DRAFT PROBLEM APPRAISAL REPORT

Upper Pool 4 – Head of Lake Pepin

Upper Mississippi River

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Executive Summary

Upper Pool 4 – Head of Lake Pepin Draft Problem Appraisal Report

PURPOSE

Concern over habitat loss and degradation in Upper Pool 4 near the head of Lake Pepin has been discussed off and on by state and federal agencies and stakeholders for over two decades. Several potential restoration measures have been identified; however, a comprehensive assessment of existing resource conditions and potential restoration actions has not been finalized due to funding constraints and lack of an identified funding source for implementation of management actions. In an effort to assist state and federal agencies in addressing these concerns, the Lake Pepin Legacy Alliance and Audubon Minnesota developed this draft Problem Appraisal Report for agency consideration. By consolidating available information and providing an up-to-date assessment of current and projected future conditions in Upper Pool 4 based on previous studies and reports, state and federal agencies and partners will be better able to develop habitat restoration alternatives and implementation strategies. In addition, this report becomes an important, scientifically based tool for NGO's and agencies to engage the public in developing and advancing restoration objectives.

UPPER MISSISSIPPI RIVER SIGNIFICANCE

In 1986, Congress approved the Comprehensive Master Plan as a guide for future water policy on the Upper Mississippi River System (UMRS) through passage of Section 1103 of the Water Resources Development Act of 1986. WRDA 1986 included language recognizing the Upper Mississippi River as both a nationally significant ecosystem and a nationally significant commercial navigation system. WRDA 1986 also established the U.S. Army Corps of Engineers' Upper Mississippi River Restoration (UMRR) Program and its two elements, the Habitat Rehabilitation and Enhancement Project (HREP) element, and the Long Term Resource Monitoring (LTRM) element. The UMRR Program was formerly known as the Environmental Management Program. The HREP element is implemented by the U.S. Army Corps of Engineers (Corps) in cooperation with the U.S. Fish and Wildlife Service (USFWS) and the five Upper Mississippi River System (UMRS) states of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The LTRM element is implemented by the U.S. Geological Survey, Upper Midwest Environment Sciences Center (UMESC), in cooperation with the five Upper Mississippi River System (IUMRS) states of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The Corps provides guidance and has overall program responsibility.

An economic profile of the Upper Mississippi River (UMR) region, published in 1999, found that transportation, water use, natural resource harvests, and natural resource services reliant on the UMR bring approximately $145 billion in revenue to businesses in the 60 counties adjacent to the UMR. Manufacturing (e.g. food processing, machinery, transportation equipment, and chemicals) accounts for the largest portion of this revenue at $126 billion and 600,000 jobs. Commercial navigation amounts to $1 billion in revenue, providing 6,300 jobs and allowing for the shipment of 125 million tons of commodities, annually.

Harvesting of natural resources (commercial fishing, trapping, and musseling) and recreation (fishing, boating, hiking, sight-seeing) account for a little over $200 million in revenue. Though not included in the revenue estimate, the profile notes that about 40 percent of all waterfowl in North America rely on the Mississippi Flyway and waterfowl hunting and viewing generate over $1 billion in revenue in the UMR's five-state region. (Economic Profile of the Upper Mississippi River Region, 1999) A University of Wisconsin – River Falls study published by the Center for Economic Research found that firms within 15 miles of Lake Pepin bring in $4.6 billion in sales revenue to the four counties bordering the lake. 90% of survey respondents in this area indicated that Lake Pepin was at least somewhat important to the local economy, and 61% indicated an importance to their own business. 14% of respondents offered the comment that the siltation of Lake Pepin has negatively affected their business. (Kelly, 2013)

UPPER MISSISSIPPI RIVER RESOURCE SEDIMENT ISSUES

In 1982, the Upper Mississippi River Basin Commission identified two congressionally authorized purposes for the UMRS: commercial navigation and national wildlife refuges. Recognizing the multi-purpose use of the UMRS, the Commission made the recommendation that "immediate action be taken to reduce erosion rates to tolerable levels to help preserve the integrity of all resource values on the Upper Mississippi River System". The study went on to say: "The most pervasive and damaging problem for the Upper Mississippi River System as a diverse, vital natural ecosystem is excessive sedimentation from upland and streambank erosion in the watershed." (Comprehensive Master Plan for the Management of the Upper Mississippi River System, 1982) The Upper Mississippi River Basin Commission further noted in the Master Plan:

> The natural erosion process has been intensified by agricultural practices and other land surface modifications; the riverine sedimentation process has been intensified by the placement of navigation system locks and dams and wing dikes in the river corridor. Thus, a total approach to river management, as called for in the Master Plan legislation, must extend into upland area adjacent to the river corridors. (Comprehensive Master Plan for the Management of the Upper Mississippi River System, 1982)

UPPER POOL 4 AND LAKE PEPIN

Currently, Lake Pepin extends from the delta of the Chippewa River to Red Wing, Minnesota, covering 26,000 acres. At an average of 1.7 miles wide, it is the widest natural reach of the entire Mississippi River. Upper Lake Pepin consists of channel border islands and backwater lakes grading into an expansive, shallow open water area with little physical structure. Water depths throughout much of Upper Lake Pepin are less than five feet. Studies predict approximately one third of the lake volume will be filled by sediment within the next 100 years if present rates of sedimentation continue. (Engstrom, Almendinger, & Wolin, 2009).

In 2004, the Fish and Wildlife Workgroup prepared Environmental Pool Plans (EPP) at the request of the River Resources Forum to "identify a desired future habitat condition toward which resources agencies and other river interests can strive" in the UMR. Resource issues for areas in Upper Pool 4 include impact by sedimentation associated with the suspended sediment load from the Minnesota River and island erosion due to recreational traffic. The EPP states that sedimentation "has caused a loss in aquatic vegetation and water depth diversity of the backwater lakes and isolated wetlands in areas above Lake

Pepin," and wind action and barge travel resuspend that sediment, resulting in increased turbidity, particularly at the head of the lake. Above Lake Pepin, the EPP describes Mud Lake, Dead Slough Lake, and Goose Lake as having been severely impacted by fine sediment deposition and considered of poor habitat quality for a variety of aquatic species. (Environmental Pool Plans Mississippi River Pools 1-10, 2004)

The Minnesota Pollution Control Agency (MPCA) completed a draft Total Maximum Daily Load (TMDL) study in 2010 for Total Suspended Solids (TSS) in the South-Metro Mississippi River, extending from river mile 844 at the confluence with the Minnesota River to river mile 780 in Upper Lake Pepin. According to the study:

> Settling out of sediment occurs as the river enters Lake Pepin at rive mile 786.2. The long-term average for TSS at this monitoring station is 46 mg/L. Just five miles downstream, at river mile 781.2, the long-term average TSS is about half of this value, at 23.8 mg/L. (MPCA, South Metro Mississippi River Total Suspended Solids Total Maximum Daily Load Draft, 2010)

The study set a site-specific standard of 32 mg/L TSS summer average for the South-Metro Mississippi River. To achieve this target, the implementation section of the TMDL is coordinated with the MPCA's Sediment Reduction Strategy for the Minnesota River, which focuses on external loading. The TMDL notes that "several governmental entities, such as the MPCA, Minnesota DNR, Wisconsin DNR, U.S. Army Corps of Engineers, and U.S. Fish and Wildlife Service, will be involved in plans and efforts to decrease internal loading from wind and wave resuspension by fifty percent," in the South Metro Mississippi River, further explaining, "[building] islands in shallower areas with wide expanses of open water can reduce wind fetch in order to cut down on sediment re-suspension." (MPCA, South Metro Mississippi River Total Suspended Solids Total Maximum Daily Load, 2014)

As efforts progress to address the accelerated sediment loading to the South-Metro Mississippi River from the Minnesota River Basin and other tributaries, management actions proposed by state and federal agencies through the Environmental Pool Plans and other documents can help to offset the impacts of sedimentation. Project elements can reduce wind fetch, which causes sediment resuspension and turbidity, through the construction of islands, increase coverage of emergent vegetation, stabilize eroding shoreline, improve terrestrial habitat, and increase water depths in selected backwater sites. (Environmental Pool Plans Mississippi River Pools 1-10, 2004)

Figure 1 depicts the Upper Pool 4 and Head of Lake Pepin study area, as shown in the Environmental Pool Plans' map of existing (1989) habitat conditions. The study area will encompass the Pierce County Islands and head of Lake Pepin, beginning at river mile 792 and extending to river mile 780. Additional areas within Upper Pool 4, such as the Gantenbein Backwater Complex and the Cannon River Delta, may be added to the study area based on the outcomes of community engagement efforts.

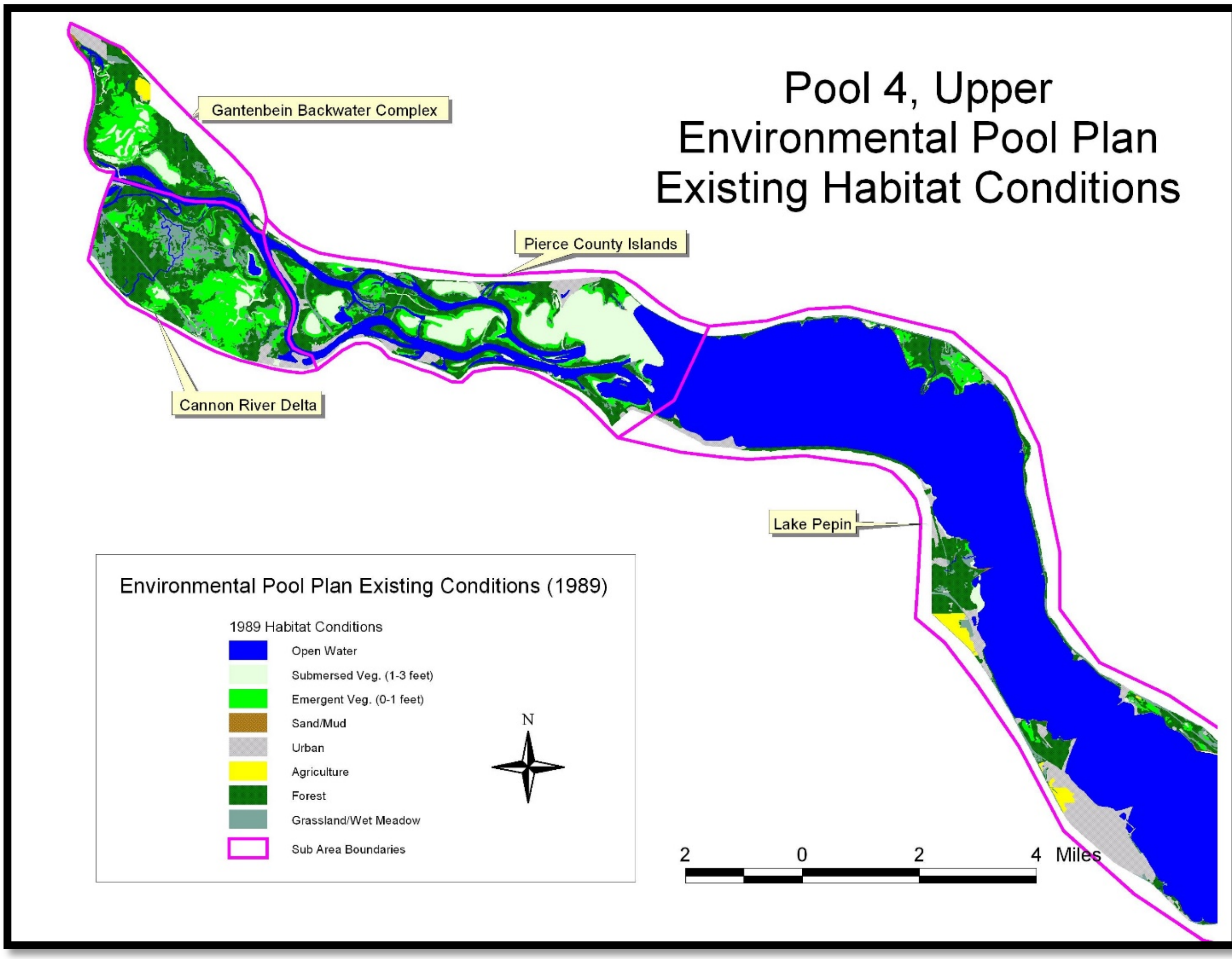

Figure 1 Habitat Conditions in Upper Pool 4 1989 (Environmental Pool Plans Mississippi River Pools 1-10, 2004)

DRAFT PROBLEM APPRAISAL REPORT

UPPER POOL 4 – HEAD OF LAKE PEPIN
UPPER MISSISSIPPI RIVER
GOODHUE COUNTY, MINNESOTA; PIERCE COUNTY, WISCONSIN

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1. INTRODUCTION

1.1 REPORT PURPOSE

The purpose of this Problem Appraisal Report (PAR) is to document existing and predict future habitat conditions and deficiencies, define habitat goals and objectives, and identify alternative measures that would address the goals and objectives.

1.2 STUDY AREA

The Upper Lake Pepin project area extends from the Pierce County Islands, beginning at river mile 792, to the upper most sections of Lake Pepin near river mile 780 on the Mississippi River, as defined in the Environmental Pool Plans (See Figure 1). The project area is located in Pierce County, Wisconsin, and Goodhue County, Minnesota. It is contained within Navigation Pool 4, formed by lock and Dam 4, located thirty miles downstream from the study area at river mile 752.8.

1.3 RESOURCE PROBLEMS/OPPORTUNITIES

The river ecosystem in Upper Pool 4 has been significantly affected by sedimentation and degraded water quality associated with high suspended sediment concentrations, originating mainly from fine sediment inputs via the Minnesota River and directly from the Cannon and vermillion Rivers. Though relatively minor in comparison, island erosion due to barge traffic and recreational traffic also affect habitat conditions. Sedimentation and sediment resuspension have caused a loss in water depth diversity of the backwater lakes and isolated wetlands above Lake Pepin as well as a loss in aquatic vegetation. The effects of wind wave action, barge travel, large recreational boat wakes, and fish activity are exacerbated by the increased sediment load available to be resuspended, continuing to limit light penetration and rooting capability of submersed aquatic vegetation. These conditions have had the greatest influence on aquatic habitat in the upper portion of Lake Pepin, Wacouta Bay, and the Bay City Flats.

Sediment resuspension and associated water quality degradation was identified as a concern with commercial tow traffic in Lake Pepin, especially at the shallow head of the lake. It was recommended in the Pool 3 and Upper Pool 4 Channel Management Study that the Navigation Work Group of the River Resources Forum investigate the potential for defining a navigation channel throughout Lake Pepin. (U.S. Army Corps of Engineers, 2001)

The habitat concerns within the study area center around habitat quality and diversity, loss of aquatic vegetation and invertebrates, and fish and wildlife in Upper Pool 4. Habitat deficiencies in the area include the loss of emergent and submergent aquatic vegetation, loss of protected wetlands and aquatic areas, degradation of habitat for migrating waterfowl and other species, degradation and loss of secondary and tertiary channels, loss of aquatic plant coverage and bathymetric diversity, and increased flows which reduce habitat value for lacustrine fish.

The opportunity exists to increase terrestrial and aquatic habitat diversity by directing flow and sediment deposition through island building and dredging. Managing the inflows and distribution of water and sediment will help to create areas within Upper Lake Pepin that will not be influences as greatly by the Minnesota River sediment and nutrient load. Channel closures, dike repair, and shoreline protection are additional actions that will improve habitat in the Pierce County Islands area.

Specific project needs to increase habitat diversity in the area include the following items. These needs will serve as the basis for selecting among the alternatives.

- Maintain/enhance/create more natural sediment transport and deposition.
- Decrease suspended solid concentrations.
- Reduce wind fetch.
- Increase aquatic vegetation; increase terrestrial habitat

1.4 DECISIONS THAT NEED TO BE MADE

1.4.1 FUNDING

Many potential funding sources require a cost share partner, which is usually the entity with ownership and/or management responsibilities in the area. The funding source and cost-share partners for this project will need to be identified.

1.4.2 WI DNR

Because this project is partially located on land managed by the Wisconsin Department of Natural Resources (WI DNR), the WI DNR will determine whether a proposed project is compatible with the goals and objectives of the area.

2. ASSESSMENT OF EXISTING RESOURCES

2.1 PHYSICAL SETTING

Pool 4 is an impoundment of the Mississippi River resulting from the construction of Lock and Dam 4 in 1935 as part of the navigation channel project. Pool 4 is 44.2 miles long, extending from Red Wing, Minnesota at River Mile 796 to Alma, Wisconsin at River Mile 753. Lake Pepin, a large river lake, is entirely contained within Pool 4 of the Upper Mississippi River (UMR). The average or typical elevation in Upper Lake Pepin is about 668.5 feet above mean seal level based on the average discharge at Lock and Dam (LD) 4 and according to Lake City gauge records from 1972 to present. (U.S. Army Corps of Engineers, 2001)

Presently, Lake Pepin is over 22 miles, extending from river mile 786 to 763.5 and averaging 1.7 miles wide. The average depth of the lake is 21 feet and the maximum depth is 60 feet, though water depths throughout much of Upper Lake Pepin are less than five feet. Lake Pepin forms the boundary between Minnesota and Wisconsin and covers approximately 26,000 acres. In 1996, a report was written by the Minnesota Department of Natural Resources to clarify the official boundary between the State of Wisconsin and the State of Minnesota at the Head of Lake Pepin. The uncertainty of the boundary had caused confusion over enforcement of fishing and hunting rules on an un-named island (locally known as Lighthouse Island). The decision was made to draw the boundary at the center of the main channel, at the time of Wisconsin's statehood, as shown in the 1933 U.S. Engineer Office Map of Land & Flowage Rights, or Figure 2, below. (Winiecki, 1996)

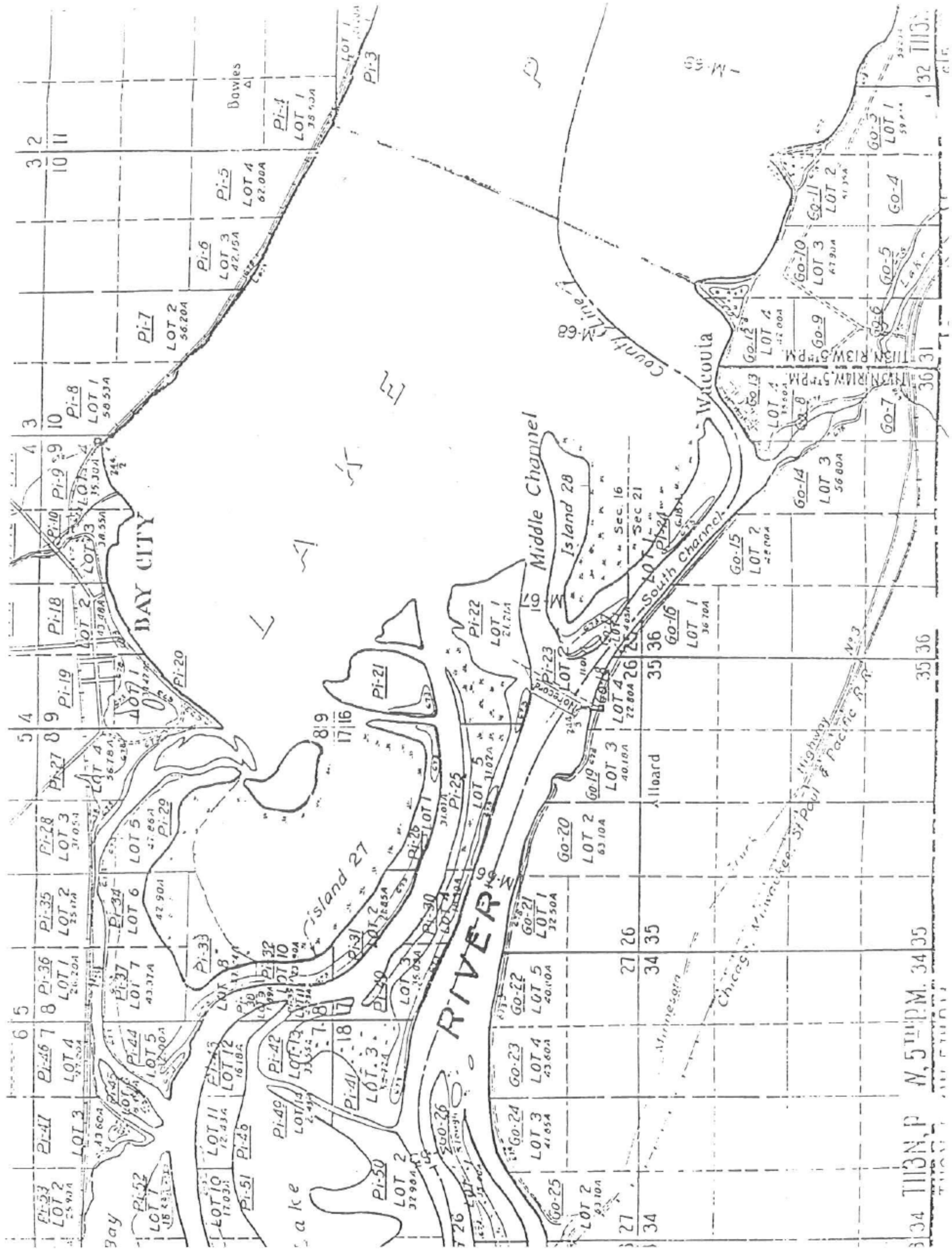

Figure 2 Minnesota - Wisconsin State Boundary: Center of 1933 Main Channel (Winiecki, 1996)

According to the Environmental Pool Plans, the I & M Rail Link railroad on the Minnesota side and the Burlington Northern Santa Fe railroad on the Wisconsin side of the Mississippi River make up the general east and west boundaries of the Pool 4 planning area. Public lands in the upper section of Pool 4 include the Wisconsin Department of Natural Resources' Pierce County Islands Wildlife Management Area and the Minnesota Department of Natural Resources' Frontenac State Park. (Environmental Pool Plans Mississippi River Pools 1-10, 2004)

Upper Pool 4, Lake Pepin, and Lower Pool 4 referenced later in this document refer to the areas outlined in Figure 3. "In 2012, the summary statistics for Pool 4 were adjusted from representing the pool as an upper and lower half, divided in the middle of Lake Pepin, to reflecting the data and pool by its three geomorphic reaches (Theiling, et al., 2000)." (USGS, Vegetation Methods, 2013)

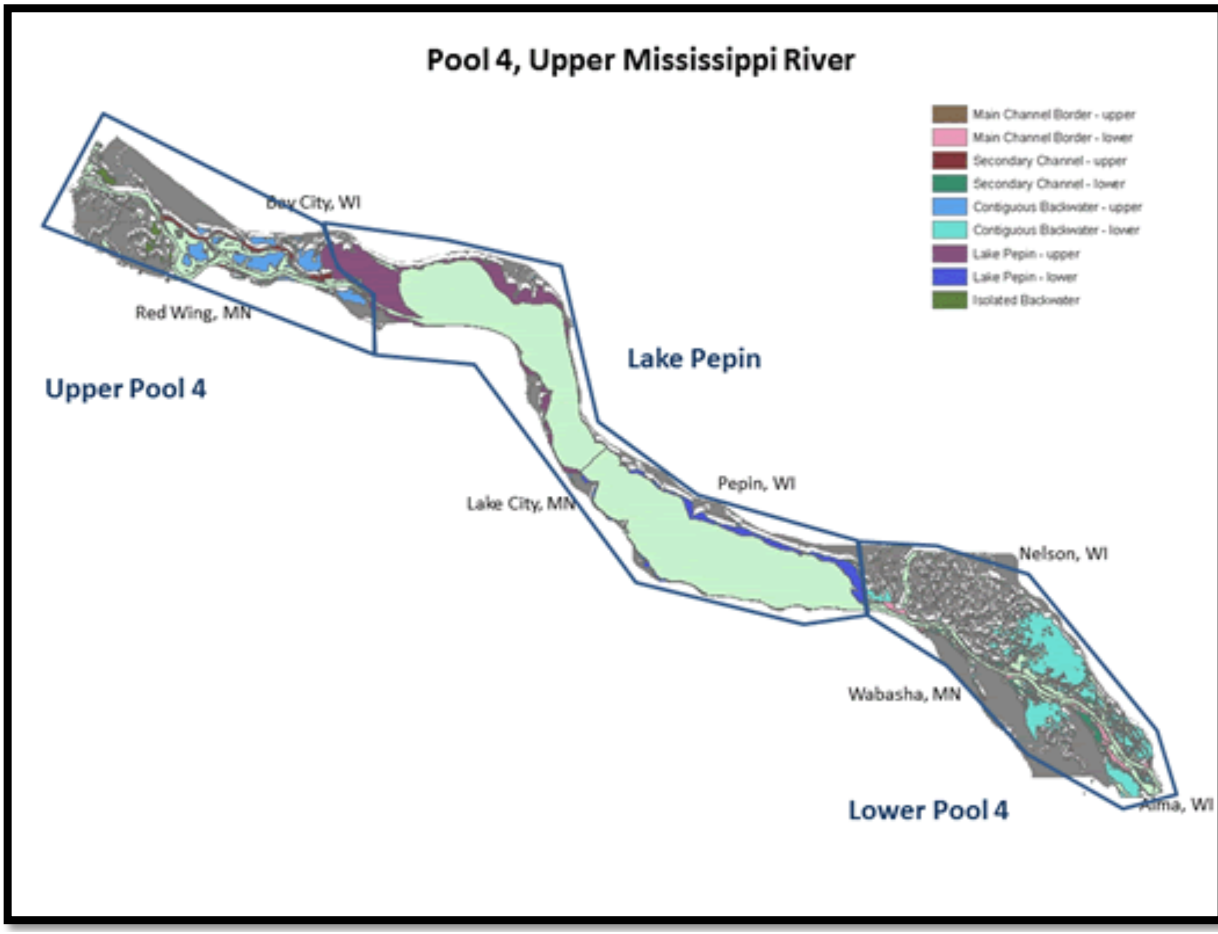

Figure 3 Pool 4 (USGS, Vegetation Methods, 2013)

2.11 PIERCE COUNTY ISLANDS

The Pierce County Islands/Head of Pepin Backwater Complex is located in Upper Pool 4 of the UMR. The 6,500 acre Pierce County Islands/Head of Pepin Backwater Complex extends from RM 784 – 792 along the left descending bank (Wisconsin Side) of the main channel to the south and the Wisconsin mainland to the north. This large area includes backwater lakes, sloughs, flowing channels, and islands.

The entire area is in Pierce County, Wisconsin. The closest community to the area is Bay City, Wisconsin, located adjacent to the backwater area.

According to the Wisconsin Department of Natural Resources,

> Pre-impoundment, the Pierce County Islands/Head of Pepin Backwater Complex was a mixture of bottomland forest, permanent and seasonal lakes and forested wetlands, wet meadow and sloughs that conveyed flow seasonally. Impoundment did not greatly affect backwater and off channel areas within the Pierce County Islands/Head of Pepin Backwater Complex. This was due to buffering by Lake Pepin and distance from Lock and Dam 4, over 30 miles downstream. A portion of the Pierce County Islands/Head of Pepin Backwater Complex (Wildlife Refuge Subunit) is designated as a "no-entry waterfowl refuge" from September 1 to December 31. All waterfowl hunting is prohibited during this time, but the area can be opened earlier to other public uses as posted by the Department. For the last several years, the refuge has been posted to allow public access after Nov. 15 to allow trapping (in an attempt to reduce damage to the old dikes) and deer hunting. (DNR, 2010)
>
> Water depths are variable throughout the area with deepest depths associated with the main channel of the Mississippi River and a larger secondary channel called the Wisconsin channel. Backwater depths are generally shallow and turbid due to long term effects of sedimentation. Most of the backwater areas that have adequate depth to provide over winter fish habitat also have flow that makes it unsuitable for over wintering centrarchids. (DNR, 2010)

2.2 WATER RESOURCES

2.21 UPPER MISSISSIPPI RIVER

Jon Hendrickson, Hydraulic Engineer, U.S. Army Corps of Engineers, St. Paul District, provided the following description:

> Inflows of sediment and nutrients to Lake Pepin depend on hydrologic conditions at Lock and Dam (LD) 3. Early summer (June) discharges at LD 3, approximately 4 miles upstream of Upper Lake Pepin, generally range from 10,000 to 35,000 cubic feet per second (cfs). By late summer, discharges usually decrease to 5,000 to 20,000 cfs. Winter low flows are generally in the range of 5,000 to 15,000 cfs.
>
> Water levels in Lake Pepin depend on hydrologic conditions in lower pool 4 which can be strongly influence by conditions on the Chippewa River. Table 1 contains water surface elevation versus discharge information for flow events at LD 4 ranging from low flow (Q = 16,950 cfs) to the 1 – percent chance flood (Q = 231,000 cfs). The water surface elevations at LD 4, Wabasha, and Upper Lake Pepin are shown in columns 6 through 8.

Table 1. Stage – Discharge data in Lower Pool 4 for river discharges ranging from low to high flow.

					Water Surface Elevation (MSL 1912 ADJ) corresponding to discharge at LD 4.		
Discharge (Q) at LD 4 (cfs)	Discharge (Q) at LD 3(cfs)	Duration (Percent of Time Exceeded Annually) [1]	Frequency (Annual Chance Flood) [2]	Description of Flow Condition	L/D 4 HW gage, RM 752.8 [3]	Wabasha gage, RM 760.5[3]	Lake City[3]
16,950	9,500	75		Low flow	666.95	667.00	667.45
43,800	28,000	25		Moderate flow	666.50	668.50	669.80
81,130	53,000	5		Bankfull Events	666.50	671.02	673.40
83,000	58,000		50		666.50	671.13	673.55
121,500	90,000		20		668.68	672.96	675.98
231,000	192,500		1	Large flood	674.55	677.74	681.04

[1] Annual discharge duration information is based on 1970 – 2010 discharge data at Lock and Dam 4.
[2] Discharge – frequency data is based on the 2004 Flow Frequency Study.
[3] Lock and Dam 4 operating curves.

Pool 4 is regulated with a mid-pool control point (located at Wabasha, Minnesota), which is typical for navigation pools in the St. Paul District. When river discharges are greater than 89,000 cfs, the gates are removed from the water at Lock and Dam 4 and the pool is unregulated. When discharges are between 27,000 and 89,000 cfs the pool is in "secondary control," i.e. a pool elevation of 666.5 feet (Note that all elevations given are NGVD 1912) is maintained at the dam. The water surface elevation at points upstream of the dam rises and falls with river discharge and the range of fluctuation is greater the father upstream from the dam one progresses.

When river discharges decline to 27,000 cfs, regulation of the pool shifts to "primary control," whereby a water surface elevation of 667.0 is maintained at the control point at river mile 760.5 at Wabasha, MN. As discharges decline below 27,000 cfs, the water surface elevation at Lock and Dam 4 gradually increases from 666.5 to 667.0 feet.

The current allowable drawdown at Lock and Dam 4 between project pool elevation 667.0 feet and the secondary control elevation of 666.5 feet is 0.5 feet. When the dam first went into operation in 1937, the allowable drawdown was 4.0 feet to elevation 663.0 ft. In 1945, the allowable drawdown was reduced to 2.5 feet and was reduced again to 1.5 feet in 1960. The current allowable drawdown of 0.5 feet was set in 1972. (Hendrickson, Hydraulic Engineer, 2014)

Figure 4 displays the maximum discharges at Lock and Dam 4 for flood years between 1965 and 2014, from an assessment of the 2014 flood and sediment transport in Pools 4 through 6 of the Upper Mississippi River. (Hendrickson & Lien, Assessment of the 2014 Flood and Sediment Transport in Pools 4 through 6, Upper Mississippi River, 2014)

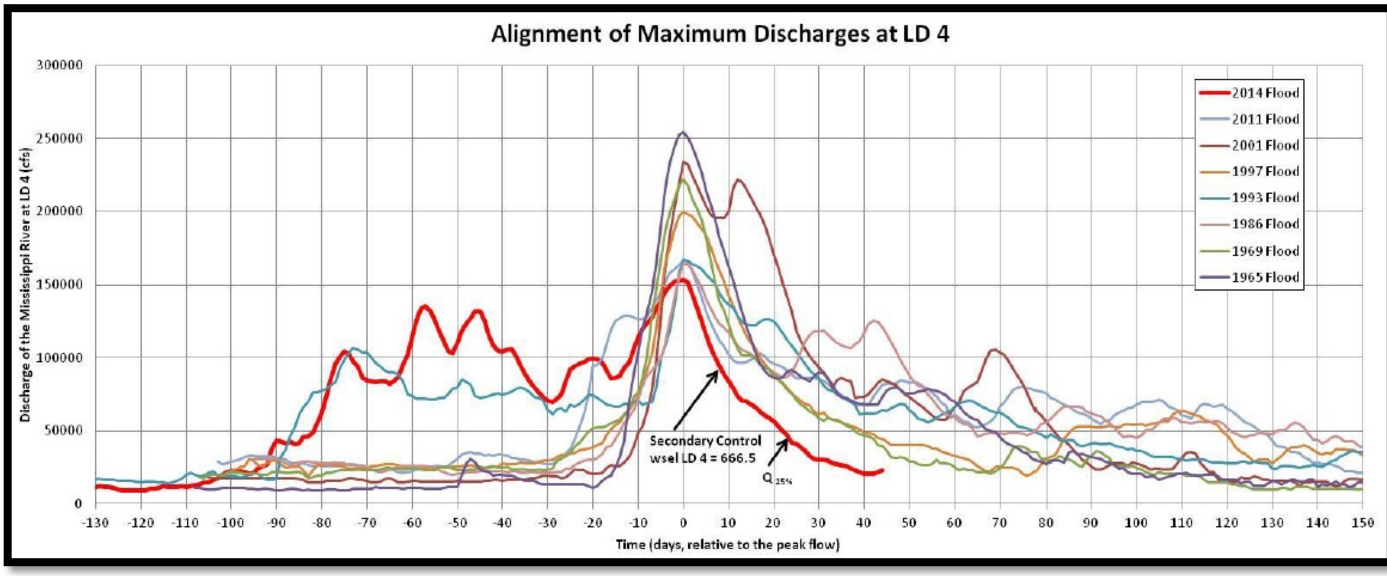

Figure 4 Alignment of Maximum Discharges at LD 4 (Hendrickson & Lien, Assessment of the 2014 Flood and Sediment Transport in Pools 4 through 6, Upper Mississippi River, 2014)

2.22 TRIBUTARIES

The South Metro Mississippi watershed, including Lake Pepin, is about 48,634 square miles and encompasses nearly half of the state of Minnesota and portions of Wisconsin. Tributaries to Pool 4 include the Cannon and Vermillion Rivers on the Minnesota side and the much larger Chippewa River on the Wisconsin side. The Cannon River is the largest tributary to enter the Mississippi River within upper sections of Pool 4. The Cannon River watershed includes about 941,000 acres of primarily agricultural landscape covering portions of eight counties in south-east and south-central Minnesota. (MPCA, South Metro Mississippi River Total Suspended Solids Total Maximum Daily Load, 2014) Although the Minnesota River enters the Mississippi River further upstream in Pool 2, its high sediment load increases sediment concentrations in the project area, which is one of the factors limiting aquatic vegetation growth and aquatic habitat.

The Wisconsin Channel is a major secondary channel in Upper Pool 4 branching off the descending navigation channel to the left at about river mile 793.3. This channel roughly parallels the navigation channel all the way to the head of Lake Pepin. The Wisconsin Channel conveys about 28 percent of the total river flow under average flow conditions (U.S. Army Corps of Engineers, 2001). The Chippewa

River, which enters the Mississippi River at the lower end of Lake Pepin, influences much of the floodplain features and water quality characteristics in the backwaters on the Wisconsin side of the main channel in lower Pool 4. The Rush River and Buffalo River in Wisconsin and several small creeks also contribute flow to the pool. (Environmental Pool Plans Mississippi River Pools 1-10, 2004)

2.23 GROUNDWATER

Large quantities of groundwater are present in terraces along the river's floodplain. Groundwater can have an effect on habitat at small spatial scales. Springs and seeps can provide warmer water during winter for overwintering fish, and cooler water during summer at specific sites. However, groundwater impact at the project scale is extremely small compared to surface water impacts.

2.24 PROJECT AREA

The project area extends from the Pierce County Islands to the upper most sections of Lake Pepin. Backwaters within the project area include Mud Lake, Dead Slough, and Goose Lake. Larger open water areas more connected to Lake Pepin include Bay City Flats and Wacouta Bay. The Wisconsin Channel is the primary side channel.

2.25 HYDRAULIC AND SEDIMENT TRANSPORT CONDITIONS IN THE PROJECT AREA

Lake Pepin serves as a depositional basin where sediments from the South Metro Mississippi River watershed have accumulated over many centuries. Sediment dating techniques show that sediment accumulation rates have increased by about a factor of 10 since European settlement. An estimated eighty percent of the sediment load is from the Minnesota River and several small Mississippi River tributaries. (Schottler, Engstrom, & Blumentritt, 2010)

From the 1930s to 1960s, the amount of sediment flowing into the South Metro Mississippi and Lake Pepin more than doubled, from 300,000 to 700,000 metric tons per year, as measured by sediment cores in Lake Pepin (Engstrom, Almendinger, & Wolin, 2009). This rapid sedimentation rate has stabilized in recent decades. Settling out of sediment from the Minnesota River that has entered the UMR begins to occur just above Spring Lake and Lock and Dam 2, around River Mile 820. The St. Croix River enters the Mississippi River at River Mile 811.3 providing significant dilution, which results in lower total suspended solids (TSS) load. The long-term TSS concentration at the mouth of the Cannon River, entering the Mississippi at River Mile 795 just above Lake Pepin, is 70 mg/L. Further settling out of sediment occurs as the river enters Lake Pepin at River Mile 786.2. The long-term average for TSS at this monitoring station is 46mg/L. Just five miles downstream, at River Mile 781.2, the long term average TSS is about half of this value, at 23.8. At Lock and Dam 4, downstream of Lake Pepin, annual average TSS loads are averaging just 8.2 mg/L TSS. These averages are based on Long-Term Resource Monitoring Program data collected at fixed stations between 1993 and 2008. (MPCA, 2010)

The project area can be best described hydraulically at its upper end as a series of channels entering a large, open water expanse. Flow velocity decreases as channels enter Lake Pepin, causing sediment to accumulate. Wind wave action stirs these flocculent sediments and creates highly turbid conditions that prevent the establishment of aquatic vegetation. Over time, open water areas fill with sediment, bathymetric diversity decreases, and deep open water habitats are lost. Figure 5 displays the 1992 bathymetry image for Pool 4. More recent data is needed.

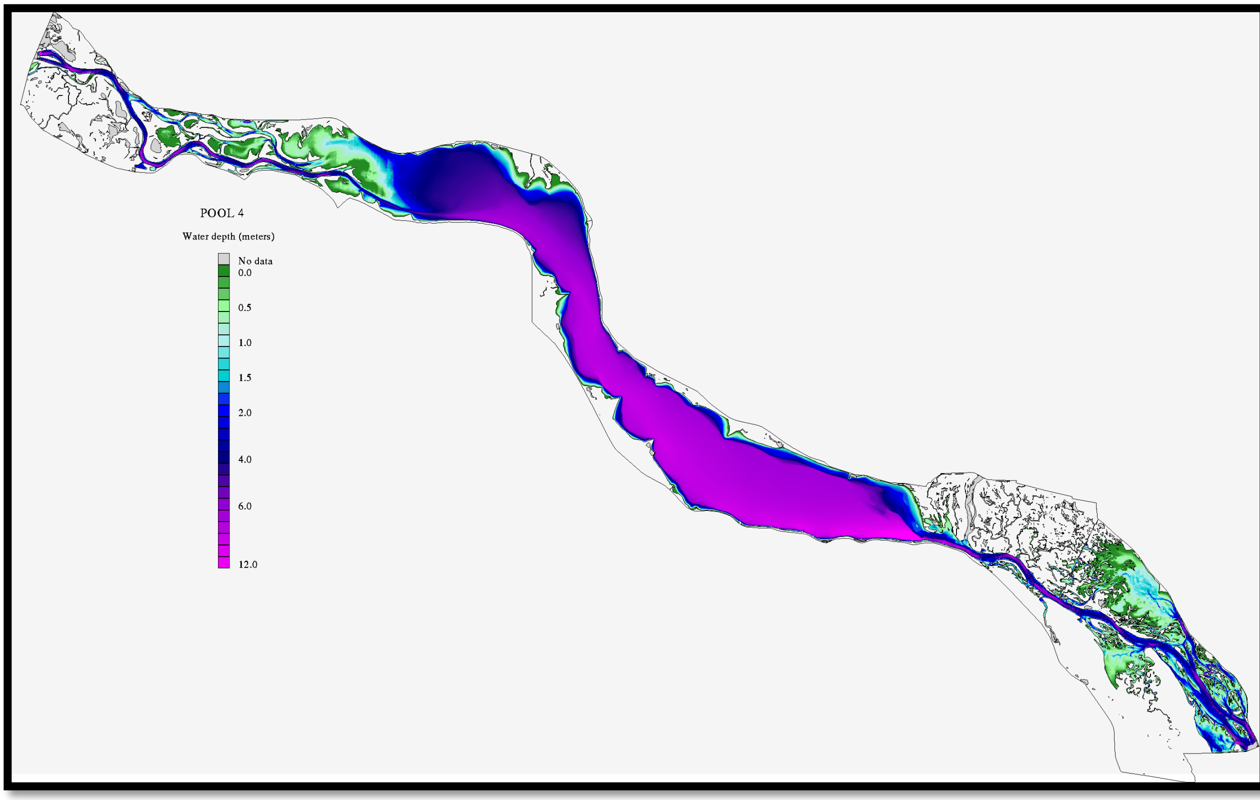

Figure 5 (USGS, United States Geology Survey Midwest Environmental Sciences Center, 2010)

The U.S. Army Corps of Engineers, St. Paul District is responsible for maintaining 243.6 miles of navigation channel on the Mississippi River from Minneapolis at river mile 857.6 to Gutenberg, Iowa, at river mile 614. Of the 35 million cubic yards of material that was dredged from 167 sites in the UMR between 1970 and 2011, Pool 4 accounts for 10.6 million cubic yards, or thirty percent of the total volume, and just 10 sites. Although sediment deposition is a significant problem at the head of Lake Pepin, the Corps doesn't have to dredge that much sand size sediment in this reach of the river. A summary of dredging events in the UMR by Pool is shown in Table 2. (Summary of Dredging Locations - St. Paul District 1970 to 2011, 2012)

Table 2. Record of Main Channel Dredging Events 1970-2011

Record of Main Channel Dredging Events 1970-2011 U.S. Army Corps of Engineers, St. Paul District

Pool	Total *Volume Dredged 1970-2011	Average Volume/Year	Number of Sites
1	1,491,111	35,503	8
2	5,252,267	249,714	13
3	1,609,996	38,333	8
4	10,652,711	253,636	10
5	6,310,724	150,255	13
6	857,793	40,848	7
7	2,210,053	52,620	7
8	3,198,722	76,160	12
9	2,451,281	58,365	7
10	1,439,997	34,286	7
Total (includes authorized harbor dredging, lock & dam dredging, and miscellaneous dredging)	34,719,544	913,672	167
***Volume is in cubic yards.**			

(Record of Dredging Events (May 2012), 2014)

2.3 GEOLOGY AND SOIL/SUBSTRATE

The following Geology and Soil/Substrate description was adjusted from the North and Sturgeon Lakes Habitat Rehabilitation and Enhancement Project Draft Problem Appraisal Report, as much of it holds true for Upper Pool 4.

> The most significant geologic event explaining the nature of the Mississippi River within Pool 4 occurred as the Pleistocene glaciation, approximately 10,000 years ago, came to a conclusion. During this time, tremendous volumes of glacial meltwater, primary from the Red River Valley's glacial Lake Agassiz, eroded the pre-glacial Minnesota and Mississippi River valleys. Glacial Lake Duluth also provided a significant amount of meltwater, carving out the St. Croix River that joins the Mississippi River upstream of the project area. As meltwaters diminished, the deeply eroded river valleys aggraded substantially to about the present levels. Prior to construction of the Lock and Dams and impoundment, the broad flood plain of the river contained depressions, sloughs, natural levees, islands, and shallow lakes.

> The bluffs of the Upper Mississippi valley along Pool 3 and Upper Pool 4 consist of exposed Lower Paleozoic sedimentary rocks, dominantly carbonates (limestone and dolomite) and sandstones, overlain by unconsolidated materials of Quaternary (Upper Cenozoic) age loess of the earlier glacial advances. Pool 3 and Upper Pool 4 are at the northwest boundary of the Driftless Area that was not covered by the Wisconsin age advances of ice sheet. Prairie Island on the Minnesota bank is a fluvial terrace that has been cut from the valley wall by the Vermillion River to form an island.
>
> In the reach from Red Wing, MN south to Alma, WI, the rock formations exposed in the bluffs are the Upper Cambrian sandstones from Jordan (Upper Cambrian). Overlying the Jordan Sandstone, with an unconformable contact, is the Lower Ordovician Prairie due Chien Formation.
>
> The principal parent materials of soils in the Pool 3 and Upper Pool 4 drainage basin are loess, and alluvium glacial drift. The loess lay either over bedrock or over clay loam till which is the major historic parent material of Pool 3 and Upper Pool 4 and associated uplands. The slopes associated with these soil types make them very susceptible to erosion in upland areas, where cover of plants is sparse or where inadequate soil conservation practices are used. The sediment load carried into Pool 3 and Upper Pool 4 by the Mississippi River accumulates in backwater areas and in the navigation channel. This project area is part of the prograding delta that continue to form at the head of Lake Pepin. (North and Sturgeon Lakes Habitat Rehabilitation and Enhancement Project, 2013)

Lake Pepin has many characteristics of an inland lake, including a fairly regular shoreline with few backwater bays and shoal water substrates comprised of sand, gravel, and rock. Much of the rock substrate is artificial bank protection where the railroad tracks border the lake. Deeper portions of the lake have predominantly silt substrates. Sedimentation has covered the pre-settlement lake bed in Lake Pepin except in the lower most area that retains significant areas of gravel substrates. Wind driven wave action in the lake maintains a breach zone of cobbled sized rock and coarse sand. Much of the beach zone is covered with shells of zebra mussels. (Environmental Pool Plans Mississippi River Pools 1-10, 2004)

Steingraeber et al (1994) found PCBs in mayflies from the Mississippi River between Minneapolis, Minnesota and St. Louis Missouri to be highest in Pool 2, followed by Pools 3 and 4 (Lake Pepin). Between Minneapolis, Minnesota and Dubuque, Iowa, Sullivan (1995) found similar results in surficial sediments, but found Lake Pepin to contain the greatest concentrations. Sullivan (1995) did not find a consistent change in PBCs in suspended sediments from 1987 to 1994, indicating the PCBs enrichment of the upper pools is continuing from direct or diffuse inputs.

Organochlorines, like DDR, dieldrin, and endrin, were found in surface sediments by Hinkro and Moody (1997) and Rostad et al. (1997) at higher levels in the upper pools, than below Lake Pepin. Pereira et al. (1995) found many of the presently used pesticides and herbicides in modern agricultural practices in water from the Minnesota River, with similar water concentrations in Pools 2, 3, and 4. Upstream, the St. Croix River has lower levels. Levels of pesticides and other chlorinated hydrocarbons are generally below detection limits in all main channel sediments and detected at low levels in backwaters. (U.S. Army Corps of Engineers, 2001)

The Minnesota Pollution Control Agency (MPCA) established three Soil Reference Values (SRVs) for sediment contaminants to evaluate appropriate usage of dredged sediment (Stollenwerk et al., 2014):

- "Level 1 Dredged Material is suitable for use or reuse on properties with a residential or recreational use category.
- Level 2 Dredged Material is suitable for use or reuse on properties with an industrial use category.
- Level 3 Dredged Material is not suitable for use or reuse."

Based on (ACOE, 2010) Lake Pepin data, non-negligible amounts of arsenic and mercury were identified in various sediment samples in 1987 or 1988. Six Lake Pepin sample sites around Bay City, Wisconsin were listed as potentially having mercury amounts exceeding Level 1. Two Lake Pepin – Bay City sediment samples contained arsenic in excess of level 1 values and three other Lake Pepin – Bay City samples contained arsenic in excess of level 2 values. Given that these samples were from 1987 or 1988, more recent data are essential; however, (ACOE, 2010) data are largely missing updated sediment samples for numerous contaminants. Therefore, a need to acquire and test updated samples may be necessary.

2.4 WATER QUALITY

The location of Lake Pepin divides the rest of the pool into Upper Pool 4 and Lower Pool 4. The smaller backwaters of Upper Pool 4 have been degraded by sedimentation and high turbidity, resulting in limited aquatic vegetation. In contrast, the larger backwaters of lower Pool 4 have less turbidity and better conditions for supporting aquatic vegetation, which is often abundant. Transparencies in the main channel above Lake Pepin during summer average 19 inches, while below Lake Pepin transparency averages 38 inches (LTRMP, Pool 4 Water Quality - Transparencies, 2014).

The high sediment and nutrient loads from the Minnesota River greatly influence light penetration, primary production, and the growth of aquatic vegetation in Pool 4. The general water chemistry of Upper Pool 4 is considered adequate to maintain most aquatic life. Because of the nutrient enrichment and longer hydraulic retention times, Lake Pepin has algal blooms that can cause significant temporal swings in dissolved oxygen, particularly in isolated sloughs and backwater lakes. Otherwise, the dissolved oxygen content of the water remains high year round and above levels required to sustain a quality fishery. Because of its turbulent nature and large flow, the river is well aerated and it can assimilate a considerable biochemical oxygen demand (BOD) loading. (U.S. Army Corps of Engineers, 2001)

Physical and chemical water quality parameters are monitored monthly throughout the year at 24 fixed sites on Pools 4, 5, and 5a, including sites on five tributaries, four sites on Lake Pepin, and sites at the inflows to and outflows from Lake Pepin and Weaver Bottoms. Water quality parameters on Pool 4 are monitored quarterly at 135 random sites stratified by habitat type. Table 3 is a comparison of the 2013 water quality conditions to normal conditions in Pool 4. Data from the Long Term Resource Monitoring Program was acquired over a 15-year period (1994-2009; data missing in 2003) and was used to determine annual 95% upper confidence limits (UCL) and lower confidence limits (LCL) of the mean for each variable/reach/episode/stratum. Estimates of the 95% upper and lower confidence limit for the year of interest, along with the median, were compared to the 15-yr annual extremes to determine unusual conditions. Estimates where the median was higher than the highest annual 15-yr UCL or lower than the lowest annual 15-yr LCL were "low" or "high," respectively. Estimates where the LCL was higher than the highest annual 15-yr UCL or the UCL was lower than the lowest annual 15-yr LCL were "very low" or "very high," respectively.

Table 3. Long Term Resource Monitoring Program Water Quality Data

Comparison of 2013 Water Quality Conditions to Normal Conditions															
Reach	Season	Stratum	TEMP	DO	COND	pH	TURB	SS	VSS	CHL	TN	NOX	NHX	TP	SRP
Pool 4	Winter	Pool	H											L	L
		MC													
		SC												l	
		BWC													
		LP	H											L	l
	Spring	Pool													
		MC													
		SC					l	l							
		BWC													
		LP													
	Summer	Pool						l							
		MC													
		SC					l	l							
		BWC					l	l	l						
		LP													
	Fall	Pool	L				l	l							
		MC	L	h			l	l						l	
		SC	L				l	l						l	
		BWC								l					
		LP	L												

Source: (LTRMP, Comparison of 2013 Water Quality Conditions to Normal Conditions, 2013) KEY: l – Very Low, L - Low, "." - Normal, h – High, H - Very High; Acronyms: MC – main channel, SC – side channel, BWC – contiguous backwater, LP – Lake Pepin, TEMP – temperature, DO – dissolved oxygen, COND – conductivity, TURB – turbidity, SS – suspended solids, VSS – volatile suspended solids, CHL – chlorophyll *a*, TN – total nitrogen, NOX – nitrate/nitrite, NHX – ammonium, TP – total phosphorus, SRP – soluble reactive phosphorus.

2.5 VEGETATION

The U.S. Army Corps of Engineers' UMRR – LTRM element, which is implemented by the USGS, has monitored vegetation abundance in portions of Lake Pepin since 1998. In Upper Lake Pepin, percent frequency of occurrence of submerged vegetation declined from 1998 to 2001. From 2001 to 2010, percent occurrence has varied annually, but has shown an increasing trend. In 2012, percent occurrence declined and was closer to late 1990 levels. The highest frequency of occurrence for both Upper and Lower Lake Pepin occurred in 2011 (Weiss, 2014). Figure 6 provides the percent frequency of submersed aquatic vegetation in the South metro TMDL section of the Mississippi River from 2006 to 2014.

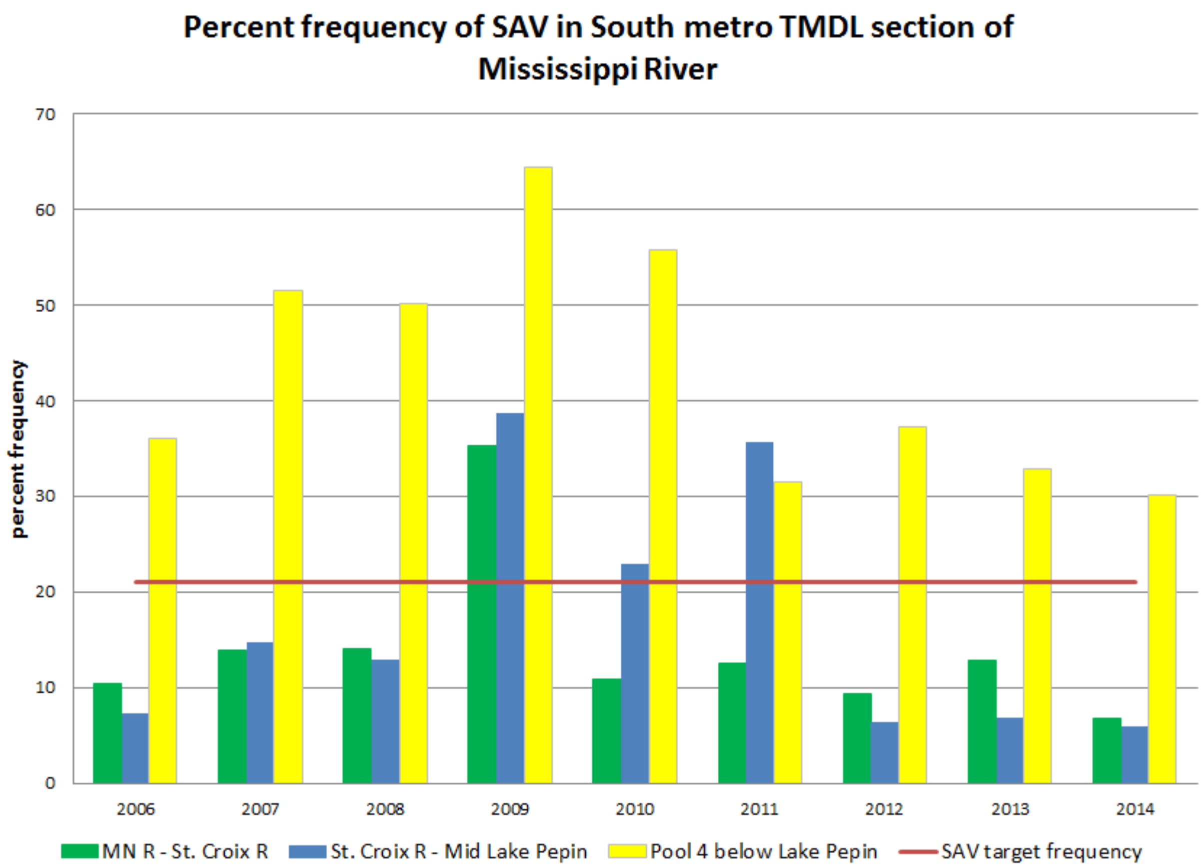

Figure 6 Percent Frequency of Submersed Aquatic Vegetation (Moore, 2014)

Submerged aquatic macrophytes are not abundant in Lake Pepin. Less than 1% of surface acres of Lake Pepin contained submerged, floating leaf, or emergent aquatic vegetation in 2006 or 2007 (Management Files). The LTRMP has conducted annual monitoring of vegetation in Lake Pepin and Pool 4 backwaters using either vegetation transects or stratified random sampling since 1991 (Rogers & Owens, 1995). They have also found submerged aquatic vegetation to be scarce in and above Lake Pepin and along the main and secondary channels; however, since 2004, LTRMP biologists have documented increasing trends of percent frequency of occurrence of submersed floating-leaf, and emergent vegetation in Upper and Lower Pool 4. Pool wide, 21 submergent, 3 floating lead, and 34 emergent species have been identified. The most common submergent species include sago pondweed (potamogeton pectinatus), wild celery (vallisneria americana), curlyleaf pondweed (P. crispus), and coon's tail (ceratophyllum demersum) (Yin, et al., 2008). (MNDNR, 2014)

Figure 7 shows the sites where submersed aquatic vegetation was found in the Mississippi River from the confluence of the St. Croix River to mid Lake Pepin.

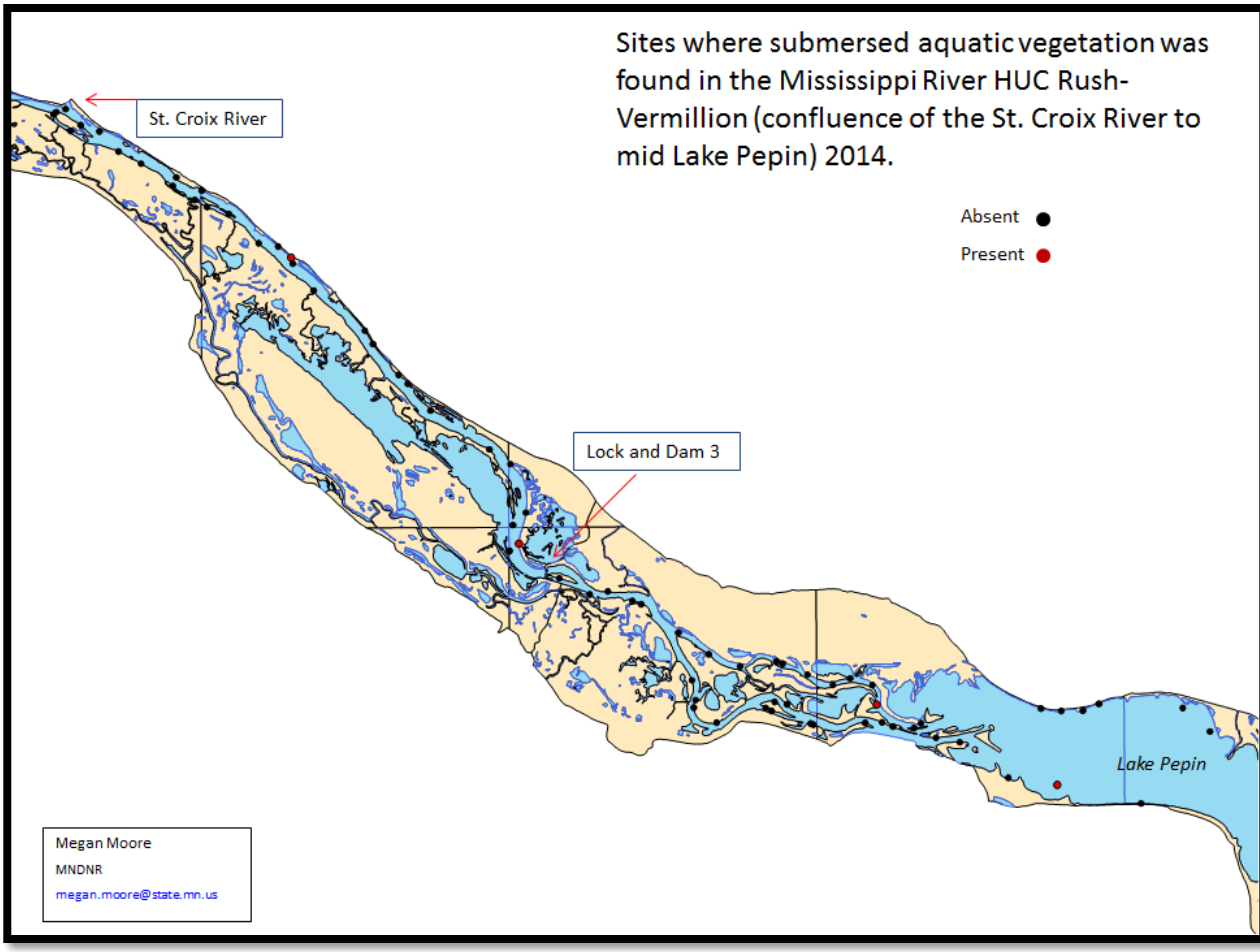

Figure 7 Submersed Aquatic Vegetation Sites (Moore, 2014)

The Environmental Protection Agency (EPA) site specific target of 21 percent average submersed aquatic vegetation frequency of occurrence is based on the EPA's Environmental Mapping and Assessment Program (EMAP) sampling design for main channel and side channel borders. A roughly equivalent target for main channel borders of about 12 percent frequency is based on the LTRMP sampling design. These submersed aquatic vegetation targets are roughly two times existing conditions based on long-term historical estimates (1976-2008) from TSS-derived submersed aquatic vegetation frequencies.

Submersed aquatic vegetation in the Mississippi River is subjected to variable light conditions throughout any growing season or series of growing seasons. Monitoring data show that submersed aquatic vegetation can withstand limited durations of high turbidity, but that prolonged turbid conditions, especially over two or more consecutive years, can impair growth and survival (Sullivan, Langrehr, Giblin, Moore, & Yin, 2009). The LTRMP program samples secchi depths in 2010 were the highest recorded since sampling began in 2003. The maximum secchi depth (3.1 meters) coincided closely with the maximum depth at which aquatic vegetation was observed. Figure 6 displays the summer mean total suspended solid concentration as it related to percent frequency of submersed aquatic vegetation, sampled at rive mile 786.2 in Upper Pool 4.

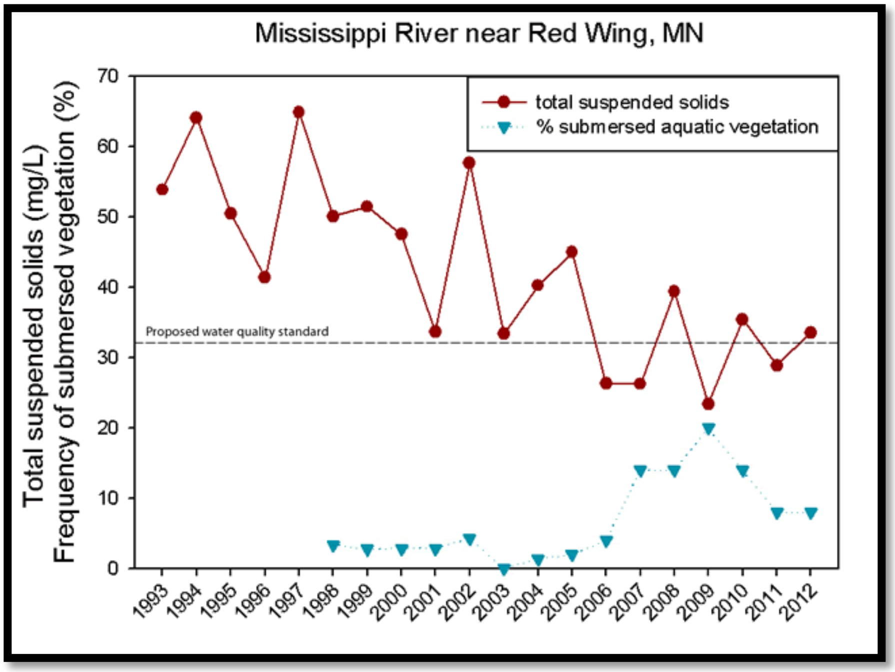

Figure 8 (LTRMP, Summer Mean Total Suspended Solid Concentrations and Percent Frequency of Submersed Aquatic Vegetation, Upper Pool 4, 2013) Collected bi-weekly at River Mile 786.2 - sampled in main and side channels of Upper Pool 4

Very little rooted floating leaf (RFV) and emergent (EM) vegetation change occurred in upper and lower Pool 4 since 2011. However, from the highest frequencies in 2009, RFV declined 10.4% in Lower Pool 4. RFV and EM remained absent in Lake Pepin and EM declined 10.4% in Upper Pool 4 since 2010. All strata in Pool 4 decreased with the exception of lower pool main and secondary channels which increased slightly (6% and 7%, respectively). The largest decreases of submersed aquatic vegetation in Pool 4 were in upper pool backwaters (32% decline) and Upper Lake Pepin (21% decline). Frequency of coontail declined by over 10% in Pool 4 (12.3%). Frequencies of Eurasian milfoil and wild celery remained stable. Sago pondweed decreased by over 10% in Upper pool 4 (13.2%) and Lake Pepin (10.1%), but remained stable in lower Pool 4. American lotus and broadleaf arrowhead remained at low but stable PFO in lower Pool 4, while no American lotus was recorded in Upper Pool 4 or Lake Pepin. (LTRMP, Pool 4 Vegetation - Percent Frequency of Occurence, 2013)

Invasive aquatic plants found in Lake Pepin include curly-leaf pondweed, Eurasian watermilfoil, and purple loosestrife (Weiss, 2014). The prevalent vegetation type found in the river floodplain is mixed lowland hardwoods, including elms, willows, silver maple, and cottonwood. In the backwater areas, beds of emergent aquatic vegetation such as arrowhead and river bulrush border the side channels and sloughs. Beds of water lilies can be found in some of the backwater areas, as can lotus beds.

2.6 HABITAT

The pool represents a significant corridor of open space and habitat for both aquatic and terrestrial plants and animals. Above Lake Pepin, the river's channels and backwaters provide critical spawning areas for important port fish species, such as sauger and walleye, which use Lake Pepin most of the year. Habitat types present in Pool 4 include most of the classifications of (Wilcox, 1993). In general, Pool 4 has good, diverse habitat for both fish and wildlife.

2.61 AQUATIC HABITAT

According to the Wisconsin Department of Natural Resources,

> Island dissection and sedimentation have greatly reduced the quality of much of the aquatic habitat in the Pierce County Islands Wildlife Area. Historically, this area was used by migratory waterbirds, but the use has been low since 1990 when aquatic vegetation declined in the area. An increase in aquatic vegetation occurred during the mid-2000s due to favorable water clarity conditions and was followed by a corresponding increase in waterfowl use. However, the observed 2005 aquatic vegetation coverage is not expected to remain stable due to continue wind fetch, current and sediment inputs from upstream sources. (DNR, 2010)

According to Dan Dieterman, Fisheries Biologist, Minnesota Department of Natural Resources, “aquatic habitat conditions in Upper Pool 4 can be generally characterized as somewhat impaired. Relatively high suspended solid concentrations, originating mainly from fine sediment inputs via the Minnesota River and directly from the Cannon and Vermillion Rivers and re-suspension of those sediments by wave action from wind, large recreational boat wakes and fish activity, continue to limit light penetration and rooting capability of submersed vegetation. These conditions have had the greatest influence on aquatic habitat in the upper portion of Lake Pepin, Wacouta Bay, and the Bay City Flats. Contiguous backwater lakes and sloughs (Mud Lake, Dead Slough, and Swinger Slough) located between Red Wing and the head of Lake Pepin also exhibit conditions impaired by fine sediment deposition and re-suspension, although not quite to the extent as areas subjected to large waves from boat wakes and wind. Consequently, these areas have a better emergent vegetation component and greater diversity and frequency of occurrence of submersed vegetation.

Sediment deposition and deltaic activity throughout Upper Lake Pepin are rapidly converting shallow windswept aquatic habitat to sandbars and mudflats. These terrestrial habitats exhibit rapid development transitioning from colonizing species of annual moist soil species to perennial forbs and grasses to willows, cottonwoods and silver maples. The shallow (<3 feet) water, and changed substrate composition in these deltas has resulted in much improved distribution, density, and diversity of submersed aquatic vegetation in recent years compared to what existed during the past 30-40 years. Emergent vegetation loss appears to have diminished as newly formed islands also serve as a physical barrier to wind and wave action, adding some protection to existing and newly formed beds of submersed vegetation.” (Dieterman, 2014)

2.62 TERRESTRIAL HABITAT

Terrestrial habitats within the floodplain of Pool 4 include areas of forest, brush and shrub areas, wet and upland meadows, and areas disturbed by commercial or residential development and agricultural land. The floodplain around Pool 4 is low and is seasonally flooded. The dominant trees are mature native trees, including silver maple (Acer saccharinum), green ash (Fraxinum pennsylvanica), black willow

(Salix niger), and box elder (Acer negundo), with some mature cottonwood (Populus deltoides) along the riverbanks. Some hardwood trees including red oak, black walnut, and American elm also occur within the floodplain.

Ground cover over much of the area is mostly reed canary grass (Phalaris arundinacea) jewelweed (Impatiens capensis), wood nettle (Laportea Canadensis), poison ivy (Rhus radicans) and wild grape (Vitis sp.). Areas with open tree canopy have dense strands of reed canary grass. The floodplain forest is low to tall broadleaf deciduous forest, open to dense, with woody vines often present.

2.7 FISH AND WILDLIFE

2.71 FISH

The fishery of Pool 4 is considered quite productive. Game fish found in the pools include northern pike, walleye, sauger, yellow perch, white bass and a variety of centrarchids. Rough fish including carp, buffalo, catfish, and drum dominate the commercial catch. Pool 4, especially Lake Pepin, is one of the most productive pools in terms of pound of fish caught commercially. (U.S. Army Corps of Engineers, 2001)

Lake Pepin is annually sampled by the Minnesota DNR as part of the DNR's Large Lake Program. The Large Lake Monitoring Program was initiated in 1983 to provide long-term monitoring information of fish populations in Minnesota's nine largest lakes and Minnesota's portion of Lake Superior. Lake Pepin was added to the monitoring program in 1986. Sampling includes shoreline seining, bottom trawling, gill netting, and electrofishing. Since 1991, 89 species have been identified by the Lake City Long Term Resources Monitoring Program in Lake Pepin. (LTRMP, Large Lake Monitoring Program: Lake Pepin, 2014)

The following is a summary of the LTRMP's fish collection efforts conducted by the Lake City Field Station for Pool 4 of the Upper Mississippi River in 2013:

- 246 fish collections were conducted using six gear types.
- Side channel borders, backwaters, and main channel borders received the most sampling effort.
- 20,377 fish representing 62 species and 2 hybrids were collected. Historical fish distribution for the Upper Mississippi River (Pilto, Vooren, & Rasmussen, 1995) documents 99 fish species from Pool 4. To date the Lake City Field Station has collected a total of 88 species and 5 hybrids.
- The three fish species with the highest total catch were 5,152 emerald shiners, 3,386 bluegill, and 3,841 mimic shiners.
- Twenty-nine shovelnose sturgeons, four lake sturgeon, six black buffalo, and one blue sucker, all Minnesota species of special concern, were collected.

The fish community is monitored on Pool 4 through indices such as relative abundance and species richness, along with the size structure of all species, during three time periods in summer and fall at stratified random sites (LTRMP, Long Term Resource Monitoring Program: Aquatic Vegetation Yearly Summary, 2014). The Pool 4 fish community as a whole is comprised of species not sensitive to silt (80%

not particularly sensitive to silt – LTRMP Fish Life History Database (in review) – 67% intermediate, 12% tolerant and 21% intolerant) (Weiss, 2014). Invasive Species found in Lake Pepin include bighead carp (one found in 2003 – 23 pounds near southern end of the lake) and grass carp (one found in 2007 – 39.4 inches, 28.7 pounds upstream of Wells Creek) (Weiss, 2014).

Direct effects of turbidity and sedimentation on fishes include: loss of benthic interstitial spaces for incubation, decreased water clarity for visual feeding species, habitat homogenization, physiological damage (e.g. gills, energy conversion, and stress), increased mortality, and altered distribution. Indirect effects include: reduced recruitment rates, loss of structure (e.g. aquatic macrophytes), altered predator/prey ratios, reduced diversity, and skewed community structure – toward tolerant species. (Ickles, 2003)

Centrarchid overwintering habitat for backwater fish (bluegill, largemouth bass, crappie, etc.) has declined in Upper Pool 4 due to sedimentation and island dissection. Historically, centrarchid overwintering habitat was present in numerous locations including Dead Slough Lake, Mud Lake, Goose Lake, Wacouta Bay, and Bay City Area. Presently, Goose Lake provides the most consistent overwintering habitat with some overwintering habitat located near the Bay City boat harbor.

2.72 WILDLIFE

A variety of mammals and birds inhabit the floodplain forests and wetlands that remain adjacent to Pool 4. These wooded and wetland areas support species including: rodents such as muskrat, beaver, mice, and common rats; moles and shrews, rabbits, red fox, skunks, and raccoons. Pool 4 is also within the Mississippi Flyway, thus available habitat is important for migrating birds. The reach contains important nesting habitat for many species of waterfowl. (U.S. Army Corps of Engineers, 2001)

2.73 AQUATIC INVERTEBRATES

Conditions for invertebrate fauna generally improve as one goes downstream from the urban, metropolitan areas of the river. Recently, the Higgins' Eye Pearly Mussel (Lampsilis higginsi), a federally listed endangered species, was found within the proposed construction site for the replacement of a bridge at Prescott, Wisconsin. Pool 4, including Lake Pepin, has known historically almost the entire mussel fauna of the Upper Mississippi River. In 1999, a rich mussel bed was found below lock and dam 3, with 27 species found in the survey. (LTRMP, Pool 4 Macroinvertebrates Annual Update, 1999) Lake Pepin also has a good mussel fauna.

Figure 9 shows the mussel species distribution in Lake Pepin from 2003 to 2011, with the most diverse sites having 14-19 species per site.

Lake Pepin
Mussel Speices Distribution

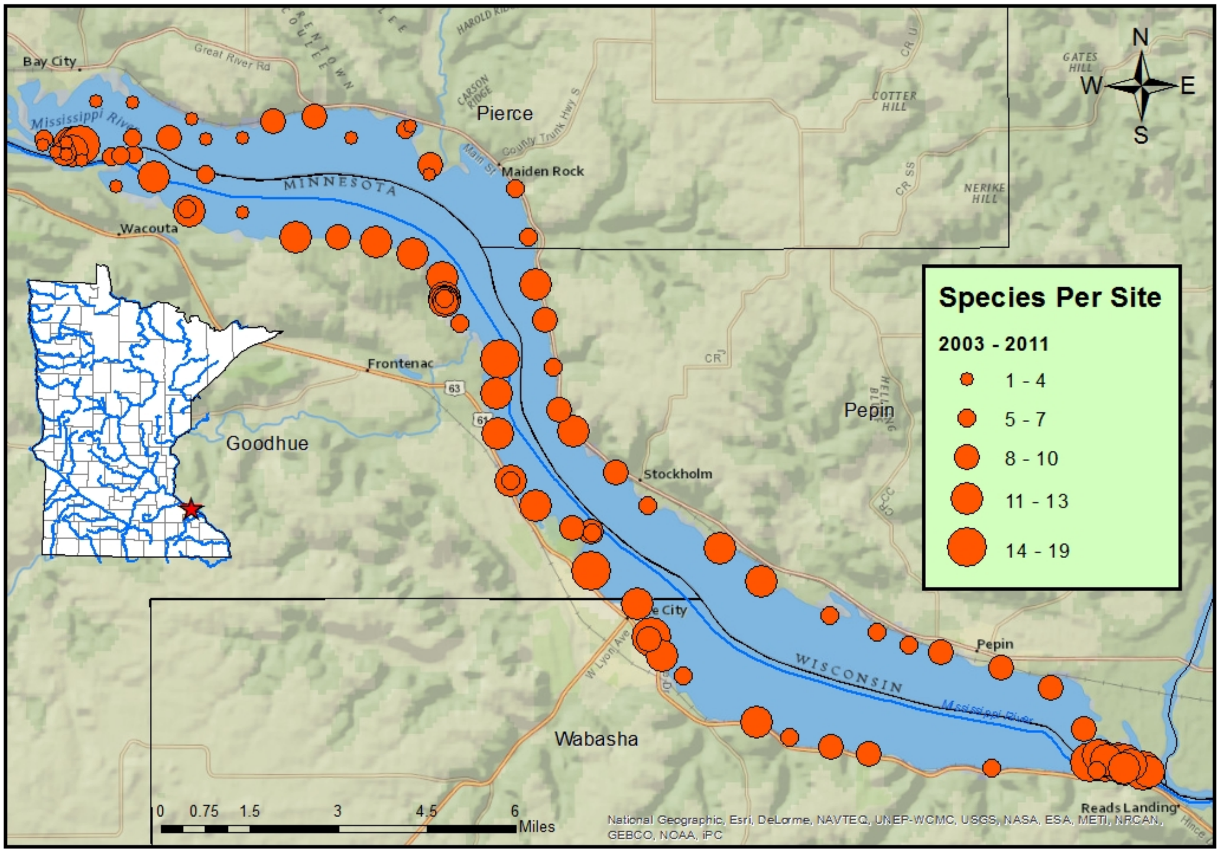

Figure 9 Lake Pepin Mussel Species Distribution (Davis, 2011)

From 1993 to 2004, mayflies, fingernail clams, midges, and zebra mussels were monitored on Pool 4 as part of the Long Term Resource Monitoring Program. After the 2004 sampling season the program was discontinued and additional sampling has not been done by LTRMP.

Invasive aquatic invertebrates include zooplankton: Daphnia lumholtzi and zebra mussels (Weiss, 2014).

2.74 THREATENED AND ENGANGERED SPECIES

According to the U.S. Army Corps of Engineers, St. Paul District Pool 3 and Upper Pool 4 Environmental Assessment:

> Pool 3 and Upper Pool 4 are within the occurrence area of a federally listed endangered species, the Higgins' eye pearly mussel (Lampsilis higginsi). Higgins' eye mussels were found in the Mississippi River near the mouth of the St. Croix at Prescott, Wisconsin. In some areas of the pools, the quality of the habitat for mussels is reduced by the heavy bedload and the frequent dredging required for maintaining the 9-foot navigation channel. The bald eagle, (Haliaeetus leucocephalus), a federally listed threatened species, also uses habitat within the project area.

There are at least two eagle overwintering roosts in the area, one between Red Wing and Wacouta. At Reads Landing, a high concentration of wintering eagles is present annually.

Seven plant species of special concern are found in this reach. All but one are listed by the states of Minnesota and Wisconsin as endangered. The Illinois tick-trefoil is listed as threatened in Minnesota. None of these species have Federal designation. (U.S. Army Corps of Engineers, 2001)

The tables below provides the protection status of plant species, aquatic species, and wildlife species found in Pool 3 and Upper Pool 4.

Table 4. Protected Plant Species of the Mississippi River Pool 3 and Upper Pool 4

Species	**Federal Status**	**Minnesota Status**	**Wisconsin Status**	**Site Occurrences by County**
Bladderpod	-	E	T	Goodhue/Pierce
Carolina Anemone	-	-	E	Pierce
Dotted Blazing Star	-	-	E	Pierce
Illinois Tick-Trefoil	-	T	-	Dakota
James' Polanisia	-	E	-	Dakota
Kitten-Tails	-	E	T	Dakota
Prairie Plum	-	-	E	Pierce

E = listed as endangered T = listed as threatened

The Assessment continues:

Nine species of fish, listed by Minnesota and/or Wisconsin as either endangered or threatened are found within pools 3 and/or 4. Most of these species are large river species preferring flowing water at least for some stage of their life cycle. The Higgins' eye pearly mussel has historicaly been recorded for this reach of river. Six mussel species, listed as endangered or threatened by Wisconsin and/or Minnesota were recently collected below lock and dam 3 (Yager, 1999). Several other State-listed fish and mussel species not listed in Table seven (below), such as ebony shell, have historically occurred in pools 3 and 4, but have not been recorded in revent surverys. (U.S. Army Corps of Engineers, 2001)

Table 5. Protected Aquatic Species of the Mississippi River Pool 3 and Upper Pool 4

Species – Mussels and Fish	Federal Status	Minnesota Status	Wisconsin Status	Site Occurrences by Pool
Butterfly (Ellipsaria lineolate)	-	T	E	Pool 4
Higgins' eye pearly mussel (Lampsilis higginsi)	E	E	E	Pool 4
Monkeyface (Quadrula metanerva)	-	T	T	Pool 4
Mucket (Actinonaias ligamentina)	-	T	-	Pool 4
Pistolgrip (Tritogonia verrucosa)	-	T	T	Pool 4
Wartyback (Quadrula nodulata)	-	E	T	Pool 4
Washboard (Meglonaias nervosa)	-	T	-	Pool 4
Black buffalo (Ictiobus niger)	-	-	T	Pool 4
Blue sucker (Cycleptus elongatus)	-	SC	T	Pool 3 & 4
Goldeye (Hiodon alosoides)	-	-	E	Pool 3 & 4
Greater redhorse (Moxostoma valenciennesi)	-	-	T	Pool 3 & 4
Paddlefish (Polyodon spathula)	-	T	T	Pool 3 & 4
Pallid shiner (Notropis amnis)	-	-	E	Pool 4
River redhorse (Moxostoma carinatum)	-	-	T	Pool 3 & 4
Skipjack herring (Alosa chrysochloris)	-	SC	E	Pool 4
Speckled chub (Macrhybopis aestivalis)	-	-	T	Pool 3 & 4

E = listed as endangered T = listed as threatened SC = special concern

Three protected wildlife species are found in this reach. The bald eagle is the only wildlife species with Federal protection under the Endangered Species Act. The bald eagle is federally listed as threatened in Minnesota and Wisconsin. The Blanding's turtle and wood turtle are listed as threatened in Minnesota and Wisconsin. (U.S. Army Corps of Engineers, 2001)

Table 6. Protected wildlife species found in Pool 3 and Upper Pool 4.

Species	Federal Status	Minnesota Status	Wisconsin Status	Site Occurrences by County
Bald Eagle	T	T	T	Dakota, Goodhue, Pierce, Pepin
Blanding's Turtle	-	T	T	Dakota, Goodhue
Wood Turtle	-	T	T	Washington, Goodhue

E = listed as endangered T = listed as threatened

2.8 CULTURAL RESOURCES

Pool 3 and Upper Pool 4 contain a number of landforms that have attracted human use and habitation for millennia. These include the Cannon and Trimbelle river deltas, and many large glacial terraces of the area such as Prairie Island, and the head of Lake Pepin. There are many archaeological sites in the Red Wing area, representing one of the major concentrations of human activity in the entire Upper Midwest about 1,000 years ago. The bluffs, terraces, river deltas, and natural levees still contain the material remains of this thriving Oneota society, as well as those that preceded it. Most of the known sites in Pool 3 and Upper Pool 4 are on higher ground away from the shoreline. The components of the Upper Mississippi River 9-Foot channel project are also historic properties. Locks and Dams 3-10 have been determined eligible for the National Register of Historic Places.

A U.S. Army Corps of Engineers and U.S. Fish and Wildlife Service report (2011) summarized the layout of cultural resources in the Pool 4 region:

> Pool 4 contains 304 recorded cultural resources. Pre-contact sites exist throughout the pool, although they are denser along the prominent terraces at Red Wing, Frontenac, Lake City, Pepin and Wabasha. Pre-contact sites include single artifacts, village sites, rock art, burials and burial mounds that span Paleo through Oneota/Mississippian traditions. The area around Red Wing supported several large Oneota/Mississippian villages as well as thousands of burial mounds, the most recorded in Minnesota and along the Upper Mississippi River. Three pre-contact sites are listed on the [National Register of Historic Properties]. Historic sites, constituting approximately eight percent of the total, are also clustered on these terraces and include mills, fur trade posts, early town sites and pottery production facilities. Two historic sites are on the NRHP, six historic districts and at least ten historic shipwrecks exist in the pool. (USACE & USFWS, 2014)

The Historic Bridges in Minnesota project is an effort to inventory and plan preservation for pre-1956 bridges in Minnesota that are eligible for the NHRP. According to the project's "List of Known Pre-1971 Historic Bridges", one historic bridge passes through Pool 4 within the project area. Bridge #9103 carries US Highway 63 in order to connect Hager City, Wisconsin and Red Wing, Minnesota, around Mississippi River mile 792. Built in 1960, it is mainly a continuous concrete slab and is eligible for listing in the NRHP. (MnDOT, 2014)

2.9 RECREATION/AESTHETIC RESOURCES

The river supports valued recreational activities and aesthetic enjoyment, which has led to the development of numerous elements of recreational and aesthetic infrastructure around Pool 4. These elements are efficiently summarized by the 2011 Mississippi River Guide (MnDNR, 2014) by the Minnesota Department of Natural Resources. Based on this guide, throughout the Pool 4 stretch there are 11 marinas, 3 docking facilities, 4 fishing piers, 11 parks, 2 resorts, 7 private campgrounds, 23 areas of public access to the river, a national wildlife refuge, and two other areas of interest.

Frontenac State Park in Minnesota is a large park and campground, covering river miles 784 to 776. It provides bird watching, public camping, 13 miles of hiking trails, picnicking, and panoramic overlooks.

Marinas surrounding Pool 4 within the project area include Red Wing Marina (Red Wing, Minnesota, river mile 791), Trenton Island Marina (Hager City, Wisconsin, river mile 791), and Bill's Bay Marina (Red Wing, Minnesota, river mile 789).

Other marinas within Pool 4 include: Hansen's Harbor & Trailer Court (Lake City, Minnesota, river mile 776), Lake City Marina (Lake City, Minnesota, river mile 773), Dan's Pepin Marina (Pepin, Wisconsin, river mile 767), Mississippi Parkside Marina (Wabasha, Minnesota, river mile 761), and Wabasha Marina & Boat Yard (Wabasha, Minnesota, river mile 759).

Additional parks and campgrounds throughout Pool 4 include Mr. Sippi campground (Hager City, Wisconsin, river mile 793), Bay Point Municipal Park (Red Wing, Minnesota, river mile 791), Colvill Municipal Park (Red Wing, Minnesota, river mile 789), Bay City Village Park and Access (Bay City, Wisconsin, river mile 787), Maiden Rock Village Park (Maiden Rock, Wisconsin, river mile 780), Stockholm Campsite (Stockholm, Wisconsin, river mile 774), Stockholm Municipal Park (Stockholm, Wisconsin, 774), Ohuta Municipal Park (Lake City, Minnesota, river mile 773), Roschen Park (Lake City, Minnesota, river mile 772), and Rieck's Lakeside Park (Alma, Wisconsin, river mile 755). (MnDNR, 2014)

2.10 SOCIOECONOMIC SETTING

The Pool 4 region is mainly composed of rural small cities, towns, villages, and unincorporated areas, capped by Lock and Dam 3 around Mississippi river mile 797 and Lock and Dam 4 near mile 753. Red Wing, Minnesota is the largest community along this stretch with a population of 16,444 and is located southeast of Lock and Dam 3 between river miles 792 and 789. Sprinkled along the River on the Wisconsin side are towns and villages with populations under 1,000, including Bay City, Maiden Rock, Stockholm, Pepin, and Nelson (Bureau, 2014).

Based on the American Community Survey (Bureau, 2014), demographic factors across counties bordering Pool 4 are quite similar. Goodhue County is 96.8% white and 2.9% Hispanic or Latino of any race, has an unemployment rate of 4.2% among the labor force, and has a median annual household income of $55,603 with 8.7% of the population below the poverty line. On the Wisconsin side, Pierce County is 97.8% white with 1.5% Hispanic or Latino of any race, has an unemployment rate of 4.0%, and has a median household income of $61,153 with 12.4% living below the poverty line.

The Burlington Northern Santa Fe Railroad closely follows all of Pool 4's shoreline on the Wisconsin side. The Canadian Pacific Railroad traces along most of Pool 4 on the Minnesota side, veering away from the river around river mile 763 in order to pass through Wabasha, Minnesota (USACE & USFWS, 2014)

The river serves as a corridor for commercial navigation of barge traffic via the 9-foot navigation channel as authorized by Congress. Barge traffic transports a wide variety of essential goods on the UMRS. Agricultural commodities, petroleum products, and coal are the leading cargoes, with farm products accounting for approximately half the total tonnage shipped.

3. PROBLEM IDENTIFICATION

3.1 EXISTING HABITAT CONDITIONS

Based on the data discussed above in Sections 2.1 – 2.10, baseline conditions for habitat in Upper Lake Pepin (project site) would generally be considered marginal to good for a variety of fish and wildlife species expected to occur in this type of habitat.

Concerns over habitat deficiencies in Upper Pool 4 include reduced habitat diversity and quality, loss of aquatic vegetation and invertebrates, and reduced abundance of fish and wildlife. Deep, protected aquatic habitat that would serve as overwintering habitat for centrarchid fish and associated species is lacking in both backwaters and within large open water areas of Upper Lake Pepin that are shallow and with little depth diversity. Specifically, the major concerns are as follows:

1. Continued sedimentation and sediment resuspension, and reduced water clarity.
2. Changes in floodplain connectivity due to island erosion.
3. The loss of emergent and submerged aquatic vegetation.
4. Loss of protected wetlands and aquatic areas.
5. Degradation of habitat for migrating waterfowl and other species.
6. Loss of aquatic plant coverage and bathymetric diversity.

3.2 FACTORS INFLUENCING HABITAT CHANGE

3.21 GENERAL

A number of factors have been identified that are believed to be influencing habitat changes in Upper Pool 4. Many of these factors are synergistic, combining to affect both the physical, chemical and biological environment.

From the 1930s to 1960s, the amount of sediment flowing into the South Metro Mississippi and Lake Pepin more than doubled, from 300,000 to 700,000 metric tons per year, as measured by sediment cores in Lake Pepin (Engstrom, Almendinger, & Wolin, 2009). This rapid sedimentation rate has stabilized in recent decades.

Sedimentation and sediment resuspension have caused a loss in water depth diversity of the backwater lakes and isolated wetlands above Lake Pepin as well as a loss in aquatic vegetation. Wind wave action and barge travel combined with flocculent sediments creates high turbidity and prevents aquatic plants from becoming established. Wind generated waves suspend material in the water, increasing turbidity and reducing light penetration, and the waves exert a physical force on aquatic vegetation.

3.22 FLOW AND CURRENT VELOCITY

Upper Pool 4 from Lock and Dam 3 to Upper Lake Pepin is a riverine system with flow passing primarily through the main channel, backwaters, secondary channels, and tertiary channels. Flow distribution affects the suitability of habitat for fish species, depending on their tolerance of current velocity. This factor can be especially critical in the winter for species adapted to quiet water conditions such as bluegill and crappie. These species cannot tolerate high current velocity in the winter, and if over-wintering areas offering refuge from current are insufficient, population levels will be adversely affected.

As flows enter Upper Lake Pepin, current velocity decreases significantly. This results in widespread sediment deposition and creates large expanses of shallow, open water where previously there was deep water which is critical to the pelagic fish species abundant in Lake Pepin. These shallow areas are susceptible to sediment resuspension from wind and wave action and contain little aquatic vegetation and poor habitat for fish and wildlife. As sediment continues to deposit, some areas fill and become exposed, creating natural sandbars and eventually islands. These habitats are important for birds. However, this process is ongoing and within an estimated 330 years Lake Pepin will be filled and there will be no large expanses of deep, open water left.

3.23 WIND AND WAVE ACTION

Wind wave action combined with inflow of flocculent sediments creates high turbidity and prevents aquatic plants from becoming established in areas like Goose Lake, Mud Lake, and Dead Slough Lake. Upper Lake Pepin especially, is subject to large wind fetches which result in the generation of large waves, which in turn affect habitat conditions. Wind generated waves suspend material in the water, increasing turbidity and reducing light penetration, and the waves exert a physical force on aquatic vegetation. The suspension and subsequent resettlement of sediment particles contributes to declines in bathymetric diversity. A general leveling of the pool bottom results as material is suspended from shallower areas by wave action and re-deposited in deeper areas.

3.24 FACTORS AFFECTING AQUATIC VEGETATION

In the late 1920s, a federal government report indicates that where the Mississippi River broadens out to form Lake Pepin, “the shallow north end and east side of the south end have developed some of the finest areas of duck food plants in this entire region. Here, wild celery, sago pondweed, clasping leaved pondweed or red-head grass, leafy pondweed, bushy pondweed, and Elodea or water-weed, which are six of the best submerged duck foods, together with numerous others, are abundant” (Uhler, 1929).

Between 1845 and the late 1920s, aquatic life appeared to remain healthy upstream of Lake Pepin despite sedimentation rates increasing by a factor of three to four times, as measured by sediment core dating techniques (Engstrom, Almendinger, & Wolin, 2009). Apparently, turbidity levels had yet to cross the threshold of having a significant, enduring impact on rooted aquatic vegetation.

Submersed aquatic vegetation in the Mississippi River is subjected to variable light conditions throughout any growing season or series of growing seasons. Monitoring data show that submersed aquatic vegetation can withstand limited durations of high turbidity, but that prolonged turbid conditions, especially over two or more consecutive years, can impair growth and survival (Sullivan, Langrehr, Giblin, Moore, & Yin, 2009).

3.3 ESTIMATED FUTURE HABITAT CONDITIONS

"Forecasted future conditions in the Pierce County Islands/Head of Pepin backwater complex anticipate continued island dissection and sedimentation," according to the Wisconsin Department of Natural Resources.

> Some island erosion may be offset with low elevation islands that may form as areas upstream continue to fill with sediment, increasing sediment delivery to the Pierce County Islands/Head of Pepin backwater area. Backwater sedimentation of fine material is expected to continue. Wave resuspension of sediment will continue to affect the sustainability of aquatic vegetation in the complex due to a combination of fine sediment deposition and island erosion.
>
> The fish community and use in the area is expected to continue being a season use with little centrarchids overwintering habitat available. Migratory waterbird habitat will continue to be variable, primarily driven by variability in year to year aquatic plant production. (DNR, 2010)

3.4 RESOURCE PROBLEMS AND OPPORTUNITIES

The river ecosystem in Pool 4 has been significantly affected by sedimentation and degraded water quality associated with the suspended sediment load from the Minnesota River and island erosion due to recreational traffic. Sedimentation and sediment resuspension have caused a loss in water depth diversity of the backwater lakes and isolated wetlands above Lake Pepin as well as a loss in aquatic vegetation. Wind wave action and barge travel combined with flocculent sediments creates high turbidity and prevents aquatic plants from becoming established.

Habitat deficiencies in the area include the loss of emergent and submergent aquatic vegetation, loss of protected wetlands and aquatic areas, degradation of habitat for migrating waterfowl and other species, degradation and loss of secondary and tertiary channels, loss of aquatic plant coverage and bathymetric diversity, and increased flows which reduce habitat value for lacustrine fish.

The opportunity exists to increase terrestrial and aquatic habitat diversity by directing flow and sediment deposition through island building, bank stabilization, and dredging. The construction of islands may reduce wind fetch and sediment resuspension. Managing the inflows and distribution of water and sediment will help to manage delta formation rates.

Proposed actions within the Pierce County Islands Wildlife Area provide the opportunity to protect, enhance, and restore quality wetland habitat for all native and desirable plant, wildlife, and fish species. Target animals include eagles, mussels, fish, turtles, migrating waterfowl, terrestrial mammals, and waterbirds. Targeted plants include emergent vegetation such as arrowhead, bureed, and bulrush; submersed vegetation such as wild celery and sago pondweed; and terrestrial vegetation such as swamp white oak, cottonwood, and button bush.

3.41 RESOURCE PROBLEM: LOSS OF EMERGENT AND FLOATING LEAF AQUATIC VEGETATION

Description: The emergent and floating-leafed aquatic plant communities are integral to habitat diversity in the Upper Lake Pepin area. As sediment inflow and resuspension continues, the emergent and floating leaf aquatic vegetation are expected to further decline. The stressors on emergent and floating leaf aquatic vegetation include: sediment flow from the Minnesota River; large wind fetches leading to wave resuspension of sediments, reduced water clarity, and plant breakage; elevated river current erosion; and alterations in growing season water levels.

Opportunities: As Upper Lake Pepin continues to fill with sediment, the opportunity exists to direct how and where that sediment accumulates. By constructing islands and dredging, more habitat diversity can be created and maintained. Islands could protect large areas from wind/wave action, with subsequent improved water quality conditions and habitat for emergent and floating-leafed aquatic plant communities.

3.42 RESOURCE PROBLEM: LOSS OF QUALITY AND ACREAGE OF SUBMERGSED AQUATIC VEGETATION

Description: Upper Lake Pepin is a transition area from backwaters and channels to a large expanse of shallow, open water. The area is exposed to long wind fetches from the south and water quality is greatly influenced by wind generated wave action. The quantity and quality of submersed vegetation coverage is lacking.

Opportunities: By constructing islands and dredging, more habitat diversity can be created and maintained. Islands could protect large areas from wind/wave action, with subsequent improved water quality conditions and suitable conditions for submersed aquatic vegetation.

3.43 RESOURCE PROBLEM: LOSS OF ISLAND HABITAT AND FLOODPLAIN FOREST

Description: Islands provide habitat diversity and are an important “structural” component in the transition area of upper Lake Pepin. Islands help define running sloughs, add habitat complexity, break up wind fetch, provide visual and thermal isolation, and in and of themselves provide habitat for a variety of fish and wildlife species. Stressors include wind generated wave and river current erosion of islands.

Opportunities: Islands can be constructed in the open water expanses of upper Lake Pepin to manage the flow of water and movement of sediment in the project area. They can also reduce wind fetch and sediment resuspension, thereby improving conditions for aquatic plants.

3.44 RESOURCE PROBLEM: LOSS OF DEEP WATER AQUATIC AREAS

Description: Within the upper Lake Pepin area there are large expanses of shallow, open water grading to deep water habitat further downstream. These shallow areas are exposed to wind fetch and are highly turbid with little aquatic vegetation. Stressors include: large wind fetches leading to wave resuspension of sediments, reduced water clarity, and little aquatic vegetation.

Opportunities: Protection of existing islands and construction of islands provide an opportunity to reduce wind-generated wave action. There is also an opportunity to increase elevations from disposal of access and habitat dredging in selected areas to promote the establishment of emergent marsh and important isolated wetlands for fish and wildlife and wild rice production.

3.45 RESOURCE PROBLEM: DEGRADATION OF HABITAT FOR MIGRATING WATERFOWL

Description: The upper end of the study area is part of the Pierce County Islands Wildlife Management Area, which is a critical feeding and resting area for waterfowl during the spring and fall migration. The existing islands and emergent wetlands provide somewhat limited visual isolation and thermal barriers for migrating waterfowl, and much of the emergent wetland habitat is projected to decline in the future without action. The lower end of the project area is the large, shallow, open water expanse of upper Lake Pepin. Once an important feeding and resting area for waterfowl, this area now has little food or available habitat. Stressors include: large wind fetches leading to wave resuspension of sediments, reduced water clarity, and little aquatic vegetation.

Opportunities: There is an opportunity to maintain and increase carrying capacity for migrating waterfowl during migration by improving conditions for aquatic vegetation and providing thermal cover and visual barriers by the construction of islands.

3.46 RESOURCE PROBLEM: DEGRADATION/LOSS OF SECONDARY AND TERTIARY CHANNELS

Description: As flows from the main channel and Wisconsin back channel enter the large open water expanse of Lake Pepin, they decrease significantly. Sediments settle to the bottom evenly creating large areas of shallow water that were historically deep water habitats. These shallow areas provide little habitat, until they fill enough to form natural islands and create sloughs and other channels. This process is slow and results in a continuous movement of large shallow areas downstream. Stressors include high sediment loading evenly distributed over large open water areas providing little bathymetric diversity, and high turbidity from resuspension by wind-generated waves resulting in little aquatic vegetation.

Opportunities: The opportunity to direct current flow and subsequently sediment deposition by building islands and dredging will create more channels and habitat diversity. Islands will reduce wind fetch and improve water clarity with a resulting increase in aquatic vegetation.

3.47 RESOURCE PROBLEM: LACK OF PROTECT OFF CHANNEL LACUSTRINE FISHERIES HABITAT

Description: Protected off-channel lacustrine fisheries habitat is an important component of the Mississippi river ecosystem. This type of habitat has decline in upper Lake Pepin with the leveling effects of sedimentation and loss of deep water areas. Creating more depth diversity would improve habitat conditions for a large variety of backwater and channel fish species. Adequate water depths (greater than 4 feet) will need to be provided to improve Centrarchid overwintering habitat. Stressors include lack of protected deepwater areas as fish overwintering habitat (greater than 4 feet deep).

Opportunities: There is an opportunity to build islands to create protected areas. Deep water habitat can be created by dredging for use as topsoil/random fill on constructed islands and for the creation of emergent marsh/mudflats and isolated wetlands.

4. OBJECTIVES

4.1 INSTITUTIONAL GOALS

4.11 UPPER MISSISSIPPI RIVER SYSTEM GOALS

Slowing the filling of Lake Pepin from sediment originating within the watershed is outside the scope of this Problem Appraisal Report. However, it is recognized that reductions in sediment through Best Management Practices and other conservation efforts within the watershed is the most critical need facing Lake Pepin and is a top priority of resource managers.

Institutional goals are derived from the System and Reach Planning efforts conducted through the Navigation and Ecosystem Sustainability Program (NESP, 2010), and the Environmental Pool Plans (EPPs), Pools 1 through 10 (2004). The management goals and objectives which apply most directly to the study area include:

Reduce Erosion, Sediment, and Nutrient Impacts

- Reducing wave resuspension of bottom sediment
- Providing shoreline protection of eroding sites
- Increasing the diversity and abundance of floodplain terrestrial vegetation

Return of Natural Floodplain to Enable More Habitat Diversity

- Raising the elevation of lands or islands within the floodplain to promote a diversity of terrestrial communities.

Manage Sediment Transport, Deposition, and Side Channels

- Stabilizing historic, maintaining existing, or constructing "new" islands at selected locations.
- Increasing depth through dredging or directing flow in selected areas to promote scouring of sediment.

4.12 MINNESOTA POLLUTION CONTROL AGENCY GOALS AND OBJECTIVES

The Minnesota Pollution Control Agency's Total Suspended Solids (TSS) Total Maximum Daily Load (TMDL) study for the South-Metro Mississippi River found that TSS loads from the Minnesota River Basin and other heavy-loading watersheds will need to decrease by 50 to 60 percent to meet the site-specific standard for turbidity in the South Metro Mississippi River. Loads from other tributaries will need to decrease by 20 percent. These reduction will need to occur in years of medium and higher flows with sufficient frequency to meet a summer mean of 32 mg/L TSS in at least fiver summers over a 10-year period. If these conditions are met, one biological response will be increased coverage of submersed aquatic vegetation. As an additional benefit, the TSS load reductions would reduce the rate of sediment in-filling of Lake Pepin by about one-half.

The South Metro Mississippi River TSS TMDL stated that the MPCA will work with several partners, such as the Minnesota Department of Natural Resources, the U.S. Army Corps of Engineers, and the U.S. Fish and Wildlife Service to reduce in-river loading from wind and wave resuspension by 50 percent by building islands and other work in the river. Islands in shallower areas with wide expanses of open water, such as upper Lake Pepin, can reduce wind fetch in order to cut down on sediment re-suspension.

4.13 PIERCE COUNTY ISLANDS/HEAD OF PEPIN GOALS AND OBJECTIVES

Goals and objectives were developed by the Wisconsin Department of Natural Resources for the Pierce County Islands/Head of Pepin Backwater Complex. The proposed project's primary objectives include: restoring a sediment transport regime where sediment transport rates and future change in geomorphic patterns are within acceptable limits, restored pattern of channels and floodplain features, restored diversity of floodplain topography, and restored habitat connectivity.

Secondary objectives include: greater hydraulic connectivity, improved water clarity, reduced nutrient loading, reduced sediment loading from tributaries and sediment resuspension in and loading to backwaters and upper Lake Pepin, restored riparian habitat, restored aquatic off-channel areas, restored terrestrial floodplain areas, restored channel areas, restored large contiguous patches of native plant communities to provide a corridor, and diverse and abundant native aquatic vegetation communities, floodplain forest and prairie communities, native fish community, native mussel community, native bird community, and amphibian and reptile community.

Restoration of hydraulic connectivity to emulate more natural conditions in portions of the Pierce County Islands/Head of Pepin Backwater Complex will result in: a change in sediment transport and deposition patterns in backwater channels and backwater lakes, increased diversity and variability of water velocities within the backwater complex, and areas that are connected at a variety of discharge/stage levels, but are not connected during low discharge events or year round. Improved water clarity in the spring and summer will reduce year to year variability of submersed vegetation coverage. Reduced resuspension of sediment will improve water clarity during open water season (i.e. late-March through November) at below bank full discharge events.

Proposed project features will restore patterns of channels and floodplain features to a combination of states that existed immediately post impoundment with some features present prior to impoundment.

Restoration of landforms in the Pierce County Islands/Head of Pepin Backwater Complex will increase the abundance of terrestrial species and number of nesting birds within the complex. Restoration/enhancement of centrarchid over-wintering habitat will increase seasonal survival and year round abundance of backwater species, and reduction in resuspension and delivery of suspended sediments, combined with increase diversity of water velocities, will increase the diversity and distribution of aquatic vegetation communities within the complex.

Restoration of bathymetric diversity, hydraulic connectivity and increased residence time will increase the abundance and diversity of the native fish community and improve the survival of target backwater species. Abundance of channel fish species will increase in response to improved habitat conditions along the left descending bank of the Pierce County Islands Head of Pepin Backwater where there will be an increase in water velocities and defined channel border area. Native freshwater mussel density and diversity will increase within the project where channel habitat is restored/enhanced through modification of hydraulic connectivity, water velocity and sediment transport/distribution. Restoration of areas of seasonal connectivity and isolated wetlands will increase the diversity and abundance of amphibians within the complex. (DNR, 2010)

4.2 PROJECT GOALS AND OBJECTIVES

Earlier sections of this report discussed in detail existing habitat conditions and problems (see Section 3.1 Existing Habitat Conditions, Section 3.3 Estimated Future Habitat Conditions, and 3.4 Resource Problems and Opportunities). The habitat goals and objectives were summarized by NGO's (Lake Pepin Legacy Alliance, Audubon Minnesota) based on previous documents prepared by Minnesota and Wisconsin DNRs as well as meetings and discussions about potential project features as part of a coordinated effort on the part of all of the resource agencies and interests involved in the study.

The following factors were considered important in the development of the objectives:

1. Management objectives of the Wisconsin and Minnesota DNRs
2. Historic and existing fish and wildlife habitat conditions
3. Resource problems, opportunities, and constraints
4. Habitat deficiencies, now and in the future for Lake Pepin in general
5. Species groups and individual species habitat requirements
6. Desirable hydraulic and sediment transport conditions to sustain habitat
7. Use of channel maintenance dredge material
8. Recreational access within shallow areas of Upper Lake Pepin

4.21 PROJECT GOALS

GOAL A: Enhance and protect quality habitat for all native and desirable plant, animal and fish species in Upper Lake Pepin.

This is the primary goal for the Upper Lake Pepin area. This area has large expanses of shallow open water that is turbid with little aquatic vegetation and limited habitat quality.

GOAL B: Emulate the structure, function and dynamic processes of a sustainable ecosystem in Upper Lake Pepin.

Lake Pepin, created by the delta of the Chippewa River at one time extended to current day St. Paul. Natural rates of sedimentation have been slowly filling Lake Pepin since the end of the last glacial period, approximately 12,000 years ago. Lake Pepin currently extends from Red Wing to Reads Landing, covering approximately 26,000 acres with an average depth of 21 feet.

The rate of filling has increased dramatically in the last 150 years following European settlement and the conversion of prairies and wetlands to agricultural and urban lands. Sedimentation rates are currently 10 times greater than historical rates, and Lake Pepin is expected to fill with sediment within 330 years. The Upper end of Lake Pepin is expected to fill in only 100 years.

Currently, Upper Lake Pepin consists of channel border islands and backwater lakes grading into an expansive, shallow open water area with little physical structure. Water depths throughout much of Upper Lake Pepin are less than 5 feet. Wind wave action combined with flocculent sediments creates high turbidity and prevents aquatic plants from becoming established. Directing flow and sediment deposition in Upper Lake Pepin through island building and dredging can increase terrestrial and aquatic habitat diversity. While not slowing the rate of filling, such efforts can dramatically improve habitat for fish and wildlife in Upper Lake Pepin.

GOAL C: Enhance channel habitat for riverine fish and mussel species.

The existing secondary and main channel border habitats in the project area are important areas for riverine aquatic species. However, these areas do not exist in the large open water expanse of Upper Lake Pepin. Creation of more islands will diversity current velocity, substrate, and cover conditions and enhance habitat for riverine species.

GOAL D: Create and maintain protected lacustrine habitat for backwater fish species

Habitat conditions in the study area are considered poor for backwater fish species, especially in the larger, open shallow expanses of Upper Lake Pepin. Improving conditions for Centrarchids (bluegill, largemouth bass, and black crapper), which are a major component of the Upper Mississippi River backwater fisheries, is desired. Additionally, many other species that use the same habitats as Centrarchids will benefit.

4.22 PROJECT OBJECTIVES

Based on the project goals, specific objectives were established and are listed below. Many of these objectives are interrelated and will assist in meeting one or more of the four main goals. Specific planning and design criteria for each of the objectives are described in Section 5.3 Planning and Design Considerations. The guidance for developing objectives is provided in Corps planning guidance ER 1105-2-100 and specifies that objectives must be clearly defined, must provide information on the effect desired, the subject of the objective, the location where the effect will occur and the timing and duration of the effect. For the purpose of the Problem Appraisal Report, the location for all objectives is generally defined as the Upper Lake Pepin study area. However, in development of the Definite Project Report objectives may be scaled to sub-areas as identified by conditions most suitable to achieve the specified objective. For example, objective 1 will likely be targeted at shallow water sub-areas within Upper Lake Pepin because shallow waters are most suitable for emergent and floating leafed aquatic vegetation. The timing or duration of the objectives is assumed to be the 50 year period of analysis.

Objective 1 – Increase the acreage of emergent and floating leafed aquatic vegetation
Objective 2 – Increase the acreage of submerged aquatic vegetation
Objective 3 – Manage delta formation processes to support a unique diversity of species and manage sedimentation and delta growth into desirable habitat areas
Objective 4 – Improve or maintain the quantity and quality of habitat for riverine aquatic species
Objective 5 – Improve or maintain the quantity and quality of habitat for migratory bird species
Objective 6 – Improve or maintain the quantity and quality of backwater habitat for Centrarchids

The relationship between objectives and the criteria to determine achievement of that objective is summarized in Table 7. It should be noted that not all criteria must be met in order to achieve the objective; the criteria are indicators of ideal conditions. The relationship between resource problems, opportunities, goals, and the objectives are summarized in Table 8.

Table 7. Objectives and Criteria

Objective 1 – Increase the acreage of emergent and floating leafed aquatic vegetation
- Reduce sediment resuspension in Upper Lake Pepin
- Reduce wave action
- Direct rate and location of sediment transport and deposition
- Water depth (less than three feet deep)

Objective 2 – Increase the acreage of submerged aquatic vegetation
- Reduce sediment resuspension in Upper Lake Pepin
- Reduce wave action
- Direct rate and location of sediment transport and deposition

Objective 3 – Manage delta formation processes to support a unique diversity of species and direct sedimentation and delta growth into desirable habitat areas
- Reduce sediment deposition and delta migration into desirable habitat areas.

Objective 4 – Improve or maintain the quantity and quality of habitat for riverine aquatic species
- Flowing channels
- Depth diversity

Objective 5 - Improve or maintain the quantity and quality of habitat for migratory bird species
- Habitat criteria as indicated by the diving duck, dabbling duck, and shorebird models

Objective 6 - Improve or maintain the quantity and quality of backwater habitat for Centrarchids
- Criteria for improved habitat conditions as defined by the bluegill model

Table 8. Resource Problems, Opportunities, Goals, and Objectives

Loss of emergent aquatic vegetation
- Protection of existing and creation of additional islands to reduce wind/wave and river current erosion would protect and expand emergent and floating leaf aquatic vegetation.
- Goals A, B, and D; Objective 1

Lack of submerged aquatic vegetation
- Submerged aquatic vegetation are likely to lack resilience and sustainability and show even greater fluctuations in the future. The extent and quality of submersed aquatic vegetation could be improved by modifying current patterns and reducing wave action; thereby improving water clarity in the study area.
- Goals A, B, and D; Objective 2

Loss of protected wetlands and aquatic areas
- Protect existing islands, promote establishment of emergent marsh and isolated wetlands important for fish and wildlife.
- Goal A and B; Objective 3, 5, 6, 7

Degradation of habitat for migrating waterfowl and other species
- Stressors include: large wind fetches resulting in wave resuspension of sediments, plant breakage, and reduced water clarity; and excessive sedimentation. There are opportunities with strategic placement of islands to modify current patterns and wind generated wave action to improve water quality and protect and enhance aquatic vegetation.
- Goals A and B; Objectives 1, 2, 3,6

Degradation and loss of secondary and tertiary channels
- Islands and wetlands could confine flows and provide self-sustaining running channel habitat. Islands would increase the amount and quality of shoreline and littoral habitat. There is an opportunity while creating new island to incorporate features to enhance the value for a variety of fish and wildlife species.
- Goals A and B; Objectives 1, 2, 4,5, 7

Loss of aquatic plant coverage, bathymetric diversity and increased flows reduces habitat value for lacustrine fish.
- The shallow, expansive, open water areas in Upper Lake Pepin provide little overwintering habitat for bluegills and other lacustrine species.
- There is an opportunity to direct flows by building islands and dredging, creating deeper areas for overwintering fish. Dredging can provide topsoil/random fill for constructed islands and the creation of emergent marsh/mudflats.

- Goals C and D; Objectives 5, 7

5. ALTERNATIVE MEASURES

5.1 PLANNING CONSTRAINTS

5.11 INSTITUTIONAL

The Upper Lake Pepin area lies partially within the Wisconsin Department of Natural Resources' Pierce County Islands Wildlife Management Area, and privately owned floodplain areas within the states of Wisconsin and Minnesota. The management goals and objectives of these areas must be considered, and all federal, state, and local laws and regulations must be complied with.

5.12 ENGINEERING

Because of shallow water depths, access for construction equipment can be difficult in many areas without extensive dredging. Unconsolidated sediment deposits in upper Lake Pepin will make island construction and dredging more difficult than what is typically experienced in other reaches of the river. Equipment restrictions and construction access will need to be considered in the planning and design of habitat restoration measures. The effects of project features on flood elevation have to be minimized and will be coordinated with the MNDNR and WIDNR.

5.13 ENVIRONMENTAL

Any project developed for the Upper Lake Pepin area will need to avoid adversely affecting federally listed endangered species. Additionally, several state threatened and endangered species are present within the project area, requiring review and coordination to avoid/minimize affecting these species. Contaminated sediments, which are likely to be found in Upper Lake Pepin may require special handling techniques.

5.14 CULTURAL

304 archeological and historic sites are known for Pool 4. Cultural resources located near the project area are detailed in Section 3.8 of this report.

5.15 SOCIOECONOMIC/RECREATIONAL

In developing ecosystem restoration measures and alternatives, it was assumed the Operation and Maintenance of the 9-Foot Navigation Channel would continue, including maintaining the impounded conditions and water regulation.

5.2 ALTERNATIVE MEASURES IDENTIFIED FOR FURTHER STUDY

5.21 NO ACTION

The no action alternative is defined as no implementation of a project to modify habitat conditions in the study area. Habitat quality would continue to be poor with high sediment loading and turbidity, little bathymetric diversity, and limited aquatic vegetation.

5.22 POTENTIAL MEASURES TO MEET OBJECTIVES

Table 9 outlines the objectives; the chemical, physical, and biological stressors that need to be addressed to reach the objectives; and the potential management measures to address these stressors. Sections 5.23 through 5.210 address the potential management measures in more detail.

Table 9. Objectives, Stressors and Potential Restoration Measures

Objective 1 – Increase the acreage of emergent and floating leafed aquatic vegetation

- Stressors: Wind/wave action, water clarity, Pool 4 impoundment
- Restoration measures: Bank protection, island restoration/creation, creation of emergent wetlands, seasonal water level variation through moist soil management, isolated wetlands

Objective 2 – Increase the acreage of submerged aquatic vegetation

- Stressors: Wind/wave action, water clarity
- Restoration measures: Bank protection, island restoration/creation

Objective 3 – Maintain delta formation processes to support a unique diversity of species and direct delta growth

- Stressors: Wind/wave action, rate of sediment deposition, hydraulic connectivity
- Restoration measures: Bank protection, island restoration/creation, closure structures, desirable habitat areas connectivity

Objective 4 - Improve or maintain habitat for riverine aquatic species

- Stressors: Wind/wave action, river currents, lack of substrate and bathymetric diversity
- Restoration measures: Bank protection, island restoration/creation, flowing channels

Objective 5 – Improve or maintain quantity and quality of habitat for migratory bird species

- Stressors: Lack of habitat and available forage
- Restoration measures: Island restoration/creation, establishment of emergent marsh or isolated wetlands, moist soil management

Objective 6 - Improve or maintain quantity and quality of backwater habitat for centrarchids

- Stressors: Hydraulic connectivity, lack of protected overwintering fish habitat, including areas >4 feet deep meeting water quality criteria
- Restoration measures: Bank protection, island restoration/creation, closure structure, habitat dredging (>4feet)

5.23 ISLAND RESTORATION/CREATION

Island restoration/creation could serve a variety of habitat purposes in Upper Lake Pepin. Islands protect shallow areas from wind and wave action, which in turn protects existing aquatic vegetation beds and improves conditions for the growth of aquatic vegetation in other shallow areas. Islands provide terrestrial habitat, and their restoration increases habitat availability to wildlife. Islands can also be designed in a manner to direct flows to enhance or restore secondary channel habitat, maintain bathymetric diversity, and manage sediment deposition.

5.24 BANK PROTECTION

Bank protection is a measure that can be used to control erosion. Generally, with habitat projects on the Upper Mississippi River, bank protection is done with a combination of hard structures and living vegetation. Hard structures include vanes, groins, or rock mounds usually constructed with rock, but sometimes including large woody debris (LWD) such as logs or root wads. In some conditions a layer of rock on the bank (traditional riprap design) is used. Bank protection was evaluated for all the remnant natural islands in the study area.

5.25 CLOSURE STRUCTURES

Closures (or partial closures) are structural measures designed to control or reduce flow in existing secondary channels. Closure structures are generally constructed with rock, although design concepts involving the incorporation of woody material have been used. Usually these structures are designed with a top elevation near the bank full event so that seasonal hydraulic connectivity is maintained. Some of these structures include a low flow notch and are termed partial closure structures. Closure structures, either rock sills or woody material, were identified as measures for consideration at locations where island erosion has resulted in the formation of channel into historic backwater lakes and wetlands.

5.26 DREDGING

Backwater dredging is a potential measure to improve fish habitat. Dredging provides the opportunity to obtain materials for island construction. Backwater dredging when combined with construction of islands would incrementally improve Centrarchid habitat in the study area. Increased availability of deeper water combined with reduced velocities would greatly improve wintertime habitat conditions.

5.27 EMERGENT WETLANDS/MUDFLATS

Emergent wetlands or mudflats could be created in the shallow flats near the existing or new islands. These would be constructed to an elevation near normal pool. This would increase the amount of emergent vegetation or mudflat habitat in the Upper Lake Pepin area. It would also provide placement sites for unsuitable and/or excess material dredged for access and habitat dredging for use as granular fill or topsoil for the islands.

5.28 ISOLATED WETLANDS

Creation of isolated wetlands was considered for areas in Upper Lake Pepin. Isolated wetlands would be shallow wetlands (less than 2 feet deep under normal pool) that would not be connected to other aquatic areas during bank-full conditions. These areas would generally be fish-free, because they would not provide suitable habitat for fish. These areas could provide excellent habitat for amphibians, reptiles, waterfowl, and other similar wildlife. In addition, these areas may be beneficial for Wild Rice production. Additionally, moist soil management within portions of the Pierce County Island Wildlife serve similar functions as isolated wetlands.

5.3 PLANNING AND DESIGN CONSIDERATIONS

River managers, engineers, and other partners will provide a number of ideas for consideration in the planning and design of project measures and alternatives. The Environmental Design Handbook (USACE 2012) also provides recommendations for consideration in planning and design of project measures.

5.31 EMERGENT AQUATIC VEGETATION

General conditions and criteria for:

Emergent aquatic vegetation:
- Less than 2 feet water depths for average river flows
- Mean weighted wind fetch less than 3,500 feet for water depths of 2 feet
- Secchi transparency greater than 0.8 meter on average during the June 1- September 1 growing season in backwaters
- Current velocities less than 0.5 feet per second for normal high water and less than 0.2 feet for average river flows.

Constructed emergent wetlands/mudflats:
- Emergent wetlands located in proximity to islands are the optimum condition
- It is important to maintain and enhance micro-topography within expanses of emergent wetlands/mudflats.

- 50 percent of emergent wetlands/mudflats should be above and below ELEVATION MSL to promote diversity of habitat types.
- Create mini wetlands by modifying islands

Constructed isolated wetlands for amphibians and water and marsh birds:
- Less than 3 feet under average pool elevation (ELEVATION MSL) with topographic diversity
- Berms containing the isolated wetlands should not be breached and should be constructed so they are not overtopped during normal high water (ELEVATION MSL – around the 1.5 year flood event)
- Topsoil should be considered on the berms to increase stability and increase vegetation diversity.

5.33 FLOATING LEAF AND SUBMERSED AQUATIC VEGETATION

- Less than 5 feet water depths for average river flows
- Mean weighted wind fetch less than 6,000 feet for water depths of 3 feet
- Suspended sediment probability from wind wave action less than 60 percent
- Secchi transparency greater than 0.8 meter on average during the June1 – September 1 growing season in backwaters
- Current velocities less than 0.5 feet per second for normal high water and less than 0.2 feet for average river flows

5.34 ISLANDS

The UMRR, Design Handbook (2012) provides a variety of recommendations on island layout, elevation, width, side slopes, topsoil and vegetation. Some of the more germane recommendations from the Engineering and Design Handbook recommendations are summarized below:

- Islands should be positioned to reduce wind fetch to less than 3,500 feet in 2 feet of water.
- A mix of high and low elevation islands is preferred.
- Use of rock should be minimized to allow for more aesthetic and natural looking conditions. Shorelines deemed critical to maintaining the integrity of an island or an overall island complex should be protected using bioengineering techniques, if possible. Noncritical shorelines should be vegetated with grass or left as sand.
- Slopes of 10:1 extending from the tow of islands outward for 30 feet or more are desirable. This objective could be accomplished either through direct construction or providing sufficient material in an island berm for beach formation.
- Do not plant willows on every portion of an island. Create dynamic shorelines with a transition zone (i.e. an above water beach) to provide more habitat that is suitable for shorebirds.
- Locate islands to induce the maintenance and/or formation of channels to maintain/improve bathymetric diversity.
- Islands should generally be located in shallow water to reduce costs and increase stability; however a barrier island in deeper water should be considered.
- Existing island remnants should be incorporated into restored islands for aesthetics.
- Islands should be positioned so that shoreline stabilization is in shallow water.
- Minimize access dredging to minimize secondary effects and costs.

- Position islands to have the greatest effect on hydraulic and sediment regimes.
- Rock sills should be incorporated to provide floodplain flow for more frequent floods
- Flood impacts should be minimized with low elevation islands or aligned in upstream/downstream orientation.

5.35 MIGRATORY WATERFOWL

- Less than 5 feet water depths for average river flows.
- Mean weighted wind fetch less than 6,000 feet for water depths of 3 feet.
- Suspended sediment probability from wind wave action less than 60 percent.
- Secchi transparency greater than 0.8 meter on average during the June 1 – September 1 growing season in backwaters.
- Maintain at least 1.877 million kilocalories of gross energy production from aquatic plant seeds and tubers.
- Provide thermal and visual barriers to waterfowl

5.36 MARSH AND WATER BIRDS AND SHOREBIRDS

- Provide gradual sloping beaches on the sheltered side of the new islands
- Create irregular shorelines to increase edge habitat
- Create mudflats/emergent wetlands
- Create isolated wetlands
- Increase shoreline and littoral habitat, with a diversity of native emergent, rooted floating leaf, and submersed aquatic vegetation

5.37 NEOTRPOICAL MIGRANT BIRDS

- Plant new islands to grasses and or trees
- Design islands with a diversity of elevations to provide a more complex and diverse terrestrial vegetation community

5.38 RIVERINE FISH

Riffle/pool/gravel bar habitat in secondary or tertiary channel areas:
- Dominant substrate type within riffle complex of cobble/boulder with intermixed gravel
- At least 35 percent cover in the form of boulders, stumps, dead trees and crevices
- Approximately 1:2:2 riffle/pool/gravel bar ratio
- Riffle water velocities of 1 to 2 ft/sec
- Pool depths greater than 6 ft

Secondary channel:
- Continue flows under average and normal high river flows to promote substrate and current velocity diversity and to maintain them as self-sustaining channel habitat
- Restore channel habitat where possible

- Restore river bank and associated diverse littoral habitat, important structural components of flowing main, secondary, and tertiary channels

5.39 MUSSELS

- See criteria for riverine fish
- Minimize construction related impacts on mussels
- Access for project construction should be limited to shallow draft vessels to minimize access dredging and/or access areas should be identified through additional mussel surveys as containing few to no mussels

5.310 LUCUSTRINE FISH

The conceptual models developed as part Upper Mississippi River System Ecosystem Restoration Objectives report (2009) provides a variety of recommendations on performance criteria for evaluating and planning lentic fish habitat restoration. The specific criteria were developed based on the experiences of State and Federal fishery biologists as to what would be desirable to provide suitable habitat for backwater fish species. Pertinent ones are summarized below.

a) Restore/maintain lentic fish habitat to yield desired fixed site electro-fishing catch per unit effort of age 1 plus fish in overwintering sites.

- Fair - Good:
  - 100 to 200 bluegills/hour
  - 50 to 100 largemouth bass/hour
- Good - Excellent:
  - 200 to 300 bluegills/hour
  - 100 to 150 largemouth bass/hour
- Excellent:
  - More than 300 bluegills/hour
  - More than 150 largemouth bass/hour

b) Aquatic vegetation cover in the range of 40 to 60 percent (summer) and 25 to 50 percent (winter) in off channel areas.

c) Water depth greater than 4 feet in 30 to 60 percent of the project area.

d) High quality overwintering areas less than 2 to 4 miles apart.

e) Substrates of sand and/or gravel available for spawning.

f) DO levels as measured at mid-depth:

- Spring/summer: greater than 5mg/l

- Winter: greater than 3 mg/l

g) Water temperature (winter):
   - 4 C over 35 percent of the area
   - 2 to 4 C over 30 percent of the area
   - 0 to 2 C over 35 percent of the area

h) Winter current velocity less than 0.3 cm/sec over 80 percent of the backwater lake area.

6. DEVELOPMENT AND EVALUATION OF ALTERNATIVES

Alternatives will be developed as groups of measures to protect and enhance habitat quality in Upper Lake Pepin and the Pierce County Islands Project Area.

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