Appendix L

MONITORING AND ADAPTIVE MANAGEMENT

1. Introduction

The 1985 Supplemental Appropriations Act (Public Law 99-88) and Section 1103 of the Water Resources Development Act of 1986 (Public Law 99-662) authorized implementation of ecosystem restoration projects to ensure the coordinated development and improvement of the Upper Mississippi River System. Section 2039 of WRDA 2007 requires that when conducting a feasibility study for ecosystem restoration, the proposed project includes a plan for monitoring the success of the ecosystem restoration. Additionally, paragraph (3)(d) of Section 2039 states that "an adaptive management plan will be developed for ecosystem restoration projects...appropriately scoped to the scale of the project." The implementation guidance for Section 2039, in the form of a CECW-PB Memo dated 31 August 2009, also requires that an adaptive management plan be developed for all ecosystem restoration projects. Adaptive management "prescribes a process wherein management actions can be changed in response to monitored system response, so as to maximize restoration efficacy or achieve a desired ecological state" (Fischenich et al. 2012).

At the programmatic level, knowledge gained from monitoring one project can be applied to other projects. Opportunities for this type of adaptive management are common within the UMRR. Using an adaptive management approach during project planning enabled better selection of appropriate design and operating scenarios to meet the Piasa and Eagle's Nest Islands HREP project objectives. Lessons learned in designing, constructing, and operating similar restoration projects within the UMRS have been incorporated into the planning and design of this HREP to ensure that the proposed plan represents the most effective design and operation to achieve project goal and objectives.

The adaptive management for the Piasa and Eagle's Nest Islands HREP describes and justifies whether adaptive management is needed in relation to the proposed project management alternatives identified in the project feasibility study. This appendix outlines how the results of the project-specific monitoring plan would be used to adaptively manage the project, including monitoring targets which demonstrate project success in meeting project objectives. The District's intent was to develop monitoring and adaptive management actions appropriate for the project's goal and objectives.

2. Goal and Objectives

The primary goal of the Piasa and Eagle's Nest Island HREP is to restore and improve the quality and diversity of aquatic and island ecosystem resources within the Project Area. Full realization of the potential habitat value in Piasa and Eagle's Nest Islands has been hindered by loss of depth and flow into Piasa Chute, loss of connectivity between the Piasa Island Backwater and the main channel of the Mississippi River, loss of islands due to inundation caused by impoundment, and the subsequent degradation of aquatic resources. Establishing connectivity between the backwater and main channel would contribute to overwintering fish habitat as well as feeding areas for migratory wildlife; providing bathymetric diversity and flow within Piasa Chute would provide important side channel habitat within Pool 26; and restoring historic islands would allow the Project Area to realize the highest benefit to fish and wildlife. The objectives identified to meet the project goal are to:

1. Restore depth (>8 feet) and increase velocity over existing conditions to improve sediment transport and geomorphic processes within Piasa Chute.
2. Increase the depth and connectivity between the Piasa Backwater and the Mississippi River, as measured by acres of deep water habitat (>5 feet) and number of days connected.
3. Increase the spatial coverage of islands, as measured in acres.

The following restoration measures were considered to achieve the Project goal and objectives:

- No Action
- Excavate Piasa Chute
- Excavate Piasa Island Backwater
- Construct river training structures
- Construct islands with excavated material and stone protection

3. Sources of Uncertainty

Adaptive management provides a process for making decisions in the face of uncertainty. The primary incentive for implementing an adaptive management plan is to increase the likelihood of achieving desired project outcomes given the identified uncertainties, which can include incomplete description and understanding of relevant ecosystem structure and function; imprecise relationships among project management actions and corresponding outcomes; engineering challenges in implementing project alternatives; and ambiguous management and decision-making processes. Following is a list of uncertainties associated with the aquatic and island habitat in the Piasa and Eagle's Nest Islands HREP.

- **Side Channel Habitat (Piasa Chute)**
  - It is expected that implementation of the notched rock structure would not significantly alter the hydraulic forces over the existing mussel beds within the Project Area. If monitoring demonstrates a significant impact to mussels in the known mussel beds, a modification of the structure would be required.
  - The District evaluated the level of uncertainty and risk in the Piasa Chute dredging measure and determined it did not require the use of Adaptive Management to address uncertainty in the potential of the measure to meet performance criteria. Dredging to increase depth and flow has been shown to be successful through the St. Louis District's Biological Opinion and Regulating Works Program. In addition, the Project Area underwent extensive physical and numerical hydraulic modeling to evaluate the persistence of the dredge cut and project measures. Furthermore, lessons learned from the St. Louis District's efforts as well as work from the Kansas City District were used in the design of the side channel dredging for this Project. Monitoring will be conducted to determine project success.
- **Backwater Fish Habitat (Piasa Island Backwater)**
  - It is expected that overwintering and summer habitat in the dredged backwater will not be limited by dissolved oxygen, flow, or depth. However, uncertainty still remains since the proposed project is only removing the sediment plug at the entrance of the backwater. If monitoring demonstrates that conditions of the interior backwater were not improved then an adaptive management measure of installing a rock structure (similarly to the constructed chevron on Bolter's Island of the Pools 25 and 26 Islands HREP) to promote scour or additional backwater interior excavation would be implemented.
- **Island Habitat**
  - It is expected the implementation of the island building will become permanent features in the Project Area; however there is some uncertainty as to whether the islands will remain as sand bar islands (which is the desired for the endangered Least Tern habitat) or become established with woody vegetation. If monitoring demonstrates a need to remove establishment of woody vegetation, an adaptive management measure to re-evaluate the team's desire to maintain sandbar habitat versus vegetated island habitat.

If the interagency team determined that sandbar habitat was still the target habitat then an adaptive management measure of removing the woody vegetation would be implemented.

4. Monitoring of Objectives to Determine Project Success and Adaptive Management Measures

The power of a monitoring program developed to support determinations of project success and inform adaptive management lies in the establishment of feedback between continued project monitoring and corresponding project management. This monitoring and adaptive management plan was developed with input from state and federal resource agencies. Performance indicators to the above objectives were developed with the best available knowledge. They were developed to be specific, measurable, attainable, realistic, and timely. Current performance indicators are summarized in Table 1. The conceptual monitoring schedule and estimated costs are provided in Table 2.

- **Side Channel Habitat (Piasa Chute).**
  - Bathymetric surveys will be conducted upon completion of the Project 2-year post construction to determine base depth conditions and construction compliance. A comparison survey (ISOPACH) survey will be conducted at year 7 to map and quantify the amount of the side channel greater than 8 feet in depth.

    Success Criteria:

Monitoring Target	Years 1-5	Year 25	Year 50
% of side channel ≥ 8 feet deep	>75%	>65%	>50%

  - ADCP surveys will be conducted upon completion of the Project to determine base flow conditions at year 2. A comparison survey will be conducted at year 7 to map and quantify the average current velocity greater than 2.0 ft/sec.

    Success Criteria:

Monitoring Target	Years 1-5	Year 25	Year 50
Average Current Velocity ft/sec	>2.0	>2.0	>2.0

  - Water quality data collected from the site annually under UMRR-LTRM will be used to determine dissolved oxygen concentrations throughout the year.

    Success Criteria:

Monitoring Target	Years 1-5	Year 25	Year 50
Minimum dissolved oxygen (mg/L)	>5.0	>5.0	>5.0

  - Comparison of fish habitat use during the year will be compared with pre-project habitat use to aid in determining Project success. The UMRR-LTRM (i.e., daytime electrofishing) will complete the fish surveys used to conduct this comparison.

    Success Criteria:

Monitoring Target	Years 1-5	Year 25	Year 50
Catch-per-unit-effort of native fish preferring flowing habitat (i.e., fluvial specialists and dependents)	Increase over pre-construction		

o Comparison of post-construction mussel density with post-construction mussel density will be used to aid in determining Project success.

Success Criteria:

Monitoring Target	Years 1-5	Year 25	Year 50
Mussel Density (individuals per m^2) of Piasa Head Bed and Piasa Toe Bed maintained/enhanced	>1.5/m^2 - (Piasa Head)	>1.5/m^2 - (Piasa Head)	>1.5/m^2 - (Piasa Head)
	>5.5/m^2 (Piasa Toe)	>5.5/m^2 (Piasa Toe)	>5.5/m^2 (Piasa Toe)

Adaptive Management Trigger and Measure. If post-construction mussel survey monitoring results indicate an inability to reach the success criteria *and* mussel density is reduced by more than 50% over pre-construction mussel surveys, then modifications to the notched rock structure would be implemented to modify flow over the beds.

- **Backwater Fish Habitat (Piasa Island Backwater)**
  o Bathymetric surveys will be conducted upon completion of the Project 2-year post construction to determine base depth conditions and construction compliance. A comparison survey (ISOPACH) survey will be conducted at year 7 to map and quantify the amount of the backwater greater than 5 feet in depth. Pre-construction backwater is approximately 49 acres. The proposed backwater dredging would result in 9 acres of deepwater habitat restored, or approximately 18% of the backwater.

Success Criteria:

Monitoring Target	Years 1-5	Year 25	Year 50
% if backwater ≥ 5 feet deep	>15%	>12%	>10%

o Water quality data collected from the site annually under UMRR-LTRM will be used to determine dissolved oxygen concentrations throughout the year.

Success Criteria:

Monitoring Target	Years 1-5	Year 25	Year 50
Minimum dissolved oxygen (mg/L)	>5.0	>5.0	>5.0

o Comparison of fish habitat use during the year will be compared with pre-project habitat use to aid in determining Project success. The UMRR-LTRM (i.e., daytime electrofishing) will complete the fish surveys used to conduct this comparison.

Success Criteria:

Monitoring Target	Years 1-5	Year 25	Year 50
Catch-per-unit-effort of native fish preferring slackwater habitat	Increase over pre-construction		

o Comparison of days Piasa Island Backwater is connected to the main channel will be compared with pre-project days connected to aid in determining Project success. Visual observations and gage readings will be used to conduct this comparison

Success Criteria:

Monitoring Target	Years 1-5	Year 25	Year 50
% of year Piasa Island Backwater is connected to the main channel	>75%	>65%	>50%

Adaptive Management Trigger and Measure. If monitoring result indicate an inability to reach success criteria by year 6 post-construction *and* more than 50% of the restored deepwater habitat is lost (i.e., approximately 5 acres), 3 more more fish kills in the backwater have been observed, and/or restored connectivity is reduced by more than 50% from Year 1, then installation of scouring rock structure or dredging of the backwater would be re-visited by the Corps and sponsor.

- **Island Habitat**
  - o Aerial imagery along with hydrographic survey and topographic surveys will be conducted upon completion of the Project to determine base acres constructed and construction compliance. A comparison survey will be conducted at years 1, 5, and 10 to map and quantify the acres of island habitat greater than 421.0 feet (NGVD29). The results of this will study will inform Project success, inform adaptive management triggers and measures, and inform future HREPs.

Success Criteria:

Monitoring Target	Years 1-5	Year 25	Year 50
Acres of island habitat (>421.0 feet NGVD29)	>75	>65	>60

  - o Vegetative monitoring would be conducted by visual observations during site inspections by the sponsor and the Corps. During planning, the desire was to restore sandbar islands with minimal woody vegetation establishment. If more than 50% of woody vegetation on the restored islands greater than 5 feet becomes established by year

Success Criteria:

Monitoring Target	Years 1-5	Year 25	Year 50
% cover of woody vegetation cover taller than 5 feet	<15%	<25%	<50%

Adaptive Management Trigger and Measure. If site inspections result indicate more than 50% of woody vegetation on the restored islands greater than 5 feet in height becomes established by year 8 then the Corps and the sponsor would determine if vegetation removal is still desired.

5. Documentation, Implementation Costs, Responsibilities, and Project Close-Out

Documentation, Reporting, and Coordination. The Project Delivery Team will document each of the performed assessments and communicate the results to the HREP program manager and partners designated for the Project. Periodic reports will be produced to measure progress towards the Project goal and objectives as characterized by the selected performance measures.

Cost. The costs associated with implementing monitoring an adaptive management measures were estimated based on currently available data and information developed during plan formulation as part of the feasibility study. Because uncertainties remain as to the exact Project measures, monitoring elements, and adaptive management opportunities, the estimated costs in Table 2 will need refinement in PED during the development of the Detailed Monitoring and Adaptive Management Plans.

Responsibilities. The Corps will be responsible for collecting hydrographic surveys, aerial imagery analysis, and mussel surveys. The UMRR-LTRM will be responsible for fish and water quality data collection and the Corps will be responsible for analyzing and evaluating these data. The sponsor and the Corps will be responsible for site inspections and visual observations to assist in overall project success evaluation.

Project Close-Out. Close-out of the Project would occur when it is determined that the Project has successfully met the Project success criteria described above. Success would be considered to have been achieved when the Project objectives have been met, or when it is clear that they will be met based upon the trends for the site conditions and processes. Project success would be based on the following:

- Success criteria met;
- Continued site inspections to determine continued Project status; and
- Continued OMRR&R into the future

Table 1. Project objectives, performance indicators, monitoring target, and adaptive management triggers and measures

Objective	Performance Indicator	Monitoring Target (Desired Outcome)	Responsible Party	Action Criteria (AM triggers)	AM Measure
Restore depth and increase flow within Piasa Chute	Bathymetric Diversity	% of side channel ≥ 8 feet deep	Corps	Not applicable. See discussion in text	Not applicable. See discussion in text
	Average current velocity (ft/s)	> 2.0 ft/sec	Corps		
	Minimum dissolved oxygen (mg/L)	> 5.0 mg/L	UMRR-LTRM		
	Native fish assemblage	Increase in abundance (Catch-per-unit-effort) over existing conditions of fish species preferring flowing habitat (i.e. fluvial specialists or dependents)	UMRR-LTRM		
	Mussel	Mussel density (individuals per m²) of Piasa Island Head Bed and Piasa Toe Bed maintained/enhanced	Corps	Post construction mussel survey show mussel density reduced by more than 50% over existing	Modify notched rock structure
Increase depth and connectivity of Piasa island Backwater	Bathymetric Diversity	% of backwater ≥ 5 feet deep	Corps	By year 6 post construction: >50% loss of restored deepwater habitat	Install a scouring rock structure and/or re-excavate
	Minimum dissolved oxygen (mg/L)	> 5.0 mg/L	UMRR-LTRM		
	Native fish assemblage	Increase in abundance (Catch-per-unit-effort) over existing conditions of fish species preferring slackwater habitat	UMRR-LTRM	3+ fish kills observed	
	Connectivity	% of year Piasa Island Backwater is connected to main channel	Sponsor/Corps	Restored connectivity reduced by >50% from Year 1	
Increase surface area of islands	Acres of islands	Acres of restored islands >421 feet	Corps	By year 8 post-construction: >50% woody vegetation cover taller than 5 feet established	Vegetation Removal
	Vegetation	<50% woody vegetation cover taller than 5 feet	Corps		

Table 2. CCNWR HREP conceptual monitoring schedule and estimated monitoring costs. Construction completion is set at year 0.

Obj.	Work Category	Activity	Post-Construction Years 1	2	3	4	5	6	7	8	9	10	SUBTOTAL
Piasa Chute		Hydrographic/ADCP Survey		20000					20000				40000
	Monitoring, Analysis, & Reporting	UMRR LTRM Fisheries	X	X	X	X	X	X	X	X	X	X	0
		UMRR LTRM Water Quality	X	X	X	X	X	X	X	X	X	X	0
		Mussel Survey			40000					40000			80000
	AM Feature: Notch Rock Structure/Install Rock (if needed)					35000							35000
f Piasa Island Backwater	Monitoring, Analysis, & Reporting	UMRR LTRM Fisheries	X	X	X	X	X	X	X	X	X	X	0
		UMRR LTRM Water Quality	X	X	X	X	X	X	X	X	X	X	0
		Gage Data Analysis	1000		1000		1000		1000		1000		5000
	AM Feature: Install rock/excavate backwater entrance (if needed)							70000					70000
Islands	Monitoring, Analysis, & Reporting	Public Aerial Imagery & Analysis	5000				5000					5000	15000
	AM Feature: Vegetation removal (if needed)				5000					5000			10000
Overall Project	Monitoring, Analysis, & Reporting	Site Inspections	2000			2000			2000		2000		8000
		Performance Evaluation Reporting					10000					10000	20000
												Subtotal	283,000
												Contingencies (30%)	84,900
												TOTAL	**$367,900**
		Annualized Cost (FY17 2.875% discount rate; 50 year period of analysis)												**$12,000**

* The Project falls within a Corps UMRR-LTRM study reach; therefore no additional funds would be needed to collect data. Assessment of the data is included in the cost of preparing the Performance Evaluation Report

6. References

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UPPER MISSISSIPPI RIVER RESTORATION
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PIASA & EAGLE'S NEST ISLANDS
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