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Manistee River Assessment

Thomas J. Rozich

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COVER: “Canfields Rollway” on the Pine River - Lake County, T20N, R12W, Section 12, NW1/4 of NW 1/4. Date of photograph unknown, but thought to be in the 1880s. Photo courtesy of Wexford County Historical Society Museum, from Merlin “Red” Anderson collection donated to the museum.

"The Manistee River has been long known as one of the most remarkable streams in the Northwest--in this, that it never floods, seldom freezes, and is never affected by droughts."

A.S. Wordsworth - 1869

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EXECUTIVE SUMMARY

The Manistee River Assessment is one of a series being prepared by the Michigan Department of Natural Resources, Fisheries Division, for river basins in Michigan. This assessment described fisheries and related resources, identifies issues that are of concern to fishery managers, and outlines management options to address those issues. The assessment provides an organized approach to identifying opportunities and solving problems. It provides a mechanism for public involvement in management decisions, allowing citizens to learn, participate, and help determine decisions. It also provides an organized reference for Fisheries Division personnel, other agencies, and citizens who need information about a particular aspect of the river system.

The document consists of four main sections: introduction, assessment, management options, and public comment and response. The assessment is the nucleus of the document. Physical, biological, and cultural characteristics of the watershed are described under twelve sections: geography, history, biological communities, geology and hydrology, channel morphology, soils and land use patterns, special jurisdictions, recreational use, dams and barriers, water quality, fisheries management, and citizen involvement.

Management options are provided. These options are consistent with the mission statement of the Michigan Department of Natural Resources, Fisheries Division and convey four approaches to correcting problems in a watershed. These include options to protect and preserve existing resources, options requiring additional surveys, opportunities for rehabilitation of degraded resources, and opportunities to improve areas or resources beyond existing conditions. Options are related primarily to aquatic communities; but wildlife, botanical, and social factors are noted where they are important and directly affect aquatic communities. Some options are simple, but most are complex, sometimes involving management of the entire watershed and taking many years to accomplish. Management options listed are not necessarily preferred by Fisheries Division, but are intended to provide a foundation for public discussion and comment, eventually resulting in the selection of acceptable management objectives for the Manistee River and tributaries.

The Manistee River is located in the northwest portion of Michigan’s Lower Peninsula and drains an area about 1,780 square miles. The mainstem is 232 mi long, with a 671 foot drop in elevation from the source to Lake Michigan. Portions of eleven counties are included in the watershed: Antrim, Benzie, Crawford, Grand Traverse, Kalkaska, Lake, Manistee, Missaukee, Osceola, Otsego, and Wexford. There are three major tributaries: Bear Creek, North Branch of the Manistee, and Pine rivers. Other important tributaries include Goose, Portage, Big Cannon, Hopkins, Manton, Buttermilk, Wheeler, Slagle, and Pine creeks. Also, there are hundreds of other tributaries that empty directly into the mainstem or named tributaries.

The watershed was settled beginning in mid-1800s, near the mouth of the mainstem. Interior portions were not exploited until the late 1800s, when lumbering affected river habitat and adjacent uplands. Hydroelectric development followed in the early 1900s, along with placement of small dams on tributaries.

The Manistee River has one of the most stable flow patterns in the country, producing good conditions for fish reproduction and survival. These stable flows are from the watershed geology that provide excellent groundwater flows. The settlement agreement, between Consumers Energy Company, Michigan Department of Natural Resources, Michigan State Historic Preservation Officer United States Department of Interior-Fish and Wildlife Service, United States Department of

Interior-National Parks Service, and United States Department of Agriculture-Forest Service established stable flows for the lower portion of the mainstem that formerly had peaking high and low flows below the hydroelectric facilities.

An accurate description of the original fish communities in the Manistee River watershed is not available. Michigan grayling disappeared from the watershed shortly after 1900 despite efforts to culture it in hatcheries. The demise of the grayling was due to three factors: over fishing; habitat destruction; and introduction of exotics (brook trout). Muskellunge are another rare species originally more abundant in the Manistee River. It may be present today in very limited numbers. Lake sturgeon, a formerly abundant species that used high gradient waters now inundated by Tippy Dam for spawning, is making a comeback with stable flows.

Seventy-six species of fish made up the native fish community. Thirteen non-native species of fish have been introduced into the watershed through accidental and intentional introductions or migrations. One species, the Michigan grayling, has been extirpated. Three other species: pugnose shiner, tadpole madtom, and white bass are historic records and may be extirpated. Additional fish surveys are needed to accurately determine distributions of these and other species in the watershed.

Two species are listed as threatened in Michigan: lake herring and lake sturgeon. Lake herring are thriving in several inland lakes in the watershed. Lake sturgeon are found below Tippy Dam and in the Hodenpyl backwaters.

Comprehensive studies of invertebrates, amphibians, and reptiles in any portion of the watershed are unavailable. Information on special concern, threatened, and endangered species are in the Michigan Natural Features Inventory. Ten species of invertebrates are listed, eight have special concern status and two, Lake Huron locust and Karner blue butterfly, are proposed to be listed as threatened. Three reptile species, one snake and two turtles, are listed as special concern. Two mammals (marten-threatened and woodland vole-special concern) and eight bird species (three are endangered: Kirtland's warbler, loggerhead shrike, and king rail; and four are threatened: bald eagle, common loon, red-shouldered hawk, and osprey) are listed in the Natural Features Inventory.

Urban and agricultural development are minor in the watershed. However, the number of rural homes and seasonal dwellings are on the rise. Upland erosion into watercourses is significant. Water withdrawal for irrigation is not a factor on the mainstem, but is an issue on some tributaries. Hundreds of road and stream crossings exist and are major sediment producers.

Sixty-three dams and impoundments are located in the watershed. Two major backwaters, both operating hydroelectric dams, are located on the mainstem. Most other dams are small recreational structures on tributaries. All dams are detrimental to the overall health of the river because they impound high gradient habitat, eliminate areas of river habitat, raise water temperatures, trap sediment, nutrients, and large woody debris, kill fish, block fish movement, and fragment aquatic habitats. Five dams are wildlife floodings sited on cold water tributaries and are candidates for removal.

Overall water quality in the Manistee River is very good. Deep permeable sands and limited development have served to preserve water quality. The stream bed quality however is degraded in many portions due primarily to human activity. Chemical contaminants causing public health advisories on eating fish in the watershed include mercury, PCBs, chlordane, and PAHs. DDT, DDE, and dioxins are other chlorinated organic chemical contaminants in fish that can affect the health of wildlife species. Organic contaminants in fish have been reduced significantly since the 1970s and are primarily found in species that use Lake Michigan for part of their life history. Mercury is a concern for inland fish species and levels do not appear to be decreasing; atmospheric emissions appear to be the predominant source of mercury.

Fishing and canoeing are the two most popular recreational uses of the Manistee River. Other forms of outdoor recreation include camping, picnicking, hiking, cross-country skiing, bird watching, trapping, and hunting. Certain types of fishing are limited on the mainstem due to blockage by hydroelectric dams.

The Manistee River and tributaries are all mostly trout streams. From the headwaters to M-72, the wild trout fishery is good and improving. The reach from M-72 to Smithville is also good, but natural reproduction is supplemented with annual brown trout stocking. Between Smithville and Hodenpyl Dam, the brown trout fishery is good, with walleye and smallmouth becoming more abundant. The reach between Hodenpyl and Tippy Dams is high gradient, containing a mix of brown trout, walleye, and smallmouth bass. The area below Tippy Dam is a potamodromous fishery for steelhead and salmon. There are walleye and smallmouth present in this area, but primarily below High Bridge Road. The two backwaters offer a good walleye, pike, smallmouth bass, and panfish fishery. All tributaries, except one or two, have good to excellent resident trout fisheries. Bear Creek is similar to the mainstem below Tippy Dam in that it is primarily a potamodromous fishery. The Pine River is unique in that it is an excellent fishery for brook, brown, and non-migratory rainbow trout. The North Branch of the Manistee is a good wild brook trout stream.

Although there are ongoing bank stabilization projects on the mainstem, Bear Creek, and the Pine River, there remains great potential for additional enhancement and rehabilitation. The scope of projects range from remediating road and stream crossings to addition of large woody debris (primarily in the mainstem) to implementing and enforcing best management practices for all activities. All of these activities would increase natural reproduction and reduce reliance in the stocking of trout. Stocking of muskellunge below Tippy Dam is recommended. Fish passage over the two hydroelectric dams would more fully use the rivers potential, while increasing natural reproduction and angler catch.

Many agencies have regulatory responsibilities that affect the river system. These range from small local governments to large federal bureaucracies. The Federal Energy Regulatory Commission has authority over hydroelectric dams. The US Fish and Wildlife Service, US Forest Service, US Department of Agriculture, Natural Resources Conservation Service, and US Environmental Protection Agency have responsibilities for land and natural resources management. The Michigan Departments of Natural Resources and Environmental Quality manage many natural resources and regulatory activities.

Local governmental interests, along with the eleven counties, include 67 townships and 18 cities, villages and towns. Local agencies conduct zoning and other land management activities. County drain commissioners have responsibility for legally designated drains. Several organized local fishing and hunting groups and recreational groups have shown an interest in management of the watershed. Lake Michigan sport-fishing groups and river guides are intensely interested in the river due to migratory fish species that seasonally use the river.

The first draft of this assessment was made available to the public through direct mailings and posting in local libraries from July through December 1996. Comments from three public meetings and written comments were incorporated into the final assessment. A fisheries management plan will be written based on the final assessment and public comment received. Updates of both the assessment and management plan will occur.

INTRODUCTION

This river assessment is one of a series of documents being prepared by the 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. However, this assessment is admittedly biased towards aquatic systems.

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 the system. With 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 the surrounding land; the amount varies. Therefore each assessment focuses on ecosystem maintenance and rehabilitation. Maintenance involves either slowing or preventing the losses of ecosystem structures and processes. Rehabilitation is putting back some of the structures or processes.

River assessments are based on ten guiding principles of the 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. As well these projects 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 it's watershed using a standard list of topics. These include:

> **Geography -** a brief description of the location of the river and it's 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 the watershed.

Geology and Hydrology - patterns of water flow over and through the 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.

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 of the goals of fishery management. Species occurrence, extirpation, and distribution are also important clues to the character and location of habitat problems.

Channel Morphology - the shape of the river channel: width, depth, sinuosity. River channels are often thought of as fixed, aside 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.

Soils and Land Use Patterns - in combination with climate, soils 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.

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

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

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 non-point source land runoff.

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

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 July, 1996. Three public meetings were held: September 4, 1996 in Grayling, September 5, 1996 in Cadillac, and September 6, 1996 in Wellston. Written comments were received through January 3, 1997. Comments were either incorporated in this assessment or responded to in this 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.

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

Michigan Department of Natural Resources
Fisheries Division
8015 Mackinaw Trail
Cadillac, MI 49601

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

RIVER ASSESSMENT

Geography

The Manistee River is located in the northwestern portion of Michigan's Lower Peninsula. It drains 1,780 square miles into Lake Michigan (Figure 1). The watershed, one of the largest in Michigan, includes parts of eleven counties: Antrim, Otsego, Crawford, Kalkaska, Missaukee, Grand Traverse, Wexford, Osceola, Lake, Mason, and Manistee. The mainstem, that is about 232 mi, originates in a cedar swamp in southeast Antrim County (6 mi from the Village of Alba), at an elevation of 1,250 ft. From this point the river meanders south until it reaches about 6 mi west of Grayling. Here (M-72) the river turns and meanders to the southwest until it reaches Manistee Lake near Lake Michigan. The discharge into Lake Michigan is at an elevation of 579 ft, a total drop of 671 ft.

For purposes of discussion, the river system is divided into segments based on habitat types, fish communities, gradient, large independent tributaries, and fisheries management zones (Figure 1). The segments are: 1) headwaters to M-72 Bridge (29 mi); 2) M-72 Bridge to Smithville (55 mi); 3) Smithville to M-115 Bridge (101 mi); 4) Hodenpyl Dam to Red Bridge (8 mi); 5) Tippy Dam to M-55 Bridge (25 mi); 6) North Branch Manistee; 7) Bear Creek; and 8) Pine River. These specific segments are discussed in detail in **Biological Communities** - *Present Fish Communities*, **Channel Morphology -** *Channel Gradient*, and **Fisheries Management**.

The Manistee River has 109 named tributaries (Figure 2). Major tributaries of the mainstem include: North Branch Manistee and Pine rivers, and Bear and Pine creeks. There are also a number of unnamed tributaries, several that flow directly into the mainstem.

Landmarks, from the headwaters to the mouth, include: Alba, Deward, Grayling, Manistee Lake (Kalkaska County), Lake Margrethe, CCC Bridge, Sharon, Smithville, Fife Lake, Hodenpyl Dam, Tippy Dam, and City of Manistee (Figure 3). On the Pine River they include: Rose Lake, City of Cadillac, and Stronach Dam. On Bear Creek they are: Bear Lake , Village of Bear Lake, and Kaleva.

History

The Manistee River and its watershed were formed near the end of the last glaciation period (the Wisconsin Period of the Pleistocene Epoch). The southern portion of Michigan was ice free around 16,000 years ago and modern topography and soils are the result of post glacial erosion and soil formation processes acting on glacial deposits (Albert et al. 1986). Earliest archaeological evidence of human inhabitants dates to the Paleo-Indian period, over 10,000 years ago. These were nomadic people who followed herds of game animals. By 500 BC, there was a change to a more sedentary lifestyle (Archaic period) as people established camps for a season or more and agricultural practices were developed (B. Mead, Michigan Department of State, Archaeological Section, personal communication).

The Manistee River watershed, before European exploration in the first half of the 1600s, was controlled by the Algonquin Indian Nation. Three tribes of that Nation, Huron, Chippewa, and Ottawa, used this area and its resources (Tanner 1986). The Potawatomi from Southern Michigan also used the area, but to a lesser extent. These tribes built no large settlements, but rather traveled throughout; hunting, fishing, and trapping, and left the watershed in winter. The Huron were less nomadic, founding villages and semi-organized communities. The Chippewa and Ottawa, neighbors and allies, evidenced by intertribal marriages, were more war-like. Of these two the Ottawa were the more peaceful and followed agricultural pursuits (Powers 1912).

French explorers came to the region, primarily motivated by the fur trade. Jean Nicolet is thought to be the first European to visit northern Michigan. His 1634 route followed the St. Lawrence River and the St. Clair River into Lake Huron and the Straits of Mackinac. He was followed in 1694 by Antoine de la Mothe Cadillac, who founded Detroit in 1705. As an employee of the Northwest Fur Company, he established Michilimackinac at the Straits (Powers 1912).

In 1760, the English defeated the French and took control of northern Michigan. In June of 1773, Pontiac, the great Algonquin chief, rebelled against the “cold, calculating English” in what is known as the "Fort Michilimackinac massacre" (Powers 1912).

In 1776, the area became United States soil. The Ordinance of 1787 allowed retention of Michigan posts by the English until 1796. On April 3, 1802, an Act of Congress created the State of Ohio, also making Michigan part of the Territory of Indiana. A January 1805 Act of Congress provided for the organization of the Territory of Michigan. On October 13, 1813 General Lewis Cass was appointed Civil Governor of Michigan Territory. He created the first county, Michilimackinac, bounded on the east by the Cheboygan River, the south by the Manistee River, the west by the Manistique River, and by Canada on the north (Peterson 1972).

By 1830, the Government Land Office survey of Michigan began, creating the township, range, and section system we now have. Before this time, the Manistee River watershed was still undeveloped, being visited only by various Indian tribes and fur trappers. In 1837, statehood came for Michigan and in 1840, the creation of counties as known today. In 1843, names of the counties were changed to their present designation from Indian names: Lake County, from Aishcum - a Potawatomi chief; Osceola (a great Seminole chief) County, from Unwatin an Ottawa chief; Kalkaska County, from Wabasse - a Potawatomi chief; and Wexford County, from Kautawaubet - an Indian chief (tribe unknown). The State of Michigan derived its name from “Michigane”--the Huron tribe of the Algonquin Nations word meaning Fresh Water Sea. The Manistee River was also named by the Indians. This name has several documented meanings: "river at whose mouth are islands"; "river with white bushes along the banks"; "crooked river"; and "spirit of the woods" (Peterson 1972).

The first Europeans credited with visiting Manistee City area and the Manistee River were French fur traders. They found the Manistee River valley inhabited primarily by the Chippewa tribe of the Algonquin Nation. In the 1830s, the Campeau family, French fur traders from Grand Rapids, settled in Manistee (Powers 1912).

The watershed was late in developing, because of a large sand bar at the river’s mouth that was reported in 1840, and also due to the high gradient waters located not far upstream (the present day site of Tippy Dam). In 1854-55, a canal was dug through the sand bar allowing rapid settlement of the City of Manistee and later lumbering industry and log drives in the river. The interior portion of the watershed was not logged until after 1870, as the river was choked with logs and log jams. The Manistee River was not a water highway, but contained so much woody debris, it was rare to find a 1 mi stretch of open water. Before construction of the Manistee Bridge (now M-37 Bridge north of Sherman), the only river crossing was by way of a log jam so solid horses and livestock could cross. Logging company crews clearing the river for log drives did not reach Sherman until 1870 (Peterson 1972).

The Manistee River, particularly the upper reaches, was famed for its grayling fishery. Vincent (1962) reported three men caught 600 plus pounds of grayling in two days. This equals about 1,000 fish. Other reports were "good grayling stream" (Norman 1887) and "Upper Manistee, best grayling fishing in the state" (Vincent 1962).

In 1900, the Manistee River was proclaimed the last of Michigan's great rivers unharnessed and capable of producing 40,000 horsepower of electricity (Powers 1912). Stronach Dam, on the Pine River (South Branch Manistee River), was the first hydroelectric dam on the system, being completed in 1912. Stronach Dam originally supplied power to the City of Manistee. The Michigan Railway Company acquired the project around 1915, with the intention of supplying power to a proposed electric railway. Consumers Power Company acquired the project in 1917 after the electric railway plans were abandoned and operated the plant until July 8, 1953. Tippy Dam was completed and began producing power in 1918 and Hodenpyl Dam in 1925. Tippy Dam was then called Junction Dam, being at the confluence of the mainstem and South Branch Manistee, as the Pine River was formerly called (refer to **Dams and Barriers**).

All the historic developments have left their mark. Three hundred eighty (380) archeological sites are listed in the watershed (Table 1). Actual scholarly study of the Manistee River archaeology has been limited.

The most extensive scholarly archaeological investigation took place in 1965. The area covered was from Sharon to Sherman (Figure 1) and disclosed many sites. These included Indian burials, village locations and transient campgrounds, and most were dated from 8,000 BC to 500 AD.

The Manistee River's cultural value is most evident in the way it has influenced people's lifestyles since early times. The American Indians depended on the river for transportation, food, and water -- it was vital to their existence. Early settlers depended on it in much the same way, as it later became the sole means of transporting logs to the sawmills and thereby was very important to early resident’s way of life. Today the river fills different purposes, but is also important to everyday life. It is a recreation resource to many people, and providing a livelihood for local people. Current local culture has been determined by in part the need to meet the demands of river users.

The river has also influenced the way people spend their time. A large portion of local people's time is spent either enjoying the river's recreational opportunities or working to enable others to benefit from the river. Their thoughts and activities are determined by the river's character. Daily conversations center on how the existing river mood will affect personal pursuits or visitors, which in turn effects the area’s economy and lifestyle.

Biological Communities

Original Fish Communities

About 75 species of fish were in the Manistee River (Table 2). However, an accurate description of the fish community at the time of European settlement (mid 1800s) is not available.

Michigan grayling were abundant in the Manistee River before European settlement, especially in the upper reaches. Suckers, shiners, northern pike, and whitefish are the only other fishes mentioned by early observers as associated with grayling in Michigan streams (Vincent 1962). Other species present, but not easily observed, would have been blacknose & longnose dace, sculpin, and chestnut and brook lamprey (G. Smith, UM, personal communication). Potamodromous species including lake sturgeon, lake trout, lake and round whitefish, burbot, walleye, and trout perch inhabited the river seasonally.

There is little doubt that brook trout were native to the Lower Peninsula of Michigan, at least to the extent they were not transplanted by humans (Jerome 1874, Anonymous 1875). The Boardman River was thought to be the most southerly stream native brook trout inhabited (Bower 1881). Brook trout may have been native to the Manistee River (Vincent 1962). A newspaper article in the Manistee Times dated Sept. 11, 1869 by George C. Depres cited that a large "mess" of speckled brook trout were taken from Pine Creek by a Mr. Ruggles and other gentlemen. He added it was the opinion of Manistee people that they would have to go to the neighborhood of Traverse City to catch speckled trout. Brook trout were actively dispersing (naturally) southward, but were also being introduced (Vincent 1962). The Jordan River changed from a grayling to a brook trout stream over 30 to 40 years (Page 1884, Norman 1887, and Whitaker 1887). The change of the Manistee River from grayling to a trout river, was attributed to competition, over harvest, and habitat destruction during the logging era (Vincent 1962).

The first comprehensive fish surveys in the Manistee River were not conducted until 1958 (Crowe 1959). These were done in conjunction with a lamprey study in the upper river areas. Thirty species of fish, including three lamprey species, were collected from 30 sampling stations in the mainstem and tributaries. Most of the sampling stations were in the upper river (Smithville area being the downstream limit) on the mainstem and tributaries. This survey was similar to studies on the upper Au Sable by Hubbs in the 1920s where 30 species were collected and Richards in 1972, where 29 species were collected (Richards 1976). Richards concluded that not much had changed in species composition since the turn of the century. Richards did however, conclude that below the Au Sable hydroelectric impoundments, there were changes in species diversity and distribution, and large changes in species composition. One species has been extirpated from the watershed, the Michigan grayling, that is extinct statewide.

Factors Affecting Fish Communities

European settlement caused dramatic changes in the Manistee River and its watershed, many of which resulted in changes to the river's fish communities. Affects of logging, hydropower dams, agricultural and urban land use, point-source discharges, and lake-level controls on the river system are discussed in detail in others sections. However, a brief discussion of the effects of settlement is appropriate here. Fish require a variety of habitats through out their life cycle, including spawning, feeding and growth, and refuge habitats (Figure 4). Equally important is the ability to move from one habitat to another (Schlosser 1991). If any one critical area is destroyed, or if the ability to migrate from one to another is restricted, the species may become locally extinct.

The turn of the century pine lumbering era had tremendous effects on native fish communities. The systematic removal of large woody debris and scouring of the channel by log drives, resulted in extreme erosion of soils and addition of sediments, causing heavy mortality of eggs and fry (Vincent 1962).

> "Early construction of dams and draining of wetlands for settlement eliminated spawning areas, or access to them, for all of the original potamodromous fish species. These large fish were [initially] concentrated below the dams,…and overharvest quickened their [population reduction or] demise (Trautman 1981). Dams also blocked migrations among critical seasonal habitats (summer, winter, or spawning…) within the river itself. Dams have degraded fish communities through the inundation of [valuable] scarce, high gradient reaches and through their cumulative affects on water temperature and flow patterns (see **Dam and Barriers).** These effects have been shown to reduce the fishes present to those few species able to tolerate these harsh

> conditions; typically large, adult, warmwater fishes (Cushman 1985; Gislason 1985; Nelson 1986; Bain et al. 1988). Most small species and juveniles of larger species are eliminated.

Since early settlement, land drainage for human use ([timber harvest,] agriculture or urban) has degraded the originally stable flow regime [of the Manistee River]. Draining wetlands, channelizing streams, and creating new drainage ditches all served to decrease flow stability by increasing peak flows and diminishing recharge into groundwater tables. Increased peak flows negatively affects both spawning and survival of young fish of many species. Summer water temperatures have become warmer and more variable due to lower base flows, channel modifications, and clearing of shading stream-side vegetation. Both landscape perturbations and increased peak flows accelerated erosion within the basin and increased the sediment load of the river. These sediments contributed to increased turbidity (harmful to certain species) and buried gravel and cobble substrates that serve as critical habitat for many fishes and invertebrates." (Hay-Chmielewski et al. 1995).

Fish communities have been altered through intentional and inadvertent introduction of exotic species (Table 3) (Mills et al. 1993). An overview of fish stockings for 1983-1993 is given in Table 4. In October of 1966, the mainstem of the Manistee River from Cameron Bridge to M-66 was treated with Bayluscide for chestnut lamprey control (Jacob 1966). After the treatment rainbow and brown trout were stocked in large numbers.

A vital component of the riparian zone associated with rivers is large woody debris, such as fallen trees from adjacent old growth forests. The importance of large woody debris cannot be overstated. It provides habitat diversity, cover for fish, habitat for invertebrates and other components of the aquatic food chain, adds nutrients to the aquatic system and protection to streambanks during peak flows. Most of the large woody debris was removed to facilitate downstream transport of logs. Verry (1992), provides an excellent summary of the various functions large woody debris plays in aquatic ecosystems. Present-day levels are much lower, due in part to the second growth nature of our forests.

Present Fish Communities

According to biological surveys (Crowe 1959, Lawler, Matusky, & Skelly 1991), Michigan Department of Natural Resources (MDNR), Fisheries Division surveys, and recent observations by Fisheries Division personnel, the Manistee River is thought to contain 80 fish species (Table 2). Species distributions vary from one small inland lake to watershed-wide (Appendix 1). One species has been extirpated and some are rare or threatened, but most native species are still present and range from rare to abundant in numbers. Three species are considered threatened by the State of Michigan: lake sturgeon, cisco, and pugnose shiner. Thirteen non-native fish species have been introduced into the watershed (Table 3). These include unintended and intentional introductions and migrations. All are still present. A brief description of the existing fish populations by river segment follows:

Segment 1-Headwaters to M-72 Bridge

The best trout populations in the mainstem exist in this stretch. Fisheries Division surveys (MDNR, Fisheries Division) indicate good naturally sustaining populations of brook and brown trout, with brook trout predominating. No stocking is done in this stretch. Fish habitat has partly recovered from the turn of century logging disturbances. Trout population estimates continue to show annual increases over the last ten years. This upper area increased to 1,088 trout per acre in 1993 from 902 trout per acre in 1992, almost a 21% increase. (MDNR, Fisheries Division). This segment is classified as a "Blue Ribbon" trout stream.

Segment 2 - M-72 Bridge to Smithville
This reach has fair to good populations of large brown trout, large numbers of young-of-the-year brook trout and a few rainbow trout (in riffle areas). These populations are sustained by hatchery fish because the habitat is severely degraded with a sand bedload from turn-of-the-century logging. Part of this stretch and Segment 3 are stocked by the MDNR, Fisheries Division, Manistee River Association, Upper Manistee River Association, and private parties with 30,000 brown trout and 7,500 rainbow trout annually. Chestnut lampreys are abundant in this segment.

Segment 3 - Smithville to M-115 Bridge
This reach has a fair to good population of large brown trout, with some brook trout and a coolwater community of walleye, smallmouth bass, shorthead and silver redhorse, and white suckers increasing downstream. This stretch is also planted with large numbers of brown trout, by MDNR, Fisheries Division and Walton Junction Sportsman Club. Walleye are fairly abundant from US-131 bridge down to M-115 bridge. Chestnut lampreys also abound in this reach of river. The many tributaries in this reach do provide natural recruitment of brook and brown trout.

Segment 4 -- Hodenpyl Dam to Red Bridge
A good population of large brown trout exists, as a result of stocking 15,000 yearling brown trout annually. This area also has a fair to good walleye population. Some claim this area offers the best trophy brown trout fishing in the Midwest. This stretch is unique in that it is high gradient and undeveloped, with high banks as the river cuts through a large moraine.

Segment 5 - Tippy Dam to M-55 Bridge
Potamodromous fish dominate this segment, with fall salmon and fall/winter/spring steelhead runs producing very good fisheries. A late winter-spring run of spawning walleye is present, with fish to 15 pounds reported. Lake trout run up to Tippy Dam in the fall. Modest populations of resident brown trout, smallmouth bass, northern pike, walleye, redhorse, and suckers are also present. This segment is stocked annually with 125,000 chinook, 100,000 coho, 50,000 winter steelhead, 40,000 summer steelhead, and 30,000 brown trout.

Segment 6 -- North Branch Manistee River
This stream has good self sustaining brook trout populations, with some brown trout present. Chestnut lampreys abound in the lower third of the segment, where sand bedload is a problem. An occasional "tiger trout", which is a natural cross of a brook and brown trout, is reported by anglers. The area from Mecum Road to the mouth is classified as a "Blue Ribbon" trout stream.

Segment 7 -- Bear Creek
This segment is noted for its fall chinook and fall-winter-spring steelhead fishery. The headwater's area supports a good brook trout population. Below County Road 600 (west of Kaleva) stream trout populations are low due to higher temperatures and sand bedload. No fish stockings are made in this reach. Several tributaries of Bear Creek are trout streams, with naturally reproducing populations of brook and brown trout. These tributaries are also important producers of steelhead smolts.

Segment 8 -- Pine River
Pine River has fair populations of brook, brown, and rainbow trout that are self sustaining. The Pine River is noted for its non-migratory rainbow populations, the largest such population in Michigan. The stretch from Tippy Dam backwaters to the mouth of the East Branch of the Pine River is classified as a

"Blue Ribbon" trout stream. Index station population data (MDNR, Fisheries Division) indicate the Pine River has one-third of the standing crop of trout as compared to other similar rivers (Alexander and Gowing 1980). Sand bedload from severely eroding banks and road-stream crossings (Hansen 1971) is the primary cause of this lower population. No fish stocking is done in the Pine River.

Other Tributaries

Almost all tributaries are designated trout streams (Figure 5). A few tributaries are good fisheries Goose Creek - brook trout; Big Cannon Creek - brook and brown trout; Little Cannon Creek - brook trout; Hopkins Creek - brook and brown trout, Manton Creek - brown trout; Buttermilk Creek - brown trout; Silver Creek - brown trout; Slagle Creek - brown trout; and Pine Creek - brown trout. These are all naturally produced and sustaining fisheries. Pine Creek is an important producer of steelhead (rainbow trout) and chinook smolts.

Hodenpyl and Tippy Dam Backwaters

Hodenpyl Dam backwaters provide a fishery for bluegill, smallmouth bass, pike, and walleye. Channel catfish and walleye are periodically stocked in the reservoir (Table 4). A population of lake sturgeon (size unknown) exists in the backwaters as they are occasionally taken on hook and line or observed "sunning" themselves. This population was trapped here when Tippy Dam (Junction Dam) was completed in 1918 and Hodenpyl Dam completed in 1925.

Tippy Dam pond provides a fishery for smallmouth bass, pike, and walleye. Walleye and channel catfish have been planted in the past (Table 4). The state record walleye (17 lbs. 3 oz.) was caught in the Pine River arm of the backwaters.

Unique Communities-Habitats

Populations of lake sturgeon, a state threatened species, exist in two areas. The first is in Hodenpyl Dam backwater and the second is downstream of Tippy Dam. In July of 1987 an angler caught and released a 63 inch specimen from the Hodenpyl backwaters. Estimated weight and age for this fish are 61 pounds and 42 years (Baker 1980). This indicates the specimen was hatched in 1945. Below Tippy dam a significant number of these large fish were observed by members of the Michigan River Guides Association during a low flow interval on May 14, 1991. Another was captured on May 15, 1991, near High Bridge by Consumers Power Company consultants while conducting an electrofishing survey. That specimen was 1650 mm (65 inches) in length. Estimated weight and age for this fish are 67 pounds and 45 years (Baker, 1980). These ages show the sturgeon below Tippy was born in 1946 and the one in Hodenpyl born in 1945 and indicates at least some natural reproduction both below Tippy Dam (constructed in 1918) and above Hodenpyl Dam (constructed in 1925). The landlocked population in Hodenpyl reservoir is rare, with not much known about the number of fish nor areas in which they spawn, both of which will be explored. The major cause of the decline of lake sturgeon was commercial exploitation in the 1870's and 1880's. Impoundments flooding spawning areas and peaking operation of dams have also played a role in the crash of lake sturgeon populations and their slow recovery. Since the Tippy project was converted to a run-of-river operation from a peaking mode, lake sturgeon have been observed annually on their spawning run by river guides and MDNR Fisheries staff.

Aquatic Invertebrates

There are at least three areas that have unique aquatic insect communities, besides the abundant invertebrate populations in the headwaters (Segment 1). There are areas that have significant hatches of "Michigan caddis", which is actually a mayfly (Order Ephemeroptera, Hexagenia limbata) and not a caddis fly (Order Tricoptera). Excellent hatches of Hexagenia are found around Cameron Bridge

(Segment 1); below Rainbow Jims (Segment 3); and Baxter Bridge (Segment 3). In addition, they are found in fewer numbers from Cameron Bridge to the Hodenpyl backwaters.

No comprehensive invertebrate studies have been done in the Manistee River watershed. Invertebrates often are sensitive indicators of habitat problems that are affecting fish and other aquatic life. Three macroinvertebrate studies have been conducted in the watershed. Michigan Department of Environmental Quality (MDEQ), Surface Water Quality Division (SWQD) investigated in 1985 macroinvertebrates above and below Flowing Well Trout Farm on the North Branch of the Manistee River. They found similar benthic communities above and below this private fish hatchery. SWQD conducted a biological study in 1989 above and below the Harrietta State Fish Hatchery and likewise found similar communities. Dr. Justin Leonard (1937) looked at macroinvertebrates as trout food in the Pine River. He found an abundant macroinvertebrate food source, including high densities of crayfish. A complete inventory of the macroinvertebrate fauna of the Manistee River and watershed is needed.

One mussel species is about listed in the Michigan Natural Features Inventory (Table 5). However, no definitive studies have been conducted in the watershed and a complete inventory of mussel species present is needed.

Amphibians and Reptiles

Thirty-eight species of amphibians and reptiles have been documented in the Manistee River system or its associated wetlands (Table 6). Three species are about listed as of "special concern" in the Michigan Natural Features Inventory (Table 5): Massasauga rattlesnake, spotted turtle, and wood turtle. The wood turtle is of special interest as its nesting sites are sandy stream banks and it also lives in river corridors. In May 1993, the US Forest Service began a long term study on the Huron-Manistee Forest to determine the presence and use of wood turtles on major river systems within the forest, including the Pine River (Schutz 1993). This study, that includes marking and radio telemetry, will attempt to determine sex ratios, age class structure, range, and essential wood turtle breeding areas. Breeding areas are of prime importance as nesting habitat may be reduced by river rehabilitation projects that stabilize and revegetate eroding stream banks. Studies on the Au Sable River (Lower Peninsula) and Indian River (Upper Peninsula) on the nesting requirements of the wood turtle have been completed by Dr. Jim Harding of Michigan State University (MSU). These studies indicate the wood turtle is fairly selective in choosing a nesting site, preferring gentle sloping south and west facing banks only. Bill Parsons, a graduate student from Central Michigan University, has an on-going study on the Pine River, in which nest predators appear to have a major effect on recruitment. Studies in New York, Minnesota, and Wisconsin have found that commercial and casual collection are the major cause of wood turtle decline (Buech et al. 1992; Burger and Garber 1995; Garber and Burger 1995).

Mammals

Beaver, mink, muskrat, raccoon, and otter are mammal species intrinsically associated with the Manistee River and tributaries (T. Havard, MDNR, Wildlife Division, personal communication) (Table 7). All of these species are present in moderate to very abundant populations, primarily in smaller tributaries and headwater areas. Two species of mammals are listed in the Michigan Natural Features Inventory (Table 5): pine marten (threatened) and woodland vole (special concern). Pine marten, which were extirpated, has been reintroduced along the Pine River uplands. Neither of these species is strongly dependent on the river corridor for survival. Elk have been extirpated. White-tailed deer are seasonally dependent upon river and tributary corridors, and headwater areas. Deer use these sites for yarding when severe winters force them to abandon the uplands. This can cause conflicts in management philosophies with Wildlife Division.

Birds

A variety of waterfowl nest in the watershed (Table 7). In addition, migrating ducks and geese use it as part of the Mississippi Valley Flyway. MDNR, Wildlife Division manages the Manistee River marsh for nesting and migrating waterfowl. It is located where the river empties into Manistee Lake.

Eight species of birds are listed in the Michigan Natural Features Inventory (Table 5): bald eagle (threatened), common loon (threatened), king rail (endangered), Kirtland's warbler (endangered), loggerhead shrike (endangered), northern harrier (special concern), osprey (threatened), and red shouldered hawk (threatened). Five of these are intrinsically associated with the watershed, either for habitat or feeding area, bald eagle, loon, king rail, osprey, and red shouldered hawk.

Significant great blue heron rookeries exist within the drainage and are listed in the Michigan Natural Features Inventory as an "Other Feature" (Table 5). One other scarce bird species present is the pileated woodpecker, that thrives in mature forests. Other natural features, insects and plants, and whose status is "of concern" are found in Table 5.

Pest species

Pest species are defined here as those aquatic species that have been introduced, either accidentally or intentionally, or are exceptionally damaging to economic values, that pose a significant threat to native species or their habitat. Most species do not pose any threat unless they are present in high densities. The one fish pest species that is abundant in the Manistee River, its impoundments, tributaries, or natural lakes is the chestnut lamprey. This parasite is abundant in the reach of the mainstem from County Road 612 to Sharon Bridge (Segments 1 & 2) and is very abundant in the reach from Sharon Bridge to M-115 Bridge (Segment 3). A research report by Andy Nuhfer (1993), indicated that chestnut lamprey do cause mortalities to trout, but mortality is not significant. These fish are a management concern, as a Bayluside treatment eradicating chestnut lamprey followed by liberal stocking provided a temporary improvement in the fishery (Jacob 1966). Sea lamprey invade the mainstem and tributaries below Tippy Dam annually, requiring periodic lampricide treatments with 3-triflouromethyl-4-nitrophenol (TFM) to eliminate the larval lamprey (E. Koon, US Fish and Wildlife Service, personal communication).

A pest species of mollusk, the zebra mussel, has invaded Manistee Lake, Manistee County and the shipping channel to Lake Michigan (M. Stifler, SWQD, personal communication). They were also discovered in Tippy Dam Backwaters in the summer of 1997. Zebra mussels spread primarily through veligers, being transported from one body of water to another by boaters in their outboard engines or water in the boats themselves. A 1996 survey of Bear Lake-Manistee County found no zebra mussels, nor have they been identified in any other portion of the watershed. Zebra mussels are present in Manistee Lake in large numbers and annually cause problems clogging industrial and municipal water intakes. Their long term effect on the Tippy Dam hydroelectric operation is unknown. Spiny water flea has invaded Lake Michigan, but no colonization has been documented in Manistee Lake or the river. Rusty crayfish are in the river system, being very abundant below Tippy Dam (MDNR, Fisheries Division). The "Rusty", that has been called "the crayfish from hell", is an exotic species, most probably introduced by bait dealers and anglers. It is an extremely aggressive crayfish, eating everything and anything and even attacks swimmer's toes, and has often replaced native species where introduced.

There are two known pest plant species in the Manistee River system, purple loosestrife and Eurasian milfoil. Purple loosestrife is very prevalent in the Manistee marsh, located near the river's mouth, where it has literally crowded out native plants (T. Havard, MDNR, Wildlife Division, personal communication). Eurasian milfoil is present in several lakes in the watershed.

Several terrestrial pest species are present, gypsy moth, forest tent caterpillar, spruce budworm, and jack pine budworm. None are present in high enough densities to be a problem, except the gypsy moth. This species can cause severe die-offs in forested areas. The gypsy moth itself does not kill the tree, but lowers its resistance to other diseases and parasites, causing mortality, especially in oaks on poorer sites. (R. Hoeksema, MDNR, Forest Management Division, personal communication).

Geology And Hydrology

Geology

Surface topography and soils of the Manistee River were created during the last continental glacial period, the Wisconsonian. The watershed was formed some 10,000 years ago during the glaciers final retreat northward. The watershed is largely a region of outwash plains and recessional moraines.

The moraines were formed while the ice was pushed forward at the same time the leading edge was melting (USDA 1993). There are three distinct morainal sub-sections in the Manistee River watershed: 1) Mio sub-section, from the headwaters to Segment 4; 2) Cadillac sub-section, Segment 8 (Pine River); and 3) Wellston sub-section, Segment 5, including to just below Tippy Dam. These morainal features are the high hills (ice contact hills) next to the watercourse and are the highest in the Lower Peninsula. At the same time, outwash plains were being formed by water (carrying sand) flowing away from the melting glacier. The entire basin contains vast deposits of sand and gravel capable of storing large quantities of water.

The Manistee River originates from seeps in a cedar swamp in Township 29 North, Range 5 West, Section 12- Antrim County, 6 mi southeast of the Village of Alba, at an elevation of 1,250 ft above sea level. The river then flows south and west, emptying into Lake Michigan at an elevation of 579 ft above sea level.

Climate

The basin offers a climate typical of Michigan's "north country" that is strongly influenced by Lake Michigan. The warm days and cool nights offer a pleasant summer haven for residents and tourists alike. Winter provides excellent conditions for skiing, snowmobiling, and other winter sports. Detailed geography of Michigan's climate is presented in “The Climatic Atlas of Michigan” by Eichenlaub et. al. 1990.

Weather data for the Manistee basin indicate a record high of 107°F and low of minus 45°F, both recorded in the Grayling-Fife Lake Area. There is considerable variation in climatic conditions in the basin depending on the distance from Lake Michigan. Mean January temperatures are 17.4°F and July temperatures are 58.7°F. The average monthly minimum temperature for January is 10.4°F, and the average monthly maximum temperature for July is 80.2°F. Temperatures can be expected to fall below zero three days each year near Manistee and 23 days every year near Grayling (Eichenlaub et al 1990). The average length of growing season (frost free days) is 121 days (range 84 to 158).

The summer season yields 34% of the annual precipitation, with another 30% during fall. The low occurs in February with an average monthly yield of 1.44 inches. Annual precipitation averages 32.04 inches, typical of Michigan's Lower Peninsula..

Annual Stream Flows

Draining an area of about 1,780 square miles, the Manistee River has an average discharge of 2,001 cubic feet per second (cfs) at the United States Geological Survey (USGS) Manistee gauge station, which is located near the M-55 bridge. Average discharge rates, from the headwaters downstream, are as follows: Mancelona Bridge -- 18 cfs; County Road 612 -- 116 cfs; CCC Bridge -- 256 cfs; Sharon -- 336 cfs; and Sherman -- 838 cfs. Average annual discharges of Bear Creek are 140 cfs and Pine River 250 cfs.

Seasonal Flow

Flow stability can be critical to support balanced and diverse fish communities (Richards 1990). It is also a known determining factor in ecological and evolutionary processes in streams (Poff and Ward 1989) and has been positively correlated to fish abundance, growth, survival, and reproduction (Coon 1987, Seelbach 1987 and 1991). Flow stability is important in habitat suitability for pink salmon (Raleigh and Nelson 1985), largemouth bass (Stuber et al. 1982c), smallmouth bass (Edwards et al. 1983), walleye (McMahon and Nelson 1984), brook trout (Raleigh 1982), brown trout (Raleigh et al. 1986b), and chinook salmon (Raleigh et al. 1986a).

Flow patterns are usually examined by looking at flow duration curves from various gauge stations.

> "Flow duration curves show the percentage of days during a period of record when water flows exceed a base level. Since different gauging stations on a river represent different drainage areas, overall flow volume may vary considerably among stations. Therefore, to be able to compare different flow duration curves, they have been scaled by the median flow (50% exceedence) and displayed in figure [6]. Exceedence is defined as the probability of any discharge exceeding a given value. Graphs that show high flows tend to obscure the details of low flows, so the flow duration curves above and below the 50% exceedence value are shown separately. The most stable streams in Michigan (Au Sable, Manistee, and Jordan Rivers) have 5% exceedence (high) flows that are less than twice their median flows, and have 95% exceedence (low) flows that are over 80% of their median flows." (Hay-Chmielewski et al. 1995).

The Manistee (mainstem) and Au Sable rivers have the most stable flows of any streams in the country (P. Seelbach, MDNR, Fisheries Division, personal communication). Figure 6 shows high flow duration curves for three sites on the mainstem and two sites on the Pine River, the Pine River being relatively unstable. This demonstrates the extreme stability of the mainstem, that is a reflection of the geology and soils in the watershed. The two sites on the Pine River, especially the site on the East Branch of the Pine River, have problems with high flows, below 25% exceedence, i.e., those which exceed twice the base flow at least 25% of the time. However, these sites show fairly stable flows during low (drought) flows, indicating ground water (Figure 6).

Another index of flow stability that can be used both with gauge data and short time frame and miscellaneous flow data, is to compare mean monthly highest flow to mean monthly lowest flow for each year. High ratios of these two numbers indicate unstable flows dominated by land-surface runoff, and low numbers indicate stable flows dominated by groundwater. These ratios, with 1.0 being a perfectly stable system (where high equals low), are as follows:

Ratio Class (P. Seelbach, MDNR, Fisheries Division, unpublished data).

1.0 - 2.0	Very stable - Michigan's trout streams
2.1 - 5.0	Stable - Coolwater and stable warm water rivers
5.1 - 10.0	Flashy - Less stable warm water rivers
> 10.1	Very flashy

Flow yields per square mile in the watershed, calculated from monthly mean values taken at gauging stations, along with the ratio of high:low flows [Figure 7] were used to compare sites on the Manistee River mainstem and Pine River system to other systems in the state. The yields for low monthly flow (the mean daily flow during the driest month) show that relatively low base flows exist in the East Branch of the Pine River at Tustin, indicating a surface-water driven stream. The high:low ratio indicates the stability of flows throughout the year, a low ratio shows a stable stream. For example the Au Sable River is well known as a very stable system (Richards 1990) and has a ratio of 1.5. The north branch of the Kawkawlin is extremely unstable and has a ratio of 36.5. In comparison, the Manistee is very stable, but it is easy to pick out the trouble spots. The East Branch of the Pine River, with a ratio of 9.7, is unstable. This reflects a warm water stream (it is classified as such) and is due to its arising from Rose Lake, receiving runoff from impermeable soils (very little groundwater) and agricultural land use.

Daily Flow

> "In natural streams, daily flow changes are generally gradual. Some hydroelectric operations and some lake-level control structure operations cause substantial daily flow fluctuations. These daily fluctuations can destabilize banks, create abnormally large moving sediment bedloads, disrupt habitat, strand organisms, and interfere with recreational uses of the river. Aquatic production and diversity are profoundly reduced by such daily fluctuations (Cushman 1985; Gislason 1985; Nelson 1986; Bain et al. 1988). " (Hay-Chmielewski et. al. 1995)

One active lake-level control structure is located on Lake Margrethe. This structure, that has 3 ft of head, is operated seasonally by the Crawford County Road Commission. When lake water levels are above the target lake-level, large amounts of water are rapidly released, causing stream flow below this point to rapidly increase. Conversely, when the lake water level is below the target level, flows to the stream are shut off to raise the lake level quickly; this causes the stream to dry-up.

Hydroelectric dams that operate in a peaking mode cause significant habitat degradation (Cushman 1985; Gislason 1985; Nelson 1986; Bain et al. 1988). These projects generate high flood flows during peak electrical demand (generally 8 am to 5 pm) and drought flows during non-peak periods (generally at night). Historically, both hydroelectric projects on the Manistee River were operated as peaking operations and were licensed by the Federal Energy Regulatory Commission (FERC). The peaking operation at Tippy Dam went from a high of 4,500 cfs (three turbines) to a minimum flow of 850 cfs twice daily, and average daily flow was 1,684 cfs. High flows during peaking exceeded the 10 year flood and low flows were below drought levels (Figure 8) (S. Smith, Consumer's Power Company, personal communication). These flows have devastating affects on larval and juvenile fishes, increase erosion downstream, and cause temperature fluctuations. Peaking operations have been shown to increase water temperatures 10°C (18°F) in minutes at the Alcona hydroelectric facility on the Au Sable River (Figure 9; Lawler, Matusky, and Skelly Engineers 1991). The Tippy Dam facility has not been monitored, but being a surface-draw hydroelectric station, it does increase temperatures downstream. Operating licenses were renewed in 1994 as run-of-the-river projects with outflow about equal to inflow. These facilities had been voluntarily operating at run-of-the-river, since 1989, with very positive biological benefits. Some observed benefits are abundant chinook and steelhead reproduction, reduced bank erosion, natural revegetation of stream banks, and spawning runs of lake sturgeon.

Channel Morphology

The channel morphology of the Manistee River and its major tributaries has been drastically altered by humans and their associated activities in settling the watershed. A review of H.R. Page's (1885) "History of Manistee County" gives an insight as to the shape of the river channel in pre-European settlement days.

In 1869, an exploration of the Manistee River was made under the direction of the River Improvement Company, with the accounting of that survey written (excerpts as follows) by A.S. Wordsworth, leader of the survey party (Page 1885).

> "September 18th., in two canoes, so light we could carry them upon our shoulders, we commenced descent of the Manistee, from Section 18, T28N, R4W [near Deward]. The spring sources of this stream are in hardwood timber land, but changing to pine land near the south boundary of T29N; thence for sixty miles on either bank is good pine land, or pine plains, some cork pine, but mostly Norway pine; the white pine free from punk knots, but few black knots, and comparatively free from shakes and hollow butts; prime as to age: first-class, common to good sound pine; the Manistee decidedly floatable for saw logs from Section 18, T28N, R4W: stream fifty feet wide, well defined banks; extreme freshet rise two feet. Soon after crossing the western boundary of Range 6 west [Sharon], we encountered the first flood jam worthy of notice upon the river. This jam is 20 rods [330 ft] up and down the stream: estimated expense of removal, $40 per lineal foot or $800. Near the west boundary of the last-named township, is jam number two: eighteen rods. On Section 6, T24N, R8W [Smithville] is jam No. 3, at crossing of the Ah-go-sah trail: twenty rods in extent. These jams date back in buried centuries. As evidence, we find deep-worn trails around them, where Indians have dragged their canoes; also soil accumulations from fallen leaves and freshet of the stream, with forest growth.
>
> "Cutting to the heart of a cedar twenty inches in diameter, growing over the center [of the jam], I counted 160 years growth. Near the West boundary of Range 9 west [downstream of US-131 Bridge], is jam No. 4, 20 rods. Section 17, Range 10 west, jam No. 5, 25 rods [412.5 ft]; in Range 11 west, near the center line [Harvey Bridge], jam

No. 6, 25 rods; and near the west boundary [Sherman], jam No. 7, 30 rods [495 ft]. A few rods below the west line of Range 11 west, is jam No. 8, 20 rods.

"We meet, in Range 12 west, with jams No. 9 and 10 respectively, of 25 and 30 rods extent. Near the east boundary of Range 13 West [Hodenpyl Dam site], is jam No. 11 and the last upon the stream. It is thirty rods long. To recapitulate: The eleven flood jams of the Manistee have a lineal extent, by the thread of the river, of 263 rods [4,340 ft]. Expense of working a channel through the thirty feet wide; in round numbers, $10,000; wing jams and snags, etc., etc., say $5,000; in all, $15,000. One mile below the last named flood jam, commence lumbermen's roll ways; thence downstream they become noticeable features of the river.

"Two miles down the stream, we encountered a jam of floating sawlogs of one and one-half mile extent, over or around which we were compelled to drag or carry our canoes, and pack our camp 'fixens,' and rock, clay, sand, gravel and soil specimens. At the foot we found a force of nine men at work breaking the jam.

"We here see the last of the 'Grayling,' a fish allied to the speckled trout, and called by the residents, the 'Manistee' fish. They are in great abundance near bend waters; they feed, at this season, upon a small, white miller, and readily take a fly-hook, often darting above the surface to secure their prey. Their average length is ten inches, weighing from six to twelve ounces. Hundreds can be taken with a single hook, in a day. They are the “grayling” of English and Scotch waters.

"The Manistee River has been long known as one of the most remarkable streams in the Northwest in this, that it never floods, seldom freezes, and is never affected by droughts. The secret of these singular features of the river is found in the fact that it is fed with springs which flow into the stream from its banks every few rods, so that it is safe to say there are more than a thousand spring streams that bubble up and empty their pure waters into the river within fifty miles of Manistee. These streams vary in size from a small rill to a good mill stream. Everywhere along the banks of this beautiful river they boil out and bubble up in their crystal beauty, affording water as pure and sweet as any in the world; and this probably accounts for the great abundance of the grayling fish, which is sweeter meated and every way as gamey as the brook trout."

Channel Gradient

“River gradient, together with flow volumes, is one of the main controlling influences on the structure of river channel. Steeper gradients allow faster water flows with accompanying changes in depth, width, channel meandering, and sediment transport (Knighton 1984). Gradient has been used to describe habitat requirements of smallmouth bass (Trautman 1942; Edwards et al. 1983), flathead catfish (Lee and Terrell 1987), green sunfish (Stuber et al. 1982b), northern pike (Inskip 1982), warmouth (McMahon et al. 1984), white sucker (Twomey et al. 1984), bluegill (Stuber et al. 1982a), black crappie (Edwards et al. 1982), blacknose dace (Trial et al. 1983), and creek chub (McMahon 1982).

> Gradient is measured as elevation change in feet per river mile [Figure 10 and Table 8]. The average gradient of the mainstem is [2.89] feet per mile. Naturally, some portions of the river are steeper than average and others are more gradual. These different gradient areas create different types of channel, and hence different kinds of habitat for fish and other aquatic life. Typical channel patterns in relation to gradient (G. Whelan, MDNR, Fisheries Division) are listed below. In these descriptions, hydraulic diversity refers to the variety of water velocities and depths found in the river. The best river habitat offers such variety to support various life functions of various species. Fish and other life are typically most diverse and have the best reproductive potential in those parts of a river with gradient between 10 and 69.9 feet per river mile (G. Whelan, MDNR, Fisheries Division; Trautman 1942). Unfortunately, such gradients are rare in Michigan because of the low relief landscape." (Hay-Chmielewski et al. 1995).

Areas of high gradient are the areas that were dammed or channelized by early settlers' activities.

Gradient Class	Channel Characteristics
0.0 - 2.9 ft/mi	Mostly run habitat with low hydraulic diversity
3.0 - 4.9 ft/mi	Some riffles with modest hydraulic diversity
5.0 - 9.9 ft/mi	Riffle-pool sequences with good hydraulic diversity
10.0 - 69.9 ft/mi	Well established, regular riffle-pool sequences with excellent hydraulic diversity
70.0 - 149.9 ft/mi	Chute and pool habitats with only fair hydraulic diversity
> 150 ft/mi	Falls and rapids with poor hydraulic diversity.

A 1928 report issued by the Michigan Department of Conservation on water resources of the Manistee River stated that practically the entire fall of the mainstem between Sherman and Deward could be used for hydroelectric power. Twelve sites were listed where it would be physically feasible to construct hydroelectric dams with heads ranging from 16 to 63 capable of generating 132 million kilowatt hours annually. The report further stated this could be realized without artificial storage due to the high sustained flows.

House Document No. 159 (US House of Representatives 1931) was a similar report on the Manistee River basin. The report concluded that improvement of the Manistee River upstream from Manistee Harbor, for navigation in combination with power development, control of floods, or irrigation needs was not justified at that time.

Presently, there are nine potential sites in the Manistee River basin (8 on the Manistee River and 1 on the Pine River), with gross heads ranging from 15 to 66 ft capable of generating 186,800 kilowatt hours annually (US House of Representatives 1931). All of these potential sites are on river reaches being considered for Wild and Scenic River designation. Should this designation occur, these sites would be protected from a license for a new hydroelectric power project (D. Pearson, MDNR, Forest Management Division, personal communication).

There are three retired hydroelectric projects on the Manistee River system. The largest project is Stronach Dam on the Pine River; the other two are Manton Millpond Dam and Manton Upper Power Dam on Manton (Cedar) Creek. Stronach Dam is in the process of being removed, as Consumers Power

Company agreed to set aside $750,000.00 for its removal in the new Tippy-Hodenpyl Federal Energy Regulatory Commission (FERC) license. A staged removal of 2 ft per year over five years was agreed in the FERC approved plan. To date, the catwalk and associated superstructure, old turbines, portions of the old power house have been removed. On Friday, December 13, 1996, the coffer dam was removed and water began flowing around the dam structure, beginning the drawdown. This removal will restore 2 mi of high gradient high quality coldwater fish habitat. A long-term fish study (above and below) is being conducted under the guidance of Professor Dan Hayes of Michigan State University. The results of the study will be used to determine if a fish barrier will be constructed to keep out resident coolwater fish of the Tippy Dam backwaters.

Gradient profiles in individual river segments (Figure 1) are discussed below:

Segment 1 and Segment 2 - Headwaters to Smithville

From its source to the confluence of Frenchmans Creek (Deward area), the Manistee River follows a shallow-winding woody-cover filled course. River discharge at Mancelona Bridge (headwaters) is 17.6 cfs and the gradient is 5.9 ft per mi. Shallow water, a channel with abundant vegetation and woody debris make this extremely arduous canoeing and difficult fishing.

From Frenchmans Creek to M-72 Bridge 5 mi west of Grayling, the flow and depth increases and the channel has less woody debris. River discharge at 612 Road becomes 116 cfs and gradient becomes 2.1 ft per mi. The river channel has some log and other woody debris obstacles, but additional large woody debris is desirable for trout and invertebrate habitat.

Between M-72 Bridge and Sharon the channel widens and is practically lacking large woody debris that provides trout cover and insect habitat. River discharge at CCC Bridge is 256 cfs and gradient ranges from 2.2 to 9.8 ft per mi. This section has many short, fast riffles. They are relatively shallow and are free of large rocks.

Segment 3- Smithville to M-115 Bridge

This segment is larger and deeper. It has some log jams, sharp bends, and short, deep riffles. River discharge at Sharon is 336 cfs and gradient ranges from 1.9 to 5.6 ft per mi. Discharge at Sherman, based on a direct drainage area ratio is 838 cfs. This segment is also lacking large woody debris that is trout and invertebrate habitat.

Segment 4 - Hodenpyl Dam to Red Bridge

The area inundated by Hodenpyl Dam has some of the highest gradient water on the Manistee at 11 ft/mi. This riffle area was once a high quality spawning area for potamodromous species. Very high and severely eroded banks, many sharp bends, and the impression of a deep powerful river characterize this segment below Hodenpyl Dam, as the river is cutting through a large moraine. It is totally undeveloped and lacks good access. The fluctuating water level from Hodenpyl Dam has had an overriding influence on this segment. This is also a high gradient reach, with an excellent gravel and cobble substrate, having an average gradient of 7.1 ft per mi.

Segment 5 - Tippy Dam to M-55 Bridge

The area inundated by Tippy Dam was a high gradient riffle area (6 ft/mi) and excellent gravel and cobble substrate spawning habitat. This is evidenced by the high quality gravel found throughout the first mile below the dam. The average river gradient here is 4.65 ft per mi. There is also a high gradient area on the Pine River (over 15 ft/mi) now flooded by Tippy Dam, that was high quality gravel and cobble substrate spawning habitat. The Manistee River below Tippy Dam becomes a large river flowing through lowland vegetative types with large, undulating curves. It has sparse development and infrequent access. The fluctuating water level from Tippy Dam drawdown has influenced this segment. Average discharge at Tippy Dam is 1684 cfs (Consumers Energy data). The first mile or two below Tippy Dam have high gradient gravel riffles, that are heavily used as spawning habitat by potamodromous fishes from Lake Michigan. Below this area, the river flattens out and has little or no gradient (1 ft/mi).

Segment 6 - North Branch Manistee River
The North Branch follows a slow, winding course through open marsh lands. Beaver dams, dense overhanging vegetation, and partly submerged woody debris create very difficult canoeing conditions, particularly in the upper reaches. The North Branch has a discharge rate of 26.4 cfs.

Segment 7 - Bear Creek
Bear Creek follows a narrow, winding course through agricultural and forested land. It has occasional short, fast riffles, impassable log jams, and many hairpin turns. River discharge during spring melt increases to 1,239 cfs and the low mean daily discharge equals 80 cfs. The average discharge at Brethren is 140 cfs.

Segment 8 - Pine River
The 48-mi length of Pine River traverses a variety of water conditions. It has many sharp bends, short choppy riffles, and passable log and woody debris jams. From Walker to Peterson bridges (M-37) there are occasional large rocks and clay ledges in the faster water.

The Pine River has a high mean daily flow of 1,830 cfs and a low of 175 cfs. Flood peak discharge equals 2,240 cfs. The Pine River is unusual among area rivers is that it may rise 1 to 4 ft above its average level during heavy rains or spring melt. The river gradient is about 15 ft per mi, highest of any stream in northwest lower Michigan. (Figure 11 and Table 9). This creates nearly ideal riffle-pool conditions.

Stronach Dam on the lower Pine River was operated from about 1912 to 1953 to provide electric power for local use. The impoundment has silted in, leaving about 2 to 3 ft deep water, and is now useless for power generation. Inflow equals outflow at this time. The area under Stronach Dam has a gradient of 25 ft/mi, some of the best spawning area of the entire stream.

Channel Cross Sections

The description of habitat by gradient presented in the preceding section, assumes normal channel cross sections for such gradients. However, channel cross sections can deviate from these characterizations as discussed by Heede (1980). Figure 12 (Gebhards 1973) illustrates natural and altered stream channels and what happens to fish biomass as a result. Unstable flows will create flood channels that are aggraded in some areas and degraded (scoured) in others (Figure 13). Abnormal sediment loads (either too much or too little) will modify habitat. Bridges, culverts, bank erosion, and other channel modifications will also cause deviations from expected channel form. Thus more detailed observations of channel cross-section in each reach are needed to check for these modifying factors. Figure 13a, that shows two channel cross sections below Tippy Dam, illustrates the influence of a “peaking operation” and lack of sediment. Besides having a scoured channel directly below the hydroelectric facility, pine logs from turn of the century log drives are perched in the banks below. Some of the logs are 10 ft above the present streambed, indicating excessive scouring from the twice a day flood events.

One major problem in managing the Manistee River system is the presence of a tremendous amount of sediment (sand bedload). This sedimentation is known to cause a multitude of problems for the fish inhabiting the river (Alexander and Hansen 1988). The origin of this bedload is perturbations of the uplands surrounding the river during the logging era. The loggers not only removed many log jams and large woody debris from the stream channel, they rolled logs down the banks and drove them to market in the spring. The photos in Appendix 2 show the log drives, rollways, and badly eroding banks. Soil in northwest lower Michigan is exceptionally sandy. Without trees to stabilize the soil, huge amounts of sediment were transported to the river by waterborne and airborne pathways. Once in the stream, this sediment began to affect the aquatic environment. One of the first signs of excess stream bedload is deposition of sand and sediment along the bottom. This action serves to increase the height of the water surface and causes the stream to overflow its banks and sediment begins to flow laterally and cover the edges of the stream. As the sediment builds up, the stream channel then begins to braid, forming several channels in a wide flat area. Most of the stream's irregularity and heterogeneity are lost as the stream bottom becomes smoother and the flow becomes more laminar and swift. The fish within the stream channel, lose valuable habitat for feeding, resting, and spawning.

These effects can be observed on the Manistee River. The upper stretches in the Deward Tract are beginning to recover from the logging era. However, just downstream from Cameron Bridge, the river begins to widen, has a lower gradient (lower stream power) and becomes braided. The river below County Road 612 shows this braided condition for two-thirds of the distance to Highway M-72. This sandy braided condition results from sedimentation after devegetation of the uplands surrounding the river. As the river moves downstream and picks up flow and volume, it reverts to a single channel, inferring that the single channel in the Deward area and in the lower stretches are more indicative of what was present before the damaging influences of humans.

Because of its stable flow, sediments are not moved as quickly downstream in the Manistee River as in streams that experience seasonal flooding. Therefore the Manistee River would be expected to require a substantially longer recovery period than other rivers. Considering this, it is possible that logging era sediments from the Deward area have moved downstream only as far as the Cameron Bridge area. In addition, effects of natural stream "cleansing" would not be noted over time as might be expected in other streams.

Presently, there are three bank stabilization projects in the Manistee River system. The first is in the Upper Manistee River from the headwaters to US-131 (Segments 1, 2 and 3), the second on the Bear Creek watershed (Segment 7), and the third being the Pine River (Segment 8). The Upper Manistee and Pine rivers projects are partnership agreements with MDNR, Fisheries Division, US Forest Service, Huron Pines RC & D Council, Conservation Resource Alliance (formerly Northwest Michigan RC&D Council), Natural Resource Conservation Service, County Road Commissions, Watershed and Property Owners Associations, and Trout Unlimited. The goal of these partnerships is not only to restore eroded banks, but to address erosion at road crossings, construct sediment basins, and implement appropriate land management practices on a watershed basis. These partnerships are also working on several tributaries, that are important from the standpoint of fish reproduction. The Bear Creek project just began, with the first banks being stabilized the summer of 1994. A Michigan Habitat Improvement Fund grant of $35,450.00 for 1997 will allow additional streambank stabilization.

Table 10 lists the erosion sites by reach on the Manistee River mainstem (Segments 1-5), Bear Creek (Segment 7), and Pine River (Segment 8). These data are from the Northwest Michigan Streambank Erosion Inventory prepared by the USDA, Soil Conservation Service (1986). These tables reveal: 1) the reach from Hodenpyl Dam to Tippy Dam Backwaters has 62 severely eroding sites (8.9/ mi). Although the origin of many of these was the lumbering era, they have been perpetuated by the past peaking operation at Hodenpyl Dam. The vast majority of these are clay banks, that do not contribute as detrimental sediment and are cheaper to stabilize than sand banks. 2) Bear Creek has a high number of sites per mile, but most are minor or moderate sites and a large percentage are clay banks. 3) Pine River has a large number of moderate and severe sites that are sand and are considered in need of stabilization.

The characterization of habitat by gradient presented above assumes normal channel cross sections for such gradients. However, channel cross sections can deviate from these characterizations. Unstable flows will create flood channels that are wide and shallow during typical flows. Abnormal sediment loads (either too much or too little) will modify habitat. Bridges, culverts, bank erosion, and other channel modifications will also cause deviations from the expected channel form. Thus, more detailed observations of the channel cross-section in each reach are needed to check for these modifying factors.

Coopes (1974) and unpublished data from the Department of Natural Resources, Fisheries Division are used to describe the channel in different reaches. These characterizations provide a clear, qualitative description of the channel. Besides the qualitative analysis of channel condition, five quantitative measures of channel characteristics were determined for the Manistee River and are displayed in Tables 11 through 16. These calculations were made from data collected by USGS or the Department of Natural Resources during stream discharge studies. Cross sections that were clear of bridges and most representative of the section were selected where possible. Additional cross-section data are needed for a more detailed analysis for the river above Hodenpyl Dam. These measurements are as follows:

Channel Width - Measurements of channel width can be compared to the average width of rivers with the same discharge volume using data from Leopold and Maddock (1953) and Leopold and Wolman (1957). Expected width was calculated from the relation log (Width) = 0.741436 + 0.498473 log (Mean Daily Discharge), where width is measured in ft and discharge is measured in cubic ft per second. The measured channel widths and mean discharge are compared to the theoretical width at discharge and a determination is made whether measured channel width is in the theoretical bounds for the discharge. Overly wide channels are probably produced by fluctuating flows or excessive sediment loading. Overly narrow channels are probably produced by non-erodible bed materials, bulkheads along the bank or by channel dredging.

Hydraulic Diversity - Variability of velocity and depth can be examined with the Shannon-Weiner information statistic to characterize predictability of hydraulic conditions in randomly chosen portions of a cross-section. The greater the variability of velocity and depth, the larger number of species or life stages (that is, spawning, young-of-year, juvenile, adult) can be supported in a reach. Diversity indices were calculated from counts of cross-section data points in classes of velocity in intervals of 0.5 ft/sec and depth in intervals of 0.5 ft. The diversity index ranges from 0.0 which represents constant depth and velocity across a channel as in a flume, to a maximum between 3.2 and 4.2, depending on number of samples collected, which represents a highly variable hydraulic channel. Diversity between 0 and 1.5 is considered poor hydraulic diversity; between 1.51 and 2.0 is considered fair hydraulic diversity; between 2.01 and 2.5 is considered good hydraulic diversity; and above 2.51 is considered excellent hydraulic diversity. This measurement is sensitive to sample size, so data were selected with greater than 15 samples to minimize this problem.

Percent Maximum Diversity - To allow for easier interpretation of these data, the percent maximum diversity was calculated by dividing calculated diversity value by the maximum possible diversity. This variable accounts for sample size and ranges from 0 to 100%. Channels with poor diversity in velocity and depth have percent diversities between 0 and 25%; fair channels have percent diversities between 26 and 50%; good channels have percent diversities between 51 and 75%; and excellent channels have percent diversities between 76 and 100%.

Number of Different Combinations - The number of different combinations of velocity and depth across the transect provides additional explanatory information to assist in interpreting the hydraulic diversity data. A transect that has between 1 and 4 combinations of velocity and diversity has a poor amount of variability; 5 and 6 combinations have a fair amount of variability; 7 and 8 have a good amount of variability; and above 8 combinations these transects are have excellent variability. This measurement is also influenced by sample size, so data were selected with greater than 15 samples to decrease this problem.

Percent Difference Samples - To allow for easier interpretation of these data, the percent different samples were calculated by dividing the number of different samples by the total number of samples. This variable accounts for sample size and ranges from 0 to 100%. Channels with poor variation in velocity and depth have percent diversities between 0 and 25%; fair variation have percent diversities between 26 and 50%; good variation have percent diversities between 51 and 75%; and excellent variation have percent diversities between 76 and 100%.

A limited number of channel measurements are available for the Manistee River. The only ones available on the mainstem are below the two hydroelectric dams, made during the relicensing studies in 1990 and 1991. The one area of concern is below Hodenpyl Dam, where more than 50% of the analyses indicate a channel too narrow. This is partly explained because it is a high gradient area, but the extreme downcutting and narrowness are the result of almost 60 years of peaking hydroelectric operation. Current channel cross-section work includes University of Michigan's (UM) study below Tippy Dam and MSU's study on the Pine River in conjunction with the Stronach Dam removal. The UM study is a remeasurement of Icthyological Associates, Inc. work completed for Consumers Energy before the relicensing of Tippy Dam. This work indicates that run-of-the-river hydroelectric operation is beneficial to the river, as channel morphology is stabilized, as increased exposed gravel and cobble substrate has resulted and decreased sand bedload.

These data point out the need to obtain additional channel width analysis, especially in areas above the hydroelectric dams where sediment loading is apparent. Many more transects are necessary to obtain a complete picture of the Manistee Rivers channel morphology, especially where bank stabilization is occurring.

Soil And Land Use Patterns

The historic vegetative cover of the watershed was predominantly pine forest and hardwood forest, with wetlands intermixed. The current landscape remains predominantly coniferous, deciduous, or wetland forest (54%) and few urban areas (3.3%). Land use (P. Seelbach, MDNR Fisheries Division, unpublished data) is now about as follows:

Urban and suburban	3.3%
Agricultural	39.0%
Range land	1.7%
Coniferous forest	12.2%
Deciduous forest	29.3%
Wetlands (forested & non-forested)	12.8%
Lakes and streams	1.7%

Although 39% is listed as agricultural land, little of this is cultivated cropland. The majority is pasture, fruit orchards, or Christmas tree plantations.

The majority of the soils in the watershed, especially along the mainstem, are deep sands of the Kalkaska-Rubicon-Grayling series, which are very well drained, rapidly permeable soils. There are other soil types in the watershed, but the deep sands affect mainly the hydrology of the river system (Sommers, 1977) (Figure 14). Soils in the lower watershed are of the Rifle-Carbondale-Greenwood series, which are the poorly drained organic types. The soils along the Pine River corridor are mostly the Tawas-Croswell-Lupton series, with significant acres of Rubicon-Montcalm-Graycalm series and Nestor-Kawkalin-Manistee series. Many of these series are clays, loams and mucks which are moderately to poorly drained soils.

Many agricultural land uses have dramatic effects on aquatic environments. Cultivation of soils increases erosion and sediment to streams. These sediments bury gravel and cobble critical to reproduction and survival of many fish species. Woody debris was removed from the Manistee River channel (Page 1885) and riparian vegetation was often clear-cut or burned, limiting instream cover for organisms and again contributing to increased water temperatures. Existing wetlands, often the object of drainage, are important as spawning and living areas for many species and important to the water quality of the system. The whole process destabilizes flow in the river by increasing peak flows downstream and reducing groundwater recharge from wetlands. Flow destabilization also increases the frequency and magnitude of flood flows and increases water temperature (Dunne and Leopold 1978). The major cultivated agricultural areas along the Pine River are: North Branch in Cherry Grove Township - Wexford County; East Branch in Burdell and Sherman Townships - Osceola County, and Bear Creek - Manistee County.

"Agricultural land use produces increased loadings of nutrients, pesticides, and herbicides to the river system. Nutrients affect stream productivity and excessive amounts can alter aquatic communities. Pesticides and herbicides are toxic to many organisms. Water withdrawals for irrigation reduce summer base flows and negatively affects river systems (Fulcher et al. 1986)." (Hay-Chmielewski et al. 1995). There are ongoing water withdrawals on Pine River and Bear Creek. The headwater's area has significant acreage in Christmas tree plantations, pasture land, and corn and potato fields. Many corn and potato fields are irrigated with large spray irrigation systems from ground water wells.

"Land development for urban use also has dramatic affects on the aquatic environment. Temporary sediment loads that erode from unprotected construction sites can be 500 times those of undisturbed lands (Toffaleti and Bobrin 1991). Sediments that reach stream channels clog and bury clean gravel and cobble substrates critical for many invertebrates and fish species. Sediment loads from improperly placed or maintained road crossings can also be a major input to the system."(Hay-Chmielewski et al.

1995). An inventory of the road and stream crossings exists for the Pine River watershed (Conservation Resource Alliance 1997).

> "Development noticeably increases the percentage of impervious land area, so that less water percolates into the water table and more water reaches the stream channel quickly as surface runoff. Urban and suburban areas typically have 50-100% and 25-45% impervious surface areas (Toffaleti and Bobrin 1991). Impervious surfaces include paved surfaces (roads, parking lots) and roofs of buildings. These have runoff co-efficients 6-14 times greater than for undisturbed land (Toffaleti and Bobrin 1991). Engineered stormwater runoff systems also speed surface runoff. Increased runoff causes greater peak flows, harmful to reproduction and survival of many aquatic organisms, more erosion, decreased groundwater recharge, and thus base flow, increased summer temperatures, and decreased available habitat (Leopold 1968; Booth 1991)….Runoff from impervious surfaces carries pollutants including nutrients, bacteria, metals, litter, oil and grease, herbicides, pesticides, and salts. Osborne and Wiley (1992) have shown that urbanization is the primary impact which increases summer nutrient concentrations in rivers." (Hay-Chmielewski et al. 1991).

Development of rural or seasonal dwellings is increasing in the watershed, as retirees from southern Michigan move north to enjoy their "piece of heaven." This results in construction of water wells reducing groundwater tables and summer stream baseflows, with corresponding increase in water temperature and decrease in available stream habitat. After use, this water often returns to the system as heated surface water, causing increased and more variable water temperatures.

The State of Michigan - MDNR and the US Forest Service have extensive land ownership in the Manistee watershed corridor. Table 17 reflects these ownerships by river segment (US Forest Service, 1983). A total of 65% of corridor lands is in public ownership, with MDNR controlling 42% and the US Forest Service 23%. A significant land use in this riparian zone is the Hanson Military Reserve, which is a training area for National Guard Units nationwide. This area extends from M-72 downstream to CCC Bridge south of the mainstem and Portage Creek. The major effect is to Portage Creek and consists of stream crossings by tanks and other motorized vehicles, water withdrawals, fires created by bombing and artillery, and noise pollution from land and air maneuvers.

The soils of the watershed are as follows (P. Seelbach, MDNR, Fisheries Division, unpublished data):

Clayey	7.9%
Loamy/organic/sand/gravel/sandy	41.4%
Sandy	19.4%
Wet/clayey/loamy/sandy/organic	29.6%
Inland lakes and streams	1.7%

These percentages offer insight to current land use. Heavier soils, clays and loams, are the best types for agriculture. Area of mapped loamy soils (41.4%) and agricultural land uses (39.0%) are closely correlated. A very interesting comparison is wet soils versus wetlands. The wet soils indicate where wetlands once were. About, 12.8% of the drainage basin are wetlands. This is only about half of the 29.6% wet soils. This indicates that almost 57% of the total wetlands have been filled or drained in the

Manistee River watershed. This correlates well to the loss of 5 million acres of wetlands statewide (about 50%), that has been calculated.

Special Jurisdictions

Jurisdictions regarding the river and the riparian zones are controlled by federal and state laws, county and township ordinances, and city and town by-laws. Some federal laws and many state statutes are administrated by MDEQ, Land and Water Management Division (LWMD) (Table 18).

Navigability

The entire mainstem and large tributaries are navigable. The smaller tributaries are presumed navigable as defined in Michigan Department of Natural Resources, Law Enforcement Division Report No. 9 (1993).

Portions of the Manistee River watershed have been adjudicated navigable by the Michigan Supreme Court:

> Manistee River and tributaries (174 Michigan 1)
> Manistee River, Manistee County (53 Michigan 593, 185 Michigan 302)
> Manistee River, South Branch (now Pine River) of Manistee County, downstream from lands owned in 1877 by R. G. Peters (37 Michigan 406).

None of the Manistee River system has been declared non-navigable by the courts.

Federal Energy Regulatory Commission

> "The Federal Energy Regulatory Commission (FERC) is authorized under the Federal Power Act of 1920, as amended, to license and regulate hydroelectric facilities that meet one or more of the following criteria pursuant to Section 23 (b) (1) of the Act: 1) the project is located on a navigable water of the United States; 2) the project occupies lands of the United States; 3) the project uses surplus water or water power from a governmental dam; or 4) the project is located on a body of water over which Congress has Commerce Clause jurisdiction, project construction occurred on or after August 26, 1935, and the project affects the interests of interstate or foreign commerce. About when a project is being licensed or re-licensed, power and non-power impacts of a project are balanced by FERC and the resulting license issued for the project contains specific articles to protect natural resources in the project area. The licenses are administered and enforced by FERC with MDNR having a consultation role in both the licensing and enforcement proceedings. In general, most new FERC licenses are issued for a 35 year period unless a FERC exemption is issued. The FERC exemption is a perpetual license that contains a mandatory Article 2 letter from MDNR and the US Fish and Wildlife Service (USFWS) detailing protective measures for the natural resources in the project area." (Hay-Chmielewski et al. 1995).

FERC regulates two projects on the Manistee River, Hodenpyl and Tippy dams. In 1993, a historic offer of settlement regarding the re-licensing of eleven hydroelectric dams on the Au Sable, Manistee, and

Muskegon rivers was drafted for presentation to FERC. In July 1994, FERC adopted almost all the settlement agreement and a license was issued for 40 years (Appendix 3).

County Drain Commissioners

County drain commissioners have authority to establish designated drain systems under the Drain Code (PA 40, 1956). This allows for construction or maintenance of drains, creeks, rivers, and water courses and their branches for flood control and water management. A designated drain may be cleaned out (all in-stream structures removed), straightened, widened, deepened, extended, consolidated, relocated, tiled, and connected to improve flow of water. Designated drains constructed before January 1, 1973, are exempt from the provisions of the Inland Lakes and Streams Act and the Wetlands Act.

Known designated drains in the watershed are listed by county and township (Table 19). The known public drains numbers forty; this does not include private drains. The relatively few drains in the Manistee River system indicate little development, limited agricultural areas, and mostly sandy soils. Kalkaska County, through which the mainstem of the Manistee River flows from the northeast corner diagonally to the southwest corner, has no designated drains.

Drain commissioners are also responsible for the maintenance and operation of lake-level control structures. The two known structures are: Lake Margrethe in Crawford County, and Bear Lake in Manistee County.

Natural and Scenic River Designations

Portions of the mainstem, Bear Creek, and Pine River are designated under the Federal Michigan Scenic Rivers Act of 1991 (PL 102-249). This includes 26 mi on the mainstem from Tippy Dam to M-55 bridge (Segment 5) classified as recreational, 6.5 mi of Bear Creek from Coates Highway to its mouth classified as scenic, and 25 mi of the Pine River from Lincoln Bridge to Stronach Dam backwaters, also classified as scenic.

The US Forest Service, which administers lands along these sections, is nearly finished working on a management plan for these three areas (K. Martinson, US Forest Service, personal communication).

In addition, the entire Manistee River system, including tributaries, are being studied for designation under the Michigan Natural Rivers Act (Part 305 N.R.P. Act (1994 PA 451)). This process began January 1994 (D. Pearson, MDNR, Forest Management Division, personal communication). This designation is a form of zoning that is designed to control development in a 400 foot strip on either side of the river.

In January 1995, Advisory Committees were formed covering three segments on the mainstem, the Pine River, and Bear Creek. These groups will work on drafting the zoning rules for each segment. Some are nearing completion, and one group, the Lower Manistee, has voted to dissolve.

Recreational Use

Fishing and canoeing are the two most popular recreational uses on the Manistee River. These two activities generate user conflicts in some areas during certain times of the year.

Canoeing is most popular from Cameron Bridge to Sharon (Segment 1 & 2) on the Manistee River and on the Pine River (Segment 8). The US Forest Service estimates over 20,000 canoe activity days annually in those reaches (unpublished US Forest Service data). US Forest Service records indicate the Pine River is one of the most heavily canoed waterways in the nation, with the number of launches limited by the US Forest Service on their lands by a permit system. Under this system 44,000 launches are reserved for the six canoe liveries and 11,000 reserved for private canoes annually. A percentage of the canoeists, particularly on weekends, consume considerable amounts of alcohol and demonstrate less than desirable behavior. This is in line with the Pine River's reputation as "the party river." Tubing is increasing in popularity, as a permit is not necessary. An additional area of high canoe use is from Smithville to US 131 Bridge (mid portion of Segment 3) on the mainstem. Canoe liveries are located at Cameron Bridge, Highway M-72 Bridge, Smithville, Highway US 131 Bridge, Sherman, Wellston, and Pine River Area.

Trout fishing is extremely popular throughout the river system, including the smallest of tributaries, but, is most intense below Tippy Dam (Segment 5). This river segment is extremely popular year round, especially in spring and fall during steelhead and salmon runs from Lake Michigan. A 1987 angler creel census showed that anglers fished a total of 267,159 hours annually below Tippy Dam (Rakoczy and Lockwood 1988a&b). A 1985 angler creel census on Manistee Lake showed a total of 191,822 angler hours, with over 20% expended on steelhead and salmon fishing. The 1985 creel census estimated 185,218 angler hours, annually, from Tippy Dam to the mouth of Bear Creek and 105,344 angler hours from the mouth of Bear Creek to Manistee Lake, for a total of 290,562 hours (Rakoczy and Lockwood 1988a&b). Fall 1993 brought an end to legal salmon snagging in this segment and along with it an end to the litter, poor sportsmanship, and bank erosion associated with this activity. Although angler effort declined, angler satisfaction increased. These anglers said they would return and bring fellow anglers. The number of licensed fishing guides using drift boats and jet boats has increased, particularly below Tippy Dam. This has resulted in conflicts especially among jet boats, drift boats, and wading anglers.

Quality fishing regulations are in effect from Yellowtree's Landing to C.C.C. Bridge (7.5 mi of Segment 2). The special regulations in this section are: "flies only", minimum size limit of 8 inches for brook trout, 12 inches all other trout, a daily limit of five trout, and open season of last Saturday in April through October 31st.

Other popular recreational activities include camping, picnicking, hunting, trapping, cross-country skiing, hiking, horseback riding, and bird watching. A North Country National Scenic trail is located in Segment 3 & 4 and coincides with the existing Shore to Shore Trail. This trail is managed by the US Forest Service.

The entire Manistee River mainstem can be canoed, but the upper reaches of Segments 1, 7 and 8 are hard canoeing due to brush, logjams, and beaver dams. Major portages exist over both hydroelectric dams. The portage trails need upgrading to be acceptable, which is in the settlement offer.

Upper portions of the mainstem (Segments 1, 2, and portions of 3), major tributaries (Segments 6, 7, and 8), and all lesser tributaries can be waded. Also, there are small areas in downstream reaches that can be waded, particularly in higher gradient riffle areas.

Segments 3, 6 and 5, with some areas of Segment 2 can be traversed by motorboat. Segment 5 is the only portion passable to bigger propeller driven boats. Motorboats can use both Hodenpyl and Tippy dams' backwaters, but boating is hazardous due to hundreds of stumps and deadheads. These are from trees cut after the area was flooded. Both reservoirs lack adequate public access or boat launch sites.

There are many campgrounds and public access points throughout the river system (Table 20, Figure 15). These include federal, state, local, and private facilities.

Dams And Barriers

There are currently 63 known dams in the Manistee River watershed, regulated under authority of Michigan's Dam Safety Act, Part 305 N.R.P. Act (1994 PA 451) (Table 21, Figure 16). Thirty-six have a head of 5 ft or less; 12 have a head between 6-10 ft; 10 have a head between 11-20 ft; and five have a head greater than 20 ft. The storage capacity of most of these dams is very small; 42 dams in the 0-10 acre ft range; five in the 11-49 acre-ft range; three in the 50-99 acre ft range; and 13 dams greater than 100 acre-ft. Five dams rate a significant or high hazard classification: three are a significant hazard, and two are a high hazard (failure would cause loss of human life). The two that are ranked high are the CECo hydroelectric dams (Tippy and Hodenpyl) on the mainstem. Tippy Dam has a head of 56 ft and 39,500 acre-ft of impoundment and Hodenpyl Dam has 68 ft of head and 60,700 acre-ft of impoundment.

One dam, located in T24N, R11W, Sec. 31 (Wexford County) on Wheeler Creek, is of historic significance. The dam is named the "Guthrie Dam", but is believed to be the original site of the "Wheeler Dam". The Wheeler Dam was constructed in 1867 by John Wheeler to operate a sawmill, that cut most of the lumber used in the original settling of Wexford County. Probably it was the first dam in the watershed (Peterson 1972).

> "Dams have a variety of effects on river ecosystems. As described earlier, they influence flow patterns and channel cross-sections. They also block drift and migrations by aquatic organisms, change river temperatures, increase evaporation and reduce stream flow, disrupt sediment and woody debris transport, modify water quality and cause significant fish mortalities." (Hay-Chmielewski et al. 1995).

The Manistee River shows all of these effects, although detailed investigations and quantification are not available for all effects. Impoundments also create a loss of river habitat and changes in fish and aquatic invertebrate populations.

> "Many fish species migrate long distances within rivers as part of their life history strategy. The effects of dams on potamodromous fish are an obvious negative effect. However, resident species may also need to migrate within the river (Figure [4]). They may require spawning habitat that is very different from their normal feeding habitat." (Hay-Chmielewski et al. 1995).

Clapp (1988), Regal (1992), and Hudson (1993) found that large brown trout travel long distances on daily feeding forays, seasonally to spawn, to obtain thermal refuge, and seek winter habitat.

> "Many aquatic organisms, especially insects, drift downstream as larvae until desirable habitats are found. After maturation, adult insects fly upstream to reproduce. Upstream and downstream migrations by fish and downstream drift by small aquatic organisms are generally blocked by dam. Downstream movement by organisms that require stream conditions to live or to navigate may be inhibited by lake-type conditions behind dams. Some of the organisms that pass downstream through dams are injured or killed in the process. This is especially true when organisms pass through hydropower turbines." (Hay-Chmielewski et al. 1995).

Lawler, Matusky, and Skelly Engineers (1991) estimated turbine mortalities of 25,841 fish at Tippy Dam and 29,602 fish annually at Hodenpyl Dam (Table 22). These fish mortalities are significant, amounting to over 55,000 fish lost annually at the two facilities. An annual restitution value for turbine mortality of $357,065.00 was calculated using values prescribed in Part 471 of Act 451 of 1994 (Table 22). This translates to a replacement cost of $32,939.64 using American Fisheries Society 1982 values adjusted by inflation (Anonymous 1982), calculated with the turbine mortality estimates.

The effects of fragmentation of the river by dams are difficult to document without detailed aquatic community composition data before and after dam construction, and without detailed mapping of habitat and migration patterns. Lake sturgeon populations below Tippy Dam and above Hodenpyl Dam are prime examples of fragmentation. Whelan (MDNR, Fisheries Division, unpublished data) estimates the loss of potential potamodromous fish recruitment to be in the millions annually. Currently, an estimated 57,468 angler days are provided below Tippy Dam (Rakoczy and Lockwood 1988a&b), primarily for potamodromous fish. Establishment of a potamodromous fishery for steelhead (historically good before dams) and chinook would provide at least an additional 50,000 angler days annually. This would provide an economic benefit of $1.2 million to the area. These values are considered minimums, as benefits of an expanded walleye and lake sturgeon fishery are not considered.

Temperature elevation is a major effect dams have upon a watershed and probably has contributed to the demise of brook trout in many reaches. Many small dams on tributary streams all have undesirable warming effects, that are passed downstream. Summer warming can create temperatures unfavorable for coldwater species, both adults and young. Tippy and Hodenpyl dams elevate summer temperatures between 8-12°F (MDNR, Fisheries Division, unpublished data); this has dramatic effects on coldwater species. These top draw dams constantly spill the warmest water. This can be fatal during the summer, as river water temperatures do not follow the normal diurnal pattern of cooling at night (MDNR, Fisheries Division, unpublished data). This can force young-of-the-year steelhead to leave the river as pre-smolts, whereas they usually spend two years in the river before smolting (P. Seelbach, 1987, 1991). Tippy Dam backwater stratifies thermally during the warmest summer months, with fifteen ft of 48-50°F water below the thermocline (MDNR, Fisheries Division, unpublished data). Spilling this cold water into the tailwaters may allow juvenile steelhead to remain in the river, smolt naturally, and improve stream brown trout populations.

> "Dams are a trap for sediments, woody debris, and other materials which are normally transported downstream by rivers. Stream velocities slow as a river enters the reservoir behind a dam, allowing sediment particles to settle out as velocity slows and deposited in the upper areas of the reservoir. Woody debris may continue to float but is usually blocked by the dam itself, where it will gradually become water-logged and sink [in the reservoir or removed from the trash racks by the dam operator]. These processes deprive the downstream river of sediments and woody debris (Maser and Sedell 1994). When water is discharged from the dam without its normal load of sediment, the river picks up more sediment in the downstream reach than it normally would. This increased erosion [lowers the river channel below the dam and often contributes to unusual narrowing of the river for some distance downstream and is demonstrated in the channel measurements taken below Tippy and Hodenpyl dams]….The loss of woody debris to the downstream reach reduces the amount that would otherwise be found in that part of the river. Woody debris normally creates instream flow resistance and cover, so reduced woody debris reduces the diversity of hydraulic conditions and the amount of habitat available for fish. As a result, the abundance of species such as salmonids and smallmouth bass is normally reduced below dams." (Hay-Chmielewski et al. 1995).

All dams regardless of size and the impoundments behind them modify water quality downstream. Downstream ecosystems normally function through processing of nutrients and energy bound up in organic materials that can be filtered or captured out of the stream flow. Reservoir ecosystems tend to convert these nutrients to smaller particles and dissolved constituents. Streams are usually well mixed so that oxygen in the water is in equilibrium with the atmosphere and the oxygen-consuming life processes in the river. Water in reservoirs may be vertically stratified by temperature or suspended solid gradients, so the water below the thermocline often has much lower concentrations of oxygen than water near the surface. Dissolved oxygen and temperature in the discharge from a dam are strongly influenced by the depth from which water is drawn. Most of the dams in the Manistee River watershed are shallow, so that their main effect on water quality is warming and conversion of nutrients from particulate to dissolved form.

The two large hydroelectric dams on the mainstem are known to cause most if not all the described problems. There are, however, solutions or mitigations for these problems.

Five dams in the watershed were constructed by MDNR, Wildlife Division to create floodings for wildlife habitat. Four of these, Goose Creek Impoundment, Headquarters Lake Dam, Cannon Creek Flooding No. 1, and Cannon Creek Flooding No. 2 are sited on designated trout streams. Although they are small (4-6 ft high), they have many of the same effects as large dams, including blocking fish movement, raising water temperatures, altering nutrients, and causing overall degradation of the stream. These four dams should be removed. The fifth dam is located at the Manistee River marsh, where the Manistee River empties into Manistee Lake, and has little if any effect upon the upper watershed.

The Manton Millpond Dam, a retired hydroelectric facility and owned by the City of Manton, needs to be addressed. This dam is about holding back a fraction of its original volume and causes the same effects to Manton (Cedar) Creek, a designated trout stream. The Copemish Dam, located on First Creek (headwaters of Bear Creek) is in a similar condition. The Village of Copemish, the owner, has agreed to permit the removal of the old dam structure by the Bear Creek Watershed Council. This removal is scheduled for the summer of 1998.

Water Quality

Overall water quality in the Manistee River basin is very good, due in large part to the geology of the basin (deep permeable sands), that allows precipitation to rapidly be absorbed. This leads to groundwater flows being the dominant contributor to river flow. Limited development has served to preserve the water quality.

Twelve National Pollution Discharge Elimination System (NPDES) permits exist for the basin (Table 23). Two NPDES permits are for 2 hydroelectric plants, Tippy and Hodenpyl dams, on the mainstem. One of the major concerns at these facilities is increased summer temperatures. Daily temperature extremes can occur with peaking operations, such as was documented at the Alcona facility on the Au Sable River. A rise of 20°F in minutes was recorded with the onset of the peaking (G. Whelan, MDNR, Fisheries Division) (Figure 8). This rapid rise, a violation of the NPDES permit, may also occur at Tippy Dam due to thermal stratification of the backwaters.

The Michigan Environmental Response Act, Part 201 of Act 451 of 1994, provides for identification risk assessment and evaluation of sites of environmental contamination. One hundred sites have been identified in the Manistee River Basin (Table 24). Fifty-three percent of the contaminated sites are associated with oil and gas drilling in the Niagarian Reef formation. One site is listed on EPA's national priority list (Superfund site), Packaging Corporation of America's contamination of ground water with heavy metals (chromium, arsenic, & lead) in Section 17, T21N, R16W, Manistee County, on the shores of Manistee Lake. Although no clean-up action has been taken yet, additional studies are being conducted by MDEQ, SWQD in conjunction with Environmental Protection Agency. These will be used in developing and implementing a remedial action plan. Another site, formerly Manistee Plating, located on the channel between Manistee Lake and Lake Michigan, is on EPA’s emergency action list. The site is discharging high concentrations of chromium to surface waters and requires immediate action. To present, EPA has committed $400,000 to remove on site contaminants, and MDEQ has pledged up to $500,000 to clean up ground water, eliminating discharge to the river.

With good water quality in the watershed, fish populations have not been the subject of any specific fish consumption advisories, other than the general statewide advisory regarding mercury in all inland lakes. The mercury advisory applies to all inland lakes in Michigan, due to widespread mercury contamination throughout the north central United States and Canada. It states that no one should eat more than one meal a week of the following kinds and sizes of fish: rock bass, perch, or crappie over 9 inches in length; largemouth and smallmouth bass, walleye, northern pike, or musky of any size. Nursing mothers, pregnant women, women who intend to have children, and children under the age of 15 should not eat more than one meal per month of the fish species listed above. Since humans excrete mercury over time, visitors or residents who eat these fish for one to two weeks per year can safely consume several meals during that period. The Michigan Fishing Guide, published annually by MDNR, Fisheries Division contains a section on health advisories. Detailed guidelines are determined by the Michigan Department of Public Health, Division of Health Risk Assessment.

In 1967, Fisheries Division classified streams throughout Michigan based on water quality. This classification was created for fishery management. These classes are:

> Top quality trout mainstream–contain good self-sustaining trout or salmon populations and are readily fishable, typically over 15 ft wide;
>
> Top quality trout feeder stream.–contain good self-sustaining trout or salmon populations, but difficult to fish due to small size, typically less than 15 ft wide;
>
> Second quality trout mainstream–contain good self-sustaining trout or salmon populations, but these populations are appreciably limited by such factors as inadequate natural reproduction, competition, siltation, or pollution; readily fishable, typically 15 ft wide;
>
> Top Quality warm water mainstream–contain good self-sustaining populations of warmwater game fish and are readily fishable, typically over 15 ft wide;
>
> Top quality warm water feeder stream–contain good self-sustaining populations of warmwater game fish, but are difficult to fish because of small size, typically less than 15 ft wide;
>
> Second quality warm water mainstream–contain significant populations of warmwater fish, but game fish populations are appreciably limited by such factors as pollution, competition, or inadequate natural reproduction; readily fishable, typically over 15 ft wide;
>
> Second quality warm water feeder stream–contain significant populations of warmwater fish, but game fish populations are appreciably limited by factors as pollution, competition, inadequate natural reproduction; difficult to fish because of small size, typically less than 15 ft wide.

Almost all the waters of the Manistee watershed are classed as trout streams, with only a handful of areas being warmwater (Figure 5). These warmwater areas are: Walton Junction Outlet, Sickle Creek, Rose Lake Outlet, Dutchman Creek (part), Boswell Creek (part), Fife Lake Outlet (part), the bayous and associated creeks below Tippy Dam, and the backwater of Tippy and Hodenpyl dams. Although these classifications were made in 1968, most are still valid.

Fishery Management

The first step in management of fisheries of the Manistee River is to identify the key values of the system. The key value of the Manistee river is its cold water river habitat. This is what long-term management goals should be based on, a free-flowing, cold water system. Long term goals are model in nature, addressing the fullest potential of a river system. Long term goals are based on biological communities that are naturally produced, self-sustaining and require minor management activities apart from habitat protection and preservation from over harvest.

Short-term management goals address the present altered status of the river system. For this reason, short term goals are not always consistent with long term goals that establish free-flowing, cold water river habitat. An example is the present practice of managing warm water predators in impoundments to create angling opportunities where few exist. This management is not consistent with cold water salmonid management.

The Manistee River and its tributaries have had a long standing reputation of being top-quality trout waters, but this reputation has fallen. Twelve to 15 pound brown trout are no longer prevalent. Historically, the Manistee River was heavily stocked with brook, brown, and rainbow trout throughout the 1940s, 1950s and early 1960s. Most trout anglers of that era fished primarily for those “put and take” hatchery trout. The Upper Manistee (above M-72) had a modest population of extremely large brown trout. It has been theorized that these fish were able to grow large, not because the Manistee River was such a rich environment, but because they cannibalized the multitude of hatchery trout that were stocked by the thousands, often several times each season (G. Schnicke, MDNR, Fisheries Division , personal communication).

The lack of large woody debris (adequate cover) was a major problem identified back in the 1940s. Work was done to replace instream cover through habitat restoration projects on the upper mainstem, North Branch of the Manistee River, Bear Creek, Pine River, and Slagle Creek, to name a few. These projects placed hundreds of wing diverters, log and sod covers, submerged logs, and stumps. These efforts continued through the 1970s, after which were discontinued.

Sand bedload continues as a major problem in the watershed. Lost reproduction, lost habitat, and a degraded environment all lead to low trout populations and poor fishing. One area, upstream of Deward, has recovered from effects of turn of the century logging and now has good natural reproduction of salmonids. Fisheries Division is working to restore the “structure and function” of the mainstem, Pine River, and Bear Creek. This is best accomplished by stabilizing eroding sand banks, inventorying and remediating road and stream crossings, using sediment basins (sand traps), and enhancing trout cover, both natural (large woody debris) and artificial (LUNKERS). Ongoing habitat rehabilitation on these three streams should increase natural recruitment and growth of salmonids. Long-term, habitat rehabilitation is more economical than annual stockings of hatchery fish.

Present fishery conditions were outlined by segment in *Present Fish Communities*. Only a small portion of the mainstem (Segment 1) has self-sustaining trout populations (D. Smith, MDNR, Fisheries

Division, personal communication). All tributaries have naturally produced populations and probably contribute recruitment to the mainstem. Habitat rehabilitation and sediment basin placement should also be considered on tributaries where necessary. There are ongoing habitat rehabilitation projects on the upper and lower Manistee River, Bear Creek, and Pine River which, in conjunction with 15 sediment basins, will reduce the stream bedload. Reduction and removal of these sediments will reduce redhorse and sucker species and chestnut lamprey populations.

Impairments to the fishery include the presence of small impoundments in trout streams, excessive stream bank erosion, excessive stream bed sedimentation, removal of large woody debris, beaver dams, and improper road stream crossings. Management activities such as stream-bank erosion inventories and rehabilitation, dam removal, sediment trap construction and maintenance, and enforcement of green belt zoning regulations are being implemented to address these effects. An inventory of all the road and stream crossings in the Manistee River watershed is being made by the Conservation Resource Alliance.

Channel catfish and walleye are stocked at regular intervals in the two hydroelectric impoundments and produce good to excellent fisheries. Other game fish species found in these impoundments, that are managed for warm to cool water fish communities, are northern pike, smallmouth bass, largemouth bass, yellow perch, black crappie, bluegill, pumpkinseed sunfish, and rock bass. These other species are self sustaining and provide a fishery. The impoundments also contain high populations of less desirable species such as shorthead and silver redhorse, white suckers, and common carp.

Lake Michigan chinook salmon are about experiencing problems with mortalities from bacterial kidney disease (BKD). Control of this problem through egg-take and hatchery procedures is being attempted. Elliot (unpublished data) also indicates that clinical signs of BKD are much reduced in wild chinook salmon. Recent research by Carl (1982), Zaft (1992), and Hesse (1994) on chinook salmon in Lake Michigan indicates significant natural recruitment of coho and chinook salmon from tributary streams. During the fall of 1995, chinook salmon tail sections were gathered and analyzed from the area directly below Tippy Dam downstream to the mouth of Bear Creek. The purpose was to determine an estimate of the percentage wild versus hatchery chinook (stocked chinook marked with oxytetracycline) present below Tippy Dam. The one year study indicates 80% wild, with a number estimate of 500,000 spring fingerling chinook produced annually (unpublished Fisheries Division data). In the fall of 1967, first year adult coho salmon returned to stocked streams and a total of 22,720 green adults were transferred to fifteen streams statewide. This was done to evaluate whether significant natural reproduction could be achieved. Fish were stocked above barriers (Tippy, Hodenpyl, and Stronach dams on the Manistee system) to judge the desirability of having salmon in the headwaters, as well as effects of dams, waterfalls, and impoundments on migrating salmon smolts. In summer of 1968 electrofishing surveys found coho young-of-the-year in all streams where they were transferred, documenting natural reproduction. The annual estimated natural reproduction and values are:

Chinook salmon -- 1,000,000 spring fingerlings	$90,000.00
Coho salmon -- 50,000 yearlings	$36,500.00
Steelhead -- 75,000 yearlings	$54,750.00
Brown Trout -- 50,000 yearlings	$36,500.00
Walleye -- 250,000 spring fingerlings	$5,000.00
Lake sturgeon -- Unknown	?
Lake Trout -- Unknown	?
TOTAL	$222,7550.00 +

These figures are based on an MSU estimate of chinook smolt recruitment on the Pere Marquette River of 100,000 annually (Zaft 1994; MDNR, Fisheries Divisions studies).

The Free Fish Passage Act, Part 483 of PA 451 of 1994, gives the MDNR authority to require fish passage at all dams. Elliott (Michigan State University, personal communication) also indicates that clinical signs of BKD are much reduced in wild chinook salmon. There remain unanswered questions, however, regarding brown trout-chinook salmon interactions. These questions could be answered by proposed research that may be conducted by Tom Coon at Michigan State University. Should the research prove minimal interaction, CECo should be required to construct and operate fish ladders and provide downstream passage proposed in the "Settlement Offer". Research being conducted at Hunt and Gilchrist creeks on rainbow trout-brown trout interaction will attempt to resolve this issue. Should this research show minimal interaction, then adult spawning phase steelhead should be passed. Passage of these adult fish would reduce our dependency on hatchery stocks, and return our rivers to a condition closer to what they were before European settlement. However, there are areas that should be used only for resident stream fish, notably above M-72 on the mainstem and the Pine River. Fish passage should include lake sturgeon, a native species, that uses rivers for reproduction.

The US Fish and Wildlife Service and the US Forest Service have voiced concerns over passage of Lake Michigan fish due to the contaminant load (DDE and PCB) in these fish. They claim the bald eagle population recovery has been retarded due to their eating contaminated Great Lakes fish. A status report on Michigan eagles by Best and Kubiak (1989) states:

> “Eagle populations in Michigan increased from 88 breeding pairs in 1977 to 165 pairs in 1989. Comparatively, Great Lakes populations grew from 10 to 41 breeding pairs during the same period and now comprise roughly 25 percent of the state population. Michigan has already surpassed the federal recovery goal of 140 breeding pairs”.

These numbers indicate a rapid recovery, especially with a fourfold increase by Great Lakes eagles, and exceed the federal recovery goal. Bowerman (1991) states that the literature indicates an eagle nesting success rate of 1.00 indicate a healthy eagle population. The nesting pair of eagles at Tippy Dam (Wellston nest) has reared eleven eaglets over the past six years (1989-94) for a nesting success rate of 1.83 Bowerman (1991). A nesting pair of eagles on the Pere Marquette River (Whelan Lake nest) in Mason County has reared ten eaglets over the past six years (1989-94) for a nesting success rate of 1.67 Bowerman (1991). Stalmaster and Gessamen (1984) rate food quantity as the single most important factor in eaglet production. The available literature on eagle diet composition indicates 20% of their diet is fish eating birds (gulls, terns, mergansers, and herons) (Kozie and Anderson 1991; Bowerman 1991). They also eat about 80% fish. However, the relative contaminant loading (DDE and PCB’s) is about 75 times higher in birds than in fish (Kozie 1986; Kozie and Anderson 1991; Bowerman 1991). Thus, if an eagle consumes 100 pounds of food, it gets 80 units of contaminants from eating 80 pounds of fish (80x1) and gets 1,500 units of contaminants from eating 20 pounds of birds (75x20). This results in eagles getting 5% of their contaminant loading (80/1,580) from eating fish and 95% from eating birds. Two very important points: 1) contaminant levels in Great Lakes fish are down and 2) the quantity of food an eaglet receives is the most important factor. The nesting success rate of eagles on the Pere Marquette and Manistee rivers attests to these facts and passage of Great Lakes fish beyond dams will not adversely affect eagle populations.

The following factors related to Great Lakes fish communities should be considered where fish passage, trap and transfer, or barrier removal decisions are made.

1. Decide which naturalized and native fish species could or should be passed.

2. Estimate the recruitment potential for the species. If the key management objective is to produce a sports fishery then it would be appropriate to pass fish into rivers where there is little recruitment potential. If the management objective is to increase natural reproduction of a potamodromous species then some projection of expected recruitment should be made.

3. Estimate the potential for competitive interactions with fish species already inhabiting the streams. The value of existing resident fisheries needs to be weighed against needs for additional potamodromous production or fishing opportunities.

4. Consider whether recruitment gains from fish passage will result in “over-stocking” of the Great Lakes (i.e., exceed population objectives for Great Lakes fish species). This probably will not result because increased natural recruitment will be balanced by reduced plantings of hatchery fish, particularly salmonids, recognizing geographical distribution of the fishery.

5. Recognize that naturally reproduced stocks (both native and naturalized species) are frequently adapted to local conditions and hence tend to survive and reproduce better than hatchery stocks. Where feasible this genetic diversity should be protected by promotion of natural reproduction.

Once the biological decisions of fish passage have been addressed, the social issue needs to be approached. The primary social issue is riparian ownership, as potamodromous fish are probably to attract more anglers. This, in turn creates trespass, litter, and other illegal activities. The following items need consideration when evaluating the potential for riparian conflicts:

1. The species and number of fish passed:
2. The size of the stream (larger rivers can handle more anglers with less effect):
3. Availability of public access (number of access points, parking space availability, longitudinal spacing of access sites along a stream, and amount of public land or available easements):
4. Transportation systems (both motorized and pedestrian):
5. Enforcement capabilities. Any increased enforcement needed to control trespass, litter, and other illegal activity is a cost associated with fish passage.

Since habitat is the critical factor in fisheries management, a summary of important habitat features and related problems by segment is included.

Segment 1 - Headwaters to M-72 Bridge
Habitat has been largely rehabilitated and stream morphology has returned to a more natural state. Trout population estimates agree with this and numbers continue to rise.

Segment 2 - M-72 Bridge to Smithville
Habitat is severely degraded by heavy sediment load. Bank stabilization is ongoing. Lack of large woody debris is apparent. The fishery is sustained through stocking, although abundant young-of-the-year brook trout are being found.

Segment 3 - Smithville to M-115 Bridge
The river has a heavy sediment load, many eroding banks, and lacks large woody debris. Warmwater to coolwater species predominate, with an abundant chestnut lamprey population.

Segment 4 - Hodenpyl Dam to Red Bridge
The two hydroelectric impoundments have eliminated the two highest gradient areas of the river system, limiting production. The impoundments are managed for warmwater to coolwater species. The river section between the two dams is also high gradient, but has a sediment problem and lacks large woody debris due to past peaking operations.

Segment 6 - North Branch Manistee River
The upper reach is affected by beaver dams, but is fairly productive for brook trout. The lower third has a sand bedload problem and could use more woody debris. Chestnut lamprey abound in the lower reaches.

Segment 7 -Bear Creek
The lower two thirds has a sediment problem and lacks adequate woody debris. Agricultural land use contributes to the sand bedload, elevates summer water temperature, and makes flows flashy. Potamodromous fish predominate.

Segment 8 - Pine River
This segment has excessive sedimentation from severely eroding sand banks. Some reaches have a lack of large woody debris. Stronach Dam, an abandoned hydroelectric facility, covers the highest gradient water. Many poor road and stream crossings exist. The non-migratory rainbow trout population has to be protected and enhanced, as they are a unique non-migratory population.

Tributaries
Many tributaries have a high sediment bedload, however, they support fair to good trout populations and fisheries. They provide much of the recruitment of brook and brown trout for the mainstem. Other impairments to these fisheries are blockages due to improperly designed road crossings (perched culverts), human-made dams, and beaver dams.

Citizen Involvement

Citizen involvement with management of the Manistee River comes from government agencies including: Michigan Department of Natural Resources, Michigan Department of Military Affairs, US Forest Service, US Fish and Wildlife Service, USDA - Natural Resource Conservation Service, Conservation Resource Alliance, Huron Pines Resource Conservation & Development Council, various county road commissions, county drain commissioners, and township and county offices.

Non-governmental organizations that Fisheries Division has contact with, who have an interest in and actively work on aspects of the Manistee River watershed, include: Michigan Council of Trout Unlimited, Pine River Area Chapter of Trout Unlimited, George Mason Chapter of Trout Unlimited, Michigan Steelheaders, Michigan River Guides Association, Upper Manistee River Association, Manistee River Association, Pine River Association, Bear Creek Watershed Council, Manistee County Sportfishing Association, Michigan Chapter of Fly Fishing Federation, Mackinaw Trail Fly Fishers, Pine River Canoe Livery Association, Black Creek Hunt Club, Ne-Bo-Shone Association, Wer-Hee-Gen Association, and Michigan Hydropower Coalition.

MANAGEMENT ISSUES AND OPTIONS

Agency River Management Scoping Meeting

At the beginning of this assessment, a two day meeting to discuss management issues with various management agencies was held. Those involved included Michigan Department of Environmental Quality--Land and Water Management and Surface Water Quality divisions, Michigan Department of Natural Resources--Fisheries, Forest Management, and Wildlife divisions, US Forest Service, US Fish and Wildlife Service, and the US Geologic Survey. Many issues were identified that were problems and opportunities:

Dams, hydroelectric and others	Land management
flows, run-of-river versus peaking water temperature fish passage, up and downstream erosion/sedimentation turbine entrainment and mortality fragmentation (habitat and genetic)	old growth/biodiversity in flood plain best management practices hiking/horse trails recreational use (user conflicts)/integrated recreational planning riparian development deer yard management wetland habitat loss
Water quality	**Nonpoint source pollution**
point source discharges contaminated groundwater wetland loss municipal sewer/storm outfalls temperature	road crossings, pipelines, ORV trails bridges and culverts sediments and nutrients from agricultural lands
Fish and habitat	**Management issues**
insufficient recruitment/costly stocking programs sea lamprey regulations large woody debris stream bedload	sea lamprey and chestnut lamprey rough fish (carp, redhorse, etc.) rusty crayfish and zebra mussel beaver purple loosestrife and Eurasian milfoil gypsy moth, forest tent caterpillar, and budworm (spruce & jack pine) threatened and endangered species eagles and potamodromous fish fur bearers and fish

The two major issues identified by the dozen people in attendance were: erosion control & sedimentation under dams (9 votes) and nonpoint source pollution and hydroelectric dams (8 votes). These concerns were mentioned by practically all in attendance. The balance of the items identified had 1, 2, or 3 votes.

Issues and Options

Although the Manistee River is a high quality resource, there are a number of fishery related problems that need addressing to rehabilitate the system. The management options in this document are an attempt to address the most important issues and to set priorities for future actions and investigations.

The identified options are consistent with the mission statement of the Fisheries Division, MDNR. This mission is 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. 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 understanding of fish, fishing, and fishery management.

Options convey four approaches to correcting problems in the watershed. First, we present options to protect and preserve existing resources. Second are options requiring additional surveys. Third are opportunities for the rehabilitation of degraded resources. Opportunities to improve an area or resources, above and beyond the original condition are listed last.

Further, the following options follow the recommendations of Dewberry (1992), who outlines measures necessary to protect the health of the nation’s public river ecosystems. Dewberry stresses the protection and rehabilitation of headwater streams, riparian areas, and flood plains. Streams and flood plains need to be reconnected where possible, with restrictions on the construction of seawalls and bulkheads, and the restoration of large woody debris. We must view the river system as a whole, for it is the entire system that must be managed, not fragmented pieces.

Biological Communities

The Manistee River system originally supported a large population of Michigan grayling, that through habitat destruction, over harvest, and introduction of exotic species (competition) was extirpated. Introduction of other salmonids has occurred and filled this niche. Other fish stocks, especially native potamodromous species, have suffered severe declines: walleye, Great Lakes muskellunge, lake sturgeon, lake trout, lake herring, round whitefish, and lake whitefish. Changes occurred due primarily to loss of high gradient habitat when hydroelectric dams were constructed. Loss of stream habitat was due to erosion and sedimentation of the streambed from logging, poor land use, road crossings, and “peaking” at hydroelectric facilities. Declines in populations were also affected by changes in Lake Michigan and Manistee Lake.

Present fish community information is not adequate to show distribution or scientifically manage the fishery, particularly in Segments 3 and 4. Some plant and animal species are threatened or endangered from changes to or loss of habitat.

Option: Rehabilitate historic spawning runs of potamodromous species above Tippy and Hodenpyl Dams by removing barriers or providing fish passage, both upstream and downstream.

Option: Survey current fish community, aquatic invertebrate, reptile, amphibian, and mussel distributions.

Option: Survey the pre-settlement flora and fauna in the watershed through historical records.

Option: Preserve remaining high gradient areas.

Option: Rehabilitate graveled habitats through bank stabilization, sediment basin construction, and remediate road and stream crossings.

Option: Preserve and protect wetlands within the floodplain of the river system, with no mitigation that would increase the fragmentation of the floodplain.

Option: Protect river corridors through green belt provisions and low density development through zoning or purchase of key riparian parcels or development rights.

Option: Rehabilitate fragmented segments of the river system by removal of dams and barriers.

Option: Protect endemic and naturalized species by controlling the several plant and animal pest species present that negatively affect the aquatic system. species include: sea lamprey, chestnut lamprey, rusty crayfish, zebra mussels, purple loosestrife, Eurasian milfoil, gypsy moth, mute swans, and beaver.

Geology and Hydrology

The Manistee River has very stable flows, ranking among the best in the country. Some segments have less stable flows, both high and low. East Branch of the Pine River, Pine River mainstem, and Bear Creek exhibit the least stable flows due primarily to finer till soils, geology, agricultural land use, and designated drains.

Option: Protect wetlands, floodplains and sandy uplands that act as water retention areas for ground water recharge from adverse activities.

Option: Survey historic records to determine pre-settlement flows.

Option: Rehabilitate stream corridors in agricultural areas by working with county agricultural agents to implement best management practices.

Option: Improve management of water in designated drains by working with county drain commissioners on existing management.

Option: Improve management of water in designated drains by working to change the current drain code.

Option: Rehabilitate the stream flows from Lake Margrethe by removing the lake-level control structure or changing to a fixed-crest structure.

Channel Morphology

The channel of the Manistee River has been altered. Many high gradient areas have been impounded. Turn of the century logging, land use practices, road and stream crossings, and peaking operations at dams have resulted in an aggraded and degraded streambed in both the mainstem and tributaries.

Option: Restore high gradient areas by removing hydroelectric (Tippy and Hodenpyl) and other dams, especially those no longer being used or serving little purpose (Manton Millpond, Copemish, and Goose Creek dams).

Option: Restore recruitment of large woody debris through greenbelt zoning.

Option: Survey road and stream crossings to determine ongoing sources of sediment.

Option: Survey historic records to determine pre-settlement channel form.

Option: Protect existing instream large woody debris.

Option: Rehabilitate stream channels by stabilizing all major and moderately eroding streambanks.

Land Use Patterns

Recreational, agricultural, and urban developments are low to moderate in the watershed. However, soils are predominantly sandy and very susceptible to erosion. Erosion from uplands, drainage systems, and irrigation is low to moderate.

Option: Protect riparian uplands through land-use planning and zoning that emphasize protection of critical areas.

Option: Improve stormwater management throughout the watershed..

Option: Protect lands and therefore streams by encouraging private land owners to enroll properties in programs that provide tax credits or direct payments for preserving lands in their natural state, such as the Conservation Resource Program or The Farmland and Open Space Program.

Option: Protect the river by using USDA Natural Resource Conservation practices to reduce erosion.

Option: Protect critical areas by identifying and purchasing key parcels or their development rights.

Special Jurisdictions

The State of Michigan, US Forest Service, and Consumers Energy Company own the majority of the riparian lands. The Federal Energy Regulatory Commission has authority over hydroelectric dams and project lands. The entire Manistee River system is a candidate for designation as a State Natural River, and portions of the mainstem, Bear Creek, and Pine River are designated as a Federal Scenic River.

Option: Improve land and water management activities by establishing a basin wide watershed council that will provide good stewardship and leadership.

Option: Improve ecosystem management of the watershed by recommending all governmental agencies incorporate river protection measures in their land and water management plans.

Recreational Use

Outdoor recreational activities are ubiquitous in the watershed, especially on public lands. Fishing, particularly for potamodromous species, is limited by hydroelectric dams. Impoundments also limit boating recreation and offer limited public access. There are areas that are affected by overuse and misuse by canoeists.

Option: Rehabilitate the Manistee River mainstem by removing Tippy and Hodenpyl dams.

Option: Rehabilitate the Manistee River mainstem by establishing fish passage at Tippy and Hodenpyl dams, both upstream and downstream.

Option: Improve public access to Tippy and Hodenpyl backwaters by enforcing the Settlement Agreement with Consumers Energy Company to provide adequate public access to these impoundments.

Option: Improve public access by buying and developing public access sites where needed.

Option: Improve existing access sites and make them in compliance with the American Disabilities Act.

Option: Improve the recreational experience by limiting the number of canoe launches on the Pine River during peak times.

Option: Improve the recreational experience by banning possession of alcohol in water craft on the Pine River.

Dams and Barriers

Five of the 63 dams on the Manistee River system are hydroelectric facilities, with three of these being retired (Manton Millpond, Manton Upper Power, Stronach dams). Tippy and Hodenpyl dams are active. Five others are wildlife floodings, with four located on cold water tributaries. The balance are on tributaries and used for fish rearing, swimming holes, or waterfowl. All are harmful to the river ecosystem as they fragment resident fish habitat, reduce aquatic invertebrate habitat, impound high gradient habitat, trap woody debris, nutrients, and sediments, warm the water, create flow variations, kill fish, and block potamodromous fish migrations. Tippy Dam does have a positive effect by blocking migration of adult-spawning-phase sea lamprey.

Option: Rehabilitate the river by removing retired hydroelectric dams (Manton Millpond and Manton Upper Power dams) and dams serving little purpose especially Horseshoe Lake and Ash dams.

Option: Rehabilitate the mainstem by removing four wildlife floodings, Big Cannon Creek (two), Goose Creek and Fife Lake outlet.

Option: Protect the future of the river by requiring owners of dams to escrow funds for future removal.

Option: Rehabilitate the fish community by installing fish passage for designated species, both upstream and downstream.

Option: Rehabilitate the fish community by initiating a trap and transfer of desirable potamodromous species at Tippy and Hodenpyl dams, and create downstream fish passage.

Option: Improve salmonid habitat and reproduction by installing a device to draw cold water off the bottom of Tippy Dam backwaters during June, July, and August.

Option: Improve aquatic invertebrate populations by trapping and transferring aquatic invertebrates from above to below hydroelectric dams.

Option: Rehabilitate the fish community by installing devices to screen turbine intakes at operating hydroelectric facilities.

Option: Improve the recreational experience by requiring fish passage at all dams.

Option: Survey culvert crossing to determine if they are barrier to fish passage and correct those that are fragmenting the system..

Water Quality

The overall water quality in the Manistee River basin is very good due to the geology (deep permeable sands) and limited development. Much of the river system has an excessive sand bedload and there are temperature problems below Tippy Dam. Groundwater contamination occurs sporadically. Mercury contamination in inland lakes is widespread.

Option: Rehabilitate the river by controlling non-point source sediments.

Option: Rehabilitating stream temperatures by drawing cold water from below the thermocline in Tippy Dam backwaters particularly during June, July, and August.

Option: Rehabilitate groundwater by cleaning up identified groundwater contamination sites.

Option: Improve enforcement of air quality standards, particularly concerning mercury emissions.

Option: Rehabilitate and improve water quality by establishing riparian greenbelts to reduce sediments and provide cooling overhead cover.

Fishery Management

The fishery is generally good. One of the seasonally excellent areas is below Tippy Dam. Sediment is affecting fish populations in much of the watershed. Many human made and beaver dams are affecting water quality and fish production. The two hydroelectric dams impound high gradient river areas and block potamodromous species; fishing is fair to good in these impoundments.

Option: Rehabilitate the aquatic habitat by stabilizing all severe and moderately eroding sand banks.

Option: Survey all road and stream crossings and work with county road commissions to correct problems.

Option: Rehabilitate the aquatic habitat by constructing and maintaining sediment basins.

Option: Survey and evaluate steelhead and chinook salmon reproduction below Tippy Dam.

Option: Survey existing lake sturgeon population in Hodenpyl Dam backwaters.

Option: Rehabilitate fish communities by providing fish passage at the two hydroelectric dams on the mainstem, both upstream and downstream.

Option: Rehabilitate the fish community by installing devices to screen turbine intakes at operating hydroelectric facilities.

Option: Improve brook trout populations in the North Branch of the Manistee River by removing sediment in the stream.

Option: Survey angler use throughout the watershed.

Option: Survey habitat in Tippy and Hodenpyl dam backwaters.

Option: Rehabilitate fish communities and habitat by removing retired hydroelectric dams (Manton Millpond and Upper Power).

Option: Rehabilitate fish communities and habitat by removing four wildlife floodings on trout streams (Cannon Creek (2), Goose Creek, and Fife Lake Outlet).

Option: Improve impoundment fisheries for warmwater and coolwater species until dams are removed.

Option: Survey tributaries for problem beaver areas and implement removal.

Option: Improve natural salmonid recruitment below Tippy Dam by spilling cold water from below thermocline during June, July, and August.

Option: Improve the fish community balance by chemically treating portions of the mainstem for chestnut lamprey.

Option: Survey lower mainstem (below Tippy Dam) for muskellunge and reintroduce if not found.

Option: Survey intensively, fish species distributions (rotenone and electrofishing surveys), particularly the mainstem below Sharon.

Option: Rehabilitate aquatic habitats by working with owners of private dams to remove them.

Option: Survey fish habitat, modify, and increase where necessary.

Option: Survey the unique fish community existing in the Pine River and determine the effects of Great Lakes fish on this community.

Option: Survey the fish community existing in the mainstem above M-72 and determine the effects of Great Lakes fish on this community.

Citizen Involvement

Many recreational interest groups exist that are concerned with fisheries management. The watershed encompasses many local units of government (counties, townships, villages, cities), that affect land use through zoning.

Option: Protect citizen involvement by creating a basin wide watershed council to oversee watershed planning and management.

Option: Improve and educate river users and property owners about sound watershed management.

Option: Protect the resource by continuing to work with local units of government on common stewardship issues.

PUBLIC COMMENT AND RESPONSE

Comments were received on the draft of this assessment from July 1996 through November 1996. Three public meetings were held requesting comments on the draft document. The meetings and locations were: September 4, 1996, at the Grayling High School Auditorium in Grayling; September 5, 1996, at the Carl T. Johnson Hunting and Fishing Center in Cadillac; and September 6, 1996, at the Wellston Elementary School in Wellston.

Copies of the draft assessment were placed in nine libraries in Cadillac, Fife Lake, Grayling, Kalkaska, Lake City, Manistee, Manton, Mesick, and Wellston. These draft assessments were kept in the reference section of the library so they would always be available. Copies for distribution were available at the Cadillac District and Lansing Fisheries Division offices. Copies were mailed to any person or group requesting one. Also, the Natural Rivers Unit of Forest Management Division, bought and distributed 150 copies to four study groups on the Manistee River watershed looking at future state natural river designation.

A statewide news release was issued by the Department of Natural Resources Press Office on August 22, 1996, regarding the date, time, and location of the public meetings. The notice stated copies were available at the Cadillac District Office and named local libraries. Some local newspapers also ran the public notice.

The series of three public meetings were very poorly attended, with a total of fourteen attendees. Several parties attended all three meetings. Likewise, the written comments were limited, with 34 letters received. A breakdown of the written comments reveals thirty dealt with fish passage and potamodromous species in the Pine River and Upper Manistee. The split was even, fifteen commenting only on the Pine River and the rest the Upper Manistee and Pine River. Fish passage appears to be the overwhelming issue of concern to most citizens. Only two letters addressed basin wide issues.

Introduction

Comment: Most respondents were complimentary of the watershed assessment and the process.

Response: All the supporting comments were greatly appreciated and acknowledged.

Comment: “The Department’s Fisheries Division has produced an Assessment that provides substantial information about the existing fisheries conditions on the Manistee River, particularly as they relate to cold water fisheries management. However, this Assessment falls well short of the goals for an overall river management assessment, even as a preliminary document.

“In summary, Consumers views this draft Assessment as containing valuable information regarding the historical development and current condition of the Manistee River. It does not, however, provide adequate analysis of the impacts and issues associated with the management options presented. We believe such analysis is absolutely essential to meet the objectives that the Department itself outlined for the Assessment. We do not believe that this Assessment should stand as a basis for completing a final Comprehensive River Management Plan. The Department agreed to develop a Comprehensive River Management Plan for the Manistee as well as the Au Sable and Muskegon Rivers as part of the Offer of Settlement that was filed with FERC in the relicensing of 11 of Consumers’ hydroelectric projects, including the two Manistee River projects. Reference can be made to the Offer of Settlement at paragraph 9.1 and the Offer of Settlement Explanatory and Support Statement at paragraph 9.1 (copies of which are provided as Attachment C to this letter).

"We recommend that the Department revise the draft Assessment to address the issues we have outlined in this letter and the attached detailed comments and issue a revised Assessment to a much wider public audience. After obtaining public comment on the revised Assessment, the Department would be better able to develop a management plan on which the Michigan Natural Resources Commission could receive public input and take appropriate action."

Response: All the issues outlined by Consumers Power Company are addressed in the Public Comment section. The bulk of comments received from Consumers Power Company were not requesting additional information, but statements of disagreement regarding effects of hydroelectric dams that are outlined in the assessment. Public comments were received on the Assessment and changes were made as needed. The assessment and planning process will continue and additional comment can be submitted to the Department at anytime. A comprehensive management plan will be developed based on this assessment and public comment.

Comment: "The appearance that the Fisheries Division did not obtain appropriate input from the US Fish & Wildlife Service, US Forest Service or even MDNR Divisions other than Fisheries. For example, we are aware that these agencies/divisions participated in scooping meetings in 1991 to assist the Department's Fisheries Division in developing the issues that it raised are not discussed in the Assessment. Based upon a recent meeting, we now understand the Fisheries Division will obtain this important input from other agencies and MDNR divisions."

Response: The consultation meetings were discussed in Agency River Management Scoping Meeting section. As discussed, issues mentioned at these meetings were included in the assessment. This section has been moved from the Management Option section to the Introduction section. Agencies participating in the consultation meetings also provided written comment. None of the agencies involved in the consultation process indicated any of the issues discussed in the consultation meetings were left out of the assessment.

Watershed Assessment

Comment: All of the available historic data were not included in the assessment.

Response: To include "all" of the data available would have made this assessment too voluminous. Relevant data to the topics addressed were used and new relevant data will be added to future revisions.

Geography

No comments were received on this section.

History

Comment: This history of Stronach Dam as reported is inaccurate.

Response: The history of Stronach Dam has been corrected and expanded.

Biological Communities

Comment: "The development of balanced management objectives for both resident fish, including warm water and cool water impoundment species and anadromous species is not included. Currently the Assessment is heavily biased in favor of cold water fish."

Response: The management objectives are based on the key values of the system. Clearly the key value of the Manistee River is its cold water river habitat. Long term management goals are based on a free-flowing, cold water system.

Comment: Wood turtles nest on sandy stream banks, which are systematically being stabilized and revegetated by rehabilitation committees on the Pine River, Bear Creek, and Upper Manistee. Are these programs negatively impacting wood turtle populations?

Response: The wood turtle, a state species of special concern does use sandy banks for nesting and we recognize that need. They are considered in the ongoing bank rehabilitation projects. Recent research indicates the two main causes of decline and limited recruitment are predation of adults and nests by raccoons, and collection by recreational canoeists.

Comment: Allowing steelhead and salmon from Lake Michigan into the Upper Manistee may spread the numerous exotics found there into the fragile upper river.

Response: No documentation of the spread of these exotics in "open" system like the Pere Marquette River by Great Lakes fish exists. Rather they are spread by humans.

Geology and Hydrology

No comments were received on this section.

Channel Morphology

No comments were received on this section.

Soil and Land Use Patterns

No comments were received on this section.

Special Jurisdictions

No comments were received on this section.

Recreational Use

Comment: In addition to the current user conflicts, increasing angler pressure by passing Great Lakes salmonids will elevate the problem.

Response: The mission of Fisheries Division is 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 the benefit of the people of Michigan. This is largely a social issue that will be addressed in evaluating fish passage.

Comment: The Pine Rivers canoe use and behavior must be addressed.

Response: The Department is working with the US Forest Service and landowners to resolve these user conflicts. More enforcement will help reduce conflicts. Resolution of these issues are listed as management options.

Comment: The Upper Manistee is receiving increased use by commercial canoe liveries.

Response: A watershed council working with canoe liveries and property owners would help resolve conflicts. Educational programs would also be useful.

Dams and Barriers

Comment: Several comments were made opposing removal of Tippy and Hodenpyl Dams and other small dams in the watershed. A couple supported removal of specific dams on the watershed.

Response: The two hydroelectric dams, Tippy and Hodenpyl, have been relicensed for 40 years. The Offer of Settlement (Appendix 3) provides for mitigation of some of the environmental effects of these two dams during the license term. Dam removal at other locations will be dealt with on an individual basis. One dam, Stronach Dam, is in the process of being removed.

Comment: Can Tippy and Hodenpyl dams be converted to bottom draw facilities?

Response: No, but they can be retrofitted to draw cold water from the bottom of the reservoirs. Installing this technology on Hodenpyl Dam would do little for temperatures, as the backwaters do not stratify thermally. Tippy Dam, conversely, does stratify, with a layer of cold water being present on the bottom. Studies are being conducted to determine if the addition of cold water below Tippy will affect salmonid recruitment.

Water Quality

No comments were received on this section.

Fishery Management

Comment: The majority of the comments made opposed fish passage at the two hydroelectric dams.

Response: Potential benefits of fish passage include rehabilitation of native and naturalized potamodromous fish runs, improved sport fishing, and improved natural reproduction. Concerns are possible user conflicts and affects of expanding the range of Lake Michigan fish on interacting wildlife species. Guidelines for evaluating fish passage are being developed by the Department. The protocol for implementing passage at the two facilities is outlined in the Offer of Settlement (Appendix 3).

Comment: A thorough assessment of the impacts and benefits of implementing fish passage is needed, including the species and approximate numbers to be passed, interactions between species, and potential user-group conflicts.

Response: Guidelines for evaluating fish passage are being developed by the Department.

Comment: Contaminants are a concern with fish passage.

Response: This issue will be considered in evaluating fish passage.

Comment: Installation of fish ladders at hydroelectric dams will allow sea lamprey upstream, necessitating expensive treatments every four years.

Response: Expanding the sea lamprey runs is not a scenario the Department would consider. Fish ladders can be constructed to preclude lamprey. For dam removal, there are alternative control measures to expensive TFM treatments.

Comment: A portion of the Pine River should be designated as a quality fishing area.

Response: The Department is at the maximum number of miles of quality water that can be designated under law. We are recodifying the Aquatic species Conservation Act that would allow expansion of this designation.

Comment: Allowing Lake Michigan salmonids into the upper Manistee and Pine River will spread BKD into resident stream trout populations.

Response: There is no evidence of any effect of BKD on resident populations. There are many open systems that have thriving stream trout populations.

Comment: Passage of Lake Michigan salmonids will have negative impacts on the resident brook, brown, and rainbow trout populations in the upper Manistee and Pine Rivers.

Response: The Department believes there are minimal interactions between chinook, both spawning phase and juveniles, on resident stream trout. We believe there may be interactions between spawning phase steelhead and resident stream brown trout, based on a New Zealand study that indicated interactions between spawning rainbow trout and brown trout. An ongoing study at Hunt Creek will answer this question.

Comment: The removal of Stronach Dam on the Pine River will allow an invasion of cool water and rough fish to adversely impact the resident trout populations.

Response: The Department feels strongly this will not occur, as the Pine River is not suitable habitat, being too cold and high gradient. An ongoing MSU study, before and after dam removal will look at effects and make recommendations.

Comment: "The section on Bald Eagle, Mink, River otter and Potamodromous fish underestimates the impact of introducing Great Lakes contaminants via upstream fish passage to upstream ecosystems. The Department's own research (Merna, J.W. 1986, Contamination of stream fishes with chlorinated hydrocarbons from eggs of Great Lakes salmon Trans. Am. Fish Soc. 115:64-74) documents the contamination of nonmigratory salmonids through ingestion of salmon eggs in anadromous accessible segments of the Muskegon and Manistee rivers. The contamination of the upstream ecosystems is not even considered in this assessment. One wonders just what happens to the contaminants in dying salmon and their eggs, or in the eggs of species that return to the Great Lakes. The USFWS recognizes the threat to both ecosystems and piscivorous species (e.g. Kubiak, T J and D A Best, 1991, 'Wildlife Risks Associated with Passage of contaminated Fish at Federal Energy Regulatory Commission Licensed Dams in Michigan' unpublished report. US Fish and Wildlife Service, East Lansing Field Office. The USFWS has indicated that it will not exercise its authority to require upstream fish passage until such time as the fish contaminant levels no longer post a threat to upstream wildlife and ecosystems. The Department should refer to the contaminant section in Exhibit E of CPCo's licensing application, the Biological Assessment for Bald Eagles that accompanies the FERC licenses, and in the peer-reviewed literature, Giesy et al (1994a, 1994b, 1995) for an appropriate perspective.

"This section ignores the long-standing anadromous fish contaminant problem associated with low bald eagle productivity on the Manistee River. This perspective can be obtained from the Department's own Wildlife Division records.

"Eagles use the fish resource on the Manistee River throughout the year and add to their contaminant burden as they do so. Whether or not the passage of chinooks or browns overlaps the nesting season is somewhat irrelevant. They still are a significant contaminant source available to both adults and fledglings. The depuration rate for contaminants such as PCB is slow; contaminants ingested in the non-nesting season are stored in fat and are mobilized during egg laying. Consumers' data demonstrate a high level of winter use on the Muskegon by immature eagles that would be affected by this process."

Response: The Assessment addresses the issue of contaminants as one of the many considerations in fish passage. The Department has reviewed the literature on eagles presented in Consumers Energy Company's pre-license studies and has many concerns with the conclusions of these reports. There is important information not considered in the pre-license studies. Available information indicates fish passage is a viable management option.

Data interpretation regarding effects of contaminants on eagles and other animal populations is a controversial area. In Consumers Energy Company's pre-license reports, one type of analysis is used. The Department does not agree with this data interpretation. There is no indication fish or populations of other aquatic organisms are impaired by contaminants in river reaches open to Great Lakes fish migrations, when compared to inland river reaches. Contaminants and Great Lakes fish are only one of many issues that must be considered in fish passage.

Comment: A barrier should be placed in the Pine River after Stronach Dam is removed to prevent cool water and rough fish from moving upstream.

Response: An ongoing study being conducted by MSU researchers will determine the necessity of such a structure.

Comment: The removal and addition of large wood, debris (LWD) has to be addressed.

Response: The cutting LWD by canoe liveries on the Pine River is being regulated through a cooperative effort of the Pine River Canoe Association and the US Forest Service. The addition of LWD in the Upper Manistee is listed as a management option.

Comment: Sand bedload is a major problem in our trout streams.

Response: There are ongoing stream rehabilitation projects in the Pine River, Bear Creek, and Upper and Lower (below Tippy) Manistee River. Those committees are also working on remediating poor road and stream crossings. The Michigan Department of Natural Resources and US Forest Service have sited many sediment basins (sand traps) throughout the watershed. These projects will continue and expand in the future.

Fisheries

Comment: We support a regulation change to increase the minimum size limit to 16 inches and reduce the daily limit to three fish from Tippy Dam to Lake Michigan.

Response: Great! This regulation change is one proposed in the new cold-water fishing rules being put together by a joint public-Fisheries Division committee and is endorsed by the Department. The proposed regulation would be that in certain stream sections where potamodromous fish runs occur, the season would be open year round for all salmonids, with a bag limit of 3 fish in any combination, and a minimum size of 16 inches.

Comment: Why are channel catfish stocked in Tippy and Hodenpyl Dams?

Response: To create a recreational fishery and provide a predator to control panfish populations. They typically do well in reservoirs.

Citizen Involvement

Comment: A Watershed Council should be formed to insure citizen involvement and address the issues.

Response: This is listed as a management option.

Comment: As future drafts are prepared it would be helpful and appropriate to provide further assurances that there will be opportunity for public input in the selection of alternatives.

Response: The Assessment and management plan will be updated. The public is encouraged to comment at anytime and comments will be included in future revisions. The goal the Assessment is to provide information and obtain public involvement in the planning process.

Management Options

No comments were received on this section.

GLOSSARY

backwaters - the body of water created by damming a river

base flows - the groundwater discharge to the system

basin - a drainage area, both land and water, from which water flows toward a central collector such as a stream, river, or lake at a lower elevation; synonymous with watershed

biodiversity - the different number and type of biological organisms in a system

channel morphology - a study of the structure and form of stream and river channels including width, depth, and bottom type

deciduous - vegetation that sheds its foliage annually

degradation - the process by which streambeds are lowered in elevation by the removal of material.

ecosystem - a biological community considered together with the non-living factors of its environment as a unit

endangered species- a species that is in danger of extinction throughout all or a significant portion of its range

exceedence curves - the probability of any discharge exceeding a given value.

exotic species - successfully reproducing organisms transported by humans into regions where they did not previously exist

extirpation - to make extinct, remove completely

fauna - the animals of a specific region or time

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

hydrology - the scientific study of the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere

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

LUNKERS - artificial habitat structures developed in Wisconsin used in conjunction with streambank stabilization

macroinvertebrates - animals without a backbone that are visible by the human eye

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

nonpoint source pollution - pollution to a water course that is not attributable to a single, well-defined source

panfish - a generic term used to describe any of the sunfishes, such as bluegill, pumpkinseeds, rock bass, crappies, green sunfish, warmouth, etc.

peaking mode - operational mode for a hydroelectric project that maximizes economic return by operating at maximum possible capacity during peak demand periods (generally 8 am to 8 pm) and reducing operations and discharge during non-peak periods

perched culvert - improperly placed culvert that fragments habitat by creating a significant drop between the culvert outlet and the stream surface

permeable - soils with coarse particles that allow passage of water

perturbations - disturbances

potamodromous - fish that go from fresh water lakes up fresh water rivers to spawn; migrations within fresh waters

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

rotenone - a natural substance found in the roots of plants of the pea family; it is highly toxic to most gill breathing animals; it is not toxic to most air breathing animals

run habitat - fast non-turbulent water

run-of-the-river - outflow of water about equals inflow of water; this flow regime mimics the natural flow regime of a river

Shannon-Weiner information statistic - a probability statistic that measures the number of groups of information within all of the information

TFM - 3-trifluoromethyl-4-nitrophenol, a chemical used to control sea lamprey in streams connected to the Great Lakes

thermocline - a layer of water between the warmer surface zone and the colder deep-water zone in a thermally stratified body of water, in which the temperature decreases rapidly with depth

threatened species-a species "which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range"

till - unstratified, unsorted glacial drift of clay, sand boulders, and gravel

turbidity - in water has large amounts of suspended sediments in the water column

veliger - the free-swimming larval stage of zebra mussels

watershed - a drainage area or basin, both land and water, that flow toward a central collector such as a stream, river, or lake at a lower elevation

young-of-the-year - generally refers to the young of fish species that were born this calendar year

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Table 1.–Archaeological sites (380) in the Manistee River watershed, listed by county and townships downstream from headwaters to the mouth. Data from: B. Mead, Michigan Department of State, Archaeological Section.

County and townships	Number of sites
Crawford	
Frederick	1
Beaver Creek	1
Kalkaska	
Excelsior	1
Garfield	23
Springfield	4
Missaukee	
Norwich	3
Pioneer	1
Bloomfield	9
Wexford	
Liberty	8
Greenwood	2
Hanover	3
Cedar Creek	5
Colfax	26
Antioch	16
Springville	7
Haring	4
Selma	11
Boon	30
Slagle	19
Clam Lake	5
Cherry Grove	9
Henderson	26
South Branch	27
Manistee	
Pleasanton	4
Marilla	6
Bear Lake	2
Dickson	12
Brown	21
Manistee	25
Norman	20
Stronach	23
Filer	7
Grand Traverse	
Fife Lake	8
Paradise	1

Table 1.–Continued.

County and Township	Number of sites
Osceola	
Rose Lake	1
Lake	
Dover	8
North Newkirk	1

Table 2.–List of fishes in the Manistee River watershed. Compiled by G.R. Smith, University of Michigan and Tom Rozich, Michigan Department of Natural Resources, Fisheries Division. Common family names are in bold print. Species origin: N=native; C=colonized, O=extirpated, I=Introduced. Manistee status: P=recent observation, U=historic record, current status unknown.

Common name	Scientific name	Species origin	Manistee status
Lampreys			
Chestnut lamprey	*Ichthyomyzon castaneus*	N	P
Northern brook lamprey	*Ichthyomyzon fossor*	N	P
American brook lamprey	*Lampetra appendix*	N	P
Sea lamprey	*Petromyzon marinus*	C	P
Sturgeons			
Lake sturgeon (threatened)	*Acipenser fulvescens*	N	P
Gars			
Longnose gar	*Lepisosteus osseus*	N	P
Bowfins			
Bowfin	*Amia calva*	N	P
Herrings			
Alewife	*Alosa pseudoharengus*	C	P
Gizzard shad	*Dorosoma cepedianum*	N	P
Minnows			
Central stoneroller	*Campostoma anomalum*	I	P
Lake chub (rare)	*Couesius plumbeus*	N	P
Spotfin shiner	*Cyprinella spiloptera*	N	P
Common carp	*Cyprinus carpio*	I	P
Brassy minnow	*Hybognathus hankinsoni*	N	P
Common shiner	*Luxilus cornutus*	N	P
Pearl dace	*Margariscus margarita*	N	P
Hornyhead chub	*Nocomis biguttatus*	N	P
River chub	*Nocomis micropogon*	N	P
Golden shiner	*Notemigonus crysoleucas*	N	P
Pugnose shiner (rare)	*Notropis anogenus*	N	U
Emerald shiner	*Notropis atherinoides*	N	P
Blackchin shiner	*Notropis heterodon*	N	P
Blacknose shiner	*Notropis heterolepis*	N	P
Spottail shiner	*Notropis hudsonius*	N	P
Rosyface shiner	*Notropis rubellus*	N	P
Sand shiner	*Notropis stramineus*	N	P
Mimic shiner	*Notropis volucellus*	N	P
Northern redbelly dace	*Phoxinus eos*	N	P
Finescale dace	*Phoxinus neogaeus*	N	P
Bluntnose minnow	*Pimephales notatus*	N	P
Fathead minnow	*Pimephales promelas*	N	P
Blacknose dace	*Rhinichthys atratulus*	N	P
Longnose dace	*Rhinichthys cataractae*	N	P
Creek chub	*Semotilus atromaculatus*	N	P

Table 2.–Continued.

Common name	Scientific name	Species origin	Manistee status
Suckers			
Quillback	*Carpiodes cyprinus*	N	P
Longnose sucker	*Catostomus catostomus*	N	P
White sucker	*Catostomus commersoni*	N	P
Northern hog sucker	*Hypentelium nigricans*	N	P
Silver redhorse	*Moxostoma anisurum*	N	P
Golden redhorse	*Moxostoma erythrurum*	N	P
Shorthead redhorse	*Moxostoma macrolepidotum*	N	P
Greater redhorse	*Moxostoma valenciennesi*	N	P
Bullhead catfishes			
Black bullhead	*Ameiurus melas*	N	P
Yellow bullhead	*Ameiurus natalis*	N	P
Brown bullhead	*Ameiurus nebulosus*	N	P
Channel catfish	*Ictalurus punctatus*	N	P
Tadpole madtom (rare)	*Noturus gyrinus*	N	U
Pikes			
Northern pike	*Esox lucius*	N	P
Muskellunge	*Esox masquinongy*	I	P
Tiger muskellunge	*Esox masquinongy x Esox lucius*	I	P
Mudminnows			
Central mudminnow	*Umbra limi*	N	P
Smelts			
Rainbow smelt	*Osmerus mordax*	I	P
Trouts			
Lake herring (threatened)	*Coregonus artedi*	N	P
Lake whitefish	*Coregonus clupeaformis*	N	P
Pink salmon	*Oncorhynchus gorbuscha*	C	P
Coho salmon	*Oncorhynchus kisutch*	I	P
Rainbow trout (steelhead)	*Oncorhynchus mykiss*	I	P
Chinook salmon	*Oncorhynchus tshawytscha*	I	P
Round whitefish	*Prosopium cylindraceum*	N	P
Brown trout	*Salmo trutta*	I	P
Brook trout	*Salvelinus fontinalis*	N/C	P
Lake trout	*Salvelinus namaycush*	N	P
Splake	*Salvelinus fontinalis x S. namaycush*	I	P
Arctic grayling (extirpated)	*Thymallus tricolor*	O	
Trout-perches			
Trout perch	*Percopsis omiscomaycus*	N	P
Cods			
Burbot	*Lota lota*	N	P
Killifishes			
Banded killifish	*Fundulus diaphanus*	N	P

Table 2.–Continued.

Common name	Scientific name	Species origin	Manistee status
Silversides			
Brook silverside	*Labidesthes sicculus*	N	P
Sticklebacks			
Brook stickleback	*Culaea inconstans*	N	P
Ninespine stickleback	*Pungitius pungitius*	N	P
Sculpins			
Mottled sculpin	*Cottus bairdi*	N	P
Slimy sculpin	*Cottus cognatus*	N	P
Temperate basses			
White bass	*Morone chrysops*	N	U
Sunfishes			
Rock bass	*Ambloplites rupestris*	N	P
Green sunfish	*Lepomis cyanellus*	N	P
Pumpkinseed sunfish	*Lepomis gibbosus*	N	P
Bluegill	*Lepomis macrochirus*	N	P
Longear sunfish	*Lepomis megalotis*	N	P
Smallmouth bass	*Micropterus dolomieu*	N	P
Largemouth bass	*Micropterus salmoides*	N	P
Black crappie	*Pomoxis nigromaculatus*	N	P
Perches			
Rainbow darter	*Etheostoma caeruleum*	N	P
Iowa darter	*Etheostoma exile*	N	P
Johnny darter	*Etheostoma nigrum*	N	P
Yellow perch	*Perca flavescens*	N	P
Logperch	*Percina caprodes*	N	P
Blackside darter	*Percina maculata*	N	P
Walleye	*Stizostedion vitreum*	N	P
Drums			
Freshwater drum	*Aplodinotus grunniens*	N	P

Table 3.–Non-indigenous fish species in the Manistee River. Data from: Michigan Department of Natural Resources, Fisheries Division.

Common name	Scientific name
Sea lamprey	*Petromyzon marinus*
Alewife	*Alosa pseudoharengus*
Central stoneroller	*Campostoma anomalum*
Common carp	*Cyprinus carpio*
Muskellunge	*Esox masquinongy*
Tiger muskellunge	*Esox masquinongy x Esox lucius*
Rainbow smelt	*Osmerus mordax*
Pink salmon	*Oncorhynchus gorbuscha*
Coho salmon	*Oncorhynchus kisutch*
Rainbow trout	*Oncorhynchus mykiss*
Chinook salmon	*Oncorhynchus tshawytscha*
Brown trout	*Salmo trutta*
Splake	*Salvelinus fontinalis x Salvelinus namaycush*

Table 4.–Fish stocking in the Manistee River, 1984-93. Sites are listed from headwaters to the mouth. Data from: Michigan Department of Natural Resources, Fisheries Division. Fish life stage: Fr=fry; SF=spring fingerlings; FF=fall fingerlings; Y=yearlings; A=adults.

County and common name	Stocking location	Years	Number (fish life stage)	Comments
Crawford				
Brown trout	Manistee River	84-93	58,543 (Y)	good fishery
Grayling	Manistee River	87,88	27,634 (Y)	experimental plant
Rainbow trout	Manistee River	84-86, 90	5,724 (Y)	supplemental plant
Northern pike	Lake Margrethe	84-90, 93	38,831 (SF)	on-going
Tiger muskellunge	Lake Margrethe	85-91	40,037 (FF)	on-going
Muskellunge	Lake Margrethe	90	151 (FF)	rearing pond experiment
Walleye	Lake Margrethe	84-88, 90	294,072 (SF)	on-going
Walleye	Lake Margrethe	92, 93	3.61 million (Fr)	fry plants
Walleye	Lake Margrethe	93	397 (A)	on-going
Hybrid sunfish	Howes Lake	86, 89	9,600 (Y)	create a fishery
Largemouth bass	Howes Lake	88	41 (A)	create a fishery
Kalkaska				
Brown trout	Manistee River	84-93	4,908 (A)	on-going
Brown trout	Manistee River	84-93	216,081 (Y)	on-going
Brown trout	Manistee River	84-93	72,107 (FF)	on-going
Brown trout	Bear Lake	84-93	144,353 (Y)	excellent fishery
Brown trout	Big Twin Lake	84-93	50,090 (Y)	good fishery
Brown trout	Starvation Lake	84-93	11,220 (Y)	good fishery
Grayling	Manistee River	87	13,139 (Y)	experimental plant
Brook trout	Manistee River	91-93	500 (A)	on-going
Brook trout	Manistee River	85-93	38,850 (Y)	on-going
Rainbow trout	Manistee River	84-86, 88-90, 92	18,466 (A)	on-going
Rainbow trout	Manistee River	84-86, 88-90, 92	1,500 (Y)	on-going
Rainbow trout	Starvation Lake	86-89, 91-93	7,440 (Y)	on-going
Rainbow trout	Rainbow Lake	84-86	1,390 (Y)	dropped
Rainbow trout	Big Blue Lake	87-91	9,659 (Y)	on-going
Rainbow trout	Bass Lake	88-93	7,559 (Y)	on-going
Lake trout	Big Blue Lake	90, 92-93	6,800 (Y)	on-going
Lake trout	Big Twin Lake	84	400 (A)	one-time plant
Splake	Big Blue Lake	85, 87, 89-93	17,488 (F)	on-going
Walleye	Manistee Lake	85, 87, 90, 93	100,708 (SF)	on-going
Walleye	Cub Lake	90, 93	9,052 (SF)	on-going
Walleye	East Lake	90	9,644 (SF)	on-going
Walleye	Pickeral Lake	90, 92	8,504 (SF)	on going
Missaukee				
Brown trout	Manistee River	88, 90-93	36,112 (FF)	good fishery
Wexford				
Brown trout	Manistee River	84-93	76,037 (Y)	good fishery
Brown trout	Manistee RIver	86-93	60,216 (FF)	co-op program
Brown trout	Soper Creek	89	2,000 (FF)	one time plant
Rainbow trout	Lake Billings	84-86	4,950 (Y)	dropped
Rainbow trout	Garlets Pond	84-85	2,450 (Y)	dropped
Rainbow trout	Burkett Creek	85	120 (Y)	dropped
Walleye	Hodenpyl Dam	89, 92	97,547 (SF)	good fishery
Channel catfish	Hodenpyl Dam	88, 91	47,154 (FF)	good fishery

Table 4.–Continued.

County and common name	Stocking location	Years	Number (fish life stage)	Comments
Manistee				
Brown trout	Manistee River	84-93	470,610 (Y)	good fishing
Brown trout	Pine Lake	84-93	43,122 (Y)	on-going
Steelhead, winter & summer	Manistee River	84-93	520,232 (Y)	excellent fishery
Chinook salmon	Manistee River	84-93	1,066,331 (SF)	good fishery
Coho salmon	Manistee River	93	110,030 (Y)	on-going
Walleye	Tippy Dam	84-85, 92	65,951 (SF)	good fishery
Walleye	Tippy Dam	84-85	297,500 (Fr)	good fishery
Walleye	Bear Lake	84-86, 89-91, 93	99,989 (SF)	good fishery
Channel catfish	Tippy Dam	88, 91	36,530 (FF)	on-going
Grand Traverse				
Walleye	Fife Lake	84-86, 88, 92	91,309 (FF)	good fishery
Osceola				
Walleye	Rose Lake	85, 88, 91	61,454 (SF)	good fishery

Table 5.–Natural features of the Manistee River watershed, listed from headwaters to the mouth. Data from: Michigan Department of Natural Resources, Wildlife Division, Natural Features Inventory, July 1990. Type: A=vertebrate animal; C=plant community; G=geological feature; I=invertebrate animal; O=other feature (rookery, champion tree); P=plant. Status: E=endangered; T=threatened; SC=special concern (rare, may become E or T in the future); P=proposed.

County and common name	Scientific name or feature	Type	Federal status	State status
Otsego				
Prairie or pale agoseris	*Agoseris glauca*	P		T
Arethusa or dragon's mouth	*Arethusa bulbosa*	P		SC
Red-shouldered hawk	*Buteo lineatus*	A		T
Wapiti or elk	*Cervus elaphus*	A		
Hill's thistle	*Cirsium hillii*	P		SC
Spotted turtle	*Clemmys guttata*	A		SC
Wood turtle	*Clemmys insculpta*	A		SC
Ram's head lady-slipper	*Cypripedium arietinum*	P		SC
Rough fescue	*Festuca scabrella*	P		T
Common loon	*Gavia immer*	A		T
Bald eagle	*Haliaeetus leucocephalus*	A	E/T	T
Geographical feature	Karst	G		
Marten	*Martes americana*	A		T
Spike-lipped crater	*Mesodon sayanus*	I		SC
Geographical feature	Moraine	G		
Pugnose shiner	*Notropis anogenus*	A		SC
Blazing Star borer	*Papaipema beeriana*	I		SC
Hill's pondweed	*Potamogeton hillii*	P		T
Grizzled skipper	*Pyrgus wyandot*	I		SC
Crawford County				
Prairie or pale Agoseris	*Agoseris glauca*	P		T
Secretive locust	*Appalachia arcana*	I		SC
Dusted skipper	*Atrytonopsis hianna*	I		SC
Calypso or fairy-slipper	*Calypso bulbosa*	P		T
Hill's thistle	*Cirsuim hillii*	P		SC
Wood turtle	*Clemmys insculpta*	A		SC
False-violet	*Dalibarda repens*	P		T
Kirtland's warbler	*Dendroica kirtlandii*	A	E	E
	Dry-mesic northern forest	C		
Dry woodland, upper Midwest type	Dry northern forest	C		
Rough fescue	*Festuca scabrella*	P		T
Common loon	*Gavia immer*	A		T
Great blue heron rookery	Great blue heron rookery	O		
Bald eagle	*Haliaeetus leucocephalus*	A	E/T	T
Henry's Elfin	*Incisalia henrici*	I		SC
Woodland vole	*Microtus pinetorum*	A		SC
Alleghany or sloe plum	*Prunus alleghaniensis var davisii*	P		SC
Grizzled skipper	*Pyrgus wyandot*	I		SC
Massasauga	*Sistrurus catenatus*	A		SC
Houghton's goldenrod	*Solidago houghtonii*	P	T	T

Table 5.–Continued.

County and common name	Scientific name or feature	Type	Federal status	State status
Kalkaska				
Arethusa or dragon's mouth	*Arethusa bulbosa*	P		SC
Hill's thistle	*Cirsium hillii*	P		SC
Spotted turtle	*Clemmys guttata*	A		SC
Wood turtle	*Clemmys insculpta*	A		SC
Kirtland's warbler	*Dendroica kirtlandii*	A	E	E
Common loon	*Gavia immer*	A		T
Great blue heron rookery	Great blue heron rookery	O		
Bald eagle	*Haliaeetus leucocephalus*	A	E/T	T
Osprey	*Pandion haliaetus*	A		T
Eastern Flat-whorl	*Planogyra asteriscus*	I		SC
Hill's pondweed	*Potamogeton hillii*	P		T
Massasauga	*Sistrurus catenatus*	A		SC
Missaukee				
Secretive locust	*Appalachia arcana*	I		SC
Wood turtle	*Clemmys insculpta*	A		SC
Common loon	*Gavia immer*	A		T
Great blue heron rookery	Great blue heron rookery	O		
Bald eagle	*Haliaeetus leucocephalus*	A	E/T	T
Loggerhead shrike	*Lanius ludovicianus migrans*	A		E
Marten	*Martes americana*	A		T
Eastern Flat-whorl	*Planogyra asteriscus*	I		SC
Hill's pondweed	*Potamogeton hillii*	P		T
Wexford				
Arethusa or dragon's mouth	*Arethusa bulbosa*	P		SC
	Bog	C		
Wood turtle	*Clemmys insculpta*	A		SC
Common loon	*Gavia immer*	A		T
Great blue heron rookery	Great blue heron rookery	O		
	Hardwood-conifer swamp	C		
Geographical feature	Kame	G		
	Landscape complex	C		
Marten	*Martes americana*	A		T
Virginia bluebells	*Mertensia virginica*	P		T
	Mesic northern forest	C		
Scrub bog, Upper Midwest type	Muskeg	C		
Wet meadow, Upper Midwest type	Northern wet meadow	C		
Ginseng	*Panax quinquefolius*	P		T
	Rich conifer swamp	C		
Manistee				
Lake sturgeon	*Acipenser fulvescens*	A		T
Geographical feature	Bluff	G		
	Bog	C		
Red-Shouldered hawk	*Buteo lineatus*	A		T
American beech (*Fagus grandifolia*)	Champion tree	O		
Northern harrier	*Circus cyaneus*	A		SC
Pitcher's thistle	*Cirsium pitcheri*	P	T	T
Wood turtle	*Clemmys insculpta*	A		SC
	Dry-mesic northern forest	C		

Table 5.–Continued.

County and common name	Scientific name or feature	Type	Federal status	State status
Manistee continued				
Great blue heron rookery	Great blue heron rookery	O		
	Emergent marsh	C		
	Great Lakes marsh	C		
Bald eagle	*Haliaeetus leucocephalus*	A	E/T	T
Dwarf-bulrush	*Hemicarpha micrantha*	P		SC
Infertile pond/marsh, Gt. Lk. type	Intermittent wetland	C		
Shrub swamp, Central Midwest type	Inundated shrub swamp	C		
Least pinweed	*Lechea minor*	P		SC
Marten	*Martes americana*	A		T
	Mesic northern forest	C		
Wet meadow, upper Midwest type	Northern west meadow	C		
Pugnose shiner	*Notropis anogenus*	A		SC
Barrens, Central Midwest type	Oak barrens	C		
Beach/shoredunes, Great Lakes type	Open dunes	C		
Clustered broom-rape	*Orobanche fasciculata*	P		T
Ginseng	*Panax quinquefolius*	P		T
Brown walker	*Pomatiopsis cincinnatiensis*	I		SC
	Poor conifer swamp	C		
Alleghany or Sloe plum	*Prunus alleghaniensis var davisii*	P		SC
King rail	*Rallus elegans*	A		E
	Rich conifer swamp	C		
Massasauga	*Sistrurus catenatus*	A		SC
	Southern floodplain forest	C		
	Southern swamp	C		
	Submergent marsh	C		
Lake Huron locust	*Trimerotropis huroniana*	I		PT
Grand Traverse				
Arethusa or dragon's mouth	*Arethusa bulbosa*	P		SC
	Bog	C		
Red-Shouldered hawk	*Buteo lineatus*	A		T
American chestnut (*Castanea dentata*)	Champion tree	O		
Basswood (*Tilia americana*)	Champion tree	O		
Black willow (*Salix nigra*)	Champion tree	O		
Eastern red-cedar (*Juniperus virginiana*)	Champion tree	O		
Ironwood, Hop-Hornbeam (*Ostrya virginiana)*	Champion tree	O		
Rock Elm, Cork Elm (*Ulmus thomasii*)	Champion tree	O		
Hill's thistle	*Cirsium hillii*	P		SC
Pitcher's thistle	*Cirsium pitcheri*	P	T	T
Wood turtle	*Clemmys insculpta*	A		SC
	Dry-mesic northern forest	C		
Dry woodland, upper Midwest type	Dry northern forest	C		
	Emergent marsh	C		
Common loon	*Gavia immer*	A		T
	Great Lake marsh	C		
Bald eagle	*Haliaeetus leucocephalus*	A	E/T	T
	Hardwood-conifer swamp	C		
Loggerhead shrike	*Lanius ludovicianus migrans*	A		E

Table 5.–Continued.

County and common name	Scientific name or feature	Type	Federal status	State status
Grand Traverse continued				
Marten	*Martes americana*	A		T
	Mesic northern forest	C		
Alkaline shrub/herb, upper Midwest type	Northern fen	C		
Osprey	*Pandion haliaetus*	A		T
King rail	*Rallus elegans*	A		E
	Rich conifer swamp	C		
Lake Huron tansy	*Tanacetum huronense*	P		T
	Wooded dune & swale complex	C		
Osceola				
Wood turtle	*Clemmys insculpta*	A		SC
Common loon	*Gavia immer*	A		T
Great blue heron rookery	Great blue heron rookery	O		
Geographical feature	Kettle	G		
Marten	*Martes americana*	A		T
Osprey	*Pandion haliaetus*	A		T
Lake				
Dense long-beaked sedge	*Carex sychnocephala*	P		T
Larch, Tamarack (*Larix laricina*)	Champion tree	O		
Hill's thistle	*Cirsium hillii*	P		SC
Spotted turtle	*Clemmys guttata*	A		SC
Wood turtle	*Clemmys insculpta*	A		SC
	Dry-mesic northern forest	C		
Dry sand prairie, Midwest type	Dry sand prairie	C		
Watercress snail	*Fontigens nickliniana*	I		SC
Common loon	*Gavia immer*	A		T
Great blue heron rookery	Great blue heron rookery	O		
Bald eagle	*Haliaeetus leucocephalus*	A	E/T	T
Dwarf-bulrush	*Hemicarpha micrantha*	P		SC
Karner blue	*Lycaeides samuelis*	I		PT
Marten	*Martes americana*	A		T
Moist sand prairie, Midwest type	Mesic sand prairie	C		
Barrens, upper Midwest type	Pine barrens	C		
Bog bluegrass	*Poa paludigena*	P		T
	Poor conifer swamp	C		
Alleghany or Sloe plum	*Prunus alleghaniensis var davisii*	P		SC
	Rich conifer swamp	C		
Massasauga	*Sistrurus catenatus*	A		SC
	Southern floodplain forest	C		
	Southern swamp	C		
	Bog	C		

Table 6.–Amphibians and reptiles in the Manistee River watershed, that require aquatic environment. Data from: Greg Schneider, University of Michigan.

Common name	Scientific name
Salamanders	
Spotted salamander	*Ambystoma maculatum*
Blue-spotted hybrid	*Ambystoma laterale*
Tiger salamander	*Ambystoma tigrinum*
Four-toed salamander	*Hemidactylium scutatum*
Mudpuppy	*Necturus maculosus*
Red-spotted newt	*Notophthalmus viridescens*
Red-backed newt	*Plethodon cinereus*
Lizards	
Five-lined skink	*Eumeces fasciatus*
Frogs	
American toad	*Bufo americanus*
Fowler's toad	*Bufo woodhousii*
Spring peeper	*Hyla crucifer*
Gray tree frog	*Hyla chrysoscelis*
Chorus frog	*Pseudacris triseriata*
Bullfrog	*Rana catesbeiana*
Green frog	*Rana clamitans*
Pickeral frog	*Rana palustris*
Leopard frog	*Rana pipiens*
Wood frog	*Rana sylvatica*
Turtles	
Softshell	*Apalone spinifera*
Snapping turtle	*Chelydra serpentina*
Painted turtle	*Chrysemys picta*
Spotted turtle	*Clemmys guttata*
Wood turtle	*Clemmys insculpta*
Blanding's turtle	*Emydoidea blandingii*
Map turtle	*Graptemys geographica*
Eastern box turtle	*Terrapene carolina*
Snakes	
Northern black racer	*Coluber constrictor*
Ringneck snake	*Diadophis punctatus*
Hognose snake	*Heterodon platyrhinos*
Milk snake	*Lampropeltis triangulum*
Water snake	*Nerodia sipedon*
Smooth green snake	*Opheodrys vernalis*
Queen snake	*Regina septemuittata*
Massasauga	*Sistrurus catenatus*
Brown snake	*Storeria dekayi*
Red-bellied snake	*Storeria occipitomaculata*
Ribbon snake	*Thamnophis sauritus*
Garter snake	*Thamnophis sirtalis*

Table 7. Common and scientific names of species referred to in text.

Common name	Scientific name
Fish	
Sea lamprey	*Petromyzon marinus*
Northern brook lamprey	*Ichthyomyzon fossor*
Chestnut lamprey	*Ichthyomyzon castaneus*
Lake sturgeon	*Acipenser fulvescens*
Alewife	*Alosa pseudoharengus*
Common carp	*Cyprinus carpio*
Pugnose shiner	*Notropis anogenus*
Blacknose dace	*Rhinichthys atratulus*
Longnose dace	*Rhinichthys cataractae*
Creek chub	*Semotilus atromaculatus*
White sucker	*Catostomus catostomus*
Silver redhorse	*Moxostoma anisurum*
Shorthead redhorse	*Moxostoma macrolepidotum*
Channel catfish	*Ictalurus punctatus*
Flathead catfish	*Pylodictis olivaris*
Northern pike	*Esox lucius*
Muskellunge	*Esox masquinongy*
Lake herring	*Coregonus artedi*
Lake whitefish	*Coregonus clupeaformis*
Coho salmon	*Oncorhynchus kisutch*
Rainbow trout (steelhead)	*Oncorhynchus mykiss*
Chinook salmon	*Oncorhynchus tshawytscha*
Round whitefish	*Prosopium cylindraceum*
Brown trout	*Salmo trutta*
Brook trout	*Salvelinus fontinalis*
Tiger trout	*Salvelinus fontinalis x Salmo trutta*
Lake trout	*Salvelinus namaycush*
Arctic grayling	*Thymallus arcticus*
Trout-perch	*Percopsis omiscomaycus*
Burbot	*Lota lota*
Mottled sculpin	*Cottus bairdi*
Slimy sculpin	*Cottus cognatus*
Rock bass	*Ambloplites rupestris*
Green sunfish	*Lepomis cyanellus*
Warmouth	*Lepomis gulosus*
Pumpkinseed	*Lepomis gibbosus*
Bluegill	*Lepomis macrochirus*
Smallmouth bass	*Micropterus dolomieu*
Largemouth bass	*Micropterus salmoides*
Black crappie	*Pomoxis nigromaculatus*
Yellow perch	*Perca flavescens*
Walleye	*Stizostedion vitreum*

Table 7.–Continued.

Common name	Scientific name
Aquatic invertebrates	
European spiny water flea	*Bythotrephes cederstroemi*
Rusty crayfish	*Orconectes rusticus*
Giant mayfly	*Hexagenia limbatta*
Stoneflies	*Plecoptera spp.*
Caddisflies	*Trichoptera spp.*
Mussels	
Zebra mussels	*Dreissena polymorpha*
Amphibians and reptiles	
Spotted turtle	*Clemmys guttata*
Wood turtle	*Clemmys insculpta*
Massasauga rattlesnake	*Sistrurus catenatus*
Mammals	
Woodland vole	*Microtus pinetorum*
White-tail deer	*Odocoileus virginianus*
Beaver	*Castor canadensis*
Elk	*Cervus canadensis*
Muskrat	*Ondatra zibethica*
Raccoon	*Procyon lotor*
River otter	*Lutra canadensis*
Mink	*Mustela vuison*
Pine martin	*Martes americana*
Avians	
Great blue heron	*Ardea herodias*
Red shouldered hawk	*Buteo lineatus*
Common loon	*Gavia immer*
Bald eagle	*Haliaectus leucocephalus*
King rail	*Rallus elegans*
Kirtland’s warbler	*Dendrocia kirtlandii*
Loggerhead shrike	*Lanius ludovicianus migrans*
Northern harrier hawk	*Circus cyancus*
Osprey	*Pandion halinetus*
Pileated woodpecker	*Dryocopus pileatus*
Mute swan	*Cygnus olor*
Insects	
Gypsy moth	*Portheivia dispir*
Forest tent caterpillar	*Malacosoma disstria*
Spruce budworm	*Choristoneura fumiferana*
Jack pine budworm	*Choristoneura pinus pinus*
Plants	
Purple loosestrife	*Lythrum salicaria*
Eurasian milfoil	*Myriophyllum sp.*

Table 8.–Manistee River gradient expressed as a change in elevation (ft/mi) from headwaters to mouth. Data from: Michigan Department of Natural Resources, Fisheries Division.. Class codes: R=river; H=impoundment created by operating hydroelectric facility. PAS=public access site.

River mile	Class code	Distance (mile)	Gradient (ft/mile)	Comments
202.67				Origin Antrim County
201.99	R	0.68	14.58	
200.05	R	1.94	5.08	
198.51	R	1.53	6.42	
197.22	R	4.29	7.63	
195.54	R	1.69	5.84	
194.72	R	0.82	12.02	
192.87	R	1.85	5.31	
190.98	R	1.88	5.22	
188.84	R	2.14	4.59	
184.51	R	4.33	2.31	County Road 612
178.51	R	6.00	1.67	M-72 Highway
175.75	R	2.76	3.62	
173.34	R	2.41	4.14	
170.92	R	2.42	4.13	
167.02	R	3.85	2.60	
162.52	R	4.55	2.20	
161.52	R	1.00	9.81	
158.93	R	2.59	3.80	
156.21	R	2.72	3.61	
154.53	R	1.67	5.88	
152.78	R	1.76	5.60	Sharon
147.77	R	5.00	1.97	
142.56	R	5.22	1.89	Smithville
139.84	R	2.71	3.63	
132.65	R	5.78	1.70	
128.43	R	1.41	6.96	
129.91	R	2.74	3.59	
126.74	R	3.17	3.11	PAS
125.04	R	1.71	5.77	
119.98	R	5.06	1.95	
117.55	R	2.43	4.05	
112.20	R	5.35	1.84	
108.37	R	3.83	2.57	Manton
104.38	R	3.98	2.47	
101.95	R	2.43	4.05	Baxter Bridge PAS
97.60	R	4.36	2.26	
94.83	R	2.77	3.55	
88.75	R	6.08	1.62	
85.95	R	2.80	3.52	
83.38	R	2.57	3.83	Harvey Bridge PAS
77.66	R	5.72	1.72	M-37 Highway

Table 8.–Continued.

River mile	Class code	Distance (mile)	Gradient (ft/mile)	Comments
76.88	R	0.78		
65.49	H	11.39	2.37	Hodenpyl Impoundment
63.45	H	2.04	4.90	Hodenpyl Impoundment
59.96	H	3.49	2.94	Hodenpyl Impoundment
58.08	H	1.88	10.80	Hodenpyl Impoundment
57.65	R	0.43	8.77	
56.40	R	1.25	7.88	
55.30	R	1.10	8.95	
53.26	R	2.04	4.98	
51.28	R	1.98	4.98	
47.66	R	3.62	2.72	
29.26	H	18.40	2.82	Tippy Dam Impoundment
25.03	R	4.23	4.65	From Tippy Dam tailwater to contour 186
16.81	R	8.22	1.20	PAS
10.40	R	6.41	1.54	Rainbow Bend PAS
6.61	R	3.80	1.30	
0.00	R	6.61	0.74	Hwy M-55 bridge

Table 9.–Pine River gradient expressed as a change in elevation (ft/mi) from headwaters to confluence with mainstem. Data from: Michigan Department of Natural Resources, Fisheries Division. Class codes: R=river; H= impoundment created by operating hydroelectric facility; I=impoundment created by a dam. PAS=public access site.

River mile	Class code	Distance (mile)	Gradient (ft/mile)	Comments
52.22	R	1.35	7.30	Confluence of East & North Branches
51.12	R	1.10	8.97	PAS
50.00	R	1.12	8.81	
48.66	R	1.34	7.33	PAS and Sprague Creek
47.31	R	1.35	7.31	Norman Road
45.53	R	1.98	4.97	Beaver Creek
43.96	R	1.37	7.19	Edgetts Bridge
42.13	R	1.84	5.36	PAS
40.83	R	1.30	7.57	PAS
40.35	R	0.47	20.74	
39.50	R	0.85	11.57	Coe Creek, Meadowbrook Bridge PAS
38.17	R	1.33	7.42	
36.64	R	1.53	6.42	Skookum Road and PAS
35.58	R	1.06	9.27	Footbridge Crossing
34.60	R	0.98	10.08	Sellers Creek
33.78	R	0.82	12.02	
32.39	R	1.39	7.06	Side Pond in Section 19
30.96	R	1.43	6.88	State Road and Walker Bridge
28.83	R	2.13	10.78	Silver Creek & Campground
27.03	R	1.9	9.15	Lincoln Bridge PAS & Elm Creek
22.96	R	4.08	4.02	Poplar Creek & PAS
20.82	R	2.13	6.15	Hoxey Creek
20.46	R	0.36	27.32	Section 34
18.90	R	1.56	6.31	Number. 50 road crossing & PAS
17.91	R	0.99	9.93	
16.91	R	1.00	9.86	Number. 48 1/2 road crossing
15.64	R	1.27	7.73	
14.90	R	0.74	13.33	
14.16	R	0.74	13.24	
13.02	R	1.14	8.66	M37 and MDNR PAS
12.44	R	0.58	16.85	
11.40	R	1.04	9.46	
11.03	R	0.37	26.82	
10.45	R	0.58	16.94	
9.84	R	0.61	16.19	
8.80	R	1.05	9.42	Section 23 Line
7.37	R	1.43	6.89	
6.22	R	1.15	3.52	Stronach Dam influence zone to impoundment
4.13	I	0.52	17.17	Stronach Impoundment
3.83	I	0.30	10.38	Stronach Impoundment
3.67	R	0.16	17.74	Stronach Dam Tailwater

Table 9.–Continued.

River mile	Class code	Distance (mile)	Gradient (ft/mile)	Comments
3.09	H	0.58	13.93	Tippy Impoundment - Section 17 Line
2.76	H	0.33	15.59	Tippy Impoundment
2.61	H	0.15	25.42	Tippy Impoundment
2.26	H	0.35	6.41	Tippy Impoundment - Section 8 Line
1.26	H	1.00	5.99	Tippy Impoundment
0.60	H	0.67	14.93	Tippy Impoundment
0.0	H	0.60	7.03	Tippy Impoundment - Manistee River confluence

Table 10.–Erosion sites by reach for the Manistee River (mainstem), Bear Creek and Pine River. Data from: Northwest Michigan Streambank Erosion Inventory, US Department of Agriculture, Soil Conservation Service, 1986. Br.=Bridge.

Reach	Length (mile)	Minor	Moderate	Severe	Total sites	Sites per mile
MANISTEE RIVER						
M-72 to Sharon	33	5	1	0	6	0.2
Sharon to Smithville	12	11	1	0	12	1.0
Smithville to Missaukee Br.	22	11	15	4	30	1.4
Missaukee Br. to Baxter Br.	38	8	23	15	46	1.2
Baxter Br. to Harvey Br.	27	6	20	45	71	2.6
Harvey Br. to Hodenpyl Dam Backwaters	26	2	7	1	10	0.4
Hodenpyl Dam to Tippy Dam Backwaters	7	0	2	62	64	9.1
Tippy Dam to Manistee Lk.	26	4	13	15	32	1.2
Manistee Lk. to Lk Michigan	2	3	9	0	12	0.8
Totals	193	50	91	142	283	1.5
BEAR CREEK						
9 Mile Rd. to Milks Rd.	2	7	15	0	22	11
Milks Rd to Coates	6	8	29	13	50	8.3
Coates to Griffith Rd.	2	5	3	2	10	5
Totals	10	20	47	15	82	8.2
PINE RIVER						
LeRoy, Osceola Co. to Skookum Br. in Dover Twnshp, Lake Co.	16	17	19	4	40	2.5
Ne-Bo-Shone Assoc. to Lincoln Br.	9	27	21	6	54	6.0
Lincoln Br.to Lake-Wexford Co. Line	5	5	5	2	12	2.4
Lake-Wexford Co line to Wexford-Manistee Co. Line	13	13	29	43	85	6.5
Wexford-Manistee line to Tippy Dam backwaters	6	15	27	23	65	10.8
Totals	49	77	101	78	256	5.2

Table 11.–Channel width analysis for the reach from Tippy Dam to below High Bridge Road. E transects were 1,300 ft downstream of Tippy Dam. F transects were 8,000 ft downstream of Tippy Dam. G transects were 13,000 ft downstream of Tippy Dam. H transects were 20,000 ft downstream of Tippy Dam. I transects were 1,000 ft downstream of High Bridge Road. Width is measured width. Lower limit is the lower bound of theoretical width at discharge. Mean width is the theoretical mean width at discharge. Upper limit is the upper bound of theoretical width at discharge. Difference is the difference between measured width and theoretical width. Status states if measured data is within theoretical bounds. Data from: Lawler, Matusky & Skelly 1991.

Location	Width (ft)	Lower limit(ft)	Mean width(ft)	Upper limit(ft)	Difference (ft)	Status
E1	220.5	168.4	247.8	364.8	-25.0	OK
E2	197.2	168.4	247.8	364.8	-49.4	OK
F1	215.7	155.3	227.5	333.4	-8.3	OK
F2	174.7	154.0	225.5	330.3	-48.9	OK
F3	175.9	156.7	229.7	336.7	-51.1	OK
F4	196.5	158.0	231.8	339.9	-33.2	OK
F5	207.4	161.6	237.4	348.6	-27.0	OK
F6	202.0	163.7	240.6	353.7	-34.8	OK
G3	214.2	161.9	237.8	349.3	-35.6	OK
G4	157.8	164.2	241.3	354.7	-83.6	Too narrow
G5	170.0	155.7	228.2	334.5	-55.9	OK
G6	172.7	157.4	230.8	338.4	-57.4	OK
H2	169.0	166.0	244.2	359.2	-72.4	OK
H3	179.1	152.0	222.4	325.4	-42.3	OK
H4	143.8	163.0	239.6	352.0	-92.6	Too narrow
H5	160.4	168.0	247.2	363.8	-83.4	Too narrow
H6	186.7	164.3	241.5	355.0	-54.0	OK
I1	246.7	164.5	241.9	355.6	16.9	OK
I2	194.0	160.7	236.0	346.4	35.6	OK
I3	290.7	164.4	241.7	366.3	43.2	OK
I4	313.4	176.7	260.8	385.0	82.6	OK

Table 12.–Channel width analysis for reach below Hodenpyl Dam to Slagle Creek. P transects were 18,000 ft downstream of Hodenpyl Dam. Q transects were 23,000 ft downstream of Hodenpyl Dam. R transects were located at the mouth of Slagle Creek (29,000 ft downstream of dam). Width is measured width. Lower limit is the lower bound of theoretical width at discharge. Mean width is theoretical mean width at discharge. Upper limit is the upper bound of theoretical width at discharge. Difference is the difference between measured and theoretical width. Status states if measured data is within theoretical bounds. Data from: Lawler, Matusky & Skelly 1991.

Location	Width (ft)	Lower limit (ft)	Mean width (ft)	Upper limit (ft)	Difference	Status
P1	122.4	128.1	185.6	269.0	-58.6	Too narrow - 1.1 ft
P2	107.9	127.5	184.7	267.5	-77.3	Too narrow - 20.1 ft
P3	130.6	135.0	196.2	285.1	-59.7	OK
P4	166.6	131.7	191.2	277.5	-21.6	OK
P5	136.6	125.6	181.7	263.1	-43.6	OK
P6	99.3	128.1	185.6	269.0	-80.7	Too narrow - 23.2 ft
Q1	146.5	145.8	212.9	310.8	-60.9	OK
Q2	149.1	149.2	218.1	318.8	-65.3	OK
Q3	124.6`	141.9	206.8	301.5	-80.9	Too narrow - 16.0 ft
Q4	128.3	141.0	205.5	299.4	-59.3	OK
Q5	157.9	139.7	203.5	296.4	-43.7	OK
Q6	192.8	142.5	207.7	302.8	-105.1	Too narrow - 39.9 ft
Q7	199.2	151.0	220.8	323.0	-18.4	OK
Q8	116.6	139.7	203.5	296.4	-81.7	Too narrow - 12.9 ft
R1	108.7	140.4	204.5	297.9	-76.0	Too narrow - 11.9 ft
R2	123.9	141.1	205.6	299.6	-72.9	Too narrow - 8.4 ft
R3	120.0	143.5	209.3	305.3	-89.6	Too narrow - 23.8 ft
R4	120.0	144.9	211.5	308.7	-91.8	Too narrow - 25.2 ft
R5	101.4	144.3	210.5	307.1	-104.0	Too narrow - 37.8 ft
R6	123.3	143.1	208.7	304.4	-82.7	Too narrow - 17.1 ft
R7	132.9	143.0	208.6	304.1	-70.6	Too narrow - 5.0 ft

Table 13.–Channel width analysis for minor Manistee River tributaries. Transect is data collection site. Discharge column is discharge for which the data is presented. Width column is the measured width. Lower limit column is the lower bound of the theoretical width at discharge. Mean width column is the theoretical mean width at discharge. Upper limit is the upper bound of the theoretical width at discharge. Difference column is the difference between measured width and theoretical width. Status column refers to whether measured data is within theoretical bounds. Calculated width data for the Manistee River - based on IFIM data. All measurements are in feet. Data were collected by US Geological Survey.

	Calculated	Theoretical	Width	Bounds				Difference
Transect	Width	Mean	Difference	Upper	Lower	CFS	Status	by (feet)
Goose Creek	18.0	21.8	3.8	28.1	16.9	15.70	OK	
Portage Creek	25.0	27.5	-2.5	35.9	21.0	25.10	OK	
Big Cannon Creek	24.0	30.0	-6.0	39.4	22.8	29.90	OK	
N. Br. Manistee-Sharon	12.0	26.5	-14.5	34.5	20.3	23.30	too narrow	8.3
N. Br. Manistee-Diversion	22.5	18.9	3.6	24.3	14.8	11.90	OK	
Slagel Creek - Below hatchery	13.0	21.6	-8.6	27.9	16.8	15.60	too narrow	3.8
Slagel Creek - 120’ above dam	18.5	14.8	3.7	18.7	11.7	7.28	OK	
Slagel Creek - below race	22.8	12.0	10.8	15.0	9.6	4.76	too wide	7.8
Slagel Creek - south of bridge	10.5	10.9	-0.4	13.5	8.8	3.91	OK	
Slagel Creek - above bridge	10.3	11.0	-0.8	13.7	8.9	4.01	OK	

Table 14.–Channel diversity analysis for reach from Tippy Dam to High Bridge Road. E transects were 1,300 ft downstream of Tippy Dam. F transects were 8,000 ft downstream of Tippy Dam. G transects were 13,000 ft downstream of Tippy Dam. H transects were 20,000 ft downstream of Tippy Dam. I transects were 1,000 ft downstream of High Bridge. Width is actual measured width. Discharge is cfs for which diversity is calculated. Number of samples refers to number of data points used in diversity calculation. Channel diversity is the cross-sectional diversity index value using Shannon-Wierner diversity index. Percent maximum diversity is channel diversity divided by maximum possible diversity. Number of different cells is number of different combinations of velocity and depth in cross-section. Percent different cells is the number of different combinations divided by number of samples. Data from: Lawler, Matusky & Skelly 1991.

Location	Width (ft)	Discharge (cfs)	Number of samples	Channel diversity	Percent maximum diversity	Number different cells	Percent different cells
E1	220.5	2068	36	2.70	75.4	17	47.2
E2	197.2	2068	44	3.14	82.9	26	59.1
F1	215.7	1742	53	3.08	77.5	26	49.1
F2	174.2	1712	36	3.07	85.7	23	63.9
F3	175.9	1776	36	2.93	81.8	21	58.3
F4	196.5	1808	40	2.98	80.7	25	62.5
F5	207.4	1897	21	2.75	90.3	17	81.0
F6	202.0	1950	48	3.25	84.0	29	60.4
G3	214.2	1904	43	3.20	85.0	28	65.1
G4	157.8	1960	32	3.24	93.6	28	87.5
G5	120.0	1753	35	3.23	90.9	27	77.1
G6	122.7	1293	44	3.16	83.4	28	63.6
H2	169.0	2008	34	3.02	85.5	23	67.6
H3	129.1	1664	45	3.26	85.6	24	53.3
H4	143.8	1932	29	3.03	90.0	22	75.0
H5	160.4	2058	33	3.13	89.4	26	78.8
H6	186.7	1964	38	3.48	95.8	34	89.5
I1	246.7	1970	66	3.43	82.9	41	62.1
I2	194.0	1874	47	2.98	77.5	24	51.1
I3	290.7	1966	61	3.14	76.4	30	49.2
I4	313.4	2292	67	336.00	79.8	36	53.7

Table 15.–Channel diversity analysis for reach from Hodenpyl Dam to Slagle Creek. P transects were 18,000 ft downstream of Hodenpyl Dam. Q transects were 23,000 ft downstream of Hodenpyl Dam. R transects were 29,000 ft downstream of Hodenpyl Dam just above Slagle Creek. Width is actual measured width. Discharge is cfs for which diversity is calculated. The Nimber of samples refers to number of data points used in diversity calculation. Channel diversity is the cross-sectional diversity index value using the Shannon-Wierner diversity index. Number of different cells is number of different combinations of velocity and depth in the cross-section. Percent different cells is number of different combinations divided by number of samples. Data from: Lawler, Matusky & Skelly 1991.

Location	Width (ft)	Discharge (cfs)	Number of samples	Channel diversity	Percent maximum diversity	Number different cells	Percent different cells
P1	122.4	1158	35	2.79	78.4	21	60.0
P2	107.9	1146	22	2.75	89.0	17	77.3
P3	130.6	1294	24	2.89	90.8	21	87.5
P4	166.6	1229	34	2.92	82.7	22	64.7
P5	136.6	1110	26	2.82	86.7	19	73.1
P6	99.3	1158	23	2.81	89.7	18	78.3
P7	131.0	1139	26	2.93	90.1	22	84.6
P8	140.0	1176	32	3.05	87.9	25	78.1
Q1	146.5	1525	21	2.84	93.3	18	85.7
Q2	149.1	1600	22	2.42	78.1	14	63.6
Q3	124.6	1439	25	2.53	78.6	16	64.0
Q4	128.3	1420	26	2.69	82.6	17	65.4
Q5	157.9	1393	30	2.52	73.9	16	53.3
Q6	192.8	1451	37	3.08	85.4	25	67.6
Q7	199.2	1641	46	3.46	90.4	35	76.1
Q8	116.6	1393	20	2.64	88.0	16	80.0
R1	108.7	1406	27	3.11	94.2	23	85.2
R2	123.9	1422	27	2.86	86.7	21	77.8
R3	120.0	1474	24	2.94	92.5	20	83.3
R4	120.0	1505	34	3.22	88.2	24	70.6
R5	101.4	1490	22	2.68	86.7	17	77.3
R6	123.3	1465	27	2.98	90.5	21	77.8
R7	132.9	1463	27	2.66	80.6	18	66.7

Table 16.–Channel diversity analysis for minor Manistee River tributaries. Location is data collection site. Discharge is cfs for which data are presented. Number of samples refers to number of data points used in diversity calculation. Channel diversity is the cross-sectional diversity index value using Shannon-Wiener diversity index. Percent maximum diversity is channel diversity divided by maximum possible diversity. Number of different cells is number of different combinations of velocity and depth in the cross-section. Percent different cells is number of different combinations divided by number of samples. Data from: US Geological Survey.

Location	Discharge (cfs)	Number of samples	Channel diversity	Percent maximum diversity	Number different cells	Percent different cells
Goose Creek	15.7	23	1.00	31.9	4	17.4
Portage Creek	25.1	23	1.64	52.4	6	26.1
Big Cannon Creek	29.9	22	2.05	66.5	9	40.9
N. Br. Manistee River	23.3	23	1.73	55.2	7	30.4
N. Br. Manistee River	11.9	21	1.24	40.8	4	19.0
Slagle Creek @ hatchery	15.5	25	0.74	23.0	4	16.0
Slagle Creek @ Slagle Club	7.3	25	1.29	40.0	4	16.0
Slagle Creek @ Slagle Club	4.8	28	1.37	41.1	5	17.9
Slagle Creek above Co. Line Rd.	3.9	21	0.66	21.8	2	9.5
Slagle Creek below Co. Line Rd.	4.0	20	0.69	23.1	2	10.0

Table 17.–Land ownership within the Manistee River watershed by river segment. Date from: US Department of Agriculture, Forest Service (1983) and Michigan Department of Natural Resources, Lands Division.

Segment	Private	State	Federal	Consumers Energy	Total
1	840	2,490	--	--	2,520
2	4,770	1,610	--	310	7,500
3	3,120	12,060	--	520	15,700
4	--	--	1,720	--	1,720
5	1,220	2,330	5,370	--	8,920
6	800	2,160	--	--	2,960
7	2,540	20	1,080	--	3,640
8	3,600	1,400	4,040	--	9,040
Totals	16,890	22,070	12,210	830	52,380

Table 18.–Statutes administered by Michigan Department of Environmental Quality, Land and Water Management Division, that affect the aquatic resource. Adapted from Bean and Braunscheidel (1996).

State of Michigan Acts	Previous statute
Public Health Code (1978 PA 386, as amended)	Amendments to Aquatic Nuisance Control Act (PA 86, 1977)
Part 13 N.R.P. Act(1994 PA 451)	Floodplain Regulatory Authority(PA 167, 1968)
Part 91 N.R.P. Act (1994 PA 451)	Soil Erosion and Sedimentation Control Act (PA 347, 1972)
Part 301 N.R.P. Act (1994 PA 451)	Inland Lakes and Streams Act(PA 346, 1972)
Part 303 N.R.P. Act (1994 PA 451)	Wetland Protection Act (PA 203, 1979)
Part 307 N.R.P. Act (1994 PA 451)	Inland Lake Level Act (PA 146, 1961)
Part 309 N.R.P. Act (1994 PA 451)	Inland Improvement Act (PA 345, 1966)
Part 315 N.R.P. Act (1994 PA 451)	Dam Safety Act (PA 300, 1989)
Part 323 N.R.P. Act (1994 PA 451)	Shoreland Protection and Management Act (PA 245, 1970)
Part 325 N.R.P. Act (1994 PA 451)	Great Lakes Submerged Lands Act (PA 247, 1955)
Part 341 N.R.P. Act (1994 PA 451)	Irrigation District Act (PA 205, 1967)

US Federal Acts
Federal Water Pollution Control Act, Section 314 (PL 92-55)
Coastal Zone Management Act (PL 92-583, 1972)
Clean Water Act, Section 404 (PL 95-217)
River and Harbor Act, Section 10 (1899)
Coastal Energy Impact Program (PL 92-538)

Table 19.–Designated drains in the Manistee River watershed, by county and township. Data from: county drain offices. Total drains=40.

Missaukee County	Manistee County
Bloomfield Township	*Manistee Township*
Golden Creek Drain	Bar Lake Drain
Ham Creek Drain	Gromer Drain
	McGuineas Drain
Wexford County	*Maple Grove Township*
Liberty Township	Maple Grove Drain
Cedar Creek #1	Litzan Drain
Cedar Creek #2	Bond Drain
Harmon Drain	Lindruse Luomala Drain
Liberty #4	Big Kaiser Drain
Liberty Hwy.	*Springdale Township*
Liberty Valley Hwy	Bear Creek Drain
Missaukee-Wexford Drain	*Bear Lake Township*
Seaman Drain	Big Kaiser Drain
Cedar Creek Township	Chief Lake Drain
Manton Creek Drain	Gustafson Drain
Manton Lagoon Drain	Schoolhouse Drain
Greenwood Township	Beaver Creek Drain
Briggs Drain	*Brown Township*
Colfax Drain	Chief Lake Drain
Greenwood Drain	*Filer Township*
	Green Lake Drain
Osceola County	*Pleasanton Township*
Burdell Township	Lumley Drain
Burdell Drain #1	*Norman Township*
LeRoy Township	Mud Lake Drain
Beaver Creek Drain	
LeRoy Drain #2	
Rose Lake Township	
Rose Lake Drain	
Rose Lake Drain #1	
Rose Lake Drain #2	
Rose Lake Drain #3	

Table 20.–Access and campground facilities along the Manistee River. Data from: US Department of Agriculture, Forest Service 1983. USFS=US Forest Service.

	Access		Campgrounds				
Sites	Road right of way	Developed site	County	Private	State	USFS	Number of campsites
Mancelona Bridge	X				X		
Cameron Bridge	X				X		
612 Bridge	X				X		
Manistee River Forest Camp 1& 2		X			X		26
Manistee River Camp - 72		X			X		24
T26N, R5W, Sec. 30	X				X		
CCC Camp		X			X		25
T25N, R6W, Sec. 3	X				X		
North Sharon Road	X				X		
West Sharon Road		X			X		
T25N, R7W, Sec. 22	X				X		
M-66 Campground				X			15
Smithville		X			X		19
M-66 Bridge	X				X		
Rainbow Jim		X			X		
Missaukee Bridge		X	X				
Chase Creek		X			X		9
Highway 131 Bridge							
Roadside Park		X			X		
Old 131 Camp		X			X		23
Baxter Camp		X			X		18
Baxter Bridge		X			X		
Indian Trail Camp		X			X		12
Harvey Bridge		X			X		
Sherman Bridge	X				X		
High Bridge		X				X	15
Blacksmith Bayou		X				X	12
Bear Creek		X				X	
Rainbow Bend		X				X	20
Coho Bend				X			30
Udell Rollway						X	23
M-55 Bridge	X				X		
Access 67-1		X			X		
Access 67-5		X			X		
Lakola Road	X		X		X		
Edgetts Bridge		X					
Meadow Brook Bridge		X			X		
Skookum Bridge (2)		X			X		
Walker Bridge	X				X		
Hi School Bridge	X		X				
Silver Creek Campground		X			X		

Table 20.–Continued.

Sites	Access: Road right of way	Access: Developed site	Campgrounds: County	Campgrounds: Private	Campgrounds: State	Campgrounds: USFS	Campgrounds: Number of campsites
Lincoln Bridge Campground		X			X		
Elm Flats		X				X	
Dobson Bridge		X				X	
Peterson Access		X				X	
Peterson Bridge		X			X		
Skookum Bridge	X				X		

Table 21.–Dam inventory, Manistee River system. Data from: Michigan Department of Environmental Quality, Land and Water Management Division. Trib.=tributary.

Dam	River	Town	Range	Section	Head	Acre ft
Crawford						
Lake Margrethe	Portage Creek	26N	4W	8	3	N/A
Kalkaska						
Lutz Dam	Trib. Maple Ck.	25N	7W	12		
Gray Dam	Waterhole Ck.	25N	7W	16	2	
Goulait Dam	Little Silver Ck	25N	7W	27	20	15
Simmons Dam	Trib. Manistee R.	25N	8W	22	8	
Gould Dam	Springfed trib. to Gould Creek	25N	8W	30	2	
Vantol Dam	Bourne Creek	25N	8W	32	3	
Williams Dam	Trib. Manistee R.	25N	8W	31	3	
Condon Dam	Trib. Manistee R.	25N	8W	31		
Ash Dam	Fife Lake outlet	25N	8W	18	2	
Skinner Dam	Inlet Ck.	25N	8W	17		
Goose Creek Imp. Dam	Goose Ck.	27N	5W	1		
Cotton Dam	Collar Ck.	27N	6W	28	2	
Missaukee						
Cannon Creek Dam #1	Big Cannon Ck.	24N	5W	7		
Cannon Creek Dam #2	Big Cannon Ck.	24N	6W	12	4	60
Horseshoe Lake Dam	Big Cannon Ck.	24N	6W	2	11	135
Missaukee Walleye Rearing Pond Dam	Trib. Morrisy Ck.	24N	8W	31	5	
Hamm Creek Dam	Trib. Hamm Ck.	24N	8W	10	3	1
Jenkins Dam	Trib Morrisy Ck.	24N	8W	31	11	10
Wexford						
Malstrom Dam	Trib. N. Br. Pine	21N	10W	35	5	5
Norman Smith Dam	Trib. Spaulding Ck.	21N	10W	23	16	105
Korr Dam	Yates Ck.	21N	12W	23	6	
Carlson Dam #2	Yates Ck.	21N	12W	22	8	
Olga Lake Dam	Coe Ck.	22N	11W	36	5	145
Bayma Dam	Slagle Ck.	22N	11W	17	5	4
Slagle Trout Club Dam	Slagle Ck.	22N	12W	6	6	115
Corlett Dam	Slagle Ck.	22N	12W	6	12	
Manton Millpond Dam	Manton Ck.	23N	9W	4	10	230
Manton Upper Power Dam	Manton Ck.	23N	9W	3	11	260
Brooke Dam	Trib. Soper Ck.	23N	10W	5	8	
Spink Dam	Burkett Ck.	23N	11W	6	30	
McNitt Dam	Trib. Hodenpyl Pd	23N	11W	14	3	2
Carnahan Dam	Ferguson L. Outlet	23N	11W	3		
Barnes Dam	Trib. Adams Ck.	23N	11W	11	17	84
Jackson Dam	Burkett Ck.	23N	11W	7	6	
Von Hofe Dam	Seaton Ck.	23N	12W	32	4	4

Table 21.–Continued.

Dam	River	Town	Range	Section	Head	Acre ft
Wexford continued						
Taylor Dam	East Chase Ck.	24N	9W	26	3	
Woodworth Dam	Trib. Buttermilk Ck.	24N	9W	32	5	6
Parks No. One Dam	Silver Ck.	24N	10W	36	10	
Parks No. Two Dam	Silver Ck.	24N	10W	36	10	
Kerr Upper Dam	Trib. Manistee R.	24N	11W	31	25	25
Kerr Lower Dam	Trib. Manistee River	24N	11W	31	11	5
Guthrie Dam	Wheeler Ck.	24N	11W	31	24	12
Wheeler Ck. Dam	Wheeler Ck.	24N	11W	8	17	892
Nehez Dam	Trib. Fletcher Ck.	24N	12W	5	10	10
Manistee						
Easterling Dam	Pine Ck.	21N	13W	19	4	
Prunski Dam	Trib. Pine R.	21N	13W	27		16
Stronach Dam	Pine River	21N	13W	16	18	180
Sunnybrook Dam	Pine River	21N	13W	32		
Manistee Sport & Fishing Club Dam	Pine Ck.	21N	14W	8	2	
Manistee marsh Dam	Manistee River	21N	16W	6		
Tippy Dam	Manistee River	22N	13W	31	56	39,500
Schneiders Dam	Chief Creek	22N	15W	16	5	60
Hodenpyl Dam	Manistee River	23N	12W	30	68	60,700
Benton Dam	Lemon Creek	23N	13W	6	4	
Nimitalo’s Dam	Cedar Ck.	23N	14W	24	4	
Beneke Dam	Unnamed trib.	23N	14W	35		
Copemish Dam	First Ck.	24N	13W	18	8	160
Grand Traverse						
Headquarters Lake Dam	Fife Lake outlet	25N	9W	26	5	190
Walton Dam	Walton Outlet Ck.	25N	9W	33	3	12
Osceola						
Hatt Dam	Little Beaver Ck.	19N	10W	19	4	10
Barztel Dam	Trib. Pine River	19N	10W	6		
Lake						
Crystal Springs Trout Ranch Dam	Unnamed trib to Pine R.	19N	11W	3	7	
Streator Dam	Silver Ck.	20N	11W	16		

Table 22.–Value estimates for annual turbine mortalities at Hodenpyl and Tippy dams. Entrainment and mortality data from: Lawler, Matusky & Skelly Engineers, 1991. *threatened species. **average weight of each fish is 2.85 pounds.

Species	Average length (cm)	Percent composition	Entrained	Mortality	Replacement value/fish	Restitution value/fish	Total replacement value	Total restitution value
TIPPY								
Golden redhorse	33.4	0.3	396	78	$0.40	$5.00	$31.20	$390
River redhorse*	36.1	0.3	396	78	$0.40	$5.00	$31.20	$390
Shorthead redhorse	31.6	1.0	1319	259	$0.40	$5.00	$103.60	$1,295
White sucker	38.3	32.0	42,203	8,272	$0.50	$5.00	$4,136.00	$41,360
Black crappie	5.2	3.1	4,088	801	$0.43	$10.00	$344.43	$8,010
Bluegill	14.1	3.8	5,012	982	$0.86	$10.00	$844.52	$9,820
Green sunfish	12.7	0.7	923	181	$0.69	$10.00	$124.89	$1,810
Pumpkinseed	12.0	1.0	1,319	259	$0.66	$10.00	$170.94	$2,590
Rock bass	14.0	3.4	4,484	879	$0.85	$5.00	$747.15	$4,395
Smallmouth bass	24.7	17.2	22,684	4,446	$2.89	$10.00	$12,848.94	$44,460
Sunfish species	10.5	0.3	396	78	$0.62	$10.00	$48.36	$780
Gizzard shad	33.6	3.1	4,088	801	$0.75	$5.00	$200.25	$4,005
Spottail shiner	10.5	0.3	396	78	$0.06	$5.00	$4.68	$390
Burbot	17.3	0.7	923	181	$1.00	$5.00	$181.00	$905
Logperch	4.5	0.3	396	78	$0.06	$5.00	$4.68	$390
Walleye	36.1	3.4	4,484	879	$3.71	$10.00	$3,261.09	$8,790
Yellow perch	11.1	2.1	2,770	543	$0.32	$10.00	$173.76	$5,430
Trout-perch	7.5	14.4	18,991	3,722	$0.06	$5.00	$223.32	$18,610
Brown trout	34.5	10.0	13,188	2,585	$1.89	$10.00	$4,885.65	$25,850
Rainbow trout	12.0	0.3	396	78	$0.38	$10.00	$30.42	$780
Unidentified	10.5	2.1	2,770	543	$0.06	$5.00	$32.58	$2,715
Totals			31,622	25,801			$28,427.88	$183,165

Table 22.–Continued.

Species	Average length (cm)	Percent composition	Entrained	Mortality	Replacement value/fish	Restitution value/fish	Total replacement value	Total restitution value
HODENPYL								
Black crappie	4.5	7.4	11,177	2,191	$0.39	$10.00	$854.49	
Bluegill	4.2	0.8	1,208	236	$0.34	$10.00	$80.24	
Chestnut lamprey	18.2	0.2	302	59	$0.06	$0.00	$3.54	
Logperch	4.3	3.6	5,438	1,066	$0.06	$5.00	$63.96	
Northern pike	59.5	0.2	302	59	$12.60	$30.00**	$743.40	
Rock bass	12.0	0.9	1,359	266	$0.66	$5.00	$175.56	
Smallmouth bass	3.7	4.2	6,344	1,243	$0.40	$10.00	$497.20	
Spottail shiner	6.8	2.8	4,229	829	$0.06	$5.00	$49.74	
Trout-perch	5.4	75.0	113,283	22,203	$0.06	$5.00	$1,332.18	
Walleye	21.3	0.8	1,208	236	$2.01	$10.00	$474.36	
Yellow perch	7.8	3.3	4,984	977	$0.21	$10.00	$205.17	
Centrarchidae	4.6	0.2	302	59	$0.36	$10.00	$21.24	
Unidentified	3.0	0.6	906	178	$0.06	$5.00	$10.68	
Totals			151,042	29,602			$4,511.76	

Table 23.–National Pollution Discharge Elimination System permits issued in the Manistee River watershed. Data from: Michigan Department of Environmental Quality, Surface Water Quality Division.

Permittee	Watercourse
Flowing Well Trout Farm	North Br. Manistee River
MDNR - Harrietta State Fish Hatchery	Slagle Creek
McNitt Trout Farm	Slagle Creek
M R Products, Inc.	Copemish Pond (First Creek)
Consumers Energy Co - Hodenpyl hydroelectric facility	Manistee River
Consumers Energy Co - Tippy hydroelectric facility	Manistee River
Packaging Corporation of America	Manistee Lake
Morton Salt	Manistee Lake
AKZO Salt	Manistee Lake
Morton International	Manistee Lake
Martin Marietta	Manistee Lake
City of Manistee - Waste Water Treatment Plant	Manistee Lake

Table 24.–Act 307 sites in the Manistee River watershed, by county, as of 1991. Data from: Michigan Department of Environmental Quality, Environmental Response Division.

County	Oil & gas related	Storage tanks	Industry	Other	Unknown	Total
Crawford	--	2	--	--	--	2
Kalkaska	7	1	--	1	--	9
Missaukee	--	--	--	--	1	1
Wexford	9	2	1	4	2	18
Manistee	30	5	10	4	11	60
Gr. Trav.	10	1	--	--	1	12
Osceola	--	1	--	--	1	2
Lake	--	--	--	--	1	1
Totals	56	12	11	9	17	105

RIVER SEGMENTS

Seg 1 - Headwaters to M-72
Seg 2 - M-72 to Smithville (M-66)
Seg 3 - Smithville (M-66) to M-115 Bridge
Seg 4 - Hodenpyl Dam to Red Bridge (Coates Hwy)
Seg 5 - Tippy Dam to M-55 Bridge
Seg 6 - North Branch Manistee River
Seg 7 - Bear Creek
Seg 8 - Pine River

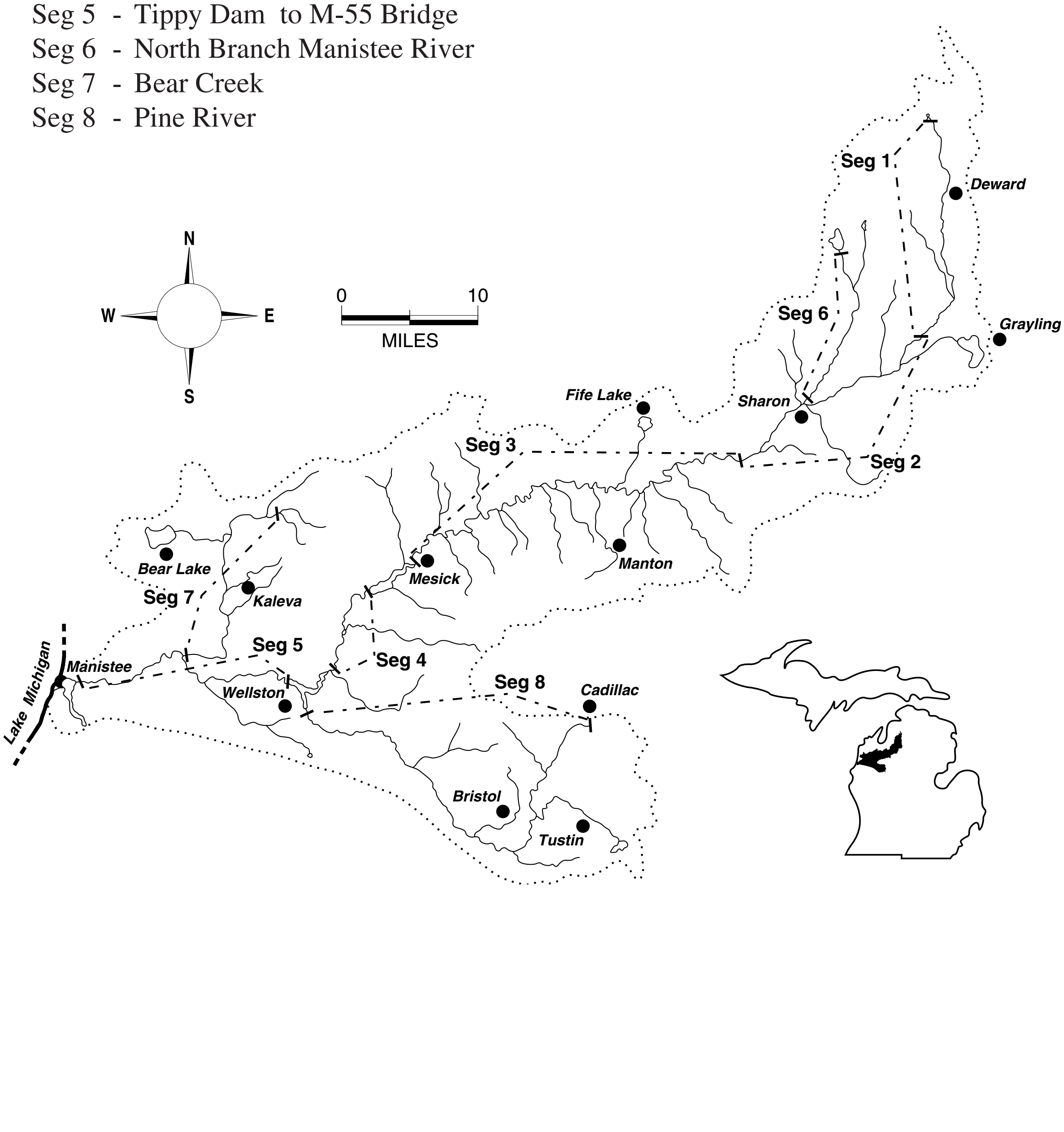


Figure 1.–The Manistee River watershed in northwestern lower Michigan.

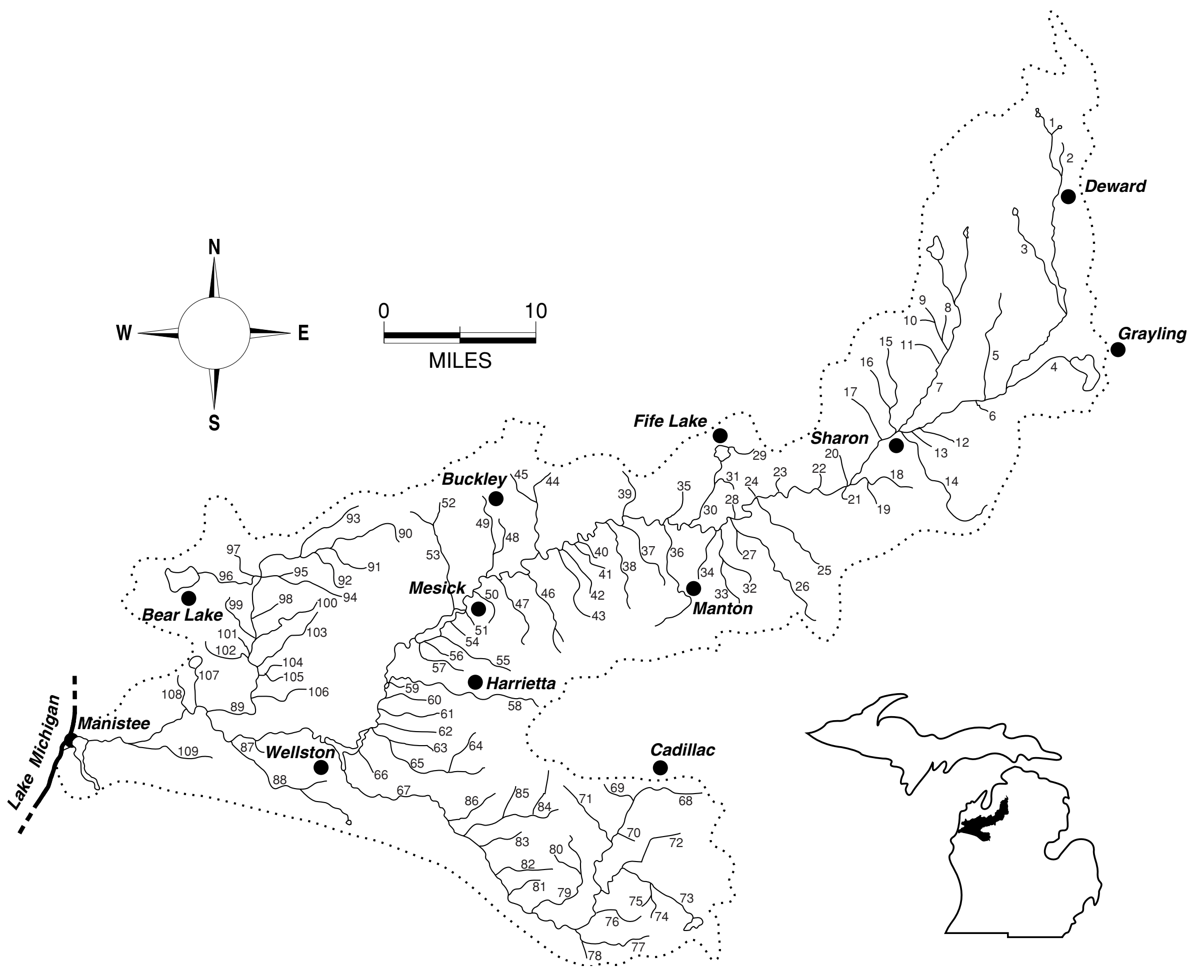


Figure 2.–Major tributaries of the Manistee River.

1. Deer Lake Outlet
2. Frenchman's Creek
3. Goose Creek
4. Portage Creek
5. Black Creek
6. Clear Creek
7. North Branch Manistee
8. Flowing Well Creek
9. Morrison Creek
10. Collar Creek
11. Sands Creek
12. Devil Creek
13. Little Devil Creek
14. Cannon Creek
15. Pierson Creek
16. Willow Creek
17. Maple Creek
18. Little Cannon Creek
19. Silver Creek
20. Waterhole Creek
21. Filer Creek
22. Nelson Creek
23. Spring Creek
24. Bourne Creek
25. Ham Creek
26. Hopkins Creek
27. Voice Creek
28. Bridson Creek
29. Fife Lake Inlet
30. Fife Lake Outlet
31. Gould Creek
32. Golden Creek
33. Morrisy Creek
34. Chase Creek
35. Walton Outlet
36. Manton (Cedar) Creek
37. Buttermilk Creek
38. Silver Creek
39. Sands Creek
40. Apple Creek
41. Blind Creek
42. Filer Creek
43. Soper Creek
44. Anderson Creek
45. West Branch Anderson Creek
46. Adams Creek
47. Cole Creek
48. East Branch Wheeler Creek
49. Wheeler Creek
50. Burkett Creek
51. Preston Creek
52. Cotton Creek
53. Fletcher Creek
54. Cripple Creek
55. Small Creek
56. Tar Creek
57. Seaton Creek
58. Slagle Creek
59. Dead Creek
60. Cedar Creek
61. Arguilla Creek
62. Hinton Creek
63. Sands Creek
64. Johnson Creek
65. Peterson Creek
66. Snyders Creek
67. Pine River
68. North Branch Pine River
69. Spalding Creek
70. Sixteen Creek
71. Fairchild (Negro) Creek
72. East Branch Pine River
73. Rose Lake Outlet
74. Edgett Creek
75. Diamond Lake Outlet
76. Sprague Creek
77. Beaver Creek
78. Little Beaver Creek
79. Coe Creek
80. Dyer Creek
81. Sellars Creek
82. Silver Creek
83. Elm Creek
84. Poplar Creek
85. Dowling Creek
86. Hoxie Creek
87. Sylvan Creek
88. Pine Creek
89. Bear Creek
90. First Creek
91. Second or Hatches Creek
92. Third Creek
93. Dutchman Creek
94. Lemon Creek
95. Healy Lake Outlet
96. Little Bear Creek
97. Green's Creek
98. Halls Creek
99. Arner Creek
100. Big Beaver Creek
101. Williamson Creek
102. Little Beaver Creek
103. Cedar Creek
104. Chicken Creek
105. Podunk Creek
106. Boswell Creek
107. Chief Creek
108. Sickle Creek
109. Claybank Creek

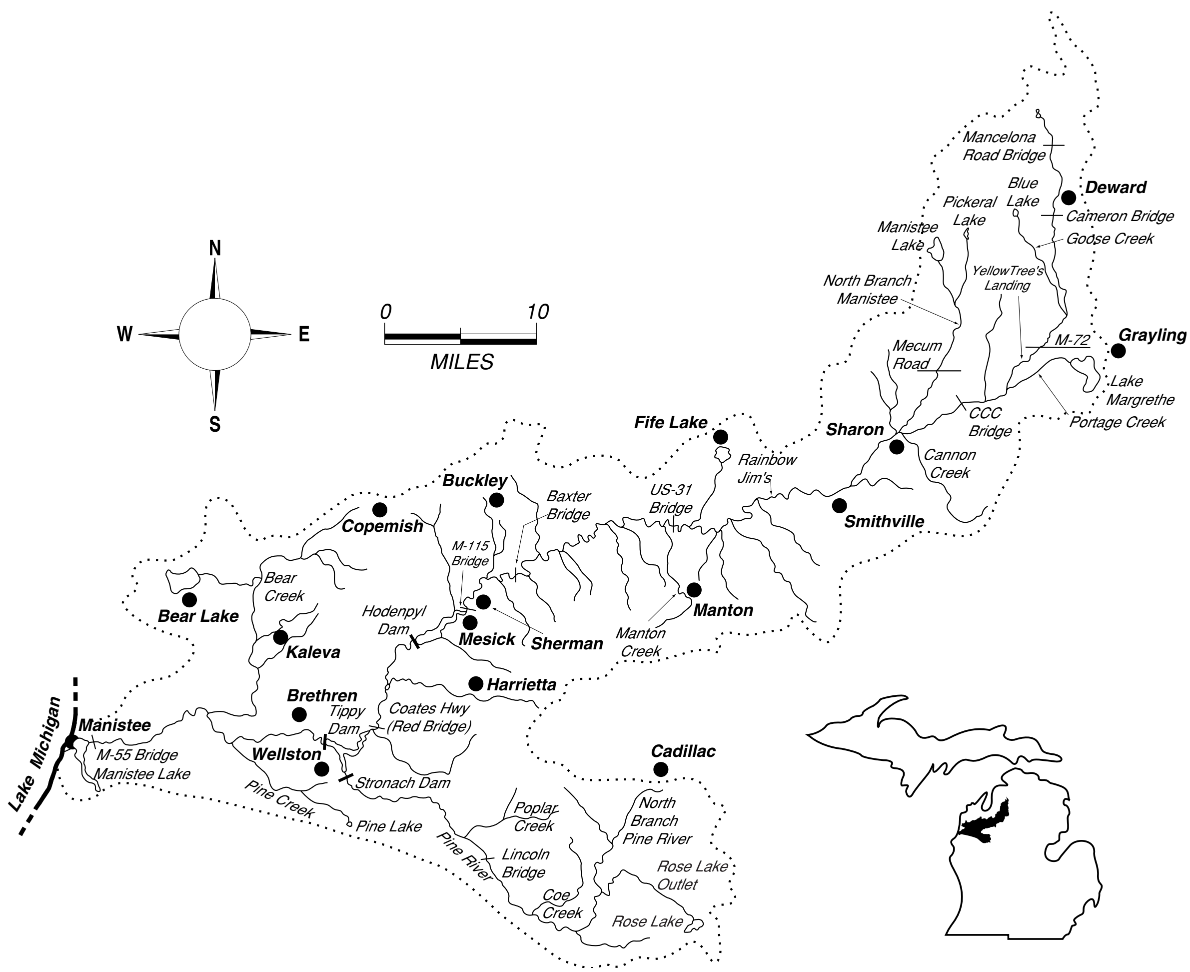


Figure 3.–General sites within watershed.

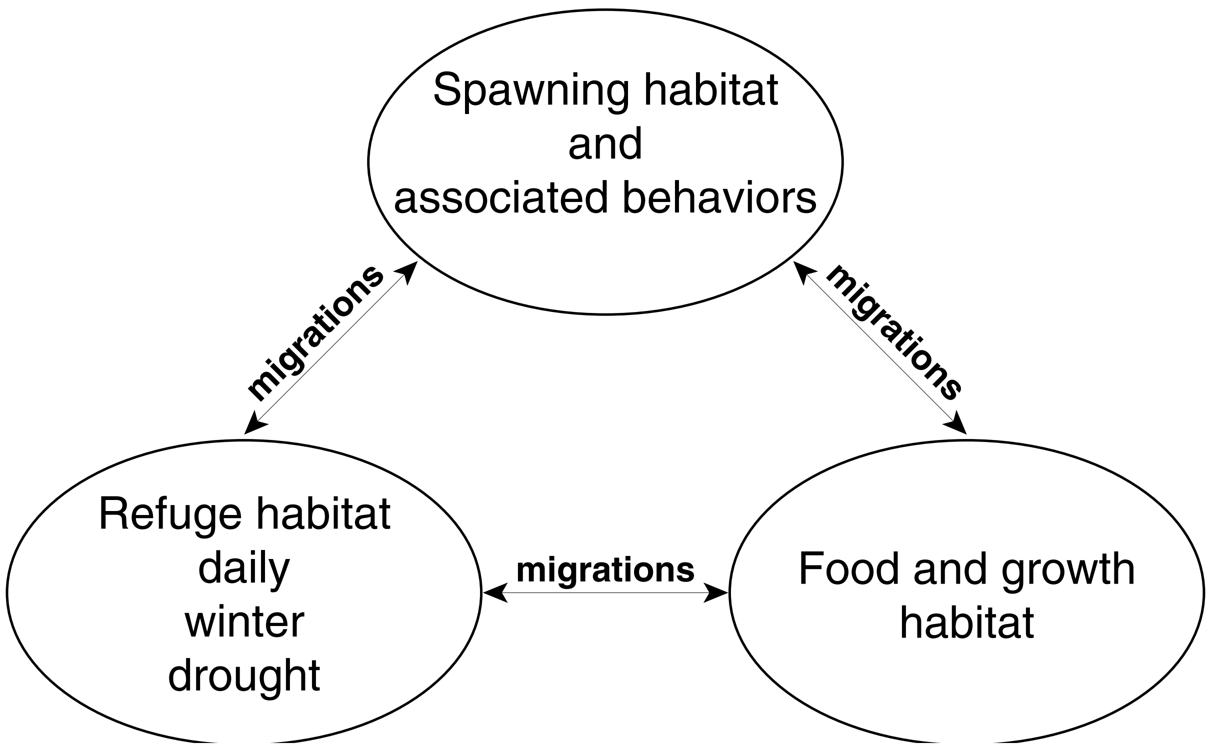


Figure 4.–The basic life cycle of stream fish with respect to habitat use (adapted from Schlosser 1991).

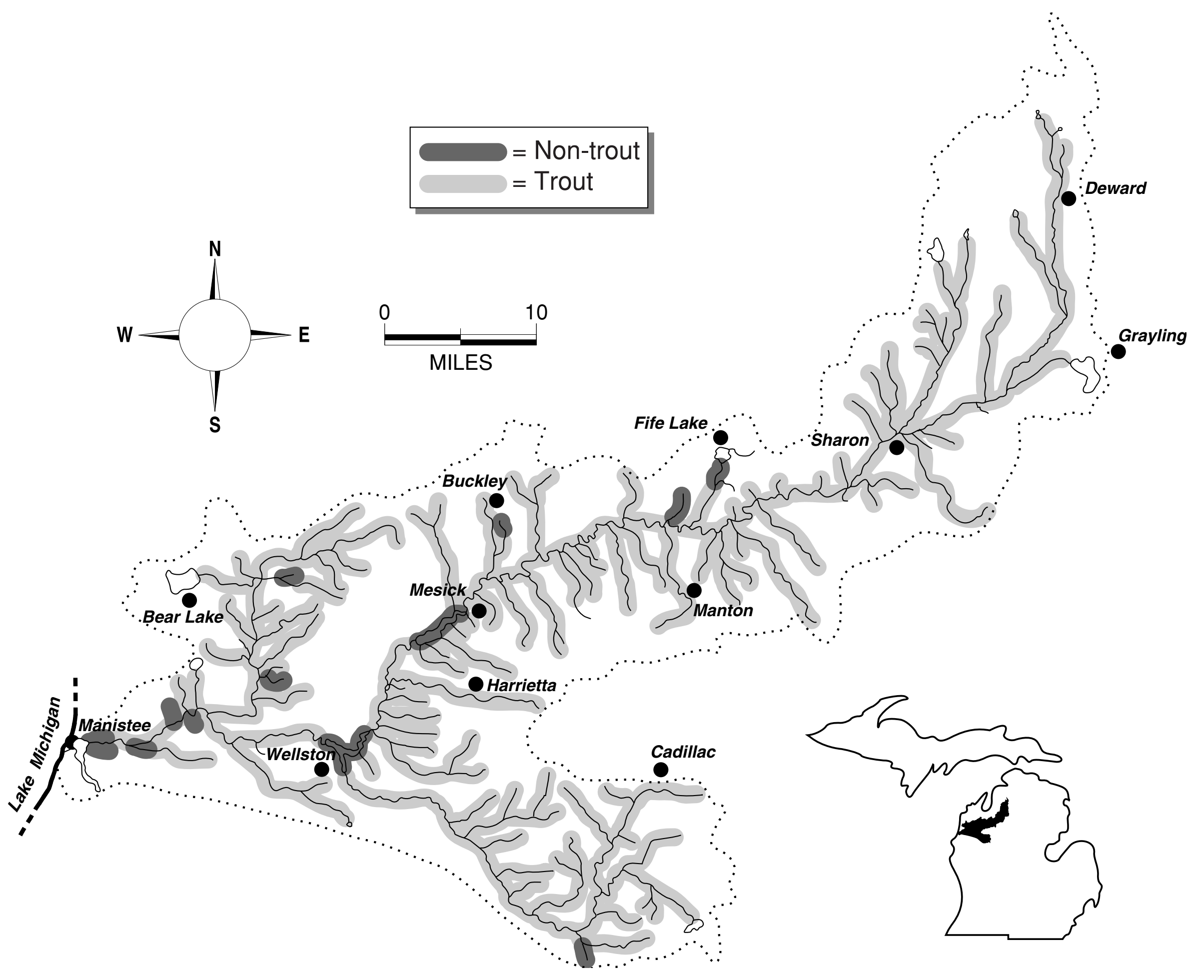


Figure 5.–Designated trout streams in the Manistee River watershed. Data from Michigan Department of Natural Resources, Fisheries Division.

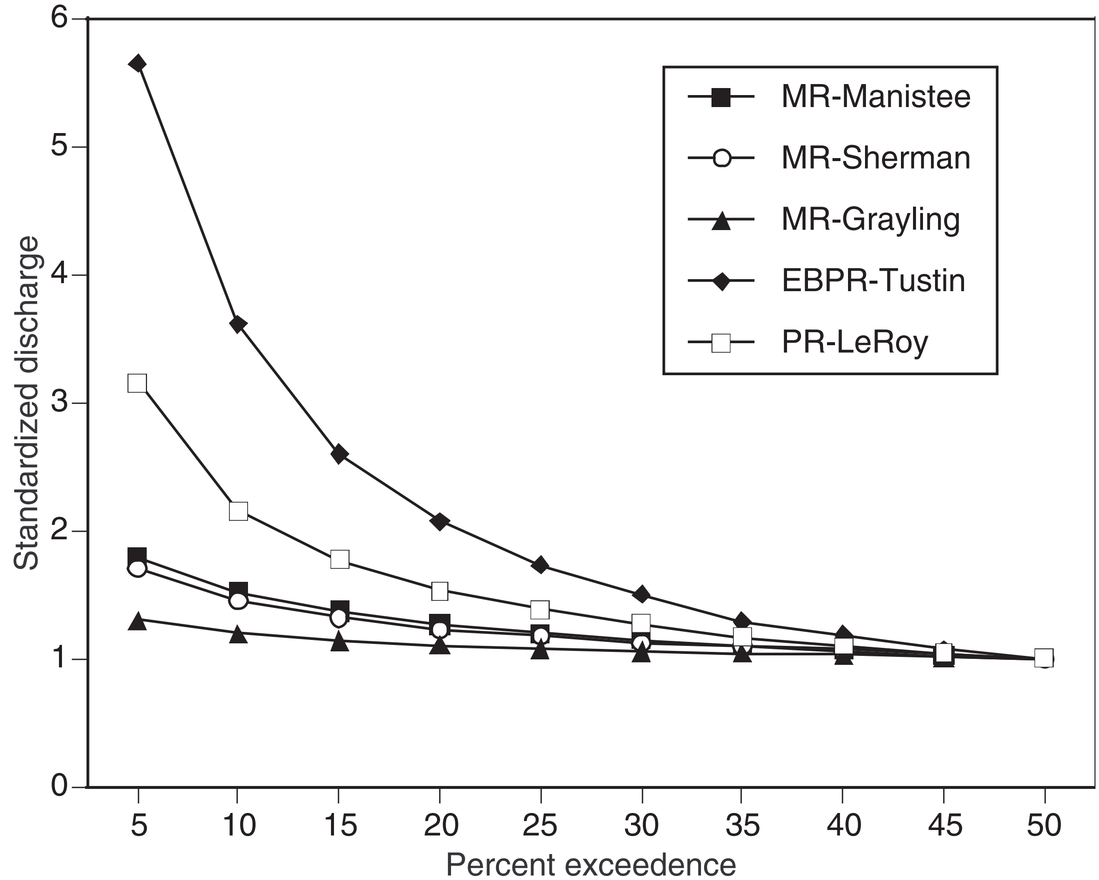


Figure 6.–Flow duration curves for selected sites on the Manistee and Pine Rivers. Information from United States Geological Survey for period of record.

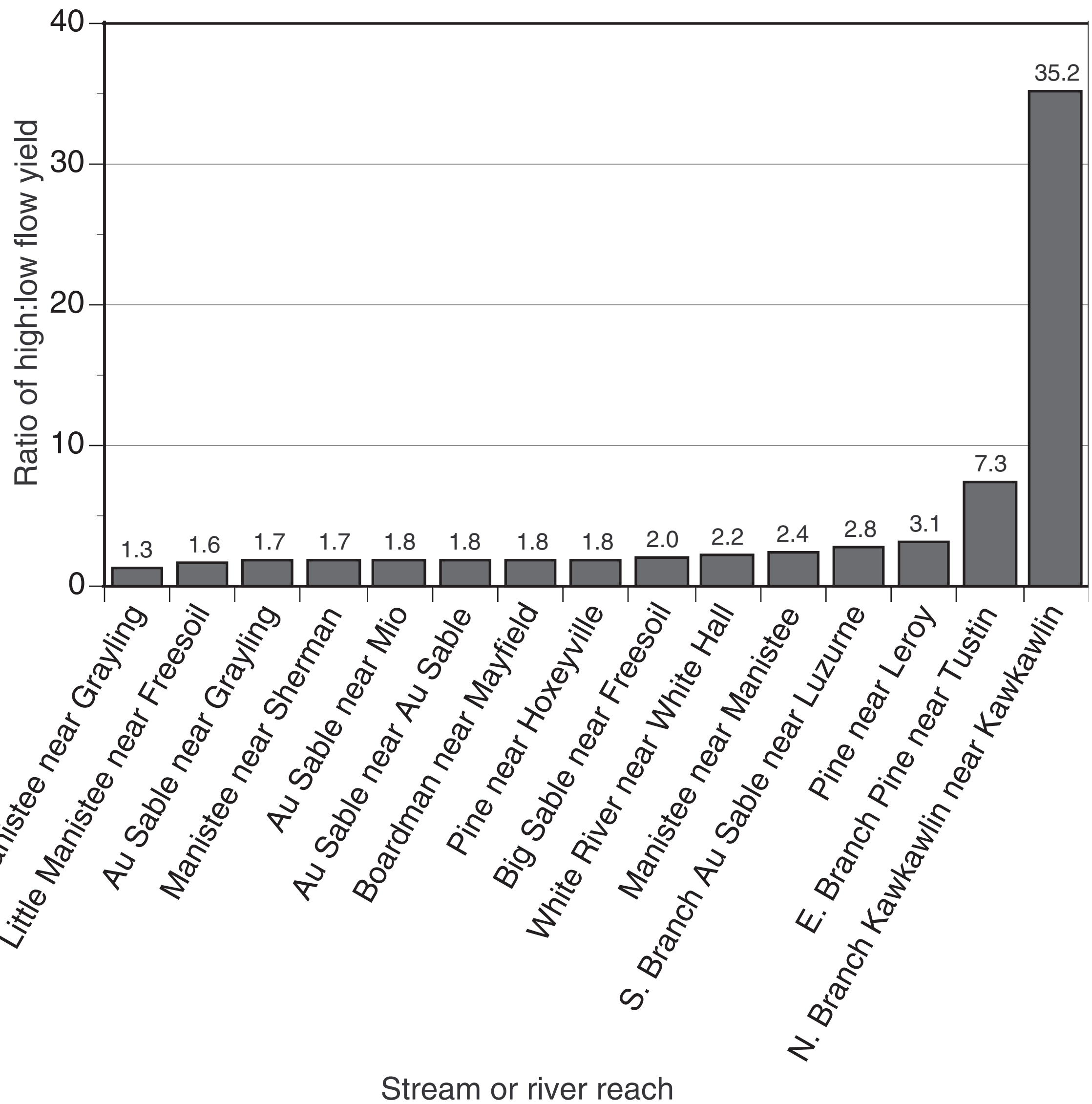


Figure 7.–Ratio of high:low flow yields for selected Michigan rivers. Data from Michigan Department of Natural Resources, Fisheries Division.

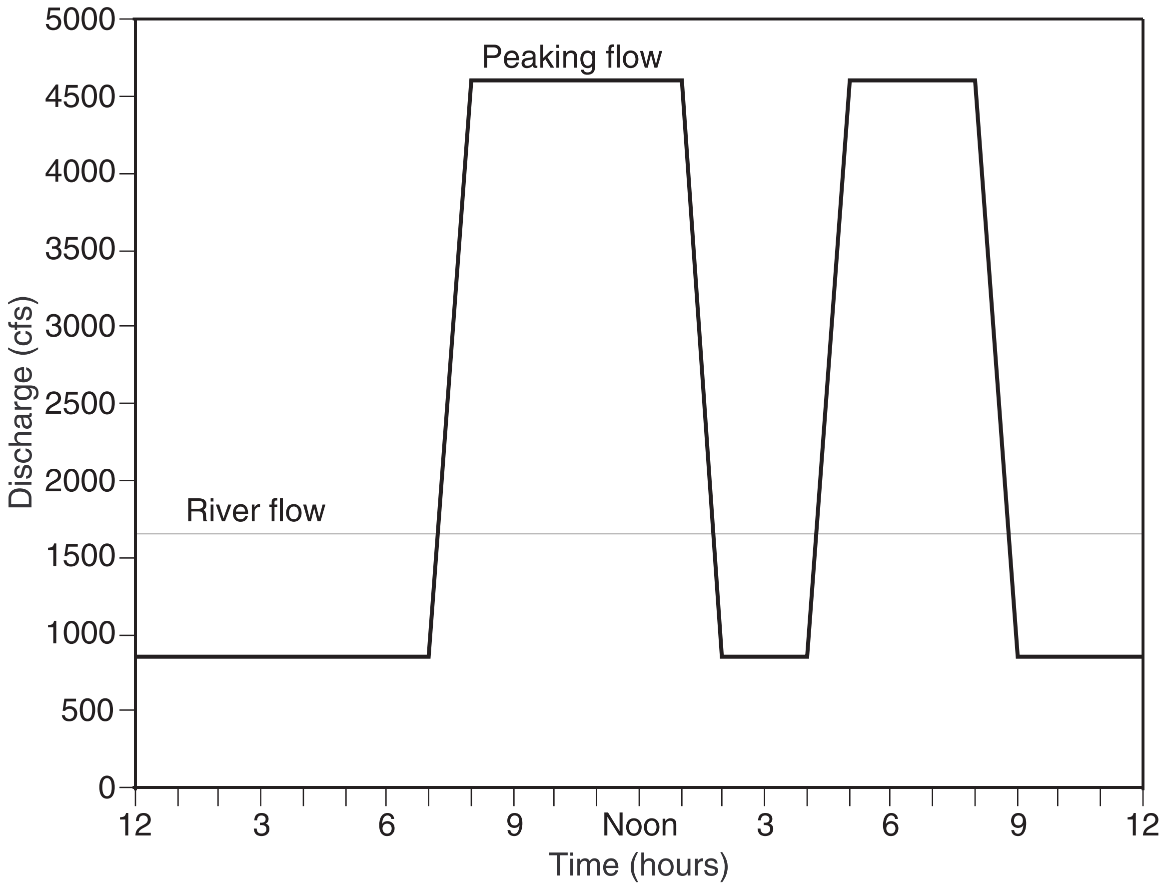


Figure 8.–Typical daily peaking flow pattern at Tippy Dam.

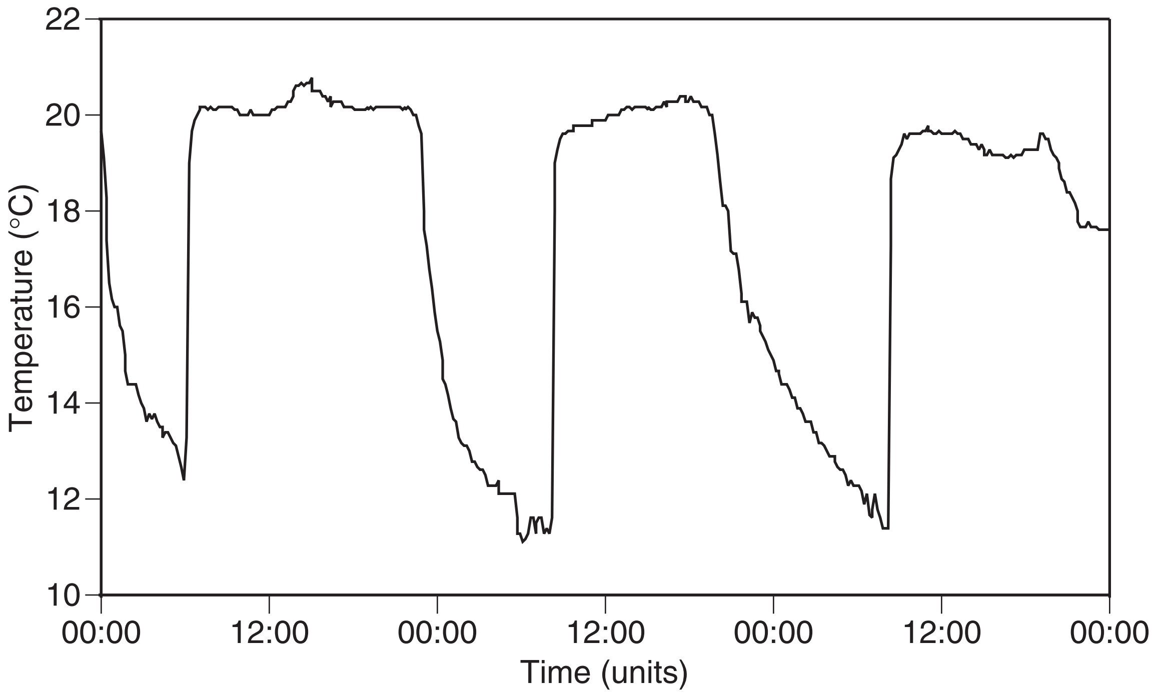


Figure 9.–Temperature patterns at Alcona peaking project on the Au Sable River, Michigan.

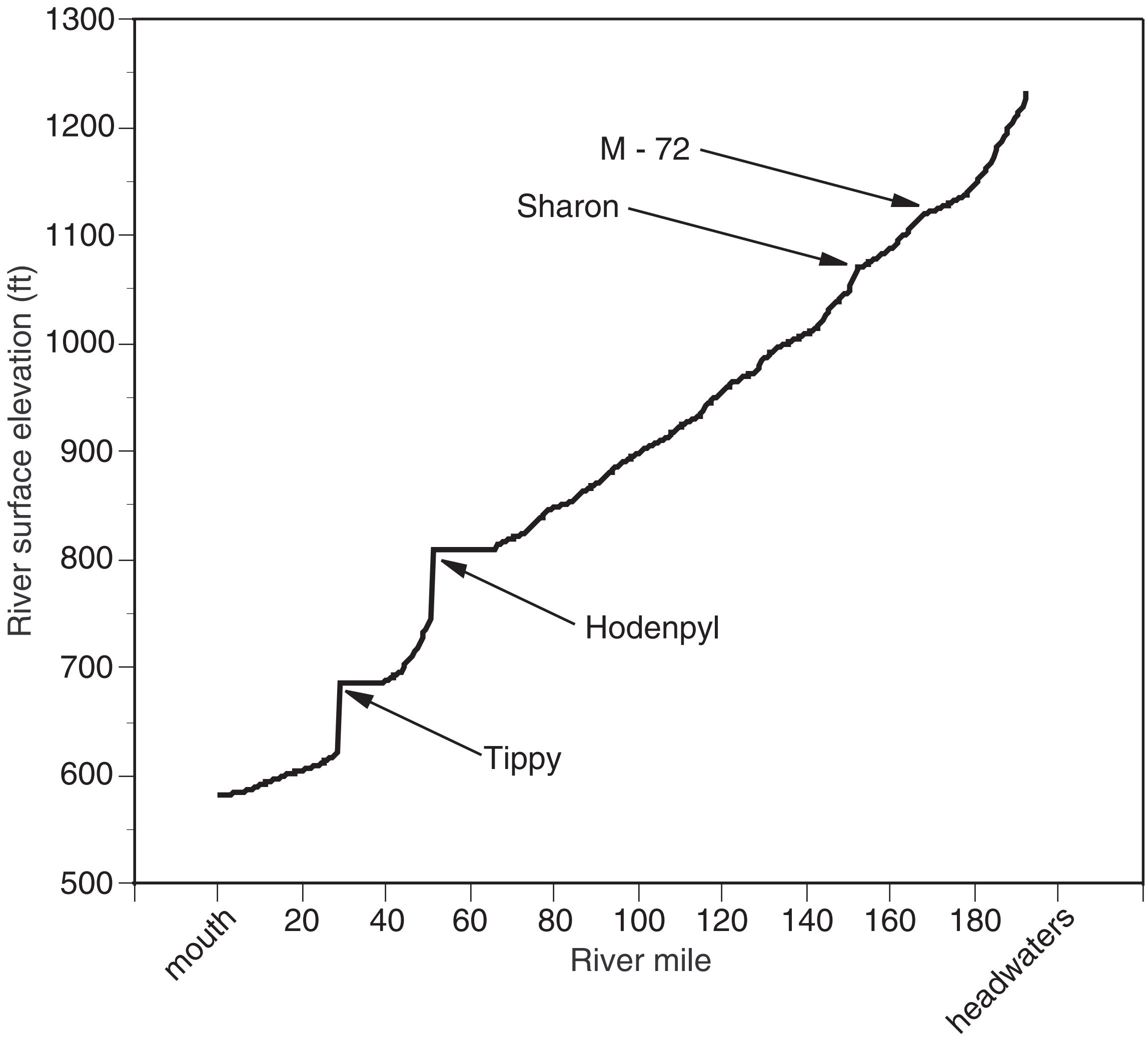


Figure 10.–Gradient (elevation change in ft/mi) of the Manistee River.

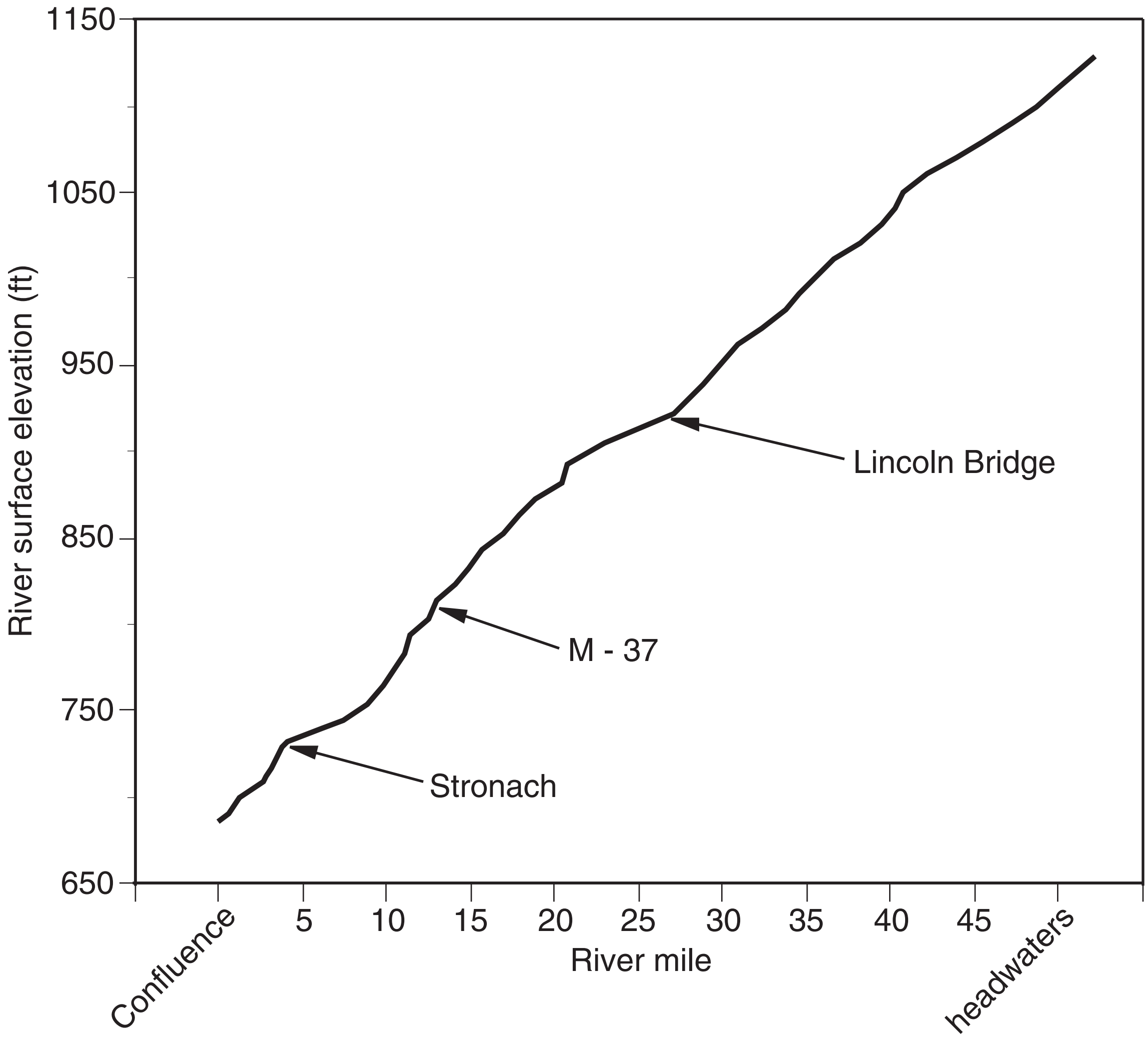
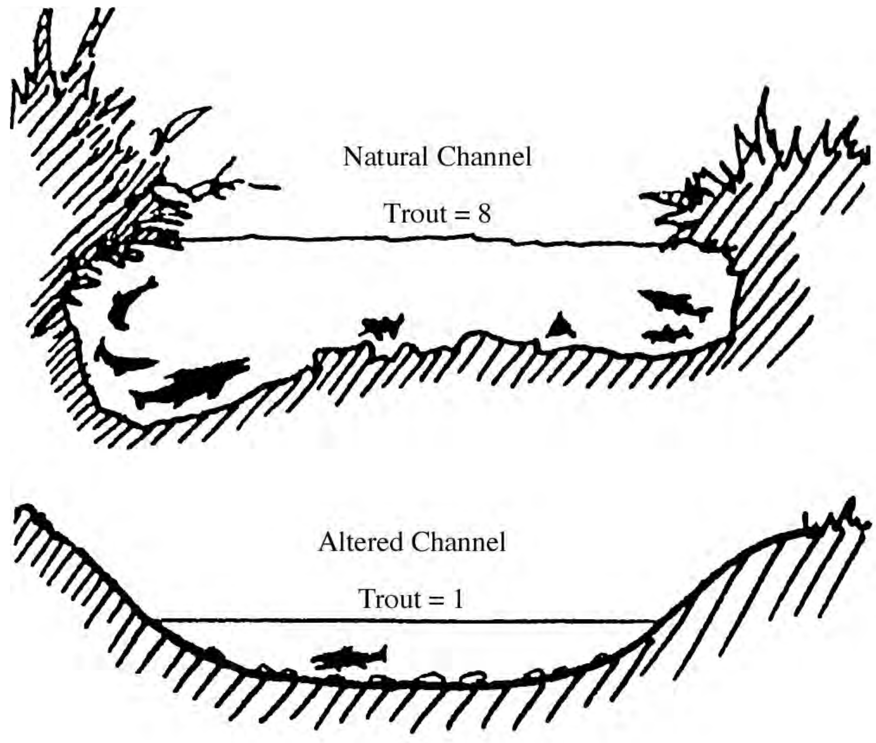
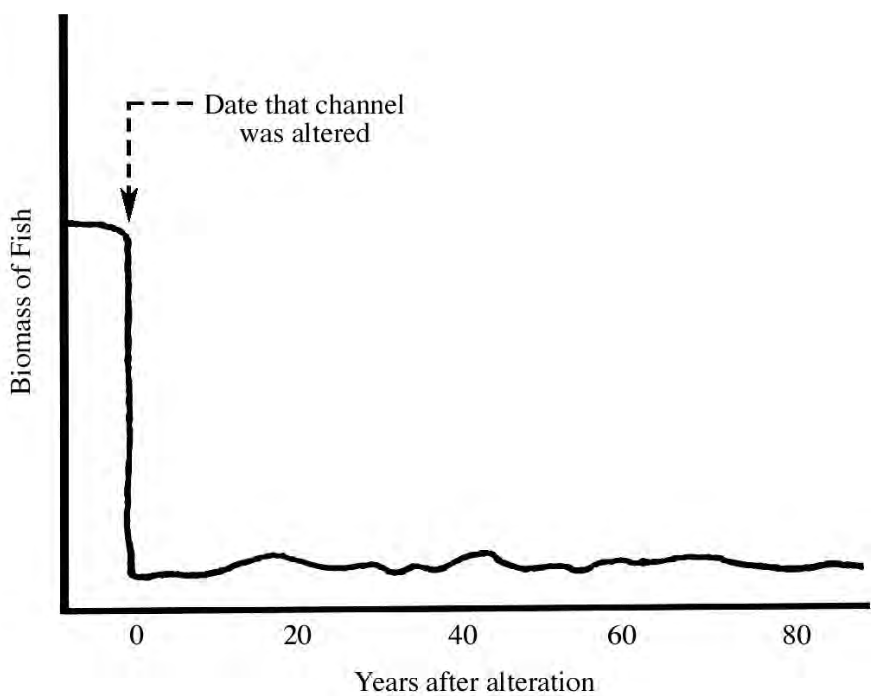


Figure 11.–Gradient (elevation change in ft/mi) of the Pine River.



In Idaho streams, undisturbed channels held 8 times greater biomass of trout on the average.



Over 80 years after channelization, biomass of fish remains 80 to 90 percent below original levels.

Figure 12.–Natural and altered channel-cross sections and trout biomass (from Gebhards 1973).

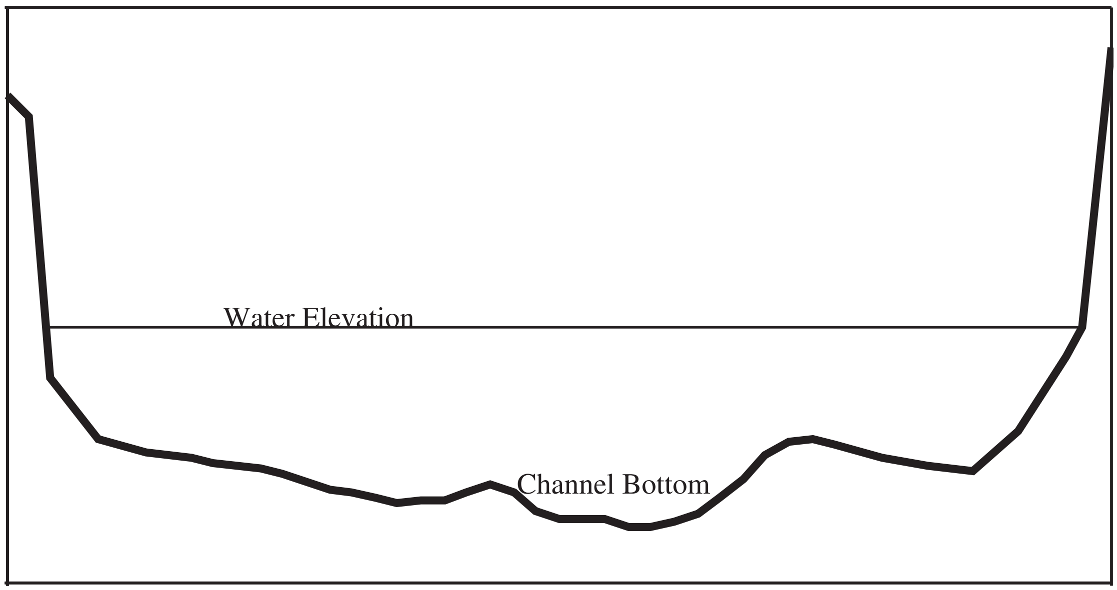


Figure 13a.–Degraded mainstem channel-cross section below Tippy Dam.

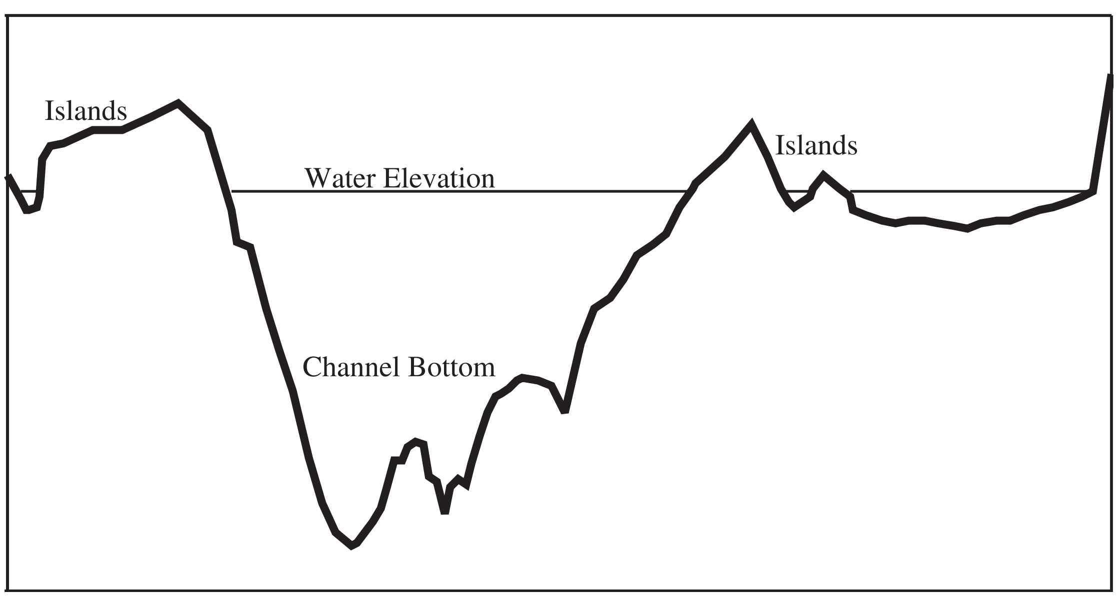


Figure 13b.–Aggraded mainstem channel-cross section below Tippy Dam.

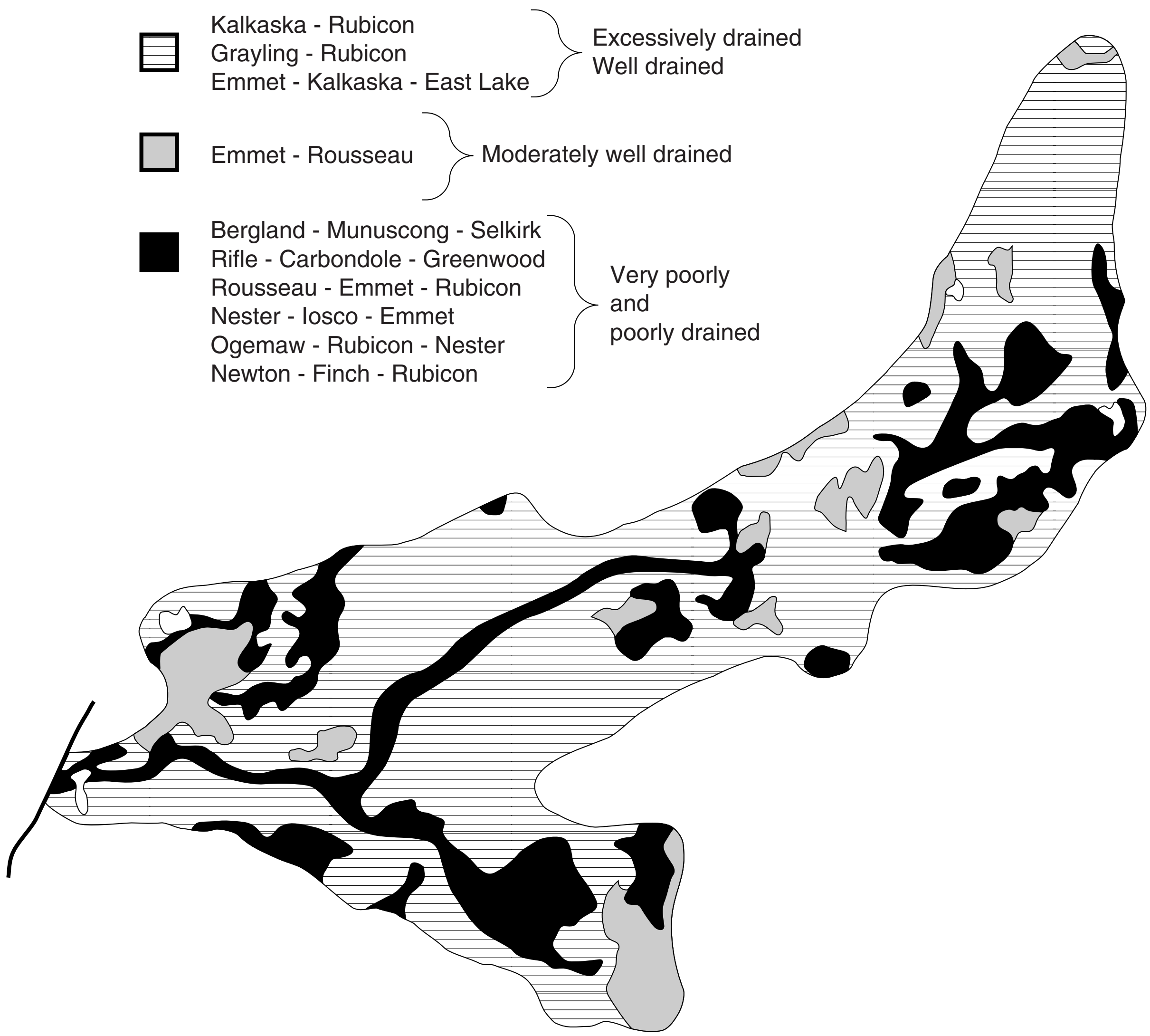


Figure 14.–Soil associations in the Manistee River watershed. Source: U.S. Department of Agriculture, U.S. Forest Service, Manistee River Wild and Scenic River Final Study Report and Environmental Impact Statement.

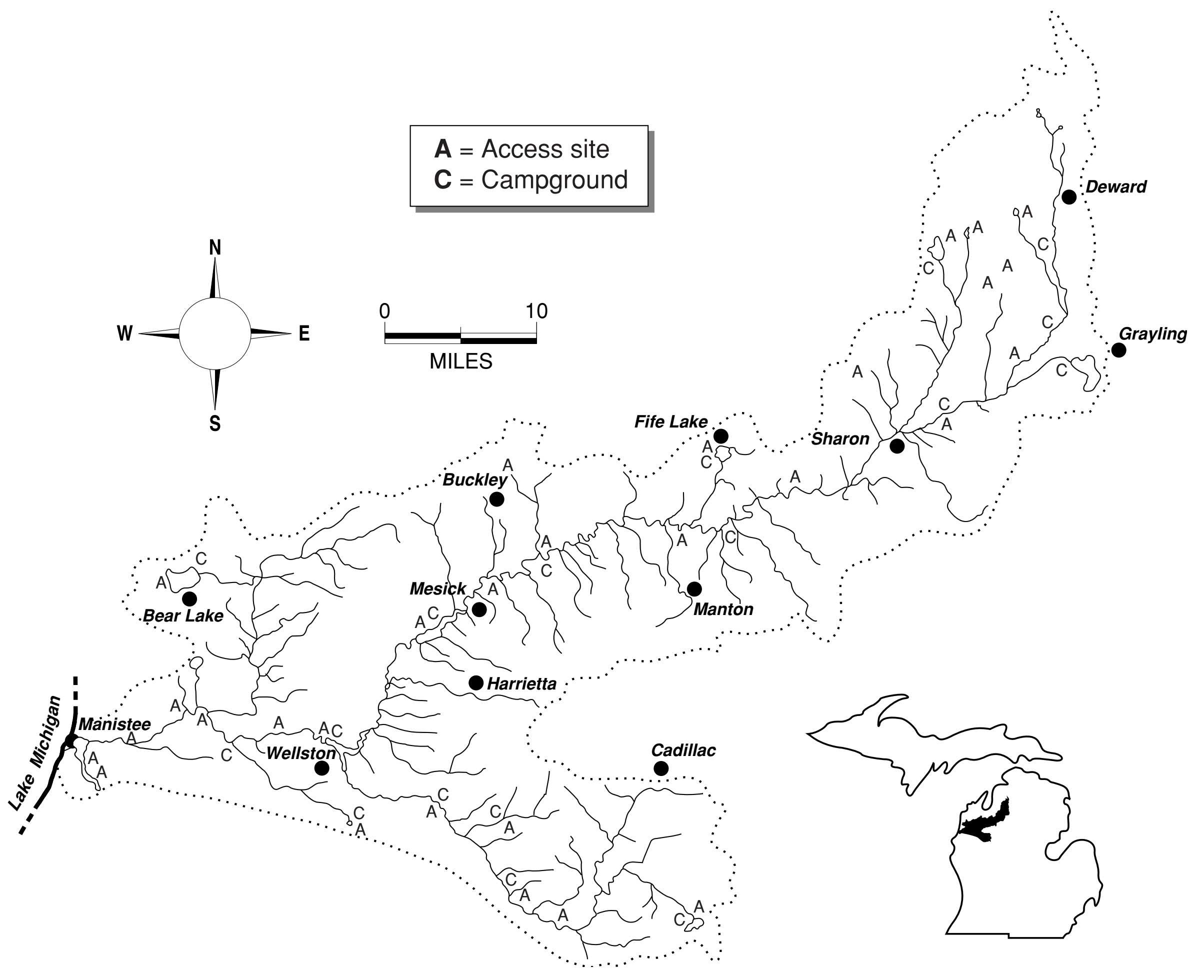


Figure 15.–Public access site and campground locations in the Manistee River watershed. Data from Michigan Department of Natural Resources, Parks and Recreation and United States

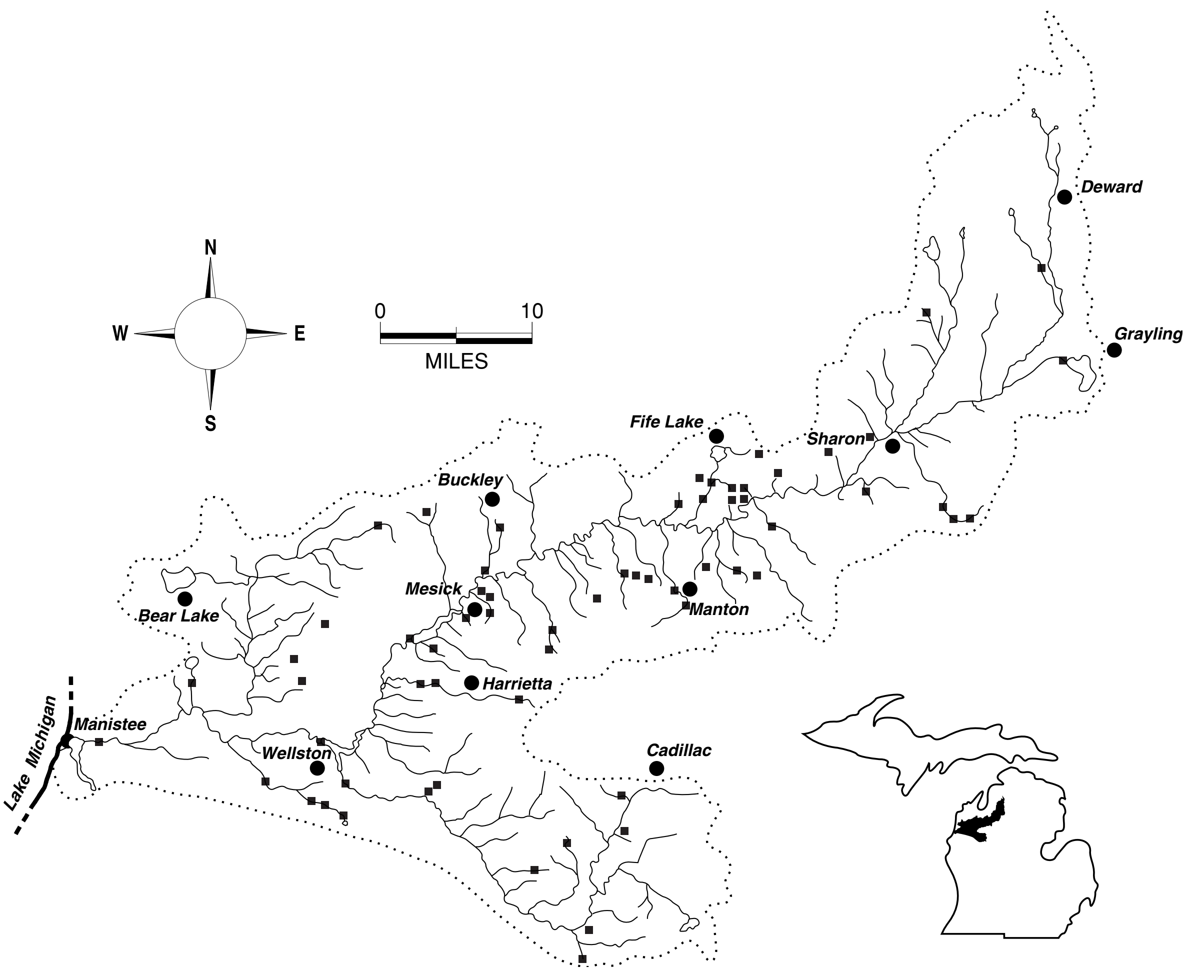


Figure 16.–Location of dams in the Manistee River watershed.