CREATION OF SHALLOW WATER HABITAT FOR MISSOURI RIVER RECOVERY

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Abstract: The Missouri River Biological Opinion and the Amended Biological Opinion set forth the requirements for the creation of Missouri River shallow water habitat with specific acreage goals. Construction methods employed to create shallow water habitat include developing chutes, backwater areas, dike lowering/notching/removal, and the placement of new structures. Shallow water habitat creation must not impact existing authorized project purposes that include navigation, flood control, and bank stabilization. Data collection, hydraulic analysis, and monitoring of physical and biological parameters are all important features of the shallow water program. A brief background of the shallow water habitat program is presented along with construction methods, design and analysis techniques, observed channel response, and limited details of the physical and biological monitoring program. Specific concerns regarding design issues, monitoring, and future program needs are discussed.

INTRODUCTION

In 1989, The U.S. Army Corps of Engineers (Corps) initiated consultation with the U.S. Fish and Wildlife Service (Service) regarding operation of the Missouri River Main Stem Reservoir System. Consultation covered operation of the Missouri and Kansas Rivers as well as the Missouri River Bank stabilization and Navigation Project. The 2000 Biological Opinion found that the actions proposed by the Corps would jeopardize the Interior least tern, pallid sturgeon, and piping plover. With the intent of precluding jeopardy to the species, the Service provided a Reasonable and Prudent Alternative (RPA). The Corps requested reinitiation of formal consultation and an amended Biological Opinion was provided in 2003. The Missouri River Biological Opinion and the Amended Biological Opinion (USFWS, 2003) set forth the requirements for the creation of shallow water habitat. In conjunction with the biological opinion, an update to the master manual that provides for the operation of the Missouri River system was completed by the Corps in 2004 (USACE, 2004). The RPA consisted of numerous elements pertaining to flow management, habitat diversity, and habitat acres. The RPA performance standard for Missouri River shallow water habitat acres below Gavins Point Dam was established as 30 acres per mile. The remainder of this paper focuses on the portion of the biological opinion that pertains to the creation of pallid sturgeon shallow water habitat within the Omaha District reach of the Missouri River between Gavins Point Dam, river mile 811, and Rulo, NE, at river mile 498.

Pallid Sturgeon Habitat: The pallid sturgeon is native to the Missouri and Mississippi Rivers and is adapted to the free flowing, warm water, turbid habitats that are in a constant state of change. Floodplains, backwater, chutes, sloughs, islands, sandbars and main channel waters formed the large river ecosystem that provided habitat for all life stages of pallid sturgeon. Evidence of reproduction for wild origin pallid sturgeon is lacking. Destruction and alteration of big river ecological functions and habitat that was once provided by the Missouri and Mississippi

Rivers is believed to be the primary cause of declines in reproduction, growth, and survival of pallid sturgeon.

Shallow Water Habitat Definition: As set within the biological opinion, the parameters used to define shallow water habitat are Missouri River flow depths less than 5 feet (1.5M) and velocities less than 2 fps (0.6 m/s). For the purposes of assessing habitat creation, the effective discharge is defined as the 50% exceedance discharge from the August flow duration curve(s). Although the habitat accounting system will be based on the effective discharge, data will be gathered and analyzed for a range of flows to provide a full impact assessment. Within the context of the RPA, defined shallow water habitat acreage refers to the following conditions:

- 50% exceedance August flow
- Flow depth less than 5 feet (1.5M)
- Flow velocity less than 2 ft/sec (0.6 m/s)

Maintenance of Existing Project Purposes: While meeting the shallow water habitat objectives defined within the RPA, all Missouri River authorized project purposes must be maintained. The authorized 300-foot wide by 9-foot deep navigation channel must be maintained along a reliable sailing line. The authorized streambank stabilization function must be maintained to the point that general channel meandering and channel avulsions are prevented. The capacity of the Federal Flood Control Projects must be maintained, as well as water supply and water quality. Although recreation is not a specific objective of the program, the recreation value of the river will likely be enhanced. However, public safety concerns must be addressed in the development of individual project sites. An illustration of a typical Missouri River channel section with relevant elevations and the navigation channel is shown in Figure 1.

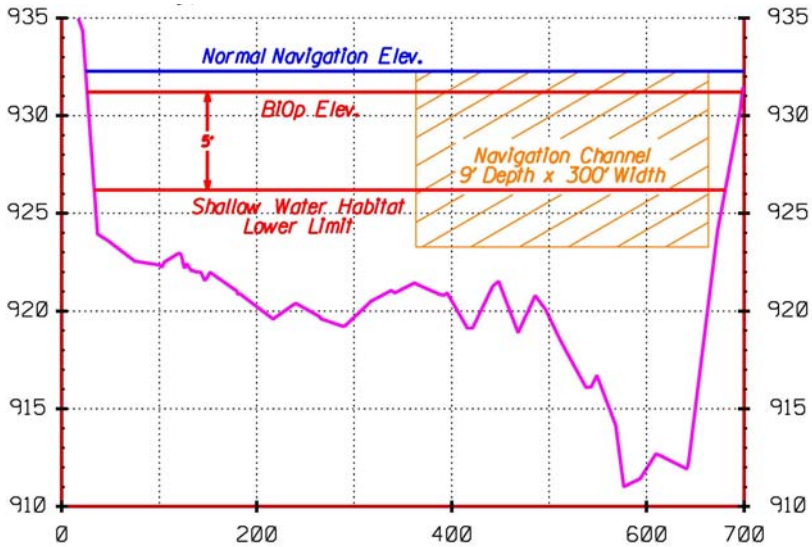


Figure 1. Typical Missouri River Channel Section

Habitat Flow Considerations: Habitat parameters (depth and velocity) are a function of discharge. In order to measure the effectiveness of the proposed project modifications; an

effective or design discharge must be defined. For the purposes of assessing habitat creation, the 50% exceedance discharge from the August flow duration curve(s) is employed as the effective discharge. Although the shallow water habitat accounting system will be based on the effective discharge, data will be gathered and analyzed for a range of flows. Shallow water habitat creation techniques are flow dependent. Flow ranges experienced during the year should be evaluated when considering the habitat created within constructed areas. A different flow regime should be expected to alter habitat acreage. Collected data will be used to develop habitat (duration) availability curves at representative sites that relate habitat acres with flow duration.

SHALLOW WATER HABITAT CREATION METHODS

Shallow water habitat is created using many different approaches that may be classified according to the construction method and location. Some methods utilize the main channel while other methods utilize the adjacent floodplain. The habitat construction methods that have been used include:

- Structure Notching (in-channel revetment and dikes)
- Dredging (off-channel)
- Pilot Channel (off-channel)
- Chute (off-channel)
- Major Dike Modification (in-channel dike lowering and chevron construction)

Employment of the various methods is often limited by physical parameters, available real estate, and other factors. For instance, not all bends are suitable for the construction of an off channel chute. Dike modifications must consider real estate requirements and adjacent floodplain uses as channel widening is generally expected to occur. A typical dike notching cross section is illustrated in Figure 2. An aerial view of a constructed dike notch is illustrated in Figure 3.

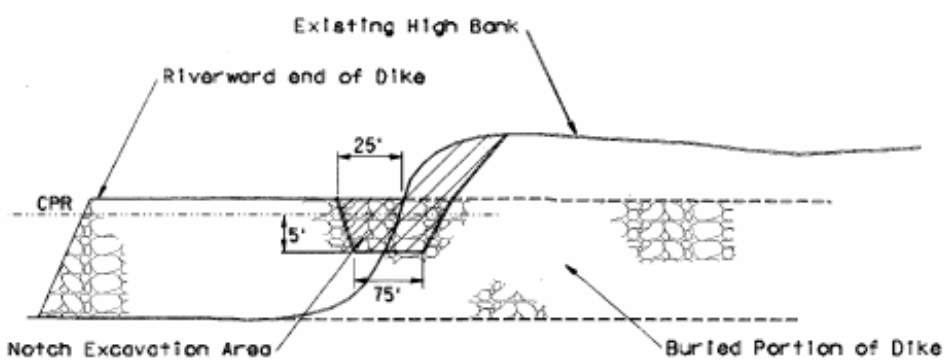


Figure 2. Typical Dike Notch Cross Section.

Figure 3. View of Constructed Dike Notch.

SHALLOW WATER HABITAT DESIGN AND ANALYSIS

Habitat Design Challenges: The successful design of shallow water habitat acreage must address several notable challenges. Creation of shallow habitat must not impact existing channel capacity and sediment transport. Existing flood plain uses and real estate limitations often limit available options. The Missouri River is also known for a variable flow-stage rating that occurs in response to seasonal vegetation, temperature, and other factors. The combination of minimizing impact to hydraulic functions including sediment transport while maximizing the created shallow water habitat acreage often limits design possibilities.

Habitat Design Methods: Habitat design methods include one-dimensional, two-dimensional, and sediment transport modeling. The models are constructed from available design data that includes aerial photos from numerous years, 4 foot contour interval floodplain mapping supplemented with site specific survey data, hydrographic channel surveys, ADCP velocity data, and measured water surface profiles.

For design of side channel chutes, the typical analysis uses a one-dimensional split flow model. The model is calibrated to available Missouri River profile data. The typical chute invert elevation is within 4 – 6 feet of the normal navigation water surface elevation to limit chute sediment intake. The typical chute takes less than 10% of the main channel flow with a flow velocity greater than 2 ft/sec at the normal navigation flow.

For design of dike modifications, the typical analysis is based on prototype experience supplemented with limited analysis. Flow through the dike field is complex with sediment transport a critical component. Analysis uses a two-dimensional model with a detailed mesh

through the dike field. The developed model is calibrated to ADCP data that specifies velocity magnitude and direction. Limited success has been achieved with using the sediment transport module combined with model results. Flow over and through the dike field is plunging with three-dimensional components.

MONITORING AND ASSESSMENT

Following habitat creation, the monitoring and performance assessment of the created habitat is a critical component of the amended biological opinion. It is not practical, from a cost or logistical point of view, to conduct detailed data collection for every river mile. Therefore, detailed data collection will be performed at selected sites in order to determine the average number of habitat acres created by each type of modification and monitor impacts to authorized project purposes. Data collection consists of hydrographic surveys, land surveys, and ADCP depth-velocity data. Due to the expense of ADCP data collection and analysis, collection of ADCP data will be limited in quantity compared with other data collection efforts.

Detailed data collection sites are classified by type of modification, relative size of modification, and river reach. Enough sites within each classification will be monitored to establish both habitat creation trends as well as project impacts. The detailed data collection process will also identify indicator parameters that will be measured at the remaining sites. The indicator parameters will be used to total the number of acres created as well as track project impacts. General monitoring will be conducted to evaluate trends and impacts. Within the different habitat classifications, physical monitoring includes the collection of hydrographic and velocity data. Physical monitoring is also required in the remainder of the river outside the constructed habitat areas. Proposed monitoring for the different classifications of shallow water habitat on the Missouri River consists of:

- Monitoring within constructed habitat areas (constructed notches, chutes, etc.)
- Control location monitoring (non-modified areas)
- General channel monitoring

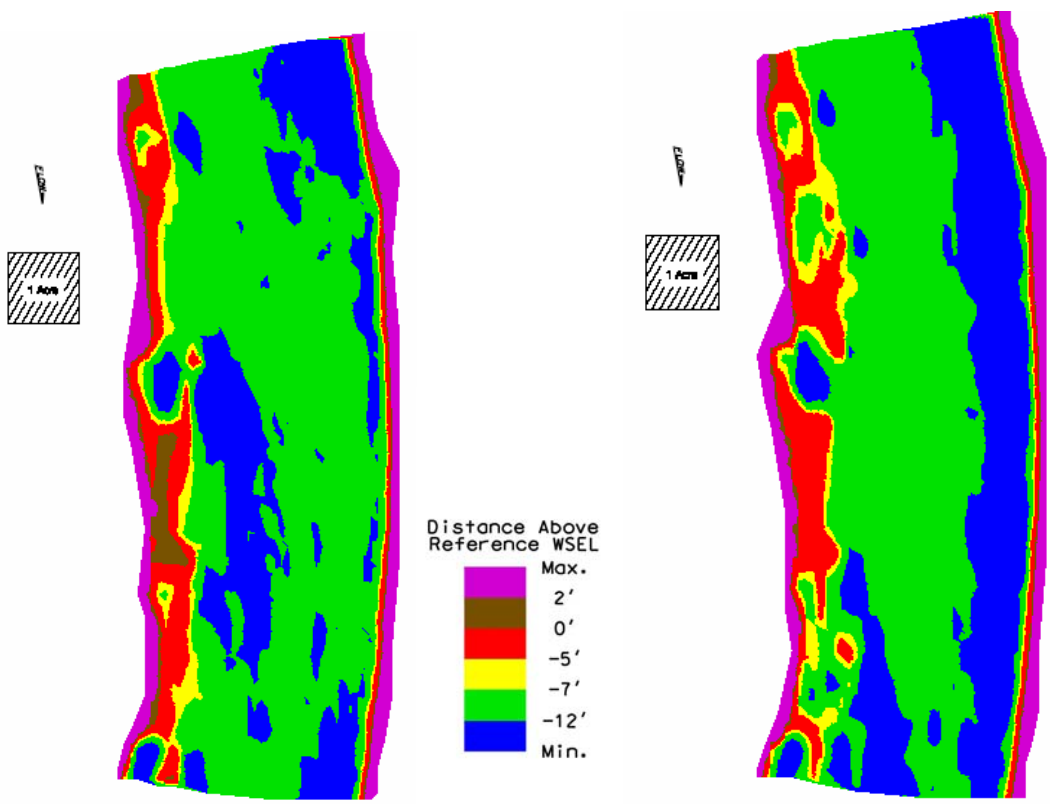
Constructed Habitat Location Monitoring: Data collection performed for monitoring of constructed habitat location monitoring will consist of the collection of hydrographic and ADCP data at selected locations. Selection of constructed habitat location monitoring sites will consider site location, the different habitat classifications, and the requirement to assemble a long-term history at a number of sites. A collection data history is necessary to track evolution of constructed habitat. Data history will also provide a basis to evaluate seasonal river changes with respect to constructed habitat changes.

Control Location Monitoring: Control location data collection will follow the same standards and format as constructed habitat location monitoring. The purpose of control location monitoring is to provide a baseline of physical change occurring within non-construction areas. Changes may be occurring as system wide river response to habitat construction or due to other factors that affect river morphology. During the course of shallow water habitat construction, monitoring at control locations that are not impacted by any construction activities will serve to provide a basis for defining shallow water habitat impacts on authorized project purposes.

Control location monitoring will also serve to determine if general channel changes are occurring that may be beneficial to the goal of shallow water habitat creation and species recovery.

General Channel Monitoring and Analysis: Additional general channel monitoring and analysis is required to evaluate system responses to constructed habitat and impacts and identify general trends. General channel monitoring consists of system wide data collection efforts including aerial photographs, channel and bank surveys, structure surveys, and sediment samples.

Data Collection Analysis: After collection of the monitoring data, analysis is performed to determine shallow water habitat acreage using the definition previously described. Analysis is based on CADD computations to evaluate the acreage difference between pre and post construction surveys. An example of difference surveys within a major dike modification site is illustrated in Figure 4.



Pre-Construction **3 Months After Construction**

Figure 4. Habitat Analysis at Typical Modified Site

Evaluation of Shallow Water Habitat Creation: Collected data is analyzed to evaluate shallow water habitat on an annual basis and track changes in shallow water habitat acres in subsequent years. Data is analyzed using CADD to perform accurate computations of acreage that meet shallow water habitat depth criteria. Data analysis results from 2004 are presented in Table 1.

Table 1. Shallow Water Habitat Acres Summary - 2004						
	RM Range	Number Structures Modified	Min. Acres	% of Total	Max. Acres	% of Total
Main Channel Projects						
Bank Notching	130-466		300	21.1%	450	24.6%
Dike Notches	130-466		492	34.6%	492	26.9%
Revetment Notches	130-466		118	8.3%	118	6.4%
Type B Notches	508-722	124	124	8.7%	248	13.5%
Major Dike Modifications	529-715	125	130	9.1%	246	13.4%
Totals		249	1164	81.9%	1554	84.9%
Off-Channel Connection Projects						
Dredging	650-754		135	9.5%	155	8.5%
Pilot Channel	171-466		44	3.1%	44	2.4%
Chutes	131-218		78	5.5%	78	4.3%
Totals		NA	257	18.1%	277	15.1%
All Types Total		249	1421		1831	

FUTURE EFFORTS AND TECHNICAL FOCUS

Future efforts will continue the shallow water habitat design, construction, and monitoring program to achieve the acreage goals specified by the amended biological opinion. Shallow water habitat design and construction techniques will be reviewed and revised using prototype experience. Monitoring may lead to adaptive management and changing design criteria based on biologic response. Analysis will be performed to develop sediment transport evaluation methods and the evaluation of impacts on a system wide basis. Prototype experience will be used to refine shallow water habitat creation methods.

REFERENCES

USACE (2004). Missouri River Master Water Control Manual, Review and Update FEIS, U.S. Army Corps of Engineers, Northwestern Division, Missouri River Basin, Water Management Division, Omaha, NE.

USFWS (2003). 2003 Amendment to the 2000 Biological Opinion on the Operation of the Missouri River Main Stem Reservoir System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System, U.S. Fish and Wildlife Service.