a foreshadowing of problems to come.

In recent years, lampricide treatments have been ranked annually according to cost effectiveness by comparing the number of larvae expected to metamorphose and leave the stream (derived from quantitative population estimates) with the estimated cost of treatment. Although sea lampreys continue to reproduce below the dam, numbers of larvae in the Manistique River have not been sufficient to justify the cost of another lampricide treatment since 1989. However, larvae have been gradually increasing above the dam both in numbers and distribution.

In 1995, a few larvae were found for the first time in an upstream tributary, Stutts Creek. Seven index stations were surveyed in 1996, with no larvae found. Surveys in 1998 showed that larvae were increasing in numbers in the mainstream above the dam, mostly consisting of the 1997 and 1998 year classes. The 1998 year class was found in the Driggs River near M28, about 50 miles above the dam, and Stutts Creek was once again infested. More surveys were conducted in 1999 and 2000 to delineate distribution and monitor growth. Larvae were found for the first time in the West Branch upstream of Stutts Creek. It appears that most of the larvae present above the dam are from the 1998 year class. A quantitative population estimate is scheduled for the 2001 field season, with the expectation that a full-scale treatment will likely be needed in 2002. The treatment is estimated to cost in excess of $525,000, depending on flow conditions and lamprey distribution.

Modifications to the dam

In recognition of the importance of the dam as a sea lamprey barrier, officials of Manistique Papers, Inc. have been extremely cooperative with the USFWS Sea Lamprey Management Program. In response to the increasing numbers of larvae found upstream, the paper company in fall 1998 repaired the downstream edge of the spillway below the easternmost Tainter gate, which provides virtually all the flow in the spring, and added a protruding steel lip. In spring 1999, sea lamprey barrier program staff inspected the dam during the peak of the lamprey run to try to determine the cause of increased escapage. They observed about 60 leaks through the east side of the flume wall, ranging from small upwellings to flowing streams. The worst example, surrounded by at least 30 attached adult lampreys, was a leak of about 7 cubic ft per second just downstream of the M94 bridge. An inspection of the dam revealed that once lampreys penetrated the east flume wall, they could likely swim up the inclined spillways of 13 bays on the dam's west side. Eight of these bays (bays 1-3 and 9 -13, numbered from the west side) were once used to manipulate flow with Tainter gates. Bays 4 - 8 had hydro turbines at their bases that were removed many years ago.

In 1999, at their own expense, the paper company built low concrete weirs across all of the bays within the flume to prevent lamprey passage. The lamprey barrier engineer inspected the work and determined by injecting dye that several bays had minor flows through deteriorated concrete underneath the weirs. The paper company then installed permeable geotextile in the problem bays secured by pea-stone gravel several ft deep. Most of the work was done in 1999 and some in 2000. Surveys scheduled for 2001 will reveal whether these modifications have solved the problem of lamprey escapage.

Lamprey adult assessment

Since 1977, the Manistique River has been an important component of a set of index streams that are trapped to provide estimates of Great Lakes adult lamprey populations. From 1977 to 1987 several portable assessment traps were set in the east channel below the dam during the spring lamprey migration. In fall 1987 USFWS adult assessment staff created an enhanced semi-permanent trap just below the dam by constructing the framework for a v-shaped steel-mesh weir that can be installed seasonally. The paper company manages spring flow in the channel by adjusting the eastern Tainter gate to provide attraction water for the lamprey trap and to maintain adequate flow over fish spawning habitat downstream.

Of about 13 lamprey traps operated annually on Lake Michigan tributaries, the Manistique River lamprey trap is the most important both for purposes of adult assessment and for collection of spawning-phase male lampreys for the sterile male release technique. The Manistique River trap is the most efficient of all traps operated on Lake Michigan tributaries, that is, it captures more than 50% of upstream migrants. Almost 90% of all the adult sea lampreys annually trapped from Lake Michigan tributaries come from the Manistique River. A mark-and-recapture population estimate each year helps to provide an index of lake-wide lamprey numbers.

The Manistique River trap also supplies more lampreys for the sterile male program than any other site in the Great Lakes. Male lampreys collected from the Manistique River are transported to the Hammond Bay Biological Station near Rogers City, sterilized and released into the St. Marys River to supplement other control methods. More than 26,000 sterilized adult male sea lamprey were released into the St. Marys River in 1999, of which about a third came from the Manistique River.

Other Aquatic Pest Species

Other aquatic pest species that could affect the watershed include zebra mussel (*Dreissena polymorpha*), spiny water flea (*Bythotrephes cederstroemi*), round goby (*Neogobius melanostomus*), tubenose goby (*Proterorhinus marmoratus*), rusty crayfish (*Orconectes rusticus*), Eurasian ruffe (*Gymnocephalus cernuus*), three spine stickleback (*Gasterostreus aculeatus*), white perch (*Morone americana*), and the crustacean *Cercopagis*. Each of these aquatic organisms exists in Michigan's Great Lakes watershed and could become pestilent species if they colonized the Manistique River watershed. Survey efforts were conducted in 2001 on the Manistique Lakes and Indian Lake, looking for spiny water flea of which none were found.

Purple loosestrife (Lythrum salicaria) and Eurasian milfoil (*Myriophylum spicatum*) could be pestillant plant species in the watershed. Data on presence and distribution does not exist. Purple loosetrife is quite common along the Lake Michigan coastal dune areas within the City of Manistique.

Forest Pest Species

Native forest pest species include the spruce budworm (*Choristoneura fumiferana*), jack pine budworm (*Choristoneura pinus pinus)*, and forest tent caterpillar (*Malacosoma disstria*) (Heyd 2002). Non-native forest pest species include Beech bark disease *(Fagus grandifolia)*, larch casebearer (*Coleophora laricella*), and gypsy moth (*Lymantria dispar)* (Heyd 2002).

Fisheries Management

From the early 1900s through the 1980s, MDNR fisheries management focused primarily on development and maintenance of sport fish populations. While waters located within Seney Wildlife Refuge were managed for sport fish, maintenance of fish populations for fish eating birds was also a prominent management goal. Beginning in the late 1990s emphasis was shifted to more holistic management and naturally functioning systems. This evolution of philosophy mimics fisheries management changes that transpired through the twentieth century.

Early fisheries management began in the 1920s with surveys to identify and document fish populations (Taylor 1954). Later in the 1930s, fish stocking was one of the first management tools used. Stocking resulted in numerous plants of walleye fry, bass, and various species of trout (brook, rainbow, brown). In-stream fisheries habitat management programs were introduced during the 1930s post depression era by the Civilian Conservation Corps (CCC). After World War II, the state fish hatchery system grew to almost 100 hatcheries and fish rearing stations (Anonymous 1974a). From 1945 to 1964, the state was stocking legal-size trout into many creeks and rivers (MDNR, Fisheries Division, files). Fisheries management from 1964-2000 incorporated fish stocking, habitat restoration, and research in day-to-day functions. Public education, land acquisition, access improvement, and coordination with other governmental units have been an instrumental part of modern fisheries management.

Beginning in the 1980s fish management began to employ a holistic ecosystem approach to managing fish populations. Management gave more emphasis to issues such as watershed based dynamics, connectivity of rivers, forage and non-game fishes, reptiles and amphibians, and a departure from single species lakes. More attention was given to appropriate system functionality and a lessening of biological manipulation to develop sport fisheries. The annual number of lakes chemically treated to eradicate fish species has declined. Walleye, tiger muskellunge, and trout stockings ceased in waters that showed poor returns to the creel.

Fisheries management was originally a responsibility of the MDNR. Additional fisheries programs were developed in the latter half of the 1900s by the USFS, Hiawatha National Forest and the U.S. Fish and Wildlife Service (USFWS), Seney Wildlife Refuge.

The Great Lakes Fishery Commission (GLFC), USFWS, Chippewa-Ottawa Treaty Fishery Management Authority, and the MDNR are signatory parties to the Great Lakes Fishery Commmission's Fish-Community Objectives for Lake Michigan (Eshenroder, et. al. 1995). The MPI dam has acted to block Great Lakes fishes from ascending the Manistique River during spawning runs. Contributions of fish from the watershed, to the Lake Michigan fish community have therefore been negligible. If fish passage were facilitated, annual spawning recruitment would have some level of influence on the Lake Michigan fish-community objectives. These objectives place a high priority on the restoration and enhancement of historic riverine spawning and nursery areas for anadromous species, with control of sea lamprey. Self-sustaining stocks of warmwater fish, whitefish species, sturgeon, and native fishes, would be aided if fish passage occurred.

MDNR management over the years has focused on fish stocking, habitat restoration, and establishing a balanced predator-prey relationship within inland lakes and streams. Regularly scheduled lake and stream surveys served to document resource deficiencies and population imbalances. Prescribed management actions were derived from the results of these surveys.

Recreational anglers fishing inland lakes have targeted their efforts on coolwater predators such as walleye and northern pike, and warmwater predators such as largemouth bass. Fisheries managers have worked to maintain good populations of these cool and warmwater predators. Despite these management efforts, a typical management problem developed when predators were over-harvested in a lake and resulting forage fish populations would proliferate. Once the predator base was cropped off, the dominant fish species in a lake often became yellow perch, white sucker, and brown bullhead. Management tools that have been implemented to restore the predator-prey relationship included fish stocking, manual removal of fish via netting or chemical eradication, in-stream fish barriers (e.g., to prevent non-trout fishes from migrating upstream into a trout lake), spawning habitat construction (e.g., walleye reefs, pike marshes), and angling harvest control via angling regulations.

Sport fishing regulation has been a tool used to achieve various results in harvest, fish population abundance, and species size structure. The Big Island Lake Wilderness area has fishing regulations in effect that are more restrictive than general state-wide regulations, to produce better size structure and predator-prey balance within these waters. Quality fishing regulations on the East Branch Fox River and lower Indian River were introduced to improve the size structure of trout populations within those waters (MDNR, Fisheries Division, files). Fishing regulations between MPI dam and the mouth of the Manistique River allow anglers to fish trout and salmon year-round.

Fisheries managers have used walleye stocking in coolwater lakes to provide an effective predator for stunted prey species (Schneider and Lockwood 2002) (Table 16). Walleye also provide a desirable recreational sport fish (see Appendix 4 for angler catch data). Stocking of walleye and muskellunge occurs on an every other year basis to bolster populations of wild fish or to develop a sport fishery in areas where sport angling use is high.

While some lakes have habitat suitable for natural reproduction of walleye, many lakes are dependent upon regular stocking to maintain a viable fishery. Walleye fry were stocked in numerous lakes during the 1930s and early 1940s. The development of a walleye propagation program by MDNR in the 1970s enabled fisheries managers to stock larger fingerling size walleye in these coolwater lakes.

During the 1970s and 1980s the MDNR used Big Manistique Lake as a source for walleye egg collection. In the 1980s, the abundant population of walleye in Little Bay de Noc enabled fisheries managers to collect eggs more easily than from Big Manistique Lake. Walleye eggs were hatched at the Thompson State Fish Hatchery and reared in outdoor borrow-pit ponds. Fingerlings raised from this walleye culturing project were used to stock many inland and Great Lake waters in the Upper Peninsula of Michigan. Walleye fingerlings used for stocking within the Manistique River watershed since the late 1980s are progeny of Little Bay de Noc fish.

The trout fishery has also been a popular draw to anglers. Trout have been managed in both lake and stream environments to support recreational fisheries. Both wild and stocked fisheries have been present throughout the State of Michigan since the early 1900s. Fisheries managers have used trout stocking to supplement wild stocks or to create fisheries where natural reproduction was limited (Table 16). Habitat enhancement has been used to improve spawning, reduce sediment bedload, add woody structure, and improve holding cover for river populations. Lake populations of trout survive best when there are no competing species of fish present. To create a lake that is free of competing fish species, fisheries managers have used netting or chemicals to thin or eradicate populations of non-trout fishes. Trout species used for riverine fisheries included brook and brown trout. Trout species used for lake fisheries have included brook, brown, rainbow, and lake trouts.

Riverine populations of brook trout occupy a greater portion of the watershed than brown trout. Most suitable riverine portions of the watershed are managed to protect and enhance wild brook trout populations. However, certain areas receive annual plants of state hatchery-reared brook trout. Trout planting is conducted to augment small populations of fish or to sustain a sport fishery in areas where sport angling use is high. Brook trout have been regularly planted in North Branch Stutts Creek, Middle Branch Stutts Creek, Indian River, Little Indian River, Big Murphy Creek, Driggs River, and Fox River. Periodic plantings have occurred elsewhere in the watershed.

Lake dwelling species of trout within the watershed include brook, brown, rainbow, lake trouts, and the hybrid, splake. Most lake fisheries for trout are sustained by annual plantings of state hatchery-reared fish. Numerous small ponds, that have connections to gravel bottom streams, have self sustaining brook trout fisheries. The stocked lakes are varied in geographic distribution, but are primarily located in portions of the Indian River watershed or the headwater region of the Driggs River system.

Centrarchids (sunfish family) have also provided abundant angling opportunities throughout the watershed. Largemouth and smallmouth bass, bluegills, black crappie, and rock bass are present in many of the coolwater lakes (Appendix 3). Management of centrarchids has focused on size structure and growth rate. When stunted populations occur or persist, thinning of these populations has become common practice. Population thinning is accomplished by removing fish during netting efforts or by bolstering predator populations. Walleye have been an effective predator that use centrarchids for forage, particularly during winter months (Schneider and Lockwood 2002; Schneider and Breck 1997). However, some centrarchid fisheries have been depressed following introduction of walleye. Limited stocking has occurred with pond-reared fingerling smallmouth bass.

Esocid fisheries are comprised primarily of northern pike (Appendix 3). Northern muskellunge exist in a few select lakes. Tiger muskellunge, the hybrid cross between male northern muskellunge and female northern pike, were stocked periodically in the 1980s. Hatchery-reared northern pike were also occasionally stocked to augment depressed populations, while netting has been used to thin populations of stunted fish. Regulations have been used to manage both stunted and fast growing populations. To increase harvest no-minimum size requirements are used on stunted populations. To reduce harvest, increased minimum size requirements are used on fast growing populations.

Minimal lake sturgeon management has been implemented in the Manistique River watershed. Lake sturgeon management actions are required to follow guidelines intended to conserve and rehabilitate self-sustaining populations. These procedures are set forth in the MDNR Lake Sturgeon Rehabilitation Strategy (Hay-Chmielewski and Whelan 1997).

Mainstem – upper

Fisheries management within this subwatershed focused primarily on the three Manistique lakes and Black Creek Flooding.

Black Creek Flooding, located immediately east of Big Manistique Lake, was created in 1956 as a wildlife flooding by the MDNR Wildlife Division. Construction of a dam at the old railroad grade created the flooding. Previous to impounding, the marsh was one to six ft deep with a sand, peat, and clay bottom. A fisheries survey in 1952 found that numerous pike used the marsh area for spawning in spring. The water control structure in the impoundment is often ineffective as the dam is inundated when the lake level on Big Manistique Lake is elevated. Current survey data are not available.

The Manistique lakes have been managed to support coolwater species of fish. North Manistique Lake, also known as Round Lake, is managed as a two-story lake with coolwater species and trout species featured (Table 16). Walleye and northern pike are the top predator species found in each of these three lakes, with muskellunge found in Big and South Manistique lakes. Natural reproduction of walleye and northern pike is sufficient in the Big and South Manistique lakes to maintain a reasonable sport fishery; however, occasional stocking took place when natural recruitment has been low. North Manistique Lake needs regular walleye planting to maintain its fishery. Muskellunge are periodically stocked in South Manistique Lake to support that fishery. Yellow perch, bluegill, and smallmouth bass provide attractive sport fisheries in each of the Manistique lakes and populations of those fish fluctuate in relation to annual year-class recruitment and abundance of predator fish populations. Lake herring are present in each of the three Manistique lakes and their abundance is also closely tied with year-class recruitment and predator populations.

Mainstem – mouth

Fisheries management below Indian Lake is focused primarily on fish stocking in the waters below the MPI dam. Currently, the MDNR stocks steelhead and chinook salmon each spring in the lower river. There are strong spring and fall spawning runs of salmonids which are targeted by sport anglers. The extreme hydraulic force of the river in this region, during spring snowmelt, precludes any physical habitat improvement projects such as spawning riffles or fish cover structures. There remains an abundance of in-stream slab wood and woody structure on the river floor, left from the logging and shipping era of the early 1900s.

Tributaries – Fox River

Primary management activities in the Tributaries-Fox River focus on the Fox River system and on a scattering of 5 brook trout ponds. Coolwater species of fish occupy the lakes within the upper reaches of this subwatershed (see species distribution map). One waterfowl flooding, Stanley Lake, exists on the headwaters of the Little Fox River.

The Fox rivers are known for good brook trout fishing opportunities. Prior to 1964, the entire Fox System was stocked with legal brook trout (Anonymous 1988). Except for the Mainstream and portions of the upper East Branch, where sediment problems occur, natural reproduction is sufficient and currently good populations of brook trout are maintained.

The headwater of the Little Fox River is Stanley Lake, an impoundment formed by a dam across its outlet. Stanley Lake was used as a logging reservoir control structure in the late 1800s. The dam was replaced in 1950 to maintain the Stanley Lake Flooding for waterfowl. Northern pike, brown bullheads, white suckers, yellow perch, and pumpkinseed comprise the lake's fishery. Fisheries management efforts here have targeted reduction of white suckers and brown bullheads to reduce their competition with other fish species. In 1981, a fisheries survey conducted by MDNR, Fisheries Division documented an over-abundance of bullheads and white suckers. Population thinning with trap nets was warranted. Northern pike are suspected to escape this impoundment and move throughout the Fox River system (J. Waybrant, MDNR, Fisheries Division, personal communication).

The East Branch Fox River is known for supporting an excellent brook trout fishery. Population estimates of brook trout ≥7.0 inches at two sites in 1981 were 38.0/acre and 20.8/acre, and 43.8/acre at one site in 1984 (MDNR, Fisheries Division, files). Michigan trout stream Type-2 fishing regulations have been put into place on this stream to protect this quality fishery (see Anonymous 2003 for definitions of Type-2 and other trout regulations). Extensive in-stream habitat improvement work has been carried out since the 1930s. This habitat work includes installation of wing deflectors, digger logs, stump covers, willow planting, and erosion control. Anglers generally access the East Branch Fox River at highway M-28 and motor upstream by small boat to an area known as the Spreads, then fish their way back downstream. The stream reach in Luce County is currently managed as a no wake zone (Anonymous 1988).

Tributaries – central basin

The waters of the Tributaries-central basin include the larger rivers and creeks: Driggs, Walsh, Ducey, Duck, Sturgeon, Smith, Hay Meadow, Marsh, Stoner, Creighton, Commencement, Star, Praire, Hickey, and Stutts; as well as numerous smaller named and un-named systems. Numerous lakes containing coolwater fish species are found within this subwatershed. There are no trout lakes.

Primary stream management efforts by the MDNR have focused on the Driggs River. Efforts to stabilize eroding stream-banks have used rock to armor raw banks and tree revetments to cushion river currents. Most of this work, conducted by the MDNR, has taken place upstream of State Highway M-28. Similar work has occurred downstream on the portion that flows through the Seney Wildlife Refuge. Unlike the Fox River, the Driggs River did not receive any habitat improvement work during the CCC era or with the MDNR Lake and Stream Improvement Program.

Primary stream management efforts by the USFS have focused on the Stutts Creek system. The North Branch, Middle Branch, and South Branch Stutts Creek were targeted by USFS habitat improvement programs, and received sediment basins and brook trout spawning riffle construction. Fenton Creek, a tributary to the Middle Branch, also received a brook trout spawning riffle.

The USFS conducted speckled tag alder removal programs along the riverine floodplain on each of the Stutts creeks during the late 1970s, but primarily on the North Branch within a 6-acre project area below highway M-94. On the North Branch, in this 6-acre tag alder removal zone, alder was cut and removed from the river's edge to the conifer river-plain edge. The cut alder stumps were treated with herbicide to inhibit the sprouting and re-growth of the vegetation. This alder removal program was implemented to achieve three objectives: 1) to allow increased sunlight penetration, which results in increased productivity of terrestrial and aquatic insects, 2) allow growth of streamside grasses and 3) encourage the stream to scour its bed into a rectangular configuration, which increases trout cover

(MDNR, Fisheries Division, files). The MDNR files do not show any post treatment evaluation of this project and by the middle 1990s much of the tag alder had re-grown to pre-treatment conditions.

Scott's Marsh is a 20,000-acre waterfowl impoundment managed by the USFS at the headwaters of the Middle Branch Stutts Creek. Here three water-control structures and a series of dikes maintain approximately 850 acres of impounded water at a depth of 3.5 ft (K. Doran, USFS, personal communication). The USFS fisheries data document presence of central mudminnows, golden shiners, brook sticklebacks, brown bullhead, white sucker, and rock bass.

Management of the inland lakes has sought to maintain proper predator-prey balances. Predator stocking of walleye in Gemini Lake and muskellunge in Cusino Lake has worked well in developing quality sport fisheries. Manual removals of brown bullheads in Nevins Lake were conducted to reduce this dominant rough fish species.

Efforts to increase the amount of woody structure in lakes were accomplished by installing wooden cribs, brush bundles, or shoreline tree drops. Boot, Steuben and Clear lakes were the recipients of USFS programs to increase the presence of woody habitat that fish use for overhead cover and spawning.

The Refuge manager governs fisheries management goals on the Seney Wildlife Refuge. While the primary goal of the Refuge ponds is waterfowl production, recreational fishing and fish production are also important priorities. Water levels on over 7,000 acres of refuge habitat are managed using a system of water control structures and dikes. (Anonymous 1998a).

Tributaries – upper Indian River

The upper Indian River offers good fisheries opportunities for both coolwater and coldwater management. Numerous lakes and streams dot this subwatershed. Physical stream habitat improvement structures such as in-stream wing-dams and bank stabilization were first implemented during the CCC era. Later habitat improvement projects by the MDNR included in-lake fish cribs and in-stream spawning riffles. In 1978 the USFS began a fisheries management program and to-date they have completed numerous habitat projects which include in-lake fish cribs, lake spawning reefs, lake shoreline tree-drops, in-stream spawning riffles, bank stabilization, in-stream cover development (half-logs, bank covers, root wads), and sand traps.

Brown trout are a prime sportfish species in the Indian River, Schoolcraft County. The remaining portion of the Indian River, Alger County, is managed for brook trout. The Indian River drains a landmass that is sandy and low in nutrients and does not have the ability to produce an abundance of large brown trout. For this reason, Type-2 fishing regulations (Anonymous 2003) have been set for the section of Indian River located in Schoolcraft County (see **Recreation**). Within the Manistique River watershed, brown trout are stocked primarily in the Indian River system.

The Big Island Lakes Wilderness area is a tract of land approximately 6,000 acres in size located in western Schoolcraft County. The Big Island Lakes Wilderness Area was designated as part of the Michigan Wilderness Act of 1987. Twenty-two lakes are situated within this complex. A memorandum of understanding between the USFS and the MDNR was established in 1995 to provide a protocol on how fisheries management will occur within this area. Motorized or wheeled equipment is prohibited. This restriction presents challenges for surveys or fish plants within this area. Aerial fish planting is not permitted within the Wilderness complex. Trout and muskellunge stocking is accomplished by carrying fish in buckets from the hatchery truck to each respective lake.

The USFS has improved in-lake fish cover with construction of fish cribs and by felling shoreline trees into the water. Fish cribs have been installed in Petes, Council, Lion, Halfmoon, Bar, Steuben, East, Thunder, Triangle, Fish, Corner, Skeels, Wedge, and Mowe lakes. Shoreline tree drops have been implemented in Kimble, Fish, Bar, Swan, McComb, Pete's, and Lion lakes.

Fisheries management goals in the upper Indian River have mirrored goals in the rest of the watershed in trying to sustain proper predator-prey relationships in lake and stream environments. In lake systems population thinnings via netting or chemical reclamation have been used to improve growth and survival of sportfish populations. Likewise, predator stocking using walleye, largemouth bass, smallmouth bass, northern pike, or muskellunge has also been used to improve species structure in lakes.

The USFS has managed in-stream sand bedload of the Indian River with bank stabilization and in-stream sediment traps. To date, approximately 3,495 ft of riverbank, consisting of 17 individual eroding banks, have been stabilized (C. Bassett, USFS, personal communication). Some debate exists as to the effectiveness of these management actions (see **Channel Morphology**).

The Little Indian River, Delias Run, and Carr, Little Murphy, and Big Murphy creeks each support populations of brook trout. These USFS habitat improvements have focused on sediment management, spawning riffle construction, and in-stream cover development. Over 1,000 lineal ft of log-bank cover development has been implemented on Carr Creek with additional log-bank cover development on Big Murphy Creek (C. Bassett, USFS, personal communication). Brook trout spawning riffles have been constructed on all of the creeks.

Tributaries – lower Indian River

Fisheries management in this subwatershed has focused primarily on Indian Lake. Indian Lake supports a coolwater fish community (Appendix 3 and 4) with walleye, smallmouth bass, northern pike, yellow perch, and bluegills being the most prominent species that attract sport angling.

Iron Creek is just upstream from Indian Lake. Historic MDNR survey data shows that brook trout have never been documented in this water and white suckers frequent the creek during spring spawning runs.

Also upstream of Indian Lake, Big Ditch drains into Barnhart Creek, which ultimately becomes Dead Creek immediately north of Indian Lake. No fisheries survey data exist for Barnhart or Dead creeks, however on November 3, 1978 the USFS surveyed five stations on the Big Ditch. The following is a note to the file by USFS fisheries biologist Chuck Bassett regarding the 1978 survey of Big Ditch:

> Big Ditch was constructed in the early 1900's to facilitate drainage of an area on which mint was grown. Spoil banks 8-15 ft. high along the ditch are eroding severely in scattered areas as the stream develops a natural meandering pattern.
>
> Groundwater input keeps midsummer water temperatures below 60° F and prevents ice formation in all but the very coldest weather.
>
> Invertebrate and vertebrate food supply is exceptionally good compared to other streams in the area despite the sandy substrate and moderate turbidity. Brook trout are reproducing, but the population is sparse. Specimens were in very good condition.
>
> Habitat improvements needed are bank stabilization and cover structures, and spawning riffles. Brook trout stocking is highly recommended.

Considerations Regarding Upstream Passage of Great Lakes Fishes

Numerous rivers in Michigan have dams located near their Great Lakes confluence. These dams prevent fish migrations upstream into interior watersheds. Blockage of fish migrations has denied vast expanses of spawning grounds and nursery habitat for fish such as: trout, lake whitefish, round whitefish, walleye, lake sturgeon, lake herring, rainbow smelt, northern pike, sunfish family (basses), suckers, and minnows. The inability of certain sport fishes to access spawning habitat has necessitated fish stocking to maintain recreational fisheries.

In the early 1990s, the issue of Great Lakes fish passage at Manistique was debated among staff from MDNR, MDEQ, USFWS, MPI, and the Great Lakes Fishery Commission. Manistique Paper Co., Inc. dam was decommissioned in 1987 as a hydroelectric generating facility and, following the cessation of electric generation, MPI had no need to maintain a full storage impoundment behind the dam. In summer 1990 MPI drew down the water level in the reservoir. This action precipitated discussions between MPI and governmental units on where future water levels should be maintained to prevent passage of sea lamprey. The issue of Great Lakes fish passage into the mainstem became a part of the discussion.

As the MPI dam discussions developed, a concept was proposed that established a fixed crest sill on the dam, an in-stream lamprey trap, and a lock system that would facilitate the movement of lake sturgeon and walleye through the dam. This concept provided blockage of sea lamprey during spring spawning runs but would possibly allow fish to have free access to the river after the spring lamprey run. This proposal was reviewed by the USFWS. The USFWS, in a memo to MDEQ, established a position that passage of any species would pose a risk to bald eagles nesting upriver because of chemical contaminants present in Great Lakes fish (Kubiak, USFWS, personal communication).

The MDNR, in internal memos, discussed the opportunity to pass steelhead and salmon into the Manistique River mainstem with blocking weirs installed at State Highway M-28 to prevent upstream fish movement into the Fox and East Fox rivers. Blockage of steelhead and salmon to the Fox rivers was proposed in an effort to prevent competition and resultant degradation of the resident brook and brown trout fisheries that existed in these rivers.

The issue of fish passage into inland watersheds has prompted debate among resource managers throughout the Great Lakes region. The concern raised is over potential transmission inland of chemicals in the flesh of migrating salmon. These chemicals may pass through the food chain to inland fish eating animals, possibly resulting in impeded growth and reproduction. However, recent literature indicate that contaminant levels within Lake Michigan, as well as other Great Lakes, continues to decrease through time (Annonymous 2002a). Corresponding to these decreases are increases in picivoris birds such as bald eagles. Currently, Michigan bald eagle nesting pairs have surpassed 400 and eagles are currently proposed to be delisted from threatened designation by state and federal agencies.

Issues regarding upstream passage of Great Lakes fishes were also addressed in the Au Sable River Assessment (Zorn and Sendek 2001):

> Passing Great Lakes fishes into the upper portions of the Au Sable River has the potential to re-establish spawning runs of native (lake sturgeon, walleye, whitefish, suckers) and naturalized (chinook salmon, coho salmon, steelhead, brown trout) fishes, and restore self-sustaining fish populations in the river and Lake Huron. Substantial fishery, recreational, and economic benefits would result from these spawning runs. Some of these fishes, however, contain elevated levels of chemical contaminants in their tissues that would be introduced into upstream reaches as fish spawned and died. These chemicals are essentially absent in fishes from the Au Sable River above Foote Dam. The

effects of these introduced chemicals on animals co-habiting upstream reaches have been a cause of concern. Bioaccumulation of these chemicals could lead to adverse effects on populations of fish-eating carnivores, such as bald eagle, cormorant, osprey, great blue heron, kingfisher, mink, and river otter.

High concentrations of specific contaminants, such as PCBs and other polychlorinated hydrocarbons, in fish and other aquatic prey, such as gulls, can have chronic effects on reproduction and health of carnivores, including bald eagles, mink, and river otter (Ludwig et al. 1993). Dioxins, dieldrin, PCBs, and DDE are the primary contaminants that affect bird reproduction and PCBs are the primary contaminants affecting mink and river otter. PCB concentrations in Lake Huron fish have declined since the early 1980s and are at low (relative to the other Great Lakes), stable levels (Day 1997). Effects of declining contaminant levels are also apparent in fish eating birds. Double-crested cormorant population levels have increased an average of 29% per year over the last 20 years (Ewins 1994). Eagle populations have also rebounded dramatically. The number of breeding pairs in Michigan has increased from 87 in 1977 to 273 in 1996 (J. Weinrich, MDNR, Wildlife Division, unpublished data). The Northern States Bald Eagle Recovery Plan set a recovery goal of 140 nesting pairs in Michigan with an average production of at least 1.0 fledglings per occupied nest (Sprunt et al. 1973). The 140 nesting pair criteria was surpassed in 1987, and the 1.0 young per nest value has been nearly achieved (1992-1996 mean productivity = 0.99 fledglings per occupied nest; T. Weise, MDNR, Wildlife Division, unpublished data). Bowerman et al. (1995) noted that the percent increase in bald eagle nesting areas between 1977 and 1993 was faster along the Great Lakes than in inland areas…. The rate of increase for all types of nesting areas would be expected to level off through time as eagle pairs occupy the limited number of suitable areas. Productivity of Great Lakes shoreline and anadromous (within 5 miles of the shoreline) nesting eagles increased during this period while that of inland eagles remained relatively unchanged…. Sprunt et al. (1973) mentioned that stable eagle populations require a productivity rate of 0.70 fledglings per occupied nest, and healthy populations require a productivity rate of 1.00 fledglings per occupied nest. For the 5-year period from 1992-1996, Lower Peninsula eagles had productivity rates of: anadromous- 0.97; Great Lakes- 0.80; and inland- 1.20 (T. Weise, MDNR, Wildlife Division, unpublished data). Using the criteria of Sprunt et al. (1973), the productivity data for the Lower Peninsula eagles suggests that anadromous eagles are "healthy" and that Great Lakes eagles are at least "stable" and approaching "healthy". The increased productivity of Great Lakes eagles is especially notable because, in addition to eating potamodromous fishes, Great Lakes eagles forage on a higher percentage of aquatic-feeding birds, such as waterfowl, gulls, and colonial water birds that are known to contain even higher contaminant levels than Great Lakes fishes (Sprunt et al. 1973).

Food quantity has been identified as the most important factor limiting eaglet production (Stalmaster and Gessamen 1984). Increased fish runs due to fish passage or dam removal may increase eagle productivity by making more forage available (Bowerman and Giesy 1991). Eaglet production from nests along Michigan streams with anadromous fish runs support this statement. Between 1989 and 1994, anadromous eagle nests on the Pere Marquette River (Pere Marquette River nest) and Manistee River (Wellston nest) had annual productivity rates of 1.67 and 1.83 fledglings per occupied nest (Rozich 1998). In addition, dam removal would make more ice-free, large river habitat available for eagle foraging. This habitat-type is important to over-wintering eagles, but is now limited in the Au Sable River system (Bowerman and Giesy 1991; Martell 1992). In summary, this information indicates that passage of fish or dam removal would have little if any adverse effect on bald eagle productivity, and may even benefit the species.

A causal link between the status of mink and otter populations and exposure to organochlorine chemicals in the Great Lakes has not yet been established (Wren 1991).

However, laboratory experiments have shown that mink are extremely sensitive to organochlorine chemicals, particularly PCBs and dioxins (Giesy et al. 1994a). Ranch mink being fed contaminant-laden carp from Lake Huron showed impaired reproductive success, liver damage, and hematological effects (Heaton et al. 1995a; Heaton et al. 1995b). Heaton et al's Hazard Index (HI) study findings should be carefully interpreted when addressing fish passage issues on the Au Sable River for several reasons: 1) they assumed a mink's daily diet consisted solely of one species of fish though actual diets are much more diverse; 2) a fish species was considered hazardous (HI>1) when, as the sole item in the mink's diet, it caused a mink to exceed the maximum allowable daily intake (MADI) of PCBs; 3) use of a safety factor of 10 in calculating MADI values caused many fish to become unsafe; without it, all fishes tested for Lake Huron (except the most contaminated carp) would have been considered safe for consumption (HI<1); 4) Great Lakes fish would mainly be available for about half the year; and 5) carp, the most highly contaminated Lake Huron fish, would probably make up an extremely minor portion of riverine mink diets because carp are rarely in high-velocity, cold water riverine habitats (significant carp populations only exist in lower mainstem impoundments) and would not be expected to use fish ladders. Using a safety factor of 10, Giesy et al. (1994a) estimated that fishes below Foote Dam could compose roughly 30% of a mink's diet before PCB hazard index values were exceeded (HI>1). He noted that PCB levels in Lake Huron fishes were less hazardous than Lake Michigan fishes, but suggested that mink could potentially receive acute doses of PCBs if they foraged heavily on dying chinook and coho salmon during spawning runs. Information for comparing Great Lakes influenced and inland mink populations in Michigan is lacking and there are no ongoing population studies. However, mink populations are assumed to be stable and at healthy levels. Harvest regulations for mink have not changed for many years and there is no bag limit.

The effect of Great Lakes fish migrations on river otter populations has not been studied in detail. However, several observations suggest that a diet containing Great Lakes fishes may be only one of several factors influencing otter distributions. Predictors of otter presence in Lower Michigan streams included fish PCB levels, limited prey availability due to low summer stream flows, and the percentages of urban and agricultural land use within the riparian corridor (Kotanchik 1997). Interestingly, Kotanchik (1997) identified a reach of the Rifle River, a stream open to potamodromous runs, as one of two stream segments in the Lower Peninsula having the highest otter density. Her data also showed a river otter density in the Pine River, an Au Sable River tributary open to Great Lakes fish migrations, is comparable to otter densities in much of the Au Sable River. O'Neal (1997) noted that sections of the White River (open to Great Lakes fish migrations) were open to otter trapping, while upstream reaches closed to Great Lakes fish migrations were closed to trapping. Wren (1991) observed that otter harvest in Michigan gradually increased during the 1950s, and was fairly level during the 1970s and 1980s. River otter harvest from 1985 to 1995 has ranged between 654 and 1551 with no clear temporal trend (O'Neal 1997). However, river otter harvest is not a good indicator of population abundance because it varies with fur prices and beaver trapping. The recent increase from 2 to 3 in Michigan's season bag limit for river otter suggests that Michigan populations are stable or increasing. Harvest of river otter is permitted within the entire Au Sable River watershed.

Despite the decreases in organochlorine contaminants, significant increases in eagle and other avian populations, and apparent increases in river otter populations in Michigan, there is still concern that contaminant levels in Great Lakes fish may be affecting wildlife populations. Contaminant hazard assessment studies were sponsored by Consumers Energy during hydroelectric dam relicensing procedures, and were summarized by Ecological Research Services, Inc. (1991), Bowerman and Giesy (1991), Giesy et al. (1994a), Giesy et al. (1994b), and Giesy et al. (1995). Effects of different contaminant levels in surrogate birds and ranch mink were used to predict contaminant levels at which the species of interest might be impaired. Wood duck (*Aix sponsa*), herring gull (*Larus argentatus*) and domestic chickens were used as surrogate species for the bald eagle. Contaminant levels in certain species of fish, along with many assumptions related to biomagnification, bioassay (cormorant blood plasma and cultured rat cellular enzymes), and estimated mercury, PCBs, DDT, DDE, and dieldrin chemical equivalence factors (dioxins or dioxin equivalents) were used to predict contaminant levels in eagles and mink. The value of some surrogate measures of contaminant concentrations in making inferences regarding reproductive success of animals has also been questioned, because of weak or non-existent relations between such measures and actual data on reproductive success. For example, Bowerman et al. (1998) found no trends in PCBs or DDE levels in eggs of bald eagles nesting along the Great Lakes, even though a very clear increase in reproductive success was observed during this time period. Hazard assessments incorporated safety factors, but not statistical uncertainty factors that may often be needed. For example, Johnson et al. (1996) noted that predatory fish did not biomagnify dioxins in the field, even though laboratory studies documented biomagnification of dioxins by fish. Various factors, including lipid levels, metabolism, site-specific transport effects, and food choice, make trophic transfer more complicated than previously thought (Johnson et al. 1996).

Studies of transport of organic contaminants into upstream areas by migrating fish indicate that the fate of contaminants appears to be limited to organisms that directly ingest contaminated eggs and fish flesh. In a study of Manistee and Muskegon river tributaries, Merna (1986) observed elevated PCB and DDT levels in brown trout and sculpins, which ate Lake Michigan salmon eggs, but could not detect elevated concentrations of contaminants in crayfish, and sand and organic sediments. He also looked for elevated dieldrin levels, but could not find them in either biota or sediment samples. Brown trout and blowfly larvae feeding on salmon eggs or flesh in Lake Ontario tributaries had elevated mirex levels, but crayfish, stoneflies, and sediments from the same locations did not (Scrudato and McDowell 1989). Johnson et al. (1996) found that fishes upstream of dioxin-contaminated site were contaminated, but sediment was not. However, fish contamination at the contamination site was attributed to uptake from sediments and through the food chain. Potential increases in contaminant loads of animals feeding on eggs and carcasses of Great Lakes fishes represents a trade-off against increases in growth of individuals and productivity of populations (Bilby et al. 1998; Stalmaster and Gessamen 1984) and the system as a whole.

Many social issues may dictate fish passage on the lower mainstem. The primary social issue involves conflicts between riparian residents and anglers, because potamodromous fish will probably attract more anglers. On private property, trespassing, littering, illegal angling, and other problems may occur. The federal and state governments, and Consumers Energy own most of the riparian land along portions of the lower mainstem that would be opened to potamodromous runs. Their ability to control access to the lower mainstem provides fair degree of control over these problems. In addition, larger rivers can more readily accommodate greater angling pressure. The potential for riparian conflict is greater further upstream of Mio where riparian ownership is largely private. Rozich (1998) suggested that any fish passage plans need to address: species and numbers of fish to be passed; the ability of the stream to accommodate increased angling, availability of public access and parking sites; and law enforcement needs.

In summary, a potential fishery management goal for the Au Sable River is rehabilitation of spawning runs of native and naturalized fishes in the river above Consumers Energy dams and rehabilitation of lost productivity of fish populations in the river by providing fish passage or removing dams. Reaches now fragmented have the potential to support economically valuable sport fisheries, and would help restore self-sustaining salmonid populations to Lake Huron. The effect of fish passage on other species needs to be

> considered in further detail. Studies of bald eagle, a species known to bioaccumulate substantial amounts of organochlorine contaminants due to their diet of aquatic birds and fishes, indicate that nesting pairs along potamodromous streams in Michigan show reproductive success similar to (and sometimes greater than) their counterparts that do not forage on potamodromous fishes. Populations of bald eagles and other fish-eating water birds in the Great Lakes, such as cormorants, have increased dramatically in the last 15 years. Harvest regulations for mink and river otter, species somewhat lower on the food chain than bald eagles, do not indicate that significant reproductive effects would occur. Limited data on river otter indicate that their populations are increasing, as supported by the 1996 increase in the Michigan bag limit, and show high population levels on streams known to have runs of Great Lakes fishes. Potential increases in contaminant loads of animals feeding on eggs and carcasses of Great Lakes fishes would be traded-off against increased productivity of their populations, and the system as a whole.

While contaminant burdens differ between lakes Michigan and Huron, contaminant levels are dropping in both lakes (Anonymous 2002a). In lake trout, whole fish concentrations of PCB, DDT, and chlordane declined in lakes Superior, Huron, Michigan, and Ontario from 1970s to 1998. Lake Michigan concentrations of PCB and DDT are higher than Lake Huron, but Lake Michigan concentrations have decreased faster and were more similar to Lake Huron in 1998 than they were in the early to mid 1980s. Chlordane levels (1998) in lakes Michigan and Huron are not significantly different from one another, nor are they different from Lake Superior.

A second theory regarding fish passage is that competition from steelhead, chinook and coho salmon would degrade inland brook and brown trout fisheries. The competition concern theorizes that there would be spawning habitat overlap and spatial competition among juvenile fish. However, potential passage of salmon into portions of the Manistique River watershed is still being considered by state and federal agencies responsible for management of Lake Michigan and its surrounding watersheds. Unpublished data from the Hunt Creek Trout Research Station (A. Nuhfer, MDNR, Fisheries Division, personal communication) and field data collection from upper peninsula streams (C. Bassett, USFS, personal communication) indicate that adequate spatial separation occurs between spawning brook trout and chinook and coho salmon. Similarly, three fold increases in densities of steelhead were necessary in a controlled setting at the Hunt Creek Trout Research Station to illicit spawning interactions between brook trout and steelhead (A. Nuhfer, MDNR, Fisheries Division, personal communication).

In 1996 Manistique Paper Co., Inc. constructed a cut in the dam which established a fix crest sill on the east side of the dam. A metal plate was added to the lip of the cut in the dam to prevent lamprey from ascending the river. Water levels have been maintained at this dam cut since then. Work has been ongoing since 1996 to remove portions of the dam flume and repairs have been made to the numerous holes that lamprey were using to migrate through the dam. To attract sea lamprey to the USFWS lamprey traps, flood-gates on the east side of the dam are periodically opened slightly to increase water flow in that area. Ongoing work is scheduled to remove the dam flume and portions of the dam no longer needed for Manistique Paper Co., Inc. operations. Regardless of ongoing work, structural integrity of the dam is poor and it continues to degrade. Lacking any major repairs the structure will eventually need to be removed (J. Pawloski, Michigan Department of Environmental Quality, Dam Safety Unit, personal communication). The USFWS, Great Lakes Fishery Commission and MDNR began planning (e.g., lamprey control, competition between residential stream fish and salmon, etc.) for the Mainstem-mouth subwatershed when the MPI dam eventually fails.

Recreational Use

The abundance of publicly owned land in the Manistique River watershed allows for many types of recreation opportunities. Recreation activities here are typical of those found in areas comprised of forest, stream, and lake habitat. These activities include: hunting, fishing, fur trapping, berry and mushroom picking, swimming, camping, snowmobiling, ORV trail riding, canoeing, boating, cross-country skiing, hiking, bike riding, sight seeing, bird and wildlife viewing, and numerous other hobbies. Access to state and federal land enables recreation seekers to enjoy all parts of the watershed, except where special regulations are in effect.

Two areas where special regulations limit certain types of recreation are the Seney Wildlife Refuge and the Big Island Lakes Wilderness Area. Because of fragile environments and nesting wildlife found within the Seney Refuge, recreationists here may not use motorized vehicles except on designated roads, use snowmobiles or ORVs, use boats on the pools, camp except in designated areas during the two-weeks of November firearm deer season, fur trap, swim, use metal detectors, or construct fires (M. Tanzy, U.S. Department of Interior, USFWS, personal communication). Motorized and wheeled vehicles are prohibited from operation in the Big Island Lake Wilderness Area. Limiting these types of recreation has provided for a quiet, serene environment for people who enjoy other recreation opportunities such as bird and wildlife observation, fishing, hiking, bike riding, cross-country skiing, and berry and mushroom picking.

While canoeists are able to access most areas of the watershed, thick growths of tag alder brush along small streams cause enthusiasts to target the larger rivers. Indian and Manistique rivers are the most popular canoeing rivers due to their length, width, and stable flows. Multiple-day canoe trips are available on the Indian and Manistique rivers. A canoe livery at the town of Germfask provides rental crafts for the Manistique River mainstem and is the only canoe livery within the watershed. No camping permits are required and canoeists may camp at dispersed or designated camp grounds.

Boating is popular on most inland lakes. Participants use motor boats, canoes, kayaks, jet skis, pontoon rafts, rowboats, paddle boats or sail crafts. Developed and primitive boat launches exist on most large water bodies and rivers (Table 10). No marinas or on-lake fueling stations exist anywhere within the watershed.

An extensive system of trails exists for snowmobiling, hiking, biking, skiing, and horseback riding. At Gemini Lake there is a 1.5 mile trail for hiking and biking. A 27.5 mile trail from the Fox River State Forest Campground extends north to the Kingston Lake State Forest Campground, offering opportunities for biking and hiking. Located at Indian Lake, a 8.5 mile groomed ski, hike, and bike trail exists. The Danaher Plains Trail, located 4 miles north of Seney, consists of a 29-mile oval route for off-road vehicles less than 50 in wide. The Danaher Plains Trail is part of the State of Michigan designated ORV trail system and is the only state designated ORV trail in the watershed. Snowmobile enthusiasts enjoy a connected series of trails that allow users to traverse the watershed in a north-south or east-west manner. The Recreational and Snowmobile Trail Grant Program administered through the MDNR Forest, Mineral and Fire Management Division is available to Counties, Townships, Cities, Villages, and Non-Profit, Incorporated snowmobile clubs and other Non-Profit organizations.

Camping is practiced in numerous sites throughout the area. State, federal, county, and township governments as well as private facilities administer numerous developed campgrounds (Table 8). Primitive camping, also known as dispersed camping, is permitted on most state and federal lands. Camping is permitted anywhere on State Forest property as long as it is not posted "No Camping", and is one mile or more from a designated State Forest Campground. Campers must follow all state land rules and must also post a camp registration card at the campsite. On National Forest lands, no permit is needed to primitive camp for up to 14 days, no closer than 50 ft from a lake or stream and not less than 100 ft from a road.

Fishing is a popular outdoor activity practiced on many of the lakes and streams within the watershed. Angler creel surveys are often used to monitor or evaluate fishing activity at selected locations. Two types of angler creel surveys are reported here. First are direct contact complimented creel survey estimates. Here two types of data are collected: counts of anglers (or units representing anglers such as boats), and angler interviews. With this type of survey angling effort (typically angler hours), catch, and catch rate are each estimated. When anglers are interviewed as they complete their daily fishing trip this type of survey is referred as an “access” survey. This access design was used at selected sites in the watershed post 1965 (Ryckman 1981, Ryckman and Lockwood 1985, Lockwood et al. 1999, and Lockwood 2000a).

Second are data from the historical MDNR “General Creel Census”. The General Creel Census was conducted from 1927 through 1965. (Note: Since not all anglers at a site were interviewed, this program is more appropriately referred to as a “creel survey” rather than “census”, however the term “census” is retained to preserve its historical reference.) These data were collected by conservation officers as they conducted their routine law enforcement duties. These data included angling location (river section or lake), date, number of anglers, hours fished, and catch (harvest) by species. Not all anglers were interviewed at a location and no counts of anglers were made. Only catch rate was estimated from these data. Walleye, northern pike, yellow perch, bluegill, smallmouth bass, and largemouth bass were the most frequently harvested fish on watershed lakes sampled during the General Creel Census. These species popularity has continued through the years. These same key species were targeted by a large proportion of anglers sampled during access creel surveys. Brook trout and brown trout were commonly caught on streams. All anglers interviewed during a 1995 Indian River (Tributaries- upper Indian) access creel survey were targeting trout (Lockwood 2000b). These same species were most often harvested by lake and stream anglers from the General Creel Census (Appendix 4). Walleye are frequently targeted on large inland lakes.

Percentage of anglers targeting key species or anything sampled during access creel surveys.

Lake	Survey year	Percent targeting key species	Percent targeting anything
Bass	1995	69.14	30.86
Petes	1993	63.67	36.33
Thunder	1995	18.37	81.63

One measure of fishing success is catch rate. Catch rates are reported as number of fish caught (harvested) per hour of fishing. Catch rate by fish species serves as a useful measure of a fishery and may be indicative of population size (J. Schneider, MDNR, Fisheries Division, personal communication). While a variety of fish species occur and are caught by anglers in the watershed, three species actively sought by anglers have been selected to characterize fisheries within each subwatershed. They are: brook trout for stream anglers; and brook trout, walleye, and northern pike for lake anglers. Additional species of interest may be listed as well.

Mainstem – upper

Both access and General Creel Census results are available for this subwatershed. Access creel surveys were conducted on Big and South Manistique lakes. Big Manistique Lake was surveyed from May 1978 to February 1979 and again from May 1979 to February 1980. Anglers fished an estimated

64,691 hours during 1978-79 and 46,068 hours during 1979-80. Yellow perch were harvested in the greatest number both years, 18,271 in 1978-79 and 16,975 in 1979-80. Walleye harvest was good during both years. Good walleye fisheries are characterized as having harvest rates (catch/hour) ≥0.1000 (J. Schneider, MDNR, personal communication). Catch per hour of walleye in 1978-79 was 0.0984 and 0.1158 in 1979-80. South Manistique Lake was surveyed from May 15 through September 9, 1978. Anglers fished an estimated 61,472 hours. Walleye were harvested in the greatest numbers, 14,137 with a catch per hour of 0.2300.

From the General Creel Census, stream anglers were interviewed between 1939 and 1964. Catch rates of brook trout varied from 0.00 to 1.22 fish per hour with an average of 0.15. Only 25% of year-location combinations reported catches of brook trout. Lake anglers were interviewed from 1928 to 1965. No brook trout were reported. Most year-location combinations, 87%, reported catches of walleye. Walleye catch rates varied from 0.00 to 1.21 with an average of 0.18. Similarly, most year-location combinations, 85%, reported catches of northern pike. Catch rates of northern pike varied from 0.00 to 0.32 with an average of 0.09.

Lake herring were reported in 28% of lake angler year-location combinations. Catch rates varied from 0.00 to 0.20 with an average of 0.01. All reported lake herring were from Manistique Lake.

Mainstem – middle

All creel data for this subwatershed comes from the General Creel Census. Only sparse information is available for stream anglers in this subwatershed. Two anglers were interviewed in 1943 and one in 1952. Catch rates of brook trout in 1943 were 0.00 and 1.60 in 1952. Average catch rate of brook trout was 0.80. Similar to the stream fishery, only minimal lake data are available. One angler was interviewed in 1941 and three in 1964. No brook trout or walleye were reported. Northern pike catch rate of 1.00 was reported in 1941 and 0.00 in 1964.

Mainstem – mouth

All creel data for this subwatershed comes from the General Creel Census. Stream anglers fishing in this subwatershed were interviewed at various locations from 1931 to 1964. Catch rates of brook trout varied from 0.00 to 4.00 with an average catch rate of 0.76. Forty-two percent of year-location combinations reported catches of brook trout. Lake anglers were interviewed from 1938 to 1965. Few brook trout were caught and only 4% of year-location combinations reported catches of brook trout. Catch rates varied from 0.00 to 1.05 with an average of 0.05. Twenty-seven percent of year-location combinations reported catches of walleye. Catch rates varied from 0.00 to 0.27 with an average of 0.02. Northern pike were more common with 82% of year-location combinations reporting catches of northern pike. Catch rates varied from 0.00 to 1.47 with an average of 0.39.

Tributaries – Fox River

All creel data for this subwatershed comes from the General Creel Census. Stream anglers fishing in this subwatershed were interviewed at various locations from 1928 to 1964. Most year-location combinations, 92%, reported catches of brook trout. Catch rates varied from 0.00 to 12.75 with an average catch rate of 1.45. Lake anglers were interviewed from 1928 to 1965. Sixteen percent of year-location combinations reported catches of brook trout. Catch rates varied from 0.00 to 1.95 with an average of 0.09. Few walleye were reported and only 1% of year-location combinations reported catches of walleye. Catch rates varied from 0.00 to 0.36 with an average <0.01. Northern pike were more common and 37% of year-location combinations reported catches of northern pike. Catch rates varied from 0.00 to 3.33 with an average of 0.21.

Because the headwater soils are well drained, the upper portion of this valley segment supports more recreation than the Mainstem-middle, Mainstem-central and headwaters of Tributaries-central basin. Snowmobiling and ORV trail riding are popular recreational activities here.

Tributaries – central basin

All creel data for this subwatershed comes from the General Creel Census. Stream anglers were interviewed from 1928 to 1964 and most stream interview data were collected from anglers fishing in headwater stream sections. These headwater sections are where greatest potential groundwater inflow occurs (see **Geology**). Most year-location combinations, 74%, reported catches of brook trout. Catch rates varied from 0.00 to 14.00 with an average catch rate of 1.39. Lake anglers were interviewed from 1930 to 1964. Twelve percent of year-location combinations reported catches of brook trout. Catch rates varied from 0.00 to 3.33 with an average of 0.10. Walleye were less common with only 3% of year-location combinations reporting catches of walleye. Catch rates varied from 0.00 to 0.33 with an average <0.01. Northern pike were quite common with 52% of year-location combinations reporting catches of northern pike. Catch rates varied from 0.00 to 3.00 with an average of 0.25.

Recreation is focused within the headwater portion of this valley segment where numerous lakes and the Driggs River provide good fishing. The dry soils here support trail riding by snowmobiles and ORVs. Camping is popular at designated campgrounds and dispersed sites. Blueberry growth here is strong and the area is targeted by pickers during the months of June and July.

The Driggs River Road parallels the east side of the Driggs River, proceeding north from Highway M-28 to Driggs Lake. Anglers pursuing brook trout fishing have numerous access points to the Driggs River from the Driggs River Road.

Tributaries – upper Indian River

Both access creel survey data and General Creel Census data are available. Access creel surveys were conducted on Bass Lake (May 28 – September 16, 1995), Corner Lake (May – August, 1978), Skeels Lake (May – August, 1978), Deep Lake (May - August, 1978), Petes Lake (May 15 – September 11, 1993), Straights Lake (May – August, 1978), Thunder Lake (May 15 – September 16, 1995), and Indian River (May 28 – September 30, 1995). Yellow perch were harvested in the greatest numbers on Bass Lake. Here anglers harvested an estimated 3,085 perch with a catch rate of 0.93. No brook trout, walleye, or northern pike were reported. Anglers fished an estimated 3,308 hours. Sunfish species were harvested in the greatest numbers from Corner Lake, 162. Northern pike were harvested in limited numbers, 77, and no walleye were reported. Anglers fished an estimated 2,286 hours. From Deep Lake, anglers harvested an estimated 119 bluegill and fished 500 hours. Walleye were the most common species harvested from Petes Lake. Anglers harvested 217 walleye and had a catch rate of 0.07. No brook trout or northern pike were reported. Anglers fished an estimated 3,009 hours. Northern pike were harvested in the greatest numbers from Skeels Lake, 371, and anglers fished an estimated 1,968 hours. No walleye were reported. Anglers fishing Straights Lake harvested 236 northern pike and fished 786 hours. No walleye were reported. Yellow perch were harvested in the greatest number on Thunder Lake. Anglers harvested an estimated 4,289 perch and had a catch rate of 0.71. No brook trout or walleye were reported. Anglers fished an estimated 6,000 hours.

An access survey was conducted on the upper Indian River during summer months in 1995. Anglers harvested an estimated 217 brook trout with a catch rate of 0.05, and fished 4,604 hours from May 28 through September 30, 1995.

From the General Creel Census, stream anglers were interviewed from 1928 to 1964. Most year-location combinations, 92%, reported catches of brook trout. Catch rates varied from 0.00 to 5.00 with an average catch rate of 1.17.

Lake anglers were interviewed from 1927 to 1964. Five percent of year-location combinations reported catches of brook trout. Catch rates varied from 0.00 to 4.45 with an average of 0.06. Similarly, 4% of year-location combinations reported catches of walleye. Catch rates varied from 0.00 to 0.50 with an average of 0.01. Northern pike were commonly reported with 46% of year-location combinations reporting catches of northern pike. Catch rates varied from 0.00 to 4.20 with an average of 0.24.

The well drained soils here support recreation in the form of camping, ORV trail riding, snowmobiling, and hunting. Campgrounds, trails, resorts, and general supply convienince stores are found in this area, which cater to recreation enthusiast needs.

Tributaries – lower Indian River

All creel data for this subwatershed come from the General Creel Census. Stream anglers were interviewed from 1950 to 1964. Sixty percent of year-location combinations reported catches of brook trout. Catch rates varied from 0.00 to 2.00 with an average catch rate of 0.70. Lake anglers were interviewed from 1930 to 1965. Brook trout were rarely reported with only 3% of year-location combinations reporting catches of brook trout. Catch rates varied from 0.00 to 0.02 with an average <0.01. Walleye were reported in 77% of year-location combinations. Catch rates varied from 0.00 to 0.83 with an average of 0.14. Northern pike were also quite common and 80% of year-location combinations reported catches of northern pike. Catch rates varied from 0.00 to 0.80 with an average of 0.14.

Sturgeon were reported from Indian Lake during the winter months of 1951, 1954, 1963, 1964, and 1965. Catch rates were low, <0.01, for each of these years. Similarly, lake herring were reported from Indian Lake during 17% of year-location combinations. Catch rates were low and varied from 0.00 to <0.01 with an average <0.01.

Citizen Involvement

Various citizen groups have been involved in fisheries habitat improvement efforts and watershed management. These citizen groups coordinate their efforts or pursue grant funding sources through government agencies such as the USFS, Seney Wildlife Refuge, or MDNR.

The Manistique River watershed Advisory Council is a partnership of citizens and government staff that focus on issues pertaining to the entire Manistique River watershed. Organized in 1993, this group has implemented bank stabilization programs on the Driggs and Fox river systems. This Council is administered through the Schoolcraft County Conservation District, located in Manistique, Michigan.

Michigan chapters of Trout Unlimited have also put forth efforts in improving fisheries habitat in the Driggs River system. The Paul H. Young chapter of Trout Unlimited of West Bloomfield, Michigan, the Two Hearted Chapter of Trout Unlimited of Newberry, Michigan, and the Fred Waara Chapter of

Trout Unlimited of Negaunee, Michigan each has concerns regarding fisheries management and habitat improvement within the Manistique River watershed. The Paul H. Young and Two Hearted chapters have contributed money for habitat improvement and bank stabilization efforts on the Driggs and Fox river systems.

Private citizens, resort and other business owners have a history of involvement in fisheries management. Numerous cooperative fisheries projects with MDNR have been completed within the Manistique River watershed. In the late 1940s, local citizens assisted the MDNR in establishing and operating a fish counting weir dam in Portage Creek between South and Big Manistique lakes. Later, in the 1960s, the Manistique Lakes Property Owners Association was formed to coordinate area fishing contests and to assist MDNR in collecting netting data and walleye spawn for the Thompson State Fish Hatchery. From 1979 through 1994, the Manistique Lakes Area Lions Club, located in the Town of Curtis, was active in rearing walleye fry and stocking South Manistique Lake and North Manistique Lake. Club members hatched fertilized walleye eggs in a facility located on Portage Creek, just east of Curtis.

MANAGEMENT OPTIONS

The Manistique River watershed is a diverse ecosystem that supports a wide array of opportunities for fishing, recreation, agriculture, forestry, and human interaction. Management options presented in this assessment address the most important issues that influence the watershed. These issues are conditions that prevent the watershed from attaining its maximum potential as a healthy system.

The options follow recommendations of Dewberry (1992), who outlined measures necessary to protect the health of river ecosystems. Dewberry (1992) stressed protection and rehabilitation of headwater streams, riparian areas, and floodplains. Streams and floodplains need to be reconnected where possible. Resource managers must view a river system as a whole, as many elements of fish habitat are driven by whole system processes.

The identified management options given here are consistent with the mission statement of MDNR Fisheries Division. This mission is to protect and enhance public trust in populations and habitat of fishes and other forms of aquatic life, and promote optimum use of these resources for the benefit of the people of Michigan. In particular, the division seeks to protect and maintain healthy aquatic environments and fish communities and rehabilitate those now degraded, provide diverse public fishing opportunities to maximize the value to anglers, and foster and contribute to public and scientific understandings of fish, fishing, and fishery management (MDNR, Fisheries Division, files).

Management options cover a wide array of scenarios relevant to the watershed future. These options are presented to address the full scope of issues related to managing the watershed. Primary management options should address habitat protection, rehabilitation (of habitat and fish stocks), and education. Opportunities to improve an area or resources, above and beyond the original condition, are also listed. Education is an option that may focus on educating managers through surveys, research, and resource assessments; or by educating the public through meetings, media, outreach, and public contact.

Geology and Hydrology

The Manistique River has fairly stable flows due to a thick surficial layer of porous glacial deposits, relatively flat landscape and pervious soils. One tributary, Duck Creek, has less-stable flows than expected based on extensive drainage occurring from the Walsh Ditch.

Option: Protect all existing coldwater, stable streams from effects of land use changes, channelization, irrigation, and construction of dams and other activities that may disrupt the hydrologic cycle, by working with land managers, planners, and MDEQ permit approvals.

Option: Protect the natural hydrologic regime of streams by protecting existing wetlands, flood plains, and upland areas that provide recharge to the water table.

Option: Install additional flow gauges in rivers and streams that are currently unmonitored. Installation of gauges will provide crucial flow regime data necessary for appropriate management of systems.

Option: Protect natural lake outlets by opposing construction of new lake-level control structures. This would allow for the natural fluctuation of water levels needed for maintenance of lake-associated wetlands and shore spawning fishes.

Option: Protect near shore habitats and floodplain connectivity by encouraging and requiring soft armor methods of bank stabilization (e.g., log or whole tree revetments, and vegetative plantings rather than rock riprap) through permitting processes and cooperative planning.

Option: Protect groundwater and stream flows by supporting laws that would require major water withdrawals to register with the Department of Environmental Quality Division. Water withdrawal operations should report the volumes used, and document that protected uses of the source of water will not be impaired

Option: Educate resource managers on the identity and location of aquifer formations in the watershed that provide good groundwater inflow and identify their related biological communities as “of special concern” with Natural Features Inventory.

Soils and Land Use Patterns

Sandy soils in the Manistique River watershed are susceptible to erosion when roadways are developed, when human activity is intense, during urban development, and when improper land use practices are employed. Erosion of soils into streams causes a loss of productivity and health of the respective watercourse.

Option: Protect and maintain forested buffers along lake shores and river corridors to retain critical habitats and to allow for natural wood deposition.

Option: Protect remaining stream margin habitats, including floodplains and wetlands, by encouraging vegetation buffer strips in zoning regulations.

Option: Rehabilitate or improve in-stream culverts or road crossings that are under-sized perched, misaligned, or placed incorrectly.

Option: Encourage use of bridges to facilitate road-stream crossings and discourage placement of culverts.

Option: Encourage bank stabilization and path development in areas where human foot traffic or ORV use is damaging and eroding a bank.

Option: Encourage careful and judicious development of bank stabilization projects, look at hydraulic flow rates to determine where erosion is naturally occurring, and use soft armor methods of protection in areas where stream valleys are unnaturally eroding.

Option: Encourage enforcement of soil sedimentation and erosion laws to prevent sedimentation of lakes and rivers.

Option: Survey road-stream crossings to identify problem areas and implement Best Management Practices at these crossings.

Soil runoff from agricultural lands and earth disturbing activities (construction sites, road building, and logging) can affect the health of the river once soils enter the watercourse. An excessive sand bedload in a watercourse can cover habitat critical for fish spawning, invertebrate production, and fill-in cover areas.

Option: Protect developed and undeveloped lands through land use planning and zoning guidelines that emphasize protection of critical areas, minimizing impervious surfaces, and improve storm water management.

Option: Protect, encourage, and rehabilitate forested floodplain corridors along the river and its tributaries. Encourage tree planting and reforestation throughout the watershed.

Option: Protect streams from degradation by promoting bore and jacking, or flume methods, of pipeline stream crossings as an alternative to open ditching.

Option: Protect agricultural landscapes by supporting best management practices and agricultural zoning plans.

Option: Protect streams from excessive sedimentation by reviewing road crossing construction proposals to ensure adequate erosion control and protection.

Option: Restore stream banks that are eroding as a result of unnatural events (i.e., human disturbance) with soft-armoring bank stabilization methods.

Option: Restore the in-stream habitat of the Driggs River, following the Seney Wildlife Refuge restoration of the Marsh Creek connection to the Driggs River.

Option: Educate land managers, through surveys, on the location of crossings that degrade streams though sedimentation, disrupt stream flow, or create barriers to fish passage.

Channel Morphology

The channel morphology of the Manistique River watershed has developed in response to slope, soils, precipitation, and vegetation. Other than landscape alterations within the Seney Wildlife Refuge, minimal large-scale geographic alteration has occurred to the morphology of stream channels as a result of human interaction. Stream channels have changed due to influences such as dams, road crossings, and channelization.

Option: Protect and restore riparian forests by educating riparian residents on how riparian forests influence water quality, stream temperatures, trophic conditions, channel morphology, bank erosion and stability, and aquatic, terrestrial and avian communities.

Option: Rehabilitate gravel habitats by removing artificially introduced sand bedload from gravel areas.

Option: Protect channel morphology by using bridges or properly sized culverts at road-stream crossings.

Option: Protect existing large woody structure in stream channels by educating riparian property owners to the value of this structure.

Option: Rehabilitate channel diversity by controlling unnatural sediment contributions and by removing artificially introduced streambed sediment load. Evaluate riverine systems to prevent inappropriate bank armoring or removal of naturally occurring streambed materials.

Option: Rehabilitate channel diversity by adding woody structure or habitat improvement structures in reaches where channel diversity is low. Examples would be in areas where past logging practices have eliminated old-growth riparian forests or instream logjams, and in reaches below dams.

Option: Survey cold water streams to identify where high beaver activity (or beaver dam density) adversely affects riparian habitats and stream channel morphology.

Option: Install water level gauge stations at important locations within the watershed (e.g., Fox River system).

Dams and Barriers

There are 54 dams present in the Manistique River watershed resulting in negative effects on aquatic resources. Dams fragment habitat for resident fish, impede potamodromous fish migrations, impound high gradient areas, trap sediments and woody structure, cause flow fluctuations, and fish mortalities, block navigation, and elevate stream temperatures.

Option: Protect the watershed from sea lamprey by working with Manistique Paper Co., Inc. and USFWS to continue blocking sea lamprey migration into the Manistique River from Lake Michigan.

Option: Remove the MPI dam and install an effective barrier to sea lamprey.

Option: Restore Great Lakes fish passage at the MPI dam.

Option: Restore and reconnect the Manistique Lake chain to the mainstem through opportunities such as removing lake-level control structures, thus allowing lakes to function naturally. If a control structure cannot be removed, ensure operation of a control structure at a fixed crest to allow natural stream flow and fluctuation.

Option: Rehabilitate stream habitats and wetland habitats at lake outlets by working with owners of private dams on lake-level management issues.

Option: Survey and develop an inventory of barriers to fish passage, such as culverts, and explore options to correct each problem.

Option: Survey state and federal owned dams to determine their usefulness or potential for removal.

Option: Educate resource managers and citizens on potential dam and lake-level control structures that could be removed by using MDEQ Dam Safety Unit inventory.

Option: Educate resource managers and citizens on the effects of lake-level control structures and the biological benefits of allowing lakes to function naturally.

The numerous road crossings over rivers and streams in the Manistique River Basin have the potential to affect the health of aquatic systems. Road crossings can impede the upstream movement of fish and aquatic organisms, cause erosion, destroy high gradient areas, impede woody structure transport and deposit large quantities of sediment in the stream. These crossings can interfere with recreational activities and degrade in-stream habitats.

Option: Protect river courses from sedimentation by working with road agencies to stabilize road surfaces and embankments, and by diverting surface water runoff to retention areas for sediment deposition. Maintain retention areas by cleaning and transporting captured sediments to upland locations

Option: Rehabilitate degraded road crossings by working with state and county road agencies to upgrade crossings with bridges or culverts that are properly sized.

Option: Educate resource managers, road commissions, local governments and citizens on the effects of improper stream crossings.

Option: Educate resource managers, road commissions, local governments and citizens on the location of perched culverts, undersized, or misaligned culverts by using surveys and inventory road crossings to identify problem sites.

Water Quality

The chemical nature of water quality is un-effected by human activity throughout most of the watershed. The thermal quality of the water within the watershed is altered in areas where dams (either human-made or beaver dams) are present.

Option: Promote public stewardship of the watershed and support educational programs that protect and teach best management practices and prevent further degradation of aquatic resources.

Option: Protect and rehabilitate cold and cool water thermal habitat areas and their biological communities.

Option: Protect water quality by developing regulatory rules requiring reporting of accidental spills or discharges to wetlands.

Option: Rehabilitate cold water reaches of streams by encouraging and promoting legal fur bearer harvest of beaver in areas where damming hampers fish migration and degrades trout spawning habitat.

Option: Survey stream temperature conditions throughout watershed to better assess potential of these waters to support different fishes.

Option: Survey thermal influence of existing man-made dams to determine their effect on downstream riverine systems.

Option: Survey stream temperature data by collecting from random sites throughout the watershed, and develop stream classification designations based on the thermal characteristics of these waters.

Option: Survey dissolved oxygen levels in managed trout lakes to establish current data establishing late winter minimums.

Option: Survey for limnology data on lakes and streams to establish current data on alkalinity, dissolved calcium carbonate, Secchi disk visibility, and thermocline.

Special Jurisdictions

Land management activities conducted by state, federal, or local units of government have the potential to affect the health, viability and function of aquatic organisms.

Option: Protect the river system by supporting cooperative planning and decision making among all involved levels of government and citizens.

Option: Protect the quality of wetlands, streams, and lakes through the enforcement of Parts 31, 91, 301 and 303 of the NREPA Act of 1994.

Option: Protect the Fox River watershed by promoting adherence to the Natural River zoning ordinances on the Fox River watershed and work with Burt Township in Alger County to adopt the state zoning rules for the portion of managed river located in Burt Township.

Option: Protect the Indian River by promoting resumption of the study phase to list the Indian River as a federally-designated Natural River. Work towards implementing the management recommendations set forth in the Indian River Wild and Scenic River Management Plan.

Option: Protect the watershed from sea lamprey infestation by working with USFWS Sea Lamprey Management program and Manistique Paper Company, Inc. to reduce the potential for migration into the Manistique River watershed.

Option: Protect the lower Manistique River by working with U.S. Army Corps of Engineers on future dredging and maintenance issues related to the lower river.

Option: Protect the watershed by coordinating with the City of Manistique, and various Townships and County Commissions on recreation, fish management, MDEQ permit issues, and water quality.

Option: Educate resource managers and citizens by annually reviewing work plans and management plans of MDNR Fisheries, MDNR Forest, Mineral and Fire Management Division, USFS, and Seney Wildlife Refuge. Coordinate and communicate on issues of mutual interest.

Biological Communities

For biological communities of the Manistique River watershed to attain their maximum potential, managers will need to address problems that degrade habitats. The most significant change to biological communities results from fragmentation of watersheds by dams, loss of large woody structure, habitat loss as a result of sediment deposition, and unbalanced predator-prey relationships. Some native species have been lost (e.g., lake sturgeon) while other species have been introduced (e.g., green sunfish). Other fish communities are unable to sustain themselves through natural reproduction and need to be stocked on a regular basis. Introductions of aquatic nuisance fish and plants pose a serious threat to the future health of the watershed.

Option: Protect fish health of the watershed by screening all private and appropriate public fish stockings to ensure they are free of diseases and undesirable species.

Option: Protect against transfer of aquatic nuisance species into the watershed. Maintain aquatic nuisance species information signage at all boat launch sites. Continue aquatic nuisance species public education discussion with media and sport group contacts.

Option: Protect against sea lamprey infestation of the watershed. Continue to work with the U.S. Fish and Wildlife Service Sea Lamprey Unit to minimize lamprey passage, to monitor sea lamprey reproduction levels within the watershed, and implement control measures as necessary.

Option: Survey to determine status of unknown fish species with historical occurrence.

Option: Survey distribution and status of species of concern and develop protection and recovery strategies for those species and explore options to protect critical habitat.

Option: Survey distribution of lake sturgeon populations and explore feasibility of sustaining these populations through stocking or habitat improvement.

Option: Survey beaver populations and effects on cold water tributaries. Identify measures to control beaver populations where their effects are excessive.

Option: Survey biological communities in waters lacking data (e.g., Tributaries-central basin, Manistique-mouth sloughs). Surveys need to include distribution and status of fishes, aquatic invertebrates, mussels, amphibians, reptiles, aquatic plants, and pest species throughout the river system.

Option: Educate resource managers on the identity and location of biological community distributions in the watershed using technology such as geographic information systems.

Option: Conduct angler creel surveys in the reach of river between the Paper Mill Dam and Lake Michigan to assess anadromous fish runs and angler catch rates.

Option: Model contribution of Manistique River fishes to the Lake Michigan fish community if fish passage is accommodated at the MPI Dam.

Option: Support goals of the Great Lakes Fishery Commission's, Lake Michigan Fish-community Objectives.

Option: Develop and coordinate a strategic plan for future monitoring of biological communities in key locations with MDEQ Water Quality Standards monitoring program. Include inland lake sampling in the strategic plan.

Option: Development of recreational facilities should consider proximity to wood turtle, and other species of concern, communities. Signage, fensing, or facility design should be considered to protect these species.

Fisheries Management

The diversity of water types within the watershed offers a wide array of management options to support a diverse and attractive sport fishery. Fisheries management goals will follow the mission of the MDNR Fisheries Division, to protect and enhance public trust in populations and habitat of fishes and other forms of aquatic life, and promote optimal use of these resources for the benefit of the people of Michigan.

Option: Restore Great Lakes fish passage into the watershed. Explore the issue of passing salmon, steelhead, brown trout, and walleye from Lake Michigan. Determine potential effects: on wild trout populations, transport of contaminants to upstream areas (effects on piscivorous wildlife), amount of natural recruitment of these Great Lake migratory fishes, and effects on sport fishing opportunities and Lake Michigan fish-community objectives.

Option: Restore predator-prey ratios through various management tools (e.g., manual removals, chemical treatments, predator stocking).

Option: Rehabilitate trout fisheries in the coldwater reaches of the watershed through habitat improvement (e.g., addition of large woody structure).

Option: Survey water temperatures and trout survival in managed waters to determine if trout stocking is prudent (e.g., summer temperatures too marginal, natural reproduction able to sustain fishery, or adjust strains).

Option: Survey potential for re-introducing lake sturgeon in remaining riverine reaches (i.e., Manistique River mainstem).

Option: Stock brook trout, brown trout, lake trout, walleye, muskellunge, smallmouth bass and largemouth bass in areas where appropriate and where self-sustaining populations are unable to maintain a fishery or support only marginal fisheries.

Option: Investigate effect of northern pike predation and thermal warming influences of the Stanley Lake dam on Little Fox River brook trout fishery.

Option: Investigate and survey the Manistique-mouth for habitat improvement possibilities, resident fish populations, and status and effects of the wood fibers that lie on the riverbed.

Option: Manage the Tributaries-upper Indian River, the upstream reaches of the Tributaries-central basin, and Tributaries-Fox River for brook trout and brown trout.

Option: Manage the Mainstem-middle and Tributaries-lower Indian River for coolwater fish communities such as walleye, largemouth bass, northern pike, and lake sturgeon.

Option: In the event the MPI dam is removed and if salmonids are shown to be biologically probelematic in the upper watershed, install a barrier near the mouth of the Manistique River to block upstream migration of salmonids.

Option: In the event the MPI dam is removed and if salmonids are shown to be biologically probelematic in the upper watershed, install barriers at Highway M-28 river crossings to block upstream migration of salmonids.

Recreational Use

Extensive and diverse recreational opportunities exist throughout the watershed due to the abundance of public-owned lands. Access to various water bodies is good while remote roadless areas also exist in abundance. Both accessible and inaccessible areas are important to provide diverse recreational experiences to the public.

Option: Protect, encourage, and support existing parks and promote responsible management of riparian areas in public ownership.

Option: Protect undeveloped access sites from eroding into neighboring water courses.

Option: Protect popular canoe resting places along rivers from excessive streambank failure due to heavy foot traffic.

Option: Encourage the development of rustic latrines at popular dispersed, non-developed, campsites.

Option: Improve canoe portages at all dams.

Option: Investigate improving existing public access to the Manistique River between MPI dam and Lake Michigan, and increase access opportunities where possible.

Option: Explore opportunities for cleaning up and improving aesthetics of land area between the MPI dam and Cedar Street boat launch, in the City of Manistique.

Option: Educate media outlets and tourism agencies to identify recreational opportunities that exist.

Option: Support funding for fishing piers, river walkways, and other facilities to provide recreational use of the river.

Citizen Involvement

Interested citizens, sport groups, government agencies, and civic municipalities will always have an interest in the health and viability of the Manistique River watershed. Future management of the watershed should involve these citizen groups to the greatest extent possible.

Option: Protect the watershed by building public support through a network of citizen involvement groups.

Option: Support communication between interest groups in the Manistique River watershed.

Option: Educate citizens, local governments, and resource managers on significant management issues by providing information through various media outlets, sport groups, civic leaders, and other land management agencies.

Option: Work with sport groups on guiding their project proposals and implementation.

Option: Provide assistance for citizen groups to solicit grants such as the MDNR, Fisheries Division, Inland Fisheries Grant.

PUBLIC COMMENT AND RESPONSE

A draft of the Manistique River Assessment was distributed for public review in spring 2004. Both printed copies and an electronic copy from the State MDNR web site were available. Statewide MDNR Press Releases were issued in conjunction with release of this draft. Printed copies were available from the MDNR Escanaba and Baraga offices, and the Institute for Fisheries Research–Arbor. In addition, printed copies were sent to: numerous local and state-wide sports and fishing groups; state, federal, and local units of government; MDEQ; USFWS; USDA Forest Service; Seney Wildlife Refuge; corporate forest groups; and any public that requested copies. A letter explaining the purpose of the river assessment and requesting review comments was enclosed with each copy.

Three public meetings were held to receive comments concerning the river assessment draft. They were: Manistique's Hiawatha Township Hall, June 15, 2004 (13 people attended); the Wetmore Township Hall, June 16, 2004 (2 people attended); and the Curtis Township Hall on June 17, 2004 (19 people attended).

The public comment period for the river assessment draft ended July 31, 2004. However, comments received after this period were accepted and included. Comments of similar subject were combined to avoid unnecessary duplication. All comments were considered. Where Fisheries Division agreed with comments, changes were made. Where Fisheries Division disagreed with comments, reasons why are stated in our response.

Comment Summary

Comment: Several comments were received commending us on a well-written comprehensive document.

> Response: Thank you.

Comment: Why didn't Forest, Minerals, and Fire Management Division and Wildlife Division contribute to this document?

> Response: All MDNR divisions were invited to participate and contribute to this document.

Comment: Wouldn't trout management of the 3 tributaries of the Stutts and some tributaries to the Indian River be aided by removing sand from the river?

> Response: Removal of sand from any river system may be beneficial if that sand is artificially introduced to the river. For river systems that are predominately sand, with little or no gravely material, removal of sand will not increase habitat. The Indian River watershed, for example, is predominately sand (98%). Removal of natural sand bed loads would not be beneficial to the Indian River watershed. The Stutts River watershed is also comprised primarily of sand. Please see **Channel morphology** *Specific power* for a more thorough discussion on sand in Michigan river systems.
>
> Growth and population densities of trout in sandy river systems are often limited by lack of woody structure. The addition of woody structure rather than removal of natural sand bed load may prove to be more beneficial to trout populations in these systems.

Comment: What is the future of the Manistique Paper Mill Dam?

Response: Interagency and private engineering consultants are currently discussing future design options for this site. Proposed design options will address issues such as upstream passage of fish, blockage of aquatic nuisance species, recreational angling, and potential contaminate concerns.

Comment: "We recommend that you more clearly define which fish species would be your priority for fish passage into the Manistique River. We recommend you briefly describe the types of fish passage structures and species each would pass."

Response: Types and quantities of fish passage will be determined based on barrier or fish passage design. This very issue is being discussed by Fisheries Division, MDEQ, USFWS, ACOE, MPI, and a consulting engineering group. Fish species such as lake sturgeon will no doubt receive high priority for passage into the watershed.

Comment: What is going to be done about the Manistique Paper Mill Dam to exclude aquatic nuisance species?

Response: Future design criteria for this site will address aquatic nuisance species concerns.

Comment: Are any major plans underway in the Manistique River watershed now?

Response: Resource management planning is a continuing process. For example numerous resource management plans are ongoing, including, but not limited to: interagency planning for the MPI dam, National Forest Service plan, Seney Wildlife Refuge, MDNR ecoteam forest plan, and MDNR forest certification. Public contribution on each of these plans is vital. Local media outlets announce information regarding each of these programs at various stages of their development.

Comment: How much invasion of foreign animals to the watershed has occurred?

Response: The only aquatic nuisance species that has accessed the watershed is the sea lamprey and they have entered the watershed in very limited numbers (see **Biological Communities** *Aquatic Nuisance Species*).

Comment: Is the fluctuation of water level on Indian Lake bad for the fish?

Response: Natural fluctuations of lake water levels are often beneficial to fish. Dams typically impede natural fluctuations, often increase fluctuations in downstream waters, and negatively influence fish populations throughout a river system. For example, by minimizing lake levels during spring months, access to spawning areas is limited. Conversely, when lake levels are artificially lowered during winter months, habitat is restricted and fish survival in reduced. The Indian Lake Dam serves to maintain a set lake level of 613.27 feet above mean sea level. By maintaining this level, river flow below the dam is accentuated. While the Indian River below the Indian Lake Dam is stable at moderate to high flows, excess water is retained during periods of low flow (<85% exceedence flows) and fish habitat below the dam is reduced. Further discussion of the influence of Indian Lake Dam is found in **Dams and Barriers**.

Comment: Does the Army Corp of Engineers have any plans to make changes in the watershed at this time?

Response: The U. S. Army Corps of Engineers retains navigational jurisdiction over United States waters to the Ordinary High Water Mark elevation of 581.5 ft above Mean Water Level at Rimouski, Quebec. In the Manistique River, this jurisdiction extends from the mouth of the river upstream to the upper end of the lumber slips (see **Special Jurisdictions** *U. S. Army Corps of Engineers*). Currently, there are no projects planned within their watershed jurisdiction beyond annual maintenance of existing break wall and navigational dredging.

Comment: When did the data gathering for the river assessment start?

Response: River assessments are a collection of current and historic data. Compilation of data, historic and current, began in 1999.

Comment: Is there a management plan for the river?

Response: Subsequent to the completion of the Manistique River Assessment, a management plan will be prepared.

Comment: How far will lampreys go up the river system?

Response: Scott and Crossman (1973) note that landlocked lampreys will move upstream as much as 49 miles during spawning.

Comment: Wood turtles are a unique species found within the watershed. Their populations have decreased by 70-80% since the 1970s. Will the Manistique River management plans address wood turtles?

Response: The Manistique River Management Plan has not been written. However, several management options to monitor, protect, and enhance reptiles within the watershed are presented in **Management Options (Biological Communities).** Further discussion in **Management Options** has been added to further protect and enhance watershed reptiles.

Comment: Table 10 (fish species) does not include the black bullhead or the channel catfish. These are both present in the watershed.

Response: Data show inconsistencies in distribution of brown and black bullhead populations. These species have been combined in Table 10 and the distribution maps. Channel catfish has been added to Table 10.

Comment: Table 16 is too large and is not displayed in an alphabetized manner under fish species strain.

Response: Table 16 has been reduced and reorganized. Fish stocking is now organized by county, water body, species, and strain. Individual strains have been summarized across years in which they were stocked and strains are alphabetized under fish species.

Comment: Last, but not least, is Appendix 4, 1 to 25. This is such a long hodge-podge of incomplete data which is of interest only to a very few people that I would suggest you put it on a CD or printed list and say in the Assessment someplace that it is "available upon request".

Response: Access to the historic angler survey data presented in Appendix 4 has always been very limited and these data have been housed in a single location. Compilation of these data and their inclusion in the Manistique River Assessment (as well as pertinent angler survey data in other assessments) serves to preserve their historic value as well as make them readily accessible.

Comment: What is the impact of the watershed on Lake Michigan or Lake Michigan's impact on the watershed (with the exception of sea lamprey and lake sturgeon)? Does the Manistique River watershed contribute to the fisheries in Lake Michigan or does Lake Michigan contribute to the Manistique River watershed?

Response: The MPI dam prevents Lake Michigan and the Manistique River watershed from interacting.

Comment: Can the fisheries management options significantly contribute to the sport fishing opportunities in Lake Michigan?

Response: If the MPI dam was removed and spawning runs were allowed to enter the Manistique River system, the watershed would contribute to sport fishing opportunities in Lake Michigan. Similarly, contributions could be expected if the MPI dam was removed and replaced with a barrier that allowed fish passage.

Comment: The document does not address the economic values and enhancements derived from watershed fisheries that are beneficial to local communities. Communities such as Germfask, Curtis, and Manistique have seen a decrease in the quality of fishing and rely on resorts, motels, etc. as a source of income. The amount of people from outside the area coming to Manistique to fish steelhead is significantly down from several years ago. This pressure can have good and bad impacts on the watershed. As a rule, assessments do not put a large priority on the human aspect/impact on a biological system, such as a watershed.

Response: Economic modeling of watershed communities was not within the scope of this document. However, demographics show that recreational activities are more diverse now than 20 years ago. This diversity provides more year-around economic benefits for communities. For example, recreational vehicles (3-wheelers, etc.) entered the market in 1983. More recent activities include: personal watercraft, kayaking, cross country skiing, biking, etc. Likewise, watershed fisheries are equally diverse, for example, with more walleye fisheries now than in the early 1980s. Continued wise stewardship and continued citizen involvement will ensure appropriately diverse fishing opportunities into the future. River assessments expressly address the effects of human influence on a biological system. Specifically, recreational activities and management opportunities are presented in **Recreational Use.**

Comment: Will the watershed will be managed for special interests, i.e., lake sturgeon and brook trout on the Fox, and disregard many of the other possibilities that exist for a greater number of people?

> Response: The river assessment promotes managing for diverse fish communities and broad fishing opportunities. Fisheries management will be based on sound scientific principles promoting ecosystem management and not on special interest goals.

Comment: "I fully support Fisheries Division efforts mentioned in this plan to control brown trout on the Fox River system, and I would encourage your efforts to prevent or control brown trout invasion of brook trout streams throughout the watershed."

> Response: Fisheries Division will continue to focus on brook trout management in coldwater systems.

Comment: Pacific salmon, including steelhead, should not be allowed to enter the watershed above paper mill dam or Indian Lake Dam due to competition with native fish species including brook trout.

> Response: As noted in the previous response, Fisheries Division will continue to focus on brook trout management in coldwater systems. However, potential passage of salmon into portions of the Manistique River watershed is still being considered by state and federal agencies responsible for management of Lake Michigan and its surrounding watersheds. Unpublished data from Hunt Creek Trout Research Station (A. Nuhfer, MDNR, Fisheries Division, personal communication) and field data collection from upper peninsula streams (C. Bassett, USFS, personal communication) indicate that adequate spatial separation occurs between spawning brook trout, and chinook and coho salmon. Similarly, three fold increases in densities of steelhead were necessary to illicit spawning interactions between brook trout and steelhead. Two management options have been discussed between cooperating state and federal agencies. First, in the event the MPI dam was removed and a barrier was constructed, fall runs of salmonids could be blocked at Manistique if they were shown to be problematic in the upper watershed. Second, is the management option to block upstream migration of salmonids at highway M-28. This second option is discussed in *Considerations Regarding Upstream Passage of Great Lakes fishes* and both options have been added to **Management Options Fisheries Management.**

Comment: "The chief objective of fisheries management on the Manistique River watershed should be to preserve and enhance the diverse native fish populations in the watershed through maintenance of a barrier to Great Lakes exotic species, and fish-borne-contaminants and the improvement of fish habit in the basin**."**

> Response: The Manistique River watershed is not an ecosystem that is isolated from the Lake Michigan basin. The Manistique River watershed is an integral component to the Lake Michigan basin. The watershed contributed to and interacted with the basin prior to construction of dams. While we may not always appreciate the way in which the fish community structure of the basin, and consequently the watershed, is changing, it is the reality we must deal with now and in the future.

Comment: This assessment characterized the chemical contaminant threat by spawning salmonids as a "misconception", yet there are risk assessments in the peer-reviewed scientific literature that document the threat posed by these fish-borne contaminants to bald eagles and mink, with inferred threat to other fish eaters such as osprey and river otters.

> Response: The section *Considerations Regarding Upstream Passage of Great Lakes Fishes* that you refer to has been clarified. However, there is continued debate and scientific study of fish-borne contaminant risks associated with spawning salmonids and piscivorous birds and mammals.
>
> Throughout this debate and study, levels of contaminants within the Great Lakes have declined and populations of eagles have increased. Great Lakes eagle populations, for example, are now being considered for delisting from the threatened designation by state and federal agencies. Currently, there are over 400 nesting pairs of bald eagle in Michigan.
>
> Chemical burdening may not be limiting eagle nest production. For example, Bowerman et al. (1998) found no relationship between trends in PCBs and DDE in eggs of bald eagles nesting along the Great Lakes and reproductive success.
>
> It should be noted that multiple factors other than chemical burdening contribute to nest success or failure. For example, Rozich (1998) noted that mean fledgling rate for the Wellston nets near Tippy Dam on the Manistee River during the period 1988-96 was 1.22. It has been pointed out by Consumers Energy Company that during the period 1994-98 no young were produced. However, a third nest (and consequently an additional pair of adult eagles) appeared in this area during the 1994-98 period (K. Kruger, MDNR, Fisheries Division, personal communication). The additional nest is a factor that must be considered. Also, nest destruction due to windstorms and egg predation by other species all potentially affect fledgling rates.

Comment: "Zorn and Sendek's Au Sable river (Lake Huron) analysis is not particularly applicable to the Manistique River in that Lake Huron fish contaminant burdens are roughly half of those found in Lake Michigan fish of the same or comparable species."

> Response: While contaminant burdens differ between lakes Michigan and Huron, contaminant levels are dropping in both lakes (Anonymous 2002a). In lake trout, whole fish concentrations of PCB, DDT, and chlordane declined in lakes Superior, Huron, Michigan, and Ontario from 1970s to 1998. While Lake Michigan concentrations of PCB and DDT are still higher than Lake Huron, the Lake Michigan concentrations decreased faster and were more similar to Lake Huron levels in 1998 than they were in the early to mid-1980s. Chlordane levels (1998) in lakes Michigan and Huron are not significantly different from one another, nor are they different from Lake Superior. As indicated in the previous Comment/Response, survival and reproductive rates of bald eagles within the Lake Michigan basin are comparable to other areas within Michigan.

Comment: "The Au Sable analysis by Zorn and Sendek includes a number of errors and misconceptions that were addressed in formal comments but were not acknowledged by them in the final version of the plan."

> Response: This is not correct. Each of Consumer Energy Company's comments were addressed and discussed in detail. Where Fisheries Division agreed, changes were made. Where Fisheries Division disagreed, reasons were stated in that document. We invite you to review the entire Au Sable River document at: www.michigan.gov/dnr/0,1607,7-153-10364_10951_19056-46270--,00.html. Specifically, see pages 104-113 in Zorn and Sendek (2001).

Comment: "The management options offered for improving soil erosion control and land use, changing channel morphology, habitat rehabilitation and the maintenance and improvement of water quality are detailed and comprehensive."

Response: Thank you.

Comment: "One item that is somewhat understated in this assessment is beaver management."

Response: Considerations for evaluation and control are presented as an option in **Channel Morphology.** Additional discussion has been added to **Biological Communities** *Mammals* and an option has been added to **Biological Communities**.

Comment: "We support the design and construction of the sea lamprey barrier and are glad to see that you have included this in your Assessment."

Response: Thank you.

Comment: "We encourage continued efforts to rehabilitate the lake sturgeon population in the Manistique River."

Response: We appreciate your continued support.

Comment: "The Service and MDNR have mutual obligations under the 2000 U. S. vs. Michigan Great Lakes Consent Decree. Currently the Assessment does not mention the Consent Decree. As the Manistique River is a tributary to Lake Michigan and may influence the Lake Michigan fishery, we recommend incorporating a brief discussion of the Consent Decree into the Assessment."

Response: The river assessment focuses on the physical and biological properties of the watershed. The 2000 Consent Decree is a dynamic, legal negotiation that is currently being implemented. Discussion issues regarding the Consent Decree is not within the scope of this document. Questions or concerns regarding the 2000 Consent Decree should be directed to the MDNR, Tribal Unit Supervisor.

Comment: "The Service and MDNR are both signatory parties to the Great Lakes Strategic Fisheries Plan. As the Manistique River is a tributary to Lake Michigan, we suggest incorporating this multi-agency Plan into your Assessment. Additionally, we would encourage you to discuss how your Assessment recommendations support the objectives provided in the "Fish-community objectives for Lake Michigan" (Eshenroder et al. 1995)."

Response: Additional discussion has been added to **Fisheries Management.**

Comment: "The Assessment uses the word exotic species on several occasions. To provide greater clarification on the intended meaning, you may find terms such as aquatic nuisance species or invasive species more descriptive than the term exotic species."

Response: The term "exotic species" has been removed and "aquatic nuisance species" or "invasive species" used in its place.

Comment: "We recommend incorporation of a brief discussion on future threats to upstream aquatic communities associated with accidental non-native species introductions through fish passage avenues."

Response: We recognized that aquatic nuisance species could become pestilent if they colonize the watershed. Potential invasive species are presented in **Biological Communities** *Aquatic Pest Species* Other Aquatic Pest Species and **Dams and Barriers**. This concern was also noted in **Management Options Biological Communities.** In addition, narrative has been modified to specifically note potential colonization by aquatic nuisance fish species in **Dams and Barriers** Mainstem – mouth.

GLOSSARY

aquatic nuisance species – see "invasive species"

alluvium – detrital material such as clay, silt, sand, or gravel deposited by running water

BP – before present

base flow – groundwater discharge to the river

benthic – associated with the bottom of a stream or lake

catchment – the area of the earth's surface that drains to a particular location on a stream

cfs – cubic feet per second; a unit commonly used to express stream discharge

coniferous – cone-bearing, typically evergreen, trees

crustal depression – depression of the earth's surface by glacial ice; this depression was approximately one foot for every three feet of ice

crustal rebound – upheaval of the earth's surface following glacial retreat

deciduous – vegetation that sheds its foliage annually

USFWS – Department of Interior, Fish and Wildlife Service

draw-down – removal of stop logs, or similar retaining structure, resulting in the lowering of water levels in an impoundment

electrofishing – the process of putting an electric current, either AC or DC, through water for the purpose of stunning and capturing fish

entrain – to pass through the turbines of a hydroelectric dam

evapotranspiration – loss of water from the soil by both evaporation and transpiration from growing plants

exceedence flow – a discharge amount that is exceeded by the stream for a given percentage of time; for example, for 90% of the year the stream's discharge is greater than its 90% exceedence flow value; consequently, the 90% exceedence flow represents a stream's summer low (drought) flow

exotic species – see "invasive species"

extirpation – to make extinct, eliminate within a specific region

fauna – the animals of a specific region or time

flora – the plant life of a specific region or time

FERC – Federal Energy Regulatory Commission

fixed-crest – a dam that is fixed at an elevation and has no ability to change from that elevation

flushing rate – the amount of time it takes for the total volume of water in an impoundment to be replaced by incoming stream flow; also referred to as retention time

game fish – see sport fish

glacial-fluvial valley – a river valley formed by glacial melt waters cutting through deposits left by a glacier

GLEAS – Great Lakes and Environmental Assessment Section of Michigan Department of Environmental Quality

gradient – the rate of descent of a river from an upstream location to a downstream location

hydrology – the study of water

impoundment – water of a river system that has been held up by a dam, creating an artificial lake

incising – down cutting of a stream channel.

instream cover – large woody structure (e.g. trees, logs, logjams) in the channel, overhanging banks, boulders, and macrophytes

invasive species – successfully reproducing organisms transported by human actions into regions where they did not previously exist

invertebrates – animals without a backbone

Kettlehole basins – a steep sided hollow in the landscape without surface drainage, created by glacial drift

lacustrine – Relating to or growing in lakes

large woody structure – trees, logs, and logjams that are in a stream

larval – early life stage beyond the embryo and prior to juvenile

Laurentide – glaciated North American area east of the Rocky Mountains

lentic – non-flowing water; for example lentic fishes are in a non-flowing water or lake environment

loam – soil consisting of varying proportions of clay, silt, and sand

lotic – flowing water; for example lotic habitats are habitats present in a flowing water environment

LWMD – Land and Water Management Division (MDEQ)

MDEQ – Michigan Department of Environmental Quality

MDNR – Michigan Department of Natural Resources

MNFI – Michigan Natural Features Inventory

mph – miles per hour

MSU – Michigan State University

macrophytes – rooted aquatic plants with stems and leaves below the surface of the water (occasional exceptions have a few small floating or aerial leaves)

mainstem – primary river channel**,** also known as mainstream

mainstem-middle – the mainstem Manistique River between the West Branch Manistique River and Boucher Creek

mainstem-mouth – the mainstem Manistique River between Lake Michigan and the West Branch Manistique River

mainstem-upper – the mainstem Manistique River upstream of Boucher Creek

mitigation – action required to be taken to compensate for adverse effects of an activity

moraine – a mass of rocks, gravel, sand, clay, etc. carried and deposited directly by a glacier

NOAA – National Oceanic and Atmospheric Administration

naturalized – animals or plants previously introduced into a region that have become permanently established, as if native

outwash – glacial deposits that have been sorted by flowing water; outwash deposits typically consist of sand, gravel, and larger substrates, with the finer-textured silts and clays having been washed away

Palmer Drought Index – Developed by W. C. Palmer in 1965, this index of drought conditions is based on the supply-and-demand concept of the water balance equation, taking into account moisture conditions that were standardized so that comparisons could be made between locations and between months

pan evaporation – a measurement of the amount or rate of evaporation in a watershed

peaking – operational mode for a hydroelectric project that maximizes economic return by operating at maximum possible capacity during peak demand periods (generally 8 a.m. to 8 p.m.) and reducing or ceasing operations and discharge during non-peak periods; in other words, stream flows alternate between flood and drought on a daily basis

permeability – the ability of a substance to allow the passage of fluids; sands and gravels have high permeability for water, because it readily moves through them

piscivorous – fish eating

Pleistocene-Epoch – also know as Ice Age; period from 1,600,000 – 10,000BP

potamodromous – fishes that migrate from large fresh-water lakes to fresh-water rivers over the course of their lives (in this report it refers to fish that migrate into the Manistique River from Lake Michigan)

refugia – an area of relatively unaltered climate inhabited by plants and animals during a period of continental climatic change (e.g., glaciation); an area from which a new dispersion and speciation may take place after climatic readjustment

retention time – the amount of time it takes for the total volume of water in an impoundment to be replaced by incoming stream flow; also referred to as the reservoir's flushing rate

riparian – adjacent to, or living on, the bank of a river

riverine – a reach or portion of a river that is freely flowing and not impounded by dams

rollway – high banks along the river upon which logs were stockpiled and rolled down to the water

run habitat – fast, non-turbulent water

run-of-river – instantaneous inflow of water to an impoundment equals instantaneous outflow of water; on impounded systems this flow regime mimics the natural flow regime of a river

seral – transitional stages of plant communities that occur over time

species richness – the number of different species collected at a site

specific stream power – rate at which potential energy is supplied to a stream channel bed and banks; primarily a function of discharge and slope

sport fish – fish species that are commonly sought by anglers; also called game fish

standing crop – the abundance of organisms at a site, expressed in terms of number or biomass per unit area

surficial – referring to something on or at the surface

thalweg – the deepest part of a river channel; a line defining the lowest points along the length of a river bed (or valley)

thermocline – a layer of water between the warmer surface zone and the colder deep-water zone in a thermally stratified body of water (such as a lake), in which the temperature decreases rapidly with increasing depth

till – unstratified, unsorted glacial deposits of clay, sand, boulders, and gravel

turbidity – water that has large amounts of suspended particles in the water column

USDA – Unites States Department of Agriculture

USFS – Unites States Department of Agriculture, Forest Service

USFWS – United States Fish and Wildlife Service

USGS – United States Geological Survey

Valders Stadial – a sub-stage within the Wisconsinian glaciation; Valders Stadial (or sub-stage) was the last major ice advance

veligers – larval stages of mussels that freely drift with water currents

wadable – a stream that is shallow enough to be traversed by someone wearing chest waders

watershed – an area of the earth's surface that drains toward a receiving body of water (such as a stream or lake) at a lower elevation

young-of-year – the offspring of fish that hatched in the current calendar year

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TABLES

Table 1.–Name, size and location of lakes 10 acres or greater in the Manistique River watershed.

Lake name	Size (acres)	County	Latitude	Longitude
A Pool	229.0	Schoolcraft	46º14.97'N	85º57.22'W
Aldrich Lake	12.0	Schoolcraft	46º07.68'N	86º18.16'W
Als Lake	11.0	Alger	46º16.58'N	86º38.19'W
Ames Lake	19.1	Alger	46º31.50'N	85º56.86'W
Anne Louise, Lake	133.2	Schoolcraft	46º07.35'N	85º54.81'W
Anne Louise, Lake (west)	33.3	Schoolcraft	46º07.32'N	85º55.95'W
Ashford Lake	13.8	Schoolcraft	46º08.66'N	86º17.94'W
A-Two Pool	180.8	Schoolcraft	46º16.74'N	86º01.36'W
B Pool	234.8	Schoolcraft	46º15.48'N	85º57.22'W
Baldy Lake	63.0	Alger	46º13.03'N	86º39.16'W
Banana Lake	21.8	Schoolcraft	46º04.15'N	86º29.21'W
Bar Lake	59.0	Alger	46º14.18'N	86º39.07'W
Bass Lake	286.3	Schoolcraft	46º10.05'N	86º28.37'W
Bear Lake	30.0	Delta	46º04.38'N	86º29.91'W
Beaton Lake	43.7	Schoolcraft	46º14.05'N	86º25.06'W
Big Island Lake	139.6	Schoolcraft	46º14.37'N	86º32.59'W
Big Twin Lake	54.3	Alger	46º16.17'N	86º38.24'W
Black Creek Flooding	140.6	Mackinac	46º13.02'N	85º42.87'W
Blue Joe Lake	27.5	Schoolcraft	46º11.75'N	86º34.67'W
Blue Lake	36.4	Alger	46º10.00'N	86º37.92'W
Bluegill Lake	25.0	Schoolcraft	46º12.12'N	86º28.74'W
Bog Lake	11.7	Delta	46º07.28'N	86º33.77'W
Bonnet Lake	32.7	Schoolcraft	46º29.73'N	86º13.84'W
Boot Lake	106.4	Schoolcraft	46º16.18'N	86º26.84'W
Bootjack Lake	26.0	Schoolcraft	46º06.68'N	86º17.37'W
Brevick Lake	13.9	Schoolcraft	46º11.40'N	86º30.04'W
Browns Lake	92.7	Mackinac	46º06.83'N	85º46.12'W
Buck Lake	21.2	Schoolcraft	46º27.63'N	86º11.67'W
Burrell Lakes (#2)	17.4	Alger	46º30.80'N	86º20.48'W
Burrell Lakes (#3)	11.3	Alger	46º30.86'N	86º20.14'W
Burrell Lakes (#4)	9.7	Alger	46º31.13'N	86º19.74'W
Byers Lake	160.0	Schoolcraft	46º12.53'N	86º29.12'W
C Pool	254.8	Schoolcraft	46º16.06'N	85º57.68'W
Camp Fortyone Lake	13.3	Delta	46º04.82'N	86º31.84'W
Camp Nine Lakes	27.0	Schoolcraft	46º04.97'N	86º14.21'W
Camp Seven Lake	51.8	Delta	46º03.45'N	86º33.16'W
Canoe Lake	35.1	Schoolcraft	46º27.70'N	86º17.54'W
Carp Lake	13.2	Alger	46º13.70'N	86º38.59'W
Carpenter Lake	48.1	Schoolcraft	46º29.82'N	85º58.92'W
Carr Lake	17.6	Delta	46º04.78'N	86º30.36'W
Casey Lake	27.7	Alger	46º31.23'N	86º02.91'W
Cedar Lake	11.7	Schoolcraft	46º08.97'N	86º27.12'W
Cedar Lake	109.2	Schoolcraft	46º05.05'N	85º56.81'W
Chamberlain Lake	14.0	Delta	46º08.03'N	86º29.54'W

Table 1.–continued.

Lake name	Size (acres)	County	Latitude	Longitude
Cherry Lake	11.2	Alger	46º15.63'N	86º39.31'W
Chip Lake	81.3	Schoolcraft	46º08.32'N	85º55.97'W
Claypit Lake	15.1	Alger	46º31.75'N	86º01.92'W
Clear Lake	108.7	Schoolcraft	46º14.87'N	86º25.29'W
Clear Slough	25.4	Schoolcraft	46º02.20'N	86º12.71'W
Cloverleaf Lake (central)	21.8	Alger	46º33.50'N	86º05.52'W
Cloverleaf Lake (east)	11.1	Alger	46º33.55'N	86º05.24'W
Cloverleaf Lake (west)	12.8	Alger	46º33.64'N	86º05.77'W
Clyde Lake	12.2	Alger	46º32.47'N	86º09.99'W
Coattail Lake	47.9	Schoolcraft	46º13.80'N	86º31.81'W
Colwell Lake	129.9	Schoolcraft	46º13.43'N	86º26.54'W
Cookson Lake	55.3	Schoolcraft	46º11.90'N	86º33.69'W
Cornell Lake	33.3	Schoolcraft	46º10.57'N	85º52.42'W
Corner Lake	150.1	Schoolcraft	46º09.60'N	86º36.41'W
Council Lake	16.1	Alger	46º14.57'N	86º38.96'W
Cranberry Lake	12.8	Schoolcraft	46º27.08'N	86º11.01'W
Crooked Lake	24.7	Luce	46º18.12'N	85º46.84'W
Crooked Lake	45.0	Alger	46º30.40'N	86º16.21'W
Crooked Lake	192.9	Schoolcraft	46º12.78'N	86º25.17'W
C-Three Pool	549.1	Schoolcraft	46º17.83'N	86º07.79'W
C-Two Pool	382.9	Schoolcraft	46º16.02'N	86º01.32'W
Cusino Lake	137.1	Schoolcraft	46º27.35'N	86º15.54'W
D Pool	164.8	Schoolcraft	46º15.95'N	85º59.19'W
Dark Lake	9.8	Schoolcraft	46º29.75'N	86º03.97'W
Davis Slough	29.0	Schoolcraft	46º02.67'N	86º10.53'W
Deadman Lake	48.1	Alger	46º32.72'N	86º03.04'W
Deep Lake	38.8	Delta	46º09.62'N	86º36.21'W
Deer Lake	17.3	Alger	46º30.42'N	86º14.61'W
Deerfoot Lake	36.3	Alger	46º31.10'N	86º04.52'W
Delta Creek Pool	13.0	Schoolcraft	46º12.03'N	86º01.90'W
Dodge Lake	83.5	Schoolcraft	46º06.80'N	86º16.11'W
Doe Lake	33.3	Alger	46º15.62'N	86º40.61'W
Doyle Lake	17.2	Schoolcraft	46º07.35'N	86º13.22'W
Driggs Lake	163.0	Schoolcraft	46º27.43'N	86º10.71'W
Dutch Fred Lake	34.1	Schoolcraft	46º28.32'N	85º58.66'W
E Pool	444.1	Schoolcraft	46º16.35'N	85º58.04'W
East Lake	49.6	Schoolcraft	46º10.75'N	86º24.66'W
Ewatt Lake	19.7	Alger	46º33.00'N	86º10.77'W
F Pool	175.4	Schoolcraft	46º17.16'N	85º57.03'W
Farm Lake	82.4	Schoolcraft	46º12.02'N	86º30.04'W
Fawn Lake	31.4	Schoolcraft	46º30.02'N	86º17.77'W
Fern Lake	11.6	Delta	46º02.45'N	86º32.19'W
Fish Lake	134.5	Alger	46º13.37'N	86º38.37'W
Foote Lake	24.3	Delta	46º09.38'N	86º29.52'W
Ford Lake	69.0	Schoolcraft	46º08.95'N	85º54.62'W

Table 1.–continued.

Lake name	Size (acres)	County	Latitude	Longitude
Fork Lake	30.0	Schoolcraft	46º29.23'N	86º14.12'W
Fork Lake	39.0	Luce	46º15.73'N	85º45.02'W
G Pool	147.1	Schoolcraft	46º16.64'N	85º59.20'W
Gemini Lakes	128.1	Schoolcraft	46º29.32'N	86º18.21'W
Goose (lower)	23.5	Schoolcraft	46º17.32'N	85º55.95'W
Goose (upper)	19.6	Schoolcraft	46º17.55'N	85º56.13'W
Gopher Lake	15.5	Alger	46º31.18'N	86º03.52'W
Grants Lake	14.6	Alger	46º11.70'N	86º37.46'W
Grass Lake	56.4	Alger	46º32.18'N	86º06.74'W
Grassy Lake	188.0	Schoolcraft	46º13.35'N	86º34.97'W
Green Bass Lake	38.3	Schoolcraft	46º12.27'N	86º32.61'W
Greenway Lake	13.3	Schoolcraft	46º27.10'N	86º09.92'W
Grimes Lake	44.1	Alger	46º16.45'N	86º39.76'W
Gypsy Lake	38.2	Alger	46º32.92'N	86º01.76'W
H Pool	90.7	Schoolcraft	46º17.04'N	85º58.01'W
Halfmoon Lake	33.5	Alger	46º15.28'N	86º39.39'W
Hammond Lake	12.4	Alger	46º11.45'N	86º37.87'W
Hemlock Lake	34.6	Alger	46º31.38'N	86º05.44'W
Herman Lake	85.3	Schoolcraft	46º14.25'N	86º34.77'W
Highbridge Lake	13.4	Delta	46º06.87'N	86º32.52'W
Hike Lake	10.8	Alger	46º14.70'N	86º39.41'W
Hovey Lake	91.4	Alger	46º17.73'N	86º42.19'W
Hub Lake	14.1	Schoolcraft	46º09.78'N	86º32.16'W
Hughes Lake	51.0	Schoolcraft	46º09.48'N	86º28.79'W
Hugoboom Lake	16.7	Delta	46º09.02'N	86º36.34'W
Hutt Lake	24.7	Schoolcraft	46º08.25'N	86º27.24'W
I Pool	104.1	Schoolcraft	46º17.46'N	85º56.99'W
Indian Lake	8647.0	Schoolcraft	45º59.50'N	86º20.01'W
Ionia Lake	40.8	Alger	46º30.38'N	86º15.31'W
Ironjaw Lake	58.8	Schoolcraft	46º10.40'N	86º33.19'W
Irwin Lake	10.2	Alger	46º13.18'N	86º37.57'W
Island Lake	31.8	Alger	46º15.96'N	86º38.92'W
Island Lake	102.7	Schoolcraft	46º07.13'N	86º16.69'W
Island Lake Slough	29.0	Schoolcraft	46º00.71'N	86º13.75'W
J Pool	179.6	Schoolcraft	46º17.45'N	85º57.99'W
Jack Lake	17.3	Schoolcraft	46º06.53'N	86º16.59'W
Jackpine Lake	57.2	Delta	46º06.98'N	86º31.27'W
Johns Lake (northeast)	20.2	Alger	46º31.79'N	85º54.04'W
Johns Lake (northwest)	16.6	Alger	46º31.84'N	85º54.28'W
Johns Lake (southeast)	11.0	Alger	46º31.53'N	85º53.92'W
Kennedy Lake	141.2	Schoolcraft	46º12.55'N	85º53.19'W
Kimble Lake	22.0	Schoolcraft	46º13.05'N	86º36.66'W
Kinsey Lake	20.5	Alger	46º30.82'N	86º13.37'W
Kitten Lake	14.9	Alger	46º18.40'N	86º42.14'W
Klondike Lake	42.6	Schoolcraft	46º13.27'N	86º30.11'W

Table 1.–continued.

Lake name	Size (acres)	County	Latitude	Longitude
Lambert Lake	35.8	Alger	46º30.53'N	86º05.11'W
Leg Lake	40.4	Schoolcraft	46º07.90'N	86º29.09'W
Legion Lake	35.8	Alger	46º31.68'N	86º21.79'W
Lilly Lake	39.5	Mackinac	46º07.85'N	85º47.52'W
Lily Lake	155.2	Schoolcraft	46º16.82'N	86º26.07'W
Lion Lake	17.2	Alger	46º14.88'N	86º39.26'W
Little Bass Lake	81.1	Schoolcraft	46º09.67'N	86º27.02'W
Little Island Lake	40.5	Schoolcraft	46º11.77'N	86º30.84'W
Little Mud Lake	42.6	Mackinac	46º14.25'N	85º51.24'W
Little Murphy Lake	10.3	Schoolcraft	46º07.67'N	86º27.12'W
Little Ross Lake	17.3	Schoolcraft	46º28.38'N	86º14.86'W
Locke Lake	12.3	Luce	46º17.20'N	85º39.92'W
Long Lake	20.6	Schoolcraft	46º30.13'N	86º05.27'W
Long Lake	117.0	Schoolcraft	46º30.33'N	86º19.17'W
Long Lake	128.1	Mackinac	46º06.93'N	85º48.01'W
Loon Lake	27.6	Alger	46º32.43'N	86º07.41'W
Lorraine Lake	13.2	Schoolcraft	46º08.68'N	86º28.97'W
Lost Lake	10.5	Schoolcraft	46º28.87'N	86º01.96'W
Lost Lake	18.7	Schoolcraft	46º11.77'N	85º52.06'W
Lost Lake	105.6	Alger	46º17.77'N	86º39.47'W
Lower Goose Pen Pool	69.7	Schoolcraft	46º13.93'N	85º56.49'W
Lower Shoe Lake	24.3	Alger	46º30.07'N	86º22.94'W
Lyman Lake	73.9	Delta	46º04.28'N	86º32.11'W
M Pool	545.1	Schoolcraft	46º14.40'N	86º00.50'W
Mahoney Lake	27.0	Schoolcraft	46º29.67'N	86º12.41'W
Mallard Lake	17.5	Alger	46º32.65'N	86º09.52'W
Mallard Lake	20.6	Alger	46º33.83'N	86º06.59'W
Man Lake	19.8	Alger	46º11.52'N	86º38.52'W
Manistique Lake	10346.1	Mackinac	46º14.00'N	85º47.01'W
Marsh Creek Pool	461.3	Schoolcraft	46º10.94'N	86º03.50'W
Marshman Lake	10.0	Alger	46º31.47'N	86º05.12'W
McComb Lake	53.8	Alger	46º11.27'N	86º39.26'W
McCormick Lake	23.9	Luce	46º17.93'N	85º40.47'W
McInnes Lake	19.4	Schoolcraft	46º13.67'N	86º31.01'W
McKeever Lake	147.2	Schoolcraft	46º12.92'N	86º35.42'W
McNeil Lake	21.3	Alger	46º17.35'N	86º37.86'W
Mervin Lake	14.4	Alger	46º31.87'N	86º11.11'W
Merwin Lake	146.5	Schoolcraft	46º01.38'N	86º04.67'W
Mezik Lake	69.8	Schoolcraft	46º08.40'N	85º58.32'W
Mid Lake	22.2	Schoolcraft	46º14.10'N	86º32.07'W
Mike White Lake	17.7	Schoolcraft	46º10.12'N	86º35.54'W
Minerva Lake	43.9	Schoolcraft	46º08.78'N	86º28.59'W
Mirror Lake	33.9	Alger	46º16.55'N	86º41.11'W
Mitchell Lake	97.8	Alger	46º32.35'N	85º54.97'W
Mitchell Lake West	21.3	Alger	46º32.35'N	85º55.16'W

Table 1.–continued.

Lake name	Size (acres)	County	Latitude	Longitude
Mitten Lake	217.1	Mackinac	46º07.18'N	85º45.11'W
Moccasin Lake	80.9	Alger	46º14.18'N	86º37.16'W
Molly Lake	10.0	Delta	46º04.53'N	86º30.69'W
Moon Lake	66.8	Schoolcraft	46º07.82'N	85º52.39'W
Moose Lake	25.4	Alger	46º30.57'N	86º03.56'W
Mowe Lake	23.6	Delta	46º08.70'N	86º34.77'W
Mud Lake	14.5	Schoolcraft	46º01.95'N	86º04.26'W
Muddy Lake	36.9	Alger	46º16.92'N	86º39.92'W
Muleshoe Lake, North	9.9	Schoolcraft	46º07.99'N	86º26.10'W
Muleshoe Lake, South	14.5	Schoolcraft	46º07.79'N	86º25.98'W
Murphy Lake	133.3	Schoolcraft	46º07.95'N	86º27.76'W
Neds Lake	13.9	Schoolcraft	46º13.08'N	86º31.19'W
Neighbor Lake	11.5	Schoolcraft	46º10.44'N	86º26.48'W
Nevins Lake	274.5	Alger	46º30.97'N	86º14.69'W
Nineteen Lake	19.5	Schoolcraft	46º10.30'N	86º32.71'W
Nita, Lake	10.5	Alger	46º33.00'N	86º03.89'W
no name	9.8	Schoolcraft	46º29.81'N	86º16.99'W
no name	10.0	Schoolcraft	46º14.14'N	86º20.81'W
no name	10.2	Schoolcraft	46º28.29'N	86º10.18'W
no name	10.2	Schoolcraft	46º00.21'N	86º13.98'W
no name	10.4	Alger	46º34.12'N	86º06.78'W
no name	10.7	Schoolcraft	46º27.50'N	86º06.11'W
no name	10.7	Alger	46º18.05'N	86º38.24'W
no name	10.8	Mackinac	46º11.01'N	85º49.96'W
no name	11.0	Schoolcraft	46º12.50'N	86º34.27'W
no name	11.2	Schoolcraft	46º24.21'N	86º09.40'W
no name	11.4	Schoolcraft	46º03.43'N	86º20.88'W
no name	11.6	Schoolcraft	46º14.06'N	86º00.11'W
no name	11.8	Schoolcraft	46º14.11'N	86º03.02'W
no name	11.8	Schoolcraft	46º28.44'N	86º10.82'W
no name	13.7	Alger	46º33.23'N	86º07.24'W
no name	13.8	Schoolcraft	46º13.64'N	86º02.29'W
no name	14.0	Schoolcraft	46º03.82'N	86º05.47'W
no name	14.1	Schoolcraft	46º14.56'N	86º18.86'W
no name	14.2	Schoolcraft	46º28.87'N	86º11.54'W
no name	14.7	Schoolcraft	46º18.99'N	85º59.37'W
no name	15.6	Schoolcraft	46º16.79'N	86º00.01'W
no name	15.8	Alger	46º30.70'N	86º09.15'W
no name	15.9	Schoolcraft	46º02.61'N	86º06.83'W
no name	18.5	Schoolcraft	46º16.23'N	85º57.97'W
no name	18.9	Schoolcraft	46º29.16'N	86º16.56'W
no name	19.7	Schoolcraft	46º27.96'N	86º09.98'W
no name	20.2	Schoolcraft	46º02.31'N	86º07.60'W
no name	20.2	Schoolcraft	46º27.21'N	86º07.91'W
no name	20.8	Schoolcraft	46º16.55'N	85º56.76'W

Table 1.–continued.

Lake name	Size (acres)	County	Latitude	Longitude
no name	22.0	Mackinac	46º09.25'N	85º51.84'W
no name	22.3	Schoolcraft	46º15.65'N	86º04.64'W
no name	23.7	Schoolcraft	46º27.75'N	86º10.07'W
no name	25.0	Schoolcraft	46º10.65'N	86º09.50'W
no name	25.2	Schoolcraft	46º17.42'N	85º56.68'W
no name	30.3	Schoolcraft	46º05.31'N	86º03.44'W
no name	37.2	Schoolcraft	46º11.27'N	86º01.92'W
no name	43.1	Schoolcraft	46º15.96'N	86º04.61'W
no name	68.0	Schoolcraft	46º16.96'N	86º02.81'W
No name	113.7	Schoolcraft	46º13.37'N	86º00.78'W
no name slough	20.6	Schoolcraft	46º01.98'N	86º10.18'W
North Manistique Lake	1709.1	Luce	46º17.25'N	85º44.34'W
Norway Lake	18.6	Delta	46º07.87'N	86º30.51'W
Nugent Lake	27.9	Alger	46º31.57'N	86º11.42'W
Ostrander Lake	54.8	Schoolcraft	46º10.08'N	86º36.74'W
Otter Lake	15.0	Schoolcraft	46º29.17'N	86º12.66'W
Otter Lake	61.9	Alger	46º18.70'N	86º43.72'W
Owl Lake	25.9	Alger	46º30.40'N	86º04.32'W
Palmer Lake	11.2	Alger	46º32.10'N	86º00.22'W
Pan Lake	10.4	Alger	46º11.18'N	86º37.66'W
Peanut Lake	11.9	Schoolcraft	46º12.12'N	86º32.24'W
Pear Lake	39.5	Schoolcraft	46º12.42'N	86º28.42'W
Pelican Lake	18.1	Alger	46º33.40'N	86º08.49'W
Perch Lake	16.9	Schoolcraft	46º26.90'N	86º08.42'W
Petes Lake	194.0	Schoolcraft	46º13.58'N	86º36.02'W
Pickerel Lake	10.9	Alger	46º33.20'N	86º08.67'W
Pickerel Lake	69.6	Alger	46º31.10'N	86º00.59'W
Porky Lakes	12.1	Alger	46º31.47'N	86º02.26'W
Powell Lake	71.1	Alger	46º18.55'N	86º39.04'W
Red Jack Lake	10.1	Alger	46º14.65'N	86º38.66'W
Red Lake	38.5	Schoolcraft	46º12.03'N	86º34.34'W
Reservoir, The	24.6	Schoolcraft	46º29.60'N	85º59.27'W
Rim Lake	14.4	Schoolcraft	46º09.73'N	86º32.42'W
Rock Lake	12.0	Alger	46º14.95'N	86º39.49'W
Ross Lake	195.9	Schoolcraft	46º28.85'N	86º15.46'W
Rumble Lake	17.9	Schoolcraft	46º11.00'N	86º33.61'W
Sand Lake	59.2	Alger	46º32.27'N	86º05.39'W
Sand Lake	113.1	Schoolcraft	46º15.63'N	86º25.46'W
Scout Lake	11.6	Alger	46º14.82'N	86º39.01'W
Second Lake	13.4	Alger	46º31.48'N	86º01.46'W
Section Thirty-six Lake	16.7	Alger	46º30.78'N	86º22.36'W
Shoe Pac Lake	9.9	Delta	46º01.82'N	86º30.19'W
Shoepac Lake	152.7	Mackinac	46º11.15'N	85º49.14'W
Sister Lake	13.8	Alger	46º18.90'N	86º39.16'W
Skeels Lake	92.5	Delta	46º09.50'N	86º37.42'W

Table 1.–continued.

Lake name	Size (acres)	County	Latitude	Longitude
Skeels Pond	15.3	Alger	46º10.68’N	86º38.12’W
Smith Lake	112.9	Schoolcraft	46º06.95’N	86º13.59’W
Smith Slough	13.8	Schoolcraft	46º01.50’N	86º18.51’W
Snyder Lake	62.9	Schoolcraft	46º29.28’N	85º56.89’W
South Manistique Lake	4132.9	Mackinac	46º10.50’N	85º45.76’W
Spring Lake	11.9	Delta	46º05.63’N	86º32.32’W
Spring Lake	12.5	Schoolcraft	46º29.55’N	86º06.91’W
Sprinkler Lake	10.1	Schoolcraft	46º10.82’N	86º33.91’W
Spruce Lake	10.4	Alger	46º31.07’N	86º04.01’W
Spur Pool	83.8	Schoolcraft	46º15.15’N	86º04.20’W
Stanley Lake	100.2	Schoolcraft	46º29.43’N	86º09.54’W
Steuben Lake	135.6	Schoolcraft	46º11.98’N	86º25.27’W
Stewart Lake	182.5	Schoolcraft	46º11.63’N	85º53.87’W
Straits Lake	190.0	Schoolcraft	46º10.38’N	86º36.29’W
Stuart Lake	30.5	Mackinac	46º11.88’N	85º51.19’W
Sturgeon Hole Slough	47.7	Schoolcraft	46º00.38’N	86º14.55’W
Sucker Lake	28.8	Schoolcraft	46º29.17’N	86º06.24’W
Swan Lake	46.0	Schoolcraft	46º09.92’N	86º34.44’W
T Lake	17.9	Luce	46º16.38’N	85º39.36’W
T Pool	232.1	Schoolcraft	46º13.28’N	85º59.26’W
Tad Lake	23.2	Schoolcraft	46º09.45’N	85º53.72’W
Taylor Lake	15.3	Schoolcraft	46º29.37’N	86º04.59’W
Teal Lake	43.7	Alger	46º33.95’N	86º05.66’W
Teal Lake (northeast)	16.8	Alger	46º34.07’N	86º05.34’W
Tee Lake	198.0	Schoolcraft	46º09.05’N	85º52.77’W
Temple Lake	16.3	Alger	46º12.18’N	86º38.81’W
Thornton Lake	30.8	Alger	46º14.68’N	86º37.41’W
Three Island Lake	34.8	Schoolcraft	46º09.12’N	86º28.34’W
Thunder Lake	331.0	Schoolcraft	46º06.10’N	86º28.37’W
Tie Lake	49.5	Alger	46º11.78’N	86º38.91’W
Toms Lake	25.7	Schoolcraft	46º09.68’N	86º35.56’W
Town Lake	40.7	Alger	46º13.65’N	86º37.02’W
Townline Lake	84.2	Schoolcraft	46º14.53’N	86º32.16’W
Triangle Lake	47.1	Alger	46º31.80’N	86º05.69’W
Triangle Lake	173.0	Schoolcraft	46º10.10’N	86º30.12’W
Twilight Lake	56.3	Schoolcraft	46º12.67’N	86º29.82’W
Twin Lakes	26.2	Schoolcraft	46º29.87’N	85º52.71’W
Upper Goose Pen Pool	39.5	Schoolcraft	46º14.61’N	85º57.22’W
Upper Shoe Lake	34.1	Alger	46º30.45’N	86º22.76’W
Upper Thunder Lake	24.5	Schoolcraft	46º06.97’N	86º28.37’W
Upper Thunder Lake	37.9	Schoolcraft	46º07.00’N	86º28.52’W
Upper Twin Lake	13.9	Alger	46º16.38’N	86º38.52’W
Vance Lake	29.3	Schoolcraft	46º12.95’N	86º30.21’W
Verdant Lake	21.0	Schoolcraft	46º10.65’N	86º32.86’W
Wedge Lake	27.0	Schoolcraft	46º12.58’N	86º35.76’W

Table 1.–continued.

Lake name	Size (acres)	County	Latitude	Longitude
West Branch Lake (north)	21.9	Alger	46º30.97'N	86º06.08'W
West Branch Lake (southeast)	10.9	Alger	46º30.73'N	86º05.76'W
West Branch Lake (southwest)	40.5	Alger	46º30.64'N	86º06.33'W
Wetmore Lake	28.1	Alger	46º22.08'N	86º35.54'W
Wetmore Lake (north)	17.3	Alger	46º22.14'N	86º33.11'W
Wise Lake	23.5	Alger	46º31.60'N	86º10.41'W
Wolf Lake	20.8	Alger	46º31.70'N	86º14.22'W
Wolf Lake	38.0	Delta	46º03.23'N	86º31.21'W
Woodruff Lake	10.6	Schoolcraft	46º02.68'N	86º16.89'W
Worchester Lake	119.6	Schoolcraft	46º26.77'N	86º16.89'W

Table 2.–United States Geological Survey gauging stations within the Manistique River watershed. Station numbers are referenced in Figure 5. Included in this table are record period for each station, mean discharge, watershed area, mean yield, flow stability index, flow stability index classification, measured river width, and calculated 95% and 5% width exceedence. Calculated channel widths outside of the 95% and 5% exdceedence widths are noted with "*".

Subwatershed name, number, and river	Location	Latitude Longitude	USGS station no.	Period of record	Mean discharge (ft^3/s)	Watershed area (mi^2)	Mean yield ($ft^3/s\ mi^2/$)	Flow index	Flow stability classification	Measured width (ft)	Calculated widths (ft) Exceedence 95%	Calculated widths (ft) Exceedence 5%
Mainstem – upper												
1 Manistique	Germfask	46°14.00′ N 85°55.67′ W	04049500	1937-70	448.4	341	1.32	1.8	Very good	81.0	77.7	163.7
Mainstem – middle												
2 Manistique	Blaney	46°05.08′ N 86°03.58′ W	04055000	1938-70	835.5	704	1.19	2.3	Good	123.0	92.0	256.7
Mainstem – mouth												
3 Manistique	Manistique	46°04.83′ N 86°09.67′ W	04056500	1938-99	1,421.5	1,100	1.29	2.4	Good	114.0*	120.0	343.0
4 Manistique	Above Manistique	45°58.30′ N 86°14.58′ W	04057004	1994-95	1,495.4	1,445	1.03	2.5	Good	129.0*	141.1	333.6
Tributaries – central basin												
5 Holland Cr.	Seney	46°20.75′ N 86°03.00′ W	04049000	1938-42	18.9	13	1.45	7.3	Fair	17.0	7.8	45.5
6 Driggs	Seney	46°20.75′ N 86°07.50′ W	04052000	1938-42	73.2	70	1.05	2.0	Very good	27.3*	35.5	68.1
7 Walsh Cr.	Seney	46°20.75′ N 86°10.67′ W	04052500	1938-42	19.4	12	1.62	7.7	Fair	15.4	8.4	43.1
8 Driggs	Germfask	46°12.00′ N 86°00.00′ W	04053000	1938-41	100.7	114	0.88	2.5	Good	38.0	34.6	87.5
9 Marsh Cr.	Shingleton	46°20.75′ N 86°14.33′ W	04053500	1938-42	11.5	20	0.58	9.4	Fair	6.9	0.0	39.1
10 Marsh Cr.	Germfask	46°10.00′ N 86°00.83′ W	04054000	1938-41	12.6	15	0.84	7.0	Fair	5.0*	5.5	34.1
11 Duck Cr.	Blaney	46°06.67′ N 86°04.58′ W	04054500	1938-54	94.0	92	1.02	4.7	Good	48.0	17.4	108.4
12 Creighton	Shingleton	46°20.75′ N 86°16.58′ W	04055500	1938-42	54.6	35	1.56	4.1	Good	50.0	15.5	76.2
13 W. B. Manistique	Manistique	46°05.33′ N 86°09.67′ W	04056000	1938-56	413.5	322	1.28	2.8	Good	105.0	60.9	198.9
Tributaries – lower Indian River												
14 Indian	Manistique	45°59.50′ N 86°17.25′ W	04057000	1992-93	385.6	302	1.28	1.9	Very good	189.0*	64.3	135.3

Table 3.–Definition of flow stability indices using weighted ratio of mean high flow to mean low flow. Data from P. Seelbach, Michigan Department of Natural Resources, Fisheries Division.

Flow stability index	Classification	Description
1.0 – 2.0	Very good	Typical of self sustaining trout streams
2.1 – 5.0	Good	Better warmwater rivers
5.1 – 10.0	Fair	Somewhat flashy warmwater rivers
>10	Poor	Very flashy warmwater river

Table 4.–Land use within the Manistique River watershed and subwatersheds by percentage of area.

		Mainstem			Tributaries			
Land use	Watershed	upper	middle	mouth	Fox	central	upper Indian	lower Indian
Agriculture	1.6%	5.1%	2.7%	2.8%	1.5%	0.6%	0.3%	3.0%
Barren	1.4%	0.2%	0.3%	0.0%	5.2%	0.5%	1.2%	0.0%
Developed	0.2%	0.1%	0.0%	1.0%	0.1%	0.2%	0.0%	0.7%
Wetland	57.1%	49.3%	67.0%	84.8%	42.8%	66.8%	41.7%	58.3%
Grassland	1.5%	0.6%	0.5%	0.3%	3.5%	1.3%	1.1%	0.4%
Open Water	5.4%	13.2%	1.7%	2.8%	1.3%	5.0%	4.7%	13.6%
Upland	32.8%	31.5%	27.8%	8.3%	45.7%	25.7%	51.0%	23.9%
Urban-recreation Grasses	<0.1%	<0.1%	0.0%	<0.1%	<0.1%	<0.1%	0.0%	0.1%

Table 5.–Dams found within the Manistique River watershed, by subwatershed. Map reference numbers correspond with Figures 40 and 41.

Map reference number	Subwatershed dam name	Latitude	Longitude	Owner	Height (feet)	Year built	Hazard rating
	Mainstem – upper						
1	Tressler Dam	46°18.20′N	85°43.90′W	Kermit Tressler	-	-	3
2	Schaefer Dam Number Two	46°18.20′N	85°46.00′W	Ray Schaefer	-	-	3
3	Brower Dam	46°16.70′N	85°46.50′W	Rev. H. Brower	-	-	3
4	Black Creek Dam	46°13.00′N	85°43.00′W	MDNR	8	1956	3
5	Manistique Lake Dam	46°15.40′N	85°52.50′W	Luce Co Road Commission	7	1977	3
6	Portage Creek Dam	46°12.30′N	85°44.80′W		-	-	3
7	Schaefer Dam Number One	46°17.70′N	85°45.30′W	Ray Schaefer	-	-	3
8	Burton Dam	46°06.80′N	85°45.70′W	William Burton	-	-	3
9	Anderson Dam	46°14.00′N	85°52.48′W	Anderson	-	-	3
	Mainstem – mouth						
10	Paper Mill Dam	45°58.00′N	86°14.80′W	Manistique Paper Inc.	25	1919	1
	Tributaries – Fox River						
11	Kings Pond Dam	46°28.00′N	85°56.70′W	MDNR	12	1983	3
12	Spring Creek Dam	46°23.90′N	85°51.80′W	MDNR	16	1965	3
13	Stanley Lake Dam	46°29.10′N	86°08.90′W	MDNR	12	1950	3
	Tributaries – central						
14	F-1 Pool	46°17.20′N	85°57.80′W	USFWS	7	1937	3
15	G-1 Pool	46°16.50′N	85°59.50′W	USFWS	7	1943	3
16	C-1 Pool	46°16.10′N	85°58.00′W	USFWS	8	1937	3
17	B-1 Pool	46°15.60′N	85°58.30′W	USFWS	8	1937	3
18	E-1 Pool	46°16.50′N	85°57.20′W	USFWS	8	1937	3
19	A-2 Pool	46°16.80′N	86°01.30′W	USFWS	12	1943	3
20	M-2 Pool	46°14.50′N	86°00.38′W	USFWS	12	1943	3
21	C-2 Pool	46°16.20′N	86°01.30′W	USFWS	12	1943	3
22	T-2 Pool	46°13.50′N	85°58.80′W	USFWS	12	1943	3
23	D-1 Pool	46°16.30′N	85°59.30′W	USFWS	8	1943	3
24	C-3 Pool	46°17.50′N	86°08.70′W	USFWS	7	1943	3
25	Marsh Creek Pool	46°11.20′N	86°03.50′W	USFWS	9	1961	3
26	J-1 Pool	46°17.50′N	85°58.00′W	USFWS	10	1937	3
27	Scotts Marsh Dike 1 Dam	46°16.77′N	86°31.72′W	Hiawatha National Forest	7	1971	3

Table 5.–Continued.

Map reference number	Subwatershed dam name	Latitude	Longitude	Owner	Height (feet)	Year built	Hazard rating
	Tributaries – central – continued						
28	Scotts Marsh Dike 2 Dam	46°16.77′N	86°31.72′W	Hiawatha National Forest	6	1974	3
29	A-1 Pool	46°15.10′N	85°57.20′W	USFWS	12	1937	3
30	Lower Goose Pen Dam	46°14.00′N	85°56.30′W	USFWS	10	1940	3
31	Upper Goose Pen Dam	46°14.50′N	85°57.30′W	USFWS	11	1940	3
32	Show Pool Dam	46°17.30′N	85°55.80′W	USFWS	9	1955	3
33	I-1 Pool	46°17.50′N	85°57.20′W	USFWS	8	1937	3
34	H-1 Pool	46°17.10′N	85°58.00′W	USFWS	8	1937	3
35	Delta Creek Pool	46°12.80′N	86°02.00′W	USFWS	11	1961	3
36	Steuben Lake Pike Marsh Dam	46°11.80′N	86°24.80′W	USDA Forest Service	-	-	3
37	USFWS Dam No 3	46°17.00′N	86°02.70′W	USFWS	-	-	3
38	USFWS Dam No 2	46°13.70′N	86°00.90′W	USFWS	-	-	3
39	Driggs River Diversion Dam	46°19.00′N	86°06.50′W	US Fish & Wildlife Service	-	-	3
40	Herb Musselman Dam	46°12.80′N	85°55.50′W	Herb Musselman	-	-	3
41	Spur Pool Dam	46°15.10′N	86°04.10′W	USFWS	-	-	3
42	USFWS Dam No 4	46°15.70′N	86°04.60′W	USFWS	-	-	3
43	Kinnunen Dam	46°23.00′N	86°28.50′W	Kinnunen	-	1970	3
44	USFWS Dam No 1	46°13.30′N	86°00.30′W	USFWS	-	-	3
	Tributaries – upper Indian River						
45	Curtis-Juday Dam	46°09.97′N	86°37.60′W	USDA Forest Service	-	-	3
46	Little Bass Lake Dam	46°09.83′N	86°27.50′W	Hiawatha National Forest	11	1974	3
47	Little Indian Hunting Club Dam	46°12.50′N	86°32.20′W	Little Indian Hunting Club	-	-	3
48	Muddy Grimes Dam	46°17.00′N	86°40.00′W	Hiawatha National Forest	8	-	3
49	Council Lake Dam	46°14.48′N	86°38.88′W	Federal	-	-	-
50	Kettle Hole Pond Dam	46°15′22″N	86°38.97′W	Federal	-	-	-
	Tributaries – lower Indian River						
51	Intake Park Dam	45°58.50′N	86°14.80′W	City Of Manistique	7	1917	3
52	Indian Lake Dam	45°58.30′N	86°16.40′W	Schoolcraft Co Drain Commission	10	1878	2
53	Carr Creek Barrier	46°05.00′N	86°30.33′W	MDNR	3	1978	3
54	Bear Lake Barrier	46°04.87′N	86°31.47′W	MDNR	-	-	-

Table 6.–Permitted discharges to the Manistique River watershed, by authorization of Michigan Department of Environmental Quality Surface Water Quality Division under the National Pollutant Discharge Elimination System (NPDES).

Facility name	NPDES permit #	Facility address	Zip code	City name	County name	Receiving Water
Manistique Saw & Planing	MIS110011	184 South Front Street	49854	Manistique	Schoolcraft	South Town Creek
Mathson Redi-Mix Inc.	MIS110881	620 Deer Street	49854	Manistique	Schoolcraft	Manistique storm sewer
Michigan Army National Guard-Manistique-OMS 23a	MIS210041	345 Elm Street	49854-1237	Manistique	Schoolcraft	Manistique River
Roy Graves Lumber Co. Inc.	MIS110001	Mill Street	49884	Shingleton	Alger	Hickey Creek
Wood Island Landfill	MIS110002	M-28 East	49894	Wetmore	Alger	Wetmore Lake

Table 7.–Manistique River watershed Public Boat Launch Directory. Ramp Code - This number tells the type of launching ramp the site user can expect to find at the access site: 1. A hard-surfaced ramp with sufficient water depth and lake size to accommodate most trailerable boats; 2. A hard-surfaced ramp, in areas of limited water depth or lake size, where launching, retrieving, and use of larger boats may be difficult; 3. A gravel surfaced ramp. Administrating codes: DNR PRD = Michigan DNR Parks and Recreation Division, DNR FMD = Michigan DNR Forest Management Division, USFS = United States Department of Agriculture, Forest Service.

Site no.	Site name and body of water	Location	Ramp code	Toilets	Parking	Administrating agency	Town	Range	Section
77-1	Manistique Municipal Ramp Manistique River (Lake Michigan Access)	City of Manistique	1	No	40	City of Manistique	41N	16W	13
77-2	Wagner Dam Fox River	10 mi NW of Seney	4	Yes	8	DNR PRD	47N	14W	16
77-3	Kennedy Lake	3 mi SE of Germfask	4	No	5	DNR PRD	44N	13W	13
77-4	Stanley Lake State Forest Campground	13 mi E of Melstrand	4	Yes	0	DNR FMD	47N	15W	11
77-5	Ten Curves Manistique River	3 mi E of Germfask	4	Yes	10	DNR PRD	45N	13W	25
77-6	Dodge Lake	11 mi N of Manistique	1	Yes	8	DNR PRD	43N	16W	23
77-7	Dutch Fred Lake	9 mi N of Seney	3	Yes	6	DNR PRD	47N	13W	18
77-10	Snyder Lake	10 mi N of Seney	1	Yes	6	DNR PRD	47N	13W	9
77-11	Ashford Lake	13 mi N of Manistique	4	Yes	5	DNR PRD	43N	16W	3
77-12	8 mi N of Seney	8 mi N of Seney	4	No	6	DNR PRD	47N	13W	15
77-15	Cusino Lake	7 mi E of Melstrand	4	Yes	5	DNR FMD	47N	16W	24
77-16	Fox River	5 mi NW of Seney	4	Yes	4	DNR PRD	46N	14W	11
77-18	North Gemini Lake State Forest Campground	6 mi E of Melstrand	2	Yes	3	DNR FMD	47N	16W	9
77-19	South Gemini Lake State Forest Campground	5 mi E of Melstrand	1	Yes	0	DNR FMD	47N	16W	9
77-20	Ross Lake State Forest Campground	7 mi E of Melstrand	1	Yes	5	DNR FMD	47N	16W	11
77-22	Mead Creek State Forest Campground	5 mi NW of Blaney Park	3	Yes	10	DNR FMD	44N	13W	30

Table 7.–Continued.

Site no.	Site name and body of water	Location	Ramp code	Toilets	Parking	Administrating agency	Town	Range	Section
77-23	Merwin Creek State Forest Campground Manistique River	6 mi NW of Gulliver	3	Yes	10	DNR FMD	42N	15W	13
77-24	West Branch W. Br. Manistique River	15 mi N of Manistique	4	Yes	2	DNR FMD	44N	15W	32
77-25	Indian Lake State Park South Unit	3 mi N of Thompson	1	Yes	20	DNR PRD	41N	16W	17
77-28	Palms Brook State Park Indian Lake	7 mi NW of Thompson	2	Yes	5	DNR PRD	42N	17W	25
77-29	Indian Lake State Park West Unit	5 mi N of Thompson	2	Yes	40	DNR PRD	41N	16W	6
77-30	Manistique River	1 mi N of Manistique	2	No	6	DNR PRD	41N	16W	1
77-31	Bass Lake	1 mi S of Steuben	3	No	2	USFS	44N	17W	31
77-32	Boot Lake	4 mi S of Shingleton	3	Yes	3	USFS	45N	17W	20
77-33	Clear Lake	4 mi N of Steuben	3	No	2	USFS	45N	17W	33
77-35	East Lake	2 mi SE of Steuben	3	No	2	USFS	44N	17W	26
77-36	Ironjaw Lake	5 mi W of Steuben	3	No	2	USFS	44N	18W	27
77-37	Minerva Lake	3 mi SW of Steuben	3	No	2	USFS	43N	17W	6
77-38	Nineteen Lake	4 mi W of Steuben	3	No	2	USFS	44N	18W	34
77-39	Pete's Lake	8 mi NW of Steuben	2	Yes	5	USFS	44N	18W	7
77-40	Steuben Lake	1 mi NE of Steuben	3	Yes	2	USFS	44N	18W	36
77-41	Triangle Lake	2 mi SW of Steuben	3	Yes	2	USFS	44N	18W	36
02-21	Fish Lake	9 mi W of Steuben	3	Yes	6	USFS	44N	19W	2
02-22	Irwin Lake	10 mi W of Steuben	2	Yes	4	USFS	44N	19W	12
21-29	Corner Lake	8 mi W of Steuben	2	Yes	4	USFS	43N	18W	6

Table 7.–Continued.

Site no.	Site name and body of water	Location	Ramp code	Toilets	Parking	Administrating agency	Town	Range	Section
21-32	Jackpine Lake	6 mi S of Steuben	3		6	USFS	43N	18W	14
48-1	Manistique Lake	9 mi SW of McMillan	1	Yes	14	DNR PRD	45N	12W	29
48-7	County Line Manistique Lake	7 mi S of McMillan	2	Yes	10	DNR PRD	45N	11W	31
48-13	Luce County Park North Manistique Lake	5 mi S of McMillan	3	Yes	25	Luce County	45N	11W	19
49-2	Curtis, Manistique Lake	Curtis	1	Yes	42	DNR PRD	44N	12W	13
49-5	Dunkles Landing South Manistique Lake	3 mi S of Curtis	1	Yes	10	DNR PRD	44N	12W	36
49-6	Wolfe Bay South Manistique Lake	2 mi SW of Curtis	1	Yes	5	DNR PRD	44N	12W	23
49-8	Cooks Bay Manistique Lake	3 mi W of Curtis	2	Yes	15	DNR PRD	44N	12W	16
49-12	South Manistique Lake State Forest Campground	3 mi SW of Curtis	3	Yes	12	DNR FMD	44N	12W	27
49-19	Portage Township Park South Manistique Lake	Curtis	2	No	30	Portage Township	44N	17W	13

Table 8.–Manistique River watershed Campground Directory. Administrating codes: DNR PRD = Michigan DNR Parks and Recreation Division; DNR FMD = Michigan DNR Forest Management Division; USFS = United States Department of Agriculture, Forest Service.

Site name	County	Location of site	Acres	Administrating agency
North Gemini Lake	Schoolcraft	10 miles NE of Melstrand via Co Rd H-58 and Twin Lakes	17	DNR FMD
South Gemini Lake	Schoolcraft	12 miles NE of Melstrand via Co Rd H-58 and Twin Lakes Truck Trail to Co Rd 450	8	DNR FMD
Ross Lake	Schoolcraft	14 miles NE of Melstrand via Co Rd H-58 & Ross Lake Rd	10	DNR FMD
Canoe Lake	Schoolcraft	9 miles E of Melstrand via H-52, Co Rd 450 & Wolf Lake Rd	4	DNR FMD
Cusino Lake	Schoolcraft	11 miles E. of Melstrand via H-52 and Co Rd 450	6	DNR FMD
Fox River	Schoolcraft	5 miles NW of Seney via Co Rd 450	7	DNR FMD
East Branch of Fox River	Schoolcraft	8 miles N of Seney via M-77	19	DNR FMD
Merwin Creek	Schoolcraft	9 miles NW of Gulliver via US-2, Co Rds 438 & 433	10	DNR FMD
Mead Creek	Schoolcraft	6 miles SW of Germfask via M-77 & Co Rd 436	10	DNR FMD
South Manistique Lake	Mackinac	6 miles SW of Curtis via S. Curtis Rd and Long point Rd	29	DNR FMD
Indian Lake State Park	Schoolcraft	Highway US-2 to Thompson, Take M-149 to County Road 442 (3 miles), 442 E. 1/2 mile to Park	157	DNR PRD
Island Lake	Alger	8 miles S of Wetmore on FH-13, 2 miles W on FR-2268	45	USFS
Widewaters on the Indian River	Alger	12 miles S of Wetmore on FH-13, then 0.5 miles NW on FR-2262	43	USFS
Colwell Lake	Schoolcraft	22 miles N of Manistique or 11 miles S of Shingleton on M-94	34	USFS
Indian River	Schoolcraft	19 miles N of Manistique or 15 miles S of Shingleton on M-94	11	USFS
Little Bass Lake	Schoolcraft	20 miles N of Manistique or 15 miles S of Shingleton on M-94, 1.5 W of CO-437 to Steuben, then 1.5 miles S on FR-2213	12	USFS
Petes Lake	Schoolcraft	10 miles S of Wetmore, 24 miles N on FH-13	41	USFS
Camp 7 Lake	Schoolcraft	13 miles W of Manistique on US-2, 10 miles N on CO-442 and CO-437 then 4 miles W on Co Rd 443, 442 then N on FR-2218	41	USFS

Table 9.–State of Michigan, Department of Environmental Quality (MDEQ), Divisions and Special Jurisdictions.

Division	Responsibilities
Air Quality	Compliance with statutes. Identification and reduction of existing outdoor air pollution problems. Air emission control programs. Air monitoring, control strategy planning, permit issuance and inspection of air emission sources
Drinking Water and Radiological	Environmental health services provided at local health departments. Public and private water supplies, subdivisions, on-site sewage, campgrounds, public swimming pools, mobile home parks, medical waste, dry cleaning and radiological health
Environmental Assistance	Assistance and publications in the areas of technical compliance, pollution prevention, waste reduction, clean air, innovative technology and site redevelopment. Workshops, seminars and conferences; treatment plant operator training and certification. Clean Corporate Citizen program, Environmental Audit. Community Right-to-Know. Financial assistance for water supply and municipal wastewater collection/treatment projects and site revitalization.
Environmental Response	Programs that govern and fund the cleanup and revitalization of contaminated sites. State-funded cleanups. Financial assistance to local units of government for local cleanup and redevelopment projects. Site cleanup activities; technical expertise, guidance, compliance, emergency response, and public outreach assistance. Liability protection to innocent parties for pre-existing site contamination. Clean Michigan Initiative (CMI) Projects.
Geological Survey	Fossil fuels, minerals, groundwater, energy resources. Geologic information, collection and dissemination. Permits and oversight of oil, gas and mineral production. Topographic and geologic maps; records of oil, gas and water wells, core and drilling samples.
Land and Water Management	Inland lakes management, floodplains, wetlands, sand dunes, development and construction activities on the Great Lakes. Permits for shoreline protection, marinas, dams, roads, and any dredging or filling of lakes, streams and wetlands. Information and technical assistance, including groundwater modeling and hydrologic analysis.
Surface Water Quality	Water quality standards and assessments, water quality trading, biosolids. Discharge permits. Investigation of complaints and response to accidental releases. Work with communities to assure that municipalities construct and maintain adequate wastewater collection and treatment facilities. Nonpoint source pollution; controls to protect and enhance the surface water quality.

Table 9.–Continued.

Division	Responsibilities
Storage Tanks	Education, prevention, remediation and compliance activities. Registration of underground storage tanks (USTs), certification of aboveground storage tanks (ASTs). Investigation, reporting and corrective action for contamination from leaking underground storage tanks. Oversight of design, construction, installation and operation of certain UST and AST systems to prevent the release of contaminants and ensure fire safety.
Waste Management	Hazardous and non-hazardous waste regulation. Management and disposal of hazardous, liquid industrial and solid waste, scrap tires, wastewater discharges to the groundwater, and land application of certain solid waste beneficial to the soil. Permits, licenses or registration of disposal facilities and transporters. Funding for the cleanup and disposal of abandoned scrap tires. Solid waste planning.
Office of the Great Lakes	Develop policies and programs that protect, enhance and manage the Great Lakes. Address water diversions, bi-national agreements. Administer the Michigan Great lakes Protection Fund. Administer the implementation of Michigan's Comprehensive Management Plan to Control Aquatic Nuisance Species. Publish the State of the Great Lakes Annual Report and monthly on-line Activity Reports.
Office of Special Environmental Projects	Administer the State Sites Cleanup Program under Section 20108c, 1996 public Act 380. Provide staff support to the independent autonomous Michigan Environmental Science Board. Represent the State's interest on the Council of Great Lakes Governors' multi-state Great Lakes Fish Advisory Task Force. Other special environmental projects as assigned by the Department of Environmental Quality.

Table 10.–Present general distribution of fishes within the Manistique River watershed, listed in phylogenetic order. Data obtained from Michigan DNR field surveys, 2002 Escanaba, (M. Zimmerman, University of Michigan, personal communication). Note: Brown and black bullhead have been combined as bullhead spp., but include *Ameiurus nebulosus* and *Ameiurus melas*.

Common name (*Scientific name*)	South Manistique Lake	Big Manistique Lake	Round Lake	Manistique River	Indian Lake	Driggs Lake	Driggs River	Ross Lake	Fox River, W. Br	Fox River, E. Br	Fox River, Little	Fox River, Main	Straits Lake	Hovey Lake	Indian River (Alger Co.)	Big Bass Lake	Big Murphy Creek	Murphy Lake	Indian River (Schoolcraft Co.)	Stutts Creek, N. Branch	Beaver Creek (trib to N. Br. Stutts Cr)	Middle Branch Stutts Creek	Commencement Creek	Stewart Lake	Bear Creek	Ann Louise Lake	Kennedy Lake	Wolf Creek (T44N R12W S20)	Mead Creek (T44N R13W S30)	Norton Creek (T43N R11/12W S6/1)	Dead Creek (T45N R13W S 2/3)
northern brook lamprey (*Ichthyomyzon fossor*)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–
silver lamprey (*Ichthyomyzon unicuspis*)	X	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–
American brook lamprey (*Lampetra appendix*)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
sea lamprey (*Petromyzon marinus*)	–	–	–	X	–	–	X	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–
lake sturgeon (*Acipenser fulvescens*)	X	X	–	X	X	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–
alewife (*Alosa pseudoharengus*)	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
common carp (*Cyprinus carpio*)	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
brassy minnow (*Hybognathus hankinsoni*)	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	X	–	–	X
common shiner (*Luxilus cornutus*)	X	X	X	X	X	–	X	–	–	X	X	–	X	X	X	–	–	X	X	–	–	–	–	–	–	–	–	–	X	–	–
pearl dace (*Margariscus margarita*)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	X	–	–	–	–	–	X	–	X	–
hornyhead chub (*Nocomis biguttatus*)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–
golden shiner (*Notemigonus crysoleucas*)	X	X	X	X	–	–	–	–	–	X	X	–	–	X	–	–	X	–	–	–	X	–	X	–	X	X	–	–	X	–	X
emerald shiner (*Notropis atherinoides*)	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
blackchin shiner (*Notropis heterodon*)	–	–	–	–	X	–	–	–	–	–	–	–	X	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
blacknose shiner (*Notropis heterolepis*)	–	–	–	–	–	–	–	–	–	–	X	–	X	–	X	–	–	–	–	–	–	–	–	–	X	X	–	X	X	–	X
spottail shiner (*Notropis hudsonius*)	X	X	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
sand shiner (*Notropis stramineus*)	X	X	X	X	X	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
mimic shiner (*Notropis volucellus*)	X	X	X	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
northern redbelly dace (*Phoxinus eos*)	–	–	–	–	X	–	–	–	–	X	X	–	–	–	X	–	–	–	–	–	X	X	X	–	–	X	–	X	X	–	X
finescale dace (*Phoxinus neogaeus*)	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	X	X	X	–
bluntnose minnow (*Pimephales notatus*)	X	X	X	–	X	–	X	–	–	–	X	X	X	–	X	–	X	X	X	–	–	–	–	–	–	–	–	–	X	–	–
fathead minnow (*Pimephales promelas*)	–	–	–	–	–	–	–	–	–	X	–	–	–	–	X	–	–	–	–	X	X	–	–	–	–	X	–	X	X	–	X
blacknose dace (*Rhinichthys atratulus*)	–	–	–	–	X	–	X	–	–	X	X	–	–	–	X	–	X	–	X	X	X	X	–	–	–	X	–	–	–	–	–
longnose dace (*Rhinichthys cataractae*)	–	–	–	X	–	–	X	–	–	X	X	X	–	–	X	–	X	–	X	X	–	–	–	–	–	–	–	–	X	–	–
creek chub (*Semotilus atromaculatus*)	–	–	–	–	–	–	–	–	–	–	X	X	–	–	X	–	X	–	X	X	X	X	–	–	X	–	–	–	X	–	X
white sucker (*Catostomus commersonii*)	X	X	X	X	X	–	X	X	–	X	X	X	X	X	X	X	X	X	X	X	X	X	–	–	X	–	X	–	X	–	–
shorthead redhorse (*Moxostoma macrolepidotum*)	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
bullhead spp. (*Ameiurus spp.*)	–	–	–	–	X	X	–	X	–	–	X	X	X	X	–	X	–	X	X	–	–	–	–	X	–	–	X	–	X	–	X
channel catfish (*Ictalurus punctatus*)	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Table 10.–Continued.

Common name (*Scientific name*)	South Manistique Lake	Big Manistique Lake	Round Lake	Manistique River	Indian Lake	Driggs Lake	Driggs River	Ross Lake	Fox River, W. Br	Fox River, E. Br	Fox River, Little	Fox River, Main	Straits Lake	Hovey Lake	Indian River (Alger Co.)	Big Bass Lake	Big Murphy Creek	Murphy Lake	Indian River (Schoolcraft Co.)	Stutts Creek, N. Branch	Beaver Creek (trib to N. Br. Stutts Cr)	Middle Branch Stutts Creek	Commencement Creek	Stewart Lake	Bear Creek	Ann Louise Lake	Kennedy Lake	Wolf Creek (T44N R12W S20)	Mead Creek (T44N R13W S30)	Norton Creek (T43N R11/12W S6/1)	Dead Creek (T45N R13W S 2/3)
northern pike (*Esox lucius*)	X	X	X	X	X	X	X	X	–	X	X	–	X	X	X	X	X	X	X	X	–	–	–	X	X	–	X	–	–	–	X
musky (*Esox masquinongy*)	X	X	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
tiger muskellunge (*Esox lucius x E. masquinongy*)	–	–	–	X	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
central mudminnow (*Umbra limi*)	X	X	–	X	–	–	X	–	–	X	–	X	–	–	X	–	X	–	X	X	X	X	X	–	X	–	–	X	X	X	X
lake herring (*Coregonus artedi*)	X	X	X	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
pink salmon (*Oncorhynchus gorbuscha*)	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
coho salmon (*Oncorhynchus kisutch*)	–	X	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
rainbow trout (*Oncorhynchus mykiss*)	–	X	X	X	X	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–
chinook salmon (*Oncorhynchus tshawytscha*)	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
brown trout (*Salmo trutta*)	–	X	X	–	X	–	X	–	X	X	–	–	X	–	X	–	X	–	–	X	–	–	–	–	–	–	–	–	–	–	–
brook trout (*Salvelinus fontinalis*)	–	X	X	X	X	–	X	–	X	X	X	X	X	–	X	–	X	–	–	X	–	X	–	–	X	–	–	–	–	–	–
lake trout (*Salvelinus namaycush*)	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
splake (*Salvelinus fontinalis x S. namaycush*)	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
burbot (*Lota lota*)	–	–	–	X	X	–	X	–	X	X	X	X	–	–	X	–	X	–	X	X	–	–	–	–	X	–	–	–	–	–	–
western banded killifish (*Fundulus diaphanus menona*)	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–
brook stickleback (*Culaea inconstans*)	X	X	–	–	X	–	–	–	–	X	–	X	–	–	X	–	–	–	X	X	X	X	X	–	–	–	–	X	X	X	X
mottled sculpin (*Cottus bairdii*)	X	X	X	–	X	–	X	–	X	X	X	X	–	–	X	–	X	–	X	X	–	X	–	–	X	–	–	–	X	–	–
rock bass (*Ambloplites rupestris*)	X	X	X	X	X	X	X	–	–	–	–	X	X	–	X	X	X	X	X	–	–	–	X	–	–	–	X	–	X	–	–
green sunfish (*Lepomis cyanellus*)	X	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–
pumpkinseed sunfish (*Lepomis gibbosus*)	X	X	X	–	X	X	X	X	–	–	–	X	X	X	X	X	–	X	X	–	–	–	–	–	–	X	X	X	–	–	X
bluegill (*Lepomis macrochirus*)	X	X	X	–	X	X	–	X	–	–	–	–	X	X	X	X	–	X	X	–	–	–	–	–	–	–	–	–	X	–	–
smallmouth bass (*Micropterus dolomieu*)	X	X	X	X	X	–	–	X	–	–	–	–	X	–	–	X	X	X	–	–	–	–	–	–	X	–	–	–	–	–	–
largemouth bass (*Micropterus salmoides*)	X	X	X	–	–	X	–	X	–	–	–	–	X	X	X	X	X	X	X	–	–	–	–	–	–	–	–	–	–	–	–
black crappie (*Pomoxis nigromaculatus*)	–	–	–	X	X	X	–	–	–	–	–	–	X	–	X	X	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–
Iowa darter (*Etheostoma exile*)	X	X	X	–	X	–	–	–	–	–	X	–	X	–	X	–	–	X	–	–	–	–	X	–	X	X	–	X	X	X	–
striped fantail darter (*Etheostoma flabellare lineolatum*)	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–
least darter (*Etheostoma microperca*)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
johnny darter (*Etheostoma nigrum*)	X	X	X	X	X	–	X	–	–	X	–	X	X	X	X	–	–	X	X	X	X	X	–	–	X	X	–	–	X	–	–
yellow perch (*Perca flavescens*)	X	X	X	X	X	X	X	X	–	X	–	X	X	X	X	X	X	X	X	–	–	–	–	X	X	–	X	X	X	X	–
logperch (*Percina caprodes*)	X	X	X	X	X	–	–	–	–	–	–	–	X	–	X	–	X	X	X	–	–	–	–	–	–	–	–	–	–	–	–
blackside darter (*Percina maculate*)	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	X	–	–	X	–	–	–	X	–	–
walleye (*Sander vitreus*)	X	X	X	X	X	–	X	–	–	–	–	–	X	–	–	–	X	–	X	–	–	–	–	–	–	–	–	–	–	–	–

Table 11.–Mussels that could be expected to reside within the Manistique River watershed; data from MDNR, Fisheries Division, files.

Common name	Scientific name
mucket	*Actinonaias carinata*
slippershell	*Alasmidonta calceolus*
elktoe	*Alasmidonta marginata*
three-ridge	*Amblema plicata*
cylindrical papershell	*Anodontoides ferussacianus*
spike	*Elliptio dilatata*
fat mucket	*Lampsilis siliquoidea*
pocketbook	*Lampsilis ventricosa*
white heelsplitter	*Lasmigona complanta*
creek heelsplitter	*Lasmigona compressa*
fluted-shell	*Lasmigona costata*
fragile papershell	*Leptodea fragilis*
black sandshell	*Ligumia recta*
pink heelsplitter	*Potamilis alatus* (formerly *Proptera alata*)
floater	*Pyganodon grandis*
squawfoot	*Strophitus undulatus*
paper pondshell	*Utterbackia imbecillis*
rainbow	*Villosa iris*

Table 12.–Amphibian and reptile species found in counties of the Manistique River watershed. Data from Harding and Holman (1992), Holman et al. (1989), and Harding and Holman (1990). Threatened (T) and special concern (SC) species are noted in bold. A = Alger, D = Delta, L = Luce, M = Mackinac, S = Schoolcraft.

Common name	Scientific name	A	D	L	M	S
Frogs and toads						
eastern american toad	*Bufo americanus americanus*	X	X	X	X	X
northern spring peeper	*Pseudacris crucifer crucifer*	X	X	X	X	X
eastern gray tree frog	*Hyla versicolor*	X	X	X	X	X
Cope's gray tree frog	*Hyla chrysoscelis*	X	X	X	X	X
green frog	*Rana clamitans melanota*	X	X	X	X	X
bullfrog	*Rana catesbeiana*	X	X	X	X	X
northern leopard frog	*Rana pipiens*	X	X	X	X	X
pickerel frog	*Rana palustris*	X	X	X	X	X
mink frog	*Rana septentrionalis*	X	X	X	X	X
wood frog	*Rana sylvatica*	X	X	X	X	X
Salamanders						
blue-spotted salamander	*Ambystoma laterale*	X	X	X	X	X
spotted salamander	*Ambystoma maculatum*	X	X	X	X	X
eastern tiger salamander	*Ambystoma tigrinum tigrinum*	X	–	–	–	–
eastern newt - central subspecies	*Notophthalmus viridescens*	X	X	X	X	X
red-backed salamander	*Plethodon cinereus*	X	X	X	X	X
four-toed salamander	*Hemidactylium scutatum*	X	X	X	X	X
mudpuppy	*Necturus maculosus maculosus*	X	X	X	X	X
Snakes and lizards						
northern water snake	*Nerodia sipedon sipedon*	X	X	X	X	X
northern red-bellied snake	*Storeria occioitomaculata occipitomaculata*	X	X	X	X	X
eastern garter snake	*Thamnophis sirtalis sirtalis*	X	X	X	X	X
northern ring-necked snake	*Diadophis punctatus edwardsi*	X	X	X	X	X
western fox snake	*Elaphe vulpina*	X	X	X	X	X
smooth green snake	*Liochlorophis vernalis*	X	X	X	X	X
five-lined skink	*Eumeces fasciatus*	X	X	–	–	–
Turtles						
snapping turtle	*Chelydra serpentina*	X	X	X	X	X
wood turtle (SC)	***Clemmys insculpta***	X	X	X	X	X
Blanding's turtle (SC)	***Emydoidea blandingii***	X	X	X	X	X
painted turtle	*Chrysemys picta*	X	X	X	X	X

Table 13.–Birds of the Manistique River watershed listed in phylogenetic order. Data from Doepker, et al. (2001). State Status Rank SC = special concern, T = threatened, E = endangered. Federal Status Rank LE = endangered.

Common name	Scientific name	Status
Common loon	*Gavia immer*	T
Pied-billed grebe	*Podilymbus podiceps*	
Red-necked grebe	*Podiceps grisegena*	
Double-crested cormorant	*Phalacrocorax auritus*	
American bittern	*Botaurus lentiginosus*	SC
Least bittern	*Ixobrychus exilis*	T
Great blue heron	*Ardea herodias*	
Green heron	*Butorides virescens*	
Black-crowned night-heron	*Nycticorax nycticorax*	SC
Trumpeter swan	*Cygnus buccinator*	T
Canada goose	*Branta canadensis*	
Wood duck	*Aix sponsa*	
Green-winged teal	*Anas crecca*	
American black duck	*Anas rubripes*	
Mallard	*Anas platyrhynchos*	
Northern pintail	*Anas acuta*	
Blue-winged teal	*Anas discors*	
Gadwall	*Anas strepera*	
American wigeon	*Anas americana*	
Redhead	*Aythya americana*	
Ring-necked duck	*Aythya collaris*	
Common goldeneye	*Bucephala clangula*	
Hooded merganser	*Lophodytes cucullatus*	
Common merganser	*Mergus merganser*	
Red-breasted merganser	*Mergus serrator*	
Turkey vulture	*Cathartes aura*	
Osprey	*Pandion haliaetus*	T
Bald eagle	*Haliaeetus leucocephalus*	T LT
Northern harrier	*Circus cyaneus*	SC
Sharp-shinned hawk	*Accipiter striatus*	
Cooper's hawk	*Accipiter cooperii*	SC
Northern goshawk	*Accipiter gentilis*	SC
Red-shouldered hawk	*Buteo lineatus*	T
Broad-winged hawk	*Buteo platypterus*	
Red-tailed hawk	*Buteo jamaicensis*	
American kestrel	*Falco sparverius*	
Merlin	*Falco columbarius*	T
Ring-necked pheasant	*Phasianus colchicus*	
Spruce grouse	*Dendragapus canadensis*	T
Ruffed grouse	*Bonasa umbellus*	
Sharp-tailed grouse	*Tympanuchus phasianellus*	SC
Wild turkey	*Meleagris gallopavo*	

Table 13.–Continued.

Common name	Scientific name	Status
Yellow rail	*Coturnicops noveboracensis*	T
King rail	*Rallus elegans*	E
Virginia rail	*Rallus limicola*	
Sora	*Porzana carolina*	
American coot	*Fulica americana*	
Sandhill crane	*Grus canadensis*	
Piping plover	*Charadrius melodus*	E LE
Killdeer	*Charadrius vociferus*	
Spotted sandpiper	*Actitis macularia*	
Upland sandpiper	*Bartramia longicauda*	
Common snipe	*Gallinago gallinago*	
American woodcock	*Scolopax minor*	
Ring-billed gull	*Larus delawarensis*	
Herring gull	*Larus argentatus*	
Caspian tern	*Sterna caspia*	T
Common tern	*Sterna hirundo*	T
Arctic tern	*Sterna paradisaea*	
Forster's tern	*Sterna forsteri*	SC
Black tern	*Chlidonias niger*	SC
Mourning dove	*Zenaida macroura*	
Black-billed cuckoo	*Coccyzus erythropthalmus*	
Yellow-billed cuckoo	*Coccyzus americanus*	
Great horned owl	*Bubo virginianus*	
Barred owl	*Strix varia*	
Long-eared owl	*Asio otus*	T
Short-eared owl	*Asio flammeus*	E
Northern saw-whet owl	*Aegolius acadicus*	
Common nighthawk	*Chordeiles minor*	
Whip-poor-will	*Caprimulgus vociferus*	
Chimney swift	*Chaetura pelagica*	
Ruby-throated hummingbird	*Archilochus colubris*	
Belted kingfisher	*Ceryle alcyon*	
Red-headed woodpecker	*Melanerpes erythrocephalus*	
Red-bellied woodpecker	*Melanerpes carolinus*	
Yellow-bellied sapsucker	*Sphyrapicus varius*	
Downy woodpecker	*Picoides pubescens*	
Hairy woodpecker	*Picoides villosus*	
Black-backed woodpecker	*Picoides arcticus*	SC
Northern flicker	*Colaptes auratus*	
Pileated woodpecker	*Dryocopus pileatus*	
Olive-sided flycatcher	*Contopus borealis*	
Eastern wood-pewee	*Contopus virens*	
Yellow-bellied flycatcher	*Empidonax flaviventris*	
Acadian flycatcher	*Empidonax virescens*	
Alder flycatcher	*Empidonax alnorum*	

Table 13.–Continued.

Common name	Scientific name	Status
Willow flycatcher	*Empidonax traillii*	
Least flycatcher	*Empidonax minimus*	
Eastern phoebe	*Sayornis phoebe*	
Great crested flycatcher	*Myiarchus crinitus*	
Eastern kingbird	*Tyrannus tyrannus*	
Horned lark	*Eremophila alpestris*	
Purple martin	*Progne subis*	
Tree swallow	*Tachycineta bicolor*	
Northern rough-winged swallow	*Stelgidopteryx serripennis*	
Bank swallow	*Riparia riparia*	
Cliff swallow	*Hirundo pyrrhonota*	
Barn swallow	*Hirundo rustica*	
Gray jay	*Perisoreus canadensis*	
Blue jay	*Cyanocitta cristata*	
American crow	*Corvus brachyrhynchos*	
Common raven	*Corvus corax*	
Black-capped chickadee	*Parus atricapillus*	
Boreal chickadee	*Parus hudsonicus*	
Red-breasted nuthatch	*Sitta canadensis*	
White-breasted nuthatch	*Sitta carolinensis*	
Brown creeper	*Certhia americana*	
House wren	*Troglodytes aedon*	
Winter wren	*Troglodytes troglodytes*	
Sedge wren	*Cistothorus platensis*	
Marsh wren	*Cistothorus palustris*	SC
Golden-crowned kinglet	*Regulus satrapa*	
Ruby-crowned kinglet	*Regulus calendula*	
Blue-gray gnatcatcher	*Polioptila caerulea*	
Eastern bluebird	*Sialia sialis*	
Veery	*Catharus fuscescens*	
Swainson's thrush	*Catharus ustulatus*	
Hermit thrush	*Catharus guttatus*	
Wood thrush	*Hylocichla mustelina*	
American robin	*Turdus migratorius*	
Gray catbird	*Dumetella carolinensis*	
Northern mockingbird	*Mimus polyglottos*	
Brown thrasher	*Toxostoma rufum*	
Cedar waxwing	*Bombycilla cedrorum*	
Blue-headed vireo	*Vireo solitarius*	
Yellow-throated vireo	*Vireo flavifrons*	
Warbling vireo	*Vireo gilvus*	
Philadelphia vireo	*Vireo philadelphicus*	
Red-eyed vireo	*Vireo olivaceus*	
Golden-winged warbler	*Vermivora chrysoptera*	
Tennessee warbler	*Vermivora peregrina*	

Table 13.–Continued.

Common name	Scientific name	Status
Nashville warbler	*Vermivora ruficapilla*	
Northern parula	*Parula americana*	
Yellow warbler	*Dendroica petechia*	
Chestnut-sided warbler	*Dendroica pensylvanica*	
Magnolia warbler	*Dendroica magnolia*	
Cape may warbler	*Dendroica tigrina*	
Black-throated blue warbler	*Dendroica caerulescens*	
Yellow-rumped warbler	*Dendroica coronata*	
Blackburnian warbler	*Dendroica fusca*	
Pine warbler	*Dendroica pinus*	
Kirtland's warbler	*Dendroica kirtlandii*	E LE
Prairie warbler	*Dendroica discolor*	E
Palm warbler	*Dendroica palmarum*	
Bay-breasted warbler	*Dendroica castanea*	
Cerulean warbler	*Dendroica cerulea*	SC
Black-and-white warbler	*Mniotilta varia*	
American redstart	*Setophaga ruticilla*	
Ovenbird	*Seiurus aurocapillus*	
Northern waterthrush	*Seiurus noveboracensis*	
Connecticut warbler	*Oporornis agilis*	
Mourning warbler	*Oporornis philadelphia*	
Common yellowthroat	*Geothlypis trichas*	
Wilson's warbler	*Wilsonia pusilla*	
Canada warbler	*Wilsonia canadensis*	
Scarlet tanager	*Piranga olivacea*	
Northern cardinal	*Cardinalis cardinalis*	
Rose-breasted grosbeak	*Pheucticus ludovicianus*	
Indigo bunting	*Passerina cyanea*	
Dickcissel	*Spiza americana*	SC
Eastern towhee	*Pipilo erythrophthalmus*	
Chipping sparrow	*Spizella passerina*	
Clay-colored sparrow	*Spizella pallida*	
Field sparrow	*Spizella pusilla*	
Vesper sparrow	*Pooecetes gramineus*	
Savannah sparrow	*Passerculus sandwichensis*	
Grasshopper sparrow	*Ammodramus savannarum*	SC
Henslow's sparrow	*Ammodramus henslowii*	T
Le conte's sparrow	*Ammodramus leconteii*	
Song sparrow	*Melospiza melodia*	
Lincoln's sparrow	*Melospiza lincolnii*	
Swamp sparrow	*Melospiza georgiana*	
White-throated sparrow	*Zonotrichia albicollis*	
Dark-eyed junco	*Junco hyemalis*	
Bobolink	*Dolichonyx oryzivorus*	
Red-winged blackbird	*Agelaius phoeniceus*	

Table 13.–Continued.

Common name	Scientific name	Status
Eastern meadowlark	*Sturnella magna*	
Western meadowlark	*Sturnella neglecta*	SC
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*	SC
Rusty blackbird	*Euphagus carolinus*	
Brewer's blackbird	*Euphagus cyanocephalus*	
Common grackle	*Quiscalus quiscula*	
Brown-headed cowbird	*Molothrus ater*	
Orchard oriole	*Icterus spurius*	
Baltimore oriole	*Icterus galbula*	
Purple finch	*Carpodacus purpureus*	
Red crossbill	*Loxia curvirostra*	
White-winged crossbill	*Loxia leucoptera*	
Pine siskin	*Carduelis pinus*	
American goldfinch	*Carduelis tristis*	
Evening grosbeak	*Coccothraustes vespertinus*	T
Common loon	*Gavia immer*	
Pied-billed grebe	*Podilymbus podiceps*	

Table 14.–Endangered, threatened or otherwise significant plant and animal species, plant communities, and other natural features of the Manistique River watershed, from (MNFI), State Status Rank SC = special concern, T = threatened, E = endangered. Federal Status Rank LE = endangered, LT = threatened.

Common name	Scientific name	Federal status	State status	Element category
Common loon	*Gavia immer*		T	animal
American bittern	*Botaurus lentiginosus*		SC	animal
Least bittern	*Ixobrycheus exilis*		T	animal
Trumpeter swan	*Cygnus buccinator*		T	animal
Black-crowned night-heron	*Nycticorax nycticorax*		SC	animal
Osprey	*Pandion haliaetus*		T	animal
Northern harrier	*Circus cyaneus*		SC	animal
Bald eagle	*Haliaeetus leucocephalus*	LT	T	animal
Cooper's hawk	*Accipiter cooperii*		SC	animal
Northern goshawk	*Accipiter gentilis*		SC	animal
Red-shouldered hawk	*Buteo lineatus*		T	animal
Merlin	*Falco columbarius*		T	animal
Spruce grouse	*Falcipennis canadensis*		SC	animal
Sharp-tailed grouse	*Tympanuchus phasianellus*		SC	animal
Yellow rail	*Coturnicops noveboracensis*		T	animal
King rail	*Rallus elegans*		E	animal
Caspian tern	*Sterna caspia*		T	animal
Common tern	*Sterna hirundo*		T	animal
Black tern	*Chlidonias niger*		SC	animal
Forster's tern	*Sterna forsteri*		SC	animal
Long-eared owl	*Asio otus*		SC	animal
Short-eared owl	*Asio flammeus*		T	animal
Black-backed woodpecker	*Picoides arcticus*		SC	animal
Marsh wren	*Cistothorus palustris*		SC	animal
Kirtland's warbler	*Dendroica kirtlandii*	LE	E	animal
Prairie warbler	*Dendroica discolor*		E	animal
Cerulean warbler	*Dendroica cerulea*		SC	animal
Dickcissel	*Spiza americana*		SC	animal
Grasshopper sparrow	*Ammodramus savannarum*		SC	animal
Henslow's sparrow	*Ammodramus henslowii*		T	animal
Western meadowlark	*Sturnella neglecta*		SC	animal
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*		SC	animal
lake sturgeon	*Acipenser fulvescens*		T	animal
lake herring	*Coregonus artedi*		T	animal
wood turtle	*Clemmys insculpta*		SC	animal
frigga fritillary	*Boloria frigga*		SC	animal

Table 14.–Continued.

Common name	Scientific name	Federal status	State status	Element category
northern blue	*Lycaeides idas nabokovia*		T	animal
tawny crescent	*Phyciodes batesii*		SC	animal
incurvate emerald	*Somatochlora incurvata*		SC	animal
ebony boghaunter	*Williamsonia fletcheri*		SC	animal
land snail	*Vertigo hubrichti*		SC	animal
land snail	*Vertigo paradoxa*		SC	animal
dry woodland, upper midwest type	*Dry northern forest*			community
	Dry-mesic northern forest			community
	Mesic northern forest			community
rich shrub/herb fen, upper midwest type	*Patterend fen*			community
	Rich conifer swamp			community
	Wooded dune and swale complex			community
Great blue heron rookery	*Great blue heron rookery*			other
geographical feature	*Spring*			other
alga pondweed	*Potamogeton confervoides*		SC	plant
flat oat grass	*Danthonia compressa*		E	plant
American shore-grass	*Littorella uniflora*		SC	plant
Canada rice-grass	*Oryzopsis canadensis*		T	plant
widgeon-grass	*Ruppia maritima*		T	plant
slender spike-rush	*Eleocharis nitida*		E	plant
Clinton's bulrush	*Scirpus clintonii*		SC	plant
Vasey's rush	*Juncus vaseyi*		T	plant
round-leaved orchis	*Amerorchis rotundifolia*		E	plant
calypso or fairy-slipper	*Calypso bulbosa*		T	plant
greenish-white sedge	*Carex albolutescens*		T	plant
Hudson Bay sedge	*Carex heleonastes*		E	plant
black sedge	*Carex nigra*		E	plant
New England sedge	*Carex novae-angliae*		T	plant
auricled twayblade	*Listera auriculata*		SC	plant
purple clematis	*Clematis occidentalis*		SC	plant
veiny meadow-rue	*Thalictrum venulosum var confine*		SC	plant
English sundew	*Drosera anglica*		SC	plant
dwarf raspberry	*Rubus acaulis*		E	plant
Farwell's water-milfoil	*Myriophyllum farwellii*		T	plant
dwarf bilberry	*Vaccinium cespitosum*		T	plant
small blue-eyed mary	*Collinsia parviflora*		T	plant
butterwort	*Pinguicula vulgaris*		SC	plant
sweet coltsfoot	*Petasites sagittatus*		T	plant
fir clubmoss	*Huperzia selago*		SC	plant

Table 15.–Mammals of the Manistique River watershed, from Doepker, et al. (2001). State Status Rank T = Threatened, E = Endangered. Federal Status Rank LE = endangered.

Common name	Scientific name	Status
Virginia opossum	*Didelphis virginiana*	
northern short-tailed shrew	*Blarina brevicauda*	
Arctic shrew	*Sorex arcticus*	
masked shrew	*Sorex cinereus*	
pygmy shrew	*Sorex hoyi*	
water shrew	*Sorex palustris*	
star-nosed mole	*Condylura cristata*	
big brown bat	*Eptesicus fuscus*	
silver-haired bat	*Lasionycteris noctivagans*	
eastern red bat	*Lasiurus borealis*	
hoary bat	*Lasiurus cinereus*	
little brown myotis	*Myotis lucifugus*	
northern myotis	*Myotis septentrionalis*	
coyote	*Canis latrans*	
gray wolf	*Canis lupus*	E LE
common gray fox	*Urocyon cinereoargenteus*	
red fox	*Vulpes vulpes*	
bobcat	*Lynx rufus*	
northern river otter	*Lutra canadensis*	
striped skunk	*Mephitis mephitis*	
ermine	*Mustela erminea*	
long-tailed weasel	*Mustela frenata*	
mink	*Mustela vison*	
American badger	*Taxidea taxus*	
common raccoon	*Procyon lotor*	
black bear	*Ursus americanus*	
moose	*Alces alces*	SC
white-tailed deer	*Odocoileus virginianus*	
woodchuck	*Marmota monax*	
eastern gray squirrel	*Sciurus carolinensis*	
eastern fox squirrel	*Sciurus niger*	
thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*	
least chipmunk	*Tamias minimus*	
eastern chipmunk	*Tamias striatus*	
red squirrel	*Tamiasciurus hudsonicus*	
northern flying squirrel	*Glaucomys sabrinus*	
southern flying squirrel	*Glaucomys volans*	
American beaver	*Castor canadensis*	
woodland jumping mouse	*Napaeozapus insignis*	
meadow jumping mouse	*Zapus hudsonius*	
southern red-backed vole	*Clethrionomys gapperi*	
meadow vole	*Microtus pennsylvanicus*	
muskrat	*Ondatra zibethicus*	
southern bog lemming	*Synaptomys cooperi*	
white-footed mouse	*Peromyscus leucopus*	
deer mouse	*Peromyscus maniculatus*	
common porcupine	*Erethizon dorsatum*	
snowshoe hare	*Lepus americanus*	
eastern cottontail	*Sylvilagus floridanus*	

Table 16.–Fish stocking in the Manistique River watershed, 1991-2001. Data from Michigan Department of Natural Resources Fisheries Division records. All private plants were conducted under permit. MRPR = marsh and rearing pond release; TWF = transplant of wild fish; priv = private; fed = federal.

County and water	Species	Strain	Dates	Number	Length (inches)	Operation
Alger						
Bernies Pond	brook trout	Assinica/Maine	92	150	5.28	state plant
		Maine	91,93	300	4.56-4.88	state plant
Bette's Pond	brook trout	Assinica	95,96,99-01	2,650	5.04-5.44	state plant
		Assinica/Maine	92	550	5.48	state plant
		Maine	93	550	4.88	state plant
		Owhi	92	250	5.44	state plant
		Saint Croix	94	550	6.08	state plant
Brians Pond	brook trout		99	350	10.16	priv plant
		Assinica	94-96,00	1,880	4.76-12.60	state plant
		Assinica/Maine	92	600	5.48	state plant
		Maine	91,93	1,200	4.52-4.88	state plant
	brown trout		99	85	10.16	priv plant
Cherry Lake	largemouth bass		91	1,000	3.08	state plant
Cheryl's Pond	brook trout	Assinica	95-97,99-00	1,150	5.04-12.60	state plant
		Assinica/Maine	92	300	5.28	state plant
		Maine	91,93	600	4.56-4.88	state plant
		Saint Croix	94	300	6.16	state plant
		Temiscame	98	300	5.92	state plant
Clover Leaf Lake	smallmouth bass		95-98	5,977	1.72-2.96	MRPR
Harrison's Pond	brook trout	Assinica	94-96,98	3,550	4.76-5.36	state plant
		Assinica/Maine	92	550	5.48	state plant
		Maine	91,93	1,200	4.56-4.88	state plant
		Temiscame	98	250	6.08	state plant
Hike Lake	brook trout	Assinica	99-01	1,850	5.04-5.44	state plant
		Maine	93	550	4.88	state plant
		Owhi	92	300	5.44	state plant
		Saint Croix	94	550	6.08	state plant
		Temiscame	97	550	3.96	state plant
Indian River	brown trout	Gilchrist Creek	99-01	4,160	3.80-4.84	state plant
		Plymouth Rock	91-92	4,050	6.72-6.80	state plant
		Seeforellen	94,97	4,910	7.08-7.16	state plant
		Soda Lake	00	3,000	6.28-7.28	state plant
		Wild Rose	93,96,98-00	7,800	6.56-8.52	state plant
Irwin Lake	brook trout	Assinica	91,95-96,98-99,01	8,016	5.04-10.68	state plant
		Assinica/Maine	92-93	4,000	5.04-5.28	state plant
		Maine	91	2,000	4.64	state plant
		MI domestic	94	500	11	state plant
		Owhi	92	1,000	5.64	state plant
		Saint Croix	94,98	2,130	6.08-11.12	state plant
		Temiscame	97	1,500	3.96	state plant
	brown trout	Plymouth Rock	94	500	7.2	state plant
	brown trout	Seeforellen	97	500	7.16	state plant
Island Lake	largemouth bass		00	1,584	2.32-16.24	MRPR
Juanita Lake	brook trout	Assinica	99-00	230	10.08-12.60	state plant
		Maine	91	300	4.56	state plant
		Temiscame	98	350	4.72	state plant
	brown trout	Plymouth Rock	93	500	3.72	state plant
		Wild Rose	92,94	1,000	4.84-5.96	state plant
Kay's Pond	brook trout	Assinica	99,01	700	6.40-10.08	state plant
		Maine	91	400	4.56	state plant
		Maine	93	400	4.88	state plant
		Temiscame	98	500	5.24	state plant
Lost Lake	largemouth bass		91	4,000	3.08	state plant

Table 16.–Continued.

County and water	Species	Strain	Dates	Number	Length (inches)	Operation
Alger – continued						
Mirror Lake	brook trout	Assinica	91,01	1,010	14.20-18.04	state plant
		Maine	91	300	15.12	state plant
	brown trout	Seeforellen	00	2,250	7.28	state plant
		Wild Rose	98	1,800	8.68	state plant
	splake		91-01	27,150	6.24-8.12	state plant
Moccasin Lake	walleye	Bay de Noc	98,00	13,705	1.60-2.08	MRPR
North Shoe Lake	splake		91-01	13,020	6.28-8.12	state plant
Rock Lake	brook trout	Assinica	92,94-96,98-01	8,294	4.28-5.68	state plant
		Maine	91,93	2,000	4.64-4.88	state plant
		Temiscame	97	750	3.96	state plant
Sand Lake	walleye	Bay de Noc	01	7,294	2.32	MRPR
Sawaski’s Pond	brook trout	Assinica	98-01	680	5.04-10.08	state plant
		Assinica/Maine	92	400	5.48	state plant
		Maine	91,93	800	4.56-4.88	state plant
Skeels Lake	walleye	Bay de Noc	91,95	25,100	1.92-2.24	MRPR
Thornton Lake	largemouth bass		96	2,000	2.32	MRPR
Triangle Lake	northern pike		92	40	22.36	TWF
Trueman Lake	brook trout	Assinica	92,94-96,00	1,280	4.64-12.6	state plant
		Maine	91,93	600	4.64-4.88	state plant
		Temiscame	97	300	3.96	state plant
	golden shiner		01	3,745	5.08	TWF
	rainbow trout	Eagle Lake	00	150	8	state plant
Delta						
Bear Lake	brook trout	Assinica	91,95-01	16,552	5.04-19.12	state plant
		Assinica/Maine	92-93	5,200	5.04-5.28	state plant
		Iron River	00	200	11.4	state plant
		Maine	91	2,600	4.56	state plant
		MI domestic	94	300	10.92	state plant
		Owhi	92	2,000	5.64	state plant
		Saint Croix	94	3,000	6.32	state plant
		Temiscame	97	2,600	3.92	state plant
	brown trout	Wild Rose	97	35	25.8	state plant
	rainbow trout	Shasta	96-97	2,217	7.88-25.04	state plant
Kilpecker Pond	brook trout	Assinica	96,98-01	1,200	5.04-5.48	state plant
		Assinica/Maine	92-93	500	5.48-5.08	state plant
		Maine	91	250	4.56	state plant
		Saint Croix	94	250	6.16	state plant
		Temiscame	97	200	3.96	state plant
Lake 23	smallmouth bass		91-93	3,123	2.20-3.04	MRPR
Norway Lake	brook trout	Assinica	95-96,99,01	7,400	4.76-10.32	state plant
		Assinica/Maine	92-93	3,400	5.04-5.28	state plant
		Iron River	99	1,000	5.12	state plant
		Maine	91	1,700	4.56	state plant
		Saint Croix	94	1,700	6.32	state plant
Section 1 Pond	brook trout	Assinica	95-96,98-01	1,150	4.76-5.48	state plant
		Assinica/Maine	92	200	5.48	state plant
		Assinica/Maine	93	200	5.04	state plant
		Maine	91	200	4.56	state plant
		Saint Croix	94	200	6.16	state plant
		Temiscame	97	150	3.96	state plant
Skeels Lake	walleye	Bay de Noc	93	9,000	2.24	MRPR
Spring Lake	brook trout		96	318	4.56	TWF
		Assinica/Maine	92	700	5.52	state plant
		Maine	91	700	4.52	state plant

Table 16.–Continued.

County and water	Species	Strain	Dates	Number	Length (inches)	Operation
Delta – continued						
Square Lake	brook trout	Assinica/Maine	92-93	1,800	5.04-5.48	state plant
		Maine	91	900	4.56	state plant
		Saint Croix	94	900	6.16	state plant
	walleye	Bay de Noc	96	200,000	0.48	state plant
Wintergreen Lake	brook trout	Assinica	92,94-96,98-01	2,800	4.64-5.68	state plant
		Assinica/Maine	93	350	5.04	state plant
		Maine	91	350	4.56	state plant
		Temiscame	97	350	3.92	state plant
Luce						
North Manistique (Round) Lake	lake trout	Apostle/Gull Is	98	13	29.16	fed plant
		Green Lake	98	23	25.72	fed plant
		Marquette	00	243	27.16-30.04	fed plant
		Marquette	93,97,99	27,858	7.12-23.96	state plant
		Seneca Lake	98	57	28.6	fed plant
			96,98	817	23.88-30.04	fed plant
	northern pike		91	8,876	3.6	state plant
			93,00	168	15.04	TWF
	smallmouth bass		97-98	8,455	2.32-2.96	MRPR
	walleye	Bay de Noc	92	1,097,400	0.2	priv plant
		Bay de Noc	92-97	386,282	1.32-2.20	MRPR
		Manistique	91	974,000	0.2	priv plant
			93	2,100,000	0.2	priv plant
Spring Creek Pond	brook trout	Assinica	95-96,98-00	3,250	1.80-2.92	state plant
		Assinica/Maine	92	650	5.44	state plant
		Maine	91,93	1,300	4.52-5.04	state plant
		Saint Croix	94	650	6.04	state plant
		Temiscame	97	650	1.88	state plant
Mackinac						
S Manistique (Whitefish) Lake	muskellunge	Northern	91	1,700	10.96	MRPR
		Northern	98	2,000	11.32	state plant
	walleye	Manistique	91-94	8,917,692	0.16-0.20	priv plant
Schoolcraft						
Ashford Lake	brook trout	Assinica	94,96	1,347	6.52-14.60	state plant
		Assinica/Maine	93-94	2,600	7.36	state plant
		Maine	93,95	1,365	7.84-19.12	state plant
		Owhi	91-92	2,600	5.64-5.92	state plant
	largemouth bass		97,99	701	3.16-3.24	MRPR
			98	101	6.2	TWF
Banana Lake	rainbow trout	Arlee	95	800	7.84	state plant
		Eagle Lake	97,00-01	2,300	6.80-8.16	state plant
		Gerrard Kamloops	99	800	8.68	state plant
		Shasta	92-94,96,98	3,900	7.32-8.32	state plant
		Wytheville	91	600	7.64	state plant
Bear (19) Lake	rainbow trout	Arlee	95	1,000	7.84	state plant
		Eagle Lake	96-97,00-01	4,100	6.80-8.16	state plant
		Gerrard Kamloops	99	1,000	8.68	state plant
		Shasta	92-94,98	3,900	7.32-8.32	state plant
		Wytheville	91	800	7.64	state plant
Big Island Lake	muskellunge	Northern	97,99	444	10.60-11.00	state plant

Table 16.–Continued.

County and water	Species	Strain	Dates	Number	Length (inches)	Operation
Schoolcraft – continued						
Big Murphy Creek	brook trout	Assinica	97,99,01	4,600	6.40-7.68	state plant
		Assinica/Maine	93-94	2,000	7.32-7.36	state plant
		Iron River	99	1,000	5.44	state plant
		Maine	95	1,000	7.76	state plant
		Owhi	91-92	2,000	5.64-5.88	state plant
	brown trout	Plymouth Rock	91-92,94	2,990	6.80-7.40	state plant
		Soda Lake	95	940	6.64	state plant
		Wild Rose	93	1,000	8	state plant
Big Spring	brook trout	Assinica	91-92	65	14.20-18.72	state plant
		Maine	92	30	19.36	state plant
		Nipigon	01	50	10.6	state plant
	lake trout	Isle Royale	96-97,99	80	28.92-35.40	state plant
		Lake Ontario	95,00	70	16.56-37.76	state plant
		Lake Superior	91-92	54	21.36-30.72	state plant
		Lewis Lake	94	35	15.12	state plant
		Marquette	93,01	70	28.68-31.84	state plant
		Seneca Lake	98	30	30	state plant
Bluegill Lake	brook trout	Assinica	92,94-95	7,100	4.32-5.28	state plant
		Maine	91,93	5,000	4.72-4.88	state plant
Boot Lake	largemouth bass		91	3,070	2.6	MRPR
			00	3,600	3.08-3.16	state plant
	walleye	Bay de Noc	91-96,99	24,176	1.60-2.24	MRPR
			98	2,700	1.76	MRPR
Clear Lake	largemouth bass		96	4,500	2.2	MRPR
	smallmouth bass		97	18,500	1.72	MRPR
	splake		91-93,95-99	41,000	6.48-7.60	state plant
Colwell Lake	largemouth bass		93	170	10.16	fed plant
Corner Lake	walleye	Bay de Noc	93	10,044	2.12	MRPR
Cusino Lake	muskellunge	Northern	91	311	10.96	MRPR
		Northern	92	27	20.12	TWF
		Northern	93,98,00	836	9.80-11.32	state plant
	tiger muskellunge		91	650	9.36	state plant
Dodge Lake	rainbow trout	Arlee	95	950	7.84	state plant
		Eagle Lake	96-97	1,900	7.24-7.80	state plant
		Shasta	92-94	5,450	7.32-8.32	state plant
		Wytheville	91	1,600	7.64	state plant
	splake		91-97	9,900	6.48-7.16	state plant
Driggs River	brook trout	Assinica	96-97	10,080	6.80-7.48	state plant
		Assinica/Maine	93-95	18,300	6.68-7.92	state plant
		Iron River	98,00-01	17,798	3.96-15.64	state plant
		Maine	95	1,200	7.64	state plant
		Owhi	91-92	11,000	5.80-6.24	state plant
Dutch Fred Lake	brook trout	Assinica	91,93-98,00-01	11,555	2.08-14.72	state plant
		Iron River	01	200	13.16	state plant
		Soda Lake	91	500	6.36	state plant
		Temiscame	97	37	13.48	state plant
East Lake	golden shiner		91	1,000	2.56	TWF
	largemouth bass		91	2,002	2.6	MRPR
	rainbow trout	Wytheville	91	2,750	7.64	state plant
Fox River	brook trout	Assinica	96-97,99,01	31,317	6.32-7.68	state plant
		Assinica/Maine	93-95	36,000	6.76-7.72	state plant
		Iron River	00-01	6,310	5.68-15.64	state plant
		Owhi	91-92	24,000	5.64-6.16	state plant
		Temiscame	98	6,000	5.04-5.80	state plant
Gemini Lake	walleye		98	3,000	1.68	MRPR
		Bay de Noc	92-94,96,00	23,606	1.72-4.68	MRPR

Table 16.–Continued.

County and water	Species	Strain	Dates	Number	Length (inches)	Operation
Schoolcraft – continued						
Indian Lake	walleye	Bay de Noc	91-95	195,540	1.64-2.36	MRPR
		Bay de Noc	93,96	15,820	1.52	priv plant
		Bay de Noc	91-92,94-96	159,880	0.20-0.48	state plant
Indian River	brook trout	Assinica	96-97,99,01	4,800	6.40-7.44	state plant
		Assinica/Maine	93-94	2,800	7.32-7.36	state plant
		Iron River	98,00	2,800	4.16-5.76	state plant
		Maine	00	1,400	7.76	state plant
		Owhi	91-92	2,800	5.48-5.88	state plant
	brown trout	Gilchrist Creek	97-01	9,920	3.80-4.84	state plant
		Plymouth Rock	91-92,94	7,650	6.44-7.40	state plant
		Seeforellen	94	2,800	7.08	state plant
		Soda Lake	95	2,560	6.64	state plant
		Wild Rose	93,96-00	13,850	6.64-8.12	state plant
Island Lake	rainbow trout	Arlee	95	1,470	7.84	state plant
		Eagle Lake	96-97	2,940	7.24-7.72	state plant
		Shasta	92-94	6,825	7.32-8.40	state plant
		Wytheville	91	1,875	7.64	state plant
	splake		91-01	15,080	6.48-7.88	state plant
Kings Pond	brook trout	Assinica	95-96,98-99	3,600	4.24-5.36	state plant
		Assinica/Maine	92	950	5.32	state plant
		Maine	91,93	1,900	4.52-5.04	state plant
		Saint Croix	94	950	6.12	state plant
		Temiscame	97	850	3.84	state plant
Little bass Lake	largemouth bass		93-94	1,749	1.72-2.04	MRPR
Lost Lake	brook trout	Assinica	96-97,99-01	2,710	6.48-7.68	state plant
		Assinica/Maine	92-94	3,600	2.64-3.12	state plant
		Soda Lake	91	1,200	2.36	state plant
		Temiscame	98	550	5.92	state plant
Manistique River	chinook salmon	Michigan	91-01	983,571	3.08-4.04	state plant
	smallmouth bass		92,95,97-98	28,646	1.72-2.96	MRPR
			94	20	2.04	priv plant
			93	149	2.84-16.24	state plant
	steelhead	Steel-MI Winter	91-01	98,414	5.72-8.24	state plant
	tiger muskellunge		91	2,100	9.04	state plant
	walleye	Bay de Noc	91-00	142,446	1.60-3.68	MRPR
			95	5,000	8.12	MRPR
			93-94,96	18,500	6.80-8.12	priv plant
McKeever Lake	muskellunge	Northern	98,01	451	11.32-12.20	state plant
Middle Branch Stutts Creek	brook trout	Assinica	96-00	3,340	6.20-7.44	state plant
		Assinica/Maine	93-94	2,000	7.32-7.36	state plant
		Iron River	98-01	2,500	4.08-5.84	state plant
		Maine	95	1,000	7.84	state plant
		Owhi	91-92	2,000	5.48-5.88	state plant
North Branch Stutts Creek	brook trout	Assinica	96-00	3,540	6.16-7.44	state plant
		Assinica/Maine	93-94	2,000	7.32-7.36	state plant
		Iron River	98-01	2,680	4.08-5.88	state plant
		Maine	95	1,000	7.76	state plant
		Owhi	91-92	2,000	5.48-5.88	state plant
Neds Lake	brook trout	Assinica	92,94-97,99,01	2,800	4.32-7.60	state plant
		Maine	91,93	1,000	4.72-4.88	state plant
		Nipigon	00	300	5.44	state plant
		Temiscame	98	300	5	state plant
Petes Lake	bluegill		93	7,000	4.08	fed plant
	walleye	Bay de Noc	91-96,98,00	36,677	1.60-3.68	MRPR

Table 16.–Continued.

County and water	Species	Strain	Dates	Number	Length (inches)	Operation
Schoolcraft – continued						
Rim Lake	brown trout	Plymouth Rock	91	1,125	6.8	state plant
Ross Lake	largemouth bass		93	5,796	2.04	MRPR
	smallmouth bass		98	1,536	2.32	MRPR
South Branch						
Stutts Creek	brook trout	Assinica	96-00	3,340	6.20-7.44	state plant
		Assinica/Maine	93-94	2,000	7.36	state plant
		Iron River	98-00	1500	4.08-5.52	state plant
		Maine	95	1,000	7.84	state plant
		Owhi	91-92	2,000	5.48-5.88	state plant
Sand Lake	walleye	Bay de Noc	00	8,215	2.12	MRPR
Steuben Lake	walleye	Bay de Noc	92-93,96	9,373	1.60-2.12	MRPR
			98	2,000	1.76	MRPR
Sunken Lake	largemouth bass		95	240	3.56	fed plant
	largemouth bass		96	600	2.2	MRPR
Thunder Lake	walleye	Bay de Noc	92,95	24,000	1.72-2.20	MRPR
Toms Lake	black crappie		91	8	7.12	TWF
	largemouth bass		91	500	2.12	MRPR
Twilight Lake	brook trout	Assinica	95-97,99,01	7,570	4.96-7.60	state plant
		Nipigon	00	1,500	5.44	state plant
		Temiscame	98	1,200	5	state plant