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ADH User Group Meeting Ecological Applications in the Upper Mississippi River

By

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12 - 13 January 2010

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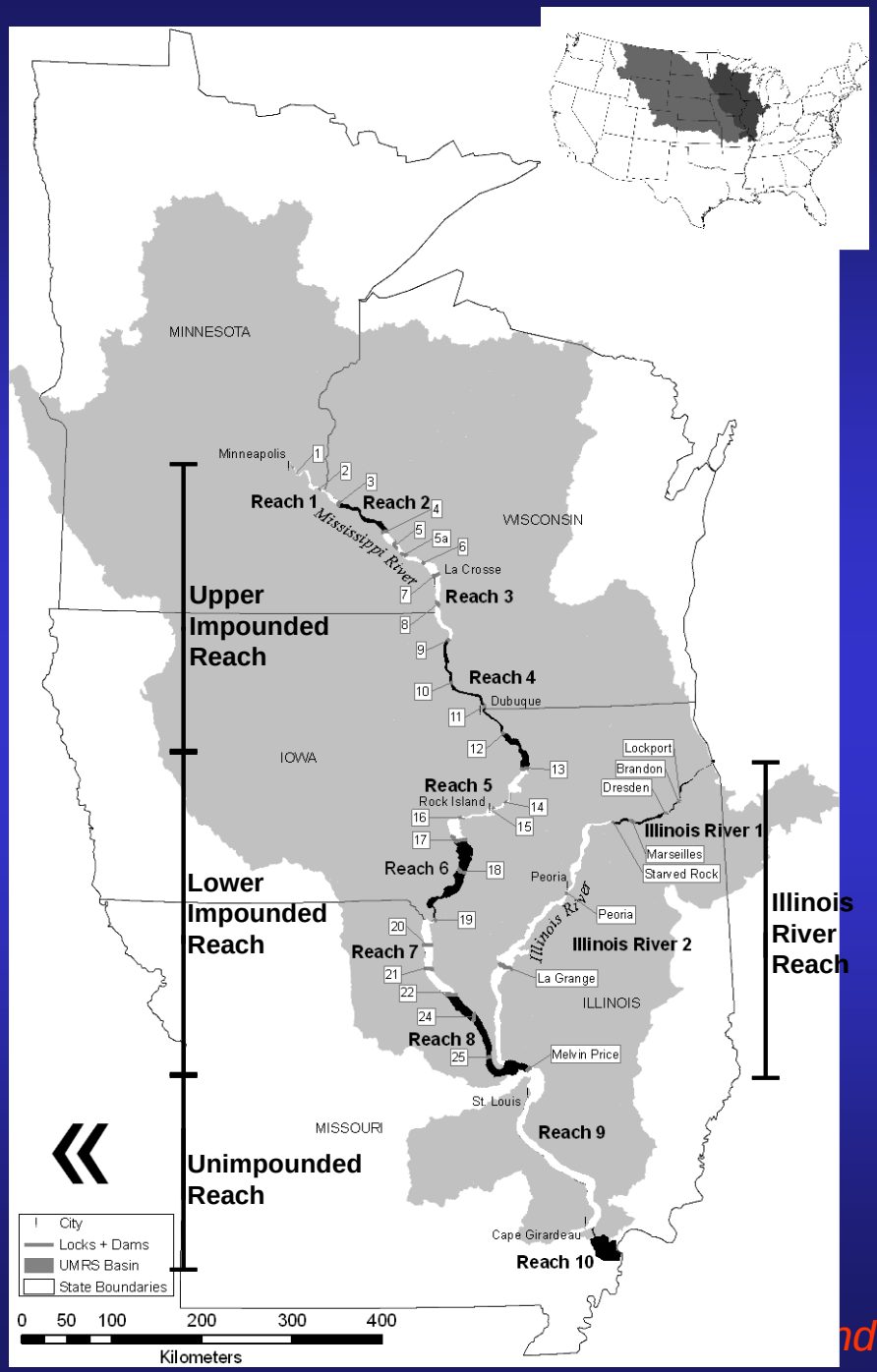
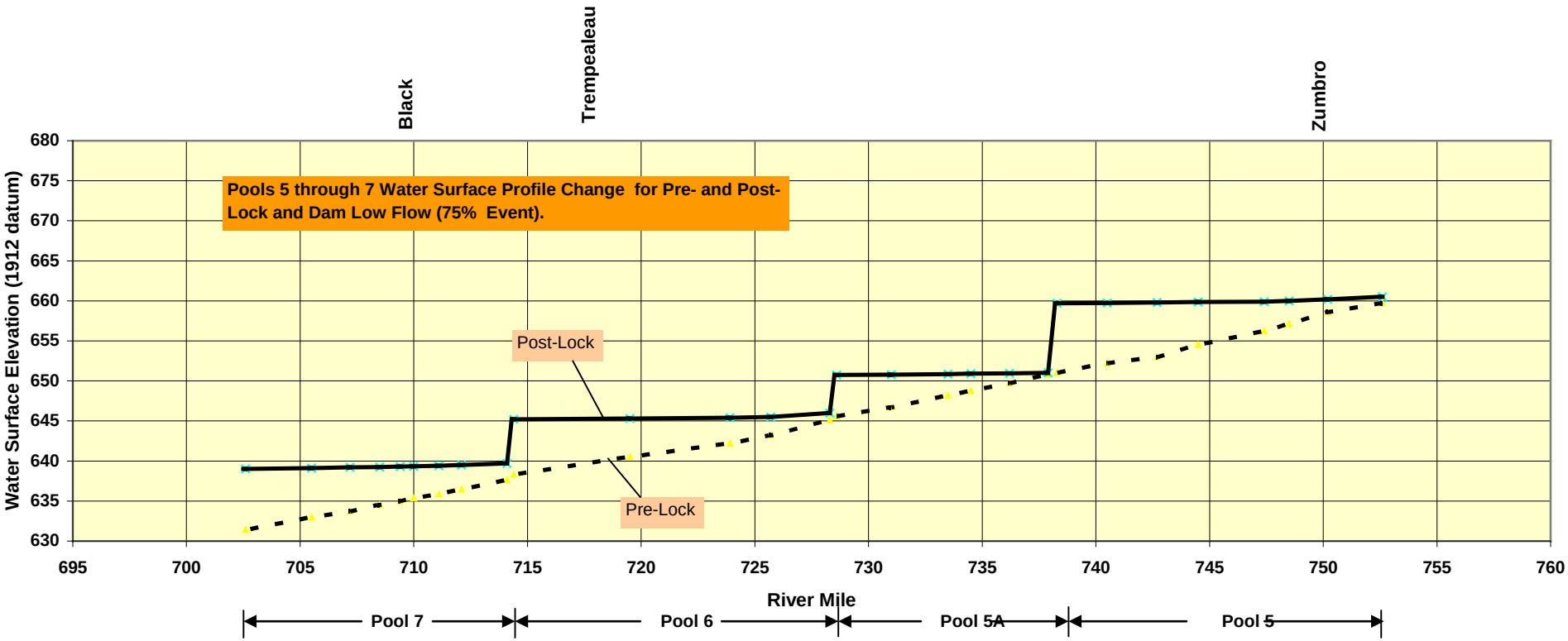


Lock and Dam construction increased water surface elevations for low flows (shown in this plot), stabilized water levels at these increased elevations, and decreased water surface slopes for all flows in each pool.

The short-term response was that plant communities were changed (e.g. floodplain terrestrial to aquatic vegetation. The sediment transport capacity was reduced in many reaches. River banks (or natural levees) in the lower and middle reaches of the pools were submerged or partly submerged.



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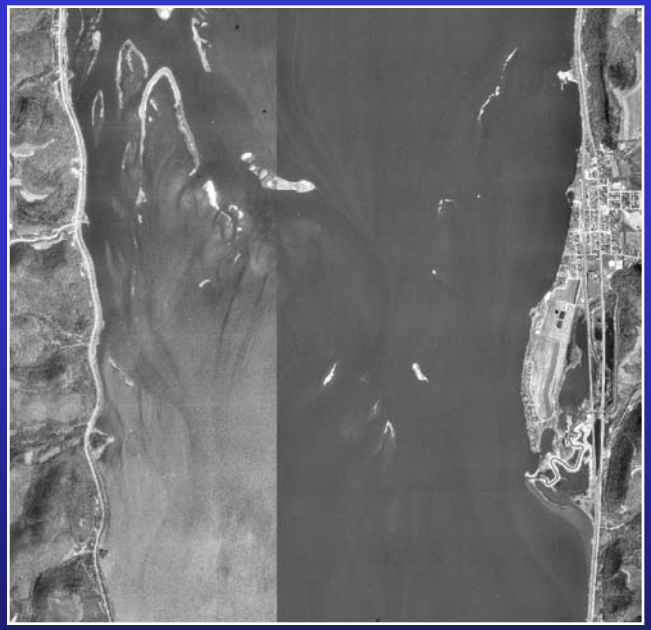
Long-Term Geomorphic and Habitat Changes in Pools

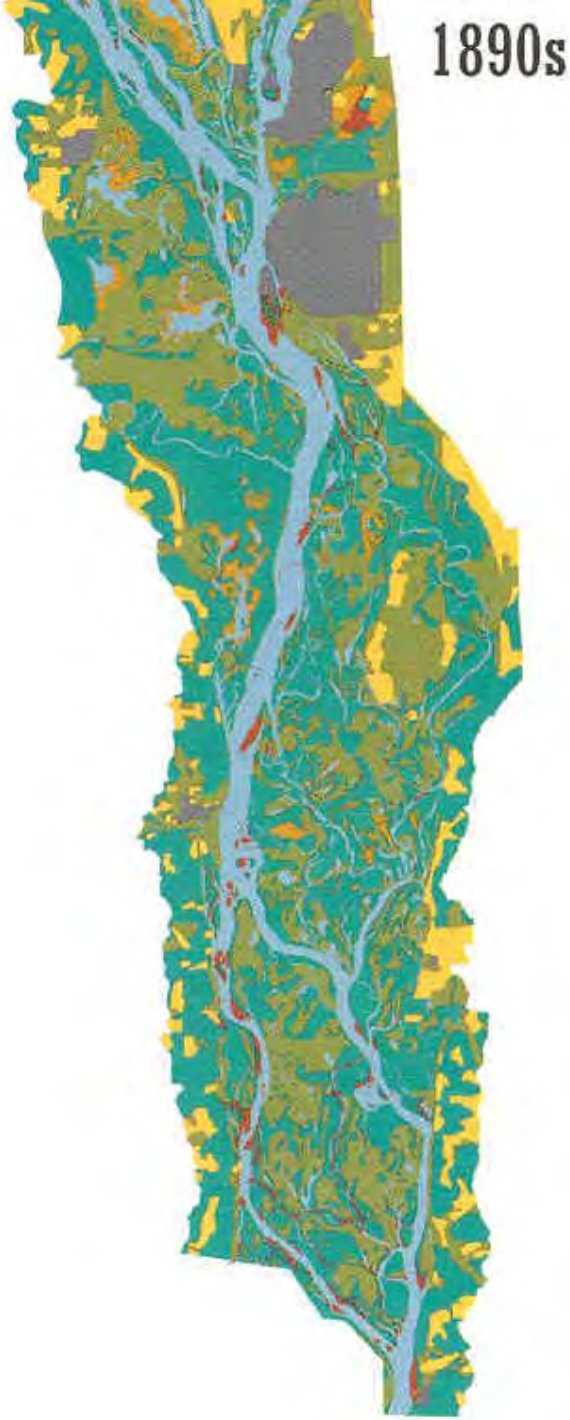
- Land Loss and Erosion
- Sediment Deposition
- Increasing Connectivity

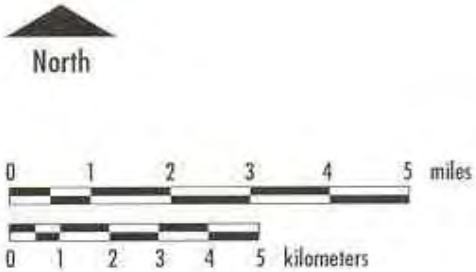
1938

1954

1991





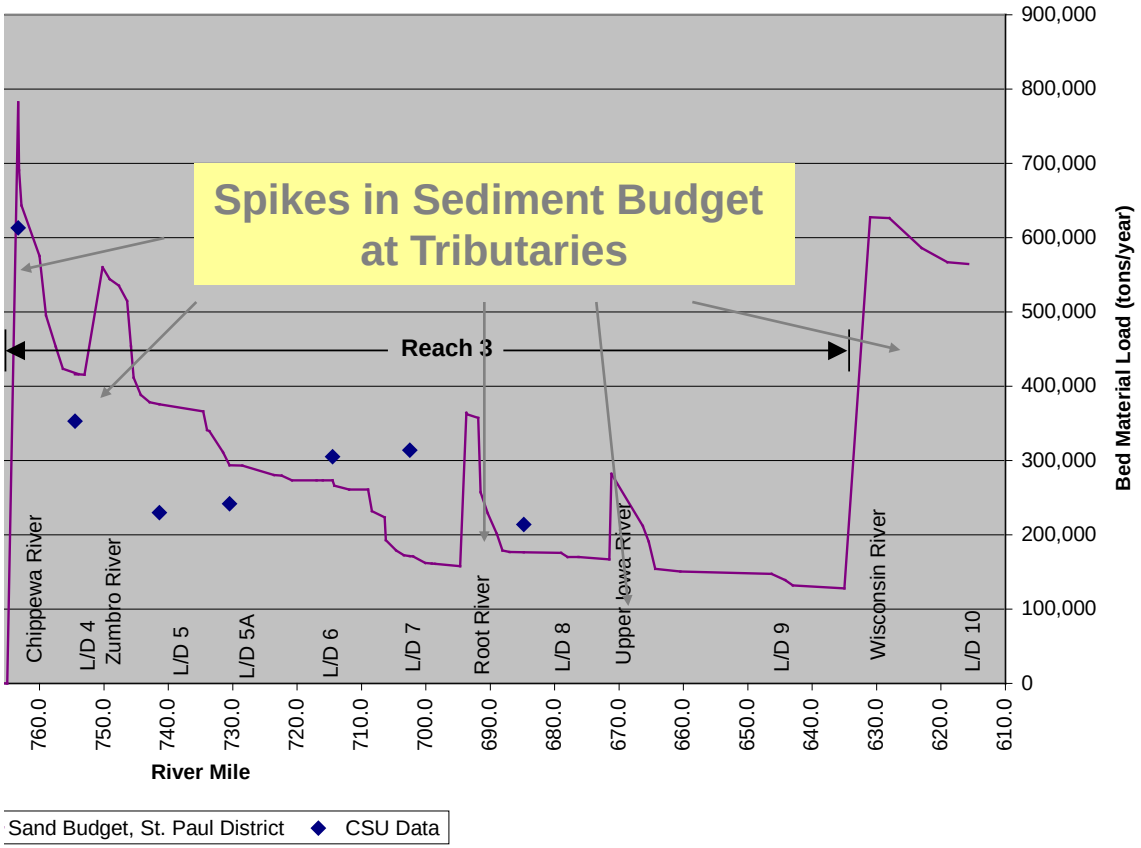


LEGEND

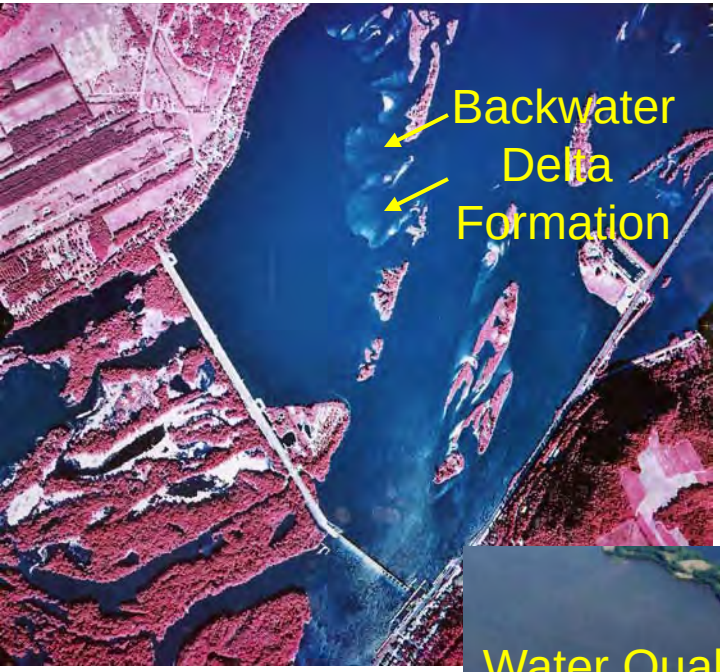
- Open Water
- Marsh
- Grasses/Forbs
- Woody terrestrial
- Agricultural
- Urban/Developed
- Sand/Mud/Rock
- No data

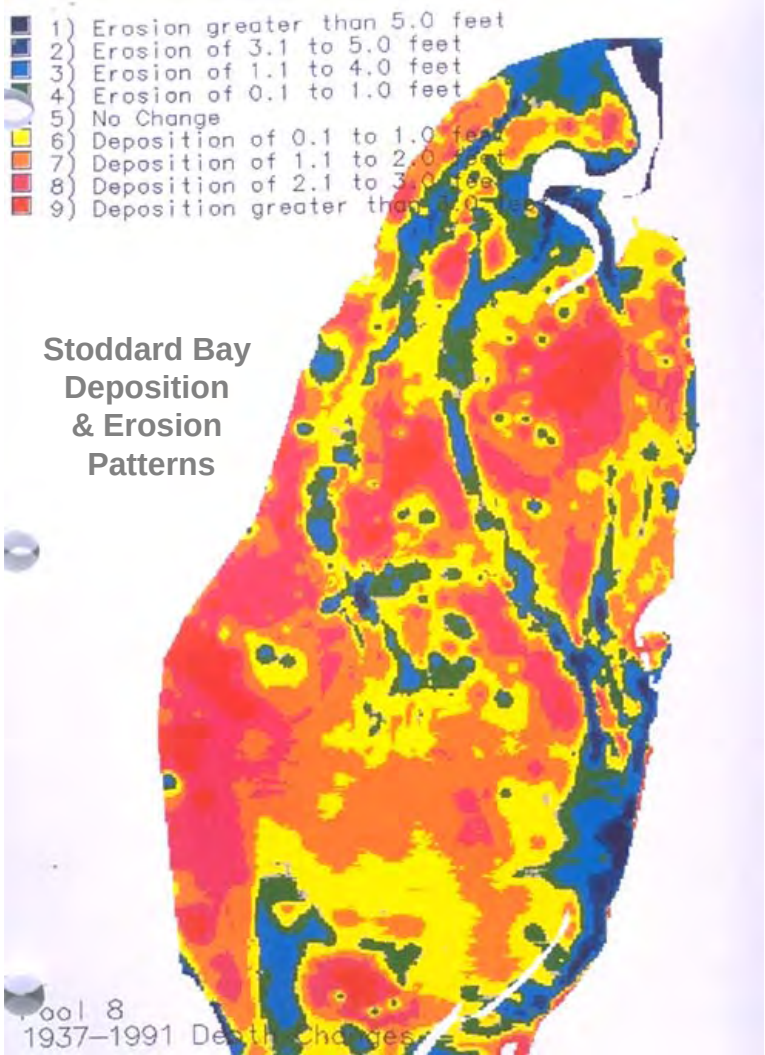
Changes in floodplain habitat in Pool 8 of the UMRS.

Tributary Channelization
Watershed Land-Use Changes



Sediment Transport & Deposition





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Ecosystem Restoration Programs

- Upper Mississippi River Environmental Management Program
  - Ongoing program since 1986
  - Habitat project construction, long-term resource monitoring
- Navigation and Ecosystem Sustainability Program (NESP)
  - New Program: Navigation and Ecosystem Improvement
  - Authorized but limited funding to date
- O&M Involvement
  - Since we are maintaining a navigation system, O&M involvement is important.

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Spring Lake Islands, 2005

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Secondary Channel Mods

Lateral Hydraulic Connectivity

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Backwater Dredging

Floodplain Elevation

Water Level Drawdowns (O&M Funding)

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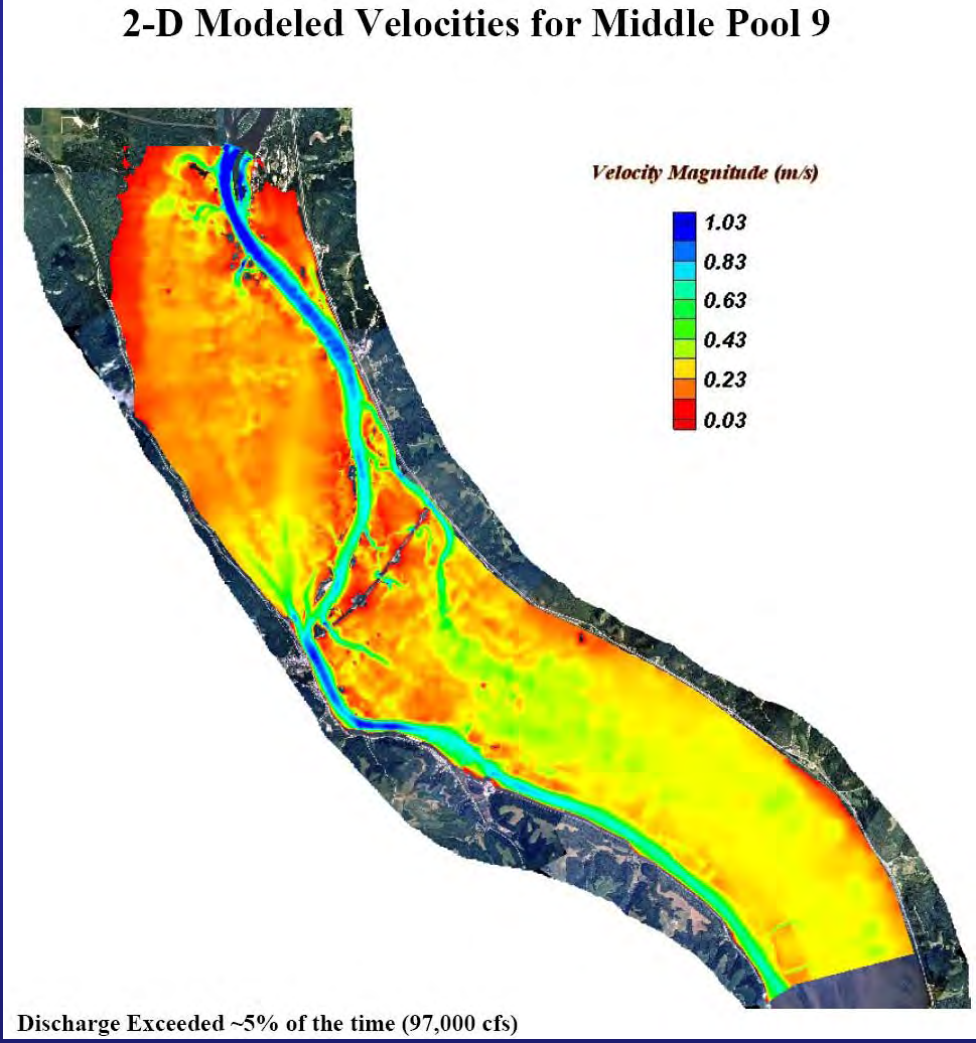
Planning Step: Inventory Existing Conditions

Data needs:
- Topography
- Flow distribution
- Vegetation cover
- Aquatic areas
- Fish and Wildlife

Model needs:
- 2D models
- Wind fetch
- Vegetation Succession



Change in modeled velocity with space and discharge

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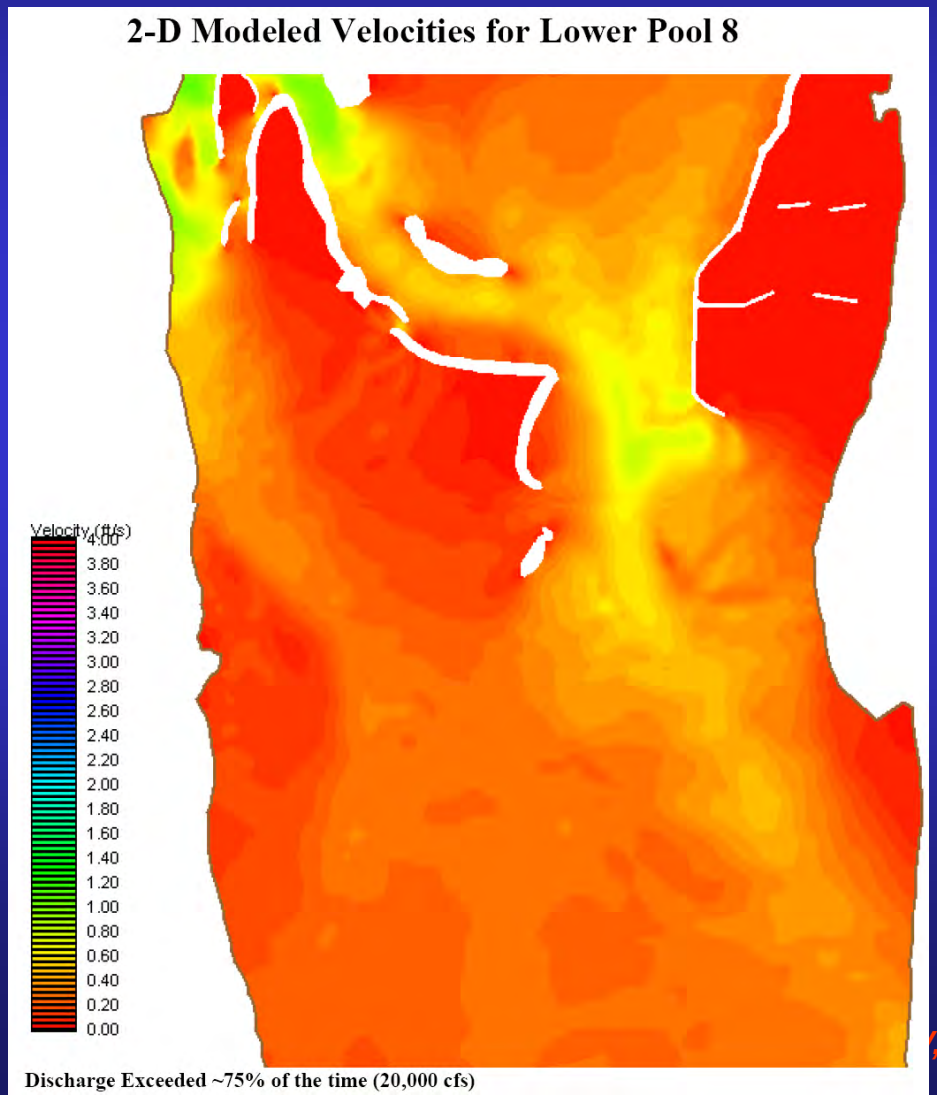

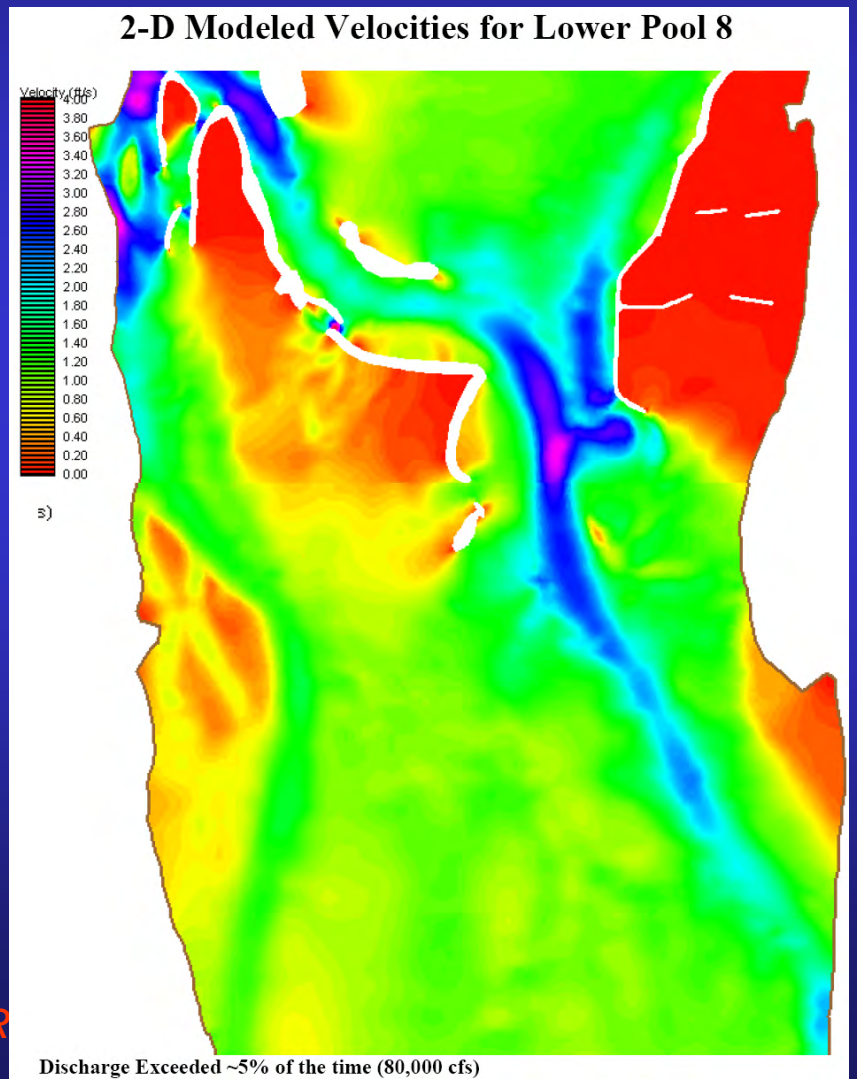

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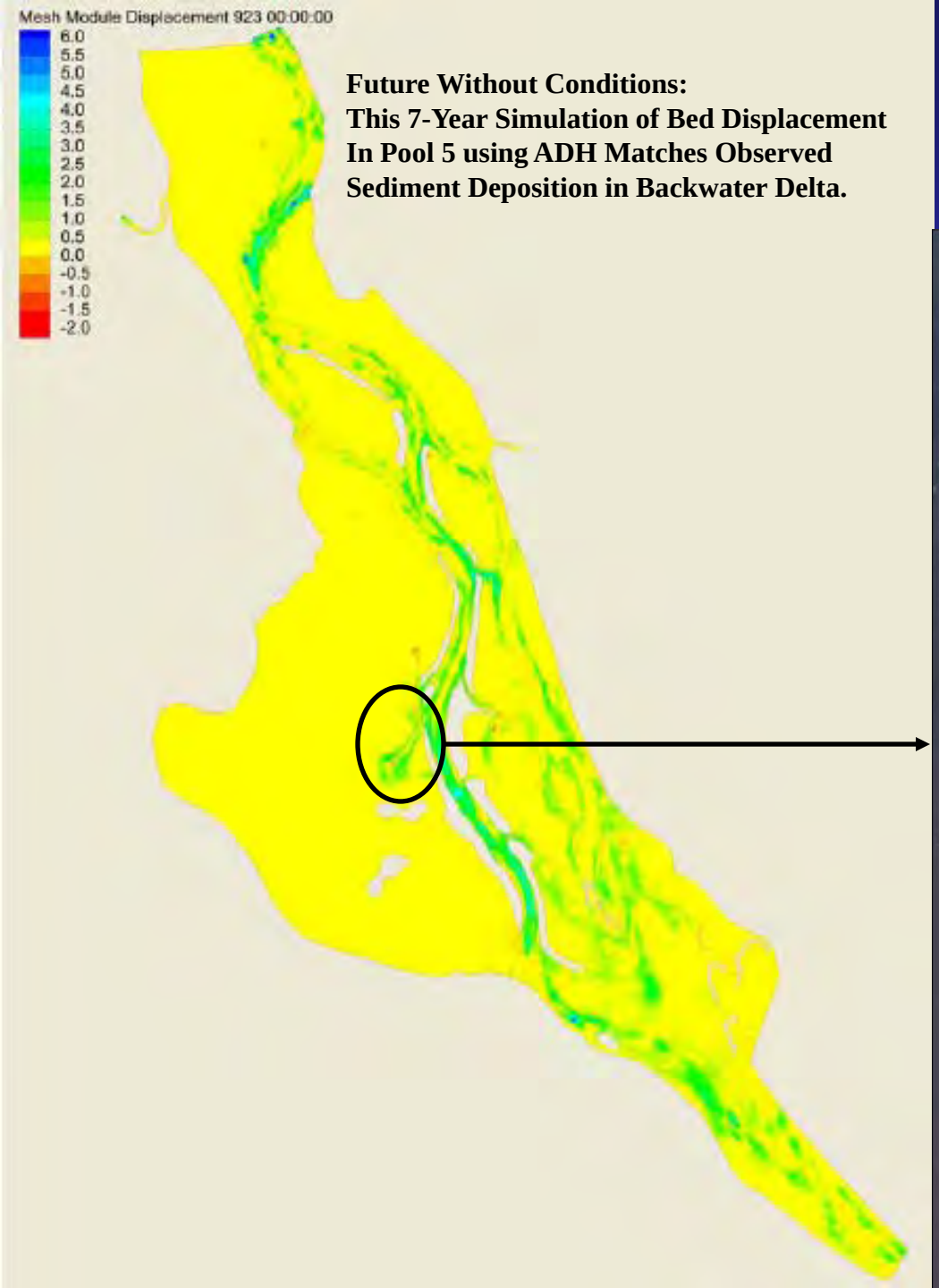
Planning Step:
Forecast Future Without-Project Conditions

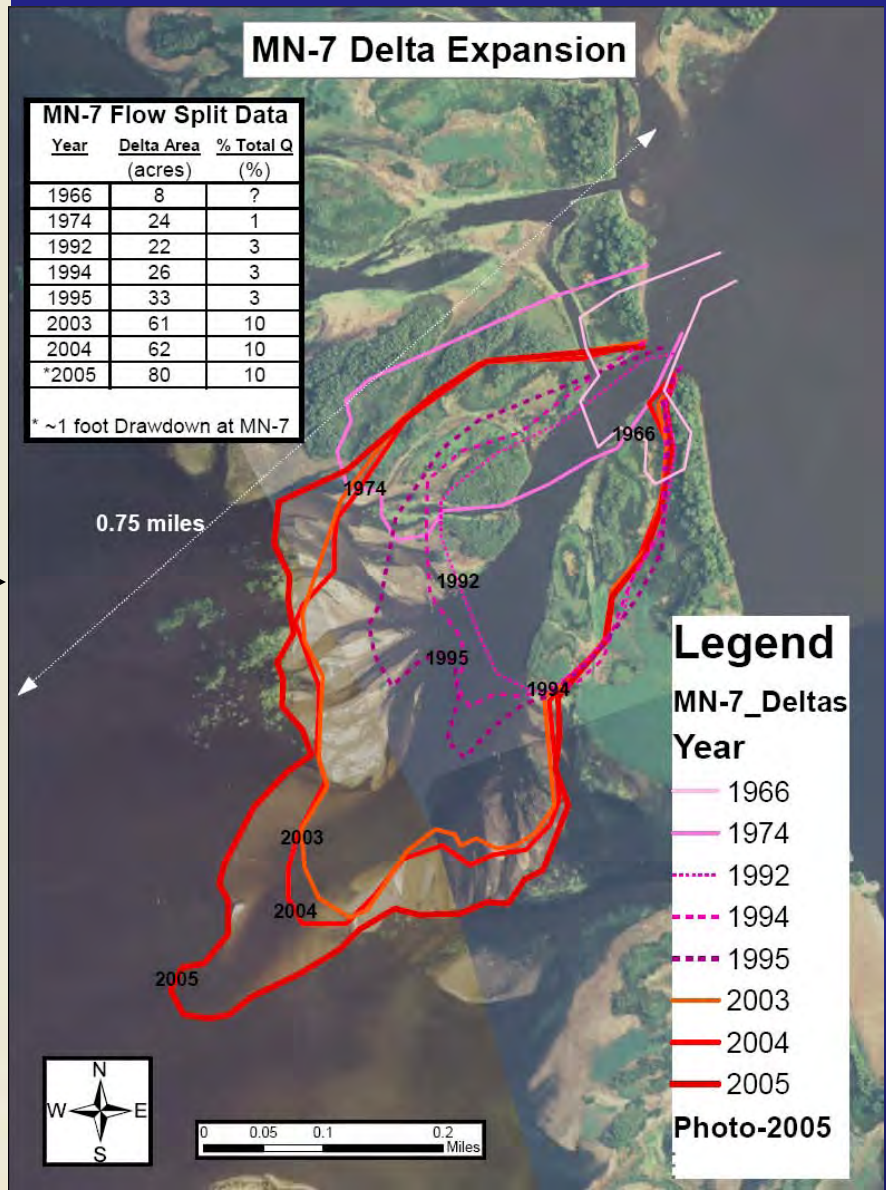
Data needs:
Existing conditions inventory

Model needs:
Geomorphic Change (channels and floodplains)
- **2D models hydraulic, sediment transport (ADH)**
- **Substrate**
- **Aerial photo analysis**

Vegetation Succession (SAV, HGM, CASM)



Future Without Conditions:
This 7-Year Simulation of Bed Displacement In Pool 5 using ADH Matches Observed Sediment Deposition in Backwater Delta.



MN-7 Flow Split Data

Year	Delta Area (acres)	% Total Q (%)
1966	8	?
1974	24	1
1992	22	3
1994	26	3
1995	33	3
2003	61	10
2004	62	10
*2005	80	10

* ~1 foot Drawdown at MN-7

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Planning Step: Identify Project Objectives

Data needs:

- **Information from existing conditions inventory**
- **Forecasted future <u>without-project</u> conditions**
- **Reference Conditions (Historic or Virtual)**

1930 Reference Conditions, Reno Bottoms

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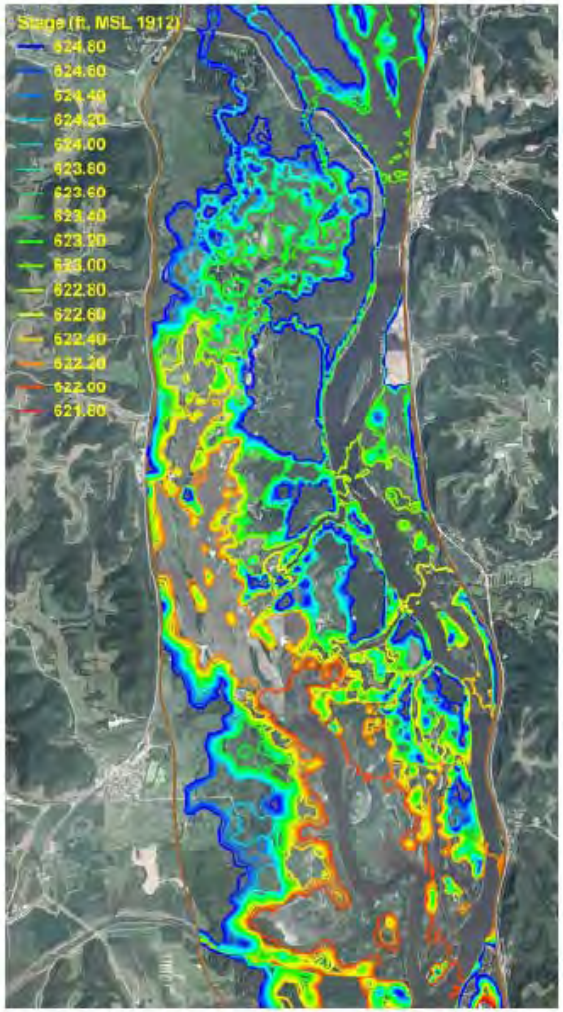
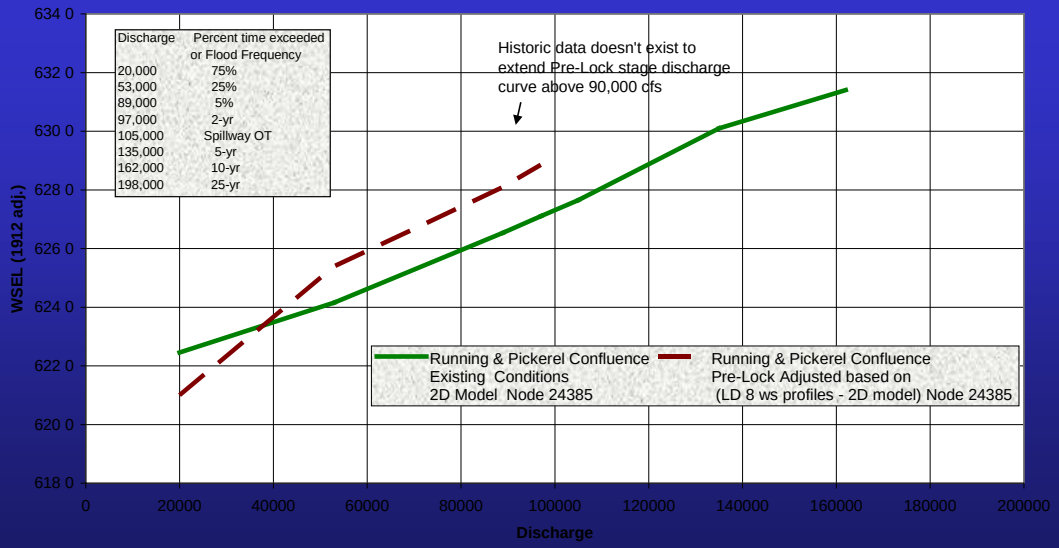


Plate 14: 1930 Reference Condition Stage Data for Total River Discharge of 32,000 cfs

Stage Discharge Relationships, Reno Bottoms (Running & Pickerel Slough Confluence)



Use of Reference Conditions in HGM analysis, Reno Bottoms

- The current FF distribution is about two feet higher in elevation than during pre-Lock and Dam periods. Interestingly, the current stage-discharge relationships at the Hastings Spillway and the confluence of Running and Pickerel Sloughs (Appendix A14) at the low discharge of 20,000 cfs are about 623', or approximately also 2 feet higher than pre-Lock and Dam periods. Apparently, current Pool 9 water management and flow through the LD8 Embankment have been responsible for shifting the FF distribution about two feet higher in most of Reno Bottoms.

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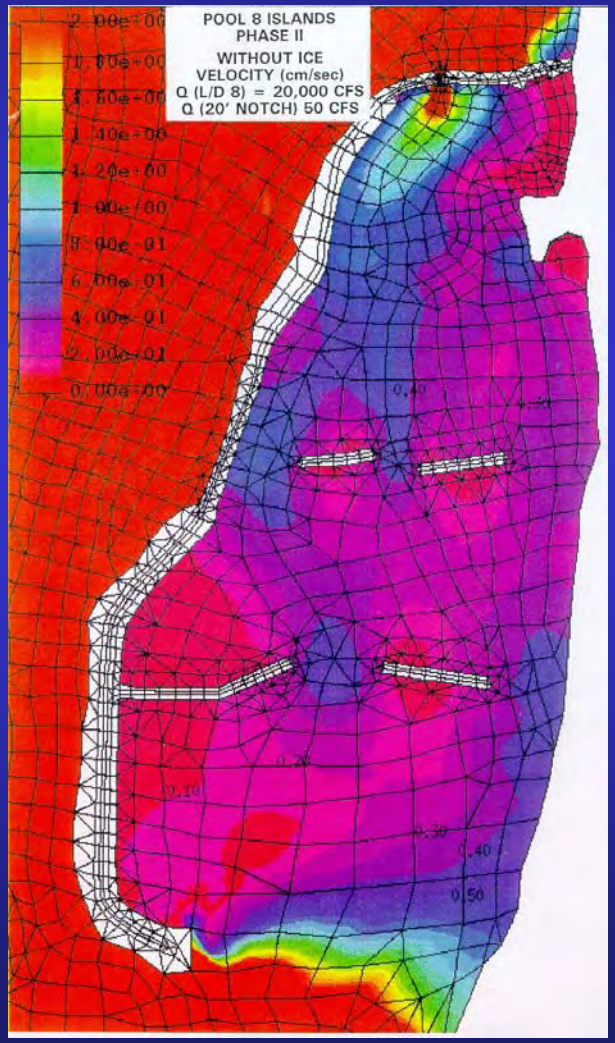
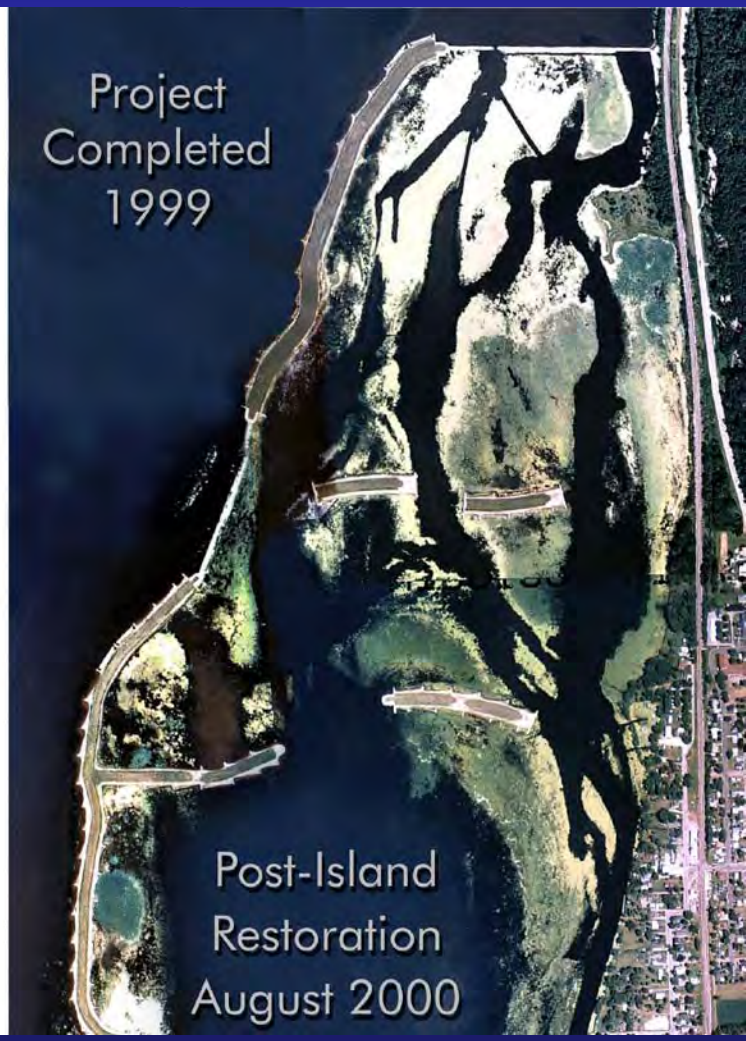
Planning Steps: Formulate, Evaluate, Select Alternative Plans





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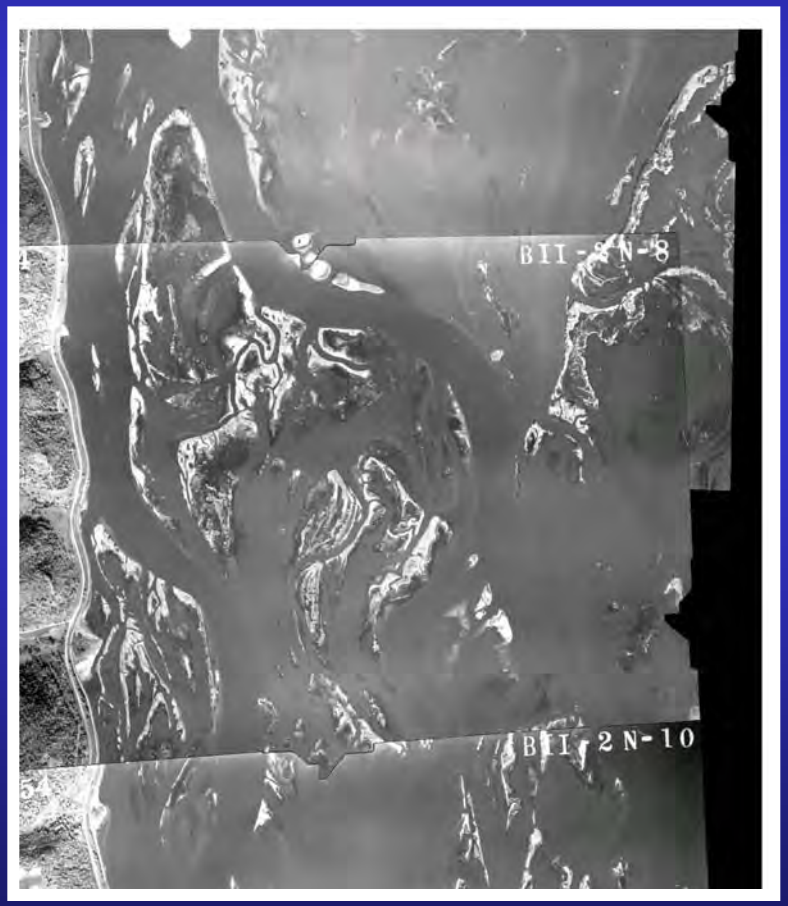
Cumulatively, these projects are improving habitat conditions and “natural processes” in lower Pool 8

1954



2009 - 2012

~~1999~~

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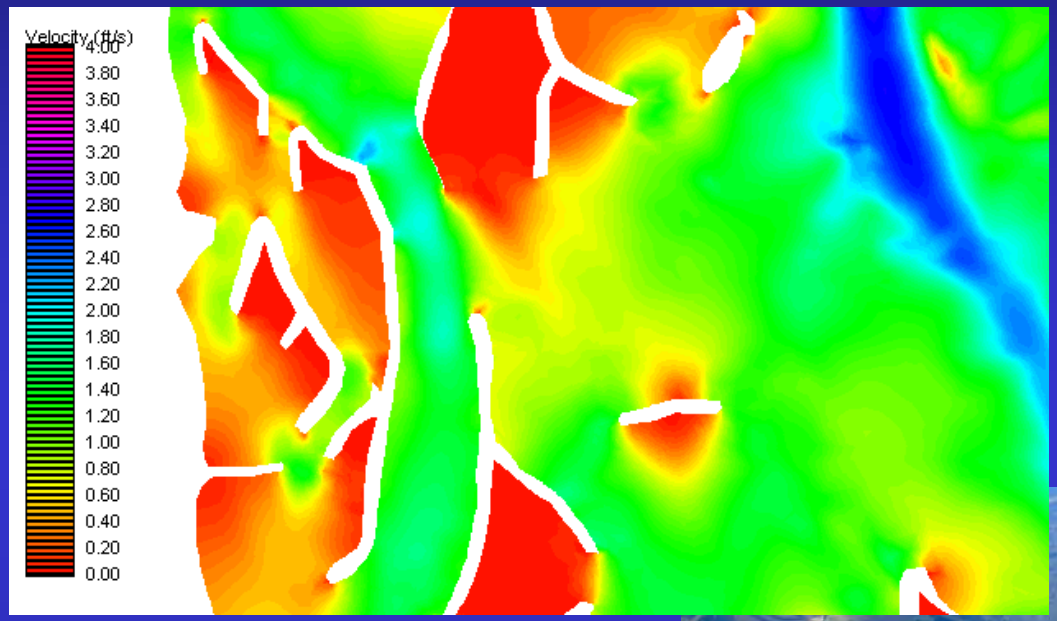

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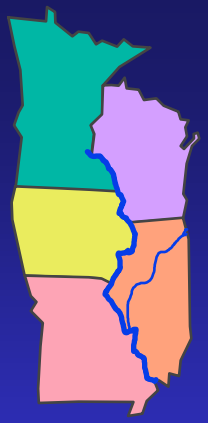
Navigation and Ecosystem Sustainability Program (NESP)



- Reach Planning
  - Stressors affecting habitat
  - Objectives for desired habitat conditions
  - Performance criteria associated with objectives
  - Identify areas/projects providing the best chance for success

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 Sullivan, et al., 2009. To achieve the above 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 (Table 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. 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 (Table 3). 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, Mississisippi 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.
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.

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Biota:
Diverse and abundant native fish community

Lentic Fish

Habitat:
Restored aquatic off-channel areas - Isolated Floodplain Lakes

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

Restored habitat connectivity:
80% of lakes accessable

Models:

Aquatic Vegetation:
Diverse and abundant native aquatic vegetation

SAV **EAV**

Geomorphology:

Restore desired sediment transport regime

Reduce Channel/Off-Channel Connections

Reduce Wind Fetch

Biogeochemistry:

Improved water clarity

Reduced sediment resuspension in and loading to backwaters

Reduced nutrient & sediment loading from Tributaries

Hydraulics and Hydrology:

A more natural stage hydrograph
Reduce daily stage variation

Connectivity: Reduce LHC to overwintering areas so current velocity < 0.01 fps

Biogeochemistry:

D.O. > 3 mg/L winter
D.O. > 5 mg/L summer
Temp > 4 degrees, 35% Area
TP < 0.1 mg/L
TN < 1.23 mg/L

Models:

Models:

Barrier Islands constructed to reestablish natural channel/floodplain flow regimes
Sand bars and mudflats exposed by A 1.5 foot drawdown
Shoreline stabilization protecting existing islands
Seed Islands constructed to increase bathymetric diversity by promoting sediment deposition downstream of the Islands and sediment erosion on either side of the islands
Pool 8 Water Level Drawdown and Island Construction
The End
7/11/2001 10:23am

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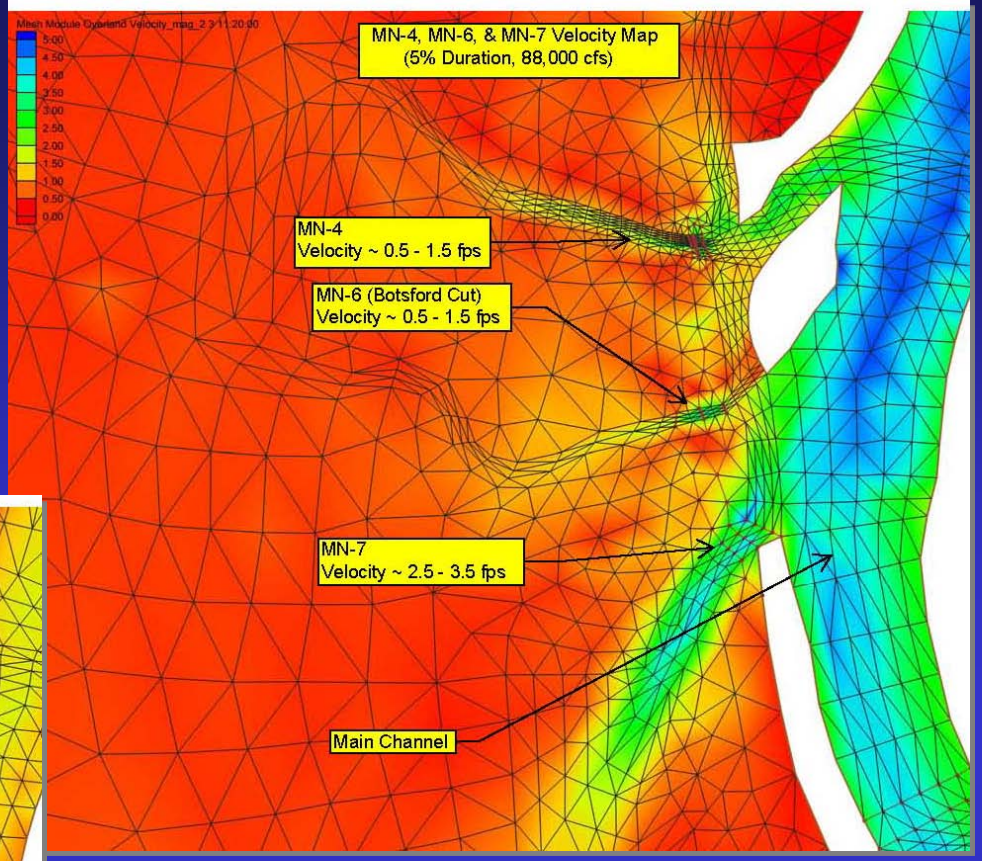
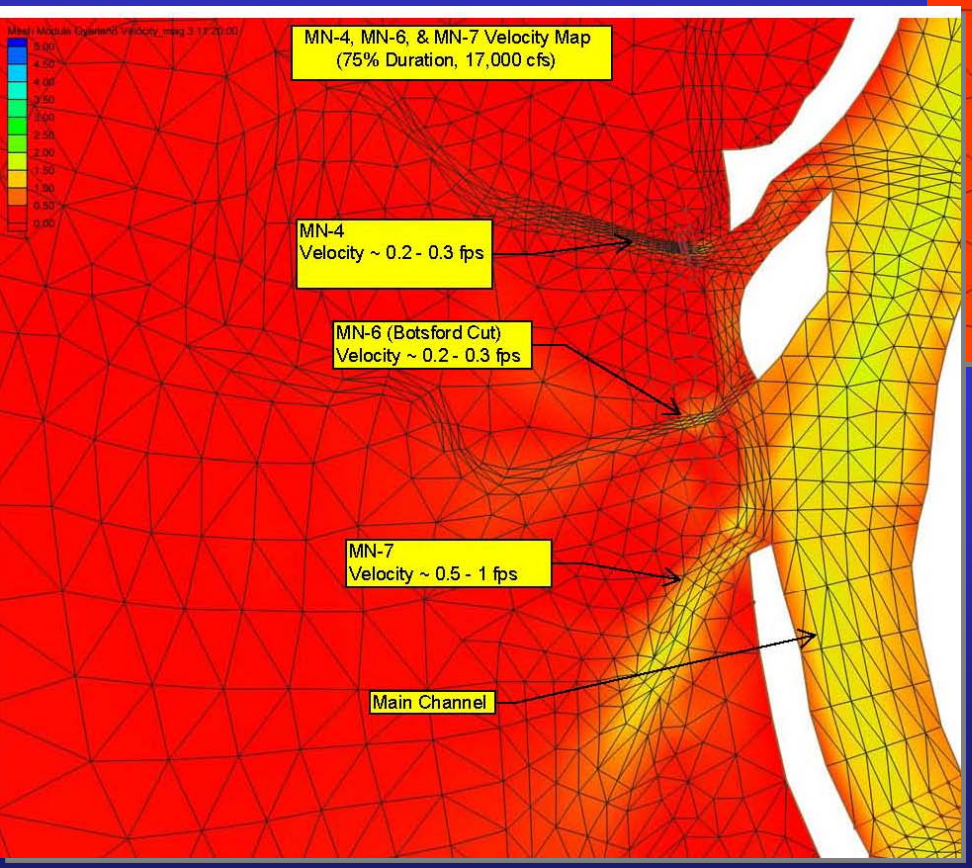
Used 2D models to assess conditions and develop performance criteria in secondary channels





Performance Criteria for Secondary Channels:

- **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%**

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Use 2D models to assess the effects of management actions

Secondary Channels Modeled Velocity									
	5% Dur. [1]				*75% Dur.* [2]				
	Existing Conditions		1.5' Drawd.	2.5' Drawd.	Velocity		Drawdown[3]	1.5' Drawd[4]	2.5' Drawd[5]
Sites	Range	Average	Average	Average	Range	Average	Average	Average	Average
Objective:	*2 - 3 fps*	*2.5 fps*	*2.5 fps*	*2.5 fps*	*0.5 - 1.5 fps*	*1 fps*	*1 fps*	*1 fps*	*1 fps*
W. Newton	3 - 4 fps	3.5 fps	3.5 fps	**3.75 fps**	0.7 - 1.2 fps	1 fps	**1.1 fps**	**1.1 fps**	**1.25 fps**
Murphy Cut	0.5 - 3 fps	1.5 fps	1.5 fps	**1.75 fps**	0.1 - 0.5 fps	0.25 fps	0.25 fps	0.25 fps	**0.2 fps**
WI-1 (Belvidere)	2.2 - 3.5 fps	2.75 fps	2.75 fps	2.75 fps	0.5 - 1 fps	0.75 fps	0.75 fps	0.75 fps	0.75 fps
WI-3 (Roebuck)	2 - 3 fps	2.5 fps	2.5 fps	2.5 fps	0.5 - 1 fps	0.75 fps	**0.65 fps**	**0.6 fps**	**0.1 fps**
MN-7	2.5 - 3.5 fps	3 fps	**3.5 fps**	**3.5 fps**	0.5 - 1.5 fps	1 fps	1 fps	1 fps	**0.5 fps**
WI-4 (Sand)	1.5 -2.5 fps	2 fps	2 fps	2 fps	0.4 - 0.8 fps	0.6 fps	**0.75 fps**	**1 fps**	**1 fps**
Lower Belvidere	1.5 - 4 fps	2.5 fps	**2.75 fps**	**3 fps**	0.5 - 1 fps	0.75 fps	0.75 fps	**1 fps**	**1 fps**
WI-5	0.7 - 1.3 fps	1.25 fps	1.25 fps	**1 fps**	0.2 - 0.5 fps	0.4 fps	**0.3 fps**	**0.3 fps**	**0.1 fps**
WI-6	1 - 1.5 fps	1.25 fps	**1 fps**	**0.5 fps**	0.4 - 0.6 fps	0.5 fps	**1 fps**	**1 fps**	**1.1 fps**
Partial Closure Structures Modeled Velocity									
MN-3	2 - 6 fps	4 fps	**4.25 fps**	**4.5 fps**	1 - 1.5 fps	1.25 fps	**1.35 fps**	**1.35 fps**	**1 fps**
MN-4	3 - 4.5 fps	4 fps	**4.5 fps**	**5 fps**	0.5 - 1.5 fps	1.25 fps	**1 fps**	**1 fps**	**0.6 fps**
MN-6 (Botsford)	2.5 - 3.5 fps	3 fps	**3.25 fps**	**3.5 fps**	0.5 - 1 fps	0.75 fps	**0.5 fps**	**0.25 fps**	**0 fps**
MN-10	0.1 - 2.5 fps	2 fps	**2.25 fps**	**2.5 fps**	0.1 - 0.8 fps	0.75 fps	0.75 fps	**1 fps**	**1.1 fps**
MN-14-1	2 -4 fps	3 fps	**3.25 fps**	**3.5 fps**	0.3 - 0.7 fps	0.5 fps	0.5 fps	0.5 fps	0.5 fps
MN-14-2	0.5 - 3.2 fps	2 fps	**2.25 fps**	**2.5 fps**	0.2 - 0.7 fps	0.6 fps	**0.5 fps**	**0.5 fps**	**0.5 fps**

Notes:

[1] 5% Duration Event (88,000cfs)

[2] 75% Duration Event (17,000cfs)

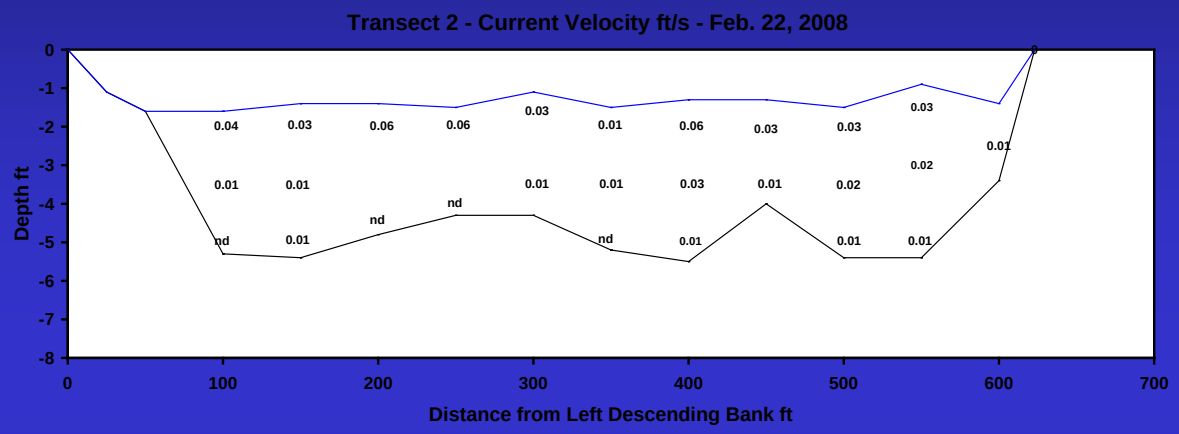
[3] 1.5' & 2.5' w/ constr.

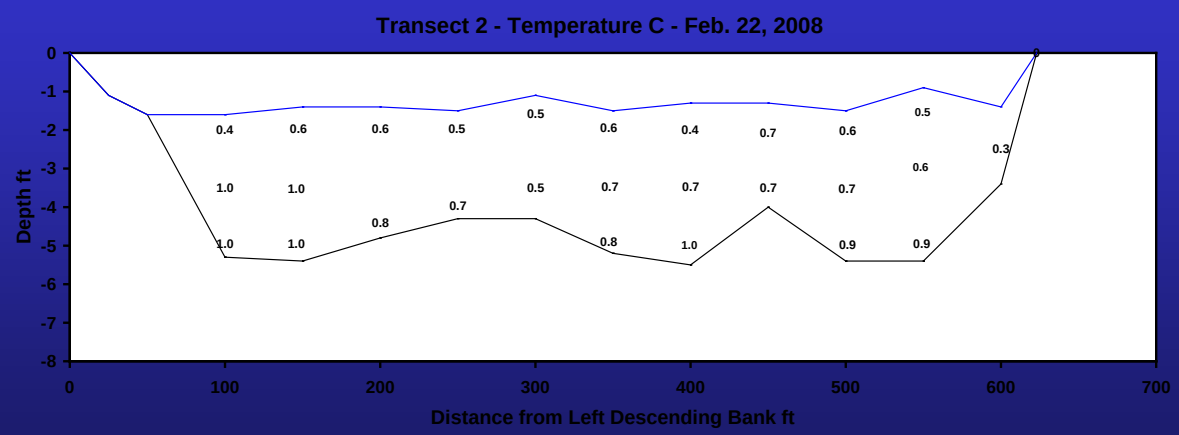
[4] 1.5' w/o constraints

[5] 2.5' w/o constaints

Post-project monitoring indicates that performance criteria was partially achieved

- Performance Criteria
  - Water Depths > 4 Feet
  - Water Velocities < 0.01 fps
  - Water temp > 0 C
  - D. O. ≥ 5 ppm





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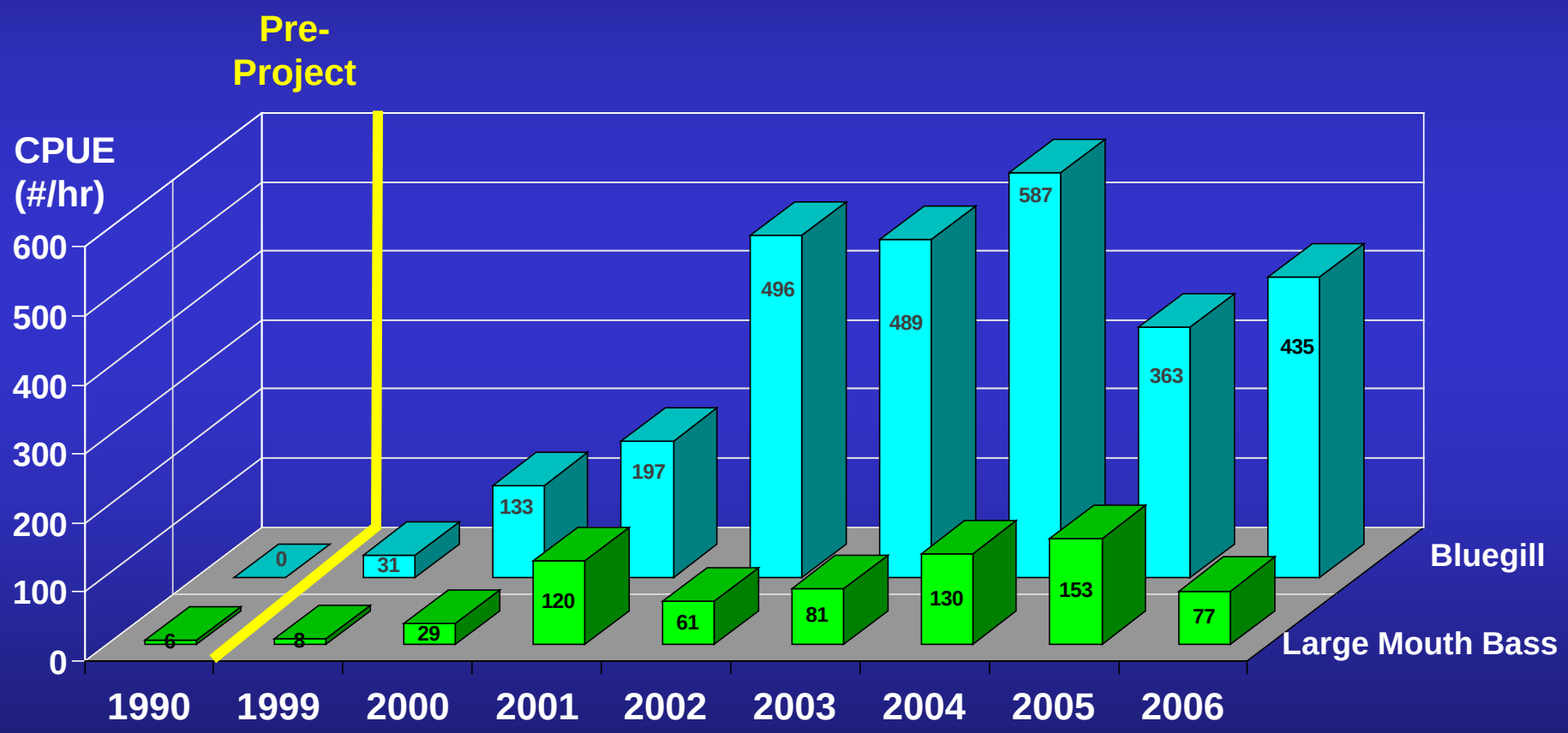
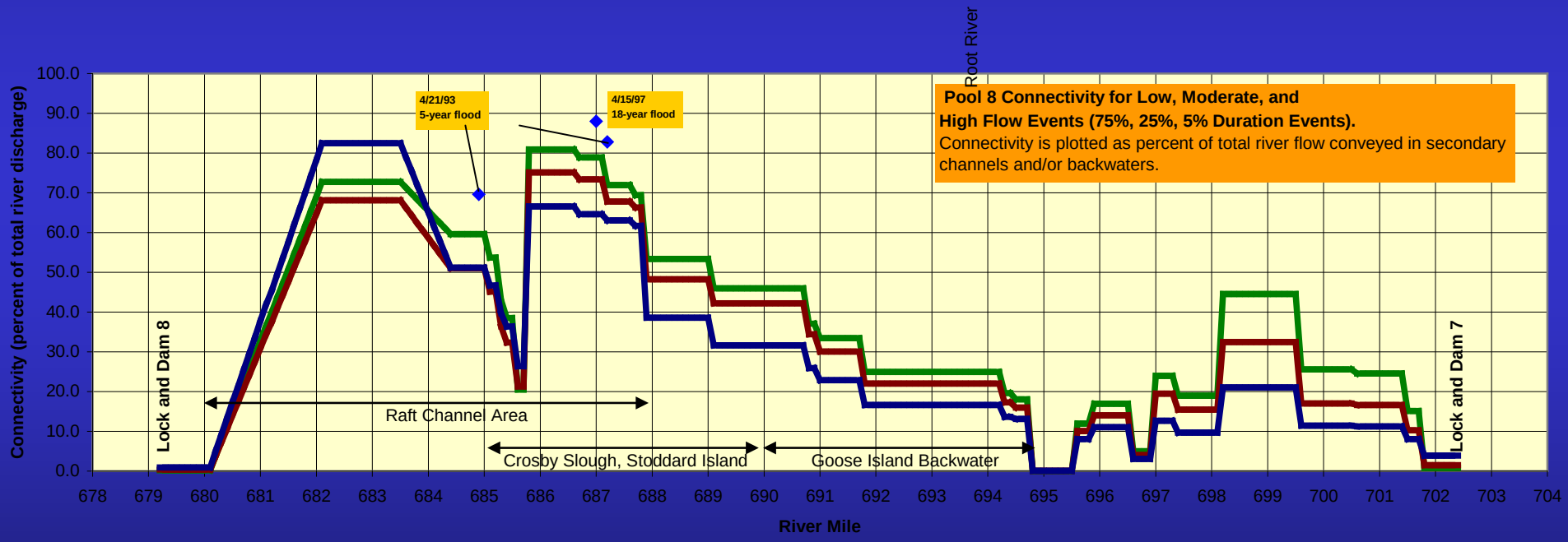
Pool 8 Islands Phase II

Pre- and Post-Project Fall Electro-fishing

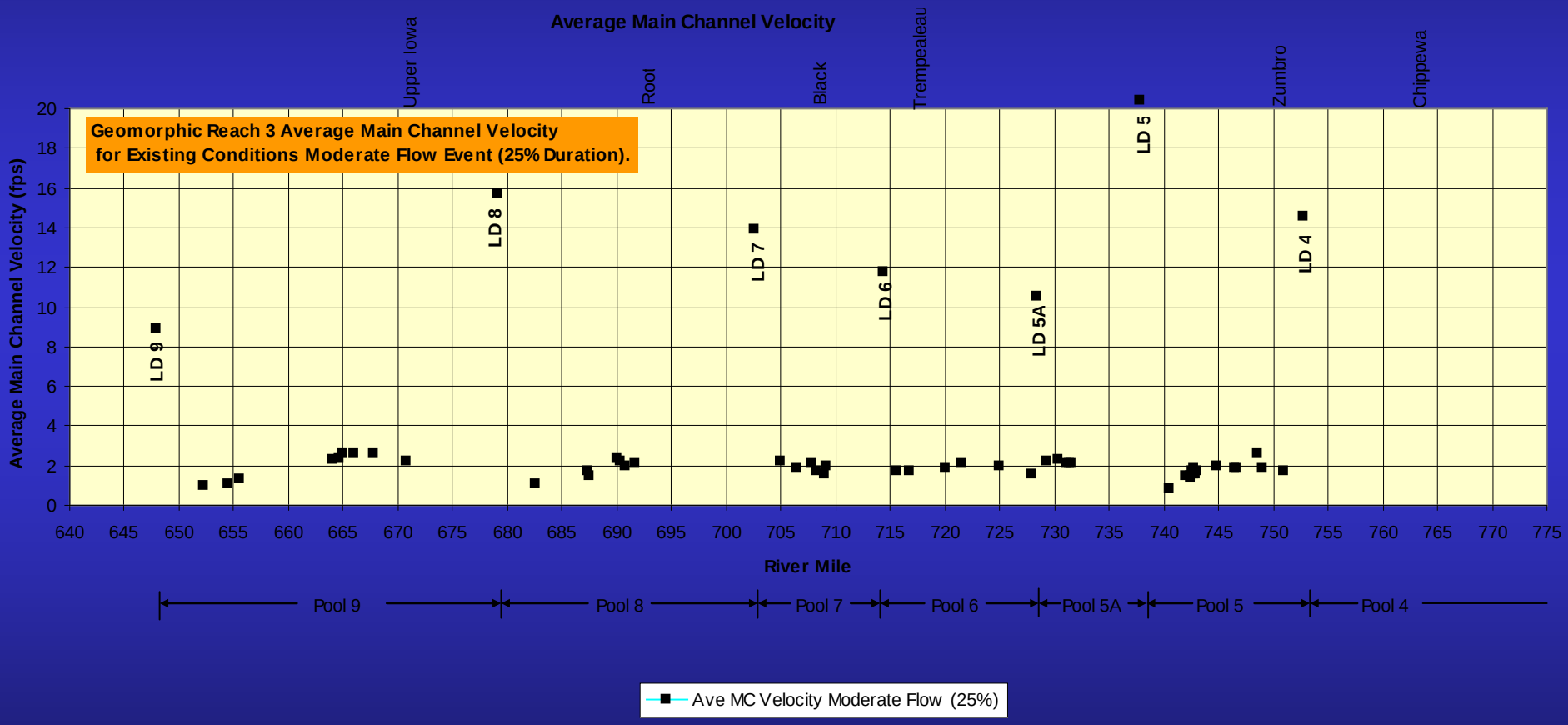
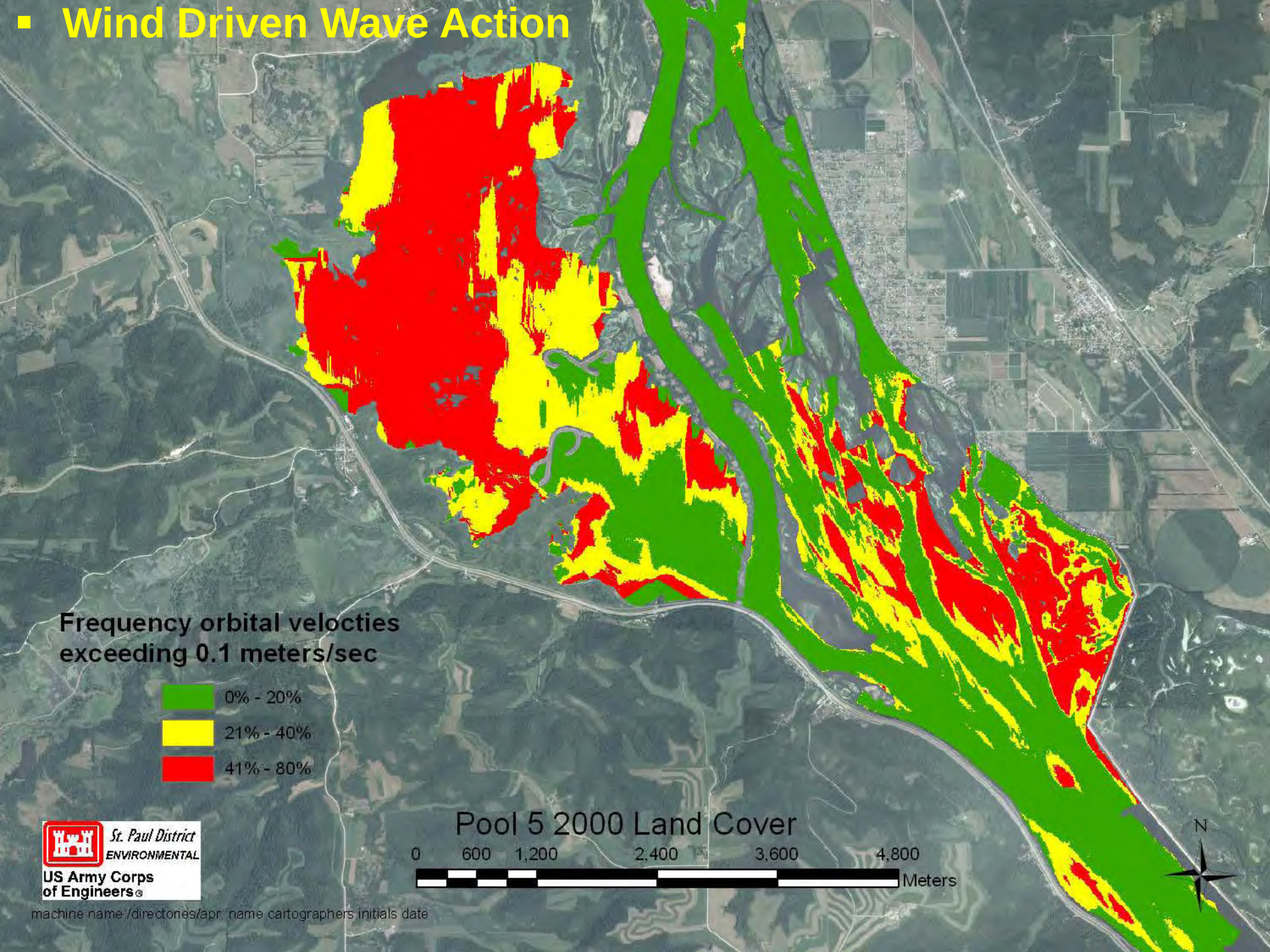


Pool 8 Lateral Hydraulic Connectivity



Connectivity values based on St. Paul District Corps of Engineers water discharge data.)

High Velocities in Dam Gates



Wind Driven Wave Action