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SECTION 1135 PROJECT MODIFICATION FOR THE IMPROVEMENT OF THE ENVIRONMENT MANISTIQUE SEA LAMPREY BARRIER SCHOOLCRAFT COUNTY, MICHIGAN DETAILED PROJECT REPORT AND ENVIRONMENTAL ASSESSMENT

Detroit District
Great Lakes and Ohio River Division
May 2018

US Army Corps of Engineers®

ACRONYMS

AAHU	Average Annual Habitat Unit
AASHTO	American Association of State Highway and Transportation Officials
AWT	Attractant Water Trap
BMP	Best Management Practice
CE	Cost Effectiveness
CFR	Code of Federal Regulations
DPR	Detailed Project Report
E.O.	Executive Order
EA	Environmental Assessment
EIS	Environmental Impact Statement
EM	Engineering Manual
EPA	U.S. Environmental Protection Agency
ER	Engineer Regulation
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
FONSI	Finding of No Significant Impact
GLFC	Great Lakes Fishery Commission
HU	Habitat Unit
ICA	Incremental Cost Analysis
MDEQ	Michigan Department of Environmental Quality
MDNR	Michigan Department of Natural Resources
MPI	Manistique Paper Incorporated
NAVD88	North American Vertical Datum 1988
NED	National Economic Development
NER	National Ecosystem Restoration
NEPA	National Environmental Policy Act of 1969
P.L.	Public Law
SHPO	Michigan State Historic Preservation Office
T&E	Threatened and Endangered
TFM	3-trifluoromethyl-4’-nitrophenol
USACE	U.S. Army Corps of Engineers, Detroit District
USC	U.S. Code
SLB	Sea Lamprey Barrier
STAAAD	Structural Analysis And Design
USFWS	U.S. Fish and Wildlife Service
WRDA	Water Resources Development Act

EXECUTIVE SUMMARY

This report was prepared under the authority of Section 1135, WRDA 1986, (P.L. 99-662) as amended; U.S. Code 33 USC 2309a. The report reflects efforts by Great Lakes Fishery Commission (GLFC) and the State of Michigan, as the non-Federal sponsors, and the U.S. Army Corps of Engineers (USACE) to provide an engineeringly feasible solution for sea lamprey control on the Manistique River. This summary is intended to inform the reader of the major factors which were considered in the investigation and influenced the decisions documented in the Detailed Project Report (DPR) and Environmental Assessment (EA).

The sea lamprey (*Petromyzon marinus*) is a destructive invasive species in the Great Lakes that contributed to the collapse of lake trout (*Salvelinus namaycush*) and other native species populations in the mid-20th century and continues to affect efforts to restore and rehabilitate the fish community. Sea lampreys attach to large bodied fish and extract blood and body fluids. It is estimated that about half of sea lamprey attacks result in the death of their prey and an estimated 18 kg (40 lbs) of fish are killed by every sea lamprey that reaches adulthood. The Sea Lamprey Management Program (SLMP) is an international effort administered by the Great Lakes Fishery Commission (GLFC) and implemented by two control agents: the Department of Fisheries and Oceans Canada (DFO) and the United States Fish and Wildlife Service (USFWS). Lamprey control is a critical component of fisheries management in the Great Lakes because it facilitates the rehabilitation of important fish stocks by significantly reducing sea lamprey-induced mortality.

The recommend alternative, a sea lamprey barrier, meets the technical definition of a dam (ER 1110-2-1156) as outlined below:

"An artificial barrier, including appurtenant works, constructed for the purpose of storage, control, or diversion of water, and which (1) is twenty-five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier if it is not across a stream channel or watercourse, to the maximum water storage elevation or (2) has an impounding capacity at maximum water storage elevation of fifty acre-feet or more. Any such barrier which is under six feet in height regardless of storage capacity, or which has a storage capacity at maximum water storage elevation not in excess of fifteen acre-feet regardless of height is not considered a dam. This lower size limitation should be waived if there is a potentially significant downstream hazard. This definition applies whether the dam has a permanent reservoir or is a detention dam for temporary storage of floodwaters. The impounding capacity at maximum water storage elevation includes storage of floodwaters above the normal full storage elevation."

The recommended alternative has an effective height of 12 ft. when measured from the toe of structure to its crest elevation and it will impound over 250 acre-feet of water at its design elevation of 600.0 ft. NAVD88. However, the Detailed Project Report will refer to the recommended alternative for its intended purpose, which is a barrier to

the upstream migration of spawning phase sea lamprey. The formulation of the recommended alternative was a risk informed process that considered the benefit to the Great Lakes Fishery and the health and safety of the citizens of the City of Manistique.

The purpose of the proposed action is to prevent migration of sea lamprey to spawning and larval habitat located upstream of the dam formerly own by Manistique Paper Incorporated (MPI). By limiting their access to suitable habitat, expansion of the sea lamprey population and use of lampricides can be reduced, thus providing benefit to Lake Michigan and the Great Lakes fishery and ecosystem. Alternatives considered for detailed analysis of potential environmental impacts include: **Alternative 1** construction of a cantilevered steel sheet pile wall immediately downstream of the existing dam; **Alternative 2** construction of a steel post and concrete panel wall on top of the existing sill of the MPI dam; and no Federal action. Other alternatives considered through the plan formulation process, but eliminated from further consideration included: construction of an adjustable crest barrier; an electrical barrier; and modification of the existing dam.

Construction of the lamprey barrier at various locations upstream and downstream of the existing dam was considered; however, based on hydraulic impacts to the floodplain, the hydraulically acceptable barrier location is just downstream of the existing MPI dam. The recommended alternative is **Alternative 1** - Fixed Crest Cantilevered Barrier structure involving construction of a cantilevered steel sheet pile wall immediately downstream of the dam. Both action alternatives include removal of approximately 2,470 feet of the center flume wall down to bedrock, installing two sea lamprey traps, and bedrock excavation leading up to the traps. Finally, the existing concrete wall located on the west bank of the river upstream of the dam will be functionally replaced by a clay berm. The berm will tie into the barrier and will extend 850 feet upstream terminating near and active rail line operated by CN railroad. The primary purpose of the berm structure is to prevent lamprey escapement during the design flood event (6.7% 15 year flood event).

In conclusion, the Detail Project Report and Environmental Assessment recommend the implementation of **Alternative 1- Fixed Crest Cantilevered Barrier.** Alternative 1 is the National Ecosystem Restoration (NER) plan because it achieves the primary environmental objective of reducing the impact to the Great Lakes fishery from the voracious appetite of the sea lamprey by blocking migrating adult lamprey from the expansive spawning habitat upstream of MPI dam. The dendritic nature of the Manistique River System upstream of the MPI dam make it difficult to treat and historically has required additional treatments to eliminate a residual lamprey population. The introduction of additional chemicals to the river increases the stress on non-target fish species and invertebrates. The proposed barrier would eliminate the additional stress to aquatic ecosystem by reducing the amount lampricide chemical used in the Manistique River system.

Finally, Since Alternative 1 is the plan that produces the greatest net economic benefits and has the highest Benefit-Cost Ratio (BCR), Alternative 1 is identified as the National Economic Development (NED) plan for this Section 1135 project on the Manistique River in Manistique, Michigan. **Table 1,** below, summarizes the average

annual benefits, average annual costs, net benefits and the benefit-cost ratio (BCR) for Alternatives 1.

Table 5 - Economic Summary of Alternative 1 in 2017 Dollars	
Construction Costs	$6,662,000
Non-Construction Costs	$961,000
LERRDS	$355,000
Interest During Construction	$143,000
[1]Total Project Costs	**$8,121,000**
Annualized O&M Costs	$6,000
Average Annual Benefits	$446,000
Average Annual Costs	$307,000
Net Economic Benefits	**$139,400**
Benefit-Cost Ratio	**1.45**

[1]Total project costs = Total Project costs – Sunk Feasibility costs + Monitoring + IDC

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ENVIRONMENTAL ASSESSMENT

1. PROJECT INFORMATION

1.0 Study Authority

This report was prepared under the authority of Section 1135, WRDA 1986, (P.L. 99-662) as amended; U.S. Code 33 USC 2309a:

Section 1135 reads:

(a) The Secretary is authorized to review water resources projects constructed by the Secretary to determine the need for modifications in the structures and operations of such projects for the purpose of improving the quality of the environment in the public interest and to determine if the operation of such projects has contributed to the degradation of the quality of the environment…

Section 506. of WRDA 1999 (PL 106-53, 113 Stat. 1494) amended Section 1135, WRDA 1986 with the following:

(2) CONTROL OF SEA LAMPREY.—Congress finds that—
(A) The Great Lakes navigation system has been instrumental in the spread of sea lamprey and the associated impacts on its fishery; and (B) the use of the authority under this subsection for control of sea lamprey at any Great Lakes basin location is appropriate…

1.1 Study Purpose and Scope

The purpose of this report is to present the findings of a feasibility investigation which was conducted to determine if there is a U.S. Army Corps of Engineers (USACE) interest in providing ecosystem improvements in the Manistique River, in Manistique, Michigan. This report analyzes the problems and opportunities and expresses desired outcomes as planning objectives. Alternatives are then developed to address these objectives. These alternatives include a plan of no action and various combinations of structural and non-structural measures. The economic and environmental impacts of the alternatives are then evaluated and a feasible plan is selected. The report also presents details on USACE and sponsor participation needed to implement the plan. The report concludes with a recommendation for construction.

An alternative, such as a steel or concrete barrier constructed across the river or stream to block the migration of sea lamprey, meets the technical definition of a dam (ER 1110-2-1156) as outlined below:

"An artificial barrier, including appurtenant works, constructed for the purpose of storage, control, or diversion of water, and which (1) is twenty-five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier if it is not across a stream channel or watercourse, to the maximum water storage elevation or (2) has an impounding capacity at maximum water storage elevation of fifty acre-feet or

more. Any such barrier which is under six feet in height regardless of storage capacity, or which has a storage capacity at maximum water storage elevation not in excess of fifteen acre-feet regardless of height is not considered a dam. This lower size limitation should be waived if there is a potentially significant downstream hazard. This definition applies whether the dam has a permanent reservoir or is a detention dam for temporary storage of floodwaters. The impounding capacity at maximum water storage elevation includes storage of floodwaters above the normal full storage elevation."

However, the Detailed Project Report will refer to any proposed alternative that impedes upstream movement of sea lamprey as function of its intended purpose, which is a barrier to the upstream migration of spawning phase sea lamprey. Hence, from this point forward this report will refer to any proposed dam solution as a sea lamprey barrier. The formulation of any alternative that reduces the impact of the parasitic sea lamprey is a risk informed process that considers the benefit to the Great Lakes Fishery and the health and safety of the citizens of the City of Manistique.

1.2 Prior Studies, Reports and Existing Water Projects

The following reports were reviewed as directed in the study authorization:

- A *Preliminary Restoration Plan* (PRP) was completed and approved in May of 2007.

  The PRP was completed during the reconnaissance phase of the study. The completion and approval of the PRP established Federal interest in further study of blocking sea lamprey from spawning habitat in the upper reaches of the Manistique River. The PRP presents preliminary alternatives, cost, and environmental benefits.

- *Manistique River and Sea Lamprey Trap* by Stanley consultants for the U.S. Fish and Wildlife Service October 2007

2. INVENTORY AND FORCASTING

2.1 Existing Conditions

2.1.1 Location

The city of Manistique is located on the south shore of the Upper Peninsula of the State of Michigan and on the north shore of Lake Michigan about 93 miles from the Mackinaw Bridge, and about 380 miles from the city of the Detroit. The city of Manistique is the county seat of Schoolcraft County and is the only incorporated municipality in the county. The Manistique River flows into Lake Michigan forming somewhat of a natural harbor which has since been improved with breakwaters, dredging, and a lighthouse. **Figure 1** depicts the proximity of the City of Manistique to major Midwest cities.

Figure 1 Location Map

2.1.2 Population & Industry

The early Native American residents, most of whom were members of the Ojibwa tribe, settled around Indian Lake and at the mouth of the French-named Manistique River. In 1832, the "Snowshoe Bishop" Fredric Baraga established a Catholic mission on the eastern shore of Indian Lake. It was also during this time that Henry Rowe Schoolcraft, Michigan's first Indian Agent and the county's namesake, was mapping the area, documenting the lives of tribal residents and negotiating treaties. Schoolcraft County was officially organized in 1871, with Manistique designated as the county seat.

Today the city has an estimated population of 3,100 people living in 1,380 households with an average household size slightly below the state average. Compared to the rest of the state, the median age of city and county residents is higher and there are more residents over the age of 65.

Much of the timber harvested from the county's forests was floated down the river to Manistique, where it was milled, loaded on ships and sent to communities around the

Great Lakes and beyond. But by the turn of the century, what had seemed an inexhaustible resource was gone.

Manistique Papers Incorporated (MPI), the city's primary employer, was founded in 1914 by the owner of the *Minneapolis Tribune* to produce newsprint. The dam and millworks came on line in 1920. By 1959 th2e company began researching the production of newsprint from recycled newspaper and by 1984 Manistique Papers completed the switch from their wood processing operation to solely producing paper products from recovered paper.

Paper manufacturing, and limestone mining and processing, developed into major industries in the City of Manistique. The city has also developed a robust tourism industry that provides visitors the opportunity to take advantage of the area's abundant wildlife, scenic views and winter-related recreation.

2.1.3 Watershed Description

The Manistique River (**Figure 2**) is a 67-mile-long (108 km) river that winds southward through the central Upper Peninsula of Michigan from its headwaters near Lake Superior to its mouth in Lake Michigan. It drains approximately 1,461 square miles (3,780 km^2) of the Upper Peninsula, including most of Schoolcraft County and small portions of Alger County, Delta County, Luce County, and Mackinac County.

Figure 2 Manistique River in the vicinity of the Manistique Paper Incorporated facilities

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

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

Natural Resources

As of 2007, 93% of the drainage was forested, largely with second-growth trees such as aspen and birch. More than one-half, 58%, of the drainage was owned by the federal government or the state of Michigan. Governmental ownership units included the Seney National Wildlife Refuge, Hiawatha National Forest, and Lake Superior State Forest. Major lakes drained by the Manistique River include Indian Lake north of Manistique, Lake Manistique in the central Upper Peninsula, and two tributary lakes, North Manistique Lake and South Manistique Lake.

Much of the land within the watershed is wetland (57%), and forested upland covers an additional 32.8%. Minimal farming occurs and is limited, mostly, to the mainstem-upper and mainstem-middle and generally occurs in areas of loamy soils. Only 1.6% of the watershed is in agricultural use. Poor soils and a short growing season inhibit agriculture. Forest and recreational habitats dominate.

Currently, 61 species of fish inhabit the Manistique River watershed. Brook trout generally inhabit upper riverine reaches while brown trout occupy middle and lower riverine reaches. In addition, riverine fish communities typically include: blacknose dace, creek chub, Iowa darter, johnny darter, logperch, and mottled sculpin. Sea lamprey are present below the Paper Mill Dam during spawning periods. Historically this dam effectively blocked sea lamprey from ascending the Manistique River. Dye test conducted in 2008 by US Fish and Wildlife Service (FWS) indicate the structural leaks in the face of the dam may have allowed lamprey to pass through the structure and upstream into the river's mainstem reaches.

Hydraulics and Hydrology

The Manistique River begins at Locke Lake in southwestern Luce County and flows in a southwestern direction approximately 67 miles to its confluence with Lake Michigan. There are 673 lakes within the Manistique River watershed and the Manistique River watershed contains 444 miles of tributaries comprised of the sub-watersheds of the Fox River system, a central tributary system, and the Indian River system. The slope of the river is gradual and regular throughout its entire course. The slope in the area of the proposed project is about 1.1feet/mile. The riverbed in the headwaters of the Manistique could be characterized as mainly sand with some silt. However the river cuts through to a limestone escarpment as it nears the city of Manistique and the MPI structure. The flow in lower portion of the river is constricted by the dam and MPI mill works.

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

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

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

Table 1 Annual precipitation by weather station within or near the Manistique River watershed.

Drought conditions sporadically occur during mid-summer periods. During 1951 through 1980, evaporation exceeded precipitation from May through October by about 17% (Madison and Lockwood 2004) and drought conditions existed during this period. Using the Palmer Drought Index, conditions reached extreme severity during 4% of the year. Soil moisture replenishment, the period when precipitation exceeds evaporation, occurred during fall and winter months. Heavy snowfalls occurring along the north edge of the watershed coupled with soil permeability provide groundwater inflow that moderates river flows and temperatures.

Physical Resources

There are 51 dams registered with MDEQ and 3 additional barriers not registered with MDEQ, within the watershed. Additionally, several small private dams and barriers are present (**Figure 3**). Their condition and effects on the watershed are not known. The 3 barriers not listed with MDEQ are located in the Tributaries-upper Indian River and Tributaries-lower Indian River sub-watersheds.

Only one dam has historically served to generate electricity (MPI Dam). The remaining dams serve as water-level control structures, fish barriers, or to create waterfowl habitat. Thirty-two dams are owned by the Federal Government (6-United States Department of Agriculture, Forest Service (USFS), 26-Department of the Interior Fish and Wildlife Service), 9 by private individuals or clubs, 5 by the MDNR, 3 by counties or municipalities, 2 by unknown owners, and 1 by a corporation (Manistique Paper Co., Inc.) (**Figure 4**)

Figure 3 Tressler Dam (N. Manistique Lake)

Figure 4 MPI Dam and Flume

2.2 Future Without Project Condition

The without project condition, also known as the No Action alternative, describes the future condition of the area if no project were implemented to address the existing problem.

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

nitrosalicylanide) was applied to the main river from the railroad trestle just above the dam, and to Weston Creek at the railroad crossing west of Bear Avenue. Additionally, the granular formulation of Bayer 73 was applied to backwaters near the mouth.

During the 1971 to early 1974 field seasons, an extensive survey of the entire watershed was undertaken, consisting of a total of 278 stations. Sea lampreys had bypassed the dam and reproduced upstream. Larval distribution was restricted to the mainstream up to the vicinity of Germfask, a stream length of about 47 miles. In August of 1974, the Manistique River received its second lampricide treatment, this time including the reach upstream of the dam.

The Great Lakes Fishery Commission estimates that without treatment the Manistique River would contribute approximately 285,400 sea lampreys to the Lake Michigan population annually. To control this recruitment the FWS, acting as an agent for the GLFC, treats the river with the lampricide. This operation involves the application of TFM in the Manistique River as needed, typically once every four years at a cost of $857,000 (in 2017 dollars) per treatment. These applications are believed to reduce recruitment by about 95% and with a natural mortality rate of 30% for metamorphosed sea lamprey, the remaining 10,000 recruits would be expected to cause the death of about 66,700 fish in Lake Michigan each year. Although lampricides are highly selective at proper application rates, higher concentrations can be extremely toxic to non-target organisms. Some impacts from the application of TFM are likely on the distribution and abundance of native species in the river, particularly on invertebrates and native lamprey populations. These impacts are not currently documented. Absent the development of other lamprey control alternatives, continued treatment of the entire Manistique River with lampricides is anticipated. **Figure 5** depicts the life cycle of sea lamprey.

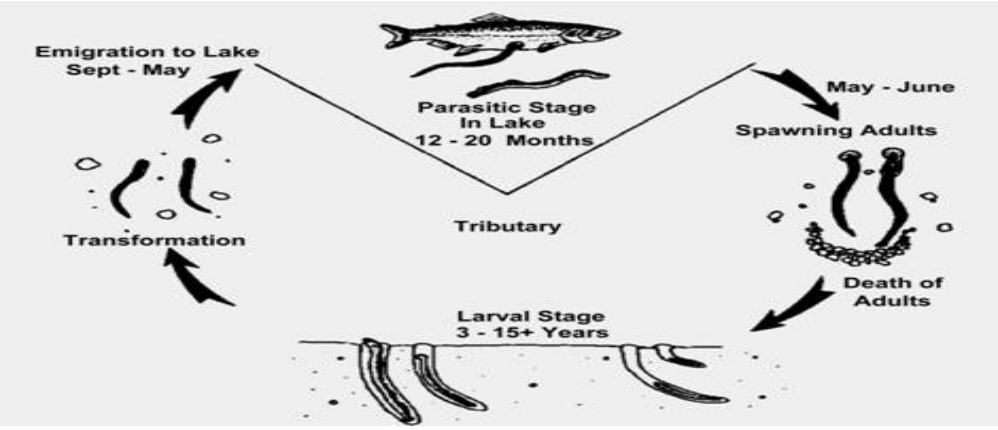


Figure 5 Sea Lamprey life cycle

The MPI dam complex, which includes the dam and flume structures, was constructed between 1904 and 1920. The structure is constructed of reinforced concrete founded on bedrock and is approximately 360 feet long. The elevation of the dam piers is approximately 612.1 feet above mean sea level (msl). The original purpose of the dam was to impound water to generate electricity at the mill and to be used in the paper production process. The flume structure is approximately 3360 feet long and separates the water used by the paper mill from the natural river. MPI abandon energy production

in 1988 as a costs cutting measure and ultimately reduced its reliance on the Manistique River for paper production. MPI operated and maintained the dam and its 11 gates until about 1990 when some gates were removed and the remaining gates were set to "run-of-the-river". Manistique Paper Incorporated closed its doors for the final time in 2015. The mill portion of the company was purchased by a local private company, however the dam and flume assets are held by Manistique Paper Incorporated Acquisition (MPIA) also known as Mbank. The dam complex is no longer operated or maintained and continues to deteriorate.

It is anticipated that within the next 50 years the MPIA dam will remain in a run-of-the-river state. The dam is capable of passing up to 28,000 cubic feet per second (cfs), which is 6,000 cfs greater than the 0.5% 200 year flood event according to the 2012 dam inspection report provided by MDEQ. It was determined that future conditions hydrology is not expected to change from the existing conditions hydrology as this area of the Upper Peninsula of Michigan is very rural, and there is little to no risk of urbanization occurring in the area during the life of the project.

The dam and its appurtenant structures will be acquired by the state of Michigan and placed in the state's Dam Safety Program. The state will continue dam inspections in accordance with Part 315, Dam Safety, of the Natural Resources and Environmental Protection Act, Act 451, of 1994 as amended. The state of Michigan will adapt existing Emergency Action Plan (EAP) established by MPIA and use it to mitigate flood impacts to the life and safety of the City of Manistique. The state's Dam Safety Program will address the deficiencies described in the inspection reports of the dam and appurtenant structures that pose the greatest risk to the structure's stability and the life and safety of the surrounding community. The MDEQ and MDNR and lamprey control personnel from the FWS will coordinate any debris removal. The visual inspections documented in the 2009, 2012 and 2016 dam inspection reports indicated the dam and appurtenant structures are not structurally deficient. It is anticipated the rate of structural deterioration will remain constant over the next 50 years. The FWS, on behalf of the GLFC, will continue to treat the river downstream of the dam with TFM every three to four years, but will increase monitoring activities upstream of the deteriorating structure to prevent lamprey from spawning upstream.

According to lamprey control experts at FWS the dam historically served as a de facto lamprey barrier, but fissure developed in the bedrock of the river up and downstream of the dam and may allow lamprey to migrate upstream of the structure. Lamprey control personnel used stoplogs and the remaining functioning gates to aid in trapping during the lamprey migration season. The GLFC and FWS believe that there is a moderate risk for lamprey escapement via the fissures that run beneath the dam in the bedrock or structural failure.

2.2.1 Life and Safety in the existing condition

State of Michigan dam safety regulations requires dam owner/operators of structures with a high hazard potential rating to file an Emergency Action Plan (EAP) with the Michigan Department of Environmental Quality (MDEQ) Dam Safety Program and the county Emergency Management Coordinator. An EAP for the current dam was completed in

April 2004 and provided to the MDEQ Dam Safety program in accordance with Part 315, Dam Safety, of the Natural Resources and Environmental Protection Act, Act 451, of 1994 as amended. The EAP developed by FutureMark-Manistique Paper Acquisitions, outlines the responsibilities of the dam owner if structural failure was eminent or the structure failed.

The EAP lists emergency contacts including local public safety personal such police and fire; the county road commissioner; City Manager and points of contact for utilities in the area and the provides the order in which emergency personnel are to be contacted. The EAP states that routine visual inspections are to be conducted by FutureMark-MPI personnel. Visual inspections are required to be conducted during periods of extreme flow conditions. In the case of extreme flow conditions combined with a prolonged rain event visual inspection with be made by FutureMark-MPI and City of Manistique public safety personnel.

The DAMBRK (Dam Break) analysis was conducted by the National Weather Service (NWS) and presented in the April 2004 EAP. The analysis used the 1990 FEMA Flood Insurance Study, topographic, bathymetric and soil survey data, Hydro Analysis of the Manistique Paper Dam including the Flume structure, and the Dam Safety Inspection report. Two dam failure areas were analyzed at two separate flow conditions: (1) a "sunny-day" failure, in which conditions of average flow and average backwater pool elevation are assumed to be occurring just prior to failure, and (2) at the peak flow and river stage for a 0.5% (200 yr.) frequency flood event (Figure 6).

Figure 6 Flood map 0.5% (200 yr.) event under existing conditions from the 2012 dam inspection report provided by MDEQ

Hydraulic modelers at NWS determined that a "sunny-day" failure flood wave would be greatest just downstream of the dam, and would be adequately contained within the natural river channel. This flood wave would be attenuated as it moves downstream with minimal flooding occurring along the east bank downstream of the M-94 Bridge causing minimal property damage. The threat to human safety would be limited to persons (e.g., fishermen) within the river channel near the dam due to its lack of warning signs, such as rising river stage during a heavy, prolonged storm event, and that threat would be reduced further downstream. Anecdotal evidence indicates that the areas immediately up and downstream of the dam are not frequented by recreation boaters or paddlers. There is a boat launch approximately 2,300 feet upstream of the existing dam (**Figure 7**). According to local officials, the launch is used to access backwater areas upstream of the launch.

Figure 7 Boat launch proximity to existing dam

The modelers at NWS determined that the magnitude of 0.5% (200 yr.) event flood wave would cause the most significant and widespread property damage. The Dam Break failure analyses indicated that areas downstream of the dam will be inundated by flood waters will be impact differently depending on its proximity to the failure, timing, magnitude of the river flow and elevation, and the water level of Lake Michigan just prior to failure. Of the four dam failures that were analyzed, the model indicated that an east side dam failure (river side), during the peak of a 0.5% (200 yr.) event, would cause the most widespread flooding and the area that would be significantly impacted lies between the dam and the M-94 bridge downstream. The flood would begin to attenuate downstream of the M-94 bridge, with moderate flooding along the east bank of the river, down to Lake Michigan. The west training wall upstream of the dam would also be overtopped during the 0.5% (200 yr.) flood event and cause considerable flooding to areas west of the river, this would happen independent of the dam failure. A rough estimate of the Population at Risk (PAR) indicates that a nighttime failure of the existing flood wall could impact up to 37 people, while daytime failure of that same structure would impact about 18 people. Approximately 18 residential structures are potentially impacted.

A “sunny-day” failure of the west training wall would result in widespread flooding to areas west of the river, including flooding a low lying area just upstream of the dam.

This would pose a significant threat to people and property nearest to the failure location. The flood wave for this type of event would quickly be attenuated down the wide, flat floodplain of Weston Creek. However, substantial flooding would occur to residences near Weston Creek. Flooding would also occur near the M-94 Bridge and downstream of this point as Weston Creek exceeds its flow capacity.

While the dam break analysis did not quantify the impacts if the west training floodwall were to overtop or fail during a flood event at a height of 609' NAVD88, an average height of the existing training wall, it is estimated that approximately 75 acres including 10 residential homes could be inundated with up to 7.5 feet of water, and approximately 10 residential homes and 7 businesses with up to 2.5 feet of water.

3.0 PLAN FORMULATION

3.1 Problem Identification, Opportunities and Constraints

Problem:
The sea lamprey population is reducing the number of native fish, particularly game fish, in the Great Lakes.

Opportunities:

- Reduce the lamprey population by decreasing access to spawning habitat.
- Reduce the population through release of sterilized males.
- Reduce the TFM treatment cost.
- Provide fish access to spawning habit upstream of the MPI dam.
- Decrease the overall costs of lamprey control on the Manistique River.
- Decrease the costs of fish stocking in Lake Michigan by virtue of decreased lamprey induced fish mortality.

Constraints:

- The dendritic nature of the river system makes treatment difficult.
- Existing flume structure below the dam makes trapping difficult.
- Section 1135 authority limits Federal financial participation.
- Proposed alternative must minimize impacts to flood elevation.

3.2 Goals and Objectives

Goals:

- Reduce the sea lamprey population in Lake Michigan
- Increase the native fish populations in Lake Michigan
- Reduce the amount of lampricide used throughout the Great Lakes

Objectives:

- Block lamprey from access to spawning habitat above the MPI dam.

- Eliminate the requirement to treat the river upstream of the dam with lampricide.
- Increase trapping efficiency.
- Decrease lamprey control costs over the life of the project.
- Provide an opportunity for the non-Federal sponsor to facilitate fish passage at the dam.

3.3 Management Measures Considered

A management measure is a feature or activity at a site, which addresses one or more of the planning objectives. A wide variety of measures were considered, some of which were found to be infeasible due to technical, economic, or environmental constraints. Each measure was assessed and a determination made regarding whether it should be retained in the formulation of alternative plans. The descriptions and results of the evaluations of the measures considered in this study are presented below:

(1) Non-Structural - The use of lampricides is the only non-structural measure that could be practically considered as a method for impacting the sea lamprey population in the Great Lakes. Additional methods of disrupting lamprey spawning are still in development.

(2) Structural – Structural measures include a fixed crest barrier, variable crest barrier, an electric barrier, or trap systems which provide only a partial solution.

Fixed Crest Barrier: This measure consists of a low-head barrier with minimum 18 inch difference between the crest elevation of the barrier and the surface elevation of the tailwater, preventing sea lamprey from proceeding further upstream. The proposed barrier would be constructed out of steel sheet piling or concrete and would extend across the river forming a cutoff wall. A jumping pool could be constructed downstream from the proposed barrier to allow passage for jumping fish species such as brook trout. This measure may also include a fishway and sea lamprey traps, which would be operated during the sea lamprey spawning migration (March thru June) to capture and remove lamprey from the system. Any fishway would require a means to remove or block sea lamprey migration.

Variable Crest Barrier: This measure consists of a barrier with a system to vary crest elevation. Crest height can be mechanically controlled on structures with stop logs by adding or removing stop logs. Other types of mechanical variable crest barriers use hoist systems, which control metal plates that can be raised or lowered to achieve the desired crest height. The inflatable variable crest barrier consists of steel gate panels, attached to a reinforced concrete foundation. Inflatable bladders are placed beneath the steel gate panels and are inflated and deflated to raise or lower the gate to maintain the required water drop to prevent sea lamprey migration. These variable crest measures may also include a fishway and sea lamprey traps. The variable crest barriers would be operated during the sea lamprey spawning migration (March thru June). At all other times the barriers would be lowered to the bottom of the river. This measure would retain the river

in a more natural free flowing state during non-spawning periods (July thru February), but is considered less reliable than a fixed crest barrier. **Figure 8** is a conceptual plan view of a lowhead barrier and fish passage.

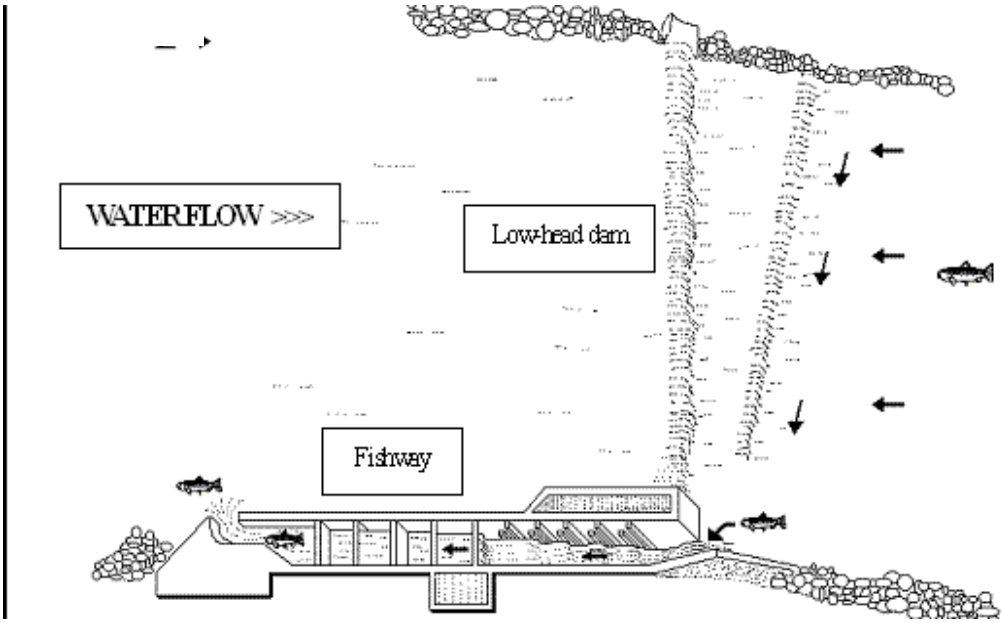


Figure 8 Plan view of a lowhead barrier with a fishway.

Electrical Barrier: This measure would prevent the upstream migration of sea lamprey through the use of an electrical current. The electrical barrier would be installed within a concrete foundation that stretches across the Manistique River. The barrier would prevent sea lamprey from traveling upstream by inducing an electric current through the water that sea lampreys avoid. The electrical barrier could be constructed into the existing riverbank. The selection of this alternative would eliminate the need for TFM treatment in the Manistique River upstream of the barrier. A fish passageway and a lamprey trap may also be required. This type of barrier would keep the river in a more natural, free flowing state year round, but is much less reliable than a fixed crest barrier.

(3) Separable features – Separable features include a fish ladder for fish passage and a sea lamprey trap for capturing lamprey.

(4) Additional Measures - With the management measures described above, there are design requirements that must be included for the formulation of complete alternative plans. These measures include the following:

- Modification of the center flume wall downstream of the proposed project.
- Excavation of the bedrock downstream of the dam to enhance flows towards the lamprey traps.
- Elevated walkway, platforms and hoist to provide access to the project across the entire river.
- Replacement or rehabilitation of the existing concrete wall on the west bank of the river from the dam to the Wyman nursery to prevent lamprey escapement during the design flood event.

3.4 Screening of Alternatives

All of the management measures considered in **Section 3.3** of this report could potentially prohibit lamprey from migrating above the MPI dam and into the headwaters of the Manistique River Watershed. Downstream of the dam to the confluence of the river and Lake Michigan will require continued treatment with a chemical lampricide. Therefore the alternatives are a combination of lampricide treatment in the lower river and a structural solution to protect the upper river and tributaries from infestation.

Electrical barriers were once used extensively with some success and have been redesigned to be much more effective in some settings. Modern electrical barriers are being used at a few Great Lakes sites but their effectiveness has not been evaluated over an extended period of time. These barriers require sophisticated control systems, are susceptible to power failures, and present unique fish passage problems. The risk of power failure, uncertainty about the affects of electric currents on native fish species and the lack of data about the effectiveness of electric barriers eliminate the electric barrier from further alternative development and analysis.

Modification of the existing dam was also eliminated from further consideration because it was not possible to achieve the 1.5 foot difference between the head and tail water elevation required to block lamprey migration. Additionally the decommissioned structure is privately owned, provides support for the City of Manistique's water supply infrastructure and the age and level of deterioration limit what could be done to make it an effective lamprey barrier.

FWS studies indicate that lowhead barrier alternatives are most effective when there is a minimum of 18 inches between the barrier crest and tailwater elevation during the migration period. This configuration takes advantage of the lamprey's poor swimming ability. The presence of the MPI dam made the barrier design and location challenging. Proposed barrier locations upstream of the MPI dam were subject to the backwater effect of the structure, making it difficult to achieve the minimum 18 inch difference between barrier crest and the tailwater elevations. Additionally, the topography of the Manistique River upstream of the MPI structure is relatively flat. Results of the hydraulic model indicated that a proposed barrier height would have to be very tall (greater than or equal to 10 feet) and would cause overbank flooding during the typical spring flow event. Barrier locations downstream were again influenced by the existing dam and were also subject to fluctuations in Lake Michigan water levels.

3.5 Alternatives considered

Alternative 1 - Fixed Crest Cantilevered Barrier: Alternative 1 consists of the construction of a cantilevered steel sheet pile (SSP) wall and the functional replacement of the upstream west concrete wall. Alternative 1 would be constructed adjacent to the existing sill on the downstream side of the MPI dam. The SSP would be placed in a trench at a depth of 7 feet below the top of the bedrock which would be backfilled with concrete. The subsurface portion of the SSP would serve as a cutoff wall and prohibit escapement of lamprey through fissures in the bedrock. The top of barrier elevation will

be at 600.0 feet (NAVD88) or about 2 feet above the existing sill. The barrier would be 360 feet long, which is the width of the river at the dam (Figure 9). Portions of the existing dam would be demolished to accommodate the barrier.

Alternative 1 also includes the removal of all 2,740 feet of the center flume wall (**Figure 10**). The removal will take place at a portion of the wall that has already been modified by MPI. The removal will eliminate the hydraulic boil at the confluence of the flume and river flows in this section of the river. The lampreys are attracted to turbulence and congregate in the area, eliminating this will promote the migration of the lamprey upstream to the barrier and the trap and sort complex.

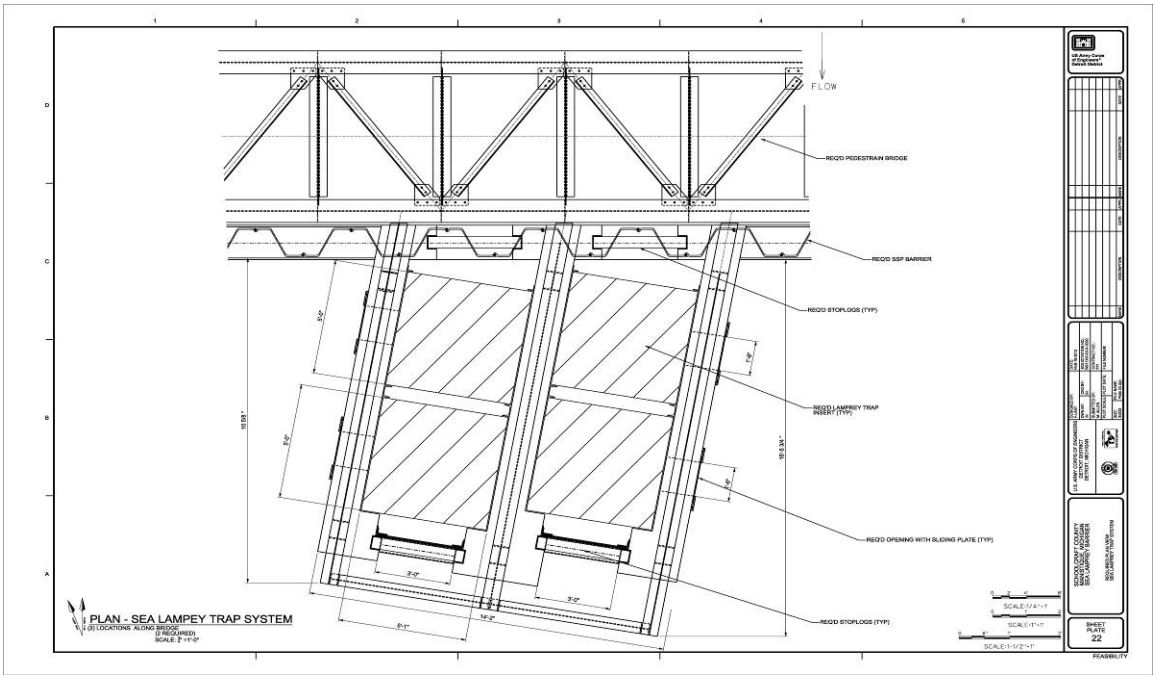


Figure 9 Plan view of lamprey Trap complex

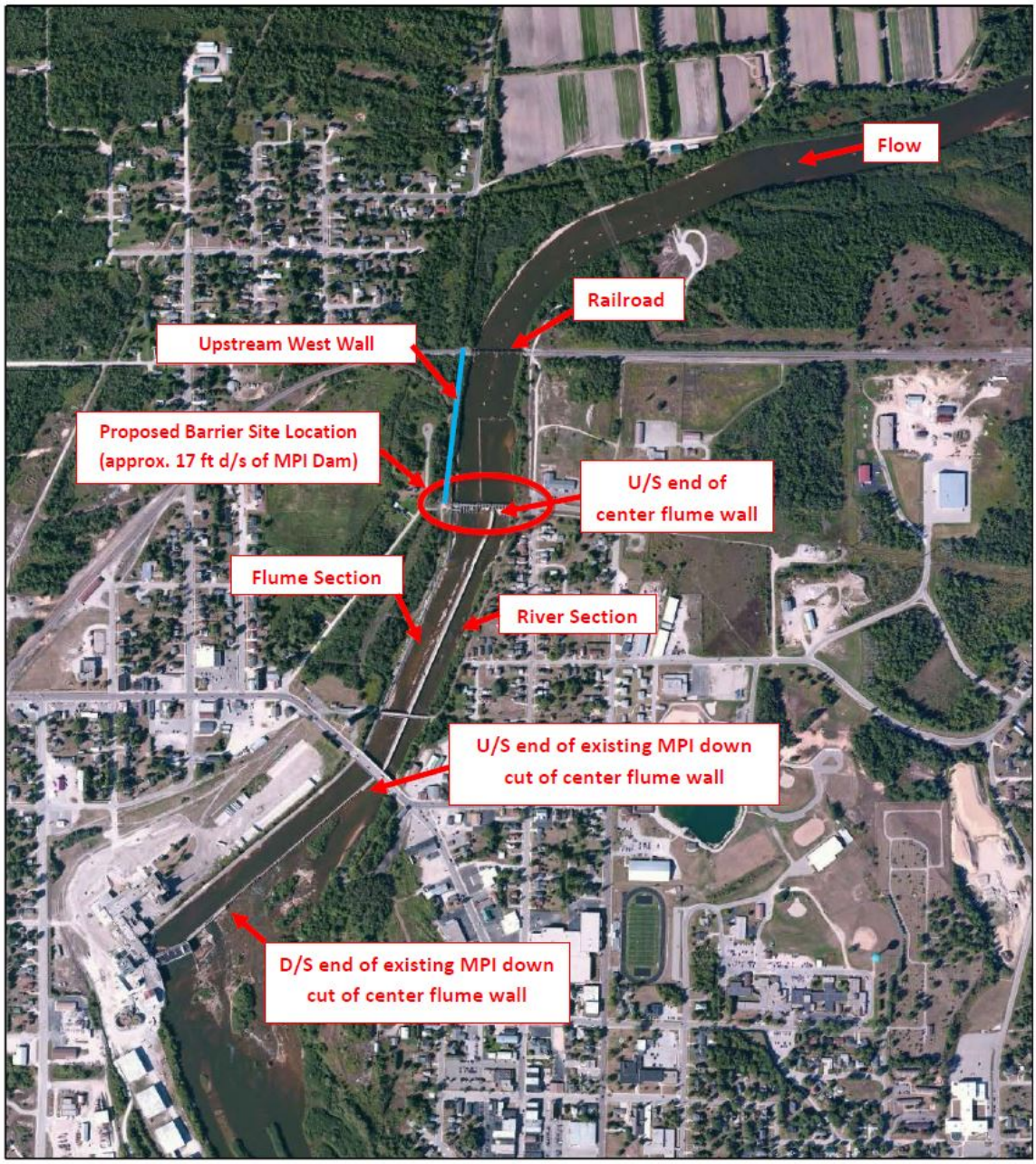


Figure 10 Section of center flume wall to be modified

A trapping and sorting complex consisting of two lamprey traps is required, one at each end of the barrier. The traps will be approximately 10-feet square and will hold three 5-foot square trap inserts. The back of the traps will be formed by the barrier while the sides will be concrete walls and the front a steel plate. Two sets of stoplogs at each trap will be used to control flow into the traps. In addition, bedrock downstream of the traps will be excavated to create an attractant flow for the lamprey.

A walkway will provide access to all lamprey traps. It will be approximately six feet wide to allow for access by a four-wheeler and trailer used for transporting the lamprey, and extend across the barrier. Additionally, the walkway will have several hinged sections to allow for use of portable traps. Per the FWS, a lift system should be designed

to lift 500 pounds of lamprey plus the trap insert from the riverbed to the platform. The barrier will include stop log sections where the State of Michigan could implement a fish passage at their convenience.

West Concrete Wall Replacement

Finally, the last component of Alternative 1 is the functional replacement of the existing upstream west concrete wall. The concrete wall was constructed in 1920 of reinforced concrete founded on bedrock. When built, the primary purpose was to contain the impounded water behind the dam along the west bank of the natural river channel. The existing 1700 foot structure is made of reinforced concrete and extends in 2 sections upstream of the dam. The first section extends 850 feet from the dam to the railroad bridge and the second 850 foot section extends from the railroad bridge to the State run nursery. Hydraulic modeling of with and without project conditions determined that the west concrete wall or a similar structure upstream of the dam is necessary for three reasons: 1) to maintain the upper pool needed to achieve the desired drop in water elevation at the barrier during the design event, 2) to prevent an increase in the floodplain for the 1% exceedance event, and 3) to prevent lamprey escapement during extreme flow events.

The Detroit District (LRE) Design Team's initial thought was to repair or reconstruct the existing concrete wall where necessary and incorporate it into the barrier project. This idea was presented to the Regional Technical Specialist (RTS) for structural engineering in the Chicago District (LRC). After reviewing a detailed pictorial survey of the wall the technical specialist advised the LRE Design Team that the structure was in such a state of disrepair that the risk to life and safety would be too great to incorporate it as a project feature. The Design Team agreed with the technical specialist and concluded that an alternative to the wall repair is the best course of action and suggested that a clay berm be constructed to replace the west concrete wall.

A clay berm is the most cost effective solution when compared to concrete or steel alternatives; the berm component would also accomplish the primary hydraulic purpose which to provide the 1.5 foot drop at the lamprey barrier during the design flood event (6.7% (15 year)). Each of the barrier alternatives includes the construction of a clay berm. Hydraulic modeling of the proposed barrier crest elevation indicates that only the portion of the wall that extends from the dam approximately 850 feet upstream to the railroad bridge is necessary to insure the optimum operation of the barrier and the flood risk to property upstream of the railroad bridge is low. The top elevation of the structure is designed to be 611.0 (INAVD88).

Alternative 2 – Fixed Crest Post and Panel Barrier: Post and Panel Wall on Existing Sill: The barrier for this alternative would consist of a steel post and panel type wall placed on top of the existing sill (**Figure 11**). Steel and precast concrete panels were considered with steel being the more cost effective choice. This alternative would require a small amount of concrete pier removal. A trapping and sorting complex with a work platform and hoist would be required similar to Alternative 1. A steel walkway would be required to provide access to the permanent traps as well as allow for the use of temporary traps. Bedrock downstream of the traps would be excavated to form attractant

flow to the lamprey. Grouting of the bedrock fissures for a distance of approximately 10 feet downstream of the barrier would be required in an effort to prevent escapement of the lamprey through the fissures in the bedrock. Like Alternative 1 the post and panel barrier would also require the implementation of the berm structure on the west side of the river upstream of the dam and terminating 850 feet upstream of the dam at the railroad bridge.

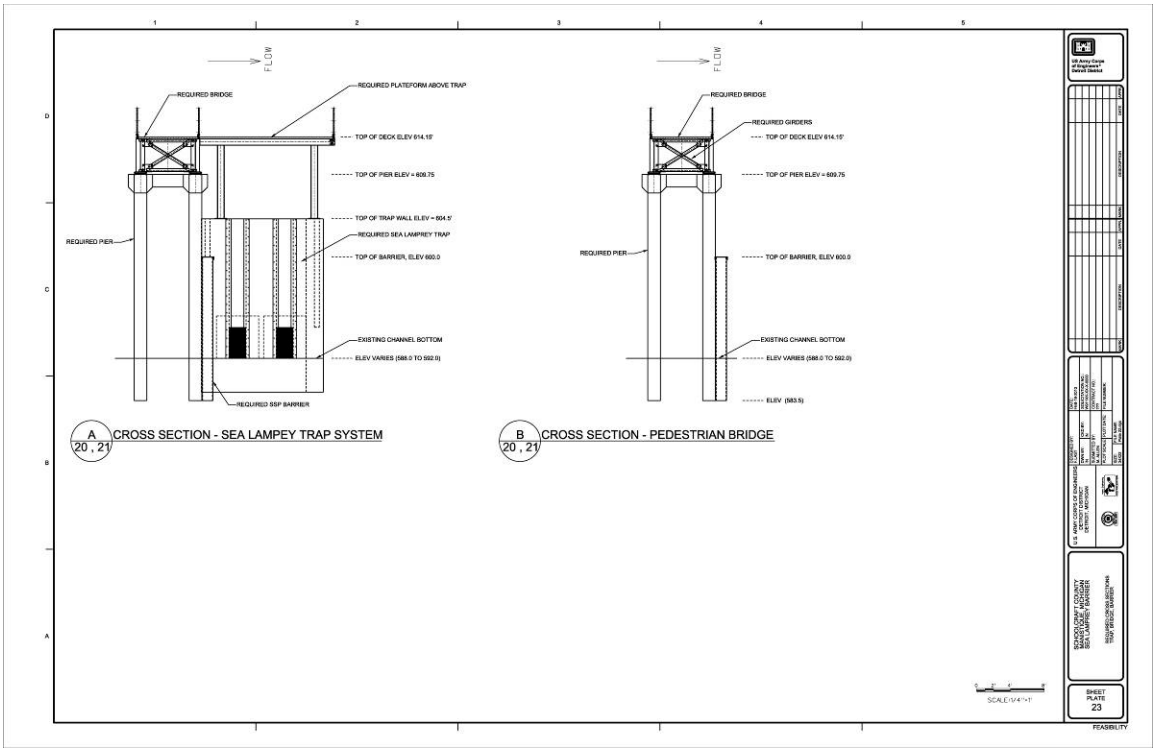


Figure 11. Alternative 2 Cross Section

Alternative 3 - No Action – Under the No Action alternative no barrier would be constructed by either the Federal government or by State or local governments. There would be no attempt to modify the dam or address the fissures in the bedrock to keep lamprey from migrating upstream. The Fish and Wildlife Service would continue to treat the entire river and its tributaries with lampricide. The GLFC through the use of the FWS would also continue to trap lamprey. The Manistique River would continue to be a major contributor to the Great Lakes sea lamprey population and continue to impede the restoration of the Great Lakes fishery.

4.0 COMPARE ALTERNATIVES

4.1. Formulation Criteria

The final array of alternative plans is compared using four formulation criteria as indicated in ER 1105-2-100, 22 APR 2000. These criteria are completeness, effectiveness, efficiency and acceptability.

4.1.1 Completeness

Completeness is a determination of whether or not the alternative includes all elements necessary to achieve the objectives of the plan. It is an indication of the degree that the outputs of the plan are dependent upon the actions of others.

Both of the barrier alternatives considered for further formulation are complete alternatives with respect to their ability to achieve the project objectives. Alternatives 1 and 2 will achieve the following project objectives:

- Block lamprey from access to spawning habitat above the MPI dam.
- Eliminate the requirement to treat the river upstream of the dam with lampricide.
- Increase trapping efficiency.
- Decrease lamprey control costs over the life of the project.
- Provide an opportunity for the non-Federal sponsor to facilitate fish passage at the dam.

The plans are unaffected by any future plans MPI might implement to demolish the existing dam or any of the flume or concrete walls upstream of the dam. Each alternative will have the capacity to provide fish passage which could be implemented by the State of Michigan post construction. **Table 2** provides a summary of the alternative features.

	Height From River Bottom (Feet)	Length (Feet)	Design Flood Event	Number of Traps required	Future Fish Passage feature	Real Estate (acres)
Alternative 1- Cantilevered barrier	8.3	360	6.7%	2	Yes	20.05
Alternative 2- Post and Panel barrier	8.3	360	6.7%	2	Yes	20.05
Alternative 3 - No Action	-	-	-	6	No	-

Table 2 Alternative feature summary table

4.1.2 Effectiveness

All of the plans in the final array provide some contribution to the planning objectives. Effectiveness is defined as a measure of the extent to which a plan achieves its objectives.

Alternatives 1 and 2 are expected to be equally effective at achieving the primary objective of blocking lamprey from spawning habitat upstream of the MPI dam. It is expected that a combination of lampricide treatments downstream of the dam, the barrier, and flow manipulation features will enhance the effectiveness of the trapping conducted

by FWS. The blocking and trapping of sea lamprey are expected to reduce the costs of Lake Michigan fish stocking operations due to a decreased in fish mortality rate attributed to adult lamprey. The No Action plan or continued use of lampricide throughout the entire river is expected to remain less effective upstream of the dam due to the massive tributary network.

4.1.3 Efficiency

Efficiency is the extent to which an alternative is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment.

The barrier alternatives provide the same level of protection to the Manistique River upstream of the dam. It can be extrapolated that each of the barriers would have the same effect on the overall lamprey population in Lake Michigan. Alternative 2 would be constructed on the sill of existing dam and would require additional work to the piers of the dam thus incurring additional costs in comparison to Alternative 1. **Table 3** list the net benefits for each barrier alternative.

Table 3 - Benefit-Costs of Proposed Alternatives in 2017 Dollars	**Alternative 1**	**Alternative 2**
Average Annual Benefits[1]	$446,400	$446,400
Average Annual Costs	$307,000	$311,000
Net Benefits of Project	**$139,400**	**$135,400**
Benefits-Cost Ratio	**1.45**	**1.44**

[1]Annual Benefits include savings on TFM treatment costs; fish stocking operations.

4.1.4 Acceptability

All of the alternatives in the final array must be in accordance with Federal law and policy. The comparison of acceptability is defined as acceptance of the plan by the local sponsor and the concerned public.

Both action alternatives support the GLFC's, vision for lamprey control in the Great Lakes as outline in *The Strategic Vision of the Great Lakes Fishery Commission for the First Decade of the New Millennium.* The GLFC planning document contains a milestone which states that 50% of sea lamprey suppression and a 20% reduction in TFM use will be accomplished through alternative control technologies, including barriers (Sullivan and Adair 2009). The City of Manistique and the Michigan Department of Natural Resources expressed their support of the study alternatives, because the implementation of either action alternative would result in the continued restoration of the Great Lakes Fishery. The Michigan Department of Environmental Quality (MDEQ) find Alternatives 1 and 2 acceptable because they minimize their impact on upstream water surface elevations during flood events and minimize the impacts on wetlands.

4.2 Comparison of Alternatives

Comparison of the alternatives is based on the evaluation of the impacts of the alternatives. The Planning Process requires that the analyzed alternatives also meet all of the following criteria: economically-justifiable, engineeringly feasible, and environmentally and socially acceptable. If an alternative does not meet one or more of these criteria, it is eliminated from further consideration. There are certain policies and circumstances that allow justification of alternatives outside of these guidelines if there is supporting rationale.

Both Manistique River alternatives considered in the final array of plans are equally effective at blocking lamprey and reduce the same amount of watershed of acreage that would require lampricide treatment. The cost for Alternative 2 differs from Alternative 1 because although both alternatives have similar design elements and produce comparable benefits, the difference in construction materials used and the implementation of Alternative 2 on the dam sill result in an increased construction cost for Alternative 2.

A typical ecosystem restoration economic evaluation would involve cost effectiveness (CE) and incremental cost analyses (ICA). Since the benefits of both alternatives are the same and Alternative 1 is the least expensive of the two action alternatives, this is the only cost effective plan. The benefits of TFM reduction are already monetized, thus it is reasonable to also utilize the benefit/cost analysis when determining the recommended plan. This method of analysis was used to justify the lamprey barrier projects constructed at Trail Creek, Indiana and Carp Lake, Michigan. **Appendix D – Economic Appendix** contains a complete benefit cost analysis.

5.0 DESCRIPTION OF SELECTED PLAN

5.1 Alternative Section

Alternative 1 - Fixed Crest Cantilevered Barrier is the recommended alternative. Alternative 1 achieves all of the project objectives to:

- Block lamprey from access to spawning habitat above the MPI dam.
- Eliminate the requirement to treat the river upstream of the dam with lampricide.
- Increase trapping efficiency.
- Decrease lamprey control costs over the life of the project.
- Provide an opportunity for the non-Federal sponsor to facilitate fish passage at the dam.

Furthermore, the cutoff wall feature of the fixed crest cantilevered barrier provides a solution to possible lamprey escapement through fissures in the bedrock. The placement of the barrier has less of an impact on existing infrastructure namely the MPI dam. Placement of the barrier downstream of the existing dam permits MPI to continue with their plans to demolish the aging decommissioned structure. The stop log section in the barrier will allow the State of Michigan to implement fish passage to non-jumping fish

species. The bedrock excavation and flow manipulation at the barrier are expected to increase the trapping effectiveness at the MPI dam site.

5.1.1 Rationale for Designation of the National Economic Development (NED) Plan

As stated in the existing and without project conditions of this report sea lamprey have had a devastating impact on the Great Lakes Fishery. The recommended alternative, Alternative 1 the Fixed Crest Cantilevered Barrier, is the NED plan because it provides economic benefits at the lowest cost in the following two areas: 1) Lampricide treatment saving resulting from not having to treat the Manistique River and its tributaries above the proposed barrier. 2) The expected decrease in fish stocking costs. The decreased lamprey population will help facilitate the recovery of Lake Michigan's lake trout population and reduce the reliance on stocking. According to the FWS the average annual benefit to Lake Michigan fish stocking operations is approximately $139,400 in 2017 dollars. See complete economic details in the Economic appendix – Appendix D

5.1.2 Rationale for Designation of the National Ecosystem Restoration (NER) Plan

The primary environmental benefit of Alternative 1 is the reduced impact to the Great Lakes fishery from sea lamprey predation. It is estimated that each lamprey destroys around 40 pounds of fish. The added efficiency of the barrier, compared to lampricide treatment, is expected save roughly 319,600 pounds of fish or approximately 53,300 6-pound fish on an annual basis.

The dendritic nature of the Manistique River System upstream of the MPI dam make it difficult to treat and historically has required additional treatments to eliminate a residual lamprey population. This introduction of additional chemical to the river increases stress on non-target fish species and invertebrates. The proposed barrier is expected to eliminate the requirement to use lampricide chemicals upstream of the MPI dam and reduce the stress to the non-targeted aquatic species in the upper portion of Manistique River system. Consequently, Alternative 1 is also considered the NER plan.

5.2 Risk and Uncertainty

Risk is a measure of the probability and consequence of uncertain undesirable events occurring. For this project, the probability factor includes the likelihood of the hydraulic event occurring (flood frequency), as well as the probability that the levee would overtop or breach at that loading (performance). Consequence measures the amount of damages that would occur if the overtop or breach did occur. A qualitative risk discussion for two water retaining features of the project (the barrier and the upstream berm) are discussed below.

The proposed barrier will have about 6 feet of head difference during large flood events, such as a 1% (100 yr.) event. This head difference is similar to the existing conditions, and the expected consequences of dam failure would be similar to those described for the existing conditions failure from the dam break analysis. It is likely that the areas downstream of the dam that will be inundated by flood waters will be impacted

differently depending on its proximity to the failure, timing, magnitude of the river flow and elevation, and the water level of Lake Michigan just prior to failure. A dam failure during a large peak flood event would cause the most widespread flooding, and the area that would be significantly impacted lies between the dam and the M-94 Bridge downstream. The flood would begin to attenuate downstream of the M-94 bridge, with moderate flooding along the east bank of the river, down to Lake Michigan.

After removal of the MPI gates, the sill of the existing dam will be left in place, with an elevation of 597.7 ft. NAVD88 with an existing spillway crest elevation of 608 ft. NAVD88. The proposed sea lamprey barrier has a crest of 600.00 ft. NAVD88, lower than the spillway crest for the 'without project' conditions. Therefore, the consequence of failure for the proposed sea lamprey barrier would be expected to be the same as the existing MPI dam. In addition, both the concrete sill and the barrier would have to fail simultaneously to allow the full head of water to be released. The occurrence risk of simultaneous structural failure is extremely low.

A full and proper levee breach analysis was not conducted for the proposed berm as a hydrologic model was never created for this project. The steady state model was quickly modified to run a representative flood hydrograph through the system and the levee was breached to see general impacts and consequences. The hydraulic analysis revealed that during a design flood event of 6.67% annual exceedance probability (15 year) the water surface would be at an approximate elevation of 606.53' NAVD88 at the berm. If the berm were to breach at this elevation, a low lying area, directly west of the river, of approximately 43 acres containing 10 residential homes could be inundated with approximately 5.5 feet of water and 7 businesses with up to 1.0 feet of water. The berm would overtop with a height of 609' NAVD88 in a hydraulic event less frequent than a 1% annual chance exceedance event (100 year event). The area estimated to be inundated if a fully loaded berm were to fail or overtop could inundate approximately 75 acres including 10 residential homes with up to 7.5 feet of water, and approximately 10 residential homes and 7 businesses with up to 2.5 feet of water (**Figure 12**).

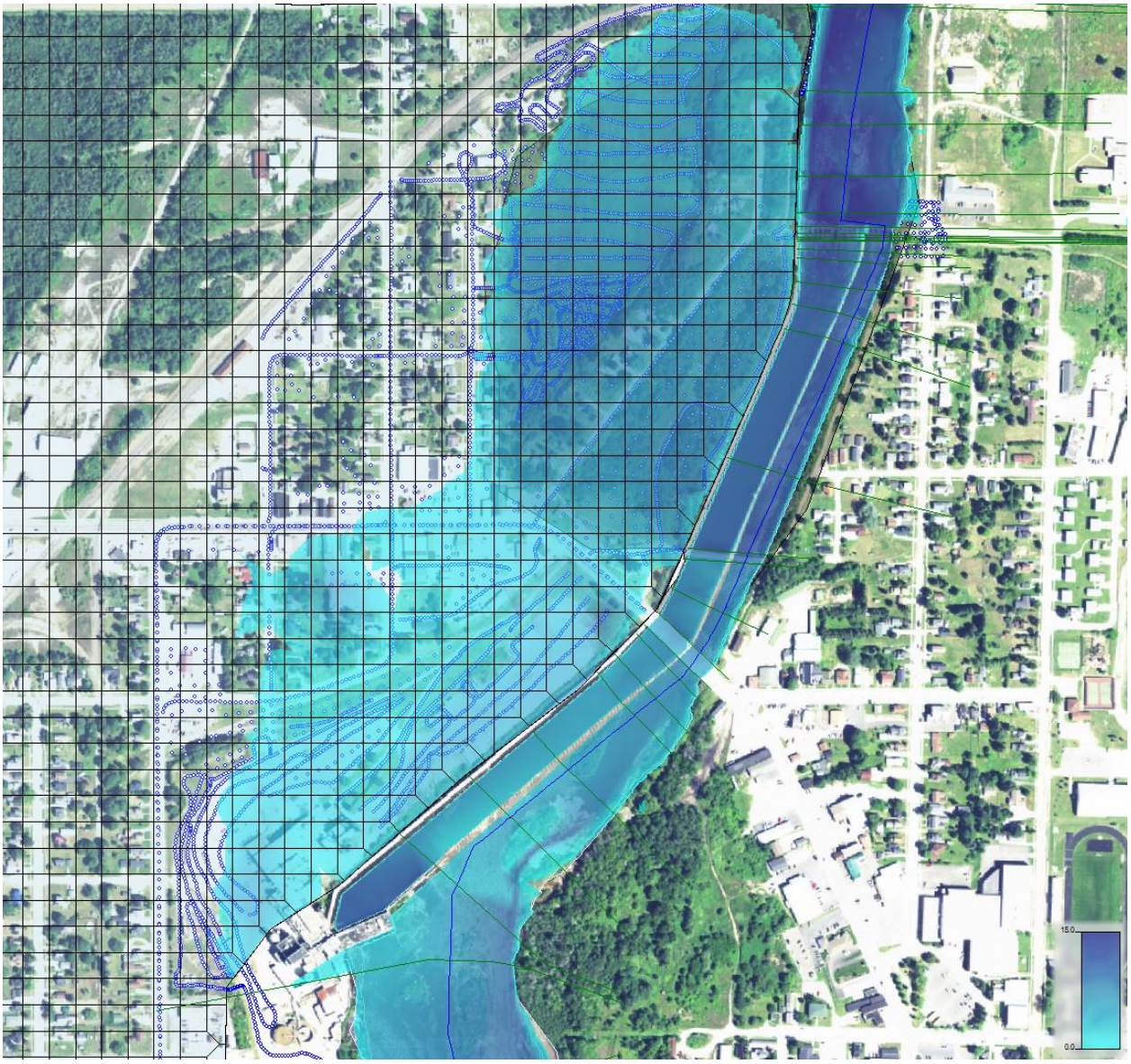


Figure 12 Max Loading Levee breach Inundation

The overall risk probability of the occurrence of undesirable consequences is reduced by the barrier project. The probability of a structural failure of the steel sheet pile barrier is low, as the structure will be embedded in bedrock and has been designed to meet USACE structural criteria. There are no consequences associated with failure of the barrier, as the water remained within the riverbank when fully loaded. The steel sheet pile barrier would be completely submerged at flood events that would cause impacts beyond the banks of the river.

The berm that is planned upstream of the barrier would have an impact to approximately 75 acres containing 10 residential homes and 7 businesses if it overtopped or breached at the full height of the berm. However, it should be noted that an existing concrete floodwall (training wall) currently exists at approximately the same height as the planned berm. The concrete floodwall is in a deteriorated state. Construction of the berm on the landside of the concrete floodwall will reduce the likelihood of a failure, therefore

reducing the overall risk. In addition, both the wall and berm would have to fail before an uncontrolled release of water occurred. This redundancy would likely allow adequate time for flood fighting to prevent a failure. Finally, based on the risk-informed information and analysis provided in this DPR, the Detroit District Chief of Engineering and Construction Office determined that the barrier project risk is low to the life and safety of the City of Manistique. **Table 4** lists a few general study risk. See the project specific risk and uncertainty table in **Appendix G**.

Area of Concern	Likelihood	Potential Impacts	Mitigation Measures
Non-Federal sponsor having the ability to provide its costs share	The likelihood is low because the GLFC and the State of Michigan have a history of participation in lamprey control activities including partnering with USACE on barrier projects	Delay the implementation of the project. Could lead to infestation upstream of the dam.	TFM treatment applied upstream of the MPI dam.
Actual cost far exceeding estimated costs	The likelihood is low since the scope of the project does not include a significant amount of work with the dam	The project may have to be constructed in phases	NA
Recommended plan could induce flood damage to surrounding property	The likelihood that the barrier project will induce flooding is low. Extensive hydraulic modeling has been done on the post project condition to decrease the uncertainty of the barriers impact on flood levels.	The project would not be permitted by the State of Michigan (MDEQ).	GLFC would be forced to implement a long-term lampricide treatment strategy upstream of the MPI Dam.
Barrier project increases the risk to the life and safety of recreational boaters	The likelihood is low that barrier project would pose a risk to the overall recreational boating use. The vicinity of project area has seen precipitous drop in recreational boating activity over the last 30 yrs. The nearest boat launch is a little over 2200 feet upstream of the project.	Project implementation would be delayed until user data could be developed.	GLFC, MDNR and USFWS would coordinate the installation of signage.

Table 4 Areas of Risk and Uncertainty

5.3 Outputs and Measurements

The proposed physical barrier would prevent sea lamprey from accessing roughly 264 acres of habitat upstream of the MPI dam. By reducing access of the parasite, the GLFC would no longer need to treat this area with the TFM lampricide. The elimination of the TFM treatments represents an annual savings of approximately $132,400 (in 2012 dollars). A quantifiable assessment of barrier performance will be measured both with riverine and lentic assessment post implementation. **Table 5** provides a summary of the GLFC TFM usage throughout the Great Lakes Basin.

Lake	Number of Streams	Number of Lentic	Discharge (m^3/s)	TFM (kg)[2]	Bayluscide (kg)[2]	Distance (km)
Superior	25	7	171.4	17,146.0	758.2	670.2
Michigan	22	5	219.3	47,778.5	397.6	1,793.8
Huron	12	1	124.3	28,282.4	2,078.6	991.4
Erie	2	0	1.8	484.5	0.0	20.0
Ontario	10	0	48.1	6,654.5	24.9	235.2
Total	**71**	**13**	**564.9**	**100,348.9**	**3,259.3**	**3,710.6**

[1]Source: *Integrated Management of Sea Lampreys in the Great Lakes 2014*
[2]Lampricide quantities are reported in kg of active ingredients

Table 5 Summary of lampricide applications in tributaries of the Great Lakes, 2014[1]

Sea lamprey control specialists believe design improvements made over the years would improve sea lamprey control success at new barriers. New barriers are believed to be almost completely effective in preventing lamprey migration whereas lampricide treatment is approximately 95% effective overall. It is estimated that the barrier would be nearly completely effective at preventing lamprey recruitment upstream of the barrier, which is 4% more effective than lampricide treatments. It is expected that lampricide treatment downstream of the barrier would continue. An 18-inch vertical drop between the crest of a sea lamprey barrier and the downstream water surface is necessary to prevent lamprey from traveling over the barrier. There is a risk that, during periods of high water, the water surface differential between the pool above the barrier and the tailwater elevation will be reduced below the 18 inch target, thereby increasing the likelihood of lamprey escapement.

This increased effectiveness would decrease the lamprey population thereby minimizing their impact on the fisheries of Lake Michigan. It is anticipated that the barrier alternative would reduce the residual lamprey population by an additional 8,000 recruits over what would be realized by a lampricide alternative. In addition, eliminating lampricide application would end any detrimental effects on non-target species that currently occur upstream of the proposed barrier. Although TFM has not been shown to have serious impacts on stream ecology, some species including various invertebrates, native lamprey and sturgeon have been shown to be sensitive.

5.3.1 Fish Benefit

The infestation of the sea lamprey in the Great Lakes was a major factor in the collapse of the fishery and control efforts have resulted in the partial recovery of many fish species. Lamprey control is a key component to maintaining this fishery as evidenced by the continuing bi-national effort supported by the GLFC. Removing adult sea lamprey

before they spawn ultimately reduces the number of larvae produced in the river, and thus the number of transformers that enter the Great Lakes.

Alternative[1]	Estimated Average # of Adult Sea Lamprey in St. Manistique River [2]	Est. Average # of Adult Lamprey Removed by Semi-permanent Traps	Est. Average # of Adult Lamprey Removed by Permanent Traps + **Barrier**	Net Estimated # of Additional Sea Lamprey Removed Annually as Compared to **No Action** [3]
Alternative 1- Cantilevered barrier	10,888	-	8,384	3,484
Alternative 2- Post and Panel barrier	10,888	-	8,384	3,484
Alternative 3 - No Action	10,888	4,900	-	-

1 - The "no action" alternative (current condition) and the action alternatives 1, and 2 assume that the USFWS will continue lampricide treatments as needed / scheduled.
2 - Approx. average based on USFWS population estimates of spawning-phase lamprey in Manistique River using mark/re-capture between the years 2006-2015.
3 - Adult lamprey die almost immediately after spawning, thus lamprey caught are assumed to have not spawned.

Table 6 – Annual Alternative Effectiveness – Effects on Spawning-Phase Adults & Great Lakes Fish

Habitat units (HU) are an assessment tool for examining the environmental impacts or outcomes for each of the proposed alternatives. For this study, a HU is defined as the removal of a sea lamprey by trapping.

The USFWS estimates that the utilization of current traps and lampricide resulted in approximately 10,888 spawning phase lamprey returning to the Manistique River annually during the spawning season. **Table 6 – Annual Alternative Effectiveness – Effects on Spawning-Phase Adults and Great Lakes Fish.**, illustrates the projected effect of each alternative on the spawning phase lamprey population in a given year.

Table 7 – Manistique River Benefits carries a portion of the information presented in **Table 6** including the environmental benefits associated with each of the alternatives. The Corps' ecosystem restoration studies generally do not require economic justification as assigning dollar values to ecosystem benefits is often not possible. However it is possible to make assumptions regarding lamprey production and survival to illustrate economic benefit. For this estimate, Average Annual Habitat Units (AAHUs) are equivalent to the number of sea lamprey removed annually. Alternative 3 "No Action" produces an estimated 4,900 habitat units. Alternatives 1 and 2 indicates 8,384 in habitat units achieved per year, or 3,484 habitat units above the existing conditions.

Alternative[1]	Estimated Number of Sea Lamprey Removed Annually by Trapping[2]	Net # of Sea Lamprey available to spawn	Number of mature sea lamprey avoided each year	Number of 6 lb. fish saved per year	Yearlings stocked per year avoided	Annual cost savings compared to the no action with stocking
Alternative 1- Cantilevered barrier **(Recommended Alternative)**	8,384	2,504	4,552	30,347	75,868	$254,146
Alternative 3 - No Action	4,900	5,988	0	0	0	0

[1]The Annual Habitat Units and economic fish benefit for the action alternatives is identical.
[2] Average Annual Habitat Units are equal to estimated number of sea lamprey removed annually. Refer to **Table 6** for additional details.

Table 7 – Manistique River Benefits

If we assume that the returning spawning phase lamprey are largely the result of the surviving transformers that left the river the previous year and that only returning spawning phase lamprey kill fish, it could be argued that a single year of transformers from the Manistique River results in the loss of at least 435,520 lbs. of fish (10,888 spawning phase lamprey killing an average of 40 lbs. of fish each). If the average size of a lake trout attacked by a lamprey is 6 lbs. the 10,888 lamprey kill approximately 72,587 fish. The combination of traps and a barrier reduces the number of lamprey actually spawning from about 10,888 down to about 2,500. If we assume that there is a linear relationship between the number of spawners and the returning adults we can estimate each spawning adult results in 1.818 returning adults (5,988 spawners under the current conditions result in 10,888 returning adults). Calculating the resulting reduction in returning adults under each alternative we can estimate the number of fish deaths avoided under each alternative when compared the no action alternative.

The preferred food source for sea lamprey are lake trout. Using data provided by the MDNR we can estimate the cost of replacing a lake trout lost to sea lamprey predation by stocking yearling lake trout from a hatchery. Successful stocking requires the use of yearling fish to achieve acceptable survival rates of 40% (so 2.5 yearlings need to be stocked to replace each adult lost). The cost to produce a yearling (Lake Superior strain) lake trout is estimated as $3.22 and the cost of placement about $0.13 for a total cost of $3.35. These numbers allow us to estimate the annual value of the fish saved under the alternatives in **Table 7**. Each of the action alternatives provides benefits in excess of the average annual costs illustrated in **Table 5**.

5.4 Significance of Outputs

As discussed in earlier paragraphs, the sea lamprey invasion of the Great Lakes was a major factor in the collapse of the Great Lakes fishery. Control efforts have resulted in

the partial recovery of many species and the Great Lakes fishery is currently estimated to generate up to $4 billion annually for the region. Sea lamprey control in the Great Lakes is both institutionally and internationally significant as evidenced by the signing of Executive Order (EO) 13340 which designated the resource issues of the Great Lakes as nationally significant and defined the Federal policy to support local and regional efforts to restore and protect the Great Lakes ecosystem through the establishment of regional collaboration. In addition Congress passed the Water Resource Development Act (WRDA) 1999 which amended Section 1135 of WRDA 1986 giving USACE the authority to participate in sea lamprey control throughout the Great Lakes. Finally international significance of the lamprey control program is demonstrated by the continuing bi-national effort supported by the GLFC.

5.5 Costs Apportionment

Under Section 1135, WRDA 1986, (P.L. 99-662) as amended, the costs for design and construction of project are split 75% and 25% between the Federal Government and non-Federal sponsors respectively. The non-Federal sponsors are responsible for all Lands, Easements, Rights of Way, Relocations, and Disposals (LERRD) as well as 100% of Operation, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R) costs. The costs for the recommended plan depicted here in **Table 8** were subject to a costs risks analysis in accordance with USACE project cost guidance. The detailed cost estimate can be found in the **Cost Appendix - Appendix C.**

	Federal Cost	Non-Federal Cost	Total Cost
Feasibility study costs[1]	$791,000	$690,000	$1,481,000
Construction costs [1]	$5,916,000	$1,972,000	$7,888,000
LERRDs	-	$362,000	$362,000
Subtotal	$6,707,000	$3,024,000	
		TOTAL PROJECT COST	**$9,731,000**[3]

[1]The first $100,000 of Feasibility Phase is 100% Federal; the remaining Feasibility phase costs are split 50/50
[2]Annual O&M costs estimated at $32,000; FWS will conduct O&M on behalf of GLFC
[3]Costs include contingency
Table 8 Cost Apportionment Table

5.5.1 Items of Local Cooperation

The O&M discussed in **Section 5.8**, along with additional repair, rehabilitation and replacement (i.e. "OMRR&R") of the project will also be the responsibility of the non-Federal sponsor for the proposed project. The non-Federal sponsor shall, prior to implementation, agree to perform the following items of local cooperation:

1. Provide 25 percent of the separable project costs allocated to environmental restoration as further specified below
   a) Provide the non-Federal share of all complete planning and design work upon execution of the PPA

b) Provide all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or ensure the performance of all relocations determined by the government to be necessary for the construction and O&M of the project
c) Provide or pay to the government the cost of providing all features required for the construction of the project
d) Provide, during construction, any additional costs as necessary to make its local contribution equal to 35 percent of the project costs allocated to the implementation of the completed Section 506 project.

2. Contribute all project costs in excess of the Corps 1135 program per-project limitation of $10,000,000
3. For so long as the project remains authorized, operate, maintain, repair, replace, and rehabilitate the completed project or the functional portion of the project at no cost to the government in accordance with applicable federal and state laws and any specific directions prescribed by the government
4. Give the government a right to enter, at reasonable times and in a reasonable manner, upon land that the local sponsor owns or controls for access to the project for the purpose of inspection and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project
5. Assume responsibility for operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) of the project of completed functional portions of the project, including mitigation features, without cost to the government in a manner compatible with the project's authorized purpose and in accordance with applicable federal and state laws and specific directions prescribed by the government in the OMRR&R manual and any subsequent amendments thereto
6. Comply with Section 221 of Public Law (P.L.) 91-611, Flood Control Act of 1970, as amended, and Section 103 of the WRDA of 1986, as amended, which provide that the Secretary of the Army shall not commence the construction of any water resource project or separable element thereof until the nonfederal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element
7. Hold and save the United States free from damages due to construction of or subsequent maintenance of the project except those damages due to the fault or negligence of the United States or its contractors
8. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project to the extent and in such detail as will properly reflect total project costs
9. Perform or cause to be performed such investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 *U.S. Code* 9601 through 9675, that may exist in, on, or under lands, easements, or rights-of-way necessary for the construction, and O&M of the project, except that the nonfederal sponsor shall not perform investigations of lands, easements, or rights-of-way that the government determines to be

subject to navigation servitude without prior written direction by the government

10. Assume complete financial responsibility for all necessary cleanup and response costs for CERCLA-regulated material located in, on, or under lands, easement, or rights-of-way that the government determines necessary for the construction and O&M of the project
11. To the maximum extent practicable, conduct OMRR&R of the project in a manner that will not cause liability to arise under CERCLA
12. Prevent future encroachment or modifications that might interfere with proper functioning of the project
13. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, P.L. 91-646, as amended in Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987, P.L. 100-17, and the uniform regulation contained in Part 24 of Title 49, *Code of Federal Regulations* (CFR), in acquiring lands, easements, and rights-of-way for construction and subsequent O&M of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said acts
14. Comply with all applicable federal and state laws and regulations, including Section 601 of Title VI of the Civil Rights Act of 1964, P.L. 88-352, and Department of Defense Directive 5500.11 issued pursuant thereto and published in 32 CFR, Part 300, as well as Army Regulation 600-7 entitled "Non-Discrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"
15. Provide 35 percent of that portion of the total cultural resource preservation, mitigation, and data recovery costs attributable to environmental restoration that are in excess of 1 percent of the total amount authorized to be appropriated for environmental restoration
16. Shall not use funds from other Federal programs, including any non-Federal contribution required as a matching share therefor, to meet any of the non-Federal obligations for the project unless the Federal agency providing the Federal portion of such funds verifies in writing that expenditure of such funds for such purpose is authorized

The specific provisions will be contained in the PPA executed by the Corps and the NFS. These provisions will control.

5.6 Implementation Schedule

The USACE will officially request the sponsors to acquire the necessary real estate immediately after the signing of the Project Partnership Agreement (PPA). The advertisement of the construction contract would follow the certification of the real estate. The final acceptance and transfer of the project to the non-Federal sponsors would follow the delivery of an O&M manual and as-built drawings. The estimated schedule for project implementation is shown in the following table:

ACTIVITY	Completion Date
Execute PPA	October 2018
Plans and Specifications Complete	November 2019
Real Estate Acquisitions Completed	January 2021
Advertise Construction Contract	June 2021
Award Construction Contract	July 2021
Completion of Construction	November 2022

Table 9 - Implementation Schedule

5.7 Description of the recommended alternative

5.7.1 Alternative components

Alternative 1 – Fixed Crest Cantilevered barrier (**Figure 13**) consists of a 360 foot long cantilevered steel sheet pile wall, partial removal of the center flume wall, excavation of the bedrock, lamprey traps and a walkway for access. The steel sheet pile wall will be constructed to with a stick-up height of 12 ft above the river bed and have crest elevation of 600.0 NAVD88. The crest elevation will provide the minimum 18 inch differential between the crest and tailwater elevations during the 6.7% (15 year) flood event. The wall will also extend approximately 7 feet below the river bottom and serve as a cutoff wall to prevent lamprey escapement through the fissures in the bedrock. The excavation of the bedrock pathways (**Figures 14 & 15**) will be graduated downstream toward the barrier. These pathways are intended to provide attractive flow to the area of the lamprey traps. The walkway will extend across the entire length of the barrier and will allow FWS personnel to access the lamprey traps and remove any debris that accumulates at the barrier.

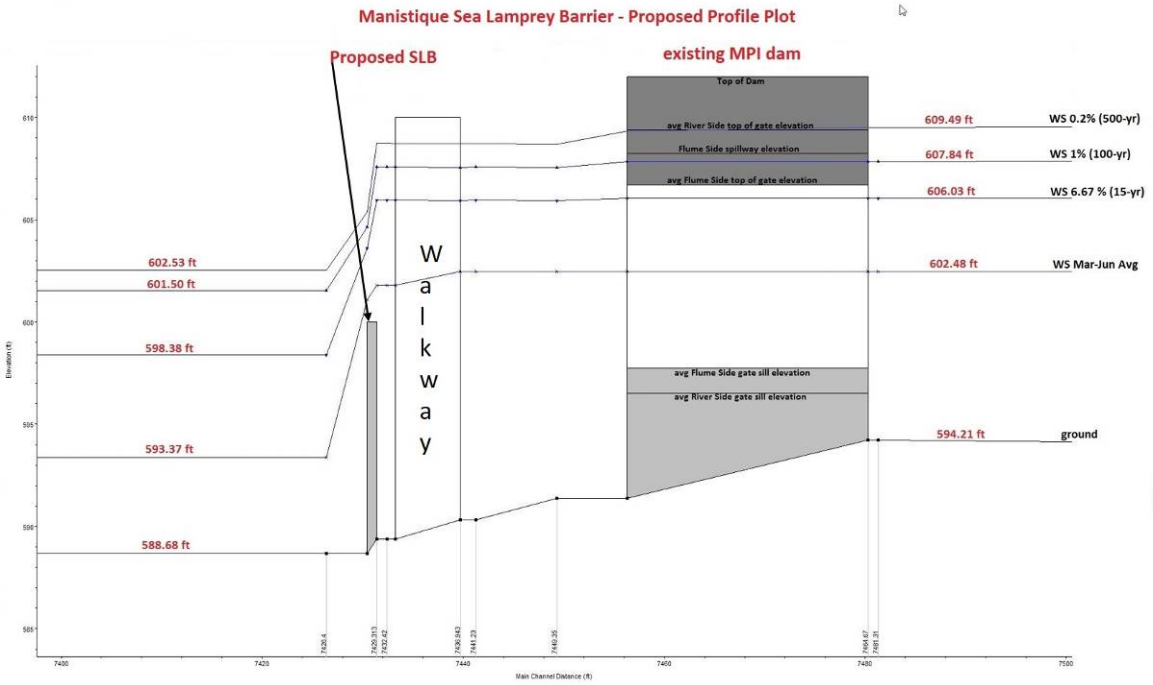


Figure 13 Profile of Proposed Barrier and Existing Dam

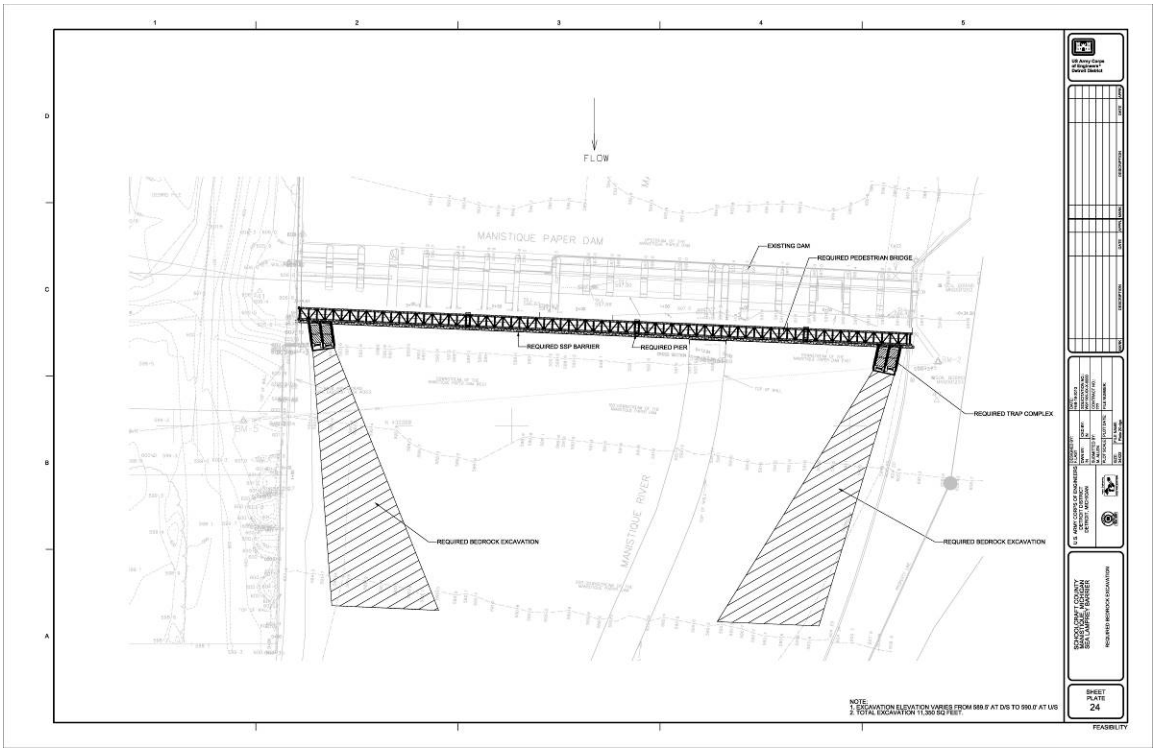


Figure 14 Plan view of bedrock excavation

Figure 15 Photo of the bedrock streambed near the dam site

In addition to the barrier and its supporting infrastructure a clay berm (**Figure 16**) will be constructed on the west side of the river upstream of the dam. The berm is vital to the operation of the barrier during the design flow event. The berm and the barrier work in tandem to maintain the desired crest elevation, prevent sea lamprey escapement and

protects against an increase in the floodplain. Finally, signage will be appropriately installed to warn recreational boaters of the risk to safe navigation.

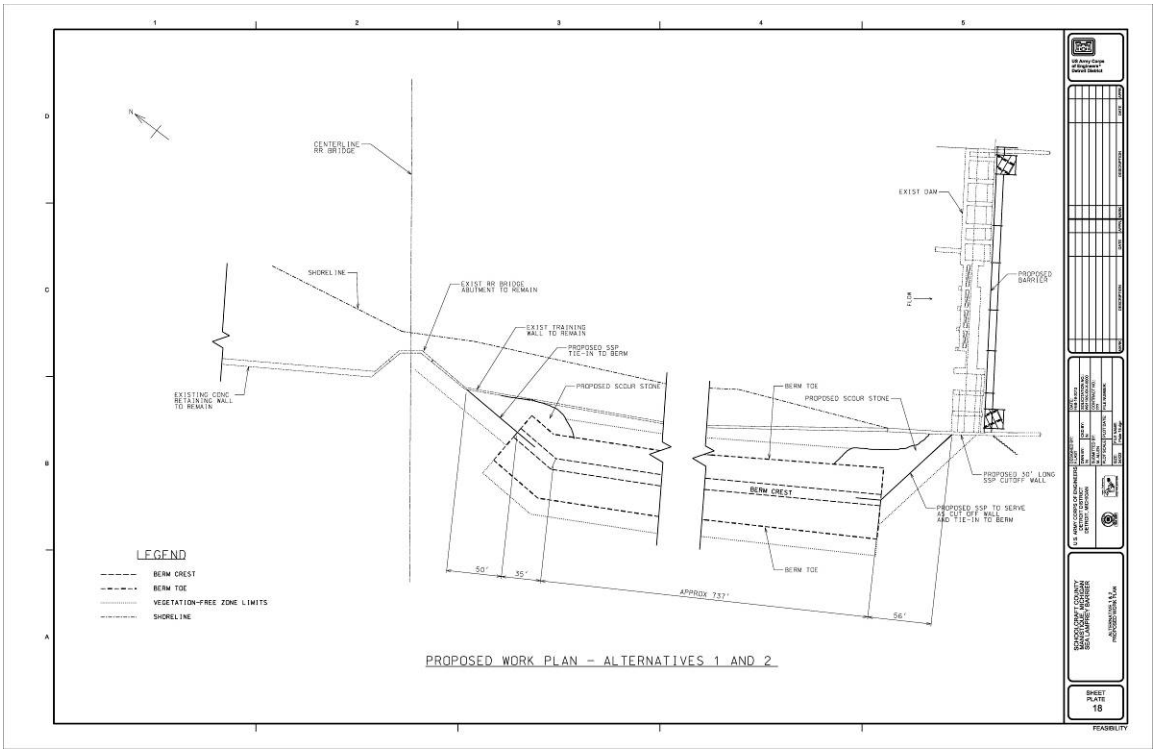


Figure 16 Clay Berm Plan view

5.7.2 Engineering Consideration

The barrier was designed according to EM 1110-2-2105 "Design of Hydraulic Steel Structures" and the American Institute of Steel Construction Manual 13th Edition unless otherwise noted in the calculations shown in Section B of the Engineering Appendix. The design method used was the Load and Resistance Factor method and all steel was designed assuming Grade 50 steel unless otherwise noted. The walkway was designed in accordance with the AASHTO Pedestrian Bridge Manual using the software program STAAD Pro v8i. Grade 50 steel was assumed. The walkway and platforms will be constructed using galvanized steel. The galvanized coating will prevent corrosion, reduce maintenance costs and extend the life of the project. Additional factors that were considered in the design included ice loading, trapping efficiency, condition of the upstream concrete wall and access restrictions from the east side of the river. Complete details of the design can be found in the **Engineering Appendix - Appendix A.**

The Manistique River flows in a southerly direction through the City of Manistique, MI, where a sea lamprey barrier is proposed to be constructed. There is an existing concrete flume on the west side of the channel, with concrete walls on either side. The center flume wall separates the flume from the natural river. The preferred barrier location is at the existing dam (**Figures 17 and 18**), owned by Manistique Papers Inc. Acquisitions, (MPIA). The minimum design criterion for the barrier's effectiveness to block lamprey is

to maintain at least a 1.5 foot separation between the barrier crest and the tailwater elevation at the 6.7% (15-year) flood frequency.

Figure 17 MPI dam looking upstream

Figure 18 MPI dam looking downstream

A hydraulic model was created to determine the appropriate barrier elevation and to evaluate floodplain impacts of the proposed project. Two final barrier design alternatives are described in the hydraulic analysis. Alternative 1 is a sheet pile wall barrier placed at the downstream face of the existing dam, and Alternative 2 is a post and panel wall barrier located on the downstream edge of the existing dam sill. Details of the hydraulic analysis can be found in **Hydraulic Appendix - Appendix B.**

5.7.3 Real Estate requirements

The proposed barrier will be constructed in the immediate, downstream vicinity of the existing dam. The dam has no utility and is not in active use for any commercial or hydro-electric purposes. The Federal Energy Regulatory Commission ("FERC") exercises no authority over the dam. The MDEQ maintains jurisdiction of the dam for "dam safety" purposes. Tri-annual inspection reports are prepared by an independent engineering firm on the condition of the dam for the MDEQ and any change or modification of the dam will require coordination with the MDEQ.

Alternative 1 requires the acquisition of a fee interest in a parcel of land that spans the Manistique River and includes "fast" lands on the West and East sides of the river for Project purposes. All project features will be constructed on a fee estate. In addition, easements will be required for work and storage areas and permanent and temporary roads.

Additional flowage easements will be required for an estimated 284 acres upstream of the sea lamprey barrier, most of this acreage is held by the State of Michigan with smaller parcels held between the City of Manistique, and a private land owner. **Table 10** displays the amount acreage held be each entity.

Property Owner	Acres
State of Michigan	201.0
Private	3.9
City of Manistique	9.8
Total	**214.7**

Table 10 Flowage Easement Acreage

The State of Michigan will be the holder of the real estate for the project. The State of Michigan has provided a letter stating their intent to participate as a non-Federal sponsor and their willingness to sign the Project Partnership Agreement along with the GLFC. The Great Lakes Fishery Commission will provide the non-Federal share of funding required for the project. The GLFC however is prohibited from holding real estate for restoration projects due to the agency's international status. The **Real Estate Plan – Appendix E** contains complete details on the real estate required for the project.

5.7.4 Local Betterments

The GLFC has not requested any betterments in association with the barrier project.

5.7.5 Environmental Consideration

The National Environmental Policy Act of 1969 (NEPA) requires Federal agencies, including the USACE, to assess the potential environmental impacts of proposed Federal actions. Typically an Environmental Assessment (EA) document is prepared to determine whether the Federal action may have significant adverse impacts on the quality of the human environment. Environmental consequences are evaluated for fish and wildlife, endangered species, wetlands, water quality, floodplains, cultural resources, recreation, noise, aesthetics, air quality, cumulative impacts, etc.

The purpose of the proposed project is to prevent upstream migration of the sea lamprey to preferred spawning and larval habitat, and to increase sea lamprey trapping efficiency resulting in a benefit to Lake Michigan and the Great Lakes fishery and ecosystem. Environmental review of the proposed action for construction of a sea lamprey barrier at the MPI dam in Manistique, Michigan has indicated that no significant cumulative or long-term adverse environmental impacts would be expected as a result of the proposed project activities.

Water and Sediment Quality. Potential threats to water quality of the river at the project site include sediment from runoff and leaks from equipment used for construction.

Wetland Resources. The currently proposed alignment of the berm would impact existing wetlands. Between the railroad bridge and north end of the site, east of the existing concrete wall, wetlands are present within the footprint of the proposed berm. Current alignment of the proposed berm would impact approximately 1.6 acres of wetland. Between the dam and railroad bridge, west of the existing concrete wall,

wetlands are present within the footprint of the proposed berm. Current alignment of the proposed berm would impact approximately 0.8 acres of wetland. Potential wetlands in the vicinity of the center flume wall removal would be avoided based on presence of existing access road and turn-around. Additional berm design and alignment options will be studied during the design phase of this project to best avoid and minimize adverse impacts to wetlands. If the berm cannot be relocated due to restrictions such as engineering feasibility, cost and / or real estate, then appropriate mitigation would be coordinated with the Michigan Department of Environmental Quality (MDEQ) and implemented as part of project implementation. By following these steps, the anticipated impact to wetlands is not significant and would be mitigated through avoidance, minimizing and wetlands mitigation.

The recommended alternative will increase upstream water surface elevations, impacting approximately 284 acres of wetlands upstream of the project. However the proposed condition is expected to induce a change in-type of wetland for only 15 of the 284 impacted acres (**Figure 19**). The affected acreage was transformed 20 years ago when the existing dam was decommissioned and the flows of the Manistique River were returned to a "run-of-the-river" state. The barrier project will allow these areas to be inundated again. Resource agencies at both the State and Federal level have agreed on a plan that will mitigate the inundation impacts of the barrier.

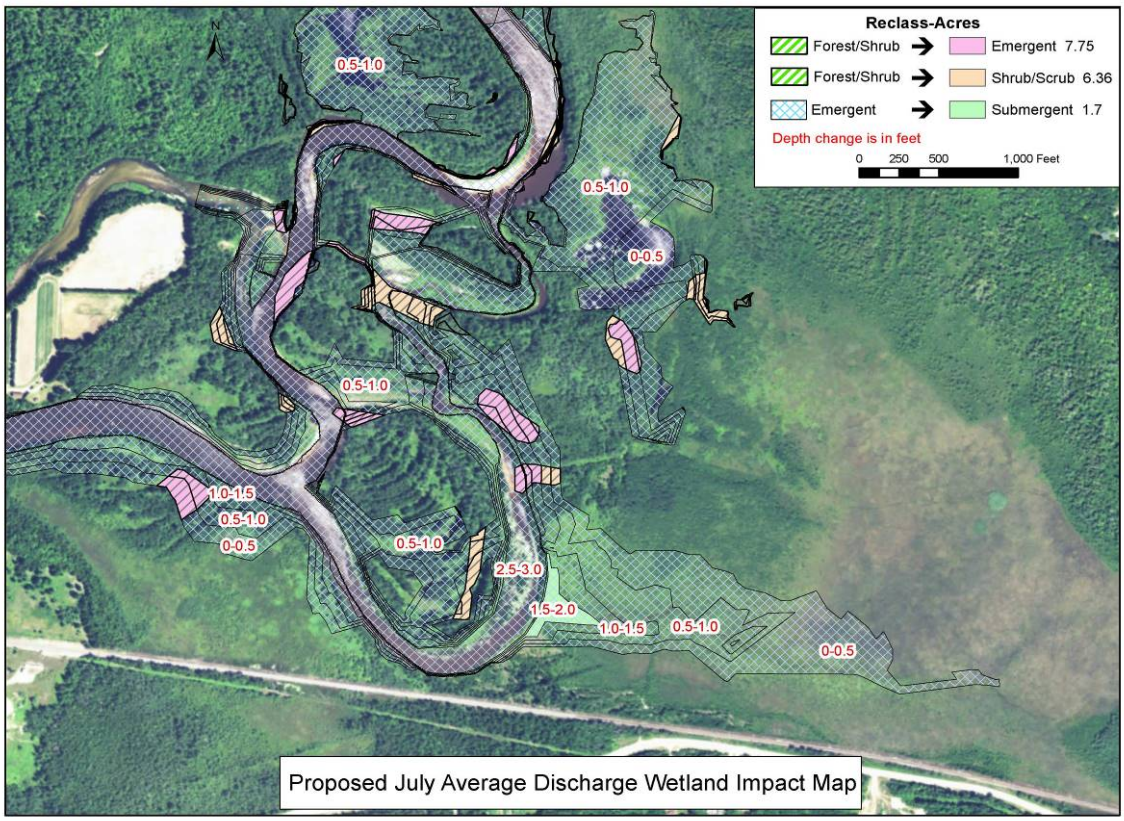


Figure 19 Converted wetland acreage

Vegetation, Wildlife Habitat, Wildlife and Aquatic Resources. The proposed barrier, berm structure improvements, and center flume wall removal would occur in areas where there have been and continue to be habitat disturbances associated with these structures. In addition, there is an active rail line near the proposed berm construction area. In summary, construction of the proposed barrier and center flume wall demolition is not anticipated to cause significant, direct impacts to vegetation, habitat or aquatic resources. Construction of the proposed berm will involve vegetation clearing and temporary disturbances to habitat in the vicinity of the existing concrete wall, however, the impacts would not be significant.

Cultural Resources. In compliance with Section 106 of the National Historic Preservation Act of 1996 and Executive Order 11593 (Protection and Enhancement of the Cultural Environment, May 1971), the National Register of Historic Places and the State Historic Preservation Office (SHPO) have been consulted. The USACE has reviewed the project site for historic and cultural resources. No known historic properties listed on or eligible for listing on the National Register, or archeological sites / items are known to be located in the area of the proposed project site at the MPI dam. Per a SHPO response letters dated January 2011 and June 2012 (Attachment C of the EA), "no historic properties are affected within the area of potential effects of this undertaking." The site was previously disturbed by original construction of the MPI dam and flume walls. Construction contracts would include clauses protective of any discovered cultural resources. If any unusual sites / items that may have historical value are encountered during the course of proposed construction, work would stop and the sites / items would be protected while the appropriate authorities, including the District archeologist, are contacted. It is not anticipated that the proposed construction of a sea lamprey barrier at the existing MPI dam would affect cultural resources.

Floodplain & Hydraulic Impacts. Hydraulic analysis was conducted to evaluate existing conditions, conditions of proposed alternatives, and the potential floodplain impacts of the proposed action. The proposed construction of a sea lamprey barrier in the Manistique River requires occupancy and development in the stream and adjacent floodplain. Hydraulic studies indicate that there would be a permanent increase in flood water levels associated with the proposed action. The floodplain inundation upstream of the barrier would be altered and is anticipated to increase due to the anticipated increase in water level elevations for all flow events. The additional land type that could be inundated is mainly upstream wetlands and some farmland. These land types are similar to that which would currently be inundated during a 1% flood frequency under current conditions. The impacts to the floodplain would be minor due to the undeveloped and non-human inhabited nature of the lands.

The proposed 1% annual chance water surface elevations are higher than the existing conditions water surface elevations upstream of the proposed barrier, but they are still lower than the effective FIS elevations. The proposed project berm required to maintain the upstream pool elevation for the 6.7% (15 year) design event will contain the 1% (100 year) annual chance event; while this will not be a flood protection berm designed to FEMA standards, it will mitigate potential overland flooding upstream of the dam. Refer to Appendix B, Hydraulic Engineering Appendix of the USACE Detailed P2roject Report

for the 1% annual chance floodplain delineation from the proposed conditions hydraulic model and additional information related to the proposed conditions.

Floodplain & Hydraulic Mitigation. The increase in flood water levels has been mitigated through minimization measures. Actions taken to minimize the impact include locating the proposed barrier in the immediate vicinity of the existing dam and the design for the proposed barrier height. Construction of a barrier at various locations upstream and downstream of the existing dam was considered. Based on the potential impacts to the area floodplain, as indicated in hydraulic modeling studies, the preferred barrier construction site is at the MPI dam because it would result in the least amount of impacts on the floodplain. The changes in flood water levels appear to include mainly upstream wetland areas and some upstream farm areas. The temporarily demolished west and center flume walls near the dam for construction access would be stabilized should a potential flood event occur. Upon completion of the project, the access ramp would be removed and the west flume wall would be replaced and a stoplog structure would be constructed at the center flume wall at the barrier.

Climate Preparedness and ResiliencyClimate Preparedness and Resiliency. Executive Order 13653 *Preparing the United States for the Impacts of Climate Change* of November 1, 2013, requires the Federal Government to build on recent progress and pursue new strategies to improve the Nation's preparedness and resilience by modernizing Federal programs, planning for climate preparedness and resiliency related risk, managing lands and waters for climate preparedness and resiliency risk, and providing and sharing information, data and tools for climate preparedness and resilience.

To this end, the USACE has directed that all water resource planning decision documents include considerations regarding possible climate preparedness and resiliency impacts to the project being studied for development. The following paragraphs meet this requirement in detailing any expected impacts of climate preparedness and resiliency on the Manistique River Sea Lamprey Barrier project.

The USACE Climate Hydrology Assessment Tool was used to examine observed streamflow trends in the vicinity of the project (**Figure 20**). The tool was used to examine the streamflow trends in the annual maximum daily discharge. The hydrologic time series of annual maximum daily discharge at the gage on the Manistique River near the City of Manistique (4056500) is in close proximity to the barrier project and is shown in the figure below. The gage exhibits a decreasing trend in *annual peak instantaneous streamflow* and this trend is not statistically significant (at the 90% confidence interval) as designated by the higher p-value (0.063081). This indicates that overall, there has been little change in flood risk (as also measured by the *annual maximum flood*) over the last 75-year period of record (1940-2015). The decrease in the slope of the trend line could be interpreted to mean that expected risk of success of the barrier is high despite the variability in the historical data. The risk that the proposed barrier project would be influenced by the fluctuating water levels of Lake Michigan is low because the project is located about 1.5 miles upstream of the lake.

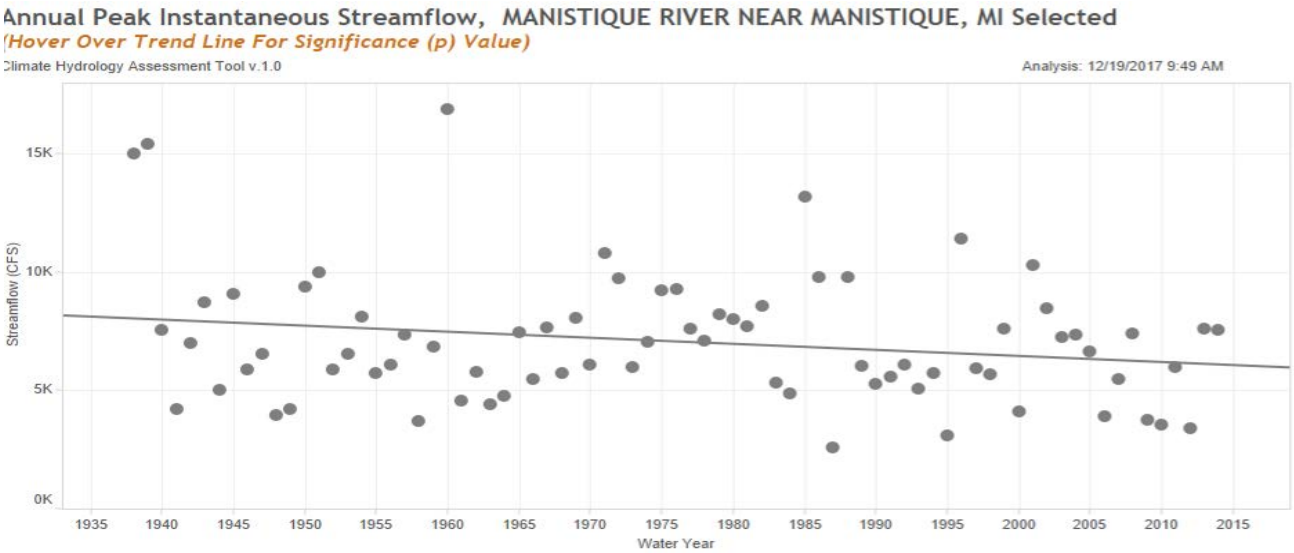


Figure 20 Manistique Historical Flow Data

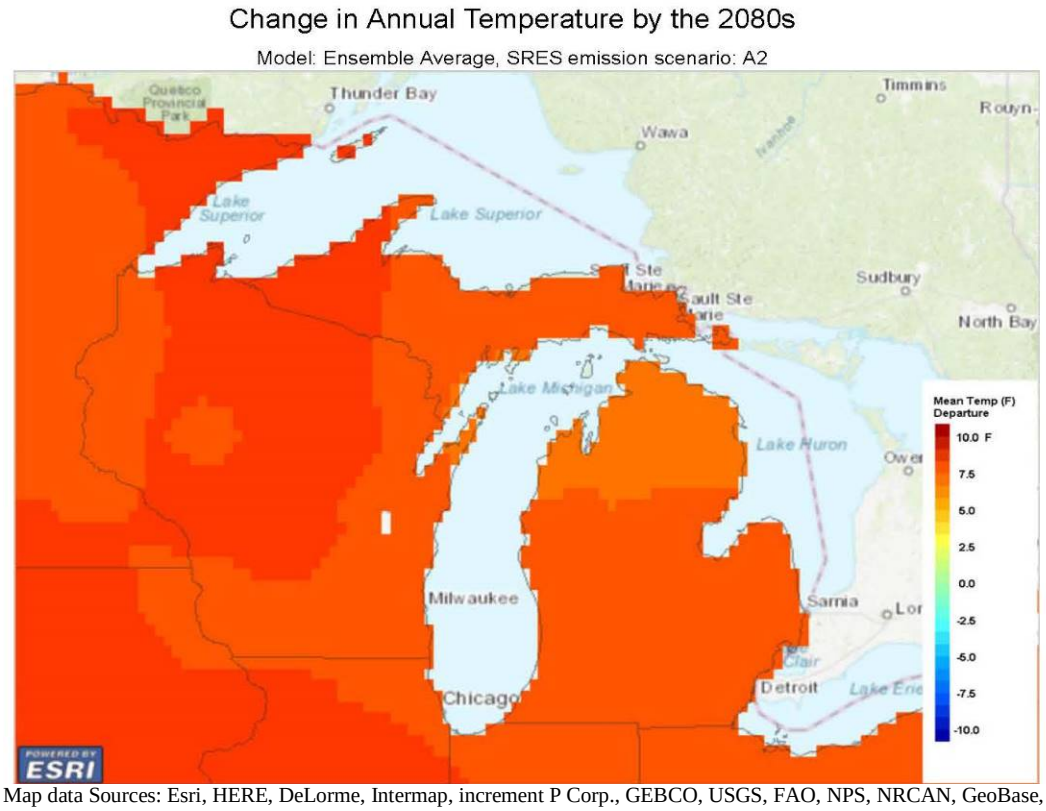
Current science-based predictions indicate that climate preparedness and resiliency in the Great Lakes region is anticipated to include higher mean air temperatures in summer and winter, with measurably less average annual rainfall, but more intensive rainfall and snowfall events when they do occur. Of all the anticipated climate preparedness and resiliency impacts, heavy precipitation and resultant flooding is the greatest concern regarding sea-lamprey projects.

Typically, the greatest source of heat in freshwater is solar radiation, which is particularly true for rivers or streams that are exposed to direct sunlight (Hauer and Hill 1996). Many small streams, however, are located under tree canopy cover that shades the water from direct sunlight. In these situations, transfer of heat from the air and the flow of groundwater are more important than direct solar radiation in governing stream temperatures (Hauer and Hill 1996). **Figure 21** below indicates a warming trend in the air temperatures of the Great Lakes Region over the next 60 plus years.

Literature Review

The USACE publication *Recent US Climate Preparedness and Resiliency and Hydrology Literature Applicable to US Army Corps of Engineers Missions* (April 28, 2015) is a Climate Preparedness and Resiliency and hydrology literature synthesis for the USACE missions in the U.S. The text below is a summary of future climate projection findings for the Great Lakes region, including the Manistique River Basin:

> "There is strong consensus in the literature that air temperatures will increase in the study region over the next century. The projected increase in mean annual air temperature ranges from 0 to 7ºC by the latter half of the 21st century. Reasonable consensus is also seen in the literature with respect to projected increases in extreme temperature events, including more frequent, longer, and more intense summer heat waves" (**Figure 21** below indicates a warming trend in the air temperatures of the Great Lakes Region over the next 60 plus years).



Map data Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Figure 21 Forecasted change in temperature mapThe literature synthesis also states: "However, projections of precipitation in the study area are less certain than those associated with air temperature. Most studies project increases, but other studies project decreases, and some project variability within the region or by season. Similarly, while the projections tend toward more intense and frequent storm events than the recent past, some show a reduction in parts of the Great Lakes region.

As such, significant uncertainty exists in hydrologic projections for this region. Projections generated by coupling GCMs with macro–scale hydrologic models in some cases indicate a reduction in future streamflow but in other cases indicate a potential increase in streamflow in portions of the Great Lakes region."

Climate Preparedness and Resiliency

Vulnerability Assessment Tool

Further, the USACE Watershed Climate Vulnerability Assessment Tool was run for Hydrologic Unit Code 0406, which includes the Manistique River basin. The results of this investigation show that there no indicated threats of note under the Ecosystem Restoration business line under both "wet" and "dry" for scenarios for the 2050 and 2085 timeframes. The tool does indicate a potential 12% increase in flood flows under the "wet" scenario between 2050 and 2085, however, the quantitative values are not statistically-significant. Output from the Nonstationarity Tool shows that no Nonstationarity is detected for the Manistique River watershed.

In summary, it is anticipated that climate preparedness and resiliency will have minimal impact on the operation of a sea lamprey project. Of greater likelihood is the potential decline in river stage caused by more frequent drought and the subsequent increase in river water temperatures, which would not have a near-term impact on lamprey spawning or any other portion of their life-cycle aside from a potentially earlier spawning run. Seasons and water temperatures directly affect when spawning-phase sea lamprey enter streams in the spring to spawn. Use of permanent traps would not be affected by fluctuating water temperatures because the USFWS would be able to install traps into the trapping complex earlier or later to account for variability in the timing of spawning runs.

Coastal Zone Management. The proposed sea lamprey barrier would be constructed north of the DEQ identified Coastal Zone, thus the proposed action would be "consistent to the maximum extent practicable" (as defined in 16 USC 1456, Coastal Zone Management Act, approved 1978) with the Michigan Coastal Zone Management Plan and not significantly impact the coastal zone.

Based on the conclusions of the Environmental Assessment, it appears that preparation of an EIS will not be required. Therefore, a Preliminary Finding of No Significant Impact (FONSI) is included with the Environmental Assessment (Attachment D). If the District Engineer determines that an EIS is not necessary, the Preliminary FONSI would be finalized. **The Environmental Assessment (EA) for the Manistique Sea Lamprey Barrier is attached to this DPR.**

5.8 Operation, Maintenance, Repair, Replacement, and Rehabilitation

The USFWS operates and maintains the barrier and trap locations throughout the Great Lakes as part of the lamprey control program on behalf of the Great Lakes Fishery Commission (GLFC). Average operation and maintenance cost include: the personnel costs associated with removing lamprey from the lamprey traps, barrier operation, and periodic inspection of the berm and barrier structures. Maintenance costs would include walkway upkeep, replacing equipment such as lift cranes and debris removal. The average O&M costs were estimated at about $32,000.

6.0 Summary of Coordination, Public Views and Comments

6.0.1 Public Involvement Program

A notice will be issued to announce the availability of the DPR and EA documents for public review, in addition to the review, a public meeting will be held in the city of Manistique, where the public will be given the opportunity to comment.

6.0.2 Institutional Involvement/Study Team

During the feasibility study, personnel from the GLFC, FWS, MDNR, city of Manistique, and MPI participated as members of the study team. They participated directly in the study effort. Many of the study team members such as FWS and MPI had been working

on a sea lamprey control solution for the Manistique River before the USACE was involved. This involvement has led to support for the implementation of the recommended alternative.

6.0.3 Report Recipients

The following Federal, State, County, local and regional agencies, environmental organizations, and interested groups and individuals will receive notice of the availability of this document:

- Michigan Department of Natural Resources
- Michigan Department of Environmental Quality
- State Historic Preservation Office
- U.S. Environmental Protection Agency
- U.S. Fish and Wildlife Service
- City of Manistique, Michigan
- Schoolcraft County
- Local Native American Tribes
- Great Lakes Fishery Commission

7.0 RECOMMENDATION

Based on the findings of the Detailed Project Report and Environmental Assessment, it is recommended that **Alternative 1 – Fixed Crest Cantilevered Barrier** be approved for implementation under Section 1135 of the Water Resources Development Act of 1986, as amended. This detailed project report indicates that **Alternative 1** is engineeringly feasible, is the NER plan and is the most cost effective plan of the implementable plans in accordance with the aforementioned guidance.

I recommend that the **Alternative 1 Fixed Crest Cantilevered Barrier** be authorized for implementation as a Federal project, with such modifications thereof in the discretion of the Commander, USACE may be advisable. The estimated total project cost of the recommended plan is **$9,731,000.** All annual OMRR&R cost will be paid by the GLFC through the FWS. The Federal portion of the estimated first cost is **$6,707,000**.

Federal Cost	Non-Federal Cost	Total Project Cost
$6,707,000	$3,024,000	$9,731,000

The recommendations contained herein reflect the information available at this time and current departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, the sponsor, the States, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

Dennis P. Sugrue
Lieutenant Colonel, U.S. Army
District Engineer

8.0 REFERENCES

Madison, G., and R. N. Lockwood. 2004. Manistique River Assessment. Michigan Department of Natural Resources, Fisheries Special Report 31, Ann Arbor.