Peterson Lake
Pool 4 Mississippi River
Habitat Rehabilitation and Enhancement Project
Project Evaluation Report

Environmental Management Program for the
Upper Mississippi River System

U.S. Army Corps of Engineers
St. Paul District
180 Fifth Street East
St. Paul, MN 55101-1638

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Note: All water elevations in this report are in feet above mean sea level, 1912 adjustment

1.0 Introduction

1.1 UMRS EMP

The Upper Mississippi River System Environmental Management Program (UMRS-EMP) is a Federal-State partnership to manage, restore, and monitor the UMRS ecosystem. The UMRS-EMP was authorized by Congress in Section 1103 of the Water Resources Development Act of 1986 (Public Law 99-662) and reauthorized in 1999. Subsequent amendments have helped shape the two major components of EMP – the Habitat Rehabilitation and Enhancement Projects (HREPs) and the Long Term Resource Monitoring Program (LTRMP) (USACE 2010). Together, HREPs and LTRMP are designed to improve the environmental health of the UMRS and increase our understanding of its natural resources (USACE 2010).

The EMP was the first program in the Nation to combine ecosystem restoration with scientific monitoring and research efforts on a large river system (USACE 2010). The EMP has served the Nation well for 25 years on the UMRS, completing 56 habitat projects benefiting approximately 100,000 acres of aquatic and floodplain habitat and contributing significantly to our scientific understanding of this complex system through monitoring and research (USACE 2010). As of October 2011, nine additional projects were under active construction and another 25 were in various planning and design stages. These projects range in size from small bank stabilization efforts that might cost less than a million dollars, to larger island or water level management projects that may exceed 15 million dollars. Most projects consist of several different restoration actions.

In addition to its achievements on the UMRS, the EMP has served as a model for other aquatic ecosystem efforts both nationally and internationally (USACE 2010). The program has matured and adapted to changing conditions and new scientific insights and continues to be an efficient and effective means of ensuring that the UMRS remains both a nationally significant ecosystem and nationally significant navigation system (USACE 2010).

1.2 Habitat Rehabilitation and Enhancement Projects

Habitat Rehabilitation and Enhancement Project (HREP) construction is one element of the UMRS-EMP. The projects provide site-specific ecosystem restoration, and are intended and designed to counteract the adverse ecological effects of impoundment and river regulation through a variety of modifications, including flow introductions, modification of channel training structures, dredging, island construction, and water level management. Interagency, multi-discipline teams including personnel from the Minnesota Department of Natural Resources (MDNR), the Wisconsin Department of Natural Resources (WDNR), the United States Fish and Wildlife Service (USFWS), and the United States Army Corps of Engineers (USACE) worked together to plan and design these projects, which are located on the navigable portion of the Upper Mississippi River and its navigable tributaries.

1.3 Purpose of Habitat Project Evaluation Reports

The purposes of this habitat project evaluation report for the Peterson Lake HREP are to:

- Document the pre and post-construction monitoring activities for the Peterson Lake project.
- Evaluate project performance on the basis of project objectives and goals.
- Evaluate the project relative to other issues such as operation and maintenance.
- Make recommendations concerning future project performance evaluation.
- Make recommendations concerning the planning and design of future HREP projects.

This report summarizes available monitoring data, operation and maintenance information, and project observations made by USACE, MNDNR, WDNR, and USFWS. It also includes other agency and public input.

1.4 Project Team

Project team members for this evaluation report included representatives from the USACE, MNDNR, WDNR, and USFWS, and are listed below. Many of these team members were also involved in the planning and construction phases of this project.

Much of the information in this report has been gathered from the project team members and others familiar with the project. This was accomplished through the use of subsequent review and revisions of this report by the project team.

Jon Hendrickson	USACE	Sharonne Baylor	USFWS
Derek Ingvalson	USACE	* Bob Dreislien	USFWS
* Don Powell	USACE	* Gary Wege	USFWS
* Dan Wilcox	USACE	Mary Stefanski	USFWS
Mike Davis	MNDNR	Pam Thiel	USFWS
Dan Dieterman	MNDNR	Phil Delphey	USFWS
Scot Johnson	MNDNR	Brian Brecka	WDNR
Megan Moore	MNDNR	Jeff Janvrin	WDNR

(* Retired)

2.0 Project Area

2.1 Location

Peterson Lake is a 500-acre backwater lake located in Upper Mississippi River Pool 4 between a string of main channel border islands and the Minnesota shoreline (Figure 1 on next page). There are 13 inflow channels (#1-13) to the lake along its northeast perimeter and one outflow channel (#14) located to the southeast. The lake is triangular in shape and is located immediately north of the earthen dike at Lock and Dam 4. Peterson Lake lies between river miles 753.0 and 754.8 of the Upper Mississippi River. The project area is defined as Peterson Lake, including the Lock and Dam 4 dike, the Minnesota shoreline, and the islands separating Peterson Lake from the main channel. Towns nearest to Peterson Lake include Alma, Wisconsin (approximately 1 mile SE) and Kellogg, MN (approximately 3 miles SW). Peterson Lake lies within the Upper Mississippi River National Wildlife and Fish Refuge. Peterson Lake is closed to the use of motors from October 15 to the end of the MN duck hunting season, with the exception of a travel corridor to the main channel.

2.2 Habitat Types and Distribution

Peterson Lake is a backwater lake bounded by uplands, a manmade dike, islands, and a side channel of the Mississippi River. Within the lake there are a variety of different habitat types. Some of these include deep water without aquatic vegetation, shallow water with and without vegetation, riparian islands, areas of little flow, and locations of moderate flows near a number channels.

2.3 Historic Changes and Habitat Conditions

The Peterson Lake area changed dramatically when the construction of the Lock and Dam 4 was completed in May, 1935. Over the next 25 years many emergent marshes and island in the area disappeared. The fast disappearance of the low islands and emergent marsh after the inundation of the navigation pool is similar to the trends observed in other navigation pools in the Upper Mississippi River Basin (USACE 1989). It appears that the vast majority of the area lost to erosion during this period was emergent marsh. These marsh areas were probably less able to withstand the erosive forces of the river than were the islands. In addition, the islands were protected to some degree for a number of years by the presence of the marshes. The rate of erosion in the area has slowed since that time, but the few remaining islands separating the lake from the main channel have continued to dwindle away. Further loss of the islands would have resulted in reduced backwater habitat conditions through increases in flow, sedimentation, wind fetch, wave action, and sediment resuspension.

Flows entering the lake previous to the project had already created unsuitable winter habitat conditions for lentic fishes due to high current velocities and low water temperatures. The loss of the islands would have substantially reduced habitat

Figure 1. Peterson Lake HREP location, channels, and islands.

diversity in the Peterson Lake area of lower Pool 4. Over the years, emergent aquatic vegetation had nearly disappeared from the lake and reduced the habitat value for both fish and wildlife.

Sedimentation was an evident problem in the lake with large sand deltas forming where channels entered. If left unchecked river managers felt this would have resulted in a significant loss of aquatic habitat in the lake. Before the project it was estimated that sedimentation would have resulted in the loss of more than 75 percent of the lake's volume over the next 50 years (USACE 1994).

Despite the habitat degradation, Peterson Lake has supported fish and wildlife species typical of many backwater lakes on the Mississippi River. The lake has historically had good water quality, good water depths and bathymetric diversity, and supported good submersed and emergent aquatic plant growth.

2.5 **Other Projects in the Peterson Lake Area**

2.5.1 Lock & Dam 4 Embankment Project

From the fall of 2007 until the summer of 2009 two berms were constructed immediately north of the existing embankment connecting the gated part of Lock and Dam 4 to the Minnesota shore. Both berms extend into Peterson Lake. They include multiple sand terraces capped with fine material and vegetation. The objective of this project was to provide erosion protection for the Lock and Dam 4 embankment using environmentally-preferred alternatives as opposed to the traditional use of riprap. The project provided both positive habitat values and erosion protection. The lowest terrace was vegetated with willow and shrubs, the next with bottomland hardwood trees, and the top terrace with native grasses and forbs. Sloped areas of the project were also capped with fine material and vegetated.

2.5.2 Finger Lakes HREP

The Finger Lakes system is a series of six connected lakes immediately south of Peterson Lake. Flow from Peterson Lake was introduced to Lower Peterson Lake and one of the Finger Lakes in 1965 via a single culvert through the Lock & Dam 4 embankment. The culvert was placed in the embankment to introduce flow and increase dissolved oxygen concentrations in the Finger Lakes. Three additional culverts were added in 1992-1993 as part of the Finger Lakes HREP.

2.6 **Fish and Wildlife in the Project Area**

When the DPR/EA (USACE 1994) was prepared for the project, 33 species of fish had been reported from Peterson Lake. Popular sport fish species that occur in Peterson Lake included: bluegill (*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*), channel catfish (*Ictalurus punctatus*), black crappie (*Pomoxis nigromaculatus*), white crappie (*Pomoxis annularis*), yellow perch (*Perca flavescens*), northern pike (*Esox lucius*), walleye (*Sander vitreus*), and sauger (*Sander canadensis*). A number of other fish species were also present in the lake. These included forage species like shiners and gizzard shad and "rough" species such as gar, bowfin (*Amia calva*), common carp, and suckers. An evaluation of fish habitat by the Minnesota Department of Natural Resources (Minnesota DNR 1987) concluded that Peterson Lake was accessible to all fish species present in the Mississippi River. Peterson Lake had excellent spawning habitat for northern pike in flooded riparian vegetation as well as good nursery and rearing habitat for many juvenile fishes. Excellent spawning habitat for bluegill and largemouth bass were also provided by shallow flats on the eastern side of the lake. Scattered submerged stumps provided spawning habitat for channel and flathead catfish as well.

The Peterson Lake fish survey results indicate that the fish community is similar to many other Mississippi River backwater lakes with centrarchids, fish such as sunfish and largemouth bass, being predominant. Benthic surveys did not reveal unusual concentrations of macroinvertebrates (MNDNR 1987). The macroinvertebrate fauna was typical of river habitat with mayflies, caddisflies, chironomids and other diptera, as well as amphipods and other crustaceans, snails, and fingernail clams.

Mussel beds had been found in the lower portion of Peterson Lake along the Lock and Dam 4 embankment. A mussel survey of the main channel, secondary channel openings, and portions of the upper and eastern side of the lake in September 1992 found relatively few mussels. This survey focused on areas that could potentially be disturbed by construction activities for the HREP project. The majority of live mussels were threeridge (*Amblema plicata*) and threehorn wartyback (*Obliquaria reflexa*). Other live mussel species found included: pimpleback (*Quadrula pustulosa*), Wabash pigtoe (*Fusconaia flava*), pink heelsplitter (*Potamilus alatus*), plain pocketbook (*Lampsillis cardium*), and paper pondshell (*Utterbackia imbecillis*). No live specimens or shells of any Federally-listed endangered or threatened mussel species were found.

Peterson Lake is used by a variety of waterfowl species including: mallard (*Anas platyrhynchos*), blue winged teal (*Anas discors*), green winged teal (*Anas carolinensis*), wood duck (*Aix sponsa*), scaup (*Aythya affinis*), American widgeon (*Anas americana*), northern shoveler (*Anas clypeata*), Canada geese (*Branta Canadensis*), tundra swans (*Cygnus columbianus*), and American coot (*Fulica Americana*). Use varies on an annual basis depending on waterfowl populations and the abundance of preferred aquatic vegetation foods in Peterson Lake and other backwaters.

Additional wildlife that had been observed in the area includes: great horned owl (*Bubo virginianus*), green heron (*Butorides virescens*), great blue heron (*Ardea Herodias*), great egret (*Ardea alba*), belted kingfisher (*Megaceryle alcyon*), red-winged blackbird (*Agelaius phoeniceus*), tree swallow (*Tachycineta bicolor*), mourning dove (*Zenaida macroura*), ruffed grouse (*Bonasa umbellus*), osprey (*Pandion haliaetus*), muskrat (*Ondatra zibethicus*), raccoon (*Procyon lotor*), beaver (*Castor Canadensis*), mink (*Neovision vison*), red fox (*Vulpes vulpes*), and white-tailed deer (*Odocoileus virginianus*).

The channel border islands along Peterson Lake had several large trees present that had been used by bald eagles (*Haliaeetus leucocephalus*) for roosting. Lower Pool 4 was an area reported to receive high use by bald eagles, both during migration and as an over-wintering area.

2.6.1 Threatened and Endangered Species in the Project Area

According to the U.S. Fish and Wildlife Service one species was listed as endangered in Wabasha County, Minnesota at the time of the project. The higgins eye mussel (*Lampsilis higginsii*) was listed as endangered in June of 1976, and its historic range is thought to have included this stretch of the Mississippi River. No empty shells or evidence of the higgins eye mussel existence was found during surveys in the project area.

The bald eagle (*Haliaeetus leucocephalus*) and the arctic peregrine falcon (*Falco peregrines tundrius*) were listed as threatened species during portions of this project. Both these species have since been delisted. The bald eagle was delisted on August 8, 2007 and the arctic peregrine falcon was delisted on October 5, 1994. Neither species was reported to be negatively affected by the project.

There were also three Minnesota listed species of special concern in Wabasha County at the time of the project. These species included the pugnose minnow (*Opsopoedus emilae*), the Walter's barnyard grass (*Echinochla walteri*), and the sea-beach needlegrass (*Aristida tuberculosa*). It was unlikely that any of these species were impacted by the project at Peterson Lake. There were no reports of these species being adversely affected during the monitoring of the project.

3.0 Project Goals and Objectives

3.1 General Goals

The general goals of the project were to reduce sedimentation in Peterson Lake, stabilize the barrier islands bordering the lake, improve migratory waterfowl habitat, and to improve winter habitat conditions for fish in the upper portion of the lake (USACE 1994).

3.2 Habitat Goals

Three habitat goals were developed at the onset of this project. The following goals were identified: 1) Maintain Peterson Lake as a productive backwater resource. 2) Optimize habitat conditions for migratory waterfowl; especially fall migration feeding and resting habitat. 3) Optimize habitat conditions for fish species typical of Upper Mississippi River backwater habitats; e.g., largemouth bass, northern pike, bluegill, crappie, and associated species.

3.3 Specific Project Objectives

The project objectives were chosen to help identify necessary actions needed to meet the project goals.

A summary of the objectives needed to meet the goals set for the Peterson Lake HREP can be found in Table 1. The five following objectives were developed for Peterson Lake.

A. Reduce sedimentation in Peterson Lake as much as practicable.

B. Maintain the 40 acres of islands in the barrier chain separating Peterson Lake from the Upper Mississippi River.

C. Maintain submersed aquatic plant growth as it generally existed in 1991, recognizing the annual variations that will occur in any natural system. The performance criteria defining the 1991 condition were:

a) Submersed aquatic plant growth extending to water depths of 5 feet.
b) Mean summer (June-September) turbidity levels of less than 15 NTU.

D. Create a winter fish refuge in the upper portions of Peterson Lake. The following conditions should be achieved in as large an area as practicable:

a) Winter dissolved oxygen levels of $\geq$ 5 mg/l.
b) Winter current velocities $\leq$ 1 cm/sec (0.03 ft/sec).
c) Winter water temperatures > 1°C (33.8°F).

E. Increase emergent aquatic plant growth in the lake by approximately 10 acres.

Table 1. Objectives Needed to Achieve Habitat Goals on Peterson Lake

Goal	Objectives to Meet Goals
1 – Maintain as a productive backwater	A, B
2 – Optimize habitat for migratory waterfowl	A, B, C, E
3 – Optimize habitat for fish species	A, B, C, D, E

3.4 **Target Future Conditions**

Target future habitat conditions for Peterson Lake were set from the goals and objectives of the project. Target future conditions included the prevention of further island erosion, the creation of winter fish refuge, maintenance or increase in lake vegetation, and reduction of sedimentation. Table 2, on the following page, summarizes the targeted future conditions of Peterson Lake.

Stabilization of the existing islands was a main concern, especially in the lower portions of the lake. The targeted future conditions would be to maintain the 40 acres of islands that distinguish Peterson Lake from the main channel. In addition to the quantifiable benefits, the preservation of these islands demonstrated additional unquantifiable benefits by avoiding the adverse effects of increased flows and sedimentation. The islands define Peterson Lake as a backwater resource, and the preservation of these islands was critical to meet the goals set for the project.

Creation of a winter fish refuge would substantially increasing the value of Centrarchid and other fish habitat in the lake. Target values for flow, dissolved oxygen, and winter water temperatures were selected for the fish refuge. Target flow velocities in Peterson Lake were to be less than 1.0 cm/sec while maintaining dissolved oxygen levels above 5 mg/l. The targeted flow velocities were also expected to affect the winter water temperature in Peterson Lake. Water temperatures were projected to increase from near zero degrees Celsius to over 1.0 degree Celsius.

The reduction in sedimentation was expected significantly extend the ecologic life of Peterson Lake as a backwater Lake. Limiting sedimentation would have an inverse effect on lake volume. The target lake volume after the 50 year life of the project was 1,150 acre-feet, an increase from less than 500 acre-feet lake volume anticipated without a project.

Table 2. Project objectives and enhancement features.

Objective	Project Accomplishment	Potential Enhancement Feature	Units	Enhancement Potential		
				Existing	Future Without	Future With
Maintain 40 acres of islands	Maintain 40 acres of islands	Bank protection Breakwaters	Acres	40 acres	27.5 acres	40 acres
Maintain submersed aquatic plant growth	Maintain or reduce sediment inputs	Side channel closures Bank protection	Depth plant growth Turbidity (NTU)	5 feet <15 NTU	<5 feet >15NTU	5 feet <15 NTU
Create winter fish refuge	100-acre refuge created in upper portion of lake	Side channel closures	mg/l DO cm/sec vel Degree C	>5mg/l 1.5-4.0 cm/sec <1 degree C	>5mg/l 1.5-4.0 cm/sec <1 degree C	>5mg/l <1.0 cm/sec >1 degree C
Increase emergent plant growth by 10 acres	Maintain/increase shallow protected habitat	Side channel closures Bank protection	Acres	<1 acre	<1 acre	>1 acre
Reduce sediment inputs to lake	Side channels closed and islands stabilized	Side channel closures Bank protection	Acre-feet of lake volume	2,200 acre-feet	<500 acre-feet	1,150 acre-feet

4.0 Project Description

4.1 Project Features

The Peterson Lake HREP included a combination of channel closures, weirs, fish access channels, as well as rock bank and rock mound protection. Initially three rock closures, three sand closures, two rock weirs, and six areas of rock bank protection were constructed. These features were completed in November 1995. Three of the sand closures washed out as a result of the spring high water of 1996. These three structures were rebuilt with rock fill in September 1996.

The numbered channels and islands in the following descriptions can be found in Figure 1. The labeled project features can be found in Figure 2.

4.1.1 Rock and Sand Closures

Sand closures were constructed at openings 2, 3, and 4, while rock closures were constructed at openings 1, 6, and 7. The sand closures had a top elevation of 670.5 (3.5 feet above low control pool), top width of 20 feet, and front and back slopes of 1V:3H and 1V:5H. The rock closures had a top elevation of 668.5 (1.5 feet above low control pool), top width of 5 feet, and side slopes of 1V:2H. These closures were designed to close off all flows and associated sediment inputs to the lake at normal river stages and up to a bankfull flood event. At channel 5 a partial closure, with a 20-foot wide opening was constructed. The size of the opening was selected as the best combination of meeting the desired summer flows and the winter fish habitat objectives. This closure was designed to provide at least 50 cfs of flow into the upper reaches of the lake during the summer for water quality purposes, while restricting winter flows as much as possible to meet the winter fish refuge objective.

4.1.2 Rock weirs

The rock weirs across channels 8 and 9 were designed to reduce bed load sediment entering the lake through these channels while at the same time allowing sufficient flow to maintain water quality. The rock weirs at channels 8 and 9 were designed with 180 and 200 foot crest lengths and crest elevations of 663.0 (4 feet below the low control pool) to insure that flows through these openings would be continuous while meeting objectives for water quality conditions in Peterson Lake. The weirs were tied into the rock mounds providing protection to Islands V and VI. It was estimated that the closures and weirs would reduce sedimentation in the lake by over 50 percent (USACE 1994).

Figure 2. Peterson Lake project features.

*Sand closures were washed out and replaced with rock.

4.1.3 Rock Mounds

The rock mound protection for Island I through VI was designed to protect the islands from further erosion. These islands were very low and narrow and had a shallow offshore bench in front of them. This design allowed the placing of the rock with little or no construction access dredging and minimal impact to the existing islands. Small openings were left in these rock mounds in areas where conditions were such that sediment transport through the opening may result in the formation of an island by the natural process of sediment accretion. The rock mounds had a top elevation of 669.0 (2 feet above low control pool), a 3 foot top width, and 1V:1.5H side slopes.

4.1.4 Riprap

On the east end of Island VII, adjacent to channel 8, a 10 foot wide rock mound with a top elevation of 669.0, and side slopes of 1V:1.5H was constructed. The purpose of constructing a rock mound this wide was to make sure that adequate rock would be available for self-healing if channel 8 continued to erode.

4.1.5 Fish Channels

Two fish channels with a bottom elevation of 661.0 (6 feet below low control pool) were constructed in Peterson Lake to provide fish access between the isolated deeper areas (below closures 1 and 7) and the main body of the lake in the winter months. The 40 foot width and 6 foot depth of the channels were considered more than adequate for fish passage. These dimensions were based on minimum constructability dimensions for marine equipment. In addition, the fish channels were excavated to a depth such that no maintenance dredging is expected during the 50-year project life.

4.1.5.1 Placement of Removed Dredge Material

It is estimated that over 7,000 cubic yards of material was excavated from the project. Dredged material from the construction of the fish channels was placed on the right descending bank of Grand Encampment Island (Figure 3). The dredge material that was removed from Peterson Lake was placed as topsoil to promote revegetation of old channel maintenance dredge material (sand) that had been previously placed on the island. The site was planted with a mixture of native prairie forbs and grasses. In June 1996 the mixture listed in Table 3 was drill seeded on the area (Anfang and Wege 2000).

Table 3. Plants used to vegetate the dredge material on Grand Encampment Island.

Grass Species	Seeding Rate	Wildflower Species	Seeding Rate
switchgrass	3lbs PLS/ac	black-eyed Susan	4 oz/ac
big bluestem	3lbs PLS/ac	yellow coneflower	1 oz/ac
little bluestem	3lbs PLS/ac	rough blazing star	2 oz/ac
Indian grass	2lbs PLS/ac	prairie clovers	3 oz/ac
side oats grama	3lbs PLS/ac	leadplant	2 oz/ac
sand dropseed	2lbs PLS/ac	stiff tickseed	3 oz/ac
perennial ryegrass	20lbs PLS/ac		

At a later date, rootstocks of the following native wildflowers were also planted.

Species	Number of Rootstocks Planted
pale purple coneflower	50
butterfly weed	100
button blazing star	100
oldfield goldenrod	50
prairie onion	50

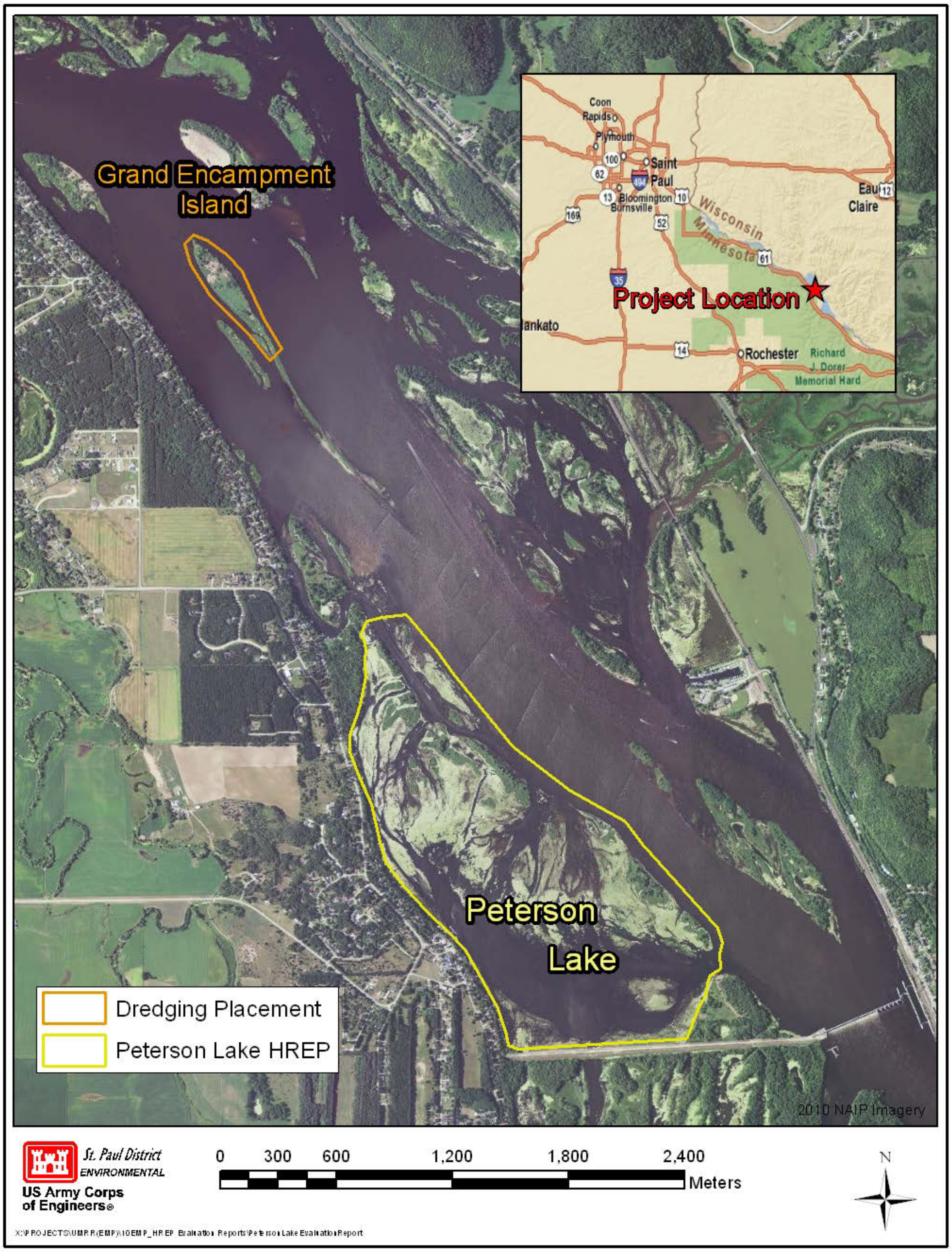

Figure 3. Dredged material from construction of the fish channels was placed on the right descending bank of Grand Encampment Island.

4.2 Planning and Implementation History

The interagency team that planned and designed the Peterson Lake project included the USFWS, MNDNR, and WDNR. The primary resource problem identified by these agencies was the loss of islands to erosion and sediment deposition in the lake. The Peterson Lake project was assessed and ranked by the Fish and Wildlife Work Group (FWWG) of the River Resources Forum (RRF), a group of river practitioners responsible for managing the river for their respective agencies. In the 1987 ranking of Mississippi River projects, the Peterson Lake project received a high score (38) by the FWWG and was ranked 8th in overall priority. Peterson Lake received this high ranking because it is a valuable resource of high importance, the ongoing and potential loss of habitat to sedimentation was clearly evident, the opportunity exists to curtail or arrest the rate of resource degradation, and the opportunity exists to benefit a wide variety of fish and wildlife (USACE 1994).

The Peterson Lake project was programmed within the St. Paul District for start of the planning and general design phase in FY 1991. A Fact Sheet was submitted to Headquarters, Washington, D.C. in December 1990 requesting approval to begin general design (study phase). Approval was received in October 1991 and general design was initiated in November 1991. A Definite Project Report (DPR)/Environmental Assessment (EA) was completed and approved for implementation by the North Central Division of the Corps of Engineers in March 1994.

A contract was awarded to L&S Industrial and Marine, Inc. of Hugo, Minnesota, in June 1995. Construction of the Peterson Lake project began in August 1995 and was initially completed in November 1995, with the exception of grading and seeding of the dredged material placement site. The grading and seeding of the placement site was completed in June 1996.

During the spring high water of 1996, sand closures constructed at 3 side channel openings washed out. These structures were rebuilt with rock. Construction of the rebuild was completed in September 1996. The O&M manual was completed in August 1997. The project was transferred to the U.S. Fish and Wildlife Service for operation and maintenance in September 1997 (USACE 1997).

5.0 Project Monitoring

5.1 Monitoring Plan

A monitoring plan for the project evaluation was designed to directly measure the degree of attainment of the selected project objectives. The monitoring plan is presented in Table 4.

Table 4. Summary of Peterson Lake monitoring plan.

Goal	Project Objective	Enhancement Feature	Unit of Measure	Measurement Plan	Monitoring Interval	Projected Cost/Effort
Enhance the value of Peterson Lake for migratory waterfowl	Maintain 40 acres of existing islands	Bank stabilization Breakwaters	Acres	Measurements from aerial photographs	1989 photographs for pre-construction 5 and 10 years post-construction	$1,000
	Maintain submergent aquatic plant growth a. Growth to 5 feet of water b. <15 NTU	Bank stabilization Side channel closures	a. Depth of plant growth b. NTU	Measurements of depth of plant growth and turbidity (June-Sept)	1991-94 for pre-construction 3,6, and 10 years post-construction	$4,000
Enhance the backwater value of Peterson Lake	Create winter fish refuge with a. > 5 mg/l DO b. < 1 cm/sec vel. c. > 1 degree C	Side channel closures	a. mg/l b. cm/sec c. degrees C	Measure dissolved oxygen, current velocity, and water temperature during the winter	1992 and 1993 for pre-construction 3 of first 5 years post-construction	$3,750
	Create 10 acres of emergent aquatic plant growth	Side channel closures Bank stabilization	Acres	Measurements from aerial photographs	1989 photographs for pre-construction 5 and 10 years post-construction	Cost included in the maintaining of existing island objective
	Reduce sediment inputs to lake	Bank stabilization Side channel closures	Acre-feet	Bathymetric surveys	5 and 10 years post-construction	$7,000

5.2 Monitoring

Monitoring work was conducted by the Corps, the WDNR, the MNDNR, the USGS Upper Midwest Environmental Science Center (UMESC) and the Long-Term Resource Monitoring Program (LTRMP) Pool 4 Field Station.

5.2.1 Habitat Monitoring

Pre-construction monitoring at Peterson Lake covered a number of different variables. Table 5, on the following page, is a complete list of the various monitoring and provides limited detail of results found. Only monitoring criteria that relate to the Peterson Lake HREP objectives are discussed in this report.

Table 5. Pre-construction monitoring at Peterson Lake

Parameter Monitored	Unit of Measurement	Period of Record	Number of Records	Agency	Results
GIS Analysis of Islands		64vs73;73vs89;64vs89	1	USACE	relatively steady change
Electrofishing Length Freq		May 19 & Jun 12 1986		MN F&W	
Fish Sightings		12-Jun-86	1	MN F&W	
Natural Reproduction - Shoal Water Seining		1986		MN F&W	
Vegetation Types	List	1986	-	MN F&W	
Benthic Organisms	List	1986	3 Stations	MN F&W	
Fish Spp. Composition	List	1986	-	MN F&W	
Lake Topography	feet	1986 & 87	1	MNDNR	Topographic Map of Peterson Lake
Trapnetting Length Freq		7-Aug-86		MN F&W	
Gill Netting Length Freq		7-Aug-86		MN F&W	
Water Temperature	°C	Graph of 1990 values			
DO	mg/L	Graph of 1990 values			
Current Velocity	m/sec	Graph of 1990 values			
Ice thickness	cm	Jan 31 & Feb 6 1992	14 Sites	MDNR	
Snow Depth	cm	Jan 31 & Feb 6 1992	14 Sites	MDNR	
Water Depth	cm	Jan 31 & Feb 6 1992	14 Sites	MDNR	
DO	mg/L	Jan 31 & Feb 6 1992	14 Sites	MDNR	All surface and bottom >10mg/L
Water Temperature	°C	Jan 31 & Feb 6 1992	14 Sites	MDNR	All <= 1°C
Current Velocity	m/sec	Jan 31 & Feb 6 1992	14 Sites	MDNR	Varies
Direction	Degrees	Jan 31 & Feb 6 1992	14 Sites	MDNR	
Aquatic Vegetation	Frequency/Relative Density	July-Aug 1992	1	USFWS	Dominant spp. V. Americana. See Fig. 1
Substrate Core		Aug 10 -11 1992	4 Holes	USACE	
Mussel Survey		1-Sep-92	6 Pollywog, 9 Sled	USACE	No End. Spp. 45 Live in 7 spp.
Inlet Discharge	cfs	Jan 7-8 & Feb 19 1993	11 Sites Jan, 6 Feb	MDNR	
Ice thickness	cm	1/14; 2/11; 3/5 1993	41 Sites	MDNR	
Snow Depth	cm	1/14; 2/11; 3/5 1993	41 Sites	MDNR	
Water Depth	cm	1/14; 2/11; 3/5 1993	41 Sites	MDNR	
DO	mg/L	1/14; 2/11; 3/5 1993	41 Sites	MDNR	All surface and bottom >10mg/L
Water Temperature	°C	1/14; 2/11; 3/5 1993	41 Sites	MDNR	All <= 1°C
Current Velocity	m/sec	1/14; 2/11; 3/5 1993	41 Sites	MDNR	Varies
Direction	Degrees	1/14; 2/11; 3/5 1993	41 Sites	MDNR	
Mixing and Flow Patterns		18-19 Feb 1993	1	USACE	
Winter DO	mg/L	Jan 11 & Feb 26 1996	28	MDNR	9.8 - 12 surface; 8.0 - 11.7 bottom
pH	pH Unit	Jan 11 & Feb 26 1997	28	MDNR	7.4 - 7.7 surface; 7.5 - 7.7 bottom
Water Temperature	°C	Jan 11 & Feb 26 1998	28	MDNR	0 - 0.6 surface; 0 - 1.1 bottom
Conductivity	umho/cm	Jan 11 & Feb 26 1999	28	MDNR	497 - 537 surface; 513 - 569 bottom
Current Velocities	m/s	Jan 11 & Feb 26 2000	28	MDNR	0.0 - 0.15 surface; 0.02 - 0.16 bottom
Ice Thickness	cm	Jan 11 & Feb 26 2001	14	MDNR	between 7cm and 77cm
Water Depth	m	Jan 11 & Feb 26 2002	14	MDNR	.87m - 4.1m
Bathymetry	depths >4 feet	1992 vs 2006	1	LTRMP	Some decreased depths, some increased
Winter DO	ppm	Feb 28 2006	10	MDNR	All greater than 5 ppm (Project Goal)
Current Velocities	cm/sec	Feb 28 2006	10	MDNR	3 of 10 less than 1 cm/sec
Water Temperature	°C	Feb 28 2006	10	MDNR	All < 1°C, (Goal was all > 3°C)
Pool 4 Discharges	m3/sec	7/12/89 - 10/24/96	>50 Peterson	USACE	

5.2.1.1 **Bathymetry**

One of the specific project objectives for the Peterson Lake HREP was to reduce sedimentation in the lake. The channel closures and weirs in the upper reaches of the lake were installed to reduce the rate of sedimentation in Peterson Lake by over 50 percent.

A bathymetric survey was completed by USACE prior to the start of the project. This bathymetry was not digitally available and therefore was not used in the GIS analysis. The most recent bathymetry digitally available prior to the start of the project was the 1992 Upper Midwest Environmental Sciences Center (UMESC) bathymetry. UMESC bathymetry from 1992 and 2006 was compared for pre-project and post-project conditions. The UMESC bathymetric data was composed from mosaics of the most recent surveys available at the time. The Peterson Lake portion of data in the 1992 UMESC bathymetry database was actually collected in June 1990 and the 2006 UMESC bathymetry database in Peterson Lake was collected in 2001. The actual years when the data was collected was used to calculate annual sediment deposition and erosion rates. For sediment transport analysis the 1992 Pool 4 bathymetry and 2006 Pool 4 bathymetry raster digital elevation model layers were subtracted from one another in GIS. There were both areas of increased and decreased depth displayed after processing the data (Figure 4). It was calculated that 86,500 cubic yards of sediment had been retained in the lake from 1990 until 2001. This amount is equivalent to 7,864 cubic yards per year.

In the DPR/EA for Peterson Lake multiple sedimentation rates were calculated using a variety of methods. A comparison of bathymetric data from 1986 and 1990 resulted in a sedimentation rate of 45 acre-feet or 72,600 cubic yards per year. An analytical method of estimating sedimentation was based on measured inflows by USACE, suspended sediment data from a USGS gage at Winona, and an assumed sediment trap efficiency. Results from this analysis gave a sedimentation rate of 43 acre-feet or 69,373 cubic yards per year. A final analysis on sedimentation rates used an estimation of the area and thickness of sand deltas in the lake along with a timeline set by conversations with resource managers and local citizens. It was determined that delta formation began prior to 1980 and possibly as early as the late 1960's. Using this information a range of 15-25 acre-feet or 24,200-40,333 cubic yards per year was calculated. Table 6 summarizes the estimated sedimentation rates.

Table 6. Comparison of sedimentation rate estimates for Peterson Lake.

Years	Method	Acre-Feet/Year	Cubic Yards/Year
1990 & 2001	Bathymetry Analysis	5	7,864
1986 & 1990	Bathymetry Analysis	45	72,600
1991-1993	Analytical Method	43	69,373
1969-1994	Sand Delta Load Estimate	15 – 25	24,200 - 40,333

In 1995 the lake volume of Peterson Lake was 2,200 acre–feet, the future (+50 yr) without project lake volume was predicted at < 500 acre–feet, and the with-project predicted enhancement potential volume was calculated at 1,150 acre–feet. The 1990 and 2001 volumes could not be directly compared to the previously calculated lake volume from 1995 because the definite boundaries from that calculation were not available. From the UMESC bathymetry data a volume of 2,233 acre–feet (97,283,001 cubic feet) was calculated for 1990 and a volume of 2,180 acre–feet (94,947,658 cubic feet) was calculated for 2001; a difference of 53 acre–feet (2,335,343 cubic feet).

In the post-construction monitoring section of the DPR/EA for Peterson Lake a target of 5 and 10 years post construction was set for bathymetric surveys. The 5 year post-construction survey was completed in 2001. The 10 year monitoring, however, has yet to be completed and is expected to be performed in the spring of 2012. From visual analysis of aerial photos and firsthand accounts from individuals familiar with the project it appears that sedimentation continues to occur in Peterson Lake. Though it appears the project may have reduced sedimentation from the 1990-2001 rates, the long-term effectiveness of the project on the reduction of sedimentation cannot confidently be determined at this time. The next bathymetric survey will enable a more accurate estimate of the rate of sediment accumulation in the lake.

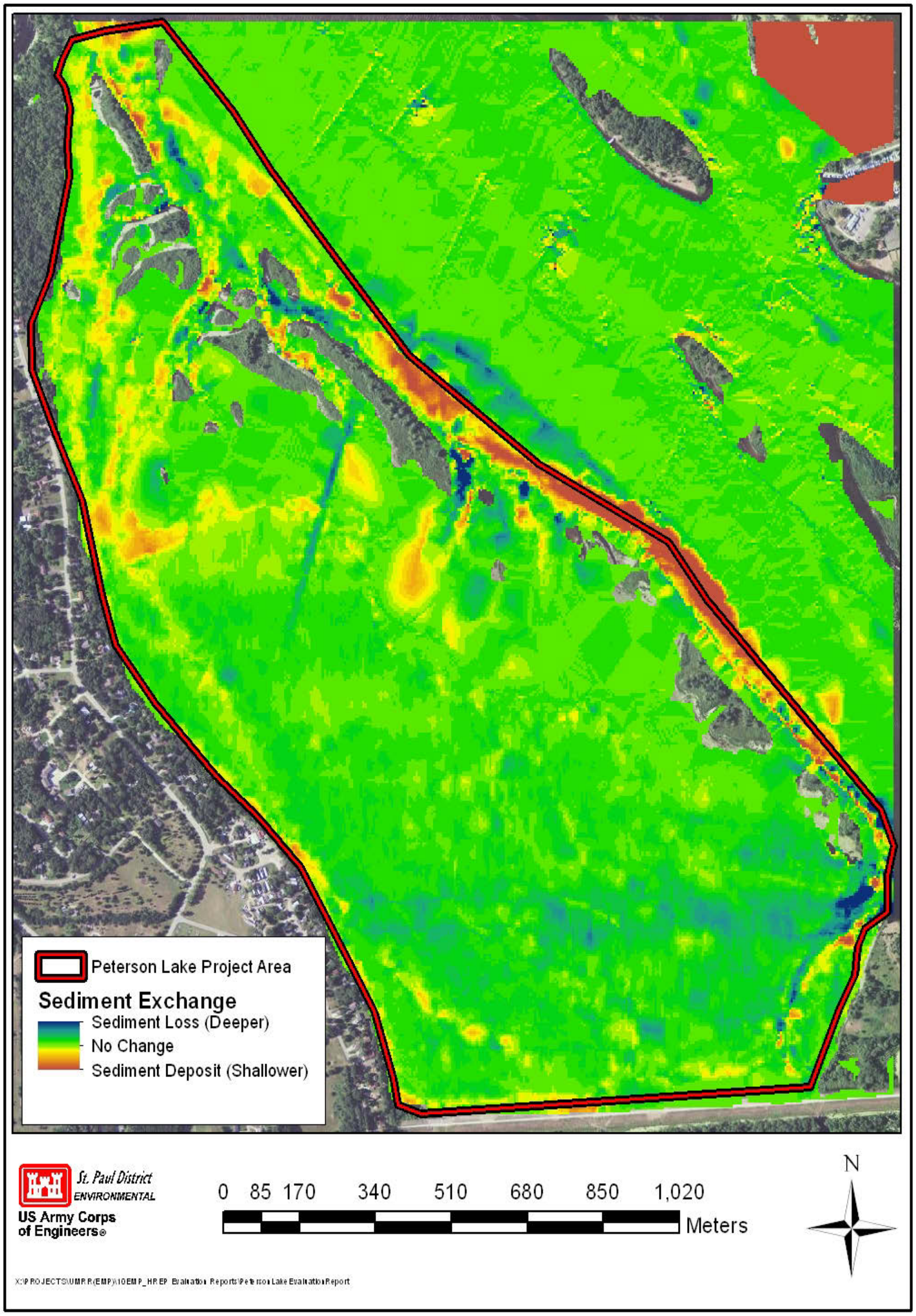

Figure 4. The figure displays the sediment exchange from 1990 until 2001. Blue areas display locations where scour or sediment loss has occurred. Areas of yellow, orange, and red represent locations of sediment accumulation. Green areas are locations where little to no change in depth has occurred.

5.2.1.2 **Total Suspended Solids**

Review of the planning documents for the Peterson Lake project in early 1994 by a team of scientists from the Environmental Management Technical Center (EMTC), which is now part of the UMESC, had raised concern about the effects of reduced flows and increased residence time on water quality in Peterson Lake. The concerns raised resulted in HREP funding being used to do a total suspended solids (TSS) study.

TSS were measured for pre-project conditions in 1994 and 1995. Sampling was done by deploying two automatic water samplers, one located at channel 5 near the upstream end of Peterson Lake and the other at channel 14 at the downstream end of the lake. Channel 5 was selected because it represented water quality conditions typical of the larger inflow channels near the upstream end. Channel 14 was selected since it is the main outflow from the lake. These samplers were set to collect a water sample every 4 hours, with all four-hour samples for each day placed in one bottle resulting in a daily composite TSS sample. The purpose of this effort was to determine how the Peterson Lake project affected TSS and to do a TSS budget. The TSS budget involves calculating the daily TSS flux by integrating daily composite TSS with daily inflows to Peterson Lake. TSS should not be confused with suspended sediment. Sampling and testing procedures for TSS usually result in quantification of the fine sediments in suspension, and not the sand that is suspended or being transported along the bed.

Figure 5 is a plot showing daily TSS data collected in 1994 at the outflow channel (site 14) and at the inflow channel (site 5). Outflow TSS was typically higher than the inflow TSS. TSS was usually lower than 20 mg/L, but was highly variable on a daily basis.

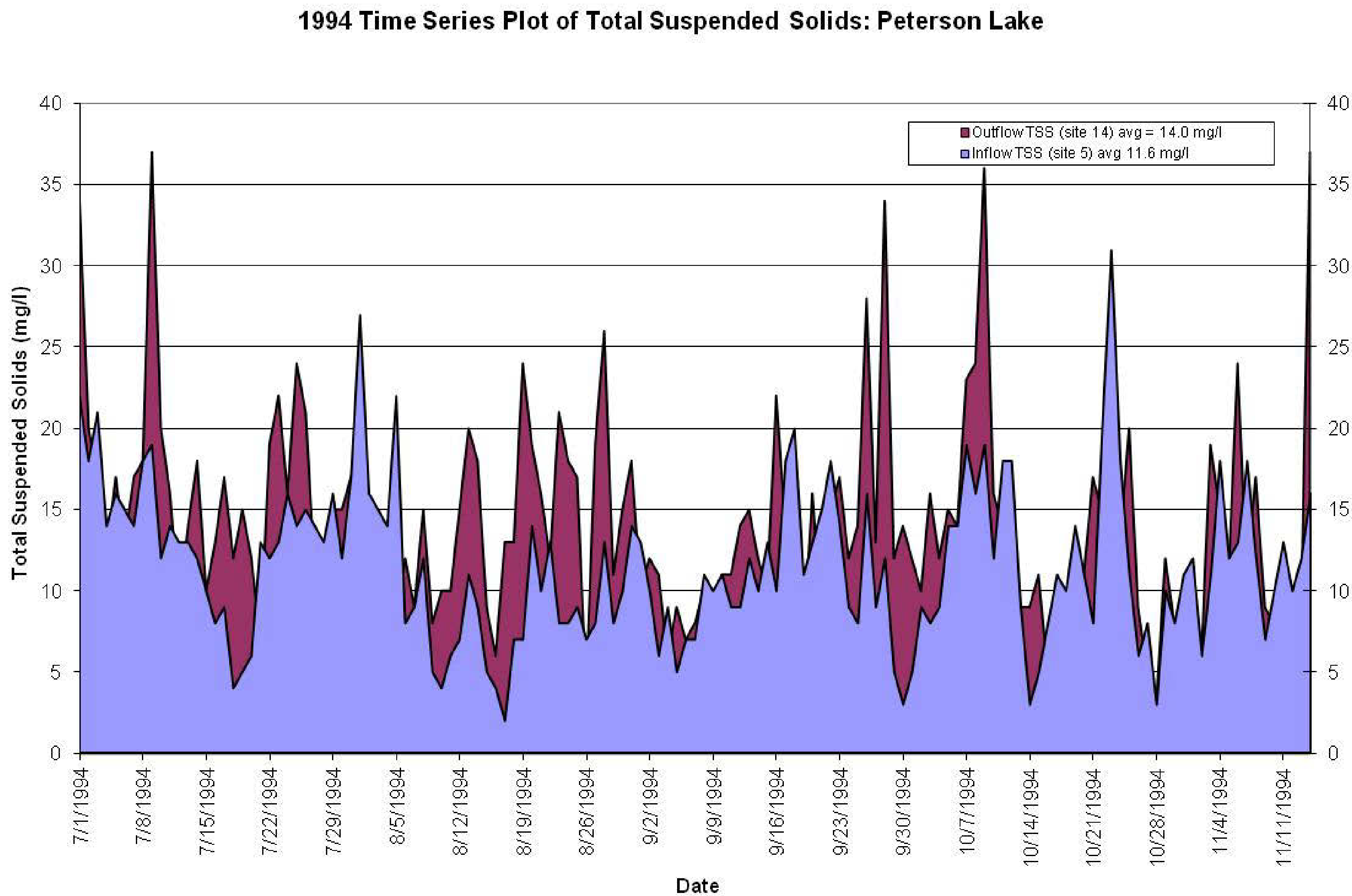

Figure 5. Inflow and outflow TSS readings in Peterson Lake for 1994

Post-project TSS conditions were sampled from April until November 1997. The methodology of this sampling was similar to that performed in the pre-project sampling.

Table 7 summarizes average annual TSS concentrations and fluxes for the 1994, 95, and 97 monitoring periods. During all three monitoring periods the average TSS outflow concentration was higher than the inflow concentration. This was due to increases in both the inorganic fraction of TSS (ie. sediment) which might be due to resuspension of sediment within the lake, and the organic fraction of TSS which could be due to algae growth. Net TSS accumulation was negative for all three monitoring periods indicating that Peterson Lake exports more TSS than it takes in. Although the average TSS outflow concentration for post-project conditions was higher than for pre-project conditions, it was not significantly higher.

Table 7. Total suspended sediment statistics for pre-project and post-project conditions in Peterson Lake.

	Sampling Dates	Average TSS Inflow Concentration (mg/L)	Average TSS Outflow Concentration (mg/L)	Average flow through lake (cfs)	Net TSS accumulation (tons)
Pre-Project Conditions	7/1/94 to 11/11/94	11.6	14	3370	-2800
	4/1/95 to 10/28/95	18.2	19.5	5355	-3800
Post-Project Conditions	4/30/97 to 11/12/97	15.6	20.9	2175	-2800

5.2.1.3 **Submersed Vegetation**

Maintaining submersed aquatic plant growth as it generally existed in 1991 was also a project objective. This included the growth of submersed aquatic vegetation to the depth of 5 feet and mean summer (June-September) turbidity levels less than 15 NTU. Figure 6 highlights the areas of Peterson Lake less than 5 feet in depth; these locations were targeted for submersed aquatic vegetation growth.

The Long Term Resource Monitoring Program (LTRMP), implemented by the U.S. Geological Survey (USGS) and the MNDNR field station, had sampled Pool 4, including Peterson Lake, for aquatic vegetation along transects from 1991–1998. Peterson Lake was divided into two sampling areas: Upper Peterson Lake (six transects across the narrower, northern half) and Lower Peterson (four transects across the southern half of the lake). Though some emergent vegetation was included in the sampling, the majority of sampling was submersed vegetation. Over the eight year period there was a significant decrease in the frequency of aquatic vegetation in both Pool 4 backwaters as a whole and in Peterson Lake specifically. Figure 7 displays this trend in Upper and Lower Peterson Lake.

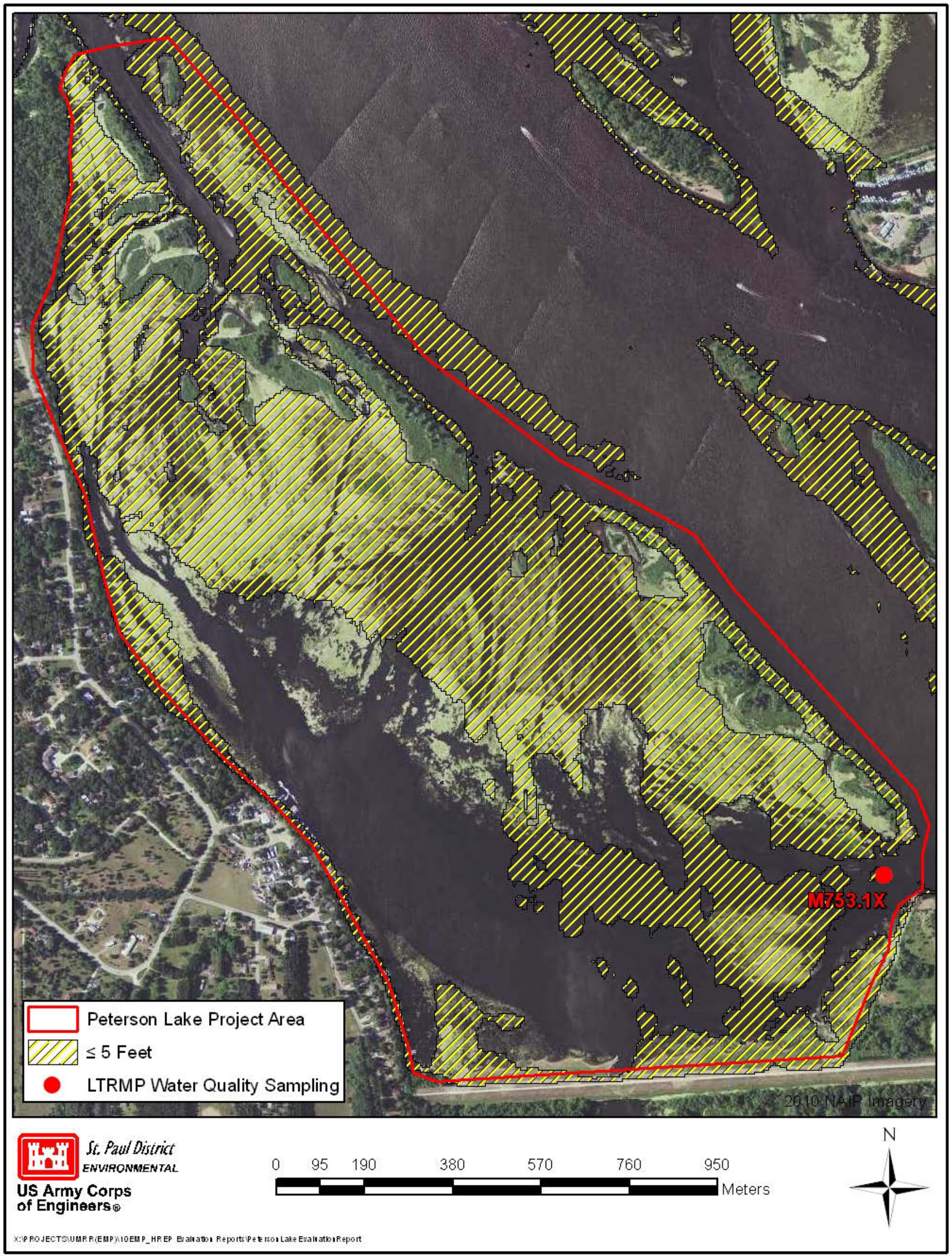

Figure 6. Locations under 5 feet in depth and the LTRMP fixed water quality sampling location in the Peterson Lake.

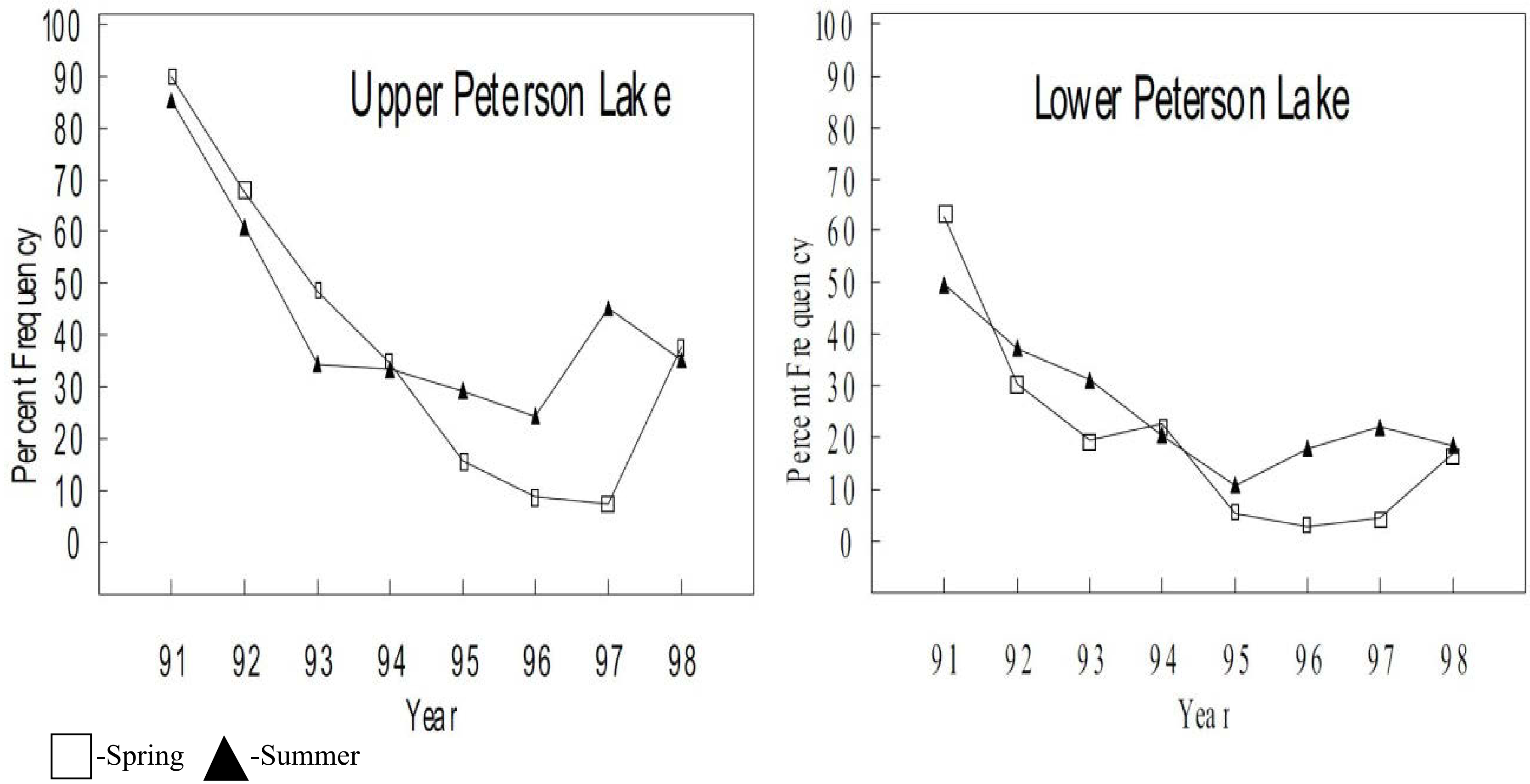

Figure 7. Percent frequency of aquatic vegetation sampled along transects in Peterson Lake from 1991-1998 (Yin et al. 2000).

GIS analysis of LTRMP land cover data for Peterson Lake in 1989 and 2000 also indicated a decrease in submersed vegetation in the area. Using this data it was determined that within the project boundary there were 172 acres of submersed vegetation in 1989 and 132 acres in 2000 (Figure 8). At the time of this report the 2010 land cover data was in the process of being completed and was unable to be analyzed. This data may be useful in submersed vegetation analysis and should be considered in any future evaluations of the project.

Lower than normal water levels in the late 1980s and early 1990s may have contributed to the decline in abundance (Rogers and Theiling 1998). According to Rogers the submersed vegetation decline in the UMR could have been the result of excess sediments and unusual nutrient changes in the water column that were the product of reduced flows and higher than normal solar radiation. This combination of factors may have stimulated high algal densities resulting in a reduced amount of light available to macrophyte leaf surfaces (1994). Since the mid 1990s it seems the areas vegetation has been on the rebound.

LTRMP changed submersed aquatic vegetation sampling from transect sampling to stratified random sampling in 1998. Though data was not readily available for Peterson Lake specifically, LTRMP data for submersed vegetation abundance and frequency in lower Pool 4 backwater contiguous areas may give an indication of the lakes condition. Backwater contiguous areas in Pool 4 displayed a marked increase in numbers as displayed in Figures 9 and 10.

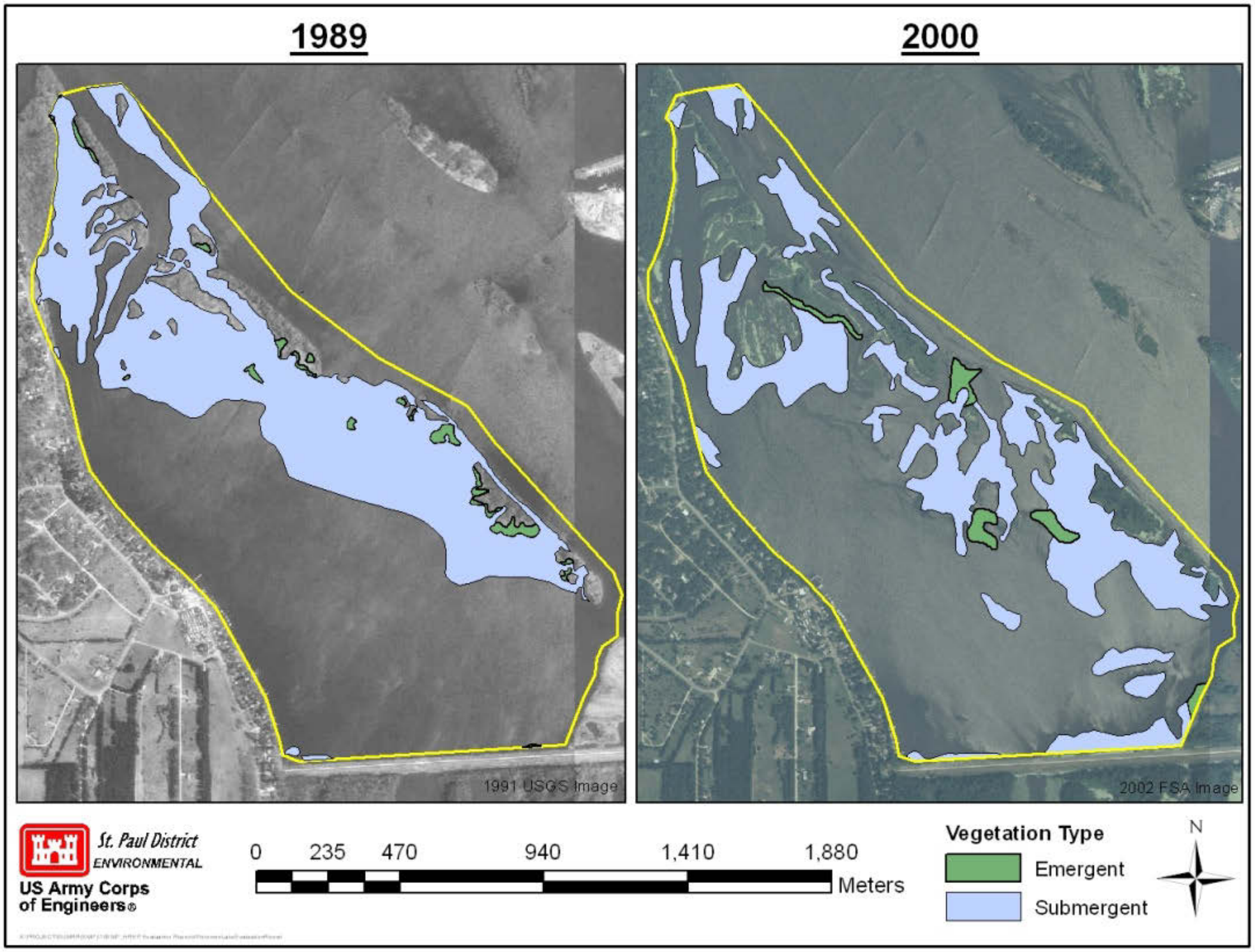

Figure 8. A comparison of submersed and emergent vegetation in 1989 and 2000 LTRMP land cover data. Submersed vegetation decreased by approximately 50 acres and emergent vegetation increased slightly between the two sampling years.

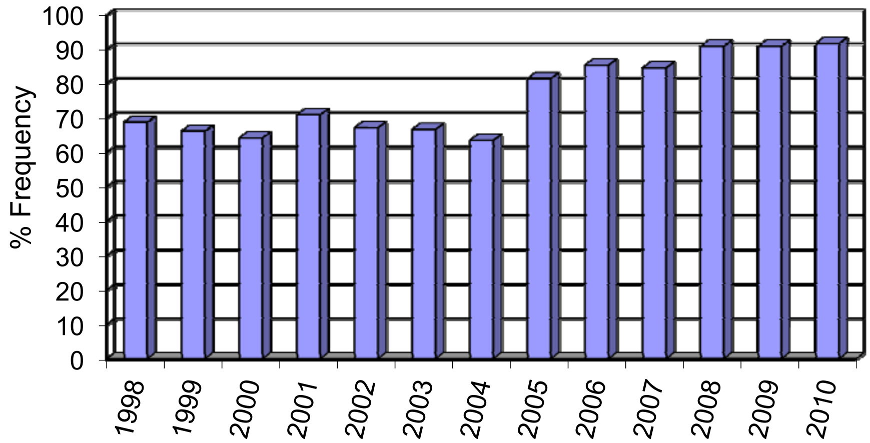

Figure 9. Percent frequency of Lower Pool 4 backwater contiguous submersed aquatic vegetation.

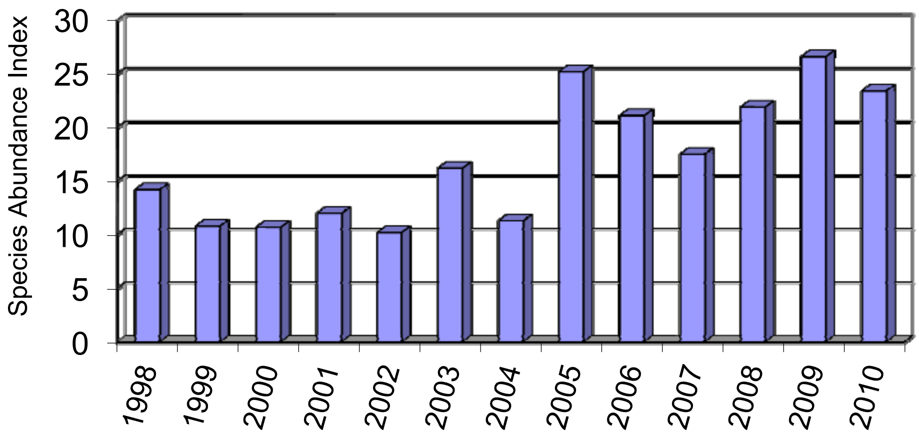

Figure 10. Lower Pool 4 species abundance index for backwater contiguous areas.

According to reports, since project completion there has been a noticeable increase in abundance. Increases in submersed vegetation have also been observed system wide in UMR backwaters during this period. It is unclear whether the increase in submersed aquatic vegetation in Peterson Lake can be attributed to the HREP project or if they are a response to larger, system-wide processes.

5.2.1.4 **Turbidity**

From 1993-2004 the LTRMP had a single fixed water quality sampling point located near the outlet of Peterson Lake (Figure 6). Over that time, turbidity had dropped from a mean summer reading of 17.8 NTU in 1993 to 9.5 NTU in 2004. The turbidity levels in Peterson Lake had been on a declining trend previous to project completion in 1995 and remained relatively stable until the fixed station sampling in Peterson Lake ended in 2004. During the sampling period mean summer turbidities met the project objective of less than 15 NTU every year since project completion (Figure 11).

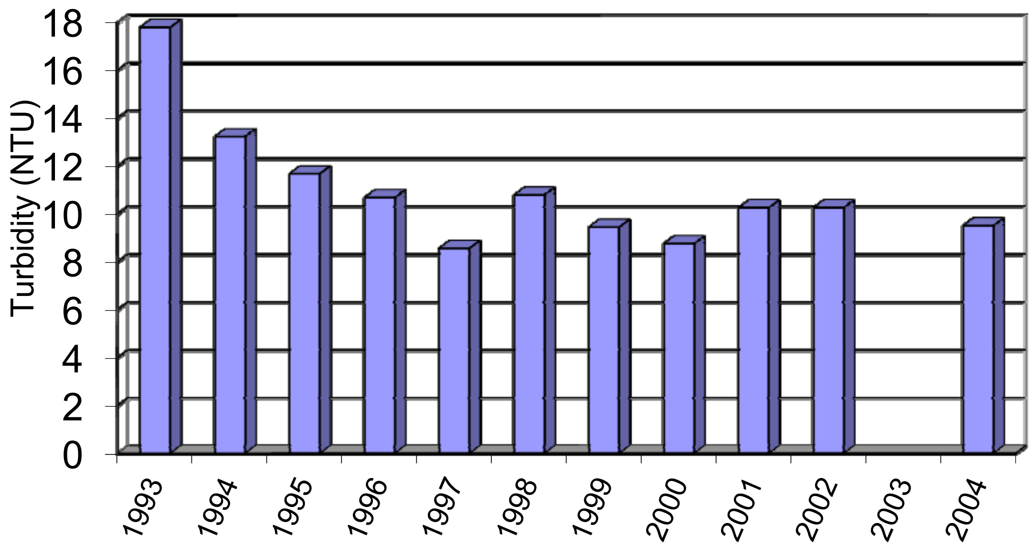

Figure 11. Mean summer (June-Sept) turbidity levels in Peterson Lake using fixed point LTRMP data from 1993–2004.

LTRMP stratified random sampling (SRS) for mean summer turbidity has also shown levels less than 15 NTU in Peterson Lake. From 1997 until 2010, every mean summer turbidity reading has fell below the acceptable project limit (Table 8). Though mean summer turbidity was defined as the period from June-September, all SRS in Peterson Lake was performed in July and August.

Table 8. LTRMP SRS for mean summer turbidity in Peterson Lake.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Mean Summer Turbidity (NTU)	5	5	3.5	4.9	4.6	10.6	-	7	4	4.9	9.5	6.3	2	4
Samples (n)	3	4	13	11	7	5	0	5	6	14	2	9	10	2

5.2.1.5 **Emergent Vegetation**

Another objective was to increase the extent of emergent aquatic plants in the lake by approximately 10 acres. LTRMP land cover data from 1989 and 2000 were analyzed for total area of emergent aquatic plants using GIS (Figure 8). From the 1989 LTRMP land cover data for Peterson Lake an area of 6.3 acres of emergent aquatic plant growth was calculated. The 2000 land cover layer indicated 8.4 acres of emergent growth. The increase of 2.1 acres falls short of the 10 acres described in the projects objectives. Reports from those familiar with Peterson Lake indicate that there has been a slight increase in emergent aquatic plant growth since the completion of the project. LTRMP surveys for percent cover of emergent species in backwater contiguous areas of lower Pool 4 have also shown a slight increase since first being assessed in 1998 (Figure 12).

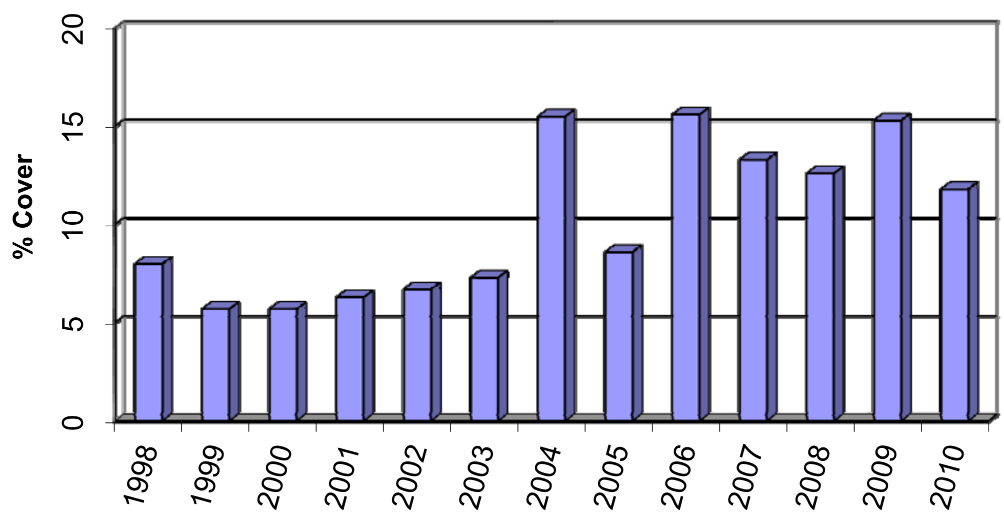

Figure 12. Percent cover of emergent aquatic vegetation in backwater contiguous area of lower Pool 4.

5.2.1.6 **Hydraulic Monitoring**

USACE staff or contractors hired by USACE measured inflows to Peterson Lake for both pre-project, 1991-1994, and post-project, 1997, conditions. Flows were recorded as the percentage of total river flow at Lock and Dam 4. The results of the sampling showed a decrease from 8.7% of the total flow in 1991-1994 to 5.8% after project completion in 1997 (Figure 13). The rock weirs at closures 8 and 9 experienced slight increases in flow, probably due to the fact that flow at sites 1 through 7 were reduced. Closures 1-4, 6, and 7 successfully cut off inflows to Peterson Lake but have been reported to have some degree of seepage in recent years. Additional sampling had been conducted in 2011 but had not been analyzed at the time of this report.

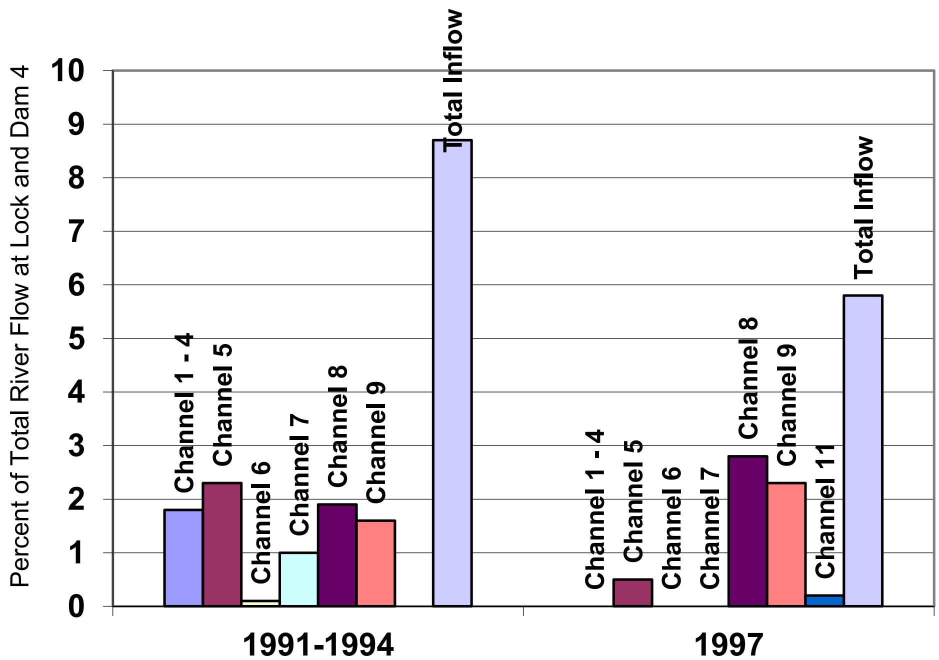

Figure 13. Inflow into Peterson Lake, Pool 4 for moderate flow conditions (based on the total river flow at Lock and Dam 4 exceeded 25% of the time).

5.2.1.7 **Fish Habitat**

Monitoring criteria for optimal winter fish habitat conditions were dissolved oxygen (DO), current velocities, and water temperatures. Table 9 summarizes the pre-project fish habitat monitoring criteria collected by the MNDNR in the winters of 1992 and 1993. Sampling at each site consisted of both surface and bottom samples.

Table 9. Data collected for the Peterson Lake fish habitat monitoring criteria.

Date of Sampling		1/31/1992	2/06/1992	1/14/1993	2/11/1993	3/05/1993	1/11/1996	2/26/1996
Number of Sites		5	8	15	14	12	14	14
DO (mg/L)	Mean	12.5	13.8	NA	NA	NA	11.3	10.2
	Range	12.0-12.8	13.2-14.5	11.9-12.5	9.5-12.0	13.0-13.8	8.1-12.0	8.0-11.5
Velocities (cm/s)	Mean	22	21	NA	NA	NA	3.6	3.2
	Range	12 - 35	3 - 42	0 - 10	0 - 9	1 - 9	0 - 16	0 - 16
Temp (°C)	Mean	0.4	0.81	0	0	0	0.1	0.2
	Range	0.1-0.8	0.2-1.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.1	0.0-0.9

Using the pre-project data, feasible criteria for winter habitat objectives were developed. Objective criteria included DO levels of ≥ 5 mg/l, current velocities of ≤ 1 cm/sec, and water temperatures of > 1°C. The MNDNR monitored fourteen Peterson Lake sites on both January 11, 1996 and February 26, 1996 for the above mentioned conditions. The majority of sites were sampled at the surface and bottom. All winter DO levels met the targeted criteria, ranging from 8.0 mg/l to 12.0 mg/l. The majority of the samples did not meet the targeted current velocities of ≤ 1 cm/sec; only seven percent of the sample velocities were ≤ 1 cm/sec. The samples ranged from 0.0 cm/sec to 16 cm/sec with an average velocity of 3.6 cm/sec. Nearly all temperature samples failed to meet the > 1°C objective; only one of the 56 samples met the criteria at 1.1°C.

5.2.1.8 **Terrestrial Resources**

The construction of the Lock and Dam 4 was completed in May, 1935. Based on measurements and a visual analysis of the aerial photos, it appears that the greatest loss of islands and emergent marsh occurred during the first 20 to 25 years of inundation.

The extent of islands and emergent wetlands in the Peterson Lake chain of channel border islands were measured from historic aerial photographs and reported in the Definite Project Report/ Environmental Assessment of Peterson Lake (USACE 1994). The islands and emergent wetlands were lumped together because it was nearly impossible to accurately separate them on the 1938 and 1958 photographs.

It was calculated from the photographs that the islands of Peterson Lake had decreased from 135 acres in 1938 to 40 acres in 1989 (Table 10). One objective of the project was to maintain the 40 remaining acres of islands that separate Peterson Lake from the Upper Mississippi River main channel. Using 1 meter resolution aerial photos taken July 2, 2010 along with GIS analysis, it was determined that the acreage of the barrier islands at Peterson Lake was approximately 39.5 acres; a total nearly equivalent to the 40 acre objective.

Table 11 displays the change in specific islands from 1938 until 2010. Calculations of island acreage from 1938 and 1958 included emergent wetland because they were indistinguishable from the islands in the photographs. Island estimates were also rounded to the nearest 5 acres.

Table 10. Amount of Islands/Emergent Wetlands Present in Peterson Lake (nearest 5 acres)

Date of Photo	Pool Elevation at Lock & Dam 4	Approximate Acres of Islands/Emergent Wetlands
August 18, 1938	666.2	135
August 3, 1958	666.6	80
August 10, 1964	666.7	55
August 27, 1973	666.6	50
August 29, 1989	667.2	40
July 2, 2010	666.6	40

Since the construction of the project, island acreage has stayed relatively stable. The maintenance of the rock structures will be important in preventing erosion and assuring the preservation of these islands.

From 1964-1973 the rate of island loss was about 0.67 acres/year. During the period 1973-1989, the rate decreased to about 0.53 acres/year. Most of the island loss during both periods was from the downriver islands in the chain (I - VII). During the period 1964-1973, about 92 percent of the loss was from these islands, while during the 1973-1989 period the loss from the downriver islands was about 82 percent of the total lost. Table 11 displays the change in island area for the period 1964 through 2010. Since 1989 little loss has occurred but has continued to take place on the downriver islands. The rate of loss since 1989 has been approximately 0.05 acres/year.

Table 11. Peterson Lake Island Acreage (1964 - 1910)

Island No.	1964 ac.	1973 ac.	1989 ac.	2010 ac.
I-III	6.0	4.5	3.5	2.6
IV	12.0	9.5	6.5	7.3
V	5.0	4.5	4.0	2.2
VI	1.5	1.0	0.5	0.7
VII	10.0	9.5	7.5	7.3
Subtotal	**34.5**	**29.0**	**22.0**	**20.1**
VIII	6.5	5.5	5.0	8.5
IX	2.5	2.0	1.5	0.9
X	2.5	2.0	1.5	0.8
XI	2.0	2.0	3.0	3.4
XII	2.5	3.5	3.0	2.2
XIII	1.5	1.5	1.5	0.9
XIV	3.0	3.5	3.0	2.7
Subtotal	**20.5**	**20.0**	**18.5**	**19.4**
Total	**55.0**	**49.0**	**40.5**	**39.5**

5.2.1.9 **Vegetation of Placed Dredge Material**

Dredged material from the construction of the fish channels was placed on the right descending bank of Grand Encampment Island (Figure 3). A list of species planted and seeded can be found in table 3.

Monitoring of the vegetation was conducted in September 1997 and August 1999. According to monitoring results from Anfang and Wege, the site appeared to be growing well. Vegetation composition was distributed fairly evenly, there was good overall percent cover, and the site had a Robel reading that exceeded the HREP goal of 1.5 decimeters after 2 years of growth.

Robel readings of 2.6 and 4.4 decimeters were recorded in 1997 and 1999. The average percent cover was 89% in 1997 and 56% in 1999. Frequency, relative frequency, dominance, and importance value were calculated for each species. The three species of highest importance value were bentgrass, rye, and foxtail in 1997 and big bluestem, swithchgrass, and Indian grass in 1999. Table 12 contains a summary of the vegetation surveys.

Table 12. Summary of Peterson Lake dredge material vegetation monitoring on Grand Encampment Island.

		Frequency		Relative Frequency		Dominance		Relative Dominance		Importance Value	
		Sep-97	Aug-99	Sep-97	Aug-99	Sep-97	Aug-99	Sep-97	Aug-99	Sep-97	Aug-99
	bentgrass	100		25.6		35.5		40.1		32.9	
*	big bluestem	10	60	2.6	28.6	0.5	25.5	0.6	44.4	1.6	36.5
*	black-eyed Susan	40	10	10.3	4.8	5.0	2.5	5.6	4.4	8	4.6
	bluegrass	30		7.7		10.0		11.3		9.5	
	foxtail	90	10	23.1	4.8	11.0	2.0	12.4	3.5	17.8	4.1
*	Indian grass	10	50	2.6	23.8	0.5	12.0	0.6	20.9	1.6	22.3
*	leadplant										
*	little bluestem	10	10	2.6	4.8	0.5	1.0	0.6	1.7	1.6	3.2
	Muhlenbergia		10		4.8		0.5		0.9		2.8
	mullein	10		2.6		2.0		2.3		2.4	
*	prairie clovers										
*	rough blazing star										
*	rye	90		23.1		23.5		26.6		24.8	
*	sand dropseed										
*	side oats grama										
*	stiff tickseed										
*	switchgrass		60		28.6		14.0		24.4		26.5
*	yellow coneflower										

*seeded species

	Sep-97	Aug-99
Average % Cover	89	56
Robel (decimeters)	2.6	4.4

5.3 Present Habitat Conditions

Peterson Lake habitat conditions have experienced some changes since the pre-project monitoring. Whether or not they are project-induced is hard to discern. There are indications of increased vegetation, increased concentrations of dissolved oxygen, a drop in turbidity, and decreased current velocities. Peterson Lake has also become very shallow in many areas near the islands. The upper portions of the lake seem to be composed of more fine material as opposed to a higher composition of sand in the southern portions.

6.0 Operation and Maintenance

As specified in the operations and maintenance manual, periodic inspections of the project by the Corps and analysis of the inspection checklist submitted by the USFWS were to be performed annually. The Corps was to inspect the project at least every third year and at other times as may be required. The Corps would contact the USFWS District Manager so that a mutually convenient date could be set up for a joint inspection, if needed. The findings of these inspections were to be transmitted to the USFWS and could include recommendations for any remedial work considered necessary to maintain the habitat project in a satisfactory operating condition (USACE 1997). Any agreed upon remedial work would be completed as soon as possible by the USFWS as provided in the Memorandum of Agreement between the USFWS and the Corps (1994).

A checklist report covering inspection, operation, and maintenance of the habitat project was to be submitted each year to the District Engineer. The USFWS could send the Peterson Lake report in conjunction with reports on other habitat projects for which it has responsibility. If so desired, these reports could be sent to the Corps with the annual Cooperative Agreement Report which was to be completed every April by the USFWS. Besides completion of the inspection checklist, each individual report was to briefly summarize the condition of the entire system, including any maintenance work done during the past l-year period. The frequency and nature of the inspections could be modified by mutual written agreement between the Corps and the USFWS (USACE 1997).

Performance monitoring of the Peterson Lake project has been conducted by the Corps of Engineers to help determine the extent to which the design meets the habitat improvement objectives. Information from this monitoring would also be used, if required, when ascertaining whether rehabilitation or abandonment of portions of this project would be the wisest choice (USACE 1997).

The USFWS provided the Corps of Engineers with the following reports. In the reports the USFWS looked at the overall condition of the project as well as each of the project features previously described in the Project Description, Section 4. The following are summaries of the reports.

October 2007: Peterson Lake 2007 HREP Annual Inspection Report

Most features were reported in good condition. . Some problems were the displacement of rock at the west end of the channel 1 closure and rock loss at the east wing of the channel 8 closure, near the channel 9 weir, and at the downriver ends of Island I, III, and IV bank protection. Recommendations were to continue monitoring the areas of concern. No action was needed as the structures were deemed to be functional.

August 2008: Peterson Lake 2008 HREP Annual Inspection Report

All features were in conditions similar to those found in the 2007 report with the exception of the east end of the channel 1 closure. This area had also begun to wash around the end of the rock closure. Recommendations were to closely monitor the channel 1 closure on both the east and west ends and to repair areas of rock loss if they become more significant in the future.

6.1 Project Features Requiring Operation and Maintenance

Maintenance of the project features was to be completed on an as needed basis to maintain their structural integrity and continued function in the manner for which they were designed.

Displaced or missing rock from the closure structures and weirs were to be replaced as soon as possible to prevent further damage to the structures and to maintain their structural integrity. In addition, the crest elevations of these features were to be maintained to insure that they function as designed (USACE 1997).

6.2 Operation and Maintenance Responsibilities

Operation and maintenance responsibilities for the Peterson Lake habitat project were originally outlined in the Definite Project Report (USACE 1994). The acceptance of these responsibilities was formally recognized by an agreement signed by the U. S. Fish and Wildlife Service (USFWS) and the St. Paul District, Corps of Engineers. The Operation and Maintenance Manual for the project delegated responsibilities and procedures for post project activities. The capability of the USFWS to carry out the maintenance responsibilities is contingent upon the passage of sufficient appropriations by Congress (USACE 1997).

As stated in the Memorandum of Agreement between the USFWS and the Corps, the Corps will be responsible for any mutually agreed upon repair and rehabilitation of the Peterson Lake project that exceeds the annual maintenance requirements and that may be needed as a result of a specific storm or flood (USACE 1997).

6.3 Operation and Maintenance Tasks and Schedule

The inspection of the closure structures, weirs, and bank protection features of the project were to be made by the USFWS District Manager at a minimum frequency of once a year. Inspections were to be made after any flood whose elevation exceeds 670.0 feet msl at the Lock 4 headwater gage (USACE 1997).

The frequency for inspection is subject to review by the USFWS and Corps and could change upon mutual agreement of both parties. The timing of the annual inspection could be made at the discretion of the District Manager.

6.4 History of Repairs

During spring high water of 1996, sand closures constructed at side channel openings 2 through 4 washed out. These structures were reconstructed with rock. Work for this was completed in September 1996.

In September 1997 the Corps made some minor repairs on the upstream end of the channel 2 closure and near the west end of the channel 7 closure. The cost was $7,000 and was funded through USFWS flood damage repair funds.

In April 2001 the second largest flood on record for the Upper Mississippi River swept through the project area.

The Corps of Engineers repaired four areas in June 2004 where rock loss had occurred. The areas involved in the repair were Island VII, the downstream wing of channel 8, Island IV, and Island III. The cost was $29,800 and was funded through USFWS flood damage repair funds (USFWS 2008).

7.0 Project Evaluation

7.1 Attainment of Project Objectives

Of the eight measurable objectives for the Peterson Lake HREP, four have been successfully reached, three have not been met, and one objective could not be determined due to a lack of data. Table 13 provides a summary of project objectives and the level of attainment.

Table 13. Project objectives and the level of attainment.

Project Objective	Unit of Measure	Measurement Plan	Actual Monitoring Interval	Level of Attainment	Objective Reached Successfully
Maintain 40 acres of existing islands	Acres	Measurements from aerial photographs 5 and 10 years post-construction	15 years post-construction using 2010 imagery	40 Acres	Yes
Maintain submergent aquatic plant growth a. Growth to 5 feet of water b. <15 NTU	a. Depth of plant growth b. NTU	Measurements of depth of plant growth and turbidity 3,6, and 10 years post-construction	a. No data available b. Yearly LTRMP data through 2004	a. Unknown b. Turbidity <15 NTU every year	a. Unknown b. Yes
Create winter fish refuge with a. > 5 mg/l DO b. < 1 cm/sec vel. c. > 1 degree C	a. mg/l b. cm/sec c. degrees C	Measure dissolved oxygen, current velocity, and water temperature during the winter 3 of first 5 years post-construction	a. 1996 b. 1996; (2011 NA) c. 1996	a. All DO >5 mg/l b. Most >1 cm/sec c. Most <1 degree C	a. Yes b. No c. No
Create 10 acres of emergent aquatic plant growth	Acres	Measurements from aerial photographs 5 and 10 years post-construction	2000 land cover data	An increase of 2.1 acres of emergent aquatic vegetation	No
Reduce sediment inputs to lake	Acre-feet	Bathymetric surveys 5 and 10 years post-construction	5 year post-construction Survey expected in 2012	Reduced from 45 to 5 acre-feet/year	Yes

7.2 **Ecological Effectiveness**

Island stabilization was one of the top priorities in this project. The islands appear to have withstood the rivers erosive forces over fifteen years after modifications to the original design were applied. Island stabilization and the construction of strategically placed closures have undoubtedly contributed to the reduction of sedimentation and turbidity. Sedimentation rates have dramatically decreased but may continue to be a problem in the upper portions of the lake.

The reduction of turbidity has created a more inviting environment for aquatic vegetation in Peterson Lake. Emergent vegetation in the lake did increase but not to the extent of the project objectives. It was unclear whether or not the submergent vegetation met the criteria for growth of depth as no sampling could be found for analysis.

7.3 **Construction and Engineering**

Construction began in August 1995 and was initially completed in November 1995, except for grading and seeding of the dredged material placement site. The grading and seeding of the placement site was completed in June 1996.

During the spring high water of 1996, sand closures constructed at side channel openings 2 through 4 were washed out. Work to rebuild the closures with rock was completed in September 1996.

Closures made of only rock have not completely blocked flows. Flowing water can move between the rocks and have resulted in some minor wash outs. The use of a rock/sand combination may help cut off flows entirely. Additional flow measurements may be useful.

7.4 **Public Acceptance**

Reports from the state resource managers indicate that the project has been generally well accepted by the public. Waterfowl and panfish numbers in the area seem to have increased since the completion of the project. According to reports, over-wintering panfish have been prevalent in northern portions of the lake and open water fishing has been productive for largemouth bass, northern pike, and walleye.

A decline in public use of the lake has also been noted. This decline may be due to shallow conditions found within the lake. Access points in and out of the lake have become more constricted in recent years from sediment accumulation. There have been reports of the public wanting more dredging to take place within Peterson Lake to deepen areas for recreational boating access. The USFWS and MNDNR have indicated preliminary plans to dredge access channels from the Peterson Lake boat landing to the main channel. Improved conditions in the nearby Finger Lakes (immediately downstream from the Lock and Dam 4 embankment) may have also attracted many anglers and recreational boaters that may otherwise use Peterson Lake for such activities.

7.5 Costs

7.5.1 Construction Costs

In the Definite Project Report/Environmental Assessment cost estimates for the entirety of the project were $986,000 (USACE 1994). The base contract for the initial construction costs totaled $636,011 and was completed in November 1995. Modifications to construction were required after three sand closures washed out in the spring of 1996. The costs of the modifications completed in September 1996 were $125,418. The total cost of construction for the Peterson Lake HREP totaled $761,429.

7.5.2 Operation and Maintenance Cost

In the Definite Project Report it was estimated that the Peterson Lake HREP would require little or no maintenance. Over the 50-year project life the estimated cost was $156,250. From the estimate, an average annual operation and maintenance cost was calculated to be $3,125 (USACE 1994). This amount included an average of 50 cubic yards of rock replacement per year ($2,500) and annual inspection and reporting costs ($625).

Table 14 is based on information provided in the 2008 USFWS Peterson Lake Annual Inspection Report. The 1997 and 2004 elevated maintenance costs were a result of major flood events in 1997 and 2001. In those years USFWS flood damage repair funds were used to finance the majority of the costs. From 1998-2003 not all Refuge operations and maintenance costs were documented (USFWS 2008).

Table 14. Operations and Maintenance History for the Peterson Lake HREP

Year	Years in O&M	Est. Annual Cost with Inflation	Actual USFWS Costs	Activities
1997	1	$3,382	$7,300*	Prescribed burn, inspections, repairs to Channels 2 and 7 closures.
1998	2	$3,436	$720	Prescribed burn, inspections.
2003	7	$3,879	$499	Inspections, rock maintenance coordination.
2004	8	$3,984	$31,836*	Rock maintenance and breach repair, coordination, inspections.
2005	9	$4,120	$0	Inspections.
2006	10	$4,251	$0	Inspections.
2007	11	$4,375	$700	Inspections.
2008	12	$4,541	$1,250	Inspections
2009	13	$4,525	$160	Inspections
2010	14	$4,600	$710	Inspections

*Majority funded by USFWS flood damage repair funds

8.0 Lessons Learned and Recommendations for Similar Projects

The sand closures in the channels were not able to withstand the high flows during spring flooding. The sand closures constructed in channels 2 through 4 washed out after floods swept through the area. In projects similar to the Peterson Lake HREP sand plugs should be avoided.

Rock closures were used to cut off some flows in the project. Rock alone, however, did not seem to completely stop flow due to water movement between the rock. Using a combination of rock and sand or other substrate may be a useful way of cutting off the flow entirely. Sites 5, 8 and 9 continue to allow considerable flow into Peterson Lake, resulting in lower winter water temperatures. Further reduction of hydraulic exchange may be needed to create more suitable winter habitat for lentic fishes.

Water flowed around some of the rock closures and scoured out large areas around them during high water events. When additional rock was added to these areas it was "feathered out" rather than leaving an abrupt rock-land transition area. This method has proved to be much more resilient to erosion in the project area.

Rock placed near deep water to stabilize island shorelines was costly to maintain. It was suggested that first constructing berms or islands with dredged material and then constructing off-shore revetments with rock may be a more effective approach. This type of shoreline stabilization may be less costly in the long term and provides a better variety of habitat conditions than does shoreline riprap.

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