Objectives, Performance Criteria, and Information Sources

Objectives and Performance Criteria for Each Geomorphic Reach

Geomorphic Reach 1

Geomorphic Reach 1 - SAF to Head of Lake Pepin Objectives	GR 1 Performance Criteria	Source of Information and Comments
Hydraulics & Hydrology: Manage for a more natural hydrologic regime		
A more natural stage hydrograph	Daily Variation: Reduce daily water surface elevation variation caused by lock and dam operation by 50%. Seasonal Variation On a periodic (e.g. one to two consecutive years in ten years) or permanent basis where feasible, maintain lower water levels starting as soon as possible following the spring flood through September 1st so that the following criteria are met: Low flow (75% exceedance) - wsel decreased 1' at lock and dams 2 and 3 Moderate flow (25% exceedance) - wsel decreased 2' at lock and dam 2 and 1' at lock and dam 3 High flow (2-year flood) - wsel decreased 2' at lock and dam 2 Decadal Variation: At ten to twenty year time intervals, increase the amount of drawdown for low flow conditions for one to two consecutive growing seasons to simulate longer-term cycles of drought to improve forest regeneration.	WSEL variation is based on a combination of ideas from the WLMTF of the RRF, the Upper Impounded Floodplain Reach Planning Team, and also by using pre-lock water surface profiles as a reference. The historic profiles indicate that for moderate flows, a 1' decrease at lock and dam 3 matches the pre-lock profiles, and that for high flows, the existing and pre-lock profiles match fairly well. Restoring decadal low flow cycles was suggested at the October 8th, 2009 Upper Impounded Floodplain Reach Planning Team Workshop. At the November 4th, 2009 workshop, the team decided that a ten to twenty year cycle may be appropriate.
Altered hydraulic connectivity	General: Alter hydraulic connectivity so that frequency, duration, magnitude, and timing of flow and resulting stage variation are within optimal limits for target biota and habitats. Specific: 1) Backwaters: Alter connectivity between backwaters and channels or between sub-areas within backwaters to reduce sediment and nutrient inputs 2) Impounded areas: Reduce hydraulic connectivity between historic floodplains and channels for total river discharges less than the two year flood to create contiguous backwaters, or isolated wetlands and floodplain lakes. 3) Vermillion River Bottoms: Eliminate flow from the Mississippi River to the Vermillion Bottoms for discharges lower than the 2-year flood event. 4) Lower tributary valleys: Increase connectivity so floodplains convey water for flood events greater than the 2-year recurrence interval. Tributary distributary channel connectivity should vary seasonally based on historic ranges. MCB and Secondary Channels Shear Stress Variation : Alter seasonal variation in connectivity to achieve desired shear stresses Low Flow Shear Stress Average = High Flow Shear Stress Average =	Connectivity performance criteria for deep water areas in backwaters developed by Upper Impounded Floodplain Reach Planning Team for conceptual modeling effort (April 09). Connectivity performance criteria for the Vermillion River Bottoms is based on discussion with Citizens Advisory Group convened as part of the Dakota County Soil and Water Conservation District, Mississippi Makeover Project. See http://www.dakotaswcd.org/wshd_missmak.html) Lower tributary valley hydraulic connectivity is being developed by the Upper Impounded Floodplain Reach Planning Team Shear Stress performance criteria for MCB and Secondary Channels developed by Upper Impounded Floodplain Reach Planning Team for Mussels conceptual model (April 09)
Biogeochemistry: Manage for processes that input, transport, assimilate, and output material within UMR basin river floodplains: e.g. water quality, sediments, and nutrients		
Improved water clarity	TSS (mg/L) - To achieve SAV targets, summer average TSS concentrations will need to be reduced about 32% (47 to 32 mg/L) from existing conditions based on the combined monitoring data for Locks and Dams 2 and 3. It is suggested that attainment be based on achieving a median and 90th percentile summer average TSS concentrations of 32 and 44 mg/L, respectively, based on combined bi-weekly monitoring at Locks and Dams 2 and 3. Achieve a Secchi depth based on June through September averages at lock and dam 3 and in Lake Pepin of 47 and 80 cm respectively by 2025. Backwaters: Achieve a Secchi depth of 80 cm for the June through September averages.	TSS performance criteria is based on the proposed site specific standard for the Lake Pepin Turbidity TMDL developed by the Minnesota Pollution Control Agency and the Wisconsin Department of Natural Resources (Sullivan, et al., 2009). As of June 2010, the proposed standard has been adopted by the Pollution Control Agency citizen board but still needs EPA approval. The 90th percentile was derived for main channel summer average data (1998-07) for Pool 13, a desirable reference pool that was used to derive the SAV targets. Achieving these TSS criteria will improve the conditions for SAV growth throughout the turbidity impaired reach and result in reduced sediment infilling of Lake Pepin. Secchi depth performance criteria for lock and dam 3 and Lake Pepin is based on Dakota County Soil and Water Conservation District, Mississippi Makeover Project Indicator Targets. See http://www.dakotaswcd.org/wshd_missmak.html) Secchi depth performance criteria for backwaters developed by Upper Impounded Floodplain Reach Planning Team for aquatic vegetation conceptual model (April 09)
Reduced nutrient loading	Reduce Phosporous loads to GR 1 by 2025. Minnesota River: 50% based on 19?? To 200? average Miss R u/s of TC: 20% based on 19?? To 200? average St. Croix River: 20% based on 19?? To 200? average Cannon River: 50% based on 19?? To 200? average Other Tributarie: 20% based on 19?? To 200? average From Scenario 17, Lake Pepin TMDL Study Backwater nutrient concentrations TP < 0.1 mg/L TN < 1.23 mg/L	Phosphorous load reduction performance criteria is from Scenario 17, Lake Pepin TMDL Study. Nutrient concentrations in backwaters are from Sullivan (2008) based on metaphyton report.

Geomorphic Reach 1 - SAF to Head of Lake Pepin Objectives	GR 1 Performance Criteria	Source of Information and Comments
Reduced sediment loading from tributaries and sediment resuspension in and loading to backwaters	Minimize Mississippi River sediment loading to the Vermillion River Bottoms for flows below the 2-year flood event. Reduce sediment loads to GR 1 L by 2025. Minnesota River: 50% from the 19?? To 200? average Miss R. u/s of TC: 20% from the 19?? To 200? average St. Croix River: 20% from the 19?? To 200? average Cannon River: 50% from the 19?? To 200? average Other Tributarie: 20% from the 19?? To 200? average	Sediment loading performance criteria for the Vermillion River Bottoms is based on discussion with Citizens Advisory Group convened as part of the Dakota County Soil and Water Conservation District, Mississisippi Makeover Project. See http://www.dakotaswcd.org/wshd_missmak.html) Sediment load reduction performance criteria is from Scenario 17, Lake Pepin TMDL Study.
Reduced contaminants loading and remobilization of in-place pollutants	Reduce contaminant loading and remobilization of contaminants to the point where fish are safe for humans to eat (Great Lakes standard).	
Geomorphology: Manage for processes that shape a physically diverse and dynamic river floodplain system		
Restore rapids	Restore ___acres of rapids habitat in the gorge by 2050 Water surface slopes should approach historic values. 1890s River Commision Maps indicated that water surface slopes gradually increase from 2.5 feet per mile in the lower half of the gorge to greater than 6.5 feet per mile in the upper quater of the gorge.	1890 Mississippi River Commission Maps used for water surface slopes (based on MDNR, S Johnson presentation to Mississippi Makeover CAG)
Restore a sediment transport regime so that transport, deposition, and erosion rates and geomorphic patterns are within acceptable limits	General: 1) Alter topography/bathymetry so that the frequency, duration, magnitude, and timing of flow and resulting stage variation are within optimal limits for target biota and habitats. 2) Achieve wind fetch criteria based on water depth in aquatic off-channel areas. Water Depth (ft) 1 2 3 4 Fetch (ft) 1500 3500 6000 9000 3) Substrate: Gravel size material should occur over 10% of MCB and secondary channels by 2050 4) Alter floodplain topography (e.g. Ridge and Swale), and soil conditions, to create optimal conditions for native tree growth. Specific: 1) Lower Pool 2 and Lower Pool 3: Decrease connectivity between existing deep water (greater than 4 feet deep) areas of backwaters and sediment sources to reduce sediment deposition and delta migration into these areas. 2) Lower Pool 2: Reduce connectivity between historic floodplains and channels for total river discharges less than the two year flood to create contigous backwaters, or isolated wetlands and floodplain lakes. 3) Vermillion River Bottoms: Eliminate connections from the Mississippi River to the Vermillion Bottoms for discharges lower than the 2-year flood event. 4) Lower tributary valleys: Floodplains and delta should be a sink for sediments. Tributary distributary channels should convey sediments to the delta fan.	Substrate criteria was developed by Upper Impounded Floodplain Reach Planning Team for conceptual modeling effort (April 09).
Habitat: Manage for a diverse and dynamic pattern of habitats to support native biota		
Restored habitat connectivity	Provide year-round fish passage for native migratory fishes through Locks and Dams 2 and 3 by 2025. Improve the longitudinal distribution of waterfowl habitat to shorten the flight distance between "stepping stones" of preferred habitat during the fall migration. Maintain existing, and where needed, create new terrestrial corridors and connectivity of native vegetation communities. Restore lateral habitat connectivity between channels and floodplain where altered by levees, railroads, and bank revetment.	
Restored riparian habitat	Restore >50% of the length of currently armored or stabilized river bank to natural channel border and riparian zone habitat by 2060. Impounded areas, Lower Pool 2: Restore natural levees that are permanently inundated to create riparian habitat	Riparian habitat restoration performance criteria developed by Upper Impounded Floodplain Reach Planning Team for conceptual modeling effort (April 09).

Geomorphic Reach 1 - SAF to Head of Lake Pepin Objectives	GR 1 Performance Criteria	Source of Information and Comments
Restored aquatic off-channel areas	Isolated wetlands and floodplain lakes: Maintain or create a spatial distribution and physical characterisitcs approaching the following criteria Parameter Bluegills Largemouth Bass Size >10 ac >10 ac Depth > 4' in 30 to 60% of lake > 6' in 40 to 70% of lake Distribution 1 to 6 per square mile 1 to 4 per 2,000 acres of floodplain Total Area > 10% of aquatic area > 10% of aquatic area Quality Areas < 2 miles apart < 4 miles apart Habitat Connectivity 80% of lakes accessable 80% of lakes accessable Hydraulic Connectivity LHC approaches zero for flow less than the 2-year flood Additional physical requirements based on the needs of lentic fish can be found in the TAB labeled "Lentic Fish" that is part of this excel file. Backwaters: 1) Restore hydraulic and sediment transport conditions in existing backwaters to desired range of variation 2) Decrease connectivity between existing deep water (greater than 4 feet deep) areas of backwaters and sediment sources to reduce sediment deposition and delta migration into these areas. Impounded areas, Lower Pool 2: Restore areas that are permanently inundated to a desired pattern of contigous backwaters, isolated wetlands, floodplain lakes. Vermillion River Bottoms: Restore hydraulic and sediment transport conditions in the Vermillion River Bottoms to desired range of variation Achieve wind fetch criteria based on water depth in aquatic off-channel areas. Water Depth (ft) 1 2 3 4 Fetch (ft) 1500 3500 6000 9000	Isolated wetland and floodplain lake performance criteria developed by Upper Impounded Floodplain Reach Planning Team for conceptual modeling effort (April 09). Wind fetch criteria was developed by the NESP Pool 5 Ecosystem Restoration Team (May 06)
Restored terrestrial floodplain areas	Alter topography (e.g. Ridge and Swale), surface and ground water seasonal variations, and soil conditions, to create optimal conditions for native tree growth. Hydraulic Connectivity - Alter hydraulic connectivity so that frequency, duration, magnitude, and timing of flow and resulting stage variation are within optimal limits for desired floodplain vegetation community structure. Habitat Connectivity - See Habitat Connectivity Objective above.	These are some basic concepts discussed by the NESP Lock and Dam 8 Embankment Team at the 9/28&29/09 HGM workshop in New Albin, IA. Habitat Connectivity criteria added based on comments from 11/4/09 reach planning team meeting
Restored channel areas	Impounded areas, Lower Pool 2: Restore secondary channels that are permanently inundated to desired hydraulic and geomorphic conditions Secondary Channel Characteristics: 2 < vc < 3 fps for 5% duration event .5 < vc < 1.5 fps for 75% duration event dc > 5 feet for 75% duration event Substrate: Rock/gravel 5% wood 5% Secondary Channel Dimension, pattern, profile result in transport of sediment to delta area or to outlet of secondary channel reach. Lower tributary valleys: Tributary distributary channel connectivity should vary seasonally based on historic ranges.	Substrate criteria was developed by Pool 5 Ecosystem Restoration Team for secondary channels (May 06)
Biota: Manage for viable populations of native species within diverse plant and animal communities		
Diverse and abundant native aquatic vegetation communities (SAV, EAV, R/F)	SAV in MCB: Increase the frequency of occurrence to >21% in the MCB areas based on the EMAP sampling protocol (this corresponds to a frequency of occurrence of > 12% using the LTRMP sampling protocol). Increase species richness (maximum # of species) to 11. SAV in Backwaters: Increase the frequency of occurrence to >49% in the Contiguous Backwaters based on the LTRMP sampling protocol. EAV in Backwaters: Increase the spatial extent of EAV Spatial coverage performance criteria for lentic fish: Summer: Aquatic vegetation cover in the range of 40-60% of off - channel areas. Winter: Aquatic vegetation cover in the range of 25-50%. Spatial coverage performance criteria for lotic fish Increase coverage in MCB and secondary channels to 10% of area	SAV in MCB and Backwaters performance criteria is based on the proposed site specific standard for the Lake Pepin Turbidity TMDL developed by Sullivan et al., 2009. As of June 2010, the Pollution Control Agency citizen board has recommended adopting the site specific standards for TSS and submersed aquatic vegetation for the Lake Pepin TMDL. This still needs EPA approval. SAV in MCB species richness based on Indicator Targets set by the Dakota County Soil and Water Conservation District, Mississsissippi Makeover Project. See http://www.dakotaswcd.org/wshd_missmak.html SAV and EAV frequency of occurrence and spatial extent criteria in backwaters is being developed by Upper Impounded Floodplain Reach Planning Team for aquatic vegetation Spatial coverage performance criteria for lentic fish developed by Upper Impounded Floodplain Reach Planning Team for lentic fish conceptual model (April 09) Spatial coverage performance criteria for lotic fish developed by Upper Impounded Floodplain Reach Planning Team for lotic fish conceptual model (April 09)
Diverse and abundant native floodplain forest and prairie communities	See Environmental Pool Plans for acres and distribution of Floodplain forests and grasslands Species diversity: Increase the area with at least 5 Dutch Elm desease resistant trees per acre by ______ acres by 2020 Reduce area dominated by reed canary grass by _____ acres by 2020 Restore >50% of the length of currently armored or stabilized river bank to natural channel border and riparian zone habitat by 2060.	See Environmental Pool Plans See NESP Systemic Forest Management Plan which is being developed by the the NESP Forest Management Project PDT for more information. Floodplain forest performance criteria was developed by the NESP Lock and Dam 8 Embankment Team with input from members of the NESP forestry team (December 08). Riparian habitat restoration performance criteria developed by Upper Impounded Floodplain Reach Planning Team for conceptual modeling effort (April 09).

Geomorphic Reach 1 - SAF to Head of Lake Pepin Objectives	GR 1 Performance Criteria	Source of Information and Comments
Diverse and abundant native fish community	Conditions will vary from year to year. Electrofishing CPUE variation for lentic and lotic fish are given below. <u>Lentic Fish Electrofishing catch per unit effort</u> Fair - good: 100-200 bluegills/hour 50 - 100 largemouth bass/hour Good - Excel: 200-300 bluegills/hour 100-150 Largmouth bass/hour Excellent: >300 bluegills/hour >150 largemouth bass/hour <u>Lotic Fish CPUE:</u> Fair - good: 40-70 YOY walleye &/or sauger/hour (calculated CPUE)? Carp biomass is greater than or equal to 50% catch in MC or MCB, Redhorse/Sucker CPUE is less than ?% Good - Excel: 70 - 100 YOY walley &/or sauger /hour (calculated CPUE)? Carp biomass is between 25% and 50%, Redhorse/Sucker CPUE is between ?% and ?% Excellent: >100 YOY walleye &/or sauger /hour (calculated CPUE)? Carp biomass less than 25% of catch in MC or MCB, Redhorse/Sucker CPUE is = or greater than ?%	The Lentic and Lotic Fish Performance Criteria was developed by Upper Impounded Floodplain Reach Planning Team for conceptual modeling effort (April 09).
Diverse and abundant native mussel community	Existing Year 2025 Catch/unit effort (% sites with > 10/min) 5 10 Catch/unit effort (% sites with < 1/min) 33 20 Species richness (# species) 28 35 Mucket mussel (% of population) 0 1 From Grier, 1920 Pools 5,6, Mucket Mussels =8% Mussel Performance Criteria from Conceptual Models: • Species Richness: 17 to 42 by sub-area • Composition: Habitat generalist, lentic, and tolerant species <40% of community • Abundance: Pool-wide >4 unionds/meter2 • Mussel Beds: >10 unionds/meter2 • Mussel Beds: every 2 miles, covering 5% of aquatic area. Zebra mussels < 10/m2 by 2010	The Mussel Performance Criteria is from the Dakota County Soil and Water Conservation District, Mississsissippi Makeover Project Indicator Targets. See http://www.dakotaswcd.org/wshd_missmak.html The Mussel Performance Criteria from conceptual models was developed by Upper Impounded Floodplain Reach Planning Team for conceptual modeling effort (April 09). Interagency mussel team needs to decide on parameters that are important and format for listing them.
Diverse and abundant native bird community	General Use-day objectives can be adapted from regional goals established under the North American Waterfowl Management Plan, Upper Mississippi River - Great Lakes Region Joint Venture. Improve longitudinal distribution within the reach of habitat so that waterfowl use-days in each pool are proportional to the aquatic area of the pool. Diving Ducks: Improve the longitudinal distribution during the fall migration to: - shorten the flight distance between "stepping stones" of preferred habitat. - improve hunting and bird-watching opportunities throughout the reach. - decrease the potential negative effects of local crashes in habitat (aquatic beds - SAV), accidentental contaminant spills, and disease outbreaks Puddle Ducks: Provide secure SAV, PEAV, within favorable patterns of bathymetric diversity. 70% of area is open water with submersed beds. Depths vary from 1 inch to 4 feet; provides seasonal use: BWTeal and wigeon early; mallard, GWTeal, gadwall mid to late season. 30% of area PEAV: wild rice, arrowhead, bulrush. • Distance to forest is <1-5 miles. Forest contains silver maple, oak, ash, elm. Area floods to some extent each fall. Forested area contains pockets (0.1 to 1.0 acres) of moist soil and emergent plants also subject to flooding. • Distance to cropland is <1-10 miles and harvested fields contain some residue • Provide secure habitat (closed areas) along the floodplain at 5-15 mile intervals in Reach 1 (need to evaluate this further). • Improve north/south distribution of puddle ducks by securing habitat at appropriate intervals, creating "stepping stones" of habitat, the length of the geomorphic reach. This will enhance opportunities for migrating birds to rest and feed, as well as enhance hunting opportunities, and decrease potential negative effects of crashes in habitat, accidental spills, and disease outbreaks. Minimize human activity in optimal feeding and resting habitat.	Waterfowl criteria were developed by a group of waterfowl specialists from the Fish and Wildlife Workgroup in March 09, and then was used by the Upper Impounded Floodplain Reach Planning Team for conceptual modeling effort (April 09). The criteria were developed for Geomorphic Reach 3, but apply, with modification, to Geomorphic Reach 1 Waterfowl surveys in Geomorphic Reach 1 began in Fall 2009.

Geomorphic Reach 2

Geomorphic Reach 2 - Lake Pepin Objectives	GR 2 Performance Criteria	Source of Information and Comments
Hydraulics & Hydrology: Manage for a more natural hydrologic regime		
Biogeochemistry: Manage for processes that input, transport, assimilate, and output material within UMR basin river floodplains: e.g. water quality, sediments, and nutrients		
Improved water clarity	Achieve a Secchi depth based on June through September averages in Lake Pepin of 80 cm respectively by 2025.	Secchi depth performance criteria for Lake Pepin is based on Dakota County Soil and Water Conservation District, Missississippi Makeover Project Indicator Targets. See http://www.dakotaswcd.org/wshd_missmak.html)
Reduced nutrient loading	Reduce Phosporous loads to GR 1 (and subsequently to Lake Pepin) by 2025. Minnesota River: 50% based on 19?? To 200? average Miss R u/s of TC: 20% based on 19?? To 200? average St. Croix River: 20% based on 19?? To 200? average Cannon River: 50% based on 19?? To 200? average Other Tributarie: 20% based on 19?? To 200? average From Scenario 17, Lake Pepin TMDL Study	Phosphorous load reduction performance criteria is from Scenario 17, Lake Pepin TMDL Study.
Reduced sediment loading from tributaries and sediment resuspension in and loading to backwaters	Reduce sediment loads to GR 1 (and subsequently to Lake Pepin) by 2025. Minnesota River: 50% from the 19?? To 200? average Miss R. u/s of TC: 20% from the 19?? To 200? average St. Croix River: 20% from the 19?? To 200? average Cannon River: 50% from the 19?? To 200? average Other Tributarie: 20% from the 19?? To 200? average	Sediment load reduction performance criteria is from Scenario 17, Lake Pepin TMDL Study.
Geomorphology: Manage for processes that shape a physically diverse and dynamic river floodplain system		
Restore a sediment transport regime so that transport, deposition, and erosion rates and geomorphic patterns are within acceptable limits	Lake Pepin: Reduce sediment accumulation amount from the existing rate of 865,000 metric tons per year to an interim target (by 2015) of 683,000 tons per year and a long-range target (by 2025) of 500,000 tons per year . Based on recommended targets from the Lake Pepin TMDL and the Mississippi Makeover.	Lake Pepin sediment accumulation performance criteria is based on Dakota County Soil and Water Conservation District, Mississississippi Makeover Project Indicator Targets. See http://www.dakotaswcd.org/wshd_missmak.html)
Habitat: Manage for a diverse and dynamic pattern of habitats to support native biota		
Biota: Manage for viable populations of native species within diverse plant and animal communities		
Diverse and abundant native fish community	Lentic Fish Electrofishing catch per unit effort Fair - good: 100-200 bluegills/hour 50 - 100 largemouth bass/hour Good - Excel: 200-300 bluegills/hour 100-150 Largmouth bass/hour Excellent: >300 bluegills/hour >150 largemouth bass/hour Lotic Fish CPUE: Fair - good: 40-70 YOY walleye &/or sauger/hour (calculated CPUE)? Carp biomass is greater than or equal to 50% catch in MC or MCB, Redhorse/Sucker CPUE is less than ?% Good - Excel: 70 - 100 YOY walley &/or sauger /hour (calculated CPUE)? Carp biomass is between 25% and 50%, Redhorse/Sucker CPUE is between ?% and ?% Excellent: >100 YOY walleye &/or sauger /hour (calculated CPUE)? Carp biomass less than 25% of catch in MC or MCB, Redhorse/Sucker CPUE is = or greater than ?%	The Lentic and Lotic Fish Performance Criteria was developed by Upper Impounded Floodplain Reach Planning Team for conceptual modeling effort (April 09). Additional information can be found in the Lentic and Lotic Fish Critiera TABS at the bottom of this file.

Geomorphic Reach 2 - Lake Pepin Objectives	GR 2 Performance Criteria	Source of Information and Comments
Diverse and abundant native mussel community	Existing Year 2025 Catch/unit effort 5 10 (% sites with > 10/min) Catch/unit effort 33 20 (% sites with < 1/min) Species richness 28 35 (# species) Mucket mussel 0 1 (% of population) From Grier, 1920 Pools 5,6, Mucket Mussels =8% Mussel Performance Criteria from Conceptual Models: • Species Richness: 17 to 42 by sub-area • Composition: Habitat generalist, lentic, and tolerant species <40% of community • Abundance: Pool-wide >4 unionds/meter2 • Mussel Beds: >10 unionds/meter2 • Mussel Beds: every 2 miles, covering 5% of aquatic area. Zebra mussels < 10/m2 by 2010	The Performance Criteria for Mussels for Lake Pepin needs to be updated. GR 1 performance criteria is listed here as a placeholder. The Mussel Performance Criteria is from the Dakota County Soil and Water Conservation District, Mississsissippi Makeover Project Indicator Targets. See http://www.dakotaswcd.org/wshd_missmak.html The Mussel Performance Criteria was developed by Upper Impounded Floodplain Reach Planning Team for conceptual modeling effort (April 09)
Diverse and abundant native bird community	General Improve longitudinal distribution within the reach of habitat so that waterfowl use-days in each pool are proportional to the aquatic area of the pool. Use-day objectives can be adapted from regional goals established under the North American Waterfowl Management Plan, Upper Mississippi River - Great Lakes Region Joint Venture. Diving Ducks: Improve the longitudinal distribution during the fall migration to: - shorten the flight distance between "stepping stones" of preferred habitat. - improve hunting and bird-watching opportunities throughout the reach. - decrease the potential negative effects of local crashes in habitat (aquatic beds - SAV), accidentental contaminant spills, and disease outbreaks Puddle Ducks: Provide secure SAV, PEAV, within favorable patterns of bathymetric diversity. 70% of area is open water with submersed beds. Depths vary from 1 inch to 4 feet; provides seasonal use: BWTeal and wigeon early; mallard, GWTeal, gadwall mid to late season. 30% of area PEAV: wild rice, arrowhead, bulrush. • Distance to forest is <1-5 miles. Forest contains silver maple, oak, ash, elm. Area floods to some extent each fall. Forested area contains pockets (0.1 to 1.0 acres) of moist soil and emergent plants also subject to flooding. • Distance to cropland is <1-10 miles and harvested fields contain some residue • Provide secure habitat (closed areas) along the floodplain at 5-15 mile intervals in Reach 1 (need to evaluate this further). • Improve north/south distribution of puddle ducks by securing habitat at appropriate intervals, creating “stepping stones” of habitat, the length of the geomorphic reach. This will enhance opportunities for migrating birds to rest and feed, as well as enhance hunting opportunities, and decrease potential negative effects of crashes in habitat, accidental spills, and disease outbreaks. Minimize human activity in optimal feeding and resting habitat.	The Performance Criteria for Waterfowl for Lake Pepin needs to be updated. GR 1 performance criteria is listed here as a placeholder. Waterfowl criteria were developed by a group of waterfowl specialists from the Fish and Wildlife Workgroup in March 09, and then was used by the Upper Impounded Floodplain Reach Planning Team for conceptual modeling effort (April 09).

Geomorphic Reaches 3 & 4

Geomorphic Reach 3 & 4 - Foot of Lake Pepin to Lock and Dam 13	GR 3 & 4 Performance Criteria	Source of Information and Comments
Hydraulics & Hydrology: Manage for a more natural hydrologic regime		
A more natural stage hydrograph	Daily Variation: Reduce daily water surface elevation variation caused by lock and dam operation by 50%. Seasonal Variation: On a periodic (e.g. one to two consecutive years in ten years) or permanent basis where feasible, maintain lower water levels starting as soon as possible following the spring flood through September 1st. A comparison of pre-lock to post-lock water surface elevations (1912 vertical datum) and the resulting increase in wsel at each dam in GR 3 & 4 for moderate flow conditions (25% exceedance) is as follows: Lock and Dam 4 5 5A 6 7 8 9 10 11 12 13 Pre-Lock 663.9 655.4 650.2 643.0 636.4 626.2 617.1 609.1 Post-Lock 666.5 659.5 650.0 644.5 639.0 630.0 619.0 610.0 Increase (ft) 1.6 4.1 -0.2 1.5 2.6 3.8 1.9 0.9 Decadal Variation: At ten to twenty year time intervals, increase the amount of drawdown for low flow conditions for one to two consecutive growing seasons to simulate longer-term cycles of drought to improve forest regeneration.	WSEL variation will be based on a combination of ideas from the WLMTF of the RRF, the Upper Impounded Floodplain Reach Planning Team. A comparison of pre-lock to post-lock water surface elevations (shown here for moderate flows), provides some guidance however criteria will have to be developed by PDTs for each lock and dam based on opportunities and constraints. Restoring decadal low flow cycles was suggested at the October 8th, 2009 Upper Impounded Floodplain Reach Planning Team Workshop
Altered hydraulic connectivity	Backwaters: Decrease connectivity between existing deep water (greater than 4 feet deep) areas of backwaters and sediment sources to reduce sediment deposition and delta migration into these deep areas. Alter hydraulic connectivity between channels and backwaters to restore more desirable hydraulic conditions. Impounded areas: Reduce hydraulic connectivity between historic floodplains and channels for total river discharges less than the two year flood to create contiguous backwaters, or isolated wetlands and floodplain lakes. Lower tributary valleys: Increase connectivity so floodplains convey water for flood events greater than the 2-year recurrence interval. Tributary distributary channel connectivity should vary seasonally based on historic ranges. MCB and Secondary Channels Shear Stress Variation : Alter seasonal variation in connectivity to achieve desired shear stresses Low Flow Shear Stress Average = High Flow Shear Stress Average =	Connectivity performance criteria for deep water areas in backwaters developed by Upper Impounded Floodplain Reach Planning Team for conceptual modeling effort (April 09). Lower tributary valley hydraulic connectivity is being developed by the Upper Impounded Floodplain Reach Planning Team in coordination with the NESP floodplain restoration team. Shear Stress performance criteria for MCB and Secondary Channels developed by Upper Impounded Floodplain Reach Planning Team for Mussel conceptual model (April 09)
Biogeochemistry: Manage for processes that input, transport, assimilate, and output material within UMR basin river floodplains: e.g. water quality, sediments, and nutrients		
Improved water clarity	Main Channel Borders: Average TSS < 30 mg/L during June-Sept Backwaters: Suggested Performance Criteria for Contiguous Backwaters for Reach 3 (Chippewa River to Wisconsin River) SAV frequency of occurrence > 50% and < 85% (LTRMP Sampling Design) This implies water depths < 2.5 meters. An upper limit is suggested to minimize hypoxia problems and to provide more diverse fish and aquatic life habitat. Average TSS < 20 mg/L during June-Sept. This is roughly equivalent to a Secchi transparency of > 0.6 meters. Average Gross Sedimentation Rate < 200 g/m^2/day during June-September using cylindrical traps with an aspect ratio (height/diameter) of 6/1. Sediment traps provide a means for integrating ambient TSS levels over time and provide a way for evaluating sediment resuspension problems other sources contributing to TSS.	UMRCC water quality criteria, 2002 Backwater Water Clarity Criteria was provided by John Sullivan, WDNR-Lax in a 11/05/09 email following the 11/04/09 reach planning team meeting. An SAV frequency of occurrence was established first and this was used to establish TSS and Average Gross Sedimentation Rate criteria. This is based on the following data sources: - LTRMP SAV data of backwater strata from lower Pool 4, Pool 8 and Pool 13. - Weaver Bottoms monitoring from 1986 to 2008 by USFWS, WDNR, USCOE and LTRMP (MDNR). - SAV Target report for Lake Pepin TMDL (Sullivan et al. 2008). Note: At the 11/04/09 reach planning team meeting it was noted that seasonal (primarily Spring) variation in water clarity should be addressed also. Seasonal criteria has not been developed at this time.
Reduced nutrient loading	Reduce Nitrogen loads from GR 3 by 40% to meet Gulf Hypoxia Task Force objectives by 2050. Backwater nutrient concentrations June through September average TP < 0.1 mg/L TN < 1.23 mg/L	Gulf Hypoxia Task Force objectives Nutrient concentrations in backwaters are from Sullivan (2008) based on metaphyton work.
Reduced sediment loading from tributaries and sediment resuspension in and loading to backwaters	Reduce sediment resuspension in backwaters so that the average Gross Sedimentation Rate < 200 g/m^2/day during June-September using cylindrical traps with an aspect ratio (height/diameter) of 6/1. Sediment traps provide a means for integrating ambient TSS levels over time and provide a way for evaluating sediment resuspension problems other sources contributing to TSS. Reduce sediment loads to GR 3 by 2025. Base this on existing tributary sediment loads	Gross sedimentation rate criteria was provided by John Sullivan, WDNR-Lax in a 11/05/09 email following the 11/04/09 reach planning team meeting. An SAV frequency of occurrence was established first and this was used to establish TSS and Average Gross Sedimentation Rate criteria. This is based on the following data sources: - LTRMP SAV data of backwater strata from lower Pool 4, Pool 8 and Pool 13. - Weaver Bottoms monitoring from 1986 to 2008 by USFWS, WDNR, USCOE and LTRMP (MDNR). - SAV Target report for Lake Pepin TMDL (Sullivan et al. 2008).
Geomorphology: Manage for processes that shape a physically diverse and dynamic river floodplain system		

Geomorphic Reach 3 & 4 - Foot of Lake Pepin to Lock and Dam 13	GR 3 & 4 Performance Criteria	Source of Information and Comments
Restore a sediment transport regime so that sediment transport rates and future change in geomorphic patterns are within acceptable limits	Lower Pool 4 through Pool 13: Decrease connectivity between existing deep water (greater than 4 feet deep) areas of backwaters and sediment sources to reduce sediment deposition and delta migration into these areas. Lower tributary valleys: Floodplains and delta should be a sink for coarse grained sediments. Tributary distributary channels should convey sediments to the delta fan. Substrate: Increase substrate variation in main channel border areas.	Substrate criteria will be developed by Upper Impounded Floodplain Reach Planning Team
Habitat: Manage for a diverse and dynamic pattern of habitats to support native biota		
Restored habitat connectivity	Provide year-round fish passage for native migratory fishes through Locks and Dams by 2025. Maintain existing terrestrial corridors and connectivity of native vegetation communities. Restore lateral habitat connectivity between channels and floodplain where altered by levees, railroads, and bank revetment.	
Restored riparian habitat	Restore >50% of the length of currently armored or stabilized river bank to natural channel border and riparian zone habitat by 2060. Impounded areas: Reduce lateral hydraulic connectivity between historic floodplains and channels for total river discharges less than the two year flood to create riparian habitat.	Riparian habitat restoration performance criteria developed by Upper Impounded Floodplain Reach Planning Team for conceptual modeling effort (April 09).
Restored aquatic off-channel areas	Isolated wetlands and floodplain lakes: Maintain or create a spatial distribution and physical characterisitcs approaching the following criteria Parameter Bluegills Largemouth Bass Size >10 ac >10 ac Depth > 4' in 30 to 60% of lake > 6' in 40 to 70% of lake Distribution 1 to 6 per square mile 1 to 4 per 2,000 acres of floodplain Total Area > 10% of aquatic area > 10% of aquatic area Quality Areas < 2 miles apart < 4 miles apart Habitat Connectivity 80% of lakes accessable 80% of lakes accessable Hydraulic Connectivity LHC approaches zero for flow less than the 2-year flood Additional physical requirements based on the needs of lentic fish can be found in the TAB labeled "Lentic Fish" that is part of this excel file. Backwaters: Decrease connectivity between existing deep water (greater than 4 feet deep) areas of backwaters and sediment sources to reduce sediment deposition and delta migration into these areas. Impounded areas: Reduce lateral hydraulic connectivity between historic floodplains and channels for total river discharges less than the two year flood to create contigous backwaters, or isolated wetlands and floodplain lakes. Achieve wind fetch criteria based on water depth in aquatic off-channel areas. Water Depth (ft) 1 2 3 4 Fetch (ft) 1500 3500 6000 9000	Isolated wetland and floodplain lake performance criteria developed by Upper Impounded Floodplain Reach Planning Team for conceptual modeling effort (April 09).
Restored terrestrial floodplain areas	Alter topography (e.g. Ridge and Swale), surface and ground water seasonal variations, and soil conditions, to create optimal conditions for native tree growth. Hydraulic Connectivity - Connectivity should be altered so that duration of overtopping suits desired community structure. Habitat Connectivity - Maintain a contiguous corridor of native vegetation communities.	These are some basic concepts discussed by the NESP Lock and Dam 8 Embankment Team at the 9/28&29/09 Hydrogeomorphic Modeling workshop in New Albin, IA.
Restored channel areas	Impounded areas: Reduce lateral hydraulic connectivity between historic floodplains that are now submerged and channels for total river discharges less than the two year flood to create secondary channel habitat. Lower tributary valleys: Tributary distributary channel connectivity should vary seasonally based on historic ranges. Secondary Channel Characteristics: 2 < vc < 3 fps for 5% duration event .5 < vc < 1.5 fps for 75% duration event dc > 5 feet for 75% duration event Substrate: Rock/gravel 5% wood 5% Dimension, pattern, profile of secondary channels result in transport of sediment to delta area or to outlet of secondary channel reach.	Substrate criteria was developed by Pool 5 Ecosystem Restoration Team for secondary channels (May 06)
Biota: Manage for viable populations of native species within diverse plant and animal communities		

Geomorphic Reach 3 & 4 - Foot of Lake Pepin to Lock and Dam 13	GR 3 & 4 Performance Criteria	Source of Information and Comments
Diverse and abundant native aquatic vegetation communities (SAV, EAV, R/F)	SAV in Backwaters: Suggested Performance Criteria for Contiguous Backwaters for Reach 3 (Chippewa River to Wisconsin River) SAV frequency of occurrence > 50% and < 85% (LTRMP Sampling Design) This implies water depths < 2.5 meters. An upper limit is suggested to minimize hypoxia problems and to provide more diverse fish and aquatic life habitat. EAV in Backwaters: Increase the spatial extent of EAV to >_____acres with >___ species richness and community Shannon diversity index > ____by 2025. Spatial coverage performance criteria for lentic fish: Summer: Aquatic vegetation cover in the range of 40-60% of off - channel areas. Winter: Aquatic vegetation cover in the range of 25-50%. Spatial coverage performance criteria for lotic fish Increase coverage in MCB and secondary channels to 10% of area	SAV Criteria was provided by John Sullivan, WDNR-Lax in a 11/05/09 email following the 11/04/09 reach planning team meeting. An SAV frequency of occurrence was established first and this was used to establish TSS and Average Gross Sedimentation Rate criteria which are performance criteria for water clarity. This is based on the following data sources: - LTRMP SAV data of backwater strata from lower Pool 4, Pool 8 and Pool 13. - Weaver Bottoms monitoring from 1986 to 2008 by USFWS, WDNR, USCOE and LTRMP (MDNR). - SAV Target report for Lake Pepin TMDL (Sullivan et al. 2008). EAV in backwaters is being developed by Upper Impounded Floodplain Reach Planning Team Spatial coverage performance criteria for lentic fish developed by Upper Impounded Floodplain Reach Planning Team for lentic fish conceptual model (April 09) Spatial coverage performance criteria for lotic fish developed by Upper Impounded Floodplain Reach Planning Team for lotic fish conceptual model (April 09)
Diverse and abundant native floodplain forest and prairie communities	See Environmental Pool Plans for acres and distribution of Floodplain forests and grasslands Species diversity: Increase the area with at least 5 Dutch Elm desease resistant trees per acre by ______ acres by 2020 Reduce area dominated by reed canary grass by _____ acres by 2020 Restore >50% of the length of currently armored or stabilized river bank to natural channel border and riparian zone habitat by 2060.	See Environmental Pool Plans See NESP Systemic Forest Management Plan which is being developed by the the NESP Forest Management Project PDT for more information. See Reno Bottoms HGM report (Heitmeyer, et al. 2009) Floodplain forest performance criteria was developed by the NESP Lock and Dam 8 Embankment Team with input from members of the NESP forestry team (December 08). Riparian habitat restoration performance criteria developed by Upper Impounded Floodplain Reach Planning Team for conceptual modeling effort (April 09).
Diverse and abundant native fish community	Conditions will vary from year to year. Electrofishing CPUE variation for lentic and lotic fish are given below. <u>Lentic Fish (Late Fall) Electrofishing catch per unit effort</u> Fair - good: 100-200 bluegills/hour 50 - 100 largemouth bass/hour Good - Excel: 200-300 bluegills/hour 100-150 Largmouth bass/hour Excellent: >300 bluegills/hour >150 largemouth bass/hour <u>Lotic Fish CPUE:</u> Fair - good: 40-70 YOY walleye &/or sauger/hour (calculated CPUE)? Carp biomass is greater than or equal to 50% catch in MC or MCB, Redhorse/Sucker CPUE is less than ?% Good - Excel: 70 - 100 YOY walley &/or sauger /hour (calculated CPUE)? Carp biomass is between 25% and 50%, Redhorse/Sucker CPUE is between ?% and ?% Excellent: >100 YOY walleye &/or sauger /hour (calculated CPUE)? Carp biomass less than 25% of catch in MC or MCB, Redhorse/Sucker CPUE is = or greater than ?%	The Lentic and Lotic Fish Performance Criteria was developed by Upper Impounded Floodplain Reach Planning Team for conceptual modeling effort (April 09). Additional information can be found in the Lentic and Lotic Fish Critiera TABS at the bottom of this file.
Diverse and abundant native mussel community	Existing / Year 2025 Catch/unit effort (% sites with > 10/min): 5 / 10 Catch/unit effort (% sites with < 1/min): 33 / 20 Species richness (# species): 28 / 35 Mucket mussel (% of population): 0 / 1 From Grier, 1920 Pools 5,6, Mucket Mussels =8% Mussel Performance Criteria from Conceptual Models: • Species Richness: 17 to 42 by sub-area • Composition: Habitat generalist, lentic, and tolerant species <40% of community • Abundance: Pool-wide >4 unionds/meter2 • Mussel Beds: >10 unionds/meter2 • Mussel Beds: every 2 miles, covering 5% of aquatic area. Zebra mussels < 10/m2 by 2015 At the 09Sept10 ADH/CASM Workshop, Mike Davis said that bottom stability was the most important factor affecting whether mussels were present or not. Substrate size wasn't as big a deal. Though Chuck T earlier said tat Ziglers mussel model suggested that mixed grain size substrate was included in the model.	The Mussel Performance Criteria is from the Dakota County Soil and Water Conservation District, Missississippi Makeover Project Indicator Targets for Geomorphic Reach 1. See http://www.dakotaswcd.org/wshd_missmak.html The Mussel Performance Criteria from conceptual models was developed by Upper Impounded Floodplain Reach Planning Team for conceptual modeling effort (April 09). Mussel team needs to decide on parameters that are important and the format for listing them.

Geomorphic Reach 3 & 4 - Foot of Lake Pepin to Lock and Dam 13	GR 3 & 4 Performance Criteria	Source of Information and Comments
Diverse and abundant native bird community	General Improve longitudinal distribution within the reach of habitat so that waterfowl use-days in each pool are proportional to the aquatic area of the pool. Use-day objectives can be adapted from regional goals established under the North American Waterfowl Management Plan, Upper Mississippi River - Great Lakes Region Joint Venture. Diving Ducks: Improve the longitudinal distribution during the fall migration to: - shorten the flight distance between "stepping stones" of preferred habitat. - improve hunting and bird-watching opportunities throughout the reach. - decrease the potential negative effects of local crashes in habitat (aquatic beds - SAV), accidentental contaminant spills, and disease outbreaks Puddle Ducks: Provide secure SAV, PEAV, within favorable patterns of bathymetric diversity. 70% of area is open water with submersed beds. Depths vary from 1 inch to 4 feet; provides seasonal use: BWTeal and wigeon early; mallard, GWTeal, gadwall mid to late season. 30% of area PEAV: wild rice, arrowhead, bulrush. • Distance to forest is <1-5 miles. Forest contains silver maple, oak, ash, elm. Area floods to some extent each fall. Forested area contains pockets (0.1 to 1.0 acres) of moist soil and emergent plants also subject to flooding. • Distance to cropland is <1-10 miles and harvested fields contain some residue • Provide secure habitat (closed areas) along the floodplain at 5-15 mile intervals in Reach 1	Waterfowl criteria were developed by a group of waterfowl specialists from the Fish and Wildlife Workgroup in March 09, and then was used by the Upper Impounded Floodplain Reach Planning Team for conceptual modeling effort (April 09).

Draft Project Proposals

1.3 Considerations in Identifying the [Name] Restoration Project Area

Upper Iowa River Delta Project

1.4 Potential Project Sponsor

Iowa Department of Natural Resources
Upper Mississippi River Fish and Wildlife Refuge

2. Location

River UMR
River miles 671.3
States Iowa
Counties Allamakee
Sub-area Upper Iowa Delta
Map

3. Significant Resources

Infrastructure
Cultural resources
Important and Unique Ecological Resources
T&E Species

4. Problem Identification

The Upper Iowa River was an important element in the formation of the complex of braided channels and other wetlands located in the vicinity of the areas that currently can be found in the top end of Lansing Big Lake, Pool Slough, Minnesota Slough, New Albin Duck Lake, Conway Lake, Big Slough, Little Slough and Shore Slough.

4.1 Historic Conditions

The Upper Iowa was channelized in the late 1920's. Several old channels still exist (shore slough, big slough, and upper Lansing big lake). The area used to consist of areas of braided channels, isolated and permanent wetlands, islands, sandbars, diverse forests, prairies, and wetlands.

4.2 Existing Conditions

The Upper Iowa is now channelized to the UMR with levees. All sediments are dumped into the main channel of the UMR. Associated wetlands and sloughs are cut off and have sediment in. Diverse forest has been replaced with silver maple mono-culture of trees.

4.3 Forecasted Future Conditions

Without project conditions will continue to degrade and the area will lose benefit to fish and wildlife.

4.4 Stressors Affecting the Condition of Habitat and Biota

The levees and channelization have stressed the current conditions to the detriment of the natural environment.

- Altered Hydraulic connectivity
- A more natural hydrograph
- Improved water clarity
- Reduced nutrient loading
- Reduced sediment loading from tributaries
- Backwaters
- Restore a sediment transport regime so that sediment transport rates and future change in geomorphic patterns are within acceptable limits
- Restored diversity of floodplain features
- Restored habitat connectivity
- 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
- Diverse and abundant native aquatic vegetation communities (SAV, EAV, R/F)
- Diverse and abundant native floodplain forest and prairie communities
- Diverse and abundant native fish community
- Diverse and abundant native mussel community
- Diverse and abundant native bird community

4.5 Restoration Opportunities

The initial phase of the project would study the feasibility of restoring Upper Iowa River flows into the backwater complex. The feasibility study would address sediment impacts and hydrology. Recommendations would be made and initialized to restore the channel braiding associated with a natural delta. The levee would be breached in several places along land currently owned or managed by the IA DNR or the Us FWS Upper Mississippi Wildlife and Fish refuge. Channels would be dug to direct flow to accomplish this. Phase II of the project would assess resource needs and recommendations from the study and a plan of action for the project would be developed. Land acquit ion would buy upstream land to enhance the restoration of the Upper Iowa River delta.

4.6 Project Ecosystem Objectives

Hydrology and Hydraulics
A more natural stage hydrograph
Altered hydraulic connectivity

Biogeochemistry
Improved water clarity
Reduced nutrient loading
Reduced sediment loading from tributaries and sediment resuspension in and loading to backwaters

Geomorphology
Restore a sediment transport regime so that 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

Habitat
Restored habitat connectivity
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

Biota
Diverse and abundant native aquatic vegetation communities (SAV, EAV, R/F)
Diverse and abundant native floodplain forest and prairie communities
Diverse and abundant native fish community
Diverse and abundant native mussel community
Diverse and abundant native bird community

5. Description of the Proposed Project

The initial phase of the project would study the feasibility of restoring Upper Iowa River flows into the backwater complex. The feasibility study would address sediment impacts and hydrology. Recommendations would be made and initialized to restore the channel braiding associated with a natural delta. The levee would be breached in several places along land currently owned or managed by the IA DNR or the Us FWS Upper Mississippi Wildlife and Fish refuge. Channels would be dug to direct flow to accomplish this. Phase II of the project would assess resource needs and recommendations from the study and a plan of action for the project would be developed that would include land acquisition upstream of the current Phase I project.

The levee would be breached and new connection channels would be dug to distribute flow across the historic delta region. Managed moist soil units would be put in place to provide managed isolated wetlands. Dredging would be accomplished in several backwaters to provide sediment for topographic diversity for forest diversity.

5.1 Project Features

Islands and diversion channels would be dug to mimic natural floodplain river delta formations.

- Islands
- Backwaters
- Primary channels
- Secondary channels
- Floodplain forest diversity
- Isolated wetlands
- Contiguous wetlands
- Sediment management
- MSU development5.2 Implementation Sequence of Project Features

5.3. Operations and Maintenance

Water delivery channels would be dug to provide water to the MSU's
Most of the river would be allowed to shape distribution channels into the Upper Iowa bottoms.
Dredging would accomplish overwintering fish haven and deep wetlands
Maintenance would need to be done on the dikes and control structures

6. Adaptive Management Activities

6.1 Learning Objectives

6.2 Project Monitoring

Pre-project

- sediment budget for the Upper Iowa River
- Identification of current overwintering fish locations
- Identification of areas to be raised for topographic diversity
-

During construction

- Armoring of hard points at new secondary channels would need to addressed

Post-construction

- Sediment deposition in water dispersions channels would need to be monitored
-

6.3 Applied Research

Hypotheses to be tested
Experimental approach

6.4 Evaluation and Reporting

7. Anticipated Ecosystem Benefits

7.1 Ecological Benefits

Processes

<u>Hydrology and Hydraulics</u>
A more natural stage hydrograph
Altered hydraulic connectivity

<u>Biogeochemistry</u>
Improved water clarity
Reduced nutrient loading
Reduced sediment loading from tributaries and sediment resuspension in and loading to backwaters

<u>Geomorphology</u>

Restore a sediment transport regime so that 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

- **Habitats**

Restored habitat connectivity
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

Biota

Diverse and abundant native aquatic vegetation communities (SAV, EAV, R/F)
Diverse and abundant native floodplain forest and prairie communities
Diverse and abundant native fish community
Diverse and abundant native mussel community
Diverse and abundant native bird community

7.2 Scales of Anticipated Benefits

Geographic extent the project study area encompasses approximately 4000 acres

Timing of anticipated responses: some response will be immediate, (forest topography, distribution channels, MSU), others will take time to become more natural

Duration of anticipated responses 0-50 years.

7.3 Anticipated Effects on Significant Resources the area will become a dynamic River delta region again

7.4 Contribution to Attaining Reach Objectives this project will help reach a multitude of reach objectives

7.5 Contribution to learning this will be the first delta restoration on UMR

7.6 Contribution to Existing Plans should affect CMMP, Pool Plans, North American Waterfowl Management Plan and many more.

8. Implementation Considerations

8.1 Affected Stakeholders

8.2 Land Ownership IA DNR, USFWS

8.3 Affected Infrastructure

8.4 River Discharge Constraints

10. Initial Costs Estimate

10.1 Planning, Engineering and Design

10.2 Construction

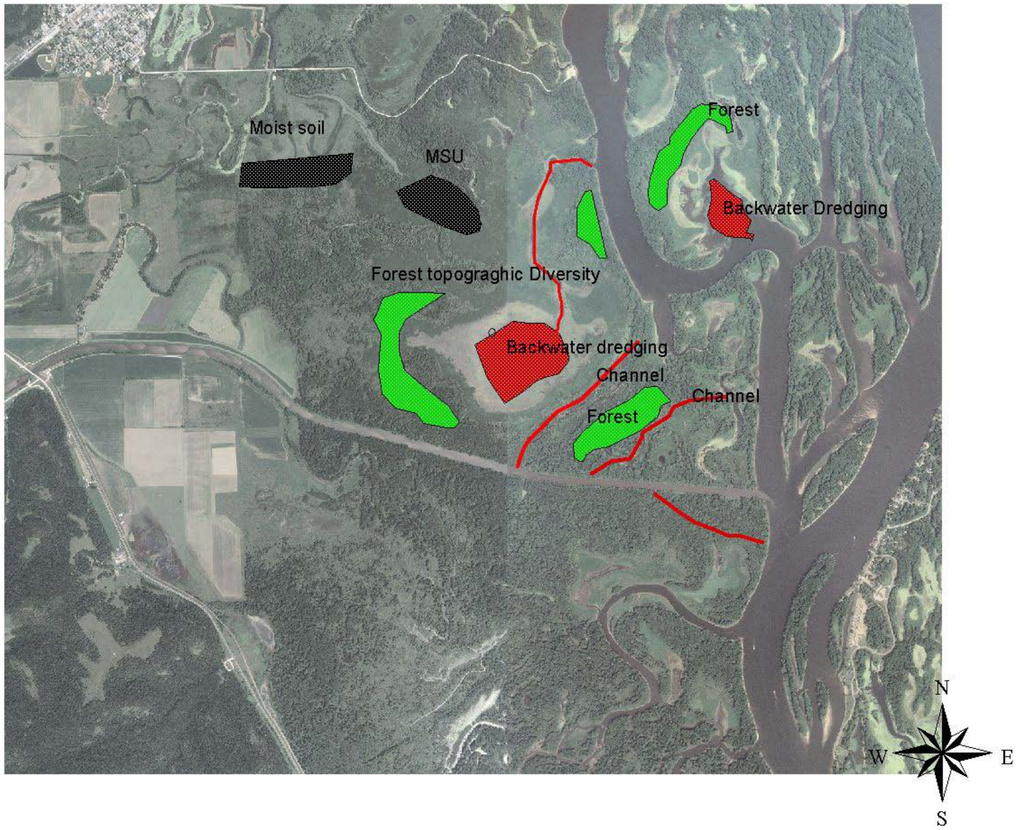
10.3 Operations and Maintenance

10.4 Adaptive Management Applied Research

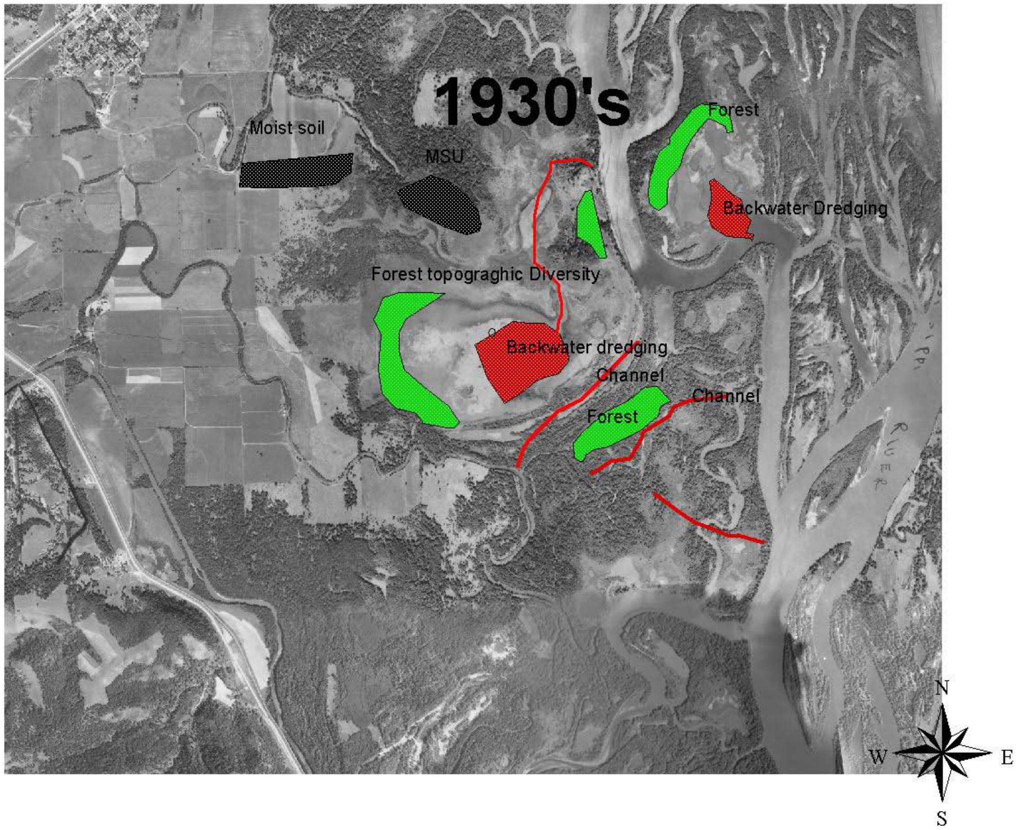
10.5 Project Monitoring, Evaluation and Reporting

11. Points of Contact

Corps District St Paul
Sponsor IADNR, USFWS
Iowa DNR



Forest
Moist soil
MSU
Backwater Dredging
Forest topograghic Diversity
Backwater dredging
Channel
Channel
Forest
N
W
E
S


1930's
Moist soil
MSU
Forest
Backwater Dredging
Forest topograghic Diversity
Backwater dredging
Channel
Forest
Channel
RIVER
N
W
E
S

Lower Pool 2 Restoration Project

Program Neutral
Ecosystem Restoration Project Proposal
UMRS Reach Planning

Navigation and Ecosystem Sustainability Program (NESP)
U.S. Army Corps of Engineers, St. Paul, Rock Island, and St. Louis Districts

January 26, 2010

Lower Pool 2 Restoration Project

Program Neutral
Ecosystem Restoration Project Proposal
UMRS Reach Planning

Navigation and Ecosystem Sustainability Program (NESP)
U.S. Army Corps of Engineers, St. Paul, Rock Island, and St. Louis Districts

January 26, 2010

1. Introduction

1.1 Reach Planning Process

The Reach Planning Team for the Upper Impounded Reach of the Upper Mississippi River identified a set of objectives for future condition of the river ecosystem (Upper Impounded Reach Planning Team 2010a). The objectives were identified with consideration of historic conditions, the forecasted future without-project conditions, the unique and important conditions within the reach, and the factors that are limiting or that will limit the abundance and distribution of native biota. The objectives address ecologically realistic target future conditions, also referred to as best attainable conditions. The best attainable future conditions for the river ecosystem will be constrained by continued operation and maintenance of the UMR-IWW navigation project, by land and water use in the river basin and by climate change.

Quantitative performance criteria for each objective were identified using ecological literature about the UMRS and other similar systems, with EMP-LTRMP data, water quality criteria, state TMDLs efforts, and lessons learned from EMP HREP projects. The performance criteria are SMART; Specific, Measurable, Achievable, Relevant, and Time-bound. The performance criteria will target values and ranges where appropriate, considering inter-annual variation and natural disturbance regimes.

The Reach Planning Team identified indicators for condition of the river ecosystem appropriate for each geomorphic reach. The indicators were selected or derived from the performance criteria for the ecosystem objectives. The indicators should be practicable to measure, readily understood, sensitive to change over time and suitable for status and trends reports.

The Reach Planning Team met several times to prepare the Reach Plan (Upper Impounded Reach Planning Team 2010b) that identifies potential future project areas and adaptive ecosystem management activities. The draft reach plan will be provided to the full Fish and Wildlife Work Group, the River Resources forum, the NESP and EMP Management Teams the NECC and EMPCC for review, refinement if needed and endorsement. The Reach Plan will be posted to the reach plans to the NESP DSS. The reach plan will be updated once every four years.

This proposal is about one of the future ecosystem restoration projects in the Upper Impounded Reach identified by the Reach Planning Team that would contribute to achieving the ecosystem objectives. This project proposal was included in Appendix B of the Upper Impounded Reach Plan.

1.2 Ecosystem Objectives for the Upper Impounded Reach

The Reach Planning Team has identified a set of ecosystem objectives, performance criteria and indicators for the Upper Impounded Reach (Appendix A). The objectives (Table 1) are organized by Essential Ecosystem Characteristics (EEC's, Harwell et al. 1999). Geomorphic reaches 3 and 4 were considered sufficiently similar that they were combined for purposes of setting objectives and identifying future restoration projects.

Table 1. Ecosystem objectives for the Upper Impounded Reach of the Upper Mississippi River.

Geomorphic Reach 1 - St. Anthony Falls to Head of Lake Pepin

<u>Hydrology and Hydraulics</u>
A more natural stage hydrograph
Altered hydraulic connectivity

<u>Biogeochemistry</u>
Improved water clarity
Reduced nutrient loading
Reduced sediment loading
Reduced sediment resuspension in backwaters
Reduced contaminants loading and remobilization of in-place pollutants

<u>Geomorphology</u>
Restore rapids
Restore a sediment transport regime so that transport, deposition, and erosion rates and geomorphic patterns are within acceptable limits

<u>Habitat</u>
Restored habitat connectivity
Restored riparian habitat
Restored aquatic off-channel areas
Restored terrestrial floodplain areas
Restored channel areas

<u>Biota</u>
Diverse and abundant native aquatic vegetation communities (SAV, EAV, R/F)
Diverse and abundant native floodplain forest and prairie communities
Diverse and abundant native fish community
Diverse and abundant native mussel community
Diverse and abundant native bird community

Geomorphic Reach 2 - Lake Pepin
Biogeochemistry
Improved water clarity
Reduced nutrient loading
Reduced sediment loading
Reduced sediment resuspension in backwaters

Geomorphology
Restore a sediment transport regime so that transport, deposition, and erosion rates and geomorphic patterns are within acceptable limits

Biota
Diverse and abundant native fish community
Diverse and abundant native mussel community
Diverse and abundant native bird community

Geomorphic Reaches 3 & 4 – Lower Pool 4 to Lock and Dam 13
Hydrology and Hydraulics
A more natural stage hydrograph
Altered hydraulic connectivity

Biogeochemistry
Improved water clarity
Reduced nutrient loading
Reduced sediment loading from tributaries and sediment resuspension in and loading to backwaters

Geomorphology
Restore a sediment transport regime so that 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

Habitat
Restored habitat connectivity
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

Biota
Diverse and abundant native aquatic vegetation communities (SAV, EAV, R/F)
Diverse and abundant native floodplain forest and prairie communities
Diverse and abundant native fish community
Diverse and abundant native mussel community
Diverse and abundant native bird community

1.3 Considerations in Identifying the Lower Pool 2 Restoration Project Area

Lower Pool 2 is located within Geomorphic Reach 1 which is arguably the most degraded reach within the St. Paul District. There have been no Habitat Rehabilitation and Enhancement Projects (HREPs) completed in this reach of the UMR.

1.4 Potential Project Sponsor

Non-federal sponsor - Minnesota Department of Natural Resources

Federal sponsor - St. Paul District Corps of Engineers

2. Location

The project area is located in Pool 2 of the Upper Mississippi River extending from river mile 832.0 to 815.0 The project area includes; Spring Lake, Lower Pool 2 Impoundment, Baldwin Lake, Mooers Lake, River Lake and Grey Cloud Slough. The project area is within the National Park Service's Mississippi National River Recreation Area (MNRRA) corridor.

River – Upper Mississippi River
River miles – 832.0 to 815.0
States - Minnesota
Counties – Dakota and Washington
Sub-areas – I-494 to Lower Grey Cloud Island and Lower Impounded
Map – see figure 1.

3. Significant Resources

Infrastructure – Within the Twin Cities metropolitan area.

Cultural resources – The floodplain and terraces are rich in cultural resources such as burial mounds, prehistoric villages and scattered artifacts.

Important and Unique Ecological Resources

- **Minnesota River influence** - The Minnesota River drains a basin with intensive row crop agriculture. Extensive surface and sub-surface agricultural drainage has modified the hydrologic regime. Many tributaries are actively eroding. The Minnesota River contributes high concentrations of suspended sediment and large woody debris flows to the Mississippi River, affecting condition of the river system downstream through Lake Pepin.

- **High recreational use** - Geomorphic Reach 1 has the highest amount of recreational boating traffic on the UMRS. There is great potential for increased urban recreational use. Established in 1988, the Mississippi National River and Recreation Area includes 72 miles of the Mississippi River stretching from the cities of Dayton and Ramsey to just south of Hastings. The MNRRA is administered by the National Park Service.

- **Low amount of leveed floodplain** - There are levees in Pool 2 protecting 356 acres of floodplain with an airport and areas of commercial urban development.

- **Water quality recovery -** Municipal wastewater and storm drainage polluted this reach of river to the point where it was often anoxic in the 1960s. Point source pollution control and a major project to separate stormwater and sanitary drains in the Twin Cities metro area have contributed to significant improvements in water quality. There are recovering macroinvertebrate, fish and mussel communities in this reach. The fish in Pool 2 are contaminated with polychlorinated biphenyls (PCBs), Perfluorooctanesulfonic acid (PFOS) and mercury, so the sport fishery is catch-and-release. There are re-establishment sites for Higgin's eye pearly mussel in lower Pool 2 and in Spring Lake in lower Pool 3. However, non-point source pollutants, primarily sediment from the Minnesota River continues to severely degrade water quality and affect habitat for fish and wildlife in Lower Pool 2. Lower Pool 2 is on the 303(d) list of impaired river reaches for high turbidity.

T&E Species - Check natural heritage data base, NESP Pool 2 Wing Dam modification project PIR and Pool 2 Channel Management Study

4. Problem Identification

4.1 Historic Conditions

Native Americans had many villages and farms along this reach of river. The river and floodplain provided an abundant source of food, supporting a large population. European settlement along this reach of river began under the protection of Fort Snelling, established in 1819. By 1890, farming and logging had extensively changed the landscape in the river basin. Mill dams were built on the Mississippi River at Minneapolis and on many tributaries.

Within Geomorphic Reach 1, the floodplain was extensively used for grazing by cattle and horses. Many floodplain trees were logged off for use as steamboat fuel. By 1989, much of the floodplain in Pools 1 and 2 were developed urban area. In Pool 3, development has occurred on Prairie Island, and Bay City became larger but most of the floodplain remains undeveloped. Upper Pool 4 above the head of Lake Pepin also remains undeveloped. The delta at the head of Lake Pepin has advanced into the lake.

Construction of the 4-ft and 6-ft deep navigation channel project in the 1800s included construction of many rock and brush wing dams, dredging and placement of dredged material between the wing dams. Areas between the wing dams accumulated sediment and grew up in trees over time. Boulders were removed from the rapids in the Mississippi River gorge in the late 1800s to improve navigation.

Impoundment of the navigation system started with the Meeker Island Dam (the original Lock and Dam 1) in 1913. That dam was removed a year later and the current Lock and Dam 1 was built farther downstream in 1917. Lock and Dam 2 was completed in 1930, and Lock and Dam 3 was completed in 1934. Impoundment of the navigation pools inundated extensive areas of floodplain, leaving the higher natural levees and terraces as islands.

Geomorphic Reach 1 supported extensive areas of emergent and submersed aquatic plants in the first decades after impoundment.

Urban wastewater and runoff badly polluted the river as the Twin Cities metropolitan area grew. Lower Pool 1 and Pool 2 became anoxic, decimating the fish and mussel communities. After improvements to the waste water treatment plants and a major project to separate the storm and sanitary drains, water quality conditions improved greatly, allowing return of fish, native mussels and mayflies to the river.

The capacity to transport sediment decreased from the upstream to downstream end of Geomorphic Reach1. The hydraulic slope in upper Pool 4, for instance, was only about 1/3 that in Pool 2 prior to Lock and Dam construction. The reduced capacity resulted in sediment aggradation in the downstream end of Geomorphic Reach 1 and the gradual migration of the Geomoprhic Reach 1 delta at the head of Lake Pepin in a downstream direction. At smaller spatial scales, both deposition and erosion occurred.

Sediment deposition in Lake Pepin, just downstream of Geomorphic Reach 1, has increased from a pre-development rate of 80,000 metric tons per year to the current value of about 900,000 metric tons per year. This suggests that sediment loads and concentrations in Geomorphic Reach 1 have increased significantly over historic conditions. Sullivan, as part of an effort to establish historic sediment concentrations, used sediment deposition results in Lake Pepin and Met Council Environmental Services data from the 1950s to show that suspended sediment concentrations were historically lower than current values near Red Wing.

Average discharge at St. Paul has increased significantly from the 1930s to the present. This has increased sediment and nutrient loads to Geomorphic Reach 1, and probably affects geomorphic processes within the reach. The St. Paul record indicates that prior to the 1930s there was a high flow period also, however the record only extends back to 1907. The increase in discharge is partly driven by the increase in annual precipitation although land-use changes in upstream watersheds are another factor.

Pre- and post-lock water surface profiles in Geomorphic Reach 1 for the 2-year flood, and for discharges exceeded 25% of the time (moderate flow), and 75% of the time (low flow). For low flow conditions, the water surface has been increased throughout Geomorphic Reach 1 due to the effects of the dams. For the two-year flood and moderate flow conditions, water surface elevations have been decreased in Upper Pool 4, Pool 3, and Upper Pool 2, while there has been an increase in Lower Pool 2. Geomorphic changes in the navigation pools (including lower Pool 4) are responsible for the decreases in the profiles. The increase in water surface profiles in lower Pool 2 is due to the fact that Lock and Dam 2, with a lift of over 12 feet for normal pool conditions, is one of the highest head dams in the St. Paul District.

4.2 Existing Conditions

Major habitat concerns for Lower Pool 2 are high turbidity, sedimentation, sediment resuspension, island dissection, shoreline erosion, loss of longitudinal connectivity, aquatic vegetation loss and reduced depth for over-wintering fish. Emergent and submersed aquatic vegetation are found in low frequency in a few locations within Lower Pool 2. Flood effects, wave generated erosion and re-suspension of fine sediments caused by continual inundation have reduced the fish and wildlife value of these areas which once provided outstanding waterfowl hunting and winter fishing close to the Twin Cities.

Watershed inputs sustain relatively high total suspended solids concentrations and high nutrient concentrations contributing to eutrophic conditions. A major contributor of sediment and nutrients is the Minnesota River watershed. The Lake Pepin TMDL has quantified its sediment and nutrient contribution to Geomorphic Reach 1. The Minnesota River watershed is responsible for approximately 90% of the 900,000 metric tons of suspended sediments delivered annually to Lake Pepin. Lake Pepin is filling in 10 times faster than pre-European settlement times. Similarly, Lower Pool 2 floodplain lakes have also experienced accelerated sedimentation rates that are attributable to upstream land use changes. Many of the bottom sediments are loose, flocculent silts and clays. Submersed aquatic plans are sparse due to limited light transparency.

The 9-Foot Channel's Lock and Dam 2 raised water levels, increased lake sizes, increased lateral connectivity, increased wind fetch and wind wave heights with the associated erosion of islands and shorelines, facilitated larger wind waves that resuspend fine-grained bottom sediments, accelerated sediment deposition because of increased sediment loading and reduced sediment transport competence/capacity. Watershed inputs sustain relatively high total suspended solids concentrations and high nutrient concentrations contributing to eutrophic conditions. Many of the bottom sediments are loose, flocculent silts and clays. Submersed aquatic plans are sparse due to limited light transparency.

4.3 Forecasted Future Conditions

Habitat degradation will continue due to shoreline and island erosion, wind resuspension of bottom sediments, limited aquatic plant beds, eutrophic conditions, limited light transparency, and accelerated sedimentation rates.

4.4 Stressors Affecting the Condition of Habitat and Biota

Sustained higher water levels due to the Lock and Dam 2 impoundment, polluted runoff from upstream watersheds – especially the Minnesota River, long wind fetches, high turbidity, high nutrient and total suspended solids concentrations, and accelerated sedimentation rates. Other stressors include channel training structures, channel maintenance dredging, urban and industrial infrastructure and major NPDES dischargers.

4.5 Restoration Opportunities

Lower Pool 2 would benefit greatly from the proposed restoration project. Opportunities include the potential Boulanger Slough main channel realignment project and the potential Nelson Mine expansion. Grey Cloud Island has many acres of disturbed land that could possibly benefit from the placement of sand and fine-grained fill material for land reclamation. Macalester College operates a biological field station on River Lake. Proximity to the Twin Cities urban population will induce great interest and use in the restoration project area. MPCA is completing the Lake Pepin TMDL and is moving into implementation planning which will further assist in restoration of the project area.

4.6 Project Ecosystem Objectives

Water Quality
1.3 Reduce mobilization of sediment contaminants
1.4 Achieve State Total Maximum Daily Loads (TMDLs)
1.5 Reduce sediment loadings to the rivers
1.7 Reduce nutrient export from the UMR to Gulf of Mexico
1.8 Maintain adequate DO concentrations for fishes
1.9 Maintain water clarity sufficient to support submersed aquatic vegetation, aquatic invertebrates and fish species appropriate to location

Geomorphology
2.1 Enhance channel geomorphic diversity
2.6 Increase the extent and number of islands
2.8 Increase topographic diversity and elevation of floodplain
2.10 Modify exchange between channels and floodplain areas
2.11 Modify contiguous backwater areas
2.12 Increase the number and extent of isolated floodplain lakes

Hydrology/River Hydraulics
3.4 Restore a more natural hydrologic regime in floodplain waterbodies
3.6 Increase storage and conveyance of flood water on the floodplain
3.7 Reduce wind fetch in open water areas

Habitat
4.2 Provide pathways for animal movements
4.3 Modify the extent, patch size and successional variety of plant communities
4.4 Modify the extent, abundance and diversity of submersed aquatic plants
4.5 Modify the extent, abundance and diversity of emergent aquatic plants
4.6 Restore and maintain large contiguous patches of plant communities
4.7 Modify backwaters to provide suitable habitat for fishes
4.8 Modify channels to provide suitable habitat for fishes
4.9 Increase habitat corridor sizes and connectivity

Biota
5.1 Maintain viable populations of native species throughout their range in the UMR at levels of abundance in keeping with their biotic potential
5.2 Maintain the diversity and extent of native communities throughout their range in the UMR
5.3 Reduce the adverse effects of invasive species on native biota

5. Description of the Proposed Project

A pool-wide drawdown of Pool 2 would benefit the entire lower Pool 2 project area. It is our understanding that the Corps is writing a separate programmatic project proposal which will include a pool-wide drawdown and/or alternative water level management operating curves to restore a more natural hydrologic regime by better emulate pre-lock and dam hydrology/hydraulics.

5.1 Project Features

Phase 1 - Spring Lake and Lower Impounded Area Island Restoration - The project involves restoration of a series of approximately 10 islands to reduce wind-generated wave erosion and sediment resuspension in the Spring Lake and Lower

Impounded Area. Island construction would utilize fine-grained substrates within the floodplain to enhance bathymetric diversity and provide topsoil on the constructed islands. Island construction would improve conditions for growth of aquatic vegetation and promote increases in depth by concentrating flows to promote scour. Ideally, this project would be sequenced with water level management that would consolidate sediments and promote growth of aquatic vegetation on the shoreline. See figure 2, 3, and 4.

Phase II - Grey Cloud Slough and Baldwin Lake Connectivity Restoration – The project involves the reestablishment of flow down Grey Cloud Slough through Lower Mooers Lake, improved connectivity between Upper Baldwin Lake and Mooers Lake and environmental depth dredging in Lower Baldwin Lake. Restored connectivity of Grey Cloud Slough and Baldwin Lake will improve habitat conditions, provide migration corridor and improve access.

If it is determined by the partners, after an appropriate level of analysis, that a pool-wide Pool 2 drawdown or change to the Lock and Dam 2 operating curves is unfeasible, the restoration of seasonal water level fluctuations to mimic summer low flow conditions to stimulate production of marsh and aquatic plant growth using alternative project designs will be considered. A possible water level management drawdown component to this phase of the project could include a demonstration drawdown within Lower Baldwin Lake by temporarily closing off the area with dikes and pumping water out to lower water levels. See figure 5, 6 and 7.

Phase III - Rebecca Lake Connectivity Restoration – The project would reestablish flow through the Lock and Dam 2 embankment down through Rebecca Lake and back out to the main channel. Rebecca Lake was connected to a significant secondary side channel that was occluded by construction of Lock and Dam 2. Restoration of longitudinal connectivity through the embankment would provide for fish passage, allow for the development of a secondary channel habitat, create additional recreational opportunities and provide a migration corridor. See figure 7.

Phase IV – River Lake Connectivity and Environmental Depth Dredging – This phase of the project would restore the natural levee along the main channel to reduce lateral connectivity during low to moderate flows. Depth dredging would improve overall fisheries habitat. Bank stabilization of an actively eroding terrace at Pine Bend (RM 825.5) would reduce sedimentation loading to the river.

If it is determined by the partners, after an appropriate level of analysis, that a pool-wide Pool 2 drawdown or change to the Lock and Dam 2 operating curves is unfeasible, the restoration of seasonal water level fluctuations to mimic summer low flow conditions to stimulate production of marsh and aquatic plant growth using alternative project designs will be considered. A possible water level management drawdown component to this phase of the project could include temporarily closing off the upper area of River Lake with dikes and pumping water out to lower water levels. See figure 8.

5.2 Implementation Sequence of Project Features

1. Phase I – Spring Lake and Lower Impounded Area Restoration
2. Phase II – Grey Cloud Slough and Baldwin Lake Connectivity Restoration
3. Phase III – Rebecca Lake Connectivity Restoration

4. Phase IV – River Lake Connectivity and Environmental Depth Dredging

5.3. Operations and Maintenance

Because of our collective agencies experience designing and constructing islands and structures in the UMR it is anticipated that operation and maintenance costs will be less that 5% of the construction cost over the life of the project.

6. Adaptive Management Activities

6.1 Learning Objectives

1. Evaluate effectiveness of island restoration to improve habitat conditions within a river reach with high ambient turbidity.
2. Evaluate effectiveness of restoring lateral and longitudinal connectivity to improve water quality.
3. Fish passage effectiveness when longitudinal connectivity is restored away from the tailwater flows.

6.2 Project Monitoring

Pre-project

1. bathymetry
2. water quality – turbidity, tss, secchi disk, dissolved oxygen, temperature, velocity
3. vegetation - species richness, frequency of occurrence
4. mussel - species richness, catch/unit effort
5. fish – fish assemblage, catch per unit effort, size structure
6. Aquatic Habitat Quality Index (AHQI)
7. waterfowl use
8. air photo interpretation

During construction – water quality

Post-construction

1. bathymetry
2. water quality – turbidity, tss, secchi disk, dissolved oxygen, temperature, velocity
3. vegetation - species richness, frequency of occurrence
4. mussel - species richness, catch per unit effort
5. fish – fish assemblage, catch per unit effort, size structure
6. Aquatic Habitat Quality Index (AHQI)
7. waterfowl use
8. air photo interpretation

6.3 Applied Research

Hypotheses to be tested – Fish are attracted to side-channel flow conditions when longitudinal connectivity is restored to non-tailwater reaches of the main channel.

Experimental approach – Measure fish passage between Pools 2 and 3 using rock ramp.

6.4 Evaluation and Reporting

Once completed, the proposed project will be fully evaluated using field observations and monitoring data. MDNR will assist the Corps with the writing of a Completion Report as soon as practical following construction. It is anticipated that reports will be done in 5 year increments for the first 20 years following completion of any particular Phase of the project.

7. Anticipated Ecosystem Benefits

7.1 Ecological Benefits

Processes - reduced wind fetch, more concentrated flow, improved light penetration (lower turbidity, lower tss, higher secchi disc readings), sheltered deeper water, sheltered shallow areas, induced scour to increase physical diversity, reduced lateral connectivity, increased longitudinal connectivity, and simulated natural water level dynamics.

Habitats – increased aquatic plant species richness, increased aquatic plant frequency of occurrence, improved waterfowl migration habitat, improved lentic fish floodplain lakes habitat, improved riverine fish habitat and improved secondary channel habitat.

Biota – Change in backwater fish assemblage to be more like Pool 13 backwaters, increased catch per unit effort for fish, improved fish size structure, improved fish passage, increased catch per unit effort for mussels, increased mussel species richness, and increased waterfowl use days during migration.

7.2 Scales of Anticipated Benefits

Geographic extent – benefits would extend throughout both the I-494 to Lower Grey Cloud Island and Lower Impounded subareas within Pool 2. Also, some benefits would accrue to upper Pool 3.

Timing of anticipated responses – immediate improvement in geomorphology, water quality, and hydrology/river hydraulics - habitat and biota response should begin soon after completion and then develop/improve over time. The successful implementation of the Lake Pepin TMDL is necessary to realize the true restoration potential of the project area.

Duration of anticipated responses – constructed islands and engineered structures >50 years, dredge cut lifespans are dependent on sediment deposition rates, habitat and biotic responses should occur as long as islands, structures and dredge cuts are present, vegetative response associated with water level management is expected to last between 3 and 10 years.

7.3 Anticipated Effects on Significant Resources

Significant Likely to have a material bearing on the decision-making process. Significance is based on institutional, technical, and public recognition. Resources and effects of alternative management actions are evaluated for significance. (U.S. Water Resources Council 1983)

7.4 Contribution to Attaining Reach Objectives

Hydrology and Hydraulics

- A more natural stage hydrograph
- Altered hydraulic connectivity

Biogeochemistry

- Improved water clarity
- Reduced nutrient loading
- Reduced sediment loading
- Reduced sediment resuspension in backwaters
- Reduced contaminants loading and remobilization of in-place pollutants

Geomorphology

- Restore a sediment transport regime so that transport, deposition, and erosion rates and geomorphic patterns are within acceptable limits

- Habitat
- Restored habitat connectivity
- Restored riparian habitat
- Restored aquatic off-channel areas
- Restored terrestrial floodplain areas
- Restored channel areas

- Biota
- Diverse and abundant native aquatic vegetation communities (SAV, EAV, R/F)
- Diverse and abundant native floodplain forest
- Diverse and abundant native fish community
- Diverse and abundant native mussel community
- Diverse and abundant native bird community

7.5 Contribution to Learning

This will be one of the first island restoration projects above Lake Pepin in Geomorphic Reach 1. It may also be the first project to restore fish passage outside of a Lock and Dam tailwater.

7.6 Contribution to Existing Plans

The project proposal contributes substantially to meeting the Environmental Pool Plans desired future conditions (DFCs).

8. Implementation Considerations

Constructing islands in conjunction with backwater dredging has proven effective for past HREP projects and can be applied to the Lower Pool 2 project area.

8.1 Affected Stakeholders

1. Minnesota Citizens
2. Minnesota DNR Division of Wildlife
3. Dakota and Washington Counties

8.2 Land Ownership

In Pool 2 the Corps purchased flowage easements rather than fee title for the 9-Foot Channel Project. There are many landowners that would need to be coordinated with including the MDNR, NPS, Macalester College, the Schilling Family, City of Hastings, Washington and Dakota Counties.

8.3 Affected Infrastructure

Washington County Highway 75, Lock and Dam 2 Embankment, Hasting's Jaycee Park and River Lake Marinas.

8.4 River Discharge Constraints – flood flows may alter or extend construction or operations schedule.

10. Initial Costs Estimate

10.1 Planning, Engineering and Design – $2,325,000 (10% of construction costs)

10.2 Construction Costs - $23,250,000 in 2010 dollars.

$ 8,250,000 Phase I – Spring Lake and Lower Impounded Area Restoration
$ 5,000,000 Phase II – Grey Cloud Slough and Baldwin Lake Connectivity
$ 7,500,000 Phase III – Rebecca Lake Connectivity Restoration
$ 2,500,000 Phase IV – River Lake Connectivity and Environmental Dredging

10.3 Operations and Maintenance - $100,000 per year

10.4 Adaptive Management Applied Research – $ 50,000

10.5 Project Monitoring, Evaluation and Reporting - $500,000

11. Points of Contact

Corps of Engineers, St. Paul District, Project Manager, 651-290-5402
Minnesota Department of Natural Resources, EMP Coordinator, 651-345-5601

References

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Upper Impounded Reach Planning Team. 2010a. Ecosystem objectives for the Upper Impounded Reach of the Upper Mississippi River. (Draft in review). St. Paul District, U.S. Army Corps of Engineers. St. Paul, Minnesota.

Upper Impounded Reach Planning Team. 2010b. Reach plan for the Upper Impounded Reach of the Upper Mississippi River. (Draft in review). St. Paul District, U.S. Army Corps of Engineers. St. Paul, Minnesota.

Appendix A – Ecosystem Objectives of the [___________] Floodplain Reach

Appendix B – Learning Objectives for the [__________] Floodplain Reach

Appendix C – Initial Costs Estimate MDNR can supply more details.

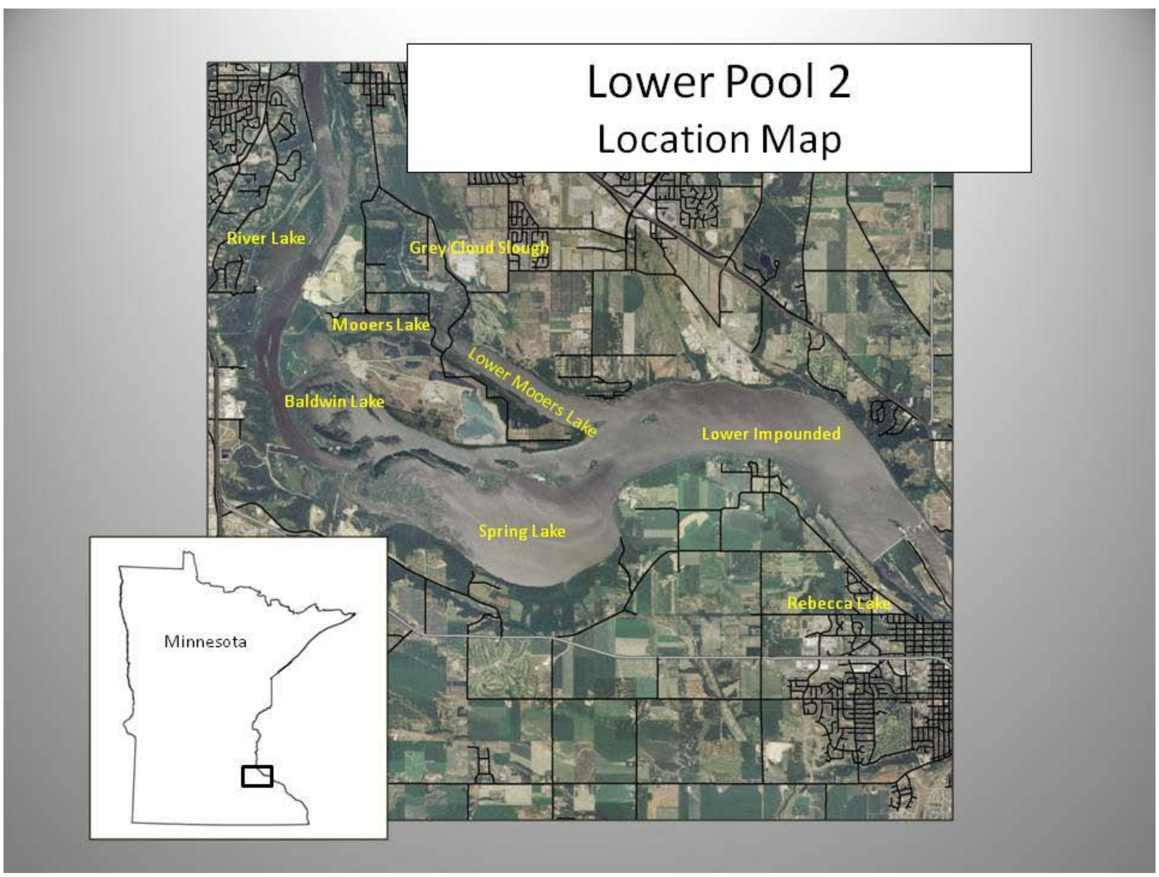


Figure 1. Lower Pool 2 Spring Lake location map.

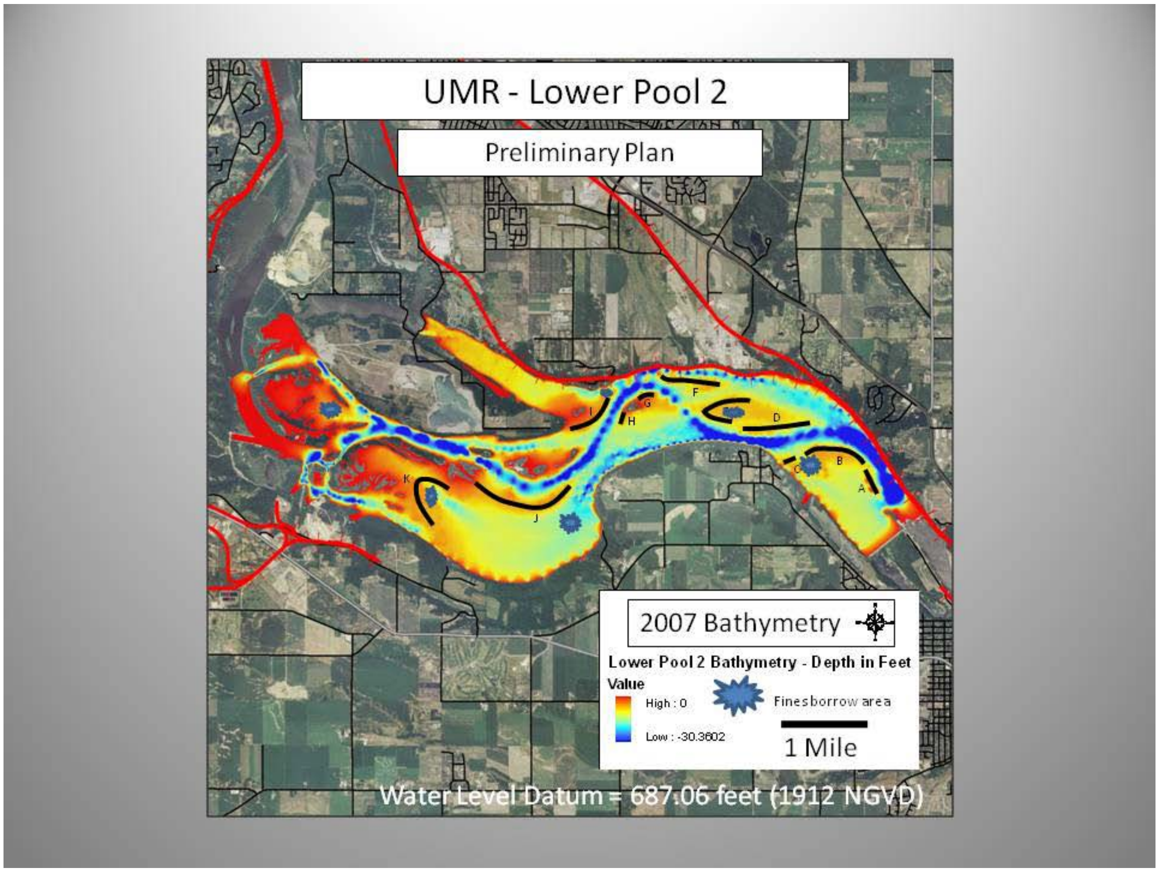
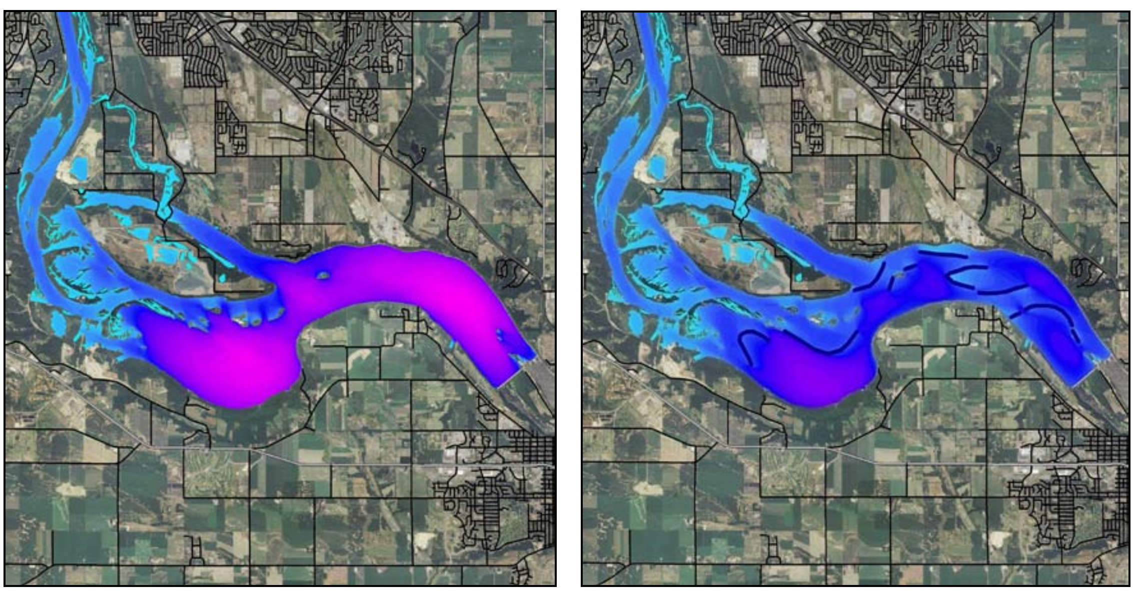
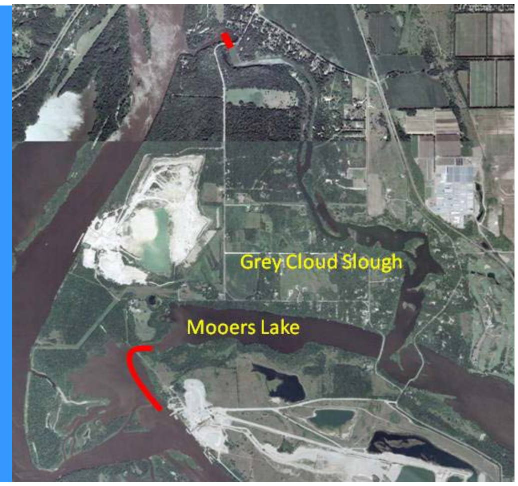


Figure 2. Spring Lake and Lower Impounded Area preliminary plan.



Figures 3 and 4. Wind Fetch Model before and after island restoration results.



Figures 5 and 6. Grey Cloud Slough and Upper Baldwin Lake Project areas – dredge cut and hydraulic opening in red.

Figure 7. Lower Baldwin Lake Project area with possible features – closures in green and dredging in red.

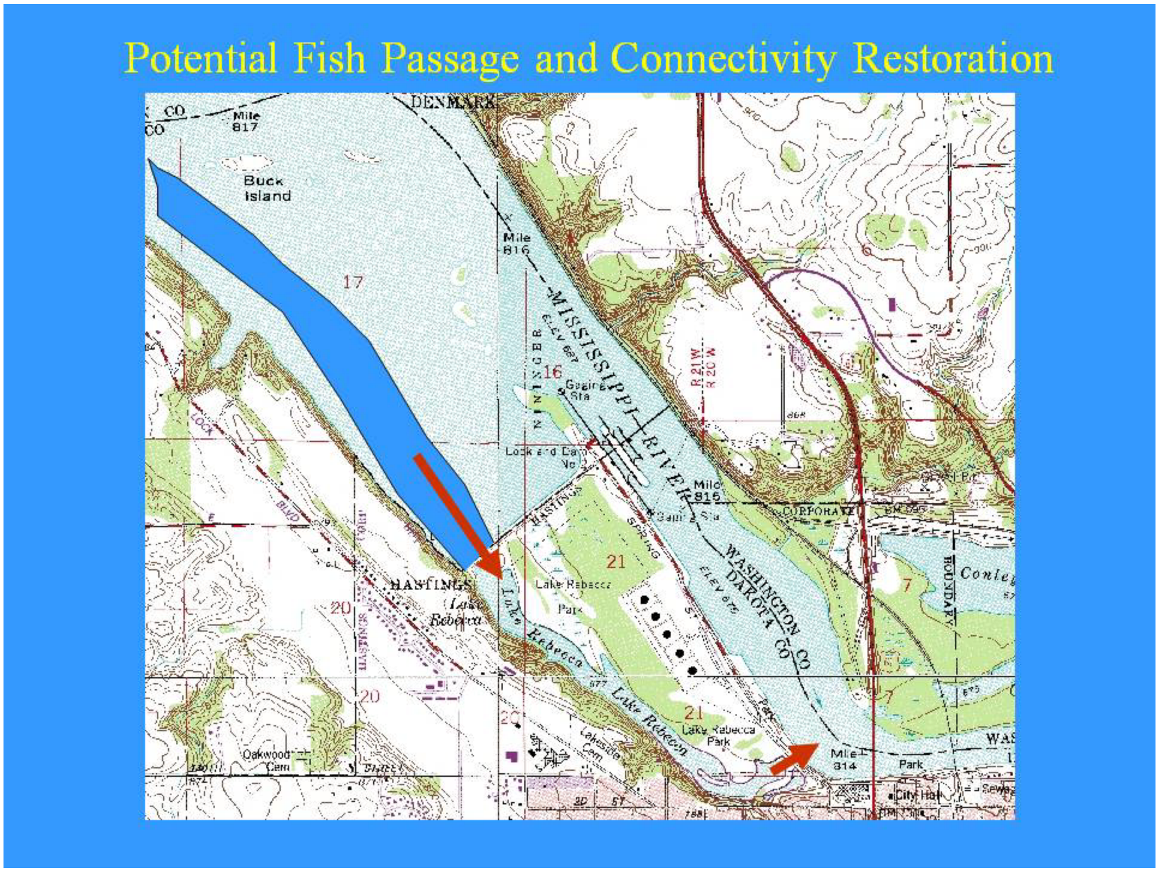


Figure 8. Rebecca Lake Connectivity Restoration Project area with possible features – red arrows depict opening in Lock and Dam 2 embankment and bridge/opening to main channel.

Figure 9. River Lake Project area with possible features – island peninsula in green, dredging in red, partial closure in dotted yellow and bank stabilization in solid yellow.

Conceptual Models

UMRS System-wide ecosystem goal (modified from Galat et al. 2007) →	**Biota: Manage for viable populations of native species within diverse plant and animal communities**		**Habitat: Manage for a diverse and dynamic pattern of habitats to support native biota**	**Biogeochemistry: Manage for processes that input, transport, assimilate, and output material within UMR basin river floodplains: e.g. water quality, sediments, and nutrients**	**Geomorphology: Manage for processes that shape a physically diverse and dynamic river floodplain system**	**Hydraulics & Hydrology: Manage for a more natural hydrologic regime**
	Animals, Fish, Birds	Vegetation Communities	Habitat (Geomorphic Landscape Category)			
	←	**Strive to link biota to structural and functional elements of the UMRS conceptual model**			→	
Reference Conditions (Natural)	Need description of animals, fish, birds. (From Bartel et al., 2006) The evolutionary history for several large floodplain river system fish species was prepared by Cavender (1986) and Cross, et al. (1986). They provided documentation that several large river backwater dependent species evolved in large floodplain river systems. Some examples of backwater dependent species that Cavender (1986) and Cross, et al. (1986) report evolved in large river floodplains are largemouth bass, bluegill (Lepomis macrochirus), yellow perch (Perca flavescens) and Esox sp.. Their conclusions were based on fossilized remains formed in limestone deposited in small lakes of expansive fluvial plains or "lowland habitat". Galstoff's (1924) description of the pre-impoundment UMR appears to be quite similar to the type of habitat Cavendar (1986) and Cross, et al. (1986) described as floodplains where some backwater dependent species evolved.	Need description of natural vegetation communities	The 1878-79 survey of the UMRS indicates an upper floodplain reach consisting of a main channel, secondary channels, isolated lakes and ponds, and extensive floodplain areas. Connected backwaters like those that exist today were largely absent.		The Upper floodplain reach was slowly aggrading since its channel didn't have the capacity to transport sediment delivered by the tributaries. Annual and seasonal variations in river discharge and sediment transport caused erosion and deposition, however several researchers suggest a relatively stable post-glacial river (Fremling, Knox, Church, Cumulative Effects Study). However, the numerous abandoned natural levees that exist in the current floodplain suggest at least some channel migration. In an aggrading system like the UMRS this may have been due to secondary channel formation, subsequent sediment delivery and deposition in floodplains, and eventual abandonement of the secondary channel. This migration was greatest downstream of major tributaries where the sediment load was highest.	Flow was conveyed in the main channel and secondary channels for below bankfull conditions. With rising flood levels, floodplain conveyance increased, but floodplain roughness probably resulted in the channels conveying the largest percentage of the water. The longitudinal slope of the river varied with proximity to major tributaries. The slope was lowest upstream of tributaries, and was greatest downstream of tributaries. The difference in water levels between tributaries and the main stem results in slopes that are several times higher than those that occur on the mainstem.
Reference Conditions (Pre-Lock, Early 1930s)	Need description of animals, fish, birds. In the pre-lock and dam era, most of the many sloughs and wetland pockets were dried out by the fall season and not suitable for migrating waterfowl. During the spring, when the bottoms were flooded, there was a greater waterfowl use and diversity . (UMRS Refuge CCP, 2006).	Need description of vegetation communities ***(see NESP DSS)	Floodplain consisting of forest, marsh, secondary channels, and isolated floodplain lakes. Contiguous backwaters were mostly non-existent.	Degraded water quality near urban centers. High total suspended sediment loads from tributaries due to poor land-use in watersheds. (high turbidity)	Channel training structures constructed in the late 1800s and early 1900s had stabilized river banks, cut off flow to secondary channels, and isolated the floodplain and secondary channels from the main channel during below bankfull conditions. Sediment deposition in main channel border areas where wing dams were constructed combined with the early practice of placing dredge material along the channel border raised and widened the natural levee further isolating the floodplain and secondary channels. Tributary sediment loads had probably increased due to poor land-use practices and channelization (especially in the lower tributary valleys). Railroads were constructed along both sides of the river valley in the late 1800s. In many cases, these embankments separated portions of the floodplain from the river.	Closing dams at secondary channels had reduced lateral hydraulic connectivity (LHC) significantly for below bank full conditions. The distribution of flow in the main channel was altered through the construction of wing dams. Pre-Lock water surface profiles indicate a steeper hydraulic slope than existing conditions profiles. This may have been partly due to training structure effects. Although water level records don't exist for the floodplain, the physical conditions created by isolating secondary channels and floodplains for below bankfull conditions probably resulted in greater water level variation in the floodplain
Reference Conditions (Post-Lock, 1940s)	Need description of animals, fish, birds. Fish passage at locks and dams limited to periods when dam gates are out of water. In 1956, the peak count of Mallards reached 190,000 birds while Canvasbacks reached only 10,000. By 1978, those numbers were almost reversed, with 195,000 Canvasbacks counted on Pool 7 and 8 only and 12,000 Mallards counted, Refuge-wide (Figure 8, pg 237, UMRS Refuge CCP, 2006).	Diverse patterns of PEAV, SAV, open water were formed in the submerged floodplain. Floodplain forest persisted on islands and in areas of the navigation pools not submerged by the lock and dam backwater .	Diverse mixture of habitat that now included contiguous backwaters.	Degraded water quality near urban centers Tributary sediment loads have decreased since the early 1900s as land-use changes occur in watersheds, however TSS continues to be high	Channel training structures submerged. Backwaters formed by submergence of floodplain. Higher sections of natural levee become islands. Wind fetch increased, but effects limited by islands and aquatic plant beds. Areas downstream of lock and dam embankments isolated from main channel water and constituent inputs. Channelized tributaries (in some cases incised) provide efficiently deliver sediments to the UMRS	Water levels were altered for low flow through 2-yr flood conditions. Allowable drawdowns from normal pool levels exceeded 3 feet in some pools as part of normal operation, however the variation between low flow and high flow levels was greatly reduced Lateral hydraulic connectivity was increased significantly by the submergence of natural levees, closing dams, and wing dams. Training structures became less of a factor influencing hydraulics
Stressor Causing Change (factors most limiting to Biota)	Disease Invasive species (e.g. Zebra Mussels, Carp, Asian Carp) Fish passage at locks and dams limited to periods when dam gates are out of water. Commercial and recreational navigation impacts. Commercial and recreational fish harvest	Transition to open water and submersed plant communities caused shift from puddle duck to diver habitat in many areas. Increased nutrient loads affecting metaphyton growth. Invasive species (e.g. Purple Loosestrife, Reed Canary Grass) displaces native vegetation Diminished capability for forest regeneration due to invasive species and loss of shade tolerant component due to desease (e.g. Dutch Elm), and high surface and ground-water levels.	Contiguous backwaters became more open and less diverse with the erosion of islands emergent plant beds, and because of sediment deposition.	High total suspended solids and nutrient levels from tributaries and main stem sources reduce available light. Concentrations vary at time scales ranging from daily (wind-driven resuspension) to seasonal (hydrological cycle) to decade-long cycles which are a function of cyclic aquatic plant growth. Higher nutrient loads may favor growth of invasives. Anthropomorphic changes (e.g. power plant discharge) in water temperatures, which could alter seasonal life-cycle and migration patterns. Contaminants from non-point and urban runoff. Disturbance of inplace contaminants.	Wind fetch and sediment resuspension - Erosion of islands and emergent plant beds increased wind fetch, which caused even more erosive conditions. Sediment deposition in backwaters Increased size and number of secondary channel connections to backwaters due to erosion. Continued floodplain encroachments such as road embankment raises, dredge material placement, agricultural levees, and urban development. Tributary sediment and nutrient loads are high due to landuse changes and are efficiently delivered to the UMRS due to channelized lower tributary valleys. Dredging: Navigation channel maintenance, sand and gravel mining. Shoreline development including Port facilities, riprap, floodwalls	**H&H Stressor:** Permanent submergence by the lock and dam system and the shift in water control pl time resulting in decreased annual drawdowns. Water levels remain high year round variation in water levels between high and low flows has been decreased. The maxim drawdown is now 1 ' or less in all pools. The hydraulic slope in each pool has been de significantly for low flows and high flows. The groundwater table in adjacent floodplai been raised and is less variable. Increased wave action in backwaters. Increasing inflows to backwaters in lower and middle reaches of pools causes increase and nutrient loads to backwaters and decreased residence times. Local effects due to infrastructure such as railroad embankments and roadways have altered hydraulic conditions. Tributary watershed development and channelization along with increase in imperviou in urban areas has altered hydrology resulting in increased annual runoff, and flood hy with higher peaks and shorter durations. Commercial and recreational navigation impacts. Hydropower facilities Artificial tailwater pulses caused by gate adjustments at lock and dams

Existing Conditions	Need description of animals, fish, birds. The UMRS refuge generally supports 60 to 75 percent (82 percent in 2005) of the Canvasbacks counted in the eastern U.S. during annual Coordinated Canvasback surveys (Figure 9, pg 238, UMRS Refuge CCP, 2006). Current observations and survey data clearly show that ducks, swans and geese are not evenly distributed on the Refuge during fall migration (Figures 11, 12, 13, pgs 239, 240 UMRS Refuge CCP, 2006) Fish passage at locks and dams limited to periods when dam gates are out of water. (From Bartel et al., 2006) One predictable riverine habitat largemouth bass have evolved to exploit may be overwintering habitat. Pitlo (1992) tracked radio-tagged largemouth bass to document migratory movements to overwintering habitats to meet seasonal habitat needs on the UMR. His study of largemouth bass movements were repeated by Raibley et al. (1997) on the Illinois River and by Karchesky and Bennett (2004) on the Pend Oreille River, Idaho. All three of these studies documented similar seasonal migratory behavior of largemouth bass in each of the river reaches studied. In all three studies, largemouth bass utilized off channel backwater habitats greater than one meter deep, with little to no current, and water temperatures greater than adjacent flowing channels in which to occupy during the winter. (From Bartel et al., 2006) Bluegills utilize overwintering habitat similar to what has been described for largemouth bass (Knights, et	Need description of existing condition of floodplain forest including effects of invasives SAV recovery from late 1980s low points in pools 5, 5A, and 6 was much slower than pools 7, 8, and 9. PEAV coverage has been decreased significantly from post-lock conditions Although some level of periphyton production and duckweed development within SAV beds may be considered natural, there is concern that prolonged shading of SAV by metaphyton may seriously threaten the health or composition of the submersed macrophyte community due to reduced growth including reproductive propagule development (Sullivan, 2008)	Contiguous backwaters are more open and less diverse with the erosion of islands emergent plant beds, and because of sediment deposition. Island construction done as part of the UMRS EMP has restored diveristy in some bacwaters.	Water quality near urban centers has improved significantly with primary and secondary wastewater treatment. Heavy metals, endocrine disruptors,.... remain a concern. Elevated turbidity and reduced light penetration associated with tributary inputs and wind-driven wave action was common in pool 5 in the mid 1990s. SAV distribution and density was low during this time period. More recent data collected by the WDNR water quality unit, LTRMP personnel, and the Corps indicates improved water quality conditions associated with increased SAV growth. LTRMP data indicates typical TSS concentrations of 20 to 40 mg/L during low flow conditions. LTRMP data indicates total Phosporous and Nitrogen concentrations of 0 to 0.3 mg/L and 0 to 5 mg/L respectively.	Backwaters continue to trap sediment, though fine sediment transport may be in balance in some backwaters due to resuspension by wave action. Management actions taken over the last twenty years (including island construction, water level management, secondary channel closures) reduce sediment load but ultimately increase the trap efficiency of backwaters. Delta formation in backwaters from secondary channels and tributary inputs creates diverse habitat. Main channel sediment deposition requires dredging at predictable, relatively short reaches of the river. Usually this deposition is caused by secondary channel outflows. Wind fetch is high in backwaters. Islands constructed as part of the UMRS EMP have reduced fetch levels in some backwaters. Secondary channel connections continue to increase in size, though many have been stabilized with riprap. The lock and dam embankments have isolated the reaches immediately downstream of them. Many lower tributary valleys are channelized	For low flow conditions, water levels have been elevated due to lock and dam construction. For 2-year flood conditions, the effects of the locks and dams and subsequent geomorphic changes have resulted in slightly elevated water levels in the lower ends of navigation pools and decreased water levels in the upper ends of pools. These combined effects have reduced the hydraulic slope of the river and the annual variation in water levels between high and low flows. These reductions are greatest in the downstream end of each navigation pool. Wave action is high in many backwaters. Lateral Hydraulic Connectivity (LHC) between the main channel and backwaters or secondary channel is high in the middle and lower reaches of each navigation pool. LHC is low in the reach downstream of the lock and dam embankments. The difference in water levels between tributaries and the main stem results in slopes that are several times higher than those that occur on the mainstem. Tributary watershed development and channelization has altered hydrology resulting in increased annual runoff, and flood hydrographs with higher peaks and shorter durations.
Forecasted Future Condition wo project		Need description of future condition of floodplain forest including effects of invasives. Variable macrophyte growth depending on timing of floods, tributary inputs, and wind events.	The Cumulative Effects Report (2000) indicates that between 1989 and 2050 in Geomorphic Reach 3, the area of contiguous backwaters will increase by 10%, while the area of islands will decrease by 14%.	Cycles of decreased light penetration related to increased TSS due to increased resuspension from wind	Wind fetch will continue to increase due to island loss, though the rate of increase is slowing. Sediment resuspension and spikes in concentration will be a function of daily wind conditions rather than seasonal hydrological conditions. Sediment deposition will continue in backwaters. The rate of delta formation in backwaters will increase. Secondary channel connections will continue to increase in number and size. Secondary channel connections with floodplain areas downstream of lock and dam embankments will increase but these areas will remain mostly isolated. Many lower tributary valleys are channelized	Raised and stable water levels limiting the variation between low flows and the 2-year flood. Similary to existing conditions. Wave action greater than desirable limits. Increased lateral hydraulic connectivity resulting in increased flow in backwater areas. LHC between channels and areas downstream of lock and dam embankments will remain low. Some lower tributary valleys will remain channelized, however land purchases by other state and federal agencies and NGOs may result in restoration of some floodplain areas. Tributary watershed development and channelization will continue to cause increased annual runoff, and flood hydrographs with higher peaks and shorter durations.
Factors Limiting Natural Processes and the Distribution and Abundance of Biota Including Exotics in the Reach	Human disturbance during migration High velocities at dams prevents fish passage during much of the year.	Describe effects of invasives Uneven distribution of food resources (plant seeds and tubers and fingernail clams and mayflies) . Variation occurs spatially and temporally.		High total suspended solids and nutrient levels Variable light penetration related to and affected by macrophyte growth, wind fetch, and tributary inputs.	Large wind fetches. Sediment deposition	Stabilized water levels Wave action Increased LHC
Desired Future Condition (Best Attainable Condition)	Describe desired future condition of biota Waterfowl: A key factor influencing waterfowl distribution and use of closed areas is carrying capacity, or the amount of available food for waterfowl, such as plant seeds and tubers or fingernail clams and mayflies. This carrying capacity component “is probably the most important variable for evaluating criteria for managing waterfowl closed areas” (Kenow, et al. 2003). Optimal bird distribution is achieved by providing adequate food resources (carrying capacity) where birds will not be disturbed, generally in closed areas of the refuge. (USFWS Comprehensive Conservation Plan, 2007). Lentic Fish: Improve the longitudinal distribution of overwintering sites for lentic fish so that over-wintering occurs throughout navigation pools including the lower reaches of the pools. Lotic Fish: Fish passage at locks at dams should occur more frequently. Improve the longitudinal distribution of overwintering sites for lotic fish.	Describe desired future condition of vegetation communities Improve SAV throughout the reach. Maintain currrent levels in Pools 7, 8, and 9, and 13. Increase SAV distribution and coverage during the low points of vegetation cycles. Reduce epiphytic and filamentous algae growth and shading in backwater areas.	Increased area of islands in the lower reaches of navigation pools. Continuous corridors of floodplain forests If habitat quality and levels of protection were similar in all Refuge pools, waterfowl distribution would continue to be somewhat uneven along the Refuge because of inherent differences in size, geomorphology, and hydrology among the pools. However, a more optimal distribution is possible if carrying capacity and habitat security are improved in pools up and downstream of Pool 7, 8, and 9 (pg 240, UMRS Refuge CCP, 2006).	UMRCC water quality criteria related to light met: TSS < 30 mg/L Turbidity < 20 NTU Secchi Transparency > .5 m 1% surface light > 4.5'	Wind Fetch: Reduce based on depth Water Depth (ft) 1 2 3 4 Fetch (ft) 1500 3500 6000 9000 or wave height in water shallower than 1' less than 10 cm. Increased area of islands in the lower reaches of navigation pools Reduce tributary sediment loads and sediment concentrations to reduce spikes in TSS. Lower tributary valley connectivity should be increased so that a functional distributary channel network and floodplain is created. Allow alluvial processes to occur driven by the steep hydraulic gradient.	Partially restore the low flow portion of the stage hydrograph so that the variation in water levels from low flows to high flows is increased. Maintain minimum slope during low flow conditions (e.g flows exceeded 95% of the time) to reduce residence times in channels and backwaters. Wave action reduced Alter LHC based on criteria for biota, constituent transport, and geomorphic processes. Increase LHC in lower tributary valleys. Restore tributary watersheds to decrease annual runoff, and flood hydrographs with lower peaks and longer durations. Reduce tailwater pulses due to gate changes (criteria may vary by season).

Upper Floodplain Reach, Geomorphic Reach 1
Reach Scale Objectives Conceptual Model Framework

Biota Objective		**Biota Objective**	**Biota Performance Criteria**	
Stressors	**Habitat Stressors**	**Biogeochemistry Stressors:**	**Geomorphology Stressors:**	**Hydraulics and Hydrology Stressors:**
Objectives	**Habitat Objective**	**Biogeochemistry Objectives:**	**Geomorphology Objective:**	**Hydraulics and Hydrology Objective:**
Performance Criteria	**Habitat Performance Criteria**	**Biogeochemistry Performance Criteria:**	**Geomorphology Performance Criteria:**	**Hydraulics and Hydrology Performance Criteria:**
Measurable Indicator		**Measurable Indicators:**		

Timeline for Achieving Objectives:

The timing of altering lateral hydraulic connectivity depends significantly on efforts to reduce sediment and nutrient loads on the Minnesota River.

Monitoring Needs:

Duck Use Days
SAV distribution
Light penetration
TSS
Nutrient concentrations
Tributary sediment loads
Hydraulic Connectivity mainstem and tributaries

Need surveys to determine duck numbers and distribution (locations of high use areas). Determine impacts of human disturbance during spring migration; probably much less than

Modeling Needs:

SAV model
Wind effects model
2D hydraulic model

Critical uncertainty:

Factors driving SAV cycles

Breeding populations affected by climate, predators; wintering populations affected by habitat conditions that affect body conditions going into the spring migration and nesting season.

How important is the UMR for divers during the spring migration? Canvasbacks use is very high in the spring, but not adequately documented.

Upper Floodplain Reach, Geomorphic Reach 1
Reach Scale Objectives Conceptual Model
Aquatic Vegetation

Primary Objective

Aquatic Vegetation Objective:

Diverse and abundant native aquatic vegetation communities (SAV, EAV, R/F)

Aquatic Vegetation Performance Criteria

SAV in MCB: Increase the frequency of occurrence to >21% in the MCB areas based on the EMAP sampling protocol (this corresponds to a frequency of occurrence of > 12% using the LTRMP sampling protocol). Increase species richness (maximum # of species) to 11.

SAV in Backwaters: Increase the frequency of occurrence to >49% in the Contiguous Backwaters based on the LTRMP sampling protocol. Increase SAV in backwaters <2m deep to >___kg/ha with species richness of >____ and Shannon diversity index > ____ by 2025.

EAV in Backwaters: Increase the spatial extent of EAV to >_____acres with >___ species richness and community Shannon diversity index > ____by 2025.

Spatial coverage performance criteria for lentic fish:
Summer: Aquatic vegetation cover in the range of 40-60% of off - channel areas.
Winter: Aquatic vegetation cover in the range of 25-50%.

Spatial coverage performance criteria for lotic fish
Increase coverage in MCB and secondary channels to 10% of area

Objectives

Habitat Objective

Restored riparian habitat

Restored aquatic off-channel areas

Restored channel areas

Biogeochemistry Objectives:

Improved water clarity

Reduced nutrient loading

Reduced sediment loading from tributaries and sediment resuspension in and loading to backwaters

Geomorphology Objective:

Restore a sediment transport regime so that transport, deposition, and erosion rates and geomorphic patterns are within acceptable limits

Hydraulics and Hydrology Objective:

A more natural stage hydrograph

Altered hydraulic connectivity

Performance Criteria

Habitat Performance Criteria

Restore >50% of the length of currently armored or stabilized river bank to natural channel border and riparian zone habitat by 2060.

Backwaters: 1) Restore hydraulic and sediment transport conditions in existing backwaters to desired range of variation

Impounded Areas, Lower Pool 2: Restore areas that are permanently inundated to a desired pattern of contigous backwaters, isolated wetlands, floodplain lakes, riparian habitat, and secondary channel habitat.

Vermillion River Bottoms: Restore hydraulic and sediment transport conditions in the Vermillion River Bottoms to desired range of variation

Biogeochemistry Performance Criteria:

TSS (mg/L) - Summer average TSS concentrations will need to be reduced about 32% (47 to 32 mg/L) from existing conditions based on the combined monitoring data for Locks and Dams 2 and 3.

Achieve a Secchi depth based on June through September averages at lock and dam 3 of 47 cm.

Backwaters: Achieve a Secchi depth of 80 cm for the June through September averages.

Reduce Sediment and Phosporous loads to GR 1 by 2025.
Minnesota River: 50%
Miss R u/s of TC: 20%
St. Croix River: 20%
Cannon River: 50%
Other Tributaries: 20%
From Scenario 17, Lake Pepin TMDL Study

Backwaters/Floodplain Nutrient Concentrations:
TP < 0.1 mg/L (Sullivan, 2008)
TN < 1.23 mg/L (Sullivan, 2008)

Minimize Mississippi River sediment loading to the Vermillion River Bottoms for flows below the 2-year flood event.

Geomorphology Performance Criteria:
Backwaters: Alter connectivity between backwaters and channels or between sub-areas within backwaters to reduce sediment and nutrient inputs

Impounded Areas, Lower Pool 2: Reduce connectivity between historic floodplains and channels for total river discharges less than the two year flood to create contigous backwaters, isolated wetlands, and floodplain lakes.

Vermillion River Bottoms: Eliminate connections from the Mississippi River to the Vermillion Bottoms for discharges lower than the 2-year flood event.

Lower tributary valleys: Floodplains and delta should be a sink for sediments. Tributary distributary channels should convey sediments to the delta fan.

Achieve wind fetch criteria based on water depth in aquatic off-channel areas.

Water Depth (ft)	1	2	3	4
Fetch (ft)	1500	3500	6000	9000

Hydraulics and Hydrology Performance Criteria:

Stage Hydrograph
On a periodic (e.g. one to two consecutive years in ten years) or permanent basis where feasible, maintain lower water levels starting as soon as possible following the spring flood through September 1st so that the following criteria are met:

- Low flow (75% exceedance) - wsel decreased 1' at lock and dams 2 and 3
- Moderate flow (25% exceedance) - wsel decreased 2' at lock and dam 2 and 1' at lock and dam 3
- High flow (2-year flood) - wsel decreased 2' at lock and dam 2

Hydraulic Connectivity:
Backwaters: Alter connectivity between backwaters and channels or between sub-areas within backwaters to reduce sediment and nutrient inputs

Impounded Areas Lower Pool 2: Reduce hydraulic connectivity between historic floodplains and channels for total river discharges less than the two year flood to create contiguous backwaters, or isolated wetlands and floodplain lakes.

Vermillion River Bottoms: Eliminate flow from the Mississippi River to the Vermillion Bottoms for discharges lower than the 2-year flood event.

Lower tributary valleys: Increase connectivity so floodplains convey water for flood events greater than the 2-year recurrence interval. Tributary distributary channel connectivity should vary seasonally based on historic ranges.

Measurable Indicator

Measurable Indicator:
SAV and RFV in MCB: Frequency of occurrence using EMAP sampling design. Biomass estimated from rake abundance.
SAV and RFV in Backwaters: Biomass, Shannon diversity index EAV in Backwaters: Spatial extent (acres), Shannon diversity index

TSS at LD2 and LD3, Secchi transparency in backwaters
Load allocations for N, P from TMDL efforts

Stage hydrograph, interannual variation, frequency of summer low stage conditions
Ratio of main channel flow to off-channel flow at the 25 percent duration level of river discharge

Timeline for Achieving Objectives:

The timing of altering lateral hydraulic connectivity depends significantly on efforts to reduce sediment and nutrient loads on the Minnesota River.

Monitoring Needs:

Discharge measurements througout the reach to update data collected in the 1990s.

Modeling Needs:

2D hydraulic model

Aquatic vegetation models (could use existing Lake Pepin TMDL information)

Sediment Transport

Critical uncertainty:

Minnesota River restoration efforts as affected by funding, agricultural trends.

Invasive species

Climate change

Upper Floodplain Reach, Geomorphic Reach 1
Reach Scale Objectives Conceptual Model
Floodplain Vegetation

Primary Objective

Floodplain Vegetation Objective:

Diverse and abundant native floodplain forest and prairie communities

Floodplain Vegetation Performance Criteria:

See Environmental Pool Plans for acres and distribution of Floodplain forests and grasslands

Species diversity:
Increase the area with at least 5 Dutch Elm desease resistant trees per acre by ______ acres by 2020

Reduce area dominated by reed canary grass by _____ acres by 2020

Restore >50% of the length of currently armored or stabilized river bank to natural channel border and riparian zone habitat by 2060.

Objectives

Habitat Objective

Restored habitat connectivity

Restored riparian habitat

Restored terrestrial floodplain areas

Biogeochemistry Objective:

Reduced Nutrient Loading

Geomorphology Objective:

Restore a sediment transport regime so that transport, deposition, and erosion rates and geomorphic patterns are within acceptable limits

Hydraulics & Hydrology Objective:

A more natural stage hydrograph

Altered hydraulic connectivity

Performance Criteria

Habitat Performance Criteria

Maintain existing terrestrial corridors and connectivity of native vegetation communities.

Restore >50% of the length of currently armored or stabilized river bank to natural channel border and riparian zone habitat by 2060.

Impounded areas, Lower Pool 2: Restore natural levees that are permanently inundated to create riparian habitat

Alter topography (e.g. Ridge and Swale), surface and ground water seasonal variations, and soil conditions, to create optimal conditions for native tree growth.

Biogeochemistry Performance Criteria:

Reduce Phosporous loads to GR 1 by 2025.
Minnesota River: 50%
Miss R u/s of TC: 20%
St. Croix River: 20%
Cannon River: 50%
Other Tributarie: 20%
From Scenario 17, Lake Pepin TMDL Study

Geomorphology Performance Criteria:

Connectivity: **Alter topography/bathymetry so that the frequency, duration, magnitude, and timing of flow and resulting stage variation are within optimal limits for target biota and habitats.**

Hydraulics and Hydrology Performance Criteria:

Annual Stage Hydrograph
On a periodic (e.g. one to two consecutive years in ten years) or permanent basis where feasible, maintain lower water levels starting as soon as possible following the spring flood through September 1st so that the following criteria are met:

- Low flow (75% exceedance) - wsel decreased 1' at lock and dams 2 and 3
- Moderate flow (25% exceedance) - wsel decreased 2' at lock and dam 2 and 1' at lock and dam 3
- High flow (2-year flood) - wsel decreased 2' at lock and dam 2

Decadal Stage Variation:
At ten to twenty year time intervals, increase the amount of drawdown for low flow conditions for one to two consecutive growing seasons to simulate longer-term cycles of drought to improve forest regeneration.

Hydraulic Connectivity: Alter hydraulic connectivity so that frequency, duration, magnitude, and timing of flow and resulting stage variation are within optimal limits for desired floodplain vegetation community structure.

Measurable Indicator

Measurable Indicator:

Acres of floodplain forest and grassland
Species diversity

Transition from invasive species dominated areas to desirable floodplain forest. Invasives include Reed Canary Grass, Buckthorn, Black Locust, Garlic Mustard, others

Timeline for Achieving Objectives:

The timing of altering lateral hydraulic connectivity depends significantly on efforts to reduce sediment and nutrient loads on the Minnesota River.

Monitoring Needs:

Discharge measurements througout the reach to update data collected in the 1990s.

Modeling Needs:

2D hydraulic model

Aquatic vegetation models (could use existing Lake Pepin TMDL information)

Sediment Transport

Critical uncertainty:

Minnesota River restoration efforts as affected by funding, agricultural trends.

Invasive species

Climate change

Upper Floodplain Reach, Geomorphic Reach 1
Reach Scale Objectives Conceptual Model
Native Birds (Diving Ducks)

Primary Objective

Biota Objective

Diverse and abundant native bird community

Diving Ducks Performance Criteria

Use-day objectives can be adapted from regional goals established under the North American Waterfowl Management Plan, Upper Mississippi River - Great Lakes Region Joint Venture.

Improve longitudinal distribution within the reach of habitat so that waterfowl use-days in each pool are proportional to the aquatic area of the pool.

Objectives

Habitat Objective

Restored habitat connectivity

Restored aquatic off-channel areas

Biogeochemistry Objectives:

Improved water clarity

Reduced nutrient loading

Reduced sediment loading from tributaries and sediment resuspension in and loading to backwaters

Geomorphology Objective:

Restore a sediment transport regime so that transport, deposition, and erosion rates and geomorphic patterns are within acceptable limits

Hydraulics and Hydrology Objective:

A more natural stage hydrograph

Altered hydraulic connectivity

Performance Criteria

Habitat Performance Criteria
Diving Ducks:
Improve the north/south distribution of diving ducks by securing habitat at appropriate intervals, creating "stepping stones" of habitat, the length of the geomorphic reach to:
- shorten the flight distance between "stepping stones" of preferred habitat.
- decrease the potential negative effects of local crashes in habitat (aquatic beds - SAV), accidentental contaminant spills, and disease outbreaks

• Provide secure habitat (closed areas) along the floodplain at 5-15 mile intervals in Reach 1 (need to evaluate this further).

Provide visual barriers between habitat and human activity and minimize human activity in optimal feeding and resting habitat.

Increase SAV in backwaters <2m deep to achieve a frequency of occurrence >49% (LTRMP sampling protocol), biomass >___kg/ha, species richness >____ and Shannon diversity index > ____ by 2025.

Increase the spatial extent of EAV to >_____acres with >___ species richness and community Shannon diversity index > ____by 2025.

Biogeochemistry Performance Criteria:

TSS (mg/L) - Summer average TSS concentrations will need to be reduced about 32% (47 to 32 mg/L) from existing conditions based on the combined monitoring data for Locks and Dams 2 and 3.

Achieve a Secchi depth based on June through September averages at lock and dam 3 of 47 cm.

Backwaters: Achieve a Secchi depth of 80 cm for the June through September averages.

Reduce Sediment and Phosporous loads to GR 1 by 2025.
Minnesota River: 50%
Miss R u/s of TC: 20%
St. Croix River: 20%
Cannon River: 50%
Other Tributaries: 20%
From Scenario 17, Lake Pepin TMDL Study

Backwaters/Floodplain:
TP < 0.1 mg/L (Sullivan, 2008)
TN < 1.23 mg/L (Sullivan, 2008)

Minimize Mississippi River sediment loading to the Vermillion River Bottoms for flows below the 2-year flood event.

Geomorphology Performance Criteria:

Backwaters: Alter connectivity between backwaters and channels or between sub-areas within backwaters to reduce sediment and nutrient inputs

Impounded areas: Reduce connectivity between historic floodplains and channels for total river discharges less than the two year flood to create contigous backwaters, isolated wetlands, and floodplain lakes.

Achieve wind fetch criteria based on water depth in aquatic off-channel areas.

Water Depth (ft)	1	2	3	4
Fetch (ft)	1500	3500	6000	9000

Hydraulics and Hydrology Performance Criteria:

Stage Hydrograph
On a periodic (e.g. one to two consecutive years in ten years) or permanent basis where feasible, maintain lower water levels starting as soon as possible following the spring flood through September 1st so that the following criteria are met:

- Low flow (75% exceedance) - wsel decreased 1' at lock and dams 2 and 3
- Moderate flow (25% exceedance) - wsel decreased 2' at lock and dam 2 and 1' at lock and dam 3
- High flow (2-year flood) - wsel decreased 2' at lock and dam 2

Hydraulic Connectivity:
Backwaters: Alter connectivity between backwaters and channels or between sub-areas within backwaters to reduce sediment and nutrient inputs

Impounded areas: Reduce hydraulic connectivity between historic floodplains and channels for total river discharges less than the two year flood to create contiguous backwaters, or isolated wetlands and floodplain lakes.

Vermillion River Bottoms: Eliminate flow from the Mississippi River to the Vermillion Bottoms for discharges lower than the 2-year flood event.

Lower tributary valleys: Increase connectivity so floodplains convey water for flood events greater than the 2-year recurrence interval. Tributary distributary channel connectivity should vary seasonally based on historic ranges.

Regulation of closed areas
Voluntary avoidance
Islands with trees for visual barriers

Partial Closures
Tributaries

Islands (Natural Levees)

Water Level Drawdowns
Islands
Closures on channels to Vermillion River
Lower Tributary Valley restoration ??? Which ones

Measurable Indicator

Measurable Indicator:
SAV and RFV in MCB: Frequency of occurrence using EMAP sampling design. Biomass estimated from rake abundance.
SAV and RFV in Backwaters: Biomass, Shannon diversity index EAV in Backwaters: Spatial extent (acres), Shannon diversity index

TSS at LD2 and LD3, Secchi transparency in backwaters
Load allocations for N, P from TMDL efforts

Stage hydrograph, interannual variation, frequency of summer low stage conditions
Ratio of main channel flow to off-channel flow at the 25 percent duration level of river discharge

Longitudinal Distribution of Diving Duck Use (Duck Use Days per pool or sub-area) during the Spring and Fall migrations

Timeline for Achieving Objectives:

The timing of altering lateral hydraulic connectivity depends significantly on efforts to reduce sediment and nutrient loads on the Minnesota River.

Monitoring Needs:

Duck Use Days
SAV distribution
Light penetration
TSS
Nutrient concentrations
Tributary sediment loads
Hydraulic Connectivity mainstem and tributaries

Need surveys to determine duck numbers and distribution (locations of high use areas). Determine impacts of human disturbance during spring migration; probably much less than during the fall migration hunting season.

Modeling Needs:

SAV model
Wind effects model
2D hydraulic model

Critical uncertainty:

Factors driving SAV cycles

Breeding populations affected by climate, predators; wintering populations affected by habitat conditions that affect body conditions going into the spring migration and nesting season.

How important is the UMR for divers during the spring migration? Canvasbacks use is very high in the spring, but not adequately documented.

Upper Floodplain Reach, Geomorphic Reach 1
Reach Scale Objectives Conceptual Model
Native Birds (Puddle Ducks)

Ecological Status

Ecological Status of Puddle Ducks in Geomorphic Reach 1:

Geomorphic Reach 1 contains several publicly and privately owned areas that provide puddle duck habitat, including: MN Valley National Wildlife Refuge, Gores Wildlife Area, Diamond Bluff Hunt Club, and Red Wing Hunt Club.

Waterfowl surveys of these areas show peak numbers of puddle ducks ranging from ____ to ______ birds.
Hunter success in certain areas is high.

Good migration habitat for dabbling ducks is dependent upon plant species composition and distribution, bathymetric diversity, fall water conditions, adjacent land use practices, and a lack of human disturbance. Duck use is further influenced by local availability of sandbars/mudflats, loafing structures, thermal protection, and visual barriers.

Potential restoration sites in Geomorphic Reach 1 include: the Pierce County Islands Wildlife Area, Sturgeon, North and Sharp Muskrat Lakes and lakes along the lower Minnesota River.

Primary Objective

Biota Objective

Diverse and abundant native bird community

Puddle Ducks Performance Criteria

Use-day objectives can be adapted from regional goals established under the North American Waterfowl Management Plan, Upper Mississippi River - Great Lakes Region Joint Venture.

Improve longitudinal distribution within the reach of habitat so that waterfowl use-days in each pool are proportional to the aquatic area of the pool.

Objectives

Habitat Objective

Restored habitat connectivity

Restored riparian habitat

Restored aquatic off-channel areas

Restored terrestrial floodplain areas

Biogeochemistry Objectives:

Improved water clarity

Reduced nutrient loading

Reduced sediment loading from tributaries and sediment resuspension in and loading to backwaters

Geomorphology Objective:

Restore a sediment transport regime so that transport, deposition, and erosion rates and geomorphic patterns are within acceptable limits

Hydraulics and Hydrology Objective:

A more natural stage hydrograph

Altered hydraulic connectivity

Performance Criteria

Habitat Performance Criteria

Puddle Ducks:
Improve the north/south distribution of puddle ducks by securing habitat at appropriate intervals, creating "stepping stones" of habitat, the length of the geomorphic reach to:
- shorten the flight distance between "stepping stones" of preferred habitat.
- decrease the potential negative effects of local crashes in habitat (aquatic beds - SAV), accidentental contaminant spills, and disease outbreaks

• Provide secure habitat (closed areas) along the floodplain at 5-15 mile intervals in Reach 1 (need to evaluate this further).

Provide visual barriers between habitat and human activity and minimize human activity in optimal feeding and resting habitat.

Increase SAV in backwaters <2m deep to achieve a frequency of occurrence >49% (LTRMP sampling protocol), biomass >___kg/ha, species richness >____ and Shannon diversity index > ____ by 2025.

Increase the spatial extent of EAV to >_____acres with >___ species richness and community Shannon diversity index > ____by 2025.
70% of area is open water with submersed beds.

Depths vary from 1 inch to 4 feet; provides seasonal use:

Biogeochemistry Performance Criteria:

TSS (mg/L) - Summer average TSS concentrations will need to be reduced about 32% (47 to 32 mg/L) from existing conditions based on the combined monitoring data for Locks and Dams 2 and 3.

Achieve a Secchi depth based on June through September averages at lock and dam 3 of 47 cm.

Backwaters: Achieve a Secchi depth of 80 cm for the June through September averages.

Reduce Sediment and Phosporous loads to GR 1 by 2025.
Minnesota River: 50%
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St. Croix River: 20%
Cannon River: 50%
Other Tributaries: 20%
From Scenario 17, Lake Pepin TMDL Study

Backwaters/Floodplain:
TP < 0.1 mg/L (Sullivan, 2008)
TN < 1.23 mg/L (Sullivan, 2008)

Minimize Mississippi River sediment loading to the Vermillion River Bottoms for flows below the 2-year flood event.

Geomorphology Performance Criteria:

Backwaters: Alter connectivity between backwaters and channels or between sub-areas within backwaters to reduce sediment and nutrient inputs

Impounded areas: Reduce connectivity between historic floodplains and channels for total river discharges less than the two year flood to create contigous backwaters, isolated wetlands, and floodplain lakes.

Achieve wind fetch criteria based on water depth in aquatic off-channel areas.

Water Depth (ft)	1	2	3	4
Fetch (ft)	1500	3500	6000	9000

Hydraulics and Hydrology Performance Criteria:

Stage Hydrograph
On a periodic (e.g. one to two consecutive years in ten years) or permanent basis where feasible, maintain lower water levels starting as soon as possible following the spring flood through September 1st so that the following criteria are met:

- Low flow (75% exceedance) - wsel decreased 1' at lock and dams 2 and 3
- Moderate flow (25% exceedance) - wsel decreased 2' at lock and dam 2 and 1' at lock and dam 3
- High flow (2-year flood) - wsel decreased 2' at lock and dam 2

Hydraulic Connectivity:
Backwaters: Alter connectivity between backwaters and channels or between sub-areas within backwaters to reduce sediment and nutrient inputs

Impounded areas: Reduce hydraulic connectivity between historic floodplains and channels for total river discharges less than the two year flood to create contiguous backwaters, or isolated wetlands and floodplain lakes.

Vermillion River Bottoms: Eliminate flow from the Mississippi River to the Vermillion Bottoms for discharges lower than the 2-year flood event.

Lower tributary valleys: Increase connectivity so floodplains convey water for flood events greater than the 2-year recurrence interval. Tributary distributary channel connectivity should vary seasonally based on historic ranges.

Regulation of closed areas
Voluntary avoidance
Islands with trees for visual barriers
Plant Mast Trees

Partial Closures
Tributaries

Islands (Natural Levees)

Water Level Drawdowns
Islands
Closures on channels to Vermillion River
Lower Tributary Valley restoration ??? Which ones

Measurable Indicator

Measurable Indicator
• SAV and RFV in MCB: Frequency of occurrence using EMAP sampling design. Biomass estimated from rake abundance.
SAV and RFV in Backwaters: Biomass, Shannon diversity index EAV in
Backwaters: Spatial extent (acres), Shannon diversity index

TSS at LD2 and LD3, Secchi transparency in backwaters
Load allocations for N, P from TMDL efforts

Stage hydrograph, interannual variation, frequency of summer low stage conditions
Ratio of main channel flow to off-channel flow at the 25 percent duration level of river discharge
• Longitudinal Distribution of Dabbling Duck Use (Duck Use Days per pool or sub-area) during the fall migration.
• Distance to adjacent floodplain forest (mast) and cropland.
• Number of pockets of small wetlands within same adjacent forest.
• Number of closed areas

Timeline for Achieving Objectives:

The timing of altering lateral hydraulic connectivity depends significantly on efforts to reduce sediment and nutrient loads on the Minnesota River.

Monitoring Needs:

Duck Use Days
SAV distribution
Light penetration
TSS
Nutrient concentrations
Tributary sediment loads
Hydraulic Connectivity mainstem and tributaries

Need surveys to determine duck numbers and distribution (locations of high use areas). Determine impacts of human disturbance during spring migration; probably much less than during the fall migration hunting season.

Modeling Needs:

SAV model
Wind effects model
2D hydraulic model

Critical uncertainty:

Factors driving SAV cycles

Breeding populations affected by climate, predators; wintering populations affected by habitat conditions that affect body conditions going into the spring migration and nesting season.

How important is the UMR for puddle ducks during the spring migration?

Upper Floodplain Reach, Geomorphic Reach 1
Reach Scale Objectives Conceptual Model
Lentic Fish

Primary Objective

Biota Objective

Diverse and abundant native fish community

Lentic Fish Performance Criteria:
Restore/maintain lentic fish habitat to yield desired electrofishing catch per unit effort of age 1 plus fish in over-wintering sites. Year to year variations should range from:

Fair - good:
- 100-200 bluegills/hour
- 50 - 100 largemouth bass/hour

Good - Excel:
- 200-300 bluegills/hour
- 100-150 Largmouth bass/hour

Excellent:
- >300 bluegills/hour
- >150 largemouth bass/hour

Objectives

Habitat Objective

Restored aquatic off-channel areas

Biogeochemistry Objective:
Improved water clarity

Reduced nutrient loading

Reduced sediment loading from tributaries and sediment resuspension in and loading to backwaters

Geomorphology Objective:

Restore a sediment transport regime so that transport, deposition, and erosion rates and geomorphic patterns are within acceptable limits

Hydraulics and Hydrology Objective:

A more natural stage hydrograph

Altered hydraulic connectivity

Performance Criteria

Habitat Performance Criteria

Restored aquatic off-channel areas
Isolated floodplain lakes: Maintain or create a spatial distribution and physical characterisitcs approaching the following criteria

Parameter	Bluegills	Largemouth Bass
Size	>10 ac	>10 ac
Depth	> 4' 30 to 60% area	> 6' 40 to 70% area
Distribution	1 to 6/square mile	1 to 2/square mile
Total Area	> 10% of area	> 10% of area
Quality Areas	< 2 miles apart	< 4 miles apart

Habitat Connectivity 80% of lakes accessable
Hydraulic Connectivity approaches zero for flow less than the 2-year flood

Restore/maintain aquatic vegetation at levels beneficial for various life stages and seasonal needs of lentic fish.

Summer: Aquatic vegetation cover in the range of 40-60% of off - channel areas.
Winter: Aquatic vegetation cover in the range of 25-50%.

Biogeochemistry Performance Criteria:
TSS (mg/L) - Summer average TSS concentrations will need to be reduced about 32% (47 to 32 mg/L) from existing conditions based on the combined monitoring data for Locks and Dams 2 and 3.

Achieve a Secchi depth based on June through September averages at lock and dam 3 of 47 cm.

Backwaters: Achieve a Secchi depth of 80 cm for the June through September averages.

Reduce Sediment and Phosporous loads to GR 1 by 2025.
Minnesota River: 50%
Miss R u/s of TC: 20%
St. Croix River: 20%
Cannon River: 50%
Other Tributaries: 20%
From Scenario 17, Lake Pepin TMDL Study

Backwaters/Floodplain:
TP < 0.1 mg/L (Sullivan, 2008)
TN < 1.23 mg/L (Sullivan, 2008)

Dissolved Oxygen Levels as meseered at mid depth:
Spring: DO > 5mg/l
Summer: DO > 5 mg/l
Winter: DO > 3 mg/l

Water Temperature:

Geomorphology Performance Criteria:

Lower Pool 2 and Lower Pool 3:
Decrease connectivity between existing deep water (greater than 4 feet deep) areas of backwaters and sediment sources to reduce sediment deposition and delta migration into these areas.

Impounded areas: Reduce lateral hydraulic connectivity between historic floodplains and channels for total river discharges less than the two year flood to create contigous backwaters, or isolated wetlands and floodplain lakes.

Substrates of sand and/or gravel available for spawning

Achieve wind fetch criteria based on water depth in aquatic off-channel areas.

Water Depth (ft)	1	2	3	4
Fetch (ft)	1500	3500	6000	9000

Hydraulics and Hydrology Performance Criteria:

Daily Water Level Variation:
Reduce daily water surface elevation variation caused by lock and dam operation by 50%.

Lateral Hydraulic Connectivity: Reduce Lateral Hydraulic Connectivity tooverwintering areas so that Winter current velocity < 0.3 cm/sec over 80% of the backwater lake area.

Tributary Restoration

Islands (Natural Levee)
Closures

Lock and Dam Gate Operation
Islands (Natural Levees)
Closures

Measurable Indicator

Measurable Indicator:
Winter water velocities in backwater areas.

Spatial distribution backwater lakes meeting crieteia for centrarchid overwintering habitat.

Seasonal disssolve oxygen levels

Winter water temperature

Ratio of aquatic vegetation coverage to open water in off channel areas

Lake fall electrofishing catch per hr of lentic fish

Timeline for Achieving Objectives:

The timing of altering lateral hydraulic connectivity depends significantly on efforts to reduce sediment and nutrient loads on the Minnesota River.

Monitoring Needs:

Spatial winter WQ data

Bathymetry

Modeling Needs:

2D hydraulic model

LIDAR for integration with bathymetry to determine timing of inflow to backwaters

Wind affect Modeling

Critical uncertainty:

Invasive species

Disease

Uncertainties

Affect of harvest on populations

Optimum aquatic vegetation coveage to prevent impacts to lentic fish

Drivers influencing zooplankton and invertebrates used as

Upper Floodplain Reach, Geomorphic Reach 1
Reach Scale Objectives Conceptual Model
Mussels

Ecological Status

Ecological Status of Native Mussels in Geomorphic Reach 1

- **Status highly variable by sub-area**
- **MN River – Highly impoverished, low density. Species: historic 39 recent 11. Long-time line for recovery.**
- **St Croix – High quality, medium densities. Species: historic 42 recent 39. 2 Federally endangered L. higginsii and Q. fragosa. Focus on maintaining.**
- **Gorge (USAF – L/D 1) – Little remaining rapids – Mussel density low. Species: historic 19, present 17.**
- **Pool 2 – Upper pool 4 – Recovering mussel fauna, low –medium densities. Re-colonization may be limited by lack of movement upstream by host fish. Species: historic 40, present 28. Re-introduction area for L.h., Q.f., & State listed species. Good opportunities for recovery.**
- **Zebra mussel densities low, except St. Croix.**

Primary Objective

Biota Objective:

Diverse and abundant native mussel community

Mussel Performance Criteria:

	Existing	Year 2025
Catch/unit effort (% sites with > 10/min)	5	10
Catch/unit effort (% sites with < 1/min)	33	20
Species richness (# species)	28	35
Mucket mussel (% of population)	0	1

From Grier, 1920 Pools 5,6, Mucket Mussels =8%

- Manage zebra mussel densities to below an affects level on native mussels.
- Prevent the introduction of Asian carp.
- Increase host availability for selected mussel species that have declined.

Objectives

Habitat Objective

Restored channel areas

Biogeochemistry Objective:

Reduced sediment loading from tributaries and sediment resuspension in and loading to backwaters

Geomorphology Objective:

Restore a sediment transport regime so that transport, deposition, and erosion rates and geomorphic patterns are within acceptable limits

Hydraulics and Hydrology Objective:

A more natural stage hydrograph (daily variations)

Altered hydraulic connectivity

Performance Criteria

Habitat Performance Criteria
Restore ___(acres) of main channel border and or secondary channels ????

Channel Characteristics:
2 < vc < 3 fps for 5% duration event
.5 < vc < 1.5 fps for 75% duration event
dc > 5 feet for 75% duration event

Substrate: Rock/gravel 5% wood 5%

Dimension, pattern, profile result in transport of sediment to delta area or to outlet of secondary channel reach.

Biogeochemistry Performance Criteria:

Reduce Sediment and Phosporous loads to GR 1 by 2025.
Minnesota River: 50%
Miss R u/s of TC: 20%
St. Croix River: 20%
Cannon River: 50%
Other Tributaries: 20%
From Scenario 17, Lake Pepin TMDL Study

Geomorphology Performance Criteria:

Substrate: Rock/gravel 5% wood 5% by 2050.

Hydraulics and Hydrology Performance Criteria:

Daily Variation:
Reduce daily water surface elevation variation caused by lock and dam operation by 50%.

Impounded areas: Reduce lateral hydraulic connectivity between historic floodplains and channels for total river discharges less than the two year flood to create secondary channel habitat.

MCB and Secondary Channels Shear Stress Variation :
Alter seasonal variation in connectivity to achieve desired shear stresses
Low Flow Shear Stress Average =
High Flow Shear Stress Average =

Measurable Indicator

Measurable Indicator:
Number of mussel beds

Species Diversity

Timeline for Achieving Objectives:

The timing of altering lateral hydraulic connectivity depends significantly on efforts to reduce sediment and nutrient loads on the Minnesota River.

Monitoring Needs:

Pool-wide mussel distribution

Modeling Needs:

2D hydraulic model

Sediment Transport

Critical uncertainty:

Minnesota River restoration efforts as affected by funding, agricultural trends.

Invasive species

Climate change

Upper Floodplain Reach, Geomorphic Reach 1
Reach Scale Objectives Conceptual Model
Amphibians (mostly, but not entirely, for species other than mudpuppies)

Note: There is no Biota Objective for Amphibians in the Upper Floodplain Reach. I left this here to retain the information that was obtained from the reach planning team on Amphibians

Primary Objective

Amphibian Objective:

Amphibian species diversity (not thinking of the needs of an individual species here) then is a function of some blend of interconnected terrestrial and wetland habitat that exist over space and time in sufficient quantity and quality in the face of the aforementioned stressors.

• These wetland-upland matrices would include relatively shallow, relatively isolated wetlands of varied size, structure, and vegetative characteristics interspersed with uplands that ranged from forest to wet meadows. In other words, diverse habitats that are well-connected within these matrices, allowing animals to move and populations to flex across the landscape.

Amphibian Performance Criteria:

• Species Richness:
• Composition:
• Abundance:
•

Stressors

Biota Stressors

• High densities of predators (fish, snakes, turtles, birds, crayfish, insects, etc.),

• Agricultural land use, clearcutting

Biogeochemistry Stressor:

• Nutrient fluxes that increase or reduce primary productivity to excessive or insufficient levels, respectively

• Contaminants, such as endocrine disruptors and others, that could reduce fitness via direct and indirect, lethal and sublethal mechanisms

• Increases in temperature that could reduce fitness via direct and indirect, lethal and sublethal mechanisms

Geomorphology Stressor:

• Land use that disrupts or alters effective habitat connectivity permanently (e.g. roads) or temporarily or results in increased densities of predators

• Sedimentation that reduces primary productivity, primarily in the form of periphyton

Hydraulics & Hydrology Stressor:

• Floods and/or insufficient hydroperiods that reduce reproductive success and, for some species, overwintering sites (e.g., physical disruptions or lack of water) or increase predation (e.g., increased predation due to fish and other species moving in with high water or mammals, such as raccoons, moving in during low water)

• Flowing or deep water of any significance

Objectives

Biota Objective

• Prevent the introduction of predators.

Biogeochemistry Objective:

• Reduce sediment, nutrient, and other constituent (e.g endocrine disruptors) concentrations to isolated water bodies.

Geomorphology Objective:

• Increase habitat connectivity between aquatic and terrestrial areas (ie. enable movement between habitats).
• Reduce sediment, nutrient, and other constituent (e.g. endocrine disruptors) loads to isolated water bodies.

Hydraulics and Hydrology Objective:

• Maintain a consistent stage hydrograph during winter.
• Reduce hydraulic connectivity for below bankfull conditions.

Performance Criteria

Biota Performance Criteria

Biogeochemistry Performance Criteria:

• Meet Lake Pepin TMDL standard for turbidity and nutrients by 2025

Geomorphology Performance Criteria:

• Use a combination of remotely sensed data and geospatial analyses integrated with data collected in situ to conduct integrated assessments of the relationships between habitat diversity, landscape connectivity, occupancy, species diversity, and interacting stressors currently coupled with predictions for the future based upon predicted and actual global change and/or management actions.

Hydraulics and Hydrology Performance Criteria:

• Water level variation for winter conditions < 1.0'
• Hydraulic connectivity should approach zero for below bankfull conditions.

Measurable Indicator

Measurable Indicator
Occupancy, relative abundance, and diversity

Reproductive success, frequencies of abnormalities, presence of pathogens

Timeline for Achieving Objectives:

The timing of altering lateral hydraulic connectivity depends significantly on efforts to reduce sediment and nutrient loads on the Minnesota River.

Monitoring Needs:

• Extensive surveys and monitoring of occupancy, relative abundance, and diversity using automated remote recorders to compare future conditions with baseline conditions and monitor trends over space and time.

• Intensive surveys for reproductive success, frequencies of abnormalities, presence of pathogens and disease to monitor any deviations over time in relation to population statuses described by extensive surveys/monitoring.

Modeling Needs:

2D hydraulic model

Sediment Transport

Critical uncertainty:

Minnesota River restoration efforts as affected by funding, agricultural trends.

Invasive species

Climate change

Upper Floodplain Reach, Geomorphic Reach 1
Reach Scale Objectives Conceptual Model
Lotic Fish

Primary Objective

Biota Objective:

Diverse and abundant native fish community

Lotic Fish Performance Criteria:

Restore/maintain lentic fish habitat to yield desired electrofishing catch per unit effort of age 1 plus fish in over-wintering sites. Year to year variations should range from:

Fair - good:
40-70 YOY walleye &/or sauger/hour (calculated CPUE)? Carp biomass is greater than or equal to 50% catch in MC or MCB, Redhorse/Sucker CPUE is less than ?%

Good - Excel:
70 - 100 YOY walley &/or sauger /hour (calculated CPUE)?
Carp biomass is between 25% and 50%, Redhorse/Sucker CPUE is between ?% and ?%

Excellent:
>100 YOY walleye &/or sauger /hour (calculated CPUE)?
Carp biomass less than 25% of catch in MC or MCB, Redhorse/Sucker CPUE is = or greater than ?%

Objectives

HabitatObjective

Restored habitat connectivity

Restored channel areas

Restore rapids

Biogeochemistry Objective:

Reduced sediment loading from tributaries and sediment resuspension in and loading to backwaters

Reduced contaminants loading and remobilization of in-place pollutants

Geomorphology Objective:

Restore a sediment transport regime so that transport, deposition, and erosion rates and geomorphic patterns are within acceptable limits

Hydraulics and Hydrology Objective:

A more natural stage hydrograph (daily variations)

Altered hydraulic connectivity

Performance Criteria

Habitat Performance Criteria

Provide year-round fish passage for native migratory fishes through Locks and Dams 2 and 3 by 2025.

Channel Characteristics:
2 < vc < 3 fps for 5% duration event
.5 < vc < 1.5 fps for 75% duration event
dc > 5 feet for 75% duration event

Substrate: Rock/gravel 5% wood 5%

Dimension, pattern, profile result in transport of sediment to delta area or to outlet of secondary channel reach.

SAV in MCB: Increase the frequency of occurrence to >21% in the MCB areas based on the EMAP sampling protocol (this corresponds to a frequency of occurrence of > 12% using the LTRMP sampling protocol). Increase species richness (maximum # of species) to 11.

Restore ___acres of rapids habitat in the gorge by 2050

Water surface slopes should approach historic values. 1890s River Commision Maps indicated that water surface slopes gradually increase from 2.5 feet per mile in the lower half of the gorge to greater than 6.5 feet per mile in the upper quater of the gorge.

Biogeochemistry Performance Criteria:

Reduce Sediment and Phosporous loads to GR 1 by 2025.
Minnesota River: 50%
Miss R u/s of TC: 20%
St. Croix River: 20%
Cannon River: 50%
Other Tributaries: 20%
From Scenario 17, Lake Pepin TMDL Study

Maintain dissolved oxygen levels sufficient to support lotic fishes, probably over 5 ppm.

Promote increase bed size of macrophytes in the main channel border and side channel border. (Structure, shift nutrient use from micro to macrophyte and helps to hold fine substrate in place.)

Geomorphology Performance Criteria:

•Substrate: rock/gravel 5% wood 5% by 2050.

Depth diversity is available for species requirement throughout the year.

Hydraulics and Hydrology Performance Criteria:

Daily Variation:
Reduce daily water surface elevation variation caused by lock and dam operation by 50%.

Impounded areas: Reduce lateral hydraulic connectivity between historic floodplains and channels for total river discharges less than the two year flood to create secondary channel habitat.

MCB and Secondary Channels Shear Stress Variation :
Alter seasonal variation in connectivity to achieve desired shear stresses
Low Flow Shear Stress Average =
High Flow Shear Stress Average =

Fish Passage Structures
Decommission and remove Lock and Dam 1

Tributary Restoration

Gate operation at dams
Islands (Natural Levees)

Measurable Indicator

Measurable Indicator:
Miles of river reconnected throughout the basin to allow year around fish migration has increased.
Tributary dams have been removed to allow fish to migrate to adjacent valuable bodies of water
Biomass / # of native species in portion to non-native species is higher.
DO below L&D does not fall below 5 ppm during summer conditions.
Historic fish collection indexes show favorable response to improved conditions on the flowing portion of the river. (This may or may not be true for YOY work.)
Increase in aquatic vegetation in MCB or SC

Timeline for Achieving Objectives:

Incrementally this has been done for many years but could step up with a program like NESP. Many factors will influence the outcome of any work in the flowing water portion of the Mississippi River but I would hope a 10% increase in native species biomass or numbers could be realized during the funding cycle for NESP (15 years is often used but we received a dollar authorization not a year authorization in NESP.)

Monitoring Needs:

Would be best to link with existing data collection to determine if work in area of flowing water, improves conditions for native lotic fish. LTRMP WQ, fish and aquatic vegetation sampling would be very helpful. Other existing data sets would be LTM on Mississippi River for WQ by WDNR, YOY sampling for walleye and sauger done by multiple agencies, catfish work, commercial fishery data,

Modeling Needs:

2D hydraulic model

LIDAR for integration with bathymetry to determine timing of inflow to backwaters

Critical uncertainty:

Invasive species
Agricultural changes
Disease
Change in harvest on populations
Climate change

Definitions:

Indicators are measurements of ecosystem condition that allow comparison to one or more reference conditions and when measured over time, allow detection of trends. Objectives for future ecosystem condition have associated indicators.

Objectives are few to many, specific, usually limited to specific subject, time-based, applicable to a particular place, usually measurable or able to recognize achievement. Objectives should not include the solution (e.g., restore depth diversity vs. dredge). (USACE Planning Manual, Nov 1996) Ecosystem objectives are statements about future condition of an ecosystem. In this conceptual model framework objectives are categorized as primary or precursor. Primary objectives are what we want to achieve (e.g. aquatic vegetation, fish, waterfowl). Precursor objectives are categorized by Essential Ecosystem Characteristic and describe the physical/chemical/biological changes that have to take place to achieve the primary objective.

Performance criteria are measureable attributes of ecosystem objectives e.g. acceptable range, thresholds, or limits; based on scientific understanding of desired ecological conditions (adapted from Harwell et al. 1999). SMART performance criteria are Specific, Measurable, Achievable, Relevant, and Time-bound.

Stressor is a human activity that causes change in an ecosystem. The changes can be positive (in terms of persistence of ecosystem components or the production of ecosystem services valued by human society), or negative.

Notes:
1. Many of the objectives listed under each EEC are related to each other. Arrows aren't shown across EECs but are implied.
2. There is no designated starting point, though describing the ecological status (blue box) and stressors (orange boxes) is a logical first step.
3. Listing of objectives and performance criteria under each EEC can be done in any order. This is not a linear process where you finish step one and only then go to step two, etc. One way is to start with the primary biota objective, and then list the secondary biota, biogeochemistry, gemorphology, and hydraulics/hydrology objectives that must be met to achieve the primary biota objective.
4. A biota objective for fish, birds, mammals isn't always listed, however if a target species or group was identified, the conceptual model should include them. A stronger case for ecosystem restoration can be made if at least a qualitative relationship to fish, birds, and mammals is described.
5. Specifying performance criteria is an important step. Performance criteria provides quantitative information on objectives (making them more SMART), helps to establish relationships between stressors, objectives, and inidcators, and establishes limits on what can be achieved.

Relationship between Tier I Essential Ecosystem Characteristics (EECs) to Biota based on conceptual models. "+" indicates increase in magnitude of parameter. "-" indicates decrease in magnitude of parameter, blank space means no parameter adjustment needed based on the conceptual models

	Aquatic Vegetation	Floodplain Vegetation	Diving Ducks	Puddle Ducks	Lentic Fish	Mussels	Amphibians	Lotic Fish
Biogeochemistry								
Water Clarity	+		+	+				
TSS	-		-	-		-	-	-
Nutrients	-	-	-	-			-	-
Dissolved Oxygen					+			+
Winter Temperature					+			
Contaminants								-
Endocrine Disruptors							-	
Geomorphology								
Sediment loads	-		-	-		-	-	-
Nutrient loads	-	-	-	-			-	-
Riparian/littoral transition zone	+	+		+		+		
Visual barriers between channels and backwaters			+	+				
Barriers providing thermal protection from wind				+				
Floodplain/Backwater elevation		+			-			
Channel elevation								+
Substrate Density (flocculent sediment)						+		
Substrate Variability (abiotic - sand,wood) (biotic - mussels)								+
Substrate Size (Gravel Bars)						+		+
Hydraulics & Hydrology								
Mainstem backwater/floodplain lateral hydraulic connectivity	-		-	-	-		-	+
Tributary lateral hydraulic connectivity		+						
Growing Season Drawdown	+	+	+	+				
Daily water level variation					-	-	-	-
Channel velocity variability						+		+
Longitudinal Connectivity at Locks and Dams						+		+