Appendix D – Economic Analysis
Manistique Sea Lamprey Barrier,
Manistique, Michigan

US Army Corps
of Engineers ®
Detroit District

APPENDIX D – ECONOMIC ANALYSIS
PROJECT MODIFICATION FOR IMPROVEMENT OF THE ENVIRONMENT
(SECTION 1135)
MANISTIQUE SEA LAMPREY BARRIER, MANISTIQUE, MICHIGAN

TABLE OF CONTENTS

Title		Page
1.0	INTRODUCTION	D-1
2.0	OVERVIEW OF ECOSYSTEM PROBLEM	D-1
2.1	Impacts of Sea Lamprey	D-1
2.2	Existing Conditions	D-2
3.0	SOCIOECONOMIC ANALYSIS	D-4
4.0	FUTURE WITHOUT PROJECT CONDITIONS	D-6
5.0	ALTERNATIVES	D-6
5.1	Alternative 1 – Fixed Crest Cantilevered Barrier	D-6
5.2	Alternative 2 – Fixed Crest Post and Panel Barrier	D-8
5.3	Alternative 3 – No Action	D-8
6.0	ECONOMIC ANALYSIS OF ALTERNATIVES	D-8
6.1	Environmental Outputs	D-9
6.2	Economic Benefits of the Sea Lamprey Barrier	D-9
6.3	Economic Costs of the Sea Lamprey Barrier	D-10
6.4	Cost Effectiveness	D-11
6.5	Benefit-Cost Analysis	D-12
7.0	RECOMMENDATION	D-12

TABLES

Table 1 – Demographic Profile	D-5
Table 2 – Labor Force Profile	D-6
Table 3 – Economic Costs in 2017 Dollars	D-11
Table 4 – Benefit-Cost Analysis of Alternatives in 2017 Dollars	D-12
Table 5 – Economic Summary of Alternative 1 in 2017 Dollars	D-13

FIGURES

Figure 1 –Fish Wound Caused by Sea Lamprey Oral Disc D-1
Figure 2 – Lifecycle of Sea Lamprey D-1
Figure 3 – Commercial Landings of Lake Trout from Lake Michigan, 1929-1950 D-2
Figure 4 – Manistique Paper's Inc. Dam D-3
Figure 5 – GLFC Estimated Lamprey Abundance D-4
Figure 6 – GLFC Estimated Fish Wound Rates D-4

1.0 INTRODUCTION

The sea lamprey (*Petromyzon marinus*) is an invasive species that migrated into the Great Lakes by way of the shipping canals and locks built for the St. Lawrence Seaway. Native to the Atlantic Ocean, this parasitic organism attaches to a host fish and feeds on its bodily fluids until the host dies. Although native lamprey can be found throughout the Great Lakes, the sea lamprey out competes its native counterparts to the point that the Great Lakes fisheries were almost destroyed shortly after its arrival.

Historically, the Manistique Paper Mill (MPI) Dam served as a migratory barrier to sea lamprey trying to gain access to valuable spawning habitat upstream in the Manistique River. In the late 1990s, this dam deteriorated to the point where lamprey were able to breech the barrier and begin spawning upstream in the river. To control the lamprey, the Great Lakes Fishery Commission (GLFC) routinely treats the Manistique River with a costly lampricide, TFM (*3-trifluoromethyl-4-nitrophenol*), and must continuously monitor the treatment's effectiveness. Consequently, the GLFC has requested the assistance of the Detroit District Army Corps of Engineers to evaluate plans to construct a physical barrier on the Manistique River which would provide a more cost effective and environmentally friendly method of controlling sea lamprey.

2.0 OVERVIEW OF ECOSYSTEM PROBLEM

2.1 Impacts of Sea Lamprey

The sea lamprey is a primitive, jawless fish, native to the Atlantic Ocean that entered the Great Lakes through the manmade locks and channels of the St. Lawrence Seaway built in-part by the USACE. Lamprey use their oral disc, which contains tooth-like structures, to attach to a host fish and begin feeding (see ***Figure 1***). The U.S. Fish and Wildlife Service (USFWS) estimates that about half of the lamprey attacks on fish are fatal and that each adult lamprey will kill approximately 40 pounds of fish during its life. Although lamprey are parasitic, they only spend a portion of their existence feeding on a host. There are four phases (*see* ***Figure 2***) in the lamprey's lifecycle and it is only during their parasitic phase that they become destructive to the ecosystem.

Figure 1 –Fish Wound Caused by Sea Lamprey Oral Disc

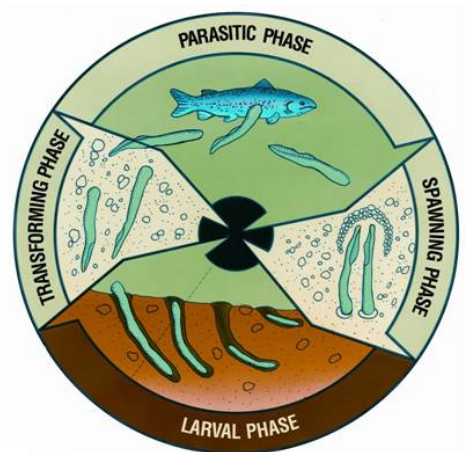

Figure 2 – Lifecycle of Sea Lamprey

While lamprey will feed on many types of fish, the lake trout (*Salvelinus namaycush)* is their ideal prey since they both share the same habitat and the lamprey can easily compromise the lake trout's soft epidermis. Prior to the lamprey's introduction, this fish was an integral part of the Great Lakes fisheries with an average annual harvest of approximately 15 million pounds. However, the lake trout became extinct in all but one of the five Great Lakes less than 20 years after the lamprey's arrival. ***Figure 3***, below, illustrates the impact of the sea lamprey on the commercial fish catches of lake trout from Lake Michigan. (Noteworthy, the significant decline in lake trout populations several years after the lamprey's introduction can be attributed to the long larval phase the organism must go through before it becomes parasitic).

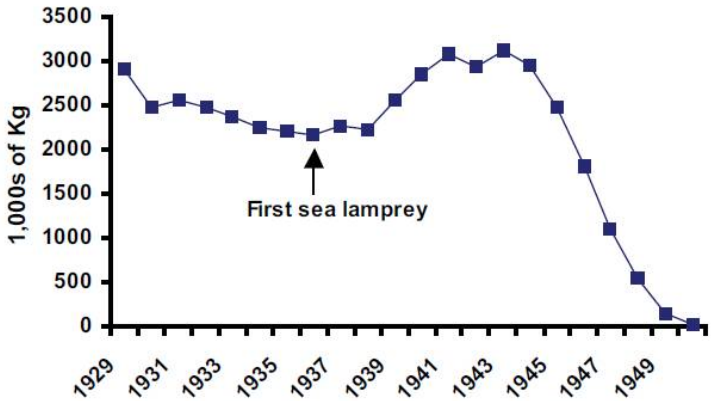

Figure 3 – Commercial Landings of Lake Trout from Lake Michigan, 1929-1950

As an important component in the region's economy, the Federal government and states have been taking steps to restore the lake trout populations through hatchery-stocking programs. In fact, the majority of lake trout found in Lake Michigan are the result of stocking juvenile fish that are born and raised in hatchery plants ran by state and Federal government. The Michigan Department of Natural Resources (MDNR) Fish Stocking Database reports an estimated 1.4 million juvenile lake trout are stocked in Lake Michigan annually.

2.2 Existing Conditions

Built in 1919, the Manistique Papers, Inc. (MPI) dam was constructed to provide hydro electrical power generation for the paper company's logging operations. The dam is located over a mile (1.6 miles) upstream from the mouth of the Manistique River and incorporates a concrete flume that extends downstream to end at the paper mill (see ***Figure 4***). In 1985, MPI discontinued power generation at the dam and in the early 1990s completely decommissioned the structure. In addition to power generation, this structure has also served as a spawning barrier to both potamodromous fish (river spawning) and sea lamprey.

After it was decommissioned, the MPI dam began to deteriorate leading to holes and cracks in the structure. Lamprey use these fissures as entry points to crossover the dam gaining access to the Manistique River. In the late 1990s, the USFWS and MPI attempted to fix and repair the dam to prevent further lamprey infestation of the upstream portion of the river.

However, these efforts were deemed unsuccessful when the GLFC's annual lamprey larval assessments began reporting an increase in the larval population above the dam.

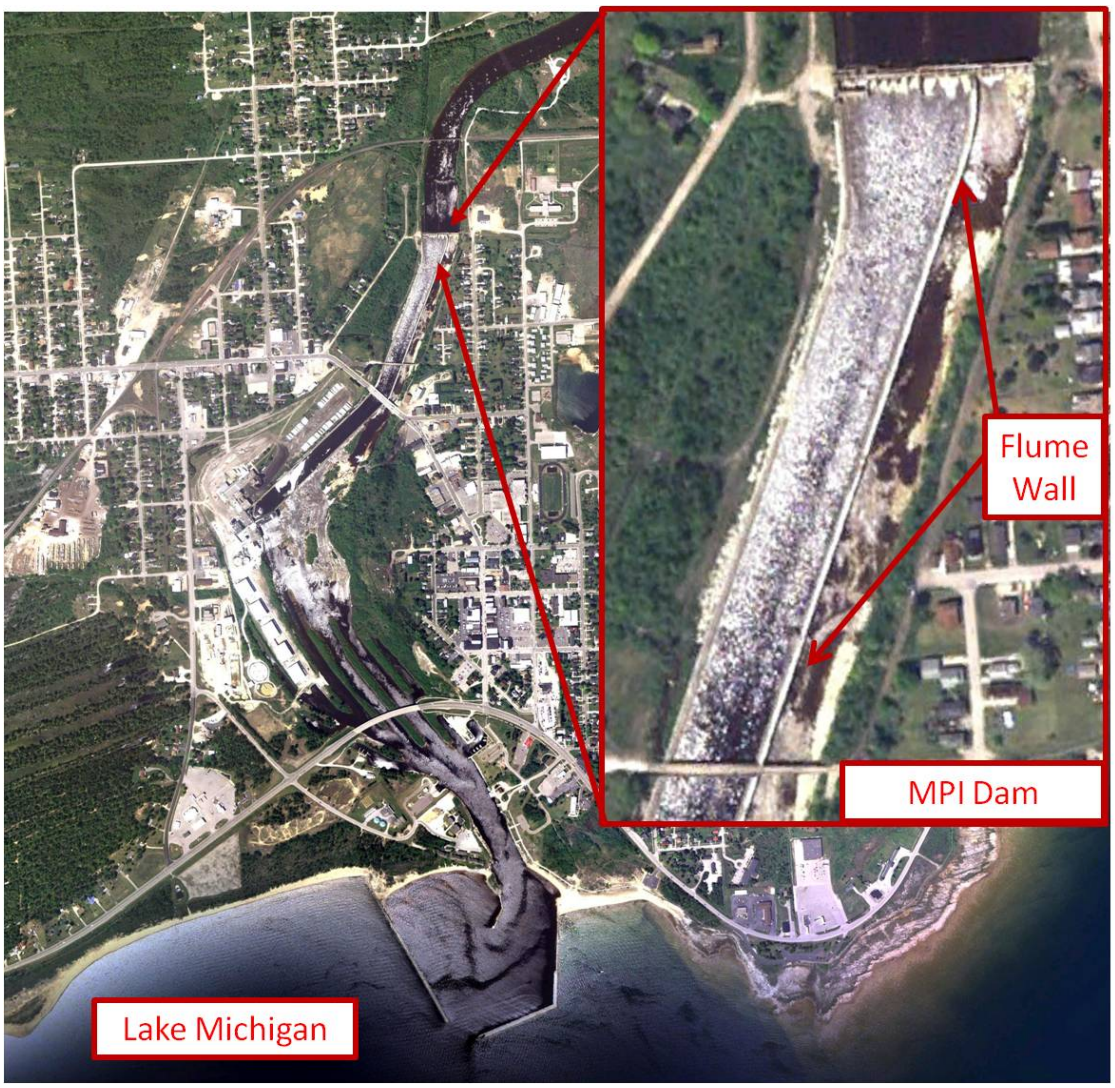

Figure 4 – Manistique Paper's Inc. Dam

Since the MPI dam no longer blocks migrating lamprey, the USFSW, in conjunction with the GLC, routinely (every four years) treats the Manistique River with TFM lampricide. The dendritic nature of the river requires extensive use of the lampricide and, thus, each treatment is costly. Costs to treat the Manistique River with lampricide, above and below the dam, were approximately $634,000 in 2009. While lampricide is approximately 95 percent effective at reducing the lamprey population, a residual population still persists even after treatment. This residual lamprey population, approximately 10,000 individuals (given a 30% mortality rate), eventually transforms into a parasitic fish and attacks Lake Michigan fisheries. The Michigan DNR's Fish Stocking Database reports that approximately 1.4 million juvenile lake trout are stocked in Lake Michigan annually. These juvenile fish have an estimated mortality rate of 60 percent, which translates into only four-in-ten lake trout surviving to

maturity. Notably, stocking these fisheries is costly to the state with an estimate price of $0.93 to $1.69 (in 2012 dollars) per juvenile fish stocked.

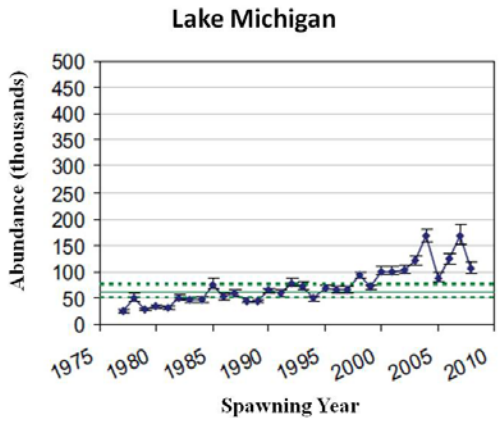

Figure 5 – GLFC Estimated Lamprey Abundance

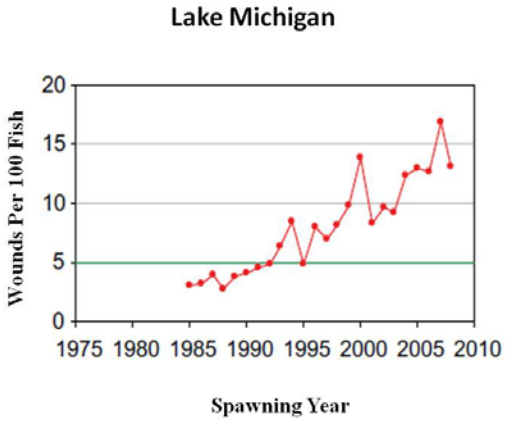

Figure 6 – GLFC Estimated Fish Wound Rates

Although the TFM lampricide is designed to target only the sea lamprey larvae; it is known to have some minimal effects on other organisms. In an effort to mitigate the risk to other organisms, the TFM treatments are typically coordinated so that they do not coincide with other species spawning periods. For example, the treatment of streams and rivers where lake sturgeon reproduction exists are scheduled for later in the year so that sturgeon larvae are larger and are less susceptible to the effects of lampricide.

3.0 SOCIOECONOMIC ANALYSIS

The proposed project is located in the City of Manistique, on the southwestern coast of Michigan's Upper Peninsula. The city is 3.19 square miles in size and is the only incorporated community in the area. With a natural harbor located at the mouth of the Manistique River, the city was formerly an important hub for shipping raw timber materials. After the lumber boom ended in the late 19th century, the area began focusing on the use of pulpwood for paper production. Notably, agricultural production has never been an important component to the regional economy due to the cool climate and poor soil composition.

Table 1, on the next page, presents demographic and socioeconomic data for the City of Manistique, Michigan. The 2010 Census reports that the city has an estimated population of approximately 3,100 people living in roughly 1,400 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. Also noteworthy is the large Native American population living in the City of Manistique and Schoolcraft County.

Table 1 - Demographic Profile	Manistique	Schoolcraft County	Michigan
Population	3,097	8,485	9,883,640
Number of Households	1,383	3,759	3,872,508
Average Househould Size	2.15	2.22	2.49
Persons under 18 years old	23%	19%	22%
Persons 65 years old and over	21%	21%	14%
Median Age	43	48.3	38.9
Native American	13%	12%	1%
High school graduates	87%	86%	88%
Bachelor's degree or higher	9%	13%	25%
Median household income	$29,375	$36,925	$48,432
Percentage of Population Living Below the Poverty Line	21%	18%	15%
Unemployment Rate (2012)	8%	10%	12%
Source: 2010 Census Bureau and 2006-2010 American Community Survey			

Consistent with the rest of the state, most residents in the City of Manistique and Schoolcraft County have received a high school diploma. In contrast, the proportion of city and county residents who have obtain higher levels of education (bachelors degree or higher) is lower in comparison to the education attainment associated with residents located in other parts of the state.

The low population density and rural surroundings does not offer local residents many opportunities for employment. **Table 2,** on the next page, indicates that fewer city and county residents participate in the labor force compared to other state residents. Thus, it is not surprising that the median household income for the city and county are lower than the median household income for the rest of the state. The limited opportunities for employment in this region have also contributed to a greater proportion of the population living below the poverty line compared to the other regions of Michigan.

Table 2 - Labor Force Profile	Manistique	Schoolcraft County	Michigan
Population 16 Years or Over	80%	83%	79%
Labor Force Participation Rate	55%	53%	63%
Percentage Not in Labor Force	45%	47%	37%
Occupations			
Management, Professional, ect.	25%	29%	34%
Service	33%	25%	18%
Sales and Office	18%	19%	25%
Natural Resources, Construction, & Maintenance	11%	13%	8%
Production, Transportation, and Material Moving	13%	14%	15%
Source: 2010 Census & Census Bureau's 2006-2010 American Community Survey			

=-

4.0 FUTURE WITHOUT PROJECT CONDITIONS

Without the proposed Section 1135 project, the GLFC would continue to treat the areas of the Manistique River upstream of the MPI dam with TFM lampricide every four years. The cost to treat this area would be approximately $857,000 (in 2017 dollars) per treatment every four years. Since the overall effectiveness of the treatments can vary from year-to-year, some areas of the river could also require additional treatments on occasion. Although the lampricide treatment reduces sea lamprey larval populations by approximately 95 percent, these treatments still leave behind a 5 percent residual population which transforms into parasitic fish.

5.0 ALTERNATIVES

The primary objective of the proposed project is to reduce the use of lampricide in the Manistique River and to build a physical barrier that will prevent sea lamprey from accessing spawning habitat upstream of the MPI dam. During the plan formulation phase of the project, several locations for this barrier were examined, but were found to be either hydraulically infeasible or did not properly block lamprey. Consequently, the location of the MPI dam was the most engineeringly feasible location for a barrier and two different designs were evaluated. Both barriers propose the same crest elevation since the “drop” between the top of the barrier and water elevation is the determinate of how well the barrier functions and prevents lamprey from accessing upstream spawning habitat.

5.1 Alternative 1 - Fixed Crest Cantilevered Barrier

Alternative 1 consists of the construction of a cantilevered steel sheet pile (SSP) wall and replacement or rehabilitation of the west concrete wall. This alternative 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 foot formed in 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 601.6 feet (IGLD 85) or about three feet above the existing sill. The barrier would be 360 feet long, which is the width of the river at the dam. Portions of the existing dam would be demolished to accommodate the barrier

Alternative 1 also includes the removal of approximately 1,060 feet of the center flume wall. This removal would take place at a portion of the wall that has already been modified by MPI. More importantly, the wall's removal would 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 the boil would promote the migration of the lamprey upstream to the barrier and the trap and sort complex.

Included in this alternative is a trapping and sorting complex, consisting of four lamprey traps, one at each end of the barrier and one either side of the center flume wall. The traps would be approximately ten-feet square and would hold three five-foot square trap inserts. Also, the back of the traps would be formed by the barrier while the sides would be concrete walls and the front a steel plate. Two sets of stoplogs at each trap would be used to control flow into the traps. In addition, bedrock downstream of the traps would be excavated to create an attractant flow for the lamprey.

In addition, this alternative includes a walkway that would provide access to all lamprey traps. It would be approximately six feet wide to allow for access by a four-wheeler and a trailer, used for transporting the lamprey, and would extend across the barrier. Additionally, the walkway would have several hinged sections to allow for use of portable traps. Per the USFWS, a lift system should be designed to lift 500 pounds of lamprey plus the trap insert from the riverbed to the platform.

The barrier would include a stop log section where the State of Michigan could implement a fish passage at their convenience. Lamprey traps and hoist systems would be installed on opposite ends of the barrier and the barrier would be configured to allow attractive flow thru the traps. These traps are integral to the trapping and sorting operation that is conducted annually by the USFWS.

West Concrete Wall Replacement

Finally, the last component of Alternative 1 is the replacement of the 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 1,700-foot structure is made of reinforced concrete and extends in two sections up stream 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-owned nursery. Hydraulic modeling of the with and without project conditions determined that the west concrete wall 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 percent chance of exceedance event; and 3) to prevent lamprey escapement during extreme flow events.

The existing 1,700-foot long concrete wall is in extremely poor condition. As a result, the concrete wall would be replaced with a levee in this alternative. The levee structure would extend approximately 850 feet upstream of the dam to the railroad bridge and then an additional 850 feet upstream of the railroad bridge toward the State owned nursery. The top elevation of the structure would be required to be 611.0 feet (IGLD 85).

5.2 Alternative 2 - Fixed Crest Post and Panel Barrier

Alternative 2 consist of the construction of a post and panel wall on the existing sill. Alternative 2 would be constructed at the existing MPI dam. A post and panel type wall would be placed on top of the existing sill to form the barrier, except in the area of the old powerhouse. This alternative would require a small amount of concrete pier removal.

West Concrete Wall Replacement

Finally, the last component of Alternative 2 is the replacement of the west concrete wall. Hydraulic modeling of with and without project conditions determined that the west concrete wall, 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 percent chance of exceedance event; and 3) to prevent lamprey escapement during extreme flow events.

The existing 1,700-foot long concrete wall is in poor condition. As a result, the concrete wall would be replaced with a clay levee in this alternative. The levee structure would extend approximately 850 feet upstream of the dam to the railroad bridge and then an additional 850 feet upstream of the railroad bridge toward the State owned Wyman nursery. The top elevation of the structure would be required to be 611.0 feet (IGLD 85).

5.3 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 USFWS would continue to treat the river with lampricide. They would also continue to trap lamprey for sterilization at the site. The Manistique River would continue to be a major contributor to Great Lake lamprey population and continue to impede the restoration of the Great Lakes Fishery.

6.0 ECONOMIC ANALYSIS OF ALTERNATIVES

The *Principles and Guidelines* (March 10, 1983) state that the Federal objective of water and land related resource planning is to contribute to national economic development (NED) consistent with protecting the nation's environment. More specifically, this guidance directs Federal agencies to formulate plans that are economically and environmentally sound. The standard Corps' methodology for evaluating alternatives in an ecosystem restoration study is cost effectiveness (CE) and incremental cost analyses (ICA).To conduct this analysis, the environmental benefits produced by each plan are quantified and then weighed

against the costs to implement each alternative plan. In addition to the CE/ICA analysis, a benefit costs analysis was also completed since the cost savings of TFM and stocking lake trout can be monetized.

6.1 Environmental Outputs

Since TFM treatments have a targeted effectiveness of approximately 95 percent and sea lamprey barriers have an expected effective rate of 99 percent, physical barriers are up to four percent more efficient at reducing the number of lamprey compared to the use of TFM. With an estimated annual recruitment population of approximately 285,400, this increase in barrier effectiveness equates to approximately 8,000 fewer lamprey entering the ecosystem and killing lake trout. Thus, the improved effectiveness of the barrier produces an environmental benefit of approximately 53,300 lake trout. In addition to an increase in lake trout, the elimination or reduction of TFM treatments also reduces the proportion of non-target aquatic organisms exposed to these chemical treatments.

The USFWS currently traps sea lamprey just downstream of the MPI dam for their Sterile Male Release Program. This technique involves trapping male lamprey, sterilizing them and then releasing them back into the spawning population in an effort to reduce the number of fertilized lamprey eggs. The proposed barrier's design would allow for trapping operations to be conducted on the downstream end of the barrier. By placing the lamprey traps right at the barrier, the USFWS is able to trap more efficiently and, thus, capture more lamprey for their Sterile Male Release Program.

6.2 Economic Benefits of the Sea Lamprey Barrier

In addition to environmental effects, the proposed barrier project would produce incident effects which translate into other monetary benefits. More specifically, the barrier would eliminate the need for TFM treatments and would reduce the cost of stocking fish. Based on guidance provided in Appendix E of ER 1105-2-100, the other direct benefits produced by a project are quantified as NED since they increase economic efficiency. This efficiency is a derived from the incidental reductions in the costs of TFM and fish stocking. To quantify these incidental effects, the costs of the with-out project conditions are used as a proxy to estimate the monetary benefits produced as a by-product of the barrier.

The proposed physical barrier would prevent sea lamprey from accessing roughly 264 acres of habitat upstream of the MPI dam. By reducing recruitment of the parasitic organism, the GLFC would no longer need to treat this area every four years with the TFM lampricide. The elimination of the TFM treatments represents an average annual benefit of approximately $397,000 (in 2017 dollars). By reducing the need to treat the Manistique River with TFM, these dollars can be used to treat other rivers with lamprey population.

Physical barriers are reported to be almost 100 percent effective at preventing sea lamprey migration whereas the TFM lampricide treatments have a target efficiency rate of 95 percent. The proposed barrier is estimated to be 4 percent more efficient and would prevent approximately 8,000 lamprey from transforming into parasites every year. Given that each

lamprey destroys around 40 pounds of fish and adult lake trout weight about six pounds, the added efficiency of the barrier would save approximately 53,300 lake trout on an annual basis. At a stocking cost of approximately $3.35 per fish, and a mortality rate of 60% for lake trout, the reduction in parasitic lamprey would provide a fish stocking benefit of $446,400 (in 2017 dollars) per year.

6.3 Economic Costs of the Sea Lamprey Barrier

In order to determine whether a project is economically justifiable, costs associated with the proposed project's implementation must be assessed. The Corp's Planning Guidance Notebook, ER 1105-2-100, specifically states: *"Project measures, whether structural or nonstructural, require the use of various resources. NED costs are the opportunity costs of resource use."*

The initial cost estimates provided by Detroit District in 2017 dollars for each of the examined alternatives are presented in **Table 3**, on the next page. These costs include: construction costs, non-construction costs (i.e. design), interest during construction, and the present value of annual operational assessments and maintenance costs. Interest during construction (or IDC) was calculated using the FY18 Federal Discount rate of 2.75 percent and is based on an eight-month construction period. Note: Costs are in 2017 dollars as the report was finalized in November 2017. FY18 discount rate is utilized though as this update fell within the 2018 fiscal year.

Working on behalf of the GLFC, the USFWS conducts annual larval assessments, or surveys, of those rivers and streams treated or infested with sea lamprey. With or without the barrier, the Manistique River would continue to have larval assessments completed on an annual basis. Consequently, environmental monitoring costs were omitted from the alternative cost estimates and are not included in **Table 3.**

The sponsor plans to evaluate the operational performance of the barrier and would incur these costs in lieu of barrier construction. As a result, the present value of the operational assessments, which are expected to occur over the first five years of the project, are included in this economic analysis and are presented below, in **Table 3**. It should be noted that if the larval assessments and/or the operation performance of the barrier does not meet the target efficiency rate of 99 percent, an adaptive management plan would need to be developed and implemented. Several physical barriers have already been constructed by USACE and USFWS and, thus, there is a low level of uncertainty regarding the performance of this barrier. Thus, the costs for an adaptive management plan were not estimated during this feasibility study.

Annual Operations and Maintenance Costs include those expenditures related to maintaining and operating the barrier. They include costs such as painting, minor repairs, facility upkeep, etc. These costs do not include the sea lamprey trapping operations since these activities are already taking place just downstream of the dam and are not anticipated to change after the new traps are constructed along with the barrier.

Table 3 - Economic Costs in 2017 Dollars			
	Alternative 1	**Alternative 2**	**Alternative 3**
Construction Cost (Inc. contingency)	$6,662,000	$6,761,000	$0
Non-Construction Costs (Inc. contingency)	$961,000	$975,000	$0
Interest During Construction[1]	$143,000	$146,000	$0
LERRDs	$355,000	$355,000	$0
Sub Total Alternative Costs	**$8,121,000**	**$8,237,000**	**$0**
Annualized Alternative Costs[2]	$301,000	$305,000	$0
Annual Lampricide Costs [3]	$0	$0	$396,800
Annual O&M Cost[4]	$6,000	$6,000	$0
Total Average Annual Costs	**$307,000**	**$311,000**	**$397,000**

[1] Calculation assumes equal monthly costs over an 8 month construction period.
[2] Annualized costs are based on a 50-year time horizon and the FY18 discount rate of 2.75%
[3] Assumes a cost of $857,000 every 4 years, annualized at the FY18 discount rate of 2.75%
[4] Annual O&M is assumed to be 2% of construction costs annualized over the life of the project

6.4 Cost Effectiveness

Both alternatives (Alternative 1- Fixed Crest Cantilevered Barrier and Alternative 2 - Fixed Crest Post and Panel Barrier are equally effective at blocking lamprey from entering the upstream portion of the Manistique River. As discussed earlier, the improved performance of the barrier would reduce the number of parasitic lamprey and would result in fewer lake trout deaths. More specifically, the increase in blocking recruiting lamprey would result in approximately 8,000 fewer lamprey from entering the system to prey on lake trout. Alternative 1 has lower implementation costs than Alternative 2 due to the difference in construction materials and construction of the barrier on the dam sill.

Cost effectiveness analysis is used to screen out alternatives that produce fewer environmental benefits at a higher per dollar cost or identify those plans that produce the same number of environmental benefits at a higher cost. Both action-oriented plans produce the same number of environmental benefits; however, Alternative 2 has a higher economic cost to implement. Consequently, Alternative 1 is the only cost effective plan and is identified as the “Best Buy” or NER plan. Since only one plan is cost effective, the incremental cost analysis was not conducted in this economic analysis.

6.5 Benefit-Cost Analysis

To measure economic efficiency, the Corp uses two decision metrics in its formulation process – the benefit-cost ratio and net benefits. The benefit-cost ratio (BCR) evaluates which alternative produces the greatest amount of benefits given its implementation costs. Net benefits are derived by subtracting the average annual benefits from the project’s average annual costs. The most efficient plan to implement is the one that maximizes net benefits and has the highest BCR.

Table 4, below, summarizes the average annual benefits, average annual costs, net benefits and the benefit-cost ratio (BCR) for Alternatives 1 and 2. As discussed earlier, both alternatives have similar design elements and produce comparable benefits; however, the plans do differ enough for there to be differences in costs. The economic costs to implement Alternative 2 are higher compared to Alternative 1 and, consequently, this alternative's net benefits and BCR are lower. Alternative 1, the locally preferred plan, produces the greatest net benefits, $139,400 (in 2017 dollars), and has the highest BCR of 1.45. In addition to monetary benefits, the proposed project also provides environmental benefits associated with the reduction in the use of lampricide.

Table 4 - Benefit / Cost of Proposed Alternatives in 2017 Dollars				
Alternatives		**Alt. 1**		**Alt. 2**
Average Annual Benefits	$	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**

7.0 RECOMMENDATION

The Federal objective for plan selection is to recommend the NER/NED plan or alternative "with the greatest net economic benefit consistent with protecting the Nation's environment". Of the action-oriented alternatives evaluated in this study, Alternative 1 is the only cost effective plan. In addition, this alternative is the plan that produces greatest net economic benefits and has the highest BCR. As a result, Alternative 1 is identified as the NER/NED plan for this Section 1135 project in Manistique, Michigan.

Table 5, on the next page, contains the adjusted costs and benefits for the recommended plan, based on a risk-adjusted costs, in terms of fiscal year 2018 at the Federal Discount rate of 2.75 percent. The total estimated cost to implement Alternative 1, inclusive of all its explicit (e.g. construction) and implicit (e.g. interest during construction) costs, is $8,121,000 (in 2017 dollars). With the risk adjusted costs, the net economic benefits of Alternative 1 are $139,400 and the BCR is 1.45.

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 exclude study sunk costs and are adjusted for risk.
Any calculations involving interest utilized the FY18 discount rate of 2.75%